MULTITUBERCULATE MAMMALS FROM THE WAHWEAP (CAMPANIAN, AQUILAN) AND KAIPAROWITS (CAMPANIAN, JUDITHIAN) FORMATIONS, WITHIN AND NEAR GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

by

Jeffrey G. Eaton
Department of Geosciences
Weber State University
Ogden, Utah 84408-2507

MISCELLANEOUS PUBLICATION 02-4
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
in cooperation with
U.S. Department of the Interior
Bureau of Land Management
Grand Staircase-Escalante National Monument

2002

UTAH GEOLOGICAL SURVEY

MULTITUBERCULATE MAMMALS FROM THE WAHWEAP (CAMPANIAN, AQUILAN) AND KAIPAROWITS (CAMPANIAN, JUDITHIAN) FORMATIONS, WITHIN AND NEAR GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

Jeffrey G. Eaton
Department of Geosciences
Weber State University
Ogden, UT 84408-2507

phone: (801) 626-6225
fax: (801) 626-7445
e-mail: jeaton@weber.edu

Cover photo by author:
Powell Point in "The Blues," the early Tertiary Claron Formation on the horizon and the Kaiparowits Formation in the foreground.

ISBN 1-55791-665-9

MISCELLANEOUS PUBLICATION 02-4
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2002

UTAH GEOLOGICAL SURVEY

UTAH GEOLOGICAL SURVEY

The **UTAH GEOLOGICAL SURVEY** is organized into five geologic programs with Administration and Editorial providing necessary support to the programs. The **ENERGY & MINERAL RESOURCES PROGRAM** undertakes studies to identify coal, geothermal, uranium, hydrocarbon, and industrial and metallic resources; initiates detailed studies of these resources including mining district and field studies; develops computerized resource data bases, to answer state, federal, and industry requests for information; and encourages the prudent development of Utah's geologic resources. The **GEOLOGIC HAZARDS PROGRAM** responds to requests from local and state governmental entities for engineering-geologic investigations; and identifies, documents, and interprets Utah's geologic hazards. The **GEOLOGIC MAPPING PROGRAM** maps the bedrock and surficial geology of the state at a regional scale by county and at a more detailed scale by quadrangle. The **GEOLOGIC INFORMATION & OUTREACH PROGRAM** answers inquiries from the public and provides information about Utah's geology in a non-technical format. The **ENVIRONMENTAL SCIENCES PROGRAM** maintains and publishes records of Utah's fossil resources, provides paleontological and archeological recovery services to state and local governments, conducts studies of environmental change to aid resource management, and evaluates the quantity and quality of Utah's ground-water resources.

The UGS Library is open to the public and contains many reference works on Utah geology and many unpublished documents on aspects of Utah geology by UGS staff and others. The UGS has several computer databases with information on mineral and energy resources, geologic hazards, stratigraphic sections, and bibliographic references. Most files may be viewed by using the UGS Library. The UGS also manages the Utah Core Research Center which contains core, cuttings, and soil samples from mineral and petroleum drill holes and engineering geology investigations. Samples may be viewed at the Utah Core Research Center or requested as a loan for outside study.

The UGS publishes the results of its investigations in the form of maps, reports, and compilations of data that are accessible to the public. For information on UGS publications, contact the Natural Resources Map/Bookstore, 1594 W. North Temple, Salt Lake City, Utah 84116, (801) 537-3320 or 1-888-UTAH MAP. E-mail: nrugs.geostore@state.ut.us and visit our web site at mapstore.utah.gov.

UGS Editorial Staff

J. Stringfellow	Editor
Vicky Clarke, Sharon Hamre	Graphic Artists
Patricia H. Speranza, James W. Parker, Lori Douglas	Cartographers

12/01

TABLE OF CONTENTS

FIGURES

TABLES

MULTITUBERCULATE MAMMALS FROM THE WAHWEAP (CAMPANIAN, AQUILAN) AND KAIPAROWITS (CAMPANIAN, JUDITHIAN) FORMATIONS, WITHIN AND NEAR GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

Jeffrey G. Eaton
Department of Geosciences
Weber State University
Ogden, UT 84408-2507

phone: (801) 626-6225
fax: (801) 626-7445
e-mail: jeaton@weber.edu

ABSTRACT

Multituberculate mammals from the Campanian Kaiparowits Formation of southern Utah include: two new species of *Mesodma* (*M. archibaldi* and *M. minor*) and a possible third new species (*Mesodma* sp. (large); three species of *Cimolodon*, including a new species (*C. foxi*); a new genus and species of a possible cimolodontid (*Kaiparomys cifellii*); a new species of *Cedaromys* (*C. hutchisoni*), a genus previously reported only from the mid-Cretaceous Cedar Mountain Formation; a taxon, *Cimexomys magnus*, is transferred to the genus *Dakotamys* (a genus previously reported only from the Cenomanian Dakota Formation); at least two species of *Cimolomys* close to *C. trochuus* and a new species questionably assigned to that genus (?*C. butleria*); two species of *Meniscoessus* (*M.* sp. cf. *M. intermedius*; *M.* sp. cf. *M. major*); and *Cimexomys* sp. cf. *C. judithae*. A possible relationship of *Cimolomys* to *Cedaromys* and *Bryceomys* is suggested. The fauna strongly supports an interpretation of a Judithian Land Mammal "Age" for the Kaiparowits Formation, however, the formation may be somewhat older than the type Judithian because of the close relationship of the fauna to the Aquilan fauna recovered from the underlying Wahweap Formation; however, this may be an artifact of both faunas being recovered from a continuous stratigraphic sequence.

Multituberculate mammals from the early Campanian Wahweap Formation include a species of *Cedaromys* (a genus also reported from the Kaiparowits Formation) and a species of *Bryceomys* (previously reported from the Turonian Smoky Hollow Member of the Straight Cliffs Formation and the older Cedar Mountain Formation). The fauna also contains the Aquilan species *Cimolodon electus* and *C. similis*. Several conferred species, including ones assigned to *Cimexomys*, *Meniscoessus*, *Mesodma*, *Cimolodon*, and *Cimolomys*, probably represent new species but are inadequately represented to diagnose new taxa. The fauna supports an Aquilan Land Mammal "Age" for the Wahweap Formation. The Wahweap fauna is enough different from that of the upper Milk River Formation (type Aquilan) to suggest either latitudinal controls or possibly a slightly older age for the Wahweap Formation. This age assessment is based on primitive characters found in the species of *Mesodma* and *Cimolodon* recovered from the Wahweap Formation.

INTRODUCTION

Many of the specimens discussed here were originally described in an unpublished Ph.D. dissertation (Eaton, 1987), and subsequently the faunas were summarized by Eaton and Cifelli (1988) and Eaton and others (1999) (multituberculate faunal lists in both were based on Eaton, 1987). Since the time of original description, many specimens have been added to the sample as a result of continued collecting by Dr. Richard L. Cifelli (University of Oklahoma) and myself. Although the process of collecting new specimens continues, it was necessary to establish an arbitrary cut-off point and describe the material in hand. These specimens were recovered by screen-washing methods described in Cifelli and others (1996) from the Kaiparowits Plateau region within or near the Grand Staircase-Escalante National Monument (figure 1).

The present study was accomplished initially without reference to Eaton, 1987; after reevaluating the systematics, the results were then compared. The identifications made by Eaton (1987) are included in the list of referred specimens or underneath the species designation for cases in which the

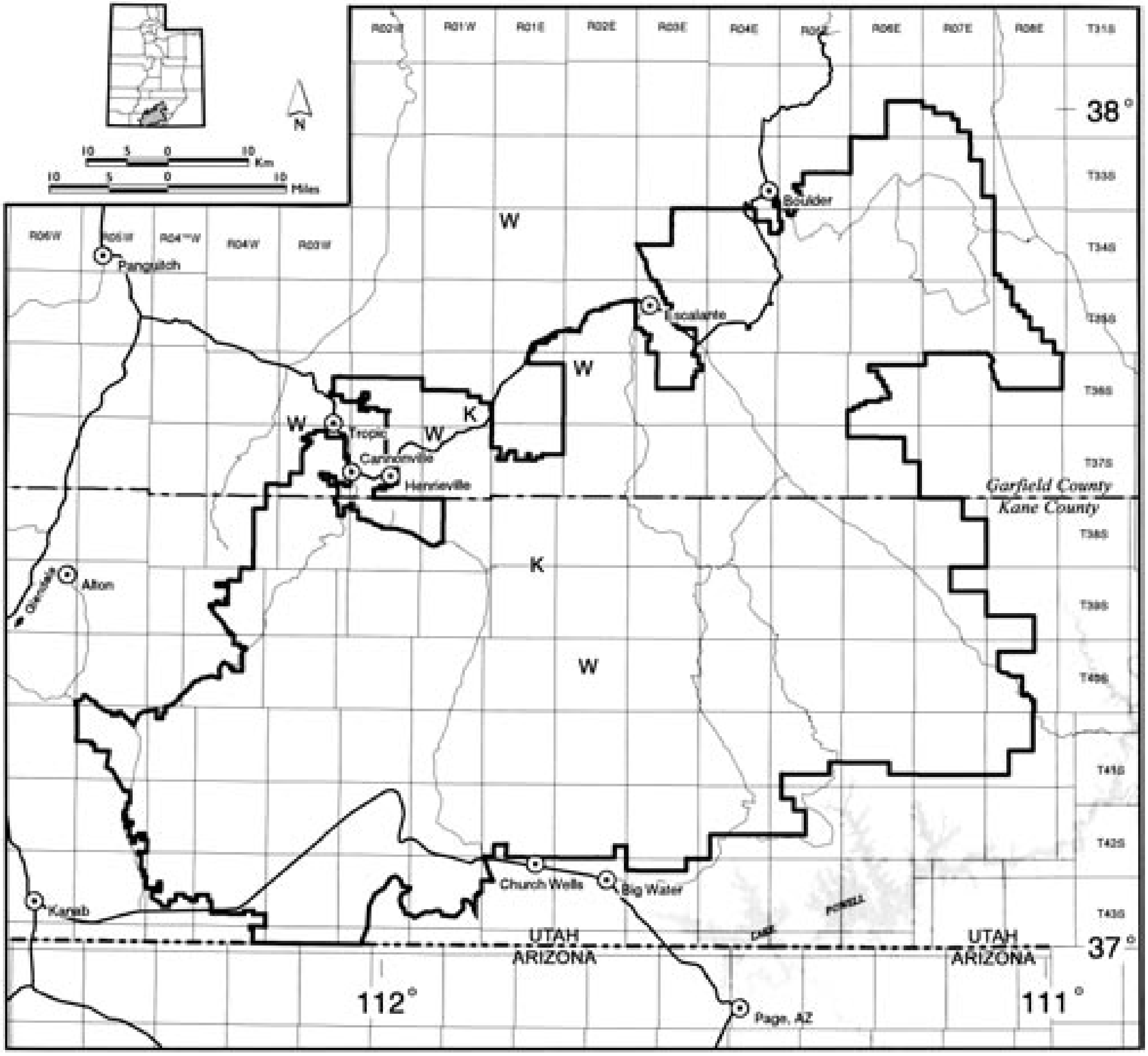

Figure 1. Location map. Boundary of Grand Staircase-Escalante National Monument shown by the dark line. W - indicates areas of localities in the Wahweap Formation; K - indicates areas of localities in the Kaiparowits Formation.

identifications differ significantly from Eaton, 1987. Where instructive, these changes are discussed in the text. The higher-level systematics are based on Kielan-Jaworowska and Hurum (2001) with some modifications.

The purpose of this paper is the alpha-level systematic description of the multituberculate faunas recovered from the Wahweap and Kaiparowits Formations and assessment of their biostratigraphic correlations to North American Land Mammal "Ages."

Stratigraphic Setting

The Wahweap Formation ranges in thickness from 360-460 m and averages about 400 m (Eaton, 1991). Although the localities range stratigraphically from near the base of the formation (MNA localities 707-2, 707-6, 456-2) to the upper member (below the capping sandstone member, see Eaton, 1991) of the formation (MNA localities 455-1, 455-2, and UMNH VP localities 77 and 130), there are no clear-cut vertical faunal changes (see Eaton and Cifelli, 1988). The formation is comprised of fluvial deposits consisting mostly of meandering river and floodplain facies (excluding the capping sandstone member from which no mammals have been recovered).

The Kaiparowits Formation is 855 m thick (Eaton, 1991) but there seems to be little faunal difference throughout the formation (see Eaton and Cifelli, 1988), suggesting rapid deposition. The stratigraphic positions of most of the localities from which multituberculates are described in this paper are shown in figures 15, 16, and 21 in Eaton (1991). Most of the localities occur in the lower 200-300 m of the formation (including localities discovered after 1991: UMNH localities 24, 51, 54, 65, and 108). Localities that occur higher in section are TB2 (MNA 453-2; OMNH V14) at 370 m, JGE 8642 (OMNH V61) at 520 m, and TB8 (MNA 1004-1; OMNH V5) at 640 m.

The faunas are described in inverse formational order, because the number of specimens is much greater in the sample recovered from the Kaiparowits Formation than for the Wahweap Formation, providing a better basis on which to make diagnoses. Discussions of the fauna from the Wahweap Formation often refer back to discussions of taxa recovered from the Kaiparowits Formation.

Photographic Figures

All specimens were photographed using a Nikon® 990 digital camera mounted on a Meiji stereo zoom microscope. The photographs were modified in Adobe Photoshop® and arranged in Adobe Pagemaker®. As there were no available guidelines for this kind of digital photomicrography, the photographic figures in the paper represent a first attempt. The usual problems of depth of field were encountered and it is strongly recommended that researchers utilize the stereo occlusal views when working from this paper. The sizes of the illustrations were determined by attempting to keep the scale as consistent as possible, while allowing for reasonable use of the printed page and permitting adequate space for stereo pairs. For this reason, there is sometimes more than one scale bar in a figure.

All specimens are oriented with their anterior margin facing the bottom of the page (except for the side view in figure 4B, in which the anterior is oriented to the right).

Measurements and Terminology

Specimens were measured using one ocular of a microscope mounted on a 2-axis micrometer measuring base with Mitutoyo 0.005 mm micrometers. Dimensions were measured as in Eaton (1995) except for additional measurements described below. All cusp formulae are given from the labial side of the tooth to the lingual. Several sets of ratios are provided to aid in comparisons of teeth. Crown height to anteroposterior dimension ratios (H:AP) are provided to provide data for comparing crown heights relative to crown length for lower fourth premolars (figure 2). The climb ratio (CR) is a measure of how steeply the cusps of the medial row of upper fourth premolars increase in height from the front of the premolar to the tallest cusp of the premolar (figure 2). This measurement is too subtle to attempt from illustrated specimens and is only provided for specimens described here. The CR is determined by measuring the distance from the tip of the first cusp of the medial row to the deepest cusp of the row in one axis (CRH in figure 2) and the anteroposterior distance between these cusp apices on the other axis (CRL in figure 2). The CRL is divided by the CRH to get the climb ratio (CR). Length ratios of molars and premolars are provided to help compare dental proportions of taxa (M1:m1; M2:M1; P4:M1; m2:m1: p4:m1; P4:p4), which the author considers to be of considerable importance in multituberculate taxonomy. The term AL (anterior length) is used on p4s as a term somewhat comparable to the L1 of Novacek and Clemens (1977) and applied extensively by Archibald (1982). Novacek and Clemens (1977) established the anteroposterior baseline on the labial side of the tooth, which I found difficult to apply on specimens other than those of *Mesodma*, such as *Cimolodon*. The baseline used here is on the lingual side of the tooth at the base of the enamel crown above the two roots (figure 2). Nevertheless, I found it difficult to consistently measure a maximum height as often there is apical crown wear and also in some of the specimens two of the serrations are essentially of the same height at the highest point of the crest. The PL (posterior length, figure 2) measurement taken on P4s is provided to help determine what proportion of the tooth's length is occupied by the posterior basin (PL:AP), which is highly variable among taxa.

Dental terminology follows that of Eaton (1995) except for additional terms discussed below. The term pyramidal is used to describe cusps with 4 distinct corners. Pyramidal cusps can be erect or lean anteriorly (M1, M2) or posteriorly (m1, m2). I consider the cusps to be subpyramidal if the posterior wall (in the case of upper molars) of the cusps is convex but maintains distinct posterior corners. A crescentic cusp (on upper molars) has lost the posterior corners (the anterior corners on lower molars) and has a convex posterior wall (anterior wall on lower molars) that meets the concave anterior face, forming only two strong edges of the cusp (unlike the 4 corners of pyramidal cusps).

Abbreviations

UMNH – Utah Museum of Natural History, Salt Lake City

MNA – Museum of Northern Arizona, Flagstaff

MOR – Museum of the Rockies, Bozeman, Montana

OMNH – Oklahoma Museum of Natural History, Norman

AMNH – American Museum of Natural History, New York

UA – University of Alberta, Edmonton

UALP – University of Arizona Laboratory of Paleontology, Tucson

UCMP – University of California, Berkeley

UW – Collection of Fossil Vertebrates, Department of Geology and Geophysics, University of Wyoming, Laramie

R – right

L – left

M – upper molar

m – lower molar

P – upper premolar

p – lower premolar

AP – anteroposterior dimension

LB – lingual-buccal dimension

H – height of crown of fourth premolars (figure 2)

CR – measure of change in cusp depth over distance for cusps of medial row of P4 (CRH:CRL in figure 2). CRL is measured along the AP axis from the tip of the first cusp of the medial row to the tip of the highest cusp (usually the last, but not always) and CRH is the change in height measured perpendicular to the AP axis (figure 2).

S:ER:IR – in tables including p4s: S = number of serrations, ER = external ridges, IR = internal ridges

***** - indicates some damage to specimen so that the measurement may not be accurate (in tables)

e – estimated values based on measuring figured specimens described in other papers (in tables)

? – denotes unavailable data such as ridge counts of p4s that are not provided in some papers or uncertain values (in tables)

! - unusual values that may suggest errors in assignment of specimens to a taxon (in tables)

AL – in p4s, the distance from the anterior of the tooth to the point of maximum height (figure 2)

PL – in P4s, distance from the last cusp of the medial row to the posterior of the tooth (figure 2)

Ri - a non-cuspate anteroexternal ridge in the position of a third cusp row on some M2s

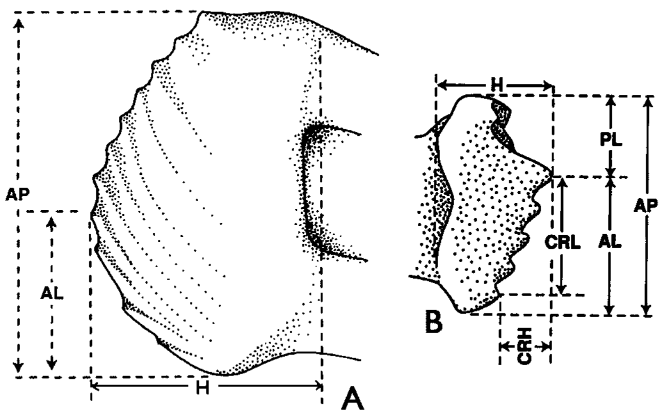

Figure 2. A, measurements taken on p4s (H = height; AL = anterior length; AP = anteroposterior); B, measurements taken on P4s (H = height; AP = anteroposterior; AL = anterior length; PL = posterior length; CRH = climb ratio height; CRL = climb ratio length).

MULTITUBERCULATE FAUNA FROM THE KAIPAROWITS FORMATION

Systematic Paleontology

Class MAMMALIA
Order MULTITUBERCULATA
Suborder CIMOLODONTA McKenna, 1975
Superfamily ?Ptilodontoidea Sloan and Van Valen, 1965
Family Neoplagiaulacidae Ameghino, 1890
Mesodma Jepsen, 1940
Mesodma archibaldi sp. nov.
tables 1-3; figures 3A-H, 4A-B

Holotype – OMNH 24039, RM1, Loc. V61.

Hypodigm – MNA V4502, Lm2, Loc. 453-2 (*Paracimexomys* n. sp. A in Eaton, 1987); MNA V5230, Lm2, Loc. 704-1 (*Paracimexomys* n. sp. A in Eaton, 1987); MNA V5303, Lm2, Loc. 704-1 (*Paracimexomys* n. sp. A in Eaton, 1987); MNA V5343, Rm1, Loc. 1004-1 (*Mesodma* sp. cf. *M. hensleighi* in Eaton, 1987); MNA V7524, LM1, Loc. 704-1; MNA V7531, Rp4-m2, Loc. 704-1; MNA V7533, Rp4, Loc. 704-1; MNA V7536, Rm1, Loc. 704-1; MNA V5284, RM1 (posterior part), Loc. 454-6 (*Mesodma* sp. cf. *M. hensleighi* in Eaton, 1987); OMNH 20511, LM1, Loc. V9; OMNH 20518, Lm2, Loc. V9; OMNH 20764, Lm1, Loc. V9; OMNH 22298, Rm1, Loc. V5; OMNH 22300, Rm1, Loc. V5; OMNH 22835, Lm1, Loc. V9; OMNH 22868, Rm2, Loc. V9; OMNH 24056, Lm1, Loc. V61; UMNH VP7643, Rm2, Loc. 51.

Distribution – Kaiparowits Formation of southern Utah and the Judith River Formation of Montana, Campanian.

Diagnosis – Small species of *Mesodma* in upper size range of *M. hensleighi* and smaller than *M. formosa*; p4 with fewer serrations and ridges than any species of *Mesodma*; M1 with fewer cusps (5:6:4) than any other species of *Mesodma*.

Etymology – named for J. David Archibald, who has greatly increased our knowledge of Mesozoic mammals and for his help with my fieldwork in southern Utah.

Description – p4. MNA V7533 (figures 3A-B) has 9 serrations, 7 external ridges and 6 internal ridges. The tooth is symmetrical, relatively low crowned (table 1), and reaches its apex at the third serration. The first two external ridges are short and ventrally directed. The third external ridge is oriented more anteriorly and intersects the second ridge. The posteromost three serrations are broadly separated, cusp-like, and oriented posteroventrally. The first internal ridge is short, the second and third almost meet and then diverge ventrally. The last three serrations have no internal ridges.

m1 – OMNH 24056 (figure 3C) has a cusp formula of 6:4. The external cusp row is broader than the internal row. The first cusp of the external row is small, conical, and well separated from the second erect cusp. Cusps 3-6 are all crescentic, subequal in height, and lean strongly posteriorly. Cusps 5 and 6 are subequal in height, lean strongly posteriorly, and are only partially separated on the labial side of the tooth but are deeply separated adjacent to the central valley. The central valley is sinuous and unpitted. The first cusp of the internal row is small, low, erect and conical. It is connected to the second cusp at its base. The second, third and fourth cusps are subequal in height, well separated, and lean posteriorly. A low pit is present on the buccal wall of cusp 4. A few specimens have a small posteromost fifth cusp on the internal row (OMNH 22298, figure 3D).

m2 – MNA V5303 (figure 3E) has a cusp formula of 4:2. Cusps of the external row are spaced evenly along the row and are progressively more poorly separated posteriorly where they are separated mostly along the lingual wall. The central valley is complex because of crossing ridges, but it is not pitted. The cusps of the internal row are deeply divided and crescentic. MNA V5230 (figure 3F) is almost identical in size and is from the same locality (704-1) as MNA V5303, but the posterior two cusps of the external row are weakly separated. The central valley on this specimen bears some deep, round pits.

M1 – OMNH 24039 (the holotype, figure 3G) has a formula of 5:6:4, which is characteristic of all the M1s in this sample. The cusps of the external row narrow posteriorly. The first cusp of the row is low, connected to the anterior face of the tooth by a short ridge, and it has a distinct pocket on a shelf labial of the cusp. The remaining cusps are subequal in height and size and are well separated. The cusps are essentially pyramidal and erect. Cusps of the medial row are crescentic, recurved strongly anteriorly, and broaden posteriorly. Internal row cusps are conical, lingually-buccally compressed, and are lower than those of either the medial or external rows. The cusps are well separated and increase in size posteriorly and each is connected to the lingual side of the medial row by a small ridge. MNA V7524 (figure 3H) is quite similar to OMNH 24039, but the medial cusp row of MNA V7524 projects anteriorly, well beyond the external cusp row whereas on OMNH 24039 the cusp rows are of the same length, resulting in a squared front of the tooth.

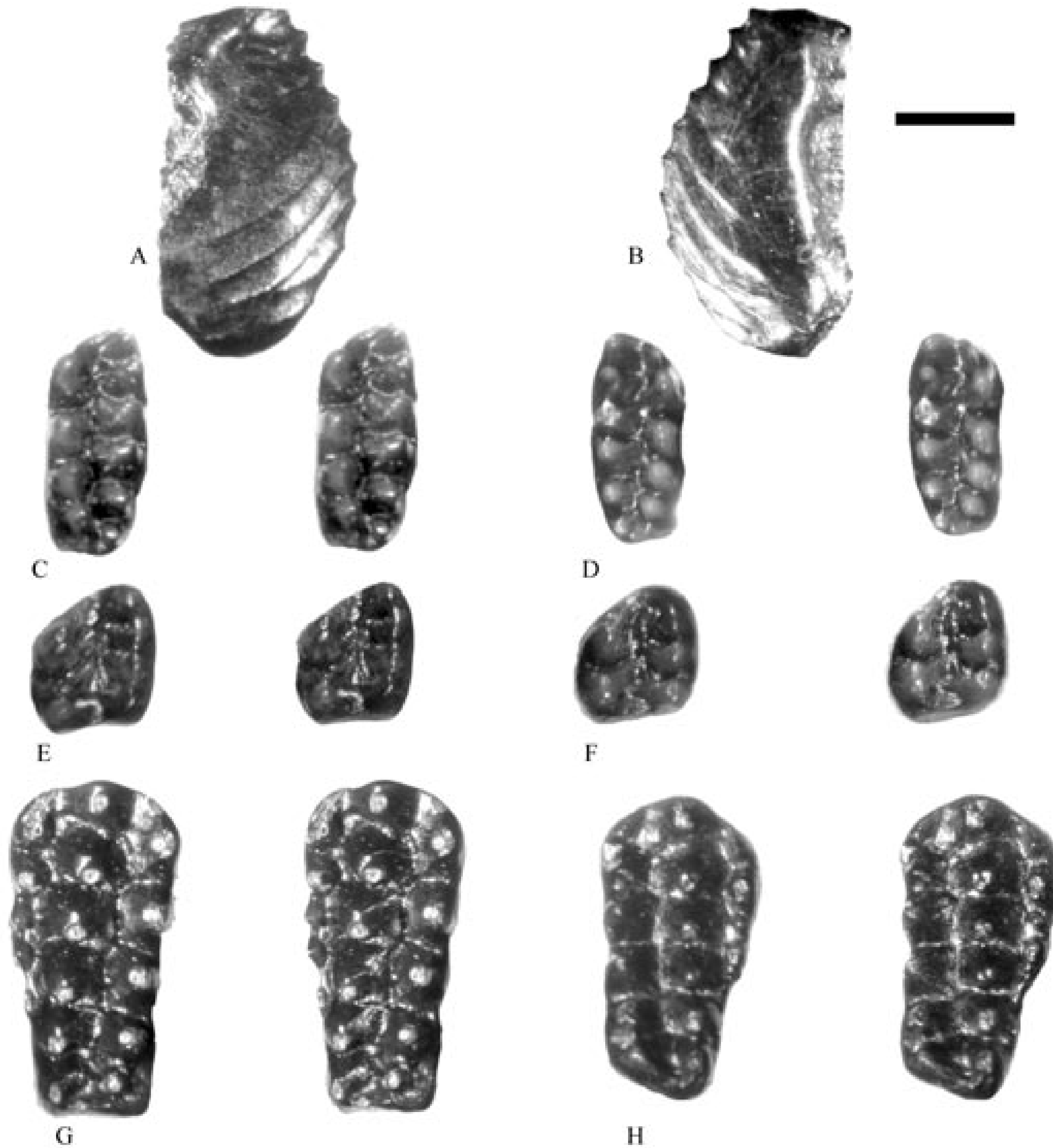

Figure 3. *Mesodma archibaldi*, sp. nov.: A, (MNA V7533), Rp4, labial view; B, lingual view; C, (OMNH 24056), Lm1, stereo occlusal view; D, OMNH 22298), Rm1, stereo occlusal view; E, (MNA V5303), Lm2, stereo occlusal view; F, (MNA V5230), Lm2, stereo occlusal view; G, (OMNH 24039), holotype, RM1, stereo occlusal view; H, (MNA V7524), LM1, stereo occlusal view. Scale bar = 1 mm.

Discussion – The single p4 assigned here is relatively low crested and symmetrical as is typical for *Mesodma*. In size, it is intermediate between specimens of *M. hensleighi* and *M. formosa* (table 1) and has fewer serrations and ridges than any other species of *Mesodma*. The ratio of its length (1.57) to the m1s of *M. archibaldi* is consistent with p4:m1 length ratios of other species of *Mesodma* (table 1). The m1s assigned here are in the size range of *M. hensleighi* (table 1) and could not be distinguished from that species without the associated M1s. The length ratio for M1:m1 (= 1.35) is typical for species of *Mesodma* (table 2). Perhaps most difficult is being certain that these molars represent *Mesodma* and not *Cimexomys*. It is characteristic for m1s of *Mesodma* to have a broad external row of strongly crescentic cusps and a narrower internal row (e.g., *M. thompsoni*, Lillegraven, 1969, figure 8-5b), whereas in *Cimexomys* the cusps of the external row are more erect, pyramidal, and not widely separated and the external cusp row is narrower than the internal cusp row (e.g., *C. gratus*, Archibald, 1982, figure 37d). This results in the anterior of m1s of *Cimexomys* being blunter than the tapering anterior of m1s of *Mesodma* (see discussion in Archibald, 1982, p. 50), with the exception of MOR 302 (Montellano and others, 2000), *C. judithae*. MNA V7531 (figures 4A-B) looks very similar to MOR 302 but is deeper jawed and has a distinct foramen on the labial side of the mandible just posterior of the lower incisor socket as in *M. thompsoni* and *M. formosa* but not MOR 302. For this reason, the jaw is considered to represent *Mesodma*; however, even in details, its morphology is strikingly similar to that of MOR 302.

The m2s assigned here are somewhat problematic because of difficulties in distinguishing m2s of *Cimexomys* and *Mesodma*. These are assigned here based on the occurrence of appropriately sized m1s of *Mesodma* in the sample and the absence of appropriately sized m1s of *Cimexomys*. Further difficulties in assignment arise because three of the specimens (MNA V4502, V5230, V5303) are about the same size and have similar LB:AP values (0.87-0.90) and three other specimens (MNA V7531, OMNH 20518, 22868) are larger, and have significantly lower LB:AP values (0.76-0.80). I was initially tempted to identify the later three specimens as *Cimexomys* because they do not taper posteriorly and posterior tapering of m2 may be a characteristic of *Mesodma* (e.g., *Mesodma* sp., Clemens, 1964, figure 15a), whereas for the few illustrated M2s of *Cimexomys*, the tooth maintains its width or expands posteriorly (*C. gratus*, Archibald, 1982, figure 36b; but less so in figure 37e and on MOR 302, *C. judithae*, Montellano and others, 2000). However, MNA V7531 (figures 4A-B) has one of the larger m2s associated with an m1 in a mandible considered to be *M. archibaldi* (see discussion above) and for that reason I have included these specimens within this species.

The M1s have fewer cusps than any described species of *Mesodma* and the specimens are in the upper size range of *M. hensleighi* and distinctly smaller than *M. formosa* (tables 1-3). These specimens fit within the range and cusp formula of specimens (UCMP 122182, 131486, 131493, 131494, 131996, 131504) described by Montellano (1992) as *Mesodma* sp., and I consider those specimens from the Judith River Formation to belong to this species. Lillegraven and McKenna (1986) described a small species of *Mesodma* from the "Mesaverde" Formation of Wyoming that has similar cusp formulae and lengths as the specimens described here, but seems to represent an unusual population of *Mesodma* in that the M1s are wider relative to length than other species of *Mesodma* (table 3) and one specimen has an internal cusp row as long as the tooth. It is uncertain if the "Mesaverde" sample represents the same species that is described here. Fox (1971) described a single M1 as ?*Mesodma* sp. that is somewhat more cuspate than the specimens described here (6:7:5 – the same formula as for *M. primaeva*) but is close to the size of *M. archibaldi* (table 3); however, the specimen has a very broad internal cusp row quite unlike these specimens.

Mesodma sp. cf. *M. archibaldi* sp. nov.
table 3; figure 4C

Referred Specimen – MNA V5291, LM1, Loc. 453-2 (*Mesodma* sp. cf. *M. hensleighi* in Eaton, 1987).

Description – M1. The external cusp row of MNA V5291 (figure 4C) has a small and lingually shifted first cusp that is connected to the larger second cusp by a high ridge. Cusps 2, 3, and 4 are well separated, subequal in height, and narrow slightly posteriorly due to the oblique angle of the central valley. The cusps are flattened lingually and bear deep grooves. Cusps of the medial row are strongly recurved anteriorly and become somewhat more erect, increase in height, and broaden posteriorly. A wall closes both valleys posteriorly. The internal row connects at about the midpoint of the third cusp of the medial row and extends more than 50% of the length of the tooth. The cusps are conical with the third cusp being the tallest of the row.

Discussion – This molar has a length most appropriate for *M. hensleighi* but has many fewer cusps than that species (table 3). The specimen is within the low end of the length range for M1s of *M. archibaldi* and its cusp formula (5:6:5) is appropriate for that species; however, the specimen is proportionally much broader LB:AP = 0.63) than in that species ($\bar{x}$LB:AP = 0.51). In this regard, the specimen is most similar to two M1s of *Mesodma* sp. described in Lillegraven and McKenna (1986) as they are proportionally broad relative to length (LB:AP values of 0.59 and 0.61). It is uncertain, due to the small sample size, if this specimen and those described by Lillegraven and McKenna (1986) should be included in *M. archibaldi* or another new species.

Mesodma minor sp. nov.
tables 2-3; figures 4D-G

Holotype – MNA V7525, RM1, Loc. 704-1.

Distribution – Kaiparowits Formation of southern Utah, Campanian.

Hypodigm – UMNH VP5606, Lm1, Loc. 51; UMNH VP7635, LM1, Loc. 108; MNA V4503, RM1, Loc. 453-2 (*Cimexomys* sp. cf. *C. judithae* in Eaton, 1987); MNA V5294, LM1 (posterior part), Loc. 453-2 (*Cimexomys* sp. cf. *C. judithae* in Eaton, 1987); MNA V7529, LM2, Loc. 704-1; MNA V7538, Rm1, Loc. 704-1; OMNH 20011, LM2, Loc. V5; OMNH 20364, RM2, Loc. V5; OMNH 20369, RM1, Loc. V5; OMNH 22296, RM2, Loc. V5; OMNH 22302, RM2, Loc. V5; OMNH 24045, LM1, Loc. V61.

Diagnosis – M1s 14% smaller than *M. archibaldi* with cusp formula (4-6:6:4) lower than any other species of *Mesodma* except *M. archibaldi*, and mean lengths slightly less than *M. hensleighi*; m1s 16% smaller than *M. hensleighi* or *M. archibaldi*.

Etymology – in reference to the small size of the taxon.

Description – m1. MNA V7538 (figure 4D) has a cusp formula of 6:4. The first cusp of the external row is tiny, low, and placed at the anteromost margin of the tooth. The second cusp is much larger. Cusp 3, the tallest of the row, and cusp 4 are weakly crescentic and are more deeply separated than the other cusps of the row. Cusps 5 and 6 are divided at their cusp apices labially but are much more deeply separated lingually. The cusps are distinctly broader than those of the internal row. The central valley is sinuous and a strong ridge connects cusp 3 of the internal row to cusp 4 of the external row. The first cusp of the internal row is very low, shifted labially, and does not lean posteriorly as do the other conical to subcrescentic cusps of the row.

M1 – MNA V7525 (holotype - figure 4E) has a cusp formula of 6:6:4. The external row is formed of six conical cusps that become progressively smaller and lower anteriorly. The row narrows posteriorly. The first two cusps are not well separated and are connected by a ridge. The third and fourth cusps are well separated with cusp 4 being the tallest of the row. Cusps 5 and 6 are connected and smaller than cusp 4. The sixth cusp is shifted slightly lingual of the straight row formed by cusps 1-5. The central valley is somewhat oblique to the anteroposterior axis of the molar. The cusps of the medial row are strongly crescentic and increase slightly in height posteriorly. The first two cusps of the internal row are small and conical with the first cusps being taller than the second. Cusp 3 is the tallest cusp of the row and, with the small weakly separated fourth cusp, forms a continuous posterolingual wall that connects to the last cusp of the medial row. There is a slight swelling anterior of the internal cusp row lingual of cusps 2 and 3. The internal row connects to the main body of the tooth at the back of the second cusp of the medial row. OMNH 20369 (figure 4F) is similar to MNA V7525, but it has one less cusp in the external row (although a tiny cuspule is present in that position) and the internal row connects to the main body of the tooth at the third cusp of the medial row.

M2 – OMNH 22296 (figure 4G) has a cusp formula of Ri:3:3. The anteroexternal platform is narrow. The anterolabial ridge forming the margin of the platform has 3 distinct cuspules produced by the continuous ridge and are not counted as cusps. There is a well-developed recess for M1 at the front of the external cusp row. The swelling of the anterior ridge is counted as a cusp of the internal cusp row but would have functioned as a cusp only after considerable wear. The second cusp is crescentic and strongly recurved anteriorly. The last cusp is also crescentic. Cusps of the internal row are distinct but closely appressed and not deeply divided.

Discussion – The M1s clearly belong to *Mesodma* as the internal cusp row distinctly exceeds 50% of the length of the molar (but see discussion below in the section on the fauna from Wahweap Formation, *Cimexomys* sp. cf. *C. antiquus*) and the cusps of the medial row are strongly crescentic. The M1s have a cusp formula close to that of *M. archibaldi* and lower than other species of *Mesodma*. If the M1s were included in *M. archibaldi* the standard deviation of the sample rises to 0.29. However, if these were considered as separate samples the standard deviation of *M. archibaldi* becomes 0.16 and for *M. minor*, 0.08. The size of the m1s and M1s plot distinctly on graphs (respectively, figures 5 and 6). The upper molars of *M. minor* are 18% shorter and the m1s are 16% shorter than those of *M. archibaldi*. In terms of size, they fit within or are slightly below the known length range of *M. hensleighi* but are proportionally broader and have fewer cusps. The lower first molars are also somewhat broader relative to length than those of either *M. hensleighi* or *M. archibaldi* and are 16% shorter than m1s of *M. hensleighi* (based on mean values for *M. hensleighi* in Lillegraven, 1969; Archibald, 1982).

The anterior faces of the M2s fit well with the posterior ends of the M1s assigned to *M. minor*. The length ratio of M2:M1 is similar to that seen in *M. thompsoni* and *M. garfieldensis* but larger than that of *M. hensleighi* and *M. formosa* (table 3). This is consistent with the mean M2 LB:AP ratio for *M. minor* which is comparable to those of *M. thompsoni* and *M. garfieldensis* and lower than the values for *M. hensleighi* and *M. formosa* (table 3); however, in size, these specimens are closest to samples of *M. hensleighi* (table 3).

Mesodma sp. (large)

tables 1-3; figures 7A-H, 8 A-D

Referred Specimens – MNA V4584, L?p4, Loc. 704-1; MNA V5267, Rm2, Loc. 454-6; MNA V5275, Lp4, Loc. 454-6; MNA V5315, LP4; Loc. 704-1; MNA V5338, Rm1, Loc. 1004-1; OMNH 20351, LP4, Loc. V5; OMNH 20356, Lm1, Loc. V5;OMNH 20366, LP4, Loc. V5; OMNH 20506, RP4 (anterior part), Loc. V9; OMNH 24041, LM2, Loc. V61; UMNH VP7633, Lp4, Loc. 108; UMNH VP7642, Rp4, Loc. 24.

Description – p4. UMNH VP7642 (figures 7A-B) has 10 serrations and 7 external and internal ridges. The specimen is high crowned (table 1) but gently arched and reaches its apex at the fourth serration at slightly more than half the length of the tooth. The posterior serrations form bulbous cusp-like projections. The posteroexternal platform is well worn.

m1 – MNA V5338 (figure 7C) has a cusp formula of 6:4 and the molar tapers anteriorly. The external cusp row is slightly broader than the internal row and the cusps are crescentic and oriented strongly posteriorly. The central valley is aligned with the anteroposterior axis of the tooth. The first cusp of the internal row is tall and well separated from the second cusp, the second and third cusps are crescentic and essentially erect, and the last cusp of the row is blade-like. OMNH 20356 (figure 7D) is similar to MNA V5338 but is more rectangular in shape and cusps 2-5 of the external row are connected to a cusp of the internal row by well-developed ridges crossing the central valley.

m2 – MNA V5267 (figure 7E) has a cusp formula of 4:2. The cusps of the external row are progressively closer together posteriorly. The first two cusps are well separated apically, and cusps 3 and 4 are only separated lingually. The cusp row broadens slightly at the valley between cusps 2-3. Grooves that lingually separate the cusps are arch-shaped and convex anteriorly. Ridges cross the central valley and a few deep pits are present. The cusps of the internal row bear lingual wear. The first cusp and the larger second cusp have deep grooves on their labial sides.

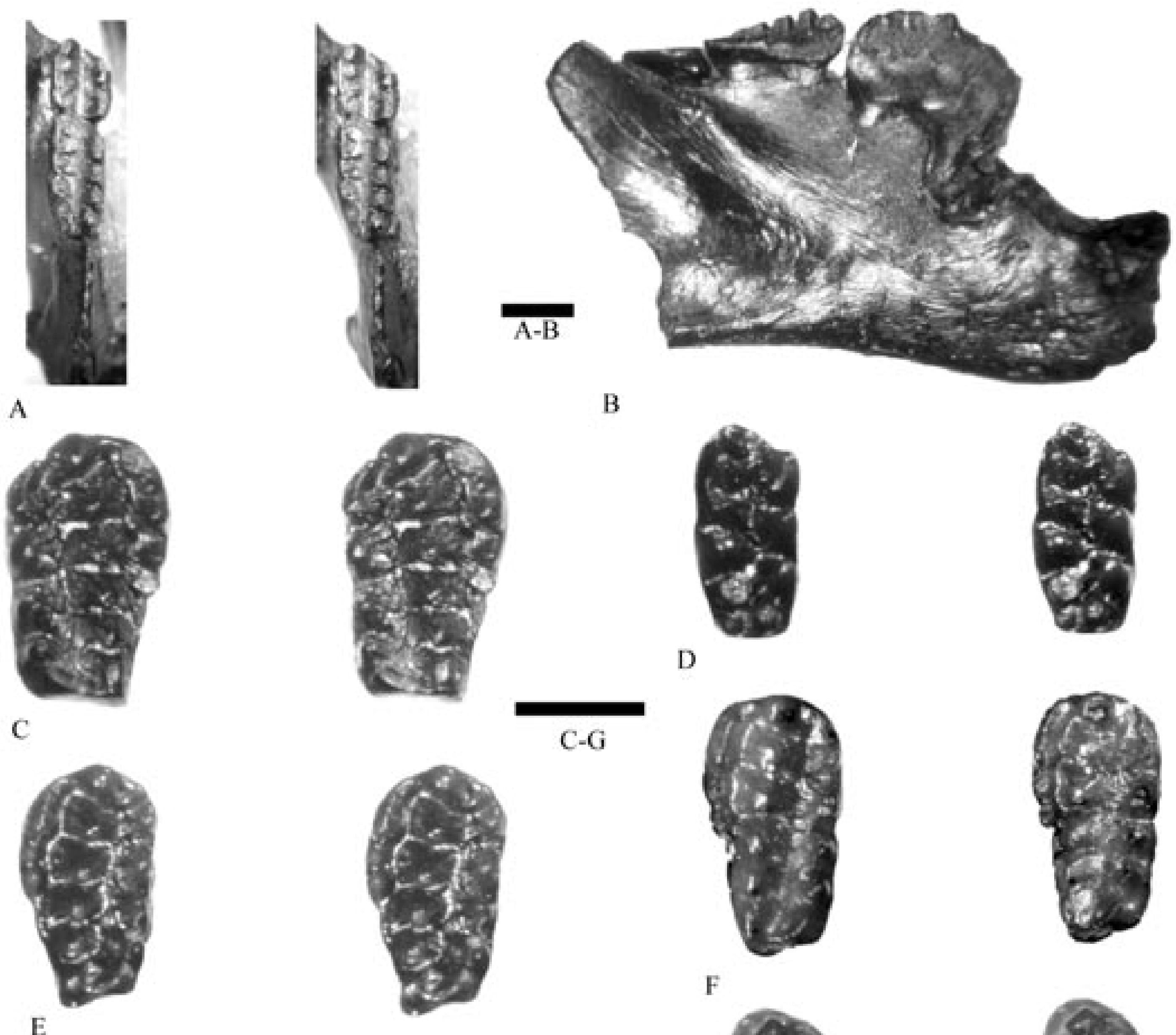

Figure 4. *Mesodma archibaldi* sp. nov.: A, (MNA V7531), Rp4-m2, stereo occlusal view; B, labial view. *Mesodma* sp. cf. *M. archibaldi* sp. nov.: C, (MNA V5291), LM1, stereo occlusal view. *Mesodma minor* sp. nov.: D, (MNA V7538), Rm1, stereo occlusal view; E, (MNA V7525), holotype, RM1, stereo occlusal view; F, (OMNH 20369), RM1, stereo occlusal view; G, (OMNH 22296), RM2, stereo occlusal view. Scale bars = 1 mm.

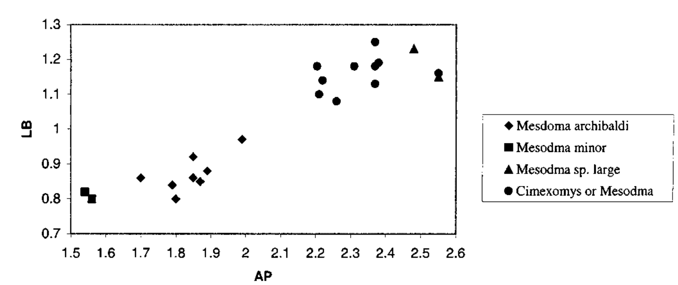

Figure 5. Graph comparing m1 AP and LB dimensions of *Mesodma archibaldi* sp. nov., *M. minor* sp. nov., *Mesodma* sp. (large), and *Cimexomys* or *Mesodma* indeterminate.

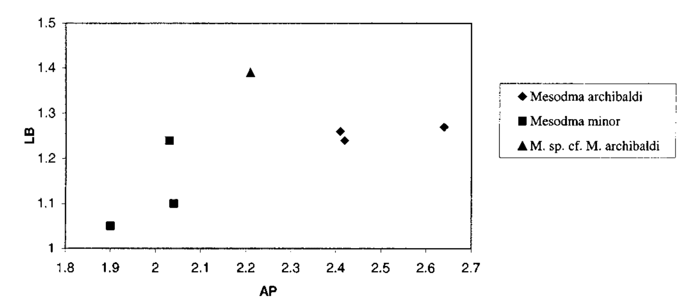

Figure 6. Graph comparing M1 AP and LB dimensions of *Mesodma archibaldi* sp. nov., *M. minor* sp. nov., and *M.* sp. cf. *M. archibaldi*.

Figure 7. *Mesodma* sp. (large): A, (UMNH VP7642), Rp4, labial view; B, lingual view; C, (MNA V5338), Rm1, stereo occlusal view; D, (OMNH 20356), Lm1, stereo occlusal view; E, (MNA V5267), Rm2, stereo occlusal view; F, (MNA V5315), LP4, stereo occlusal view; G, labial view; H, lingual view. Scale bar = 1 mm.

P4 – MNA V5315 (figures 7F-H) has a cusp formula of 2:6 and is a broad, robustly crowned tooth that bears striations. A small anteriorly positioned cusp is present on the moderately expanded anteroexternal platform and a second larger cusp is positioned much more posteriorly on the platform. The cusps of the medial row climb steeply, making the tooth deep-crowned relative to its length. The posterior basin is a deep pit bounded on the labial side by a well-developed and bulbous cusp and on the lingual size by a lower and smaller cusp. OMNH 20351 (figures 8A-C) has a cusp formula of 1:6 and is more strongly arched (in occlusal view) and more gracile in form than MNA V5315. The posterior basin is complex with an additional cusp present on the posterolabial wall above the basin.

M2 – OMNH 24041 (figure 8D) has a cusp formula of 2:3:4. The anteroexternal platform is very small and is not expanded labially. Two cusps are present on the anteroexternal corner of the tooth and three deep pits are present on the platform basin. The first cusp of the medial row is narrow and low. The second cusp is bulbous, weakly crescentic in form, and it is separated from the first cusp by deep pits. A deep valley separates the second and third cusps. The central valley is deeply pitted. The cusps of the lingual row are weakly separated lingually and are divided by deep grooves buccally. The first two cusps are closely appressed, and the third and fourth are more widely spaced.

Discussion – The p4s are deep crowned and gently arched as is characteristic for p4s of *Mesodma*. The size range of the p4s (table 1) is within that of *M. garfieldensis*, but these p4s have fewer serrations and ridges than those of that taxon. The size range is also similar to the p4s of *M. primaeva* described both by Lillegraven and McKenna (1986) and Montellano (1992); however, those p4s are much smaller than those described as *M. primaeva* in Sahni (1972) and Novacek and Clemens (1977) (table 1) and probably do not belong to that species. The upper and lower fourth premolars Lillegraven and McKenna (1986) and Montellano (1992) assigned to *M. primaeva* probably do not belong together in the same species because their P4:p4 length ratios indicate that the P4s are the same size or longer than the p4s (table 1), a condition not seen in any other species of Mesodma (length range of P4:p4 = 0.64-0.74).

The two m1s overlap in size with the m1s assigned to *Cimexomys* or *Mesodma* sp. later in this paper (figures 7C-D). I consider them to represent *Mesodma* because of the alignment of the central valley with the anteroposterior axis of the tooth, the narrowness of the internal cusp row relative to the external, the strongly crescentic nature of the external row cusps, and the tendency of the molars to narrow anteriorly. In length, these molars would fit in the upper range of m1s of *M. formosa* and close to the mean length of m1s of *M. garfieldensis*, although these molars have a higher LB:AP ratio than those of *M. garfieldensis* (table 2). In the diagnosis of *M. garfieldensis* (Archibald, 1982, p. 47), it is stated that the M1 and m1 cusp formula averages are higher than in other species of *Mesodma*. However, the stated cusp formula for m1s of *M. garfieldensis* is 6-7:4-5 (Archibald, 1982), which is identical to the formula of *M. formosa* provided by Lillegraven (1969, p. 21). As such, there is no basis on which to identify these lower molars to species.

The m2 assigned here (MNA V5267) is similar to those identified as *Cimexomys judithae* in various collections (e.g., AMNH 77105) except this tooth is proportionally broader. The tooth is considered to represent *Mesodma* because the cusps of the external row become more closely positioned posteriorly, unlike the condition in m2s of *C. gratus* (Archibald, 1982, figure 37c). In the specimens illustrated in Montellano and others (2000) as *Cimexomys* (*C. judithae*, MOR 302, figure 2), the cusps of the external row do decrease in size posteriorly but the last cusp is shifted slightly lingually. The second internal cusp is elongated on some specimens of *Mesodma* (e.g., *M. formosa*, Lillegraven, 1969, figure 7-4a) but not all (e.g., *M. primaeva* on which the first cusp is longer than the second; Sahni, 1972, figure 10G). The internal cusp row is worn prior to the external row in *Mesodma*, unlike the condition in m2s of *Cimexomys* (Archibald, 1982, figure 37e; Lofgren, 1995, figure 21). However, the m2 of MOR 302 (Montellano and others, 2000, figure 2), *C. judithae*, is unlike most specimens assigned to *Cimexomys* in being relatively squared posteriorly. Also, the second cusp of the internal row is elongated. This makes identification of the molar described here difficult. Also, the pitting present in the central row appears to be more a characteristic of *Cimexomys* than *Mesodma*. This characteristic is also strongly developed in molars of *Cimolomys*, but this specimen does not appear to represent that genus. The m2 is appropriate in size and morphology to complement the M2 (OMNH 24041) assigned here, and I am at least certain that these two molars belong to the same species, but the assignment to *Mesodma* must be considered tentative.

A single P4 is robust in form (MNA V5315) compared to the other more gracile P4s assigned here. It is not certain if these two forms represent the same taxon; however, they are close in length and the appropriate size for the p4s assigned here (P4:p4 = 0.70; table 1), and they appear to be too large for the p4s assigned to *M. archibaldi* (P4:p4 = 0.90). In size and cusp formula, these P4s are closest to those of *M. senecta*, Fox, 1971, and very similar to *Mesodma* sp. of Montellano (1992) (table 1). The p4s assigned here are smaller and have fewer serrations and ridges than do those of *M. senecta* (table 1). However, it is possible that the upper and lower fourth premolars are incorrectly associated here and there are specimens in the sample close to *M. senecta* (particularly MNA V5315). Unfortunately, only fourth premolars are described for *M. senecta* and it is not possible to compare the rest of the dentition.

The M2 is similar to specimens assigned to both *Cimexomys* and *Mesodma*. *Mesodma* tends to have a very straight central valley (*M. formosa*, Lillegraven, 1969, figure 7-5b; *M. garfieldensis*, Archibald, 1982, figure 12d) whereas it is somewhat oblique to the central axis in at least some species of *Cimexomys* (*C. gratus*, Archibald, 1982, figure 38e; but not in MOR 322, *C. judithae*, Montellano, 1992, figure 6; or MOR 302, Montellano and others, 2000, figure 1). As a result of the orientation of the central valley, the internal cusp row of M2s of *Mesodma* will tend to narrow (or in some case maintain) its width posteriorly whereas in *Cimexomys* (at least *C. gratus*) the cusp row broadens posteriorly. Also, on the M2s of *Cimexomys* represented by MOR 322 (Montellano, 1992, figure 6) and MOR 302 (Montellano and others, 2000, figure 1) the last cusp of the internal row is distinctly separated (labially and lingually) from the penultimate cusp. It is also evident that on MOR 322 the first and second cusps are well separated. On specimens of *Mesodma*, the cusps of the internal row form a ridge and the cusps are only slightly separated at their apices and divided labially by vertical grooves. On these tentative grounds, OMNH 24041 is assigned to *Mesodma* rather than the less-well preserved M2s assigned later in this paper to *Cimexomys* or *Mesodma* sp. A difficulty (also noted for the m2) in placing this M2 in *Mesodma* is the presence of distinct pits present in the central valley that I have not observed in other specimens assigned to *Mesodma*.

The molars are all in the uppermost size range or exceed that of *M. formosa* and are distinctly smaller than molars of *M. thompsoni* or *M. garfieldensis* (tables 2, 3). Within this sample there probably exists a new species of *Mesodma*. However, uncertainties about whether all the specimens assigned here really belong to a single species and the lack of knowledge of molars of the potentially most similar taxon, *M. senecta*, indicates that a formal taxon should not be proposed at this time. A better sample of this large taxon of *Mesodma*, as well as improved sampling *M. senecta* from the type area, would help in resolving whether another species of *Mesodma* is present.

Comments on Relationships of Species of *Mesodma*

The species of *Mesodma* described here retain the most primitive characters of any described species. *M. primaeva* was considered the most primitive taxon by Novacek and Clemens (1977); but all of the taxa described here have fewer cusps on molars and lower numbers of serrations and ridges on p4s. Oddly, the P4 of *M. senecta* would be considered primitive whereas the p4, with 15 serrations, would represent the most derived condition for p4. Novacek and Clemens (1977, figure 12) considered *M. hensleighi* to be nearly as primitive as *M. primaeva*. I agree that the p4s of *M. hensleighi* retain a low serration and ridge count; however, the elongation of the m1 relative to its width (at least in Lillegraven's 1969 sample - Archibald's 1982 sample is proportionally broader) is a derived character as is the low m2:m1 length ratio (table 2). In regards to m2:m1 length ratios, *M. thompsoni* and *M. primaeva* are the most primitive, *M. formosa* and *M. archibaldi* intermediate, and *M. hensleighi* and *M. garfieldensis* the most derived. In terms of P4s, *M. primaeva*, *M. senecta* and the species of *Mesodma* described here all have distinct posterior basins considered here to be a primitive characteristic. *M. formosa* is somewhat variable in that regard and *M. thompsoni*, *M. garfieldensis*, and *M. hensleighi* lack a distinct posterior basin. In terms of M1s, the taxa described here have the lowest cusp formula, and the number of cusps increase in the following order: *M. primaeva*, *M. hensleighi*, *M. thompsoni*, *M. formosa*, and *M. garfieldensis*.

From analysis of these characters it appears that the taxa described here, along with *M. primaeva*, represent the most primitive known taxa of *Mesodma*. *Mesodma formosa* and *M. thompsoni* are more derived, and *M. garfieldensis* and *M. hensleighi* are the most derived. The position of *M. senecta* is unclear due to lack of knowledge of more than the fourth premolars. Attempts to generate meaningful cladograms were fruitless as each dental position yielded significantly different results.

Family Cimolodontidae
Cimolodon Marsh, 1889
Cimolodon foxi sp. nov.
tables 4-5; figures 8F-J, 9A-I, 10A-B

Holotype – OMNH 24038, RM1, Loc. V61.

Hypodigm – MNA V4635, LM2, Loc. 454-6 (*Cimolomys* sp. B in Eaton, 1987); MNA V4638, LM1, Loc. 454-6 (*Mesodma* sp. cf. *M. thompsoni* in Eaton, 1987); MNA 4508, LP4 (anterior part), Loc. 453-2; MNA V5270, LP4, Loc. 454-6; MNA V5302, RP4, Loc. 1004-1; MNA V5339, RP4, Loc. 1004-1 (*Cimolodon* sp. B in Eaton, 1987); MNA V7540, Rm2, Loc. 704-1; OMNH 20005, Lm2, Loc. V5 (?Cimolomyid, gen. & sp. indet., in Eaton, 1987); OMNH 20483, Rp4, Loc. V9; OMNH 20491, Lm2, Loc. V9; OMNH 20492, Rm2, Loc. V9; OMNH 22316, LM2, Loc. V5; OMNH 24040, RM1, Loc. V61; OMNH 24043, RM2, Loc. V61; OMNH 24044, RM2, Loc. V61;OMNH 24326, RM1, Loc. V61; OMNH 24329, LP4 (anterior part), Loc. V61; UMNH VP7630, LP4, Loc. 108.

Distribution – Kaiparowits Formation of southern Utah, Campanian.

Diagnosis – Smallest species of *Cimolodon*, molars more than15-20% smaller than *C. similis*; P4 with formula of 4:5-6, with medial row cusps only somewhat taller than external row cusps; cusp formula M1 5-6:7:4-6 similar to *C. similis* but internal row longer relative to molar length than in *C. similis*.

Etymology – For Dr. Richard Fox's contributions to our knowledge of Cretaceous mammals, and the similarity of this taxon to that named by Dr. Fox, *Cimolodon similis*.

Description – p4. OMNH 20483 (figures 8E-F) is a small, high-crowned (H:AP = 0.61), flat-crested blade with 12 serrations, 10 external ridges, and 9 internal ridges. The valley separating the two posteromost serrations is oriented posteroventrally and extends to the top of the posteroexternal cusp.

m2 – OMNH 20005 (figure 8G) is a worn specimen with a formula of 4:2. The molar broadens posteriorly. Narrow notches divide the cusps of the external row and the cusps are not divided labially. Internal cusps are also not well divided lingually.

P4 – These P4s have a formula of 4:5-6, the teeth are low crested, and are arched in occlusal view. The posterior basin is small (PL:AL = 0.34-0.35 on relatively unworn specimens) and the climb ratio for the cusps of the medial row is low (CR = 0.27). UMNH VP7630 (figures 8H-J) has four distinct cusps on the external row. The first is the smallest and lowest, the second and third are larger than the cusps of the medial row, with the third cusp being the tallest. The fourth cusp is about the same size as the second. Five cusps are counted on the medial row although there is a tiny anterior cuspule not included in the formula. The cusps are progressively broader and more widely separated posteriorly with the last cusp being the tallest. The cusps have crenulated enamel and the premolar is low crowned (H:AP = 0.36; CR not measurable). MNA V5270 (figures 9A-C) has conical cusps on the anteroexternal platform and the third cusp is the largest and tallest of the tooth, although the medial cusp row is well worn on this specimen. The cusps of the medial row are well separated and striated. MNA V5302 (figures 9D-F) is similar to the other P4s but is less worn, the medial

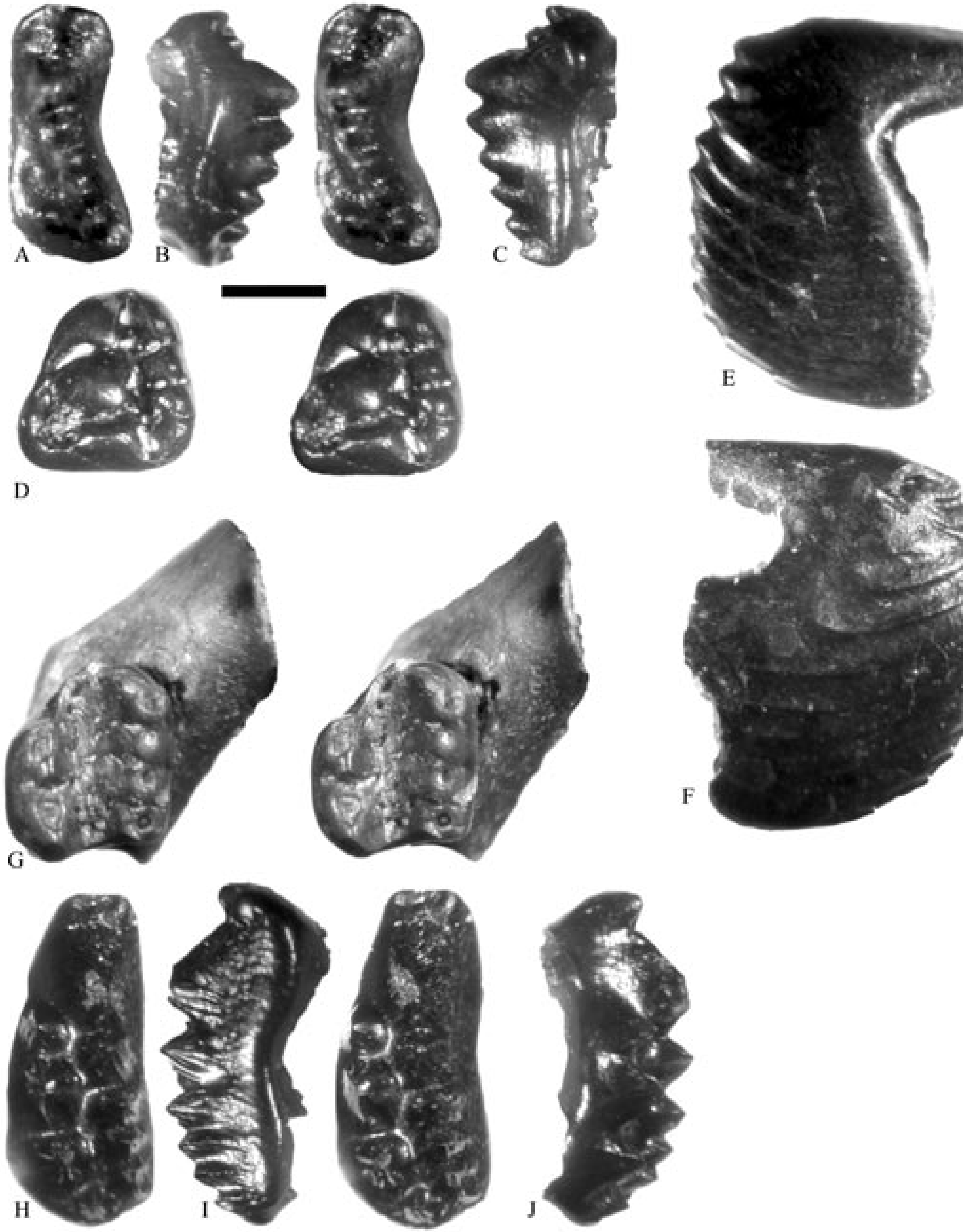

Figure 8. *Mesodma* sp. (large): A, (OMNH 20351), LP4, stereo occlusal view; B, labial view; C, lingual view; D (OMNH 24041), LM2, stereo occlusal view. *Cimolodon foxi*: E, (OMNH 20483), Rp4, labial view; F, lingual view; G, (OMNH 20005), Lm2 in mandibular fragment, stereo occlusal view; H, (UMNH VP7630), LP4, stereo occlusal view; I, labial view; J, lingual view. Scale bar = 1 mm.

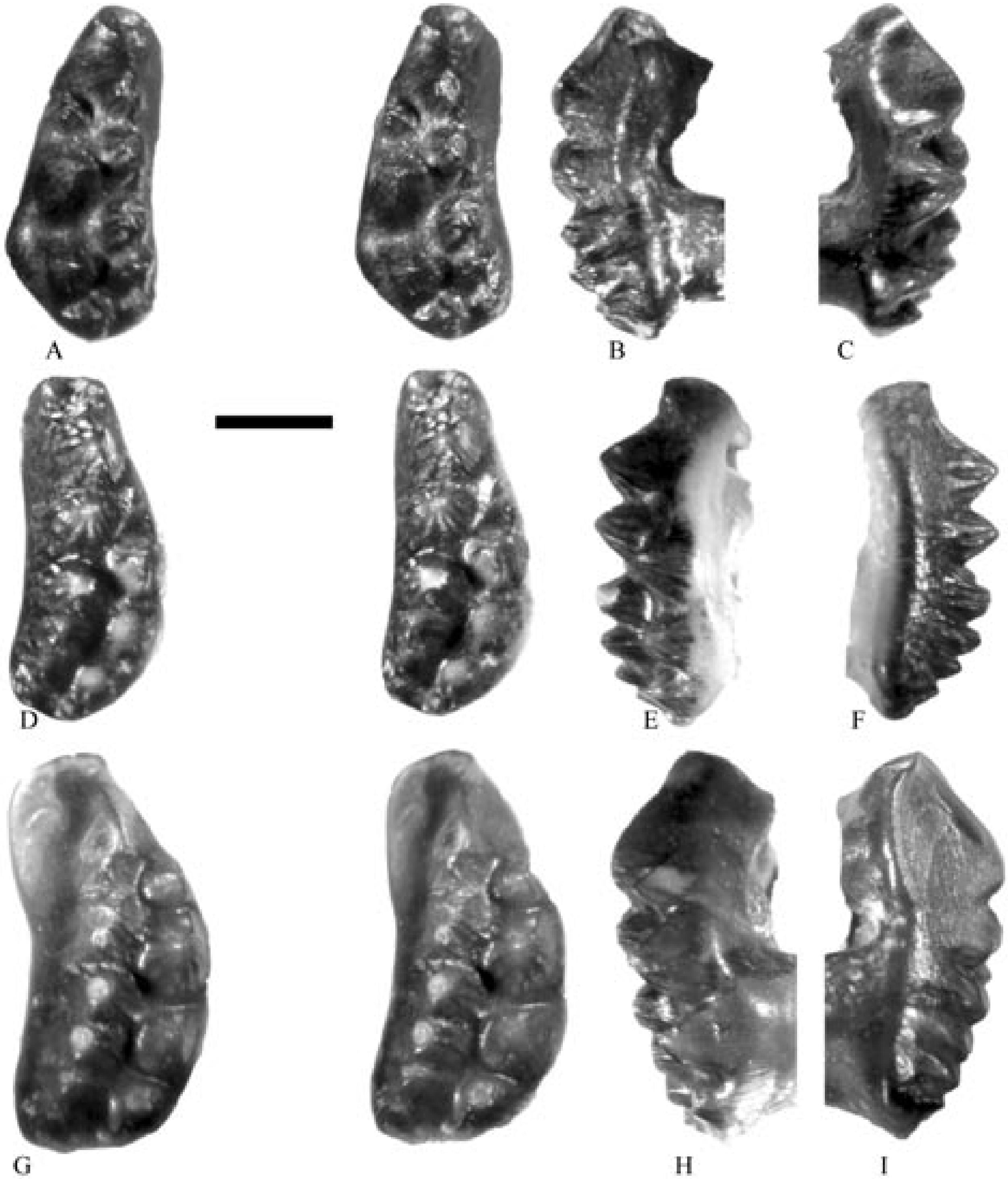

Figure 9. *Cimolodon foxi* sp. nov.: A, (MNA V5270), LP4, stereo occlusal view; B, labial view; C, lingual view; D, (MNA V5302), RP4, stereo occlusal view; E, labial view; F, lingual view; G, (MNA V5339), RP4, stereo occlusal view; H, labial view; G, lingual view. Scale bar = 1 mm.

cusp row is taller than the cusps of the external row, and there is an additional cusp in the medial row. MNA V5339 (figures 9G-I) is tentatively included here. It is strongly arched in occlusal view and is larger than the other specimens included here (table 4), but its cusp morphology is almost identical to the other specimens.

M1 – OMNH 24038 (holotype, figure 10A) has a formula of 5:7:4. All of the cusps of the external row are separated labially and attached lingually by a low, sharp crest that parallels the central valley. Each cusp of the row becomes taller, narrower, and more deeply separated posteriorly. Cusps are erect and conical. The central valley is oblique to anteroposterior axis of the molar. The cusps of the medial row are crescentic to subcrescentic (posteriorly) and are more deeply divided and taller than the cusps of the external row. Cusps of the medial row broaden posteriorly. The central valley is lower than the valley separating the medial and internal cusp rows. Cusps of the internal row are essentially conical. The first three cusps of the row are well separated and the two posteromost cusps are connected. The internal row is broad and terminates just posterior of the first cusp of the medial row.

M2 – OMNH 22316 (figure 10B) has a cusp formula of Ri:2:5. The medial cusp row has a strong anterior ridge that is unworn, uncusp-like, and is too low to function as a cusp and as such is not counted as one here (although it might well be counted as a cusp by other workers). The external ridge is comprised of lingual-buccally compressed cuspules, but none is distinct enough to be counted as an individual cusp. The first cusp (not counting the anterior ridge) of the medial row is large, oriented strongly anteriorly, and is deeply ribbed on its sides and pitted at its base. The central valley is complex with ribs and pits in this narrow valley. Cusps of the internal row are only divided at their apices. The labial wall of this row is deeply ribbed and complex. The first two cusps are large and the posterior three cusps are subequal in height and smaller.

Discussion – The p4 is high crowned as are the p4s of other species of *Cimolodon*. The p4 is smaller than those of *C. similis* (table 5) but not as small relatively as are the molars of *C. foxi*. It may be that the p4:m1 ratio for this taxon is higher than that of *C. similis* (1.4) and closer to that of *C. electus* (1.8). The P4s have the typical arch-shaped low crown and short posterior basin (primitively at least) of *Cimolodon* and are markedly smaller (27%) than those of *C. similis* (table 4).

The second lower molars of *Cimolodon* are distinguished from those of *Cimolomys* in that those of *Cimolodon* have the cusps of the external cusp row divided lingually, but not labially, such that the external row forms a high continuous ridge. The cusps of the external row of *Cimolomys* are well separated lingually and labially (*C. clarki*, Sahni, 1972, figure 11E; Lillegraven and McKenna, 1986, figure 7B; *C. gracilis*, Clemens, 1964, figure 35). In *Cimolodon*, there is also a tendency for the last cusp of the external row to shift somewhat lingually relative to the other cusps of the row, whereas in *Cimolomys* the cusps are in a straight row. OMNH 20005 is damaged at its posterolabial corner so this character cannot be assessed. One specimen tentatively included here, MNA V7540, is also damaged, making assessment of the presence and position of the last cusp of the external row impossible. MNA 7540 may also have a cusp formula too low for *Cimolodon*, ?3:2, and its rounded cusps are not very similar to those of OMNH 20005; however, the cusps of the external row are poorly divided as in *Cimolodon*. The tooth might be considered to represent *Mesodma*, but this specimen clearly broadens posteriorly, unlike illustrated specimens of *Mesodma* (*Mesodma* sp., Clemens, 1964, figure 16b; *M. formosa*, Lillegraven, 1969, fig, 7a; *M. garfieldensis*, Archibald, 1982, figure 12C). This specimen has a LB:AP ratio identical to that of OMNH 20005 (table 4).

The P4s are considered to represent *Cimolodon* because of the well-developed external cusp row on a broadly expanded anteroexternal platform, the strong arch of the premolar in occlusal view, the low-crowned nature of the tooth, and the low climb ratio of the cusps of the medial row (e.g., *C. nitidus*, Clemens, 1964, figure 30b). The P4s are smaller than any previously described for *Cimolodon* (table 4) except for UALP 15629 described by Flynn (1986) as *Cimolodon* n. sp. which is very close in size (AP = 3.07; LB =181) to these specimens and may represent the *C. foxi*.

The M1s of *C. foxi* are similar to those of *Cimolodon similis* in cusp formula and proportions; however, the length and width of the molars (table 4) are at least 20% smaller than those of *C. similis*. Fox (1971) separated *C. similis* and *C. electus* solely on the basis of size, a difference of 12-15% depending on the dimension measured. If that difference is adequate to distinguish two species, then most certainly *C. foxi* can be separated from *C. similis* on the basis of size as well as the elongation of the internal cusp row.

The M2s are thought to represent *Cimolodon* and not *Cimolomys* because: 1) the cusps of the internal row are poorly separated in *Cimolodon* (*C. nitidus*, Clemens, 1964, figure 31b) and better separated in *Cimolomys* (*C. gracilis*, Archibald, 1982, figure 23d); 2) the cuspules along the external platform form a sharp ridge in *Cimolodon* (*C. electus*, Fox, 1971, figure 5a; *C. nitidus*, Lillegraven, 1969, figure 11) and are more cusp-like in *Cimolomys*; and 3) the medial and internal cusp rows of *Cimolodon* are parallel to each other and oriented at an angle to the anteroposterior axis of the molar (as do the rows and valleys of the M1) whereas in *Cimolomys* the rows are aligned essentially anteroposteriorly (*C. clarki*, Sahni, 1972, figure 11F; Lillegraven and McKenna, 1986, figure 7D; *C. gracilis*, Clemens, 1964, figure 38b). These M2s are smaller than those described for any other species of *Cimolodon* (table 4). The primitive condition of the M2 length being close to that of the M1 is seen in *C. similis* and *C. electus*, but this species has M2:M1 length ratios within the range of the more derived taxon *C. nitidus* (table 4).

Cimolodon sp. cf. *C. nitidus* Clemens, 1964
table 4; figures 10C-F

Referred Specimens – MNA V5285, anterior part RP4, Loc. 453-2; MNA V5337, RP4, Loc. 1004-1; OMNH 24035, RP4 (posterior part), Loc. V61; OMNH 20477, LM1-2, Loc. V9.

Description – P4. MNA V5337 (figures 10C-E) has a cusp formula of 3:7. The tooth has the arched shape in occlusal view and low crest (H:AP = 0.44) typical of P4s of *Cimolodon*. The three cusps of the external row arise from a broadly expanded anteroexternal platform and are broader based than the cusps of the medial row. There is a small cuspule at the anterior margin of the tooth between the two cusp

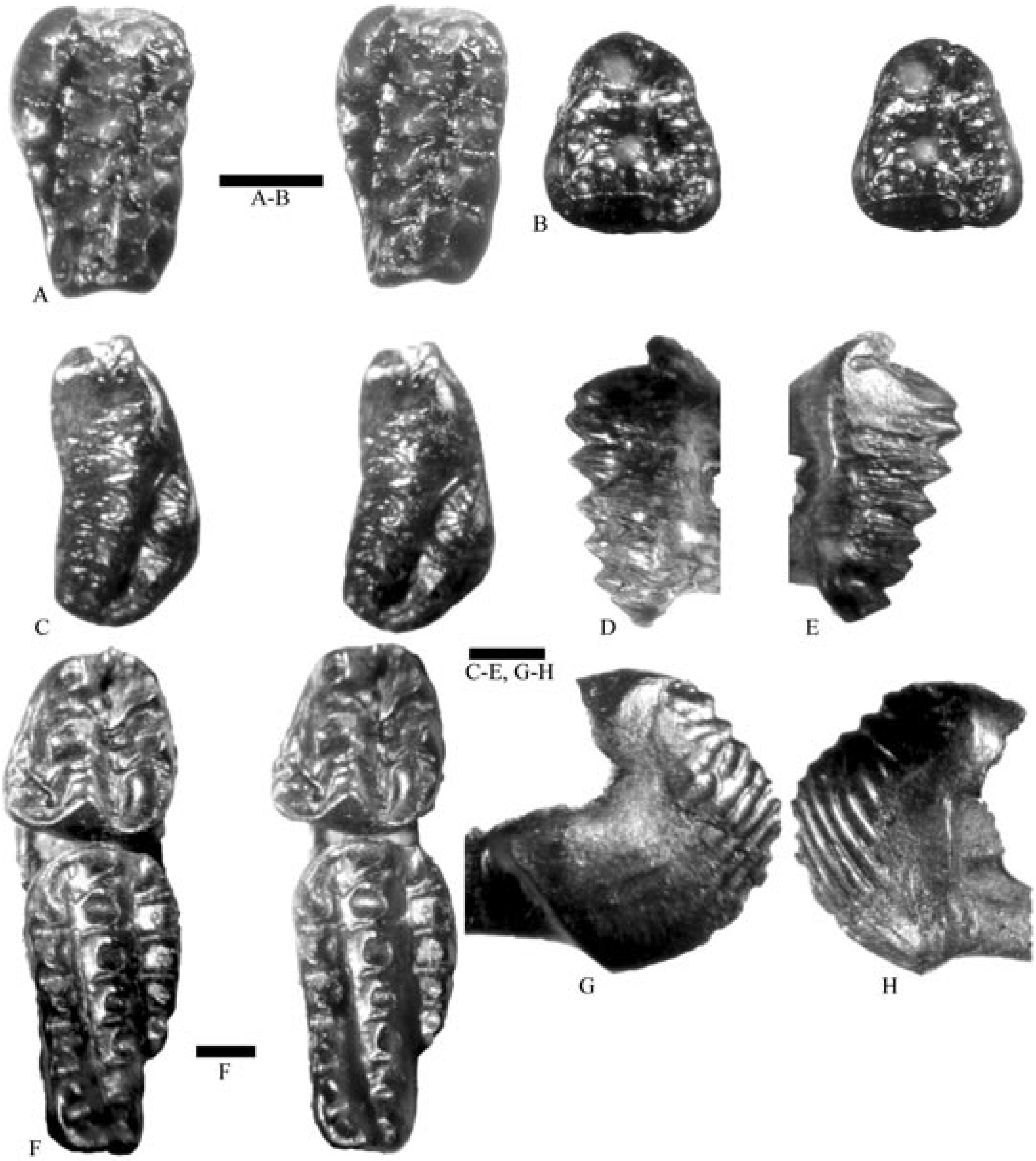

Figure 10. *Cimolodon foxi* sp. nov.: A, (OMNH 24038), holotype, RM1, stereo occlusal view; B, (OMNH 22316), LM2, stereo occlusal view. *Cimolodon* sp. cf. *C. nitidus*: C, (MNA V5337), RP4, stereo occlusal view; D, labial view; E, lingual view; F, (OMNH 20477), LM1-2, stereo occlusal view; *Cimolodon* sp. cf. *C. similis*; G, (OMNH 20484), Rp4, labial view; H, lingual view. Scale bars = 1 mm.

rows. The cusps of the medial row are only divided apically, and the row reaches its apex at the sixth cusp. The posterior heel is short (PL:AL = 0.31) and positioned just below the last cusp of the medial row. The cusps are strongly striated.

M1 – OMNH 20477 (figure 10F) has a cusp formula of 6:7:5. The central valley is oriented somewhat transversely to the anteroposterior axis of the tooth such that the cusps of the labial row narrow posteriorly while the cusps of the medial row broaden. The medial valley is higher than that separating the medial and internal cusp rows. The cusps of the medial row increase in height posteriorly. The internal cusp row is about two-thirds the length of the tooth.

M2 – OMNH 20477 (figure 10F) has a cusp formula of 3:3:2. There are two distinct cusps on the anteroexternal corner of the platform and a series of small cuspules that descend posteriorly. The first two cusps of the medial cusp row are closely positioned with the third cusp more broadly separated. The central valley has deep pits. The first two cusps of the internal row are not deeply divided, and there is a much deeper separation between cusps 2 and 3.

Discussion – The P4 is similar in length to *C. similis* but is broader and more cuspate than the P4s of that taxon (table 4). The tooth is also broader relative to length than either *C. similis* or *C. electus* and is very close to the value recorded by Lillegraven (1969) for *C. nitidus* (table 4). The P4s are in the lower size range for those of *C. nitidus* in the Lance Creek sample (Clemens, 1964) but are below the range of values provided for the Scollard sample by Lillegraven (1969, table 2) (table 4). The cusp formula is in the range of *C. nitidus* (table 4). The presence of striations, as in *C. similis* and *C. electus*, suggests a form of *Cimolodon* close to *C. nitidus* in size but retaining many primitive features. Also primitive is the high climb ratio of the cusps of the medial row (CR=0.49) which is more like the condition seen in P4s of *C. electus* (Fox, 1971, figure 5a-b) than in P4s of *C. nitidus* (Clemens, 1964, figure 30b). The retention of some primitive characteristics and the small size of the sample only permit conferring this species to *C. nitidus*. It is difficult to evaluate the proportion of the posterior basin to the total length of the tooth (PL:AP) as this appears to be highly variable in *C. nitidus*, based on calculations made from illustrated specimens (table 4).

The slight narrowing of the external cusp row of the M1 (OMNH 20477; figure 10F) is similar to that of the specimen figured by Lillegraven (1969, figure 12-3) as *C. nitidus*. The cusp formula and size of the M1 (OMNH 20477) are within the range for *C. nitidus* (in Lillegraven, 1969, but are larger than the samples described by Clemens, 1964 and Archibald, 1982) (table 4). Making certain species assignment of the M1 is complicated by the P4:M1 ratio based on the P4 (MNA V5337) described above. The resultant ratio (0.76) is well below recorded values for *Cimolodon nitidus* (see table 4). This raises a question of whether the P4 represents the same species as the M1. It could be that two species similar to *C. nitidus* are present, or a new species is present with dental proportions different than *C. nitidus*. A larger sample is required to resolve this issue. It should also be noted that the M2 (OMNH 20477; figure 10F) has one less cusp in the internal row than recorded previously for *Cimolodon nitidus* (table 4). The M2:M1 length ratio is close to the value of the sample of *Cimolodon nitidus* provided by Archibald (1982).

Cimolodon sp. cf. *C. similis* Fox, 1971
table 5; figures 10G-H

Referred Specimens – MNA 7532, Rp4, Loc. 704-1; OMNH 20347; Rp4; Loc. V5; OMNH 20484, Rp4, Loc. V9; OMNH 22313, Lp4, V5.

Description and Discussion – p4. These are high-arched, symmetrical p4s typical of *Cimolodon*. OMNH 20484 (figures 10G-H) has 12 serrations with 7 external and 12 internal ridges. This specimen is more highly arched and has more serrations than the other specimens conferred here to *C. similis*. The other specimens are less high crowned and there is considerable variation in the number of internal and external ridges (table 5). As such, these p4s may represent more than one taxon. The size of these specimens and their serration count place them closer to *C. similis* than to any other species of *Cimolodon* (table 5).

Family ?Cimolodontidae Marsh, 1889
Kaiparomys gen. nov.

Type and only species – *Kaiparomys cifellii*.

Distribution – Kaiparowits Formation of southern Utah, Campanian.

Diagnosis – m1 with formula (7:4), cusps more broadly separated than in *Mesodma* or *Cimolodon*, molars elongate and taper strongly anteriorly, cusps erect pyramidal on external row, crescentic on internal row, unlike *Cimolodon*. Molars complexly pitted unlike *Mesodma*.

Etymology – Named after the Kaiparowits Formation and mys, the Latin for mouse.

Kaiparomys cifellii sp. nov.
table 6; figures 11A-D
?*Cimolodon* sp. Eaton, 1987

Holotype – UCM 50420, Lm1-2, Loc. 83240.

Hypodigm – UCM 50384, Rm2, Loc. 83258; MNA V5264, Rm2, Loc. 454-6, MNA V5286, LM2 (part), Loc. 697-2; MNA V7530, RM2, Loc. 704-1; OMNH 20362, RM2, Loc. V5; OMNH 22325, RM2, Loc. V5; OMNH 22325, RM2, Loc. V5; OMNH 22842, Rm2, Loc. V9.

Distribution – As for genus.

Diagnosis – As for genus.

Etymology – For Dr. Richard L. Cifelli's remarkable contributions to our knowledge of Cretaceous mammals and his labors collecting many of the specimens described in this paper.

Description – m1. UCM 50420 (figure 11A) is a ramus with m1-2. The m1 has a cusp formula of 7:4. The molar is anteroposteriorly elongate relative to its width and narrows markedly anteriorly. The first two cusps of the external row are low and close together. The third cusp is well separated from and taller than the first two cusps. Cusp 4 is small, low, and labially placed. The fifth cusp is erect and in the form of an anteroposteriorly compressed pyramid. The fifth and sixth cusps are well separated lingually but, unlike the more anterior cusps, there is a low wall connecting the cusps labially closing off the valley between the cusps. This wall is tallest between the sixth and seventh cusp of the external row. These two cusps are positioned posterior to the last two

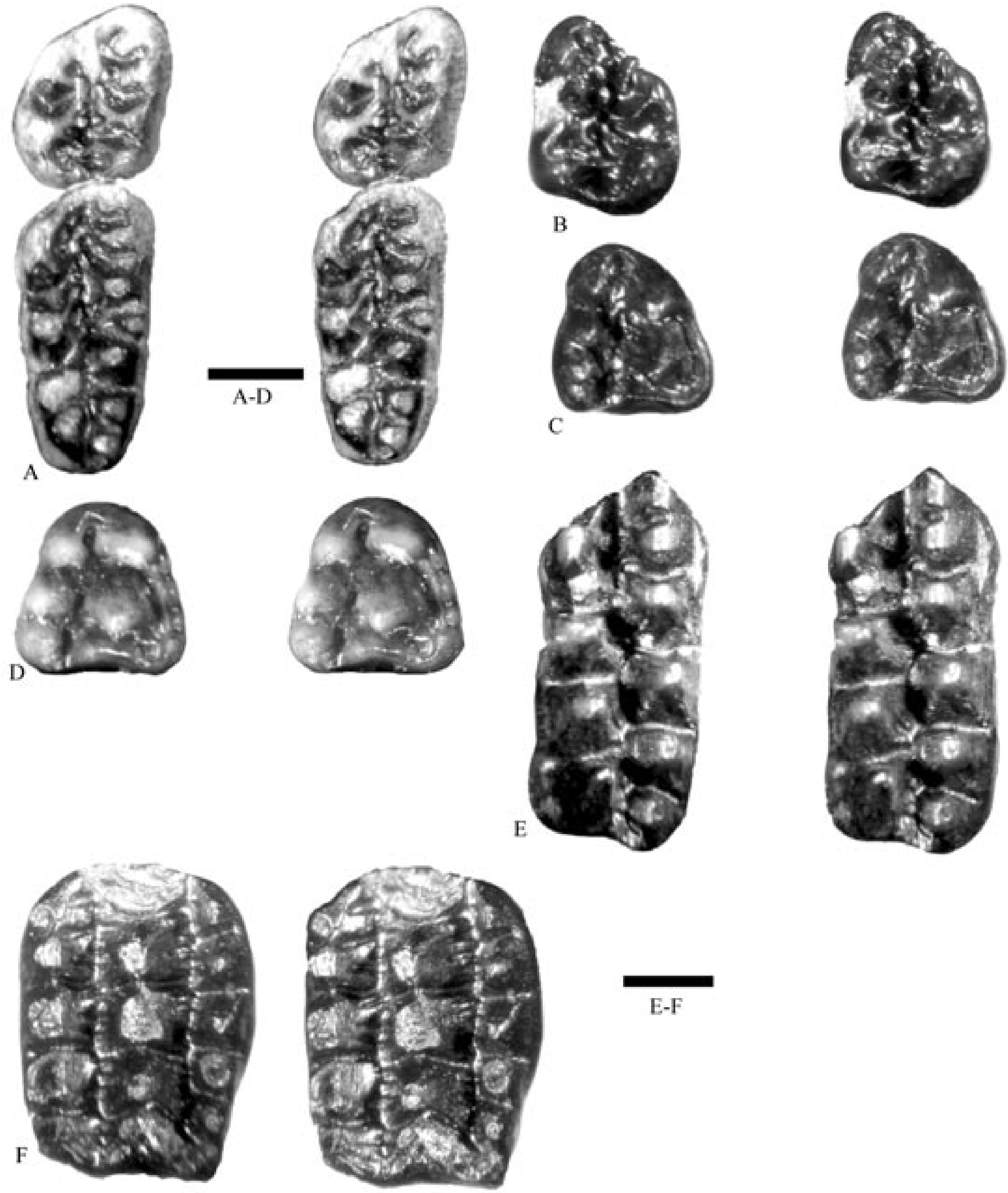

Figure 11. *Kaiparomys cifelli* gen. & sp. nov.: A, (UCM 50420), holotype, Lm1-2, stereo occlusal view; B, (UCM 50384), Rm2, stereo occlusal view; C, (MNA V7530), RM2, stereo occlusal view; D, (OMNH 22325), RM2, stereo occlusal view. *Meniscoessus* sp. cf. *M. intermedius*: E, (OMNH 20507), Lm1, stereo occlusal view; F, (OMNH 20481), LM1, partial, stereo occlusal view. Scale bars = 1 mm.

cusps of the internal row, forming a sharp inflection on the posterior wall of the molar.

The central valley is open posteriorly, probably as a result of wear. The valley is sinuous, resulting in part from the strong corners of the pyramidal cusps of the external row that cross the central valley.

Cusps of the internal row are taller than those of the external row. The first two cusps are closely appressed. The third cusp is distinctly crescentic with a rounded anterior face and a concave posterior wall bounded by strong ridge-like corners on both sides. There is a broad, deep valley between cusps 3 and 4. The fourth cusp is elongate and ribbed on its labial wall and is concave on its anterior face.

m2 – UCM 50420 (figure 11A) has cusp formula of 4:2. The valleys separating the cusps of the external row are closed buccally. The cusps of the external row lengthen posteriorly. The first cusp of the internal row has a deep pit on its labial wall. The valley separating the first and second cusps is broad and very similar to the valley separating the third and fourth cusp of the internal row of the m1. The second molar is significantly broader than the m1 (table 6).

UCM 50384 is an unworn m2 (figure 11B) with a cusp formula of 5:2. The external cusp row forms a tall wall with cusps decreasing slightly in size and height posteriorly. The cusps are separated only at their apices with deep valleys plunging into the central valley. The central valley is crossed by ribs generated from interior walls of the cusps of both rows. Deep pits are present along the valley. The first cusp of the internal row is large with a concave posterior face. The second cusp is much narrower. There is a small cuspule at the posterior margin of the second cusp.

M2 - MNA V7530 (figure 11C) has a cusp formula of Ri:3:4. The first cusp of the external row is ribbed and surrounded at its base by pits. The second cusp is about the same height and size. A distinct wall surrounds the anterior and labial margin of the tooth. The central valley is very complex as it is crossed by ribs and deeply pitted. The first three cusps of the internal row are close together and only slightly separated at their apices. The fourth cusp is more widely and deeply separated than the first three cusps. The tooth is slightly constricted in occlusal view due to slight indentations behind the third cusp of the internal row and between the two cusps of the external row. OMNH 22325 (figure 11D) has a cuspate wall with four distinct cusps along the anterolabial corner of the tooth. The first cusp of the medial row is ridge-like, whereas the second and third cusps are larger and have their apices oriented anteriorly. There is some ribbing on the posterior wall of cusp 2. The central valley has deep pits with ridges crossing it, connecting the cusps of the medial and internal rows. The cusps of the internal row are deeply separated on the labial wall and moderately well separated lingually. A deep pit is present posterior to cusp 3 at the terminus of the central valley.

Discussion – This taxon superficially resembles *Mesodma* in the elongation and the sinuous central valley of the m1, but *Mesodma* has more consistently crescentic cusps in both cusp rows of the m1 and the cusps are not as broadly separated as in *Kaiparomys*. The m1 is like that of *Cimolodon* in having the cusps of the external row pyramidal and a pitted central valley (but also see *Mesodma*, Archibald, 1982, figure 12a). But *Kaiparomys* lacks the well-developed and complex ribbing seen in the molars of *C. similis* and *C. electus*. The ratio of m2:m1 (0.65) is similar to that of *C. nitidus*, Archibald, 1982 (table 8; m2:m1=0.63) but is dissimilar to the value calculated for *C. nitidus*, Lillegraven, 1969 (m2:m1=0.71). It is interesting to note that the size range for m1s of *C. nitidus* in Archibald (1982) does not overlap with those reported by Lillegraven (1969), suggesting that there may be more than one species present in their two samples. The m2:m1 length ratio is also similar to that of *Mesodma thompsoni*, Lillegraven, 1969 (m2:m1=0.68) but not close to the value for *M. thompsoni* presented in Archibald (1982; m2:m1=0.75). It may be that m2s are often incorrectly assigned or that the lengths of m2s may be highly variable. The somewhat low, paired, and slightly offset anterior cusps of both cusp rows on m1 are more like the condition seen in m2s of *C. electus* (see Fox, 1971, figure 4) than in those of *Mesodma* (except for a somewhat odd tooth described as *M. formosa* by Lillegraven, 1969, figure 7 and some of the specimens of *Mesodma* described herein).

The m2 resembles that of *Cimolodon electus* (see Fox, 1971, figure 5), in that the cusps of the external row are not well separated labially, but the external cusp row of *C. electus* becomes taller and broadens posteriorly unlike the external cusp row of this taxon. The elongation of the second cusp of the internal row is more like the m2s of *Cimolomys* (see Archibald, 1982, figure 23e), but the cusps of the external row of the m2s of *Cimolomys* are deeply divided (see *C. clarki*, Sahni, 1972, figure 11E; Lillegraven and McKenna, 1986, figure 7B). The m2 is not similar to any figured specimens of *Mesodma*, although the length to width ratio is similar (table 6). The length-to-width ratio is intermediate between that of the m2s of *Cimolodon similis* and *C. nitidus* (table 6). The M2s appear to be more squared (mean LB:AP=0.96) than the M2s of either *Mesodma* or *Cimolodon* (table 6).

The M2 is also unlike described specimens of *Mesodma* in having strong ribs and deep pits. The ribbing and pitting are most similar to the condition seen in M2s of *Cimolomys* (*C. gracilis*, Archibald, 1982, figure 23), but the close position of the anterior two cusps of the internal cusp row is similar to the condition seen in *Cimolodon* (*C. nitidus*, Lillegraven, 1969, figure 11-5b). *Cimolodon electus* has a similar internal cusp row but has a broadly expanded anterolabial platform unlike *Kaiparomys*. The well-divided internal cusp row is more similar to M2s of *Cimolomys* than *Cimolodon*.

In overall form of the cusps, the presence of some ribs and pits, and the way in which cusps of the molars are separated, this taxon more closely resembles *Cimolodon* than any other described taxon. The resemblance however, may just be the retention of primitive characters as the strong anterior tapering of the m1 may suggest closer affinities with *Mesodma*. In many other regards the teeth, particularly the second molars, are distinctly unlike any described for *Mesodma*.

Superfamily unknown
Family Cimolomyidae Marsh, 1889
Meniscoessus Cope, 1882
Meniscoessus sp. cf. *M. intermedius* Fox, 1976
table 7; figures 11E-F

Referred Specimens – OMNH 20481, LM1 (posterior part), Loc. V9; OMNH 20507, Lm1, Loc. V9; OMNH

24057, Lm1 (anterior part), Loc. V61; UMNH VP7636, RM1 (fragment), Loc. 108.

Description – m1. OMNH 20507 (figure 11E) has a cusp formula of 6:4. The first cusp of the external row is low, cusps 2-4 are pyramidal in form and well separated, and cusps 5 and 6 are not separated labially but are separated lingually by a vertical groove. The central valley is sinuous with pitting in the posterior half of the valley. The first cusp of the internal row is small and conical with a wear facet facing the central valley. Cusps 2, 3, and 4 are pyramidal and well separated but not as deeply divided as the cusps of the external row.

M1 – OMNH 20481 (figure 11F) is the posterior part of an M1. The cusp formula is uncertain, but there are at least six cusps in the internal row. Cusps of the external and medial rows are about the same height, but those of the medial row are broader. The largest cusps of the internal row are about the same size as those of the medial row but are lower. Cusps of the external row are conical but flattened on the lingual side and are connected medially by small anteroposterior-oriented ridges. The cusps of the medial row are subpyramidal with a flattened anterior face and with cusp apices oriented slightly anteriorly. The internal cusps are basically conical and separated from the medial row by a valley that is deeper than that which separates the medial and external rows. Cusps of the medial and external rows are ribbed on the sides facing valleys.

Discussion – The m1 is smaller and less cuspate than those of *M. major* and smaller, with much less crescentic cusps than m1s of *M. robustus* (table 9). Although the specimen is also smaller than *M. intermedius*, it is just below the known range of that taxon both in terms of size and number of cusps (table 9). Older, presumably more primitive forms of *Meniscoessus* (*M. major*, Sahni, 1972, figure 12E; *M. intermedius*, Fox, 1976) have more erect and less crescentic cusps than Lancian forms (e.g., *M. robustus*, Clemens, 1964, figs. 43, 44). The taxon described here has erect subpyramidal cusps, placing it among the more primitive forms of *Meniscoessus*. The internal cusp row is not as expanded as that of the incompletely prepared M1 of *M. intermedius* (illustrated by Fox, 1976, figure 3) but otherwise appears to be very similar. Both the molars are somewhat smaller than known specimens of *M. intermedius*, and part of the lack of certainty about assignment of these specimens occurs because Fox (1971) described a smaller species, *M. ferox*. *Meniscoessus ferox* is based on a P4 (Fox, 1971). An M2 was subsequently identified (Fox, 1976), but there are no description or measurements available for that specimen. As there is a smaller species named, and the only complete measurable molar here is 12% smaller than *M. intermedius*, I confer the taxon to the better-known species recognizing that with more complete knowledge of *M. ferox*, these specimens might be more appropriately placed within that species.

Meniscoessus sp. cf. *M. major* Sahni, 1972

Referred Specimen – MNA V4587, LM1 (anterior part), Loc. 704-3.

Description and Discussion – A single partial M1 is significantly larger than the specimens described above, but there are no complete dimensions available to measure. The fragmentary specimen compares closely to M1s from the Judith River Formation (UCMP collections) in size, number of cusps, and deep grooves present at the base of the cusps, but the internal cusp row is longer, relative to the total molar length, in the Judith River specimens. However, the internal row is very similar to those described from Fox's (1980) sample of *M. major* in that the anteromost cusp of the internal row is opposite the fourth cusp of the medial row, which has a low ridge continuing to the anterior margin of the tooth. Because of the tooth size and morphology, this partial molar is tentatively conferred to *M. major*.

Cimolomys Marsh, 1889
Cimolomys sp. A cf. *C. clarki* Sahni, 1972
table 8, figures 12A-B

Referred Specimens – OMNH 24037, RM1, Loc. V61; OMNH 24324, LM2, Loc. V61; OMNH 24325, LM1 (posterior part), Loc. V61.

Description – M1. The cusp formula of OMNH 24037 (figure 12A) probably is 5:6:7, although the anteromost part of the tooth is missing and there is the slight possibility of an additional external or medial cusp. The first three cusps of the external row are conical but have flat wear facets on their lingual sides. A large, deep, broad valley separates cusps 2 and 3. The fourth cusp is conical but anteroposteriorly compressed. The fifth cusp is small, low, and connected to the posteromost cusp of the medial row by a ridge that closes off the central valley posteriorly. Although the cusps of the external row get smaller posteriorly, the width of the row does not narrow posteriorly.

The central valley is slightly sinuous and crossed by ribs at the position of the valley separating cusps 2 and 3 of the external row and also near the posterior end of the central valley. The central valley has a slight arch to it in occlusal view but is essentially oriented with the anteroposterior axis of the tooth, and it does not cross the tooth diagonally. The cusps of the medial row are subpyramidal with the four posterior cusps having apices oriented slightly anteriorly. The cusps increase in size and height posteriorly.

The internal cusp row reaches or closely approaches the anterior margin of the tooth (estimated due to the small amount of breakage anterior of the external and medial cusp rows). At the anterior of the internal cusp row are three low, connected cuspules, of which only the third is counted as a cusp in the formula. Cusps 2, 3, and 4 are distinct, conical, and well separated. Cusps 5, 6, and 7 are connected and form a high ridge. The cusps increase in height to the sixth cusp, but the seventh cusp is distinctly lower. In occlusal view the row is arched, reaching its maximum lingual breadth at the position of the fourth cusp.

M2 – OMNH 24324 (figure 12B) has a cusp formula of 3:3:4. There are three distinct cusps present anteriorly on the anteroexternal platform that grade posteriorly into a cuspate ridge. The first cusp of the medial row is low and narrow. The second cusp is strongly ribbed all the way around, and the third is well-ribbed on its posterolabial side and subequal in size to the second cusp. The central valley is finely pitted and open posteriorly. Cusps of the internal row are progressively better separated posteriorly. A tiny cuspule is present posterolabially of the fourth cusp.

Discussion – The M1 is thought to represent *Cimolomys* because of the well-developed internal cusp row, the conical cusps on the outside rows of the tooth, the anterior-leaning subpyramidal cusps of the medial row, and because the external and medial cusp rows maintain their width such that the central valley of the molar is aligned approximately with the anteroposterior axis of the tooth. The specimen is too small to represent *C. trochuus* or *C. gracilis*. It is close to the estimated size of the specimen described by Sahni (1972) as *C. clarki* (Sahni provided no dimensions but stated m1s of *C. clarki* were the same size as those of *Mesodma primaeva*) and is very similar to that specimen in overall form and cusp formula; however, the specimen appears to be significantly smaller than the sample of *C. clarki* described by Lillegraven and McKenna (1986) (see table 8). The first cusp of the external row of this specimen is subequal to the second, whereas in the specimen of *C. clarki* figured by Sahni (1972, AMNH 77219, figure 11-G) the first cusp is small and positioned lingually of the other cusps.

The M2 is considered to represent *Cimolomys* because the relatively well-separated cusps of the internal row, unlike the ridge-like cusp row of *Cimolodon* (see discussion above under *Cimolodon foxi*). It fits well against the posterior margin of OMNH 24037 (an M1), and has LB:AP and M2:M1 length ratios identical to described specimens of *Cimolomys* (table 8). The specimen is distinctly smaller than any other described M2s of *Cimolomys* and possibly, along with the M1, indicates the presence of a smaller population of *C. clarki* than previously sampled, or a new smaller species. A larger sample would be required to determine this with certainty.

Cimolomys sp. B cf. *C. clarki* Sahni, 1972
table 8; figures 12C-F

Referred Specimens – MNA V4586, RP4, Loc. 704-1; MNA V7526, RP4, Loc. 704-1; OMNH 24327, RM1 (posterior part), Loc. V61.

Description – P4. MNA V7526 (figures 12C-E) has a cusp formula of 1:5. The tooth is broad with rounded margins (in occlusal view) with a moderate crown height. The cusp apices are striated. There is a single anteroexternal cusp on the anteroexternal platform that is not broadly expanded relative to the width of the tooth. Cusp apices of the medial cusp row are well separated with the apogee reached at the fifth cusp. A complexly enameled and flattened surface descends from the apex of cusp 5 to a large posterior cusp. A small basin is formed lingual to the cusp and another smaller cusp terminates the basin internally. MNA V4586, another RP4, has a cusp formula of 1:5 and is slightly larger and more robust than MNA V7526 (table 8).

M1 – OMNH 24327 is the posterior half of a RM1 (figure 12F). The posterior four cusps of the external and medial rows are much like those of OMNH 24037, referred above to *Cimolomys* sp. A cf. *C. clarki*, but all of the cusps are more elongated anteroposteriorly. The width of the molar is less than that of OMNH 24037 (table 8). The internal row is unusual in having at least seven distinct, equal-sized, closely appressed cusps.

Discussion – The differentiation of P4s of *Cimolodon* and *Cimolomys* is not easy. Although most of the described P4s of *Cimolodon* have several cusps in the external row they may have as few as one (e.g., *C. electus*). P4s of *Cimolodon* usually have more cusps in the medial cusp row than in P4s of *Cimolomys*, but they may overlap in number (e.g., 6 cusps in some specimens of *Cimolodon nitidus* and in *Cimolomys clarki*). In general, the P4s of *Cimolodon* have an arched shape in occlusal view such that they are concave lingually and convex labially. This appears to reflect a change in direction of the cusps to correspond to curvature of the maxillary (Clemens, 1964, figure 29C). In *Cimolomys*, the medial cusp row tends to be essentially straight (Clemens, 1964, figure 36b; Sahni, 1972, figure 11-H; Lillegraven and McKenna, 1986, figure 7F); however, there is a slight curvature to the specimen of *C. gracilis* shown in Archibald (1982, figure 23C) and in the specimens assigned here to *Cimolomys*.

The height of the crown relative to the tooth length also shows certain trends. The H:AP is generally relatively low for *Cimolodon* as estimated from figures (0.33 for *C. electus*, Fox, 1971, figure 5b; 0.36 for *C. nitidus*, Clemens, 1973, figure 30c) but is estimated to be as high as 0.48 (*C. nitidus*, Archibald, 1982, figure 20b). The crown tends to be higher in *Cimolomys*, but the values overlap with those of *Cimolodon* (0.42 for *C. clarki* Sahni, 1972, figure 11-H; 0.45 for *C. gracilis* in Archibald, 1982, figure 23b; and 0.50 for ?*Cimolomys* sp. A in Fox, 1971, figure 6c). The specimens here have a H:AP range of 0.50-0.54, exceeding the known range for *Cimolodon*. This suggests affinities of these specimens to *Cimolomys*.

An attempt was made to distinguish P4s of *Cimolodon* and *Cimolomys* on the basis of the proportion of the posterior basin to the anterior part of the tooth (PL:AL). However, *C. electus* and some illustrated specimens of *Cimolomys* have a short posterior basin (range of PL:AL = 0.38-0.47). But many illustrated specimens of *Cimolodon nitidus* have relatively long posterior basins (PL:AL = 0.7), as does the P4 of *Cimolomys gracilis* (PL:AL = 0.67) figured by Clemens (1964, figure 36) and the P4 of *Cimolomys clarki* depicted by Sahni (1972, figure 11-H). So this aspect of tooth proportion may be highly variable, or apical wear has strongly altered the apparent proportions. It is also possible that the attempt to determine these proportions from illustrations yielded inaccurate data.

In overall tooth appearance, high crest, and low cusp count these specimens most closely resemble *Cimolomys*. The teeth are too large to be those of *C. gracilis* and exceed the range of described specimens of *C. clarki*. P4s assigned to *C. clarki* by both Sahni (1972) and Lillegraven and McKenna (1986) were unusually large as the teeth of *C. clarki* are usually 30% smaller than those of *C. gracilis*. The P4s they assigned to *C. clarki* are actually larger than those of *C. gracilis*. An alternate hypothesis is that the P4 assigned by Sahni (1972) to *C. clarki* may be from a species closer to *C. trochuus*, an observation consistent with Archibald's (1982, p. 122) comment that the similar-sized ?*Cimolomys* sp. A of Fox (1971) may possibly represent *C. trochuus*. MNA V7526 is close to the size of the specimen described by Fox (1971) as ?*Cimolomys* sp. A (table 8) and MNA V4586 is more robust than Fox's specimen. Fox's (1971) specimen is close to those described by Sahni (1972) as *C. clarki*, but all of Sahni's specimens may actually represent *C. trochuus*. If Fox's specimen represents *C. trochuus*, then the specimens described here should also be referred to that species. Comparison of the M1 (OMNH 24037, figure 12F) referred to here as *Cimolomys* sp. A cf. *C. clarki* with these two P4s indicates that the P4s are too large to appropriately fit the M1.

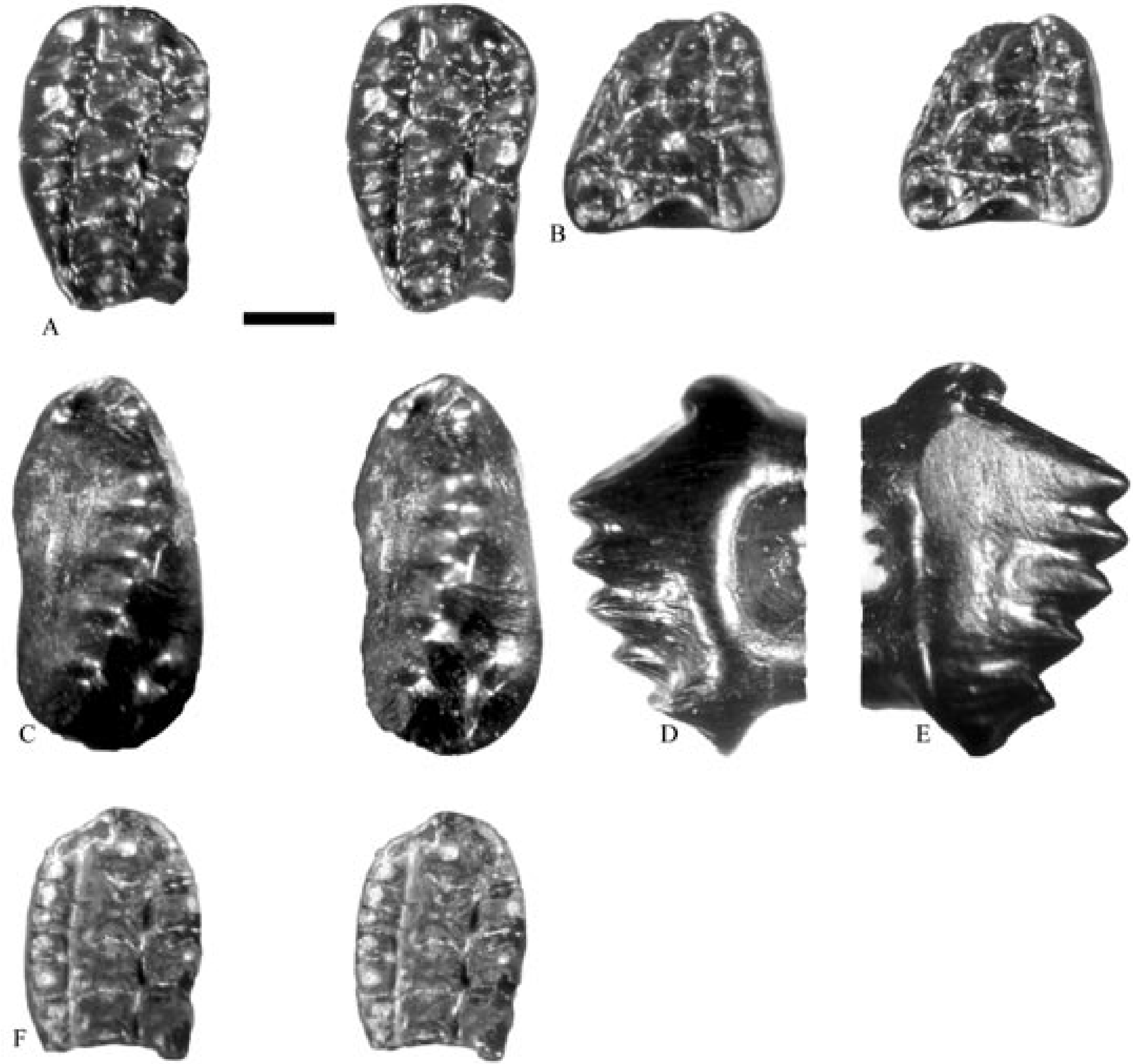

Figure 12. *Cimolomys* sp. A cf. *C. clarki*: A, (OMNH 24037), incomplete RM1, stereo occlusal view; B, (OMNH 24324), LM2, stereo occlusal view. *Cimolomys* sp. B cf. *C. clarki*: C, (MNA V7526), RP4, stereo occlusal view; D, labial view; E, lingual view; F, (OMNH 24327), partial RM1, stereo occlusal view. Scale bar = 1 mm.

Either the size range of *C. clarki* is greater than previously known or there is a species of *Cimolomys* larger than *C. clarki* such as *C. trochuus* in this sample. As such, it is possible that there are two species of *Cimolomys* present in the sample recovered from the Kaiparowits Formation.

The partial M1 included here (OMNH 24327) may be significantly longer and have an internal row that differs from that of the M1 referred above to *Cimolomys* sp. A cf. *C. clarki*. The specimen is inadequate to assign this M1 with certainly to *C. clarki*.

Family ?Cimolomyidae Marsh, 1889
?*Cimolomys butleria* sp. nov.
table 8; figures 13A-G

Holotype – MNA V5226, LM1, Loc. 704-1 (?Cimolomyid, gen. & sp. indet. in Eaton, 1987).

Hypodigm – MNA V5341, RP4, Loc. 1004-1 (*Paracimexomys* n. sp. C in Eaton, 1987); OMNH 20010, RP4, Loc. V5 (*Cimexomys* sp. in Eaton, 1987); OMHH 22306, LP4, Loc. V5; OMNH 22837, Lm1, Loc. V9.

Distribution – Kaiparowits Formation of southern Utah, Campanian.

Diagnosis – Smaller than any other species of *Cimolomys*; first lower molar formula 6:4, cusps pyramidal unlike those of other species *Cimolomys*; P4 formula 1:5, low crested and straight as in other species of *Cimolomys*; M1 squared with internal row as long as molar, cusp formula 4:6:5, external row cusps pyramidal, medial row cusps pyramidal and leaning anteriorly, medial valley crosses tooth diagonally. Molars are smaller and less cuspate than described species of *Cimolomys* or *Cimolodon*.

Etymology – for my wife, Linda Butler (her maiden name) Eaton, in recognition of her never-ending support and help with my field work, her acceptance of the never-ending parade of students and colleagues at our summer home, and her patience with my many long absences, both in the field and while writing manuscripts.

Description – m1. OMNH 22837 (figure 13A) has a cusp formula of 6:4 and the tooth narrows medially in occlusal view. The external cusp row is much longer than the internal row. The first cusp of the external row is small and low. The second cusp is the tallest of the row, and the remaining cusps are subequal in height, widely and deeply separated, and pyramidal in form. The last three cusps lean posteriorly. The central valley is deeply pitted and crossed by well-developed ridges connecting the cusps of both rows. The first cusp of the internal row is tiny and shifted medially. The second cusp is larger and leans posteriorly. The third cusp is larger still and is pyramidal in form. The fourth cusp is the broadest and tallest of the tooth. The internal cusp row is slightly higher than the external row. Cusps of the internal row are widely separated.

P4 – OMNH 22306 (figures 13B-D) has a cusp formula of 1:5. The tooth is straight and very low crowned. The anteroexternal platform has little swelling and the single cusp is placed anteriorly. The cusps of the medial row are broadly separated and the climb ratio is low (CR = 0.32), and the row reaches maximum depth at cusp 4. Cusps 3 and 5 are only slightly lower. The posterior basin is deep and is bounded on both sides by two cusps. On the labial side the posteromost cusp is small and the more anterior cusp is much larger. On the lingual side of the basin the posterior cusp is well developed and there is a hint of a small, more anteriorly placed cuspule. OMNH 20010 (figures 13E-G) is tentatively placed here due to being significantly narrower than the other P4s (table 8). The specimen is similar in cusp formula (1:5) to the other specimens but is straight and narrow and the climb ratio for the cusps of the medial row is intermediate in value (CR=0.36); however, the last cusp of the medial row is the tallest, unlike in the other two specimens on which the fourth cusp was the tallest.

M1 – MNA V5226 (holotype, figure 13H) has a cusp formula of 4:6:5 and is a squared molar with all cusp rows reaching the front of the tooth. There are four distinct cusps in the external row. The middle two cusps are erect and pyramidal. There is a small cuspule positioned anterolabially that is not counted in the cusp formula. This cusp row markedly narrows posteriorly. The central valley runs diagonally across the tooth. It is pitted and crossed by complex ribbing. The cusps of the medial row are essentially pyramidal but lean anteriorly, unlike the cusps of the external row. The cusps increase in size to the fourth cusp. Cusps 4, 5, and 6 are subequal in size.

The internal cusp row is positioned low on the tooth. The cusps of this row are widely separated and the anteromost cusps are linguobuccally compressed (however the first cusp of the row is missing). There is a small cuspule positioned posterolingual to the third cusp. The anterior of the tooth has a broad facet for the P4.

Discussion – Of illustrated specimens, the m1 is closest to ?*Cimolomys* sp. A of Fox (1971, figure 6d) and *C. clarki* of Lillegraven and McKenna (1986, figure 7A) in terms of cusp formula and shape. The cusps in all of these specimens are to a high degree pyramidal, rather unlike the revised diagnosis of the genus by Clemens (1964, p. 76) which states "Molar cusps, particularly those of lower molars, are strongly crescentic." The cusp formula of these specimens is also lower than defined for the genus by Clemens, 1964 (7-8:5-7). As such, it is questionable if these teeth actually represent *Cimolomys*. The m1 occludes perfectly with the M1 and certainly belongs to the same species. I originally thought that the m1 assigned to *C. clarki* by Lillegraven and McKenna (1986) was incorrectly assigned due to its lack of crescentic cusps; however, there are significant similarities between that tooth, and the m1 described here as ?*Cimolomys butleria*, and *Bryceomys* in terms of the broad, open valleys between lower molar cusps. It may be that a taxon similar to *Bryceomys* gave rise to *Cimolomys* such that the earliest forms of *Cimolomys* had not yet developed fully crescentic cusps (see discussion below). It may be appropriate to erect a new genus for these *Cimolomys*-like taxa that lack crescentic cusps. This new genus could include the Wahweap taxon ?*Cimolomys* sp. described later in this paper, ?*Cimolomys butleria*, ?*Cimolomys* sp. A of Fox (1971), and possibly *C. trochuus* of Lillegraven (1969).

The P4s are not strongly arched in occlusal view (or are essentially straight in the case of OMNH 20010), the cusp of the anteroexternal platform is very anteriorly placed, the crown is shallow, the medial cusp row reaches its greatest depth before the last cusp (except on OMNH 20010 in which the last cusp is the deepest), and the posterior basin is complex. These are all characters seen in specimens of *Cimolomys* (see Archibald, 1982, figure 23C, and Clemens, 1964,

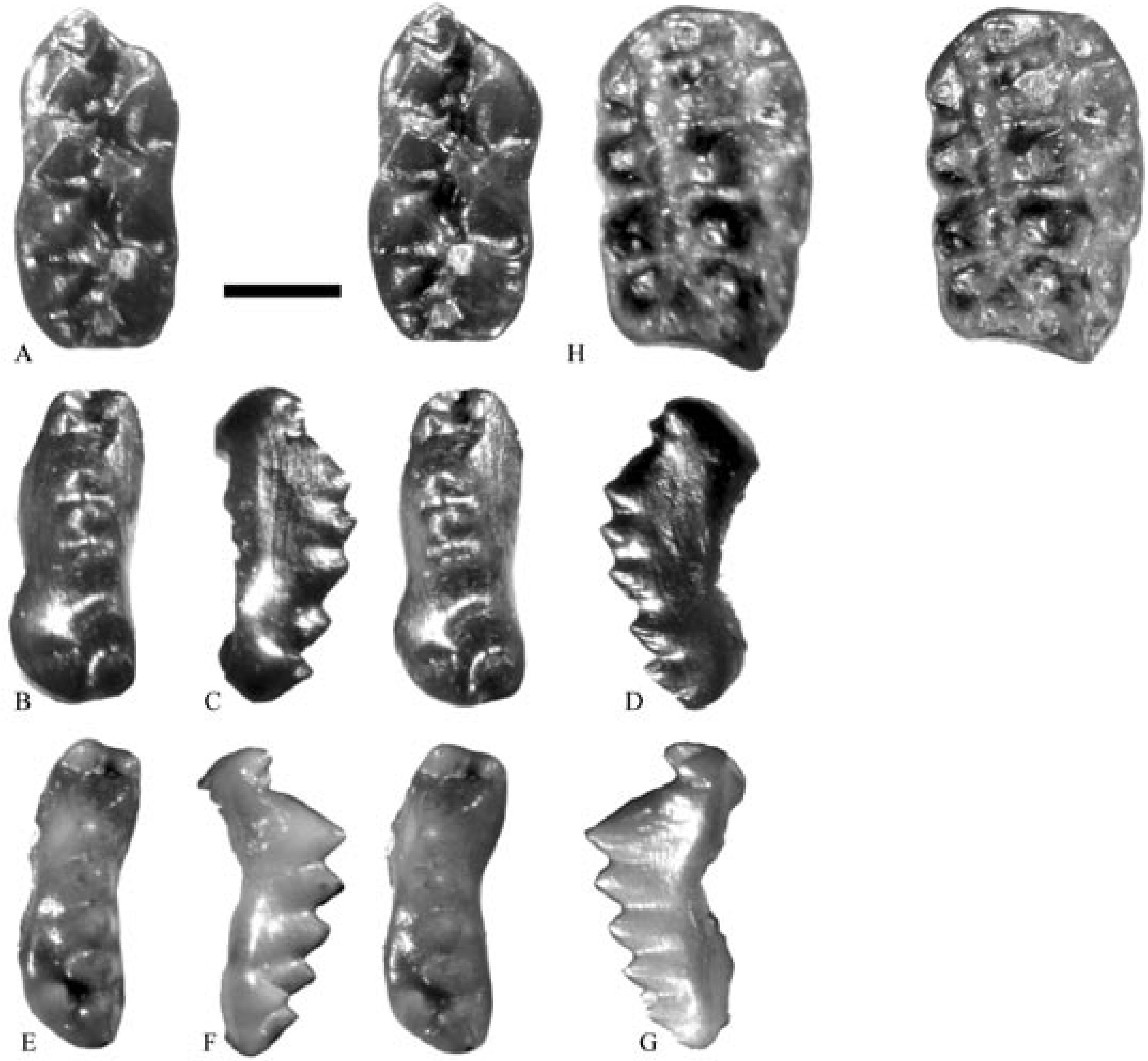

Figure 13. ?*Cimolomys butleria* sp. nov.: A, (OMNH 22837), Rm1, stereo occlusal view; B, (OMNH 22306), LP4, stereo occlusal view; C, labial view; D, lingual view; E, (OMNH 20010), RP4, stereo occlusal view; F, labial view; G, lingual view; H, (MNA V5226), holotype, LM1, stereo occlusal view. Scale bar = 1 mm.

figure 36b). If these P4s are correctly associated with the other teeth assigned here to ?*C. butleria*, then this species probably could be referred to *Cimolomys* without question. The cusps of the posterior basin of P4 are the same width as the anteromost two cusps of the M1, and the ratio of the lengths of P4s to the M1s (P4:M1 = 0.86) is close to that observed for *C. clarki* by Lillegraven and McKenna (1986) but quite different from the value for *C. gracilis* provided by Clemens (1964) (table 8). This may in part relate to the rather large size of P4s assigned to *C. clarki* by Sahni (1972) and Lillegraven and McKenna (1986) (see discussion above). The P4s included here are in the lower range of the anteroposterior dimensions of *C. gracilis* (see Archibald, 1982) but are distinctly narrower than in that species (table 8). OMNH 20010 was originally assigned to *Cimexomys* sp. by Eaton (1987), but the low cusp formula suggests that the specimen was incorrectly assigned. The identification of the specimen here is also tentative.

The squared shape of the M1 and the internal cusp row extending the entire length of the molar strongly suggests affinities with *Cimolomys*. However, the diagonal nature of the central valley with the cusp of the external row narrowing posteriorly is unlike most illustrated specimens of *Cimolomys* (*C. gracilis*, Clemens, 1964, figure 37b; *C. clarki*, Sahni, 1972, figure 11G; *C. trochuus*, Lillegraven, 1969, figure 13-4b). However, the specimen of *Cimolomys clarki* (AMNH 88485) shown in Lillegraven and McKenna (1986, figure 7C) has a diagonal central valley. Also, the cusps of the medial row of this specimen are less crescentic than those usually assigned to *Cimolomys*, a condition acknowledged by Lillegraven and McKenna (1986, p. 22). It is possible that this specimen would be more properly assigned to *Cimolodon*, because upper molars of *Cimolodon* have anteriorly directed pyramidal cusps in the medial row and a diagonal central valley (e.g., *C. electus*, Fox, 1971, figure 4d). The diagonal central valley is also present in *Mesodma primaeva*, *Paracimexomys*, *Cimolodon*, and in bolodontoids (e.g., *Bolodon*, Kielan-Jaworowska and Ensom, 1992, text-figure 6A). Djadochtatherioids (e.g., *Buginbaatar*, Kielan-Jaworowska and Sochava, 1969, pl. 1), however, show no tendency for a transverse central valley on M1.

The length of the internal row on M1 being as long as the tooth is found in some specimens of *Cimolomys* (*C. clarki*, Sahni, 1972, figure 11G; *C. trochuus*, Lillegraven, 1969, figure 13-4b) but not in others (*C. gracilis*, Clemens, 1964, figure 37b; *C. clarki*, Lillegraven and McKenna, 1986, figure 7c). This condition has not been described for M1s of *Cimolodon*. MNA V5226 is smaller (AP=3.07; LB=1.85) and bears fewer cusps than the M1s of all other taxa of *Cimolomys* and *Cimolodon*.

If the M1 identified as *Cimolomys* by Lillegraven and McKenna (1986; AMNH 88485) is correctly assigned, there would be little question of the close affinity of ?*Cimolomys butleria* to *Cimolomys*. However, it is hard to accept that a major functional feature such as the orientation of the central valley and the external and medial cusp rows would be variable within a genus. For this reason the taxon is questionably assigned to the genus *Cimolomys* while recognizing a possible closer link to cimolodontids.

Both the molars bear some similarity to the much older taxon *Bryceomys* Eaton, 1995. The broad separation of the molar cusps and tooth shape are shared by *Bryceomys*, ?*Cimolomys butleria*, and to a lesser extent by certain cimolomyids. It may be possible that *Bryceomys* represents the primitive state from which later cimolomyids were derived (see discussion in Eaton and Cifelli, 2001). Based on the sample described by Eaton (1995), it is unlikely that *Bryceomys* has a lower incisor completely covered in enamel, a condition required in the revised diagnosis of the Cimolomyidae by Archibald (1982, p. 72); however, the condition of the lower incisor of *Cimolomys* is unknown. Archibald (1982) also stated in the revised diagnosis of Cimolomyidae that M2s are long relative to M1s. However, a long M2 relative to M1 is a primitive condition that is better developed in taxa like *Paracimexomys* (*P. priscus*, Archibald, 1982, table 17, M2:M1 = 0.9), primitive cimolodontids (*C. electus*, *C. similis*; Fox, 1971, table 2, M2:M1 = 0.8), and *Bryceomys* (see Eaton, 1995, M2:M1 = 0.8) than it is in *Cimolomys* (*C. gracilis*, Clemens, 1964, table 9, M2:M1 = 0.7). As such, the phylogenetic position of *Cimolomys* is uncertain as is the position of the cimolomyid-like taxa described here.

Family unknown
Cimexomys Sloan and Van Valen, 1965
Cimexomys sp. cf. *C. judithae* Sahni, 1972
table 9; figures 14A-J

Referred Specimens – MNA V4639, LP4, Loc. 454-6; MNA V5312, Rp4, Loc. 704-1; OMNH 20190, LP4, Loc. V14; OMNH 22315, Rp4, Loc. V5.

Description – p4. OMNH 22315 (figures 14A-B) has 10 serrations and 6 external and 7 internal ridges. The highest part of the crest is reached at the fourth serration. MNA V5312 (figures 14C-D) has 9 serrations, 8 external and 7 internal ridges. The tooth is low crested and the ridges are widely spaced.

P4 – MNA V4639 (figures 14E-G) has a formula of 2:5. The anteroexternal platform is broadly expanded such that the anterior of the tooth is much broader than the posterior. The platform bears two cusps and there is a small cuspule positioned at the anterior margin of the tooth, which is not counted in the formula. The medial cusp row is low and worn. The crest posterior of the last cusp of the row is convex posterodorsally. The posterior basin bears one well-developed cusp labially, but the entire basin lingual to this cusp has been removed by wear. OMNH 20190 (figures 14H-J) has a higher cusp formula (4:6) than MNA V4639. The anteroexternal platform is only slightly broadened. The first cusp of the platform is tiny and each successive cusp is larger. The last cusp is coarsely ribbed lingually. The cusps of this row are only slightly lower than those of the medial row. The first cusp of the medial row is tiny and the remainder become progressively larger posteriorly. The climb ratio is low (CR = 0.33). The posterior basin has one large cusp bordering it labially and a small cusp lingually. Cusps are separated by a deep pit that is open posteriorly.

Discussion – The p4s are included here largely because they are low crested and have few serrations and ridges. They are very similar to the p4s of *Mesodma*. Montellano (1992) rediagnosed *Cimexomys* as having fewer serrations (8-10) than comparably sized species of *Mesodma*, but *M. archibaldi* is very similar in terms of serrations and ridges to specimens described here. Montellano (1992) also maintained that the last 2-3 serrations form distinct cusps and lack internal or external ridges in *Cimexomys*. This can also be the case in *Mesodma* (see Clemens, 1964, figure 10a-b). In the specimen figured as *C. gratus* by Archibald (1982, figure 37) only the last cusp lacks a ridge. Lower fourth premolars of *Cimexomys* were distinguished here from those of *Mesodma* based on the broad spacing of the serrations in *Cimexomys*, the tendency for the first two anteroexternal ridges to converge with the third ridge in *Cimexomys* (see Montellano, 1992, figure 8a), and the high point of the crest being reached at the fourth serration in *Cimexomys* and more posteriorly in *Mesodma*. This last character does not result in a dramatic difference in AL:AP between this small sample and other species of *Cimexomys* (table 9) or species of *Mesodma* (table 1), possibly a result of the difficulty in determining the AL dimension (see discussion above, under "Measurements and Terminology"). The p4s are in the size range of *C. judithae* (and potentially *C. antiquus*, for which p4s are unknown) (table 9) but have more internal ridges than described for that species. Otherwise, they are very close to those of *C. judithae*.

The P4s are included with *Cimexomys* rather than *Mes-*

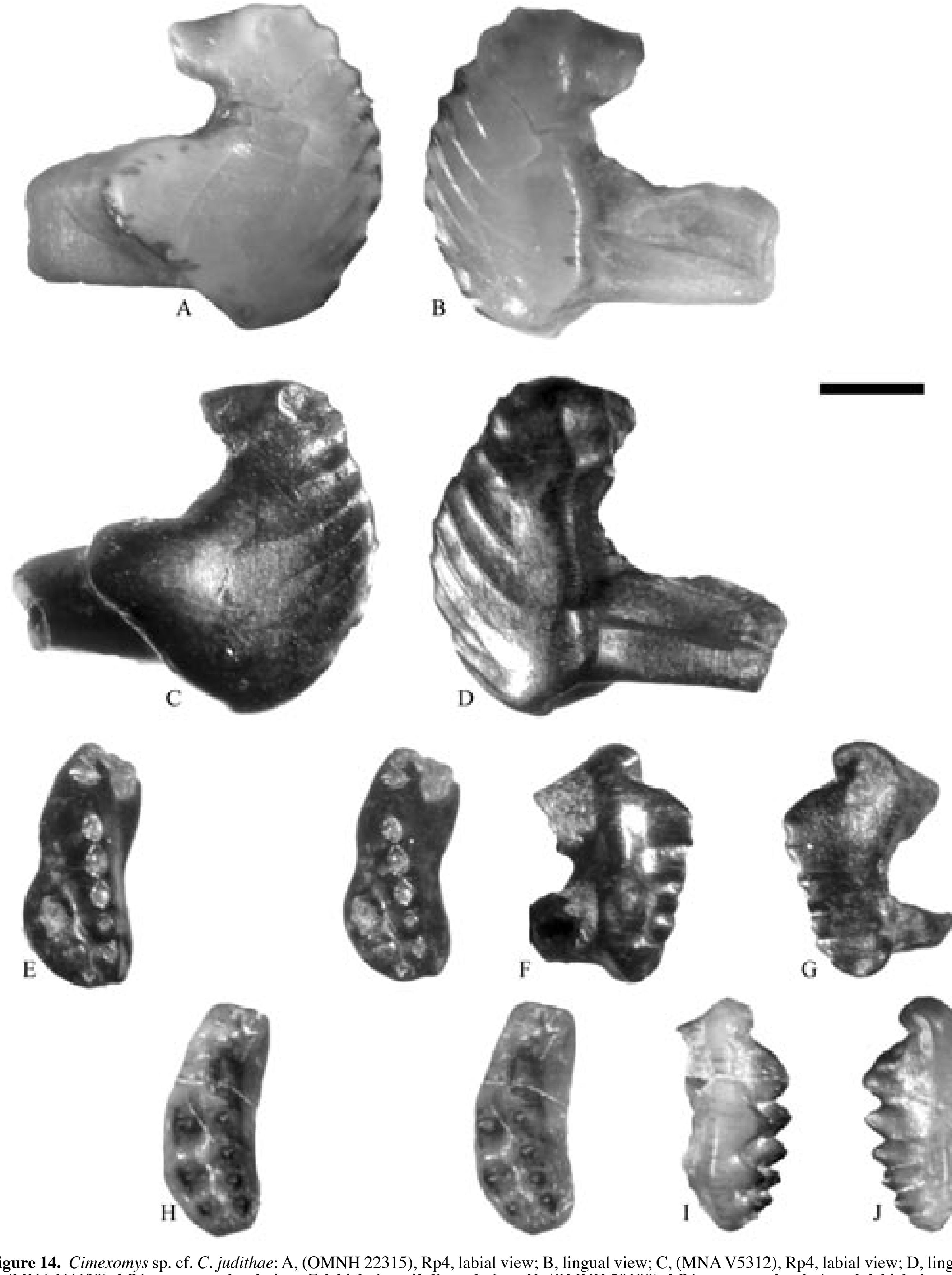

Figure 14. *Cimexomys* sp. cf. *C. judithae*: A, (OMNH 22315), Rp4, labial view; B, lingual view; C, (MNA V5312), Rp4, labial view; D, lingual view; E, (MNA V4639), LP4 , stereo occlusal view; F, labial view; G, lingual view; H, (OMNH 20190), LP4, stereo occlusal view; I, labial view; J, lingual view. Scale bar = 1 mm.

odma because they are lower crowned (H:AP) and have a lower climb ratio for the cusps of the medial row than in P4s of *Mesodma* (compare tables 1 and 9). More distinctive is the convex posterodorsal ridge posterior of the last cusp of the medial row that gives the cusp the impression of being anteriorly directed (*C. judithae*, Montellano, 1992, figure 7; *C. minor*, Archibald, 1982, figure 35a) rather than upright as in *Mesodma*. These P4s are in the size range of *C. judithae* but are also within the range of *C. minor*; however, the P4s of this taxon have a much different width-to-length ratios than do those of *C. minor*, which are almost identical to the values for *C. judithae* (table 9). The reported range of cusp formulae for P4s of *C. judithae* is 2-3:5 (Sahni, 1972; Montellano, 1992), and one of these P4s falls within that range, the other is more cuspate (4:6). Specimens in the UCMP collections identified as *C. judithae* from locality UCMP Locality V77083 (uncatalogued at the time I examined them), however, had cusp formulae of 3:6.

Although the species of *Cimexomys* described here is very close to *C. judithae*, it is not certain if that species is represented. Until a larger sample is available, this species is conferred to *C. judithae*.

Cimexomys or *Mesodma* sp.
table 10; figures 15A-D

Referred Specimens –MNA V5269, Lm1, Loc. 454-6 (?*Mesodma* sp. cf. M. formosa in Eaton, 1987); OMNH 20006, Rm1, Loc. V5; OMNH 20343, LM2, Loc. V5; OMNH 20344, RM2, Loc. V5; OMNH 20359, Lm1, Loc. V5; OMNH 20494, Lm1, Loc. V9; OMNH 22314, Rm1, Loc. V5; OMNH 22847, Rm1, Loc. V9; OMNH 24053, Lm1, Loc. V61; OMNH 24055, Lm1, Loc. V61; UMNH VP5604, Lm1, Loc. 51; UMNH V5611, Lm1, Loc. 54; UMNH VP7640, Rm1, Loc. 56.

Description – m1. OMNH 22314 (figure 15A) has a cusp formula of 6:4. The tooth is slightly (0.01 mm) broader posteriorly than anteriorly. The cusps of the internal row are broad relative to those of the external row and there is a broad facet for p4 at the anterior end of the tooth. The first two cusps of the external row are low, erect, and conical. The third and fourth cusps are about the same size and height, are well separated, and subpyramidal. Cusps 4, 5, and 6 are more deeply separated lingually than labially and lean slightly posteriorly. The central valley is slightly oblique to the anteroposterior axis of the tooth and is crossed by ribs and is deeply pitted. The first cusp of the internal row is low and occurs on the anterior edge of the second cusp. Cusps 2, 3, and 4 are of about the same height. The third cusp is the most separate and distinct. MNA V5269 (figure 15B) is broader anteriorly than posteriorly and is strongly waisted in occlusal view. OMNH 20494 (figure 15C) also is broader anteriorly than posteriorly, has a strong anterior notch for p4 visible in occlusal view, and has the cusps of the external cusp row more crescentic than in other specimens in the sample. The longest two specimens in the sample (OMNH 24053, figure 15D; UMNH VP5611) have an additional cusp in the external row. OMNH 24053 (figure 15D) is slightly broader anteriorly than posteriorly and is strongly waisted in occlusal view. The first three cusps of the external row are closely appressed, the fourth and fifth cusps are much larger and distinct, and are pyramidal in form. The sixth and seventh cusps are formed from the lingual subdivision of the posteroexternal ridge. The last four cusps lean posteriorly. The central valley is sinuous and lined with deep pits. The internal cusp row is broader anteriorly than posteriorly. The first cusp is closely appressed to the second and both are essentially conical with the labial sides of the cusp worn flat along the central valley. Cusps 2 and 3 are widely separated by a deep valley bearing two distinct pits. The valley separating cusps 3 and 4 is narrower than that separating cusps 2 and 3.

M2 – Two worn M2s assigned here have a narrow ridge that is not expanded labially and a probable cusp formula of Ri:2?:4.

Discussion – The distinction between isolated lower first molars of *Cimexomys* and *Mesodma* is difficult if not impossible to ascertain. It is likely that both molars assigned by Sahni (1972) to *C. judithae* are not *Cimexomys* at all (Archibald, 1982, p. 112). Archibald (1982), Montellano (1992), and Lofgren (1995) did not separate m1s of *Cimexomys* from *Mesodma* as both were present with overlapping size ranges. Possible methods for separating m1s, based on previously figured specimens, are as follows: 1) the internal cusp row of *Mesodma* (*M. thompsoni*, Lillegraven, 1969, figure 8-5b) tends to be narrow and blade-like relative to the broader external cusp row, whereas in *Cimexomys* (*C. gratus*, Archibald, 1982, figure 37d) the rows tend to be of equal width or the internal cusp row may even be broader than the external; 2) the m1s of *Mesodma* taper anteriorly, whereas those of *Cimexomys* tend to be blocky (see discussion in Archibald, 1982, p. 50); 3) the cusps of the external row of *Mesodma* tend to be strongly crescentic whereas they are more pyramidal and narrowly divided in *Cimexomys* (*C. gratus*, Archibald, 1982, figure 37d); and 4) the central valley is aligned with the anteroposterior axis in *Mesodma* (*M. garfieldensis*, Archibald, 1982, figure 12a, 12b; *M. hensleighi*, Lillegraven, 1969, figure 6-3c), and is somewhat oblique in *C. gratus* (see Archibald, 1982, figure 37d) and possibly in *C. antiquus* (see Fox, 1971, figure 3C). The only illustrated specimen of *Mesodma* in which the central valley is oblique to the anteroposterior axis is that of *M. primaeva* (see Sahni, 1972, figure 10F), which may indicate that early forms of *Mesodma* and *Cimexomys* share the primitive state.

The m1s here are thought most likely to represent *Cimexomys* because they have relatively broad internal cusp rows, the anterior of the teeth are broad, blunt, and have a notch for p4 evident in occlusal view, the central valley is somewhat oblique to the anteroposterior axis, and the cusps of the external cusp row tend not to be strongly crescentic (although there is variation in this character as shown by OMNH 20494, figure 15C). However, direct comparison of MNA V5269 (figure 15B) to UA 5396, *C. antiquus*, also revealed distinct differences in that the UA specimen is not waisted in occlusal view and its anterior cusps are much more closely positioned such that they appear to be fused. In size, these m1s should approach the lower end of the size range of m1s of *C. minor* based on comparison of M1:m1 length ratios for *Cimexomys* (close to 1:1) and measurements provided for M1s of *C. minor* by Lofgren, 1995. Comparison of the lengths of the p4s described above as *Cimexomys* sp. cf. *C. judithae* to these m1s yields a p4:m1 value of 1.32. The range of p4:m1 for known species of *Cimexomys* is 1.06-1.24 (table 9), which suggests that the P4s of *Cimexomys* sp. cf. *C. judithae* are probably too large for the sample of m1s

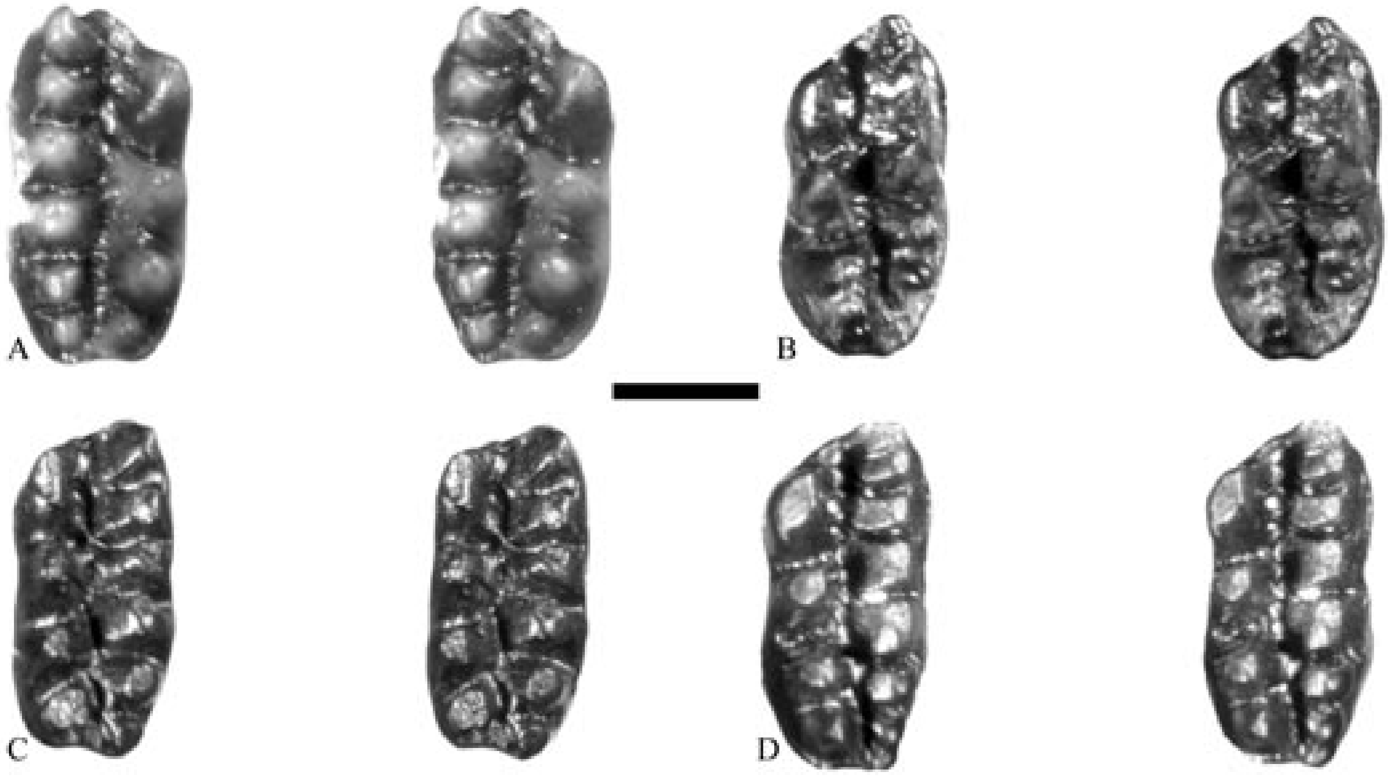

Figure 15. *Cimexomys* or *Mesodma* sp.: A, (OMNH 22314), Rm1, stereo occlusal view; B, (MNA V5269), Lm1, stereo occlusal view; C, (OMNH 20494), Lm1, stereo occlusal view; D, (OMNH 24053), Lm1, stereo occlusal view. Scale bar = 1 mm.

included here. That might suggest that these m1s would most closely approach the size of m1s of *C. minor*, but neither Archibald (1982) nor Lofgren (1995) attempted to separate m1s of *Cimexomys* from those of similar-sized species of *Mesodma*.

The M2s assigned here are almost identical in size to OMNH 24041, tentatively assigned to *Mesodma* sp. (large) (see discussion above); however, the differences between *Cimexomys* and *Mesodma* M2s are likely to be subtle, and certain morphologic criteria on which to base a distinction are lacking.

Cedaromys Eaton & Cifelli, 2001
Cedaromys hutchisoni sp. nov.
tables 11, 12; figures 16A-H
Paracimexomys n. sp. A (in part), Eaton, 1987
Paracimexomys n. sp. B (in part), Eaton, 1987
Paracimexomys n. sp. C (in part), Eaton, 1987

Holotype – OMNH 22861, LM1, Loc. V9.

Hypodigm – MNA V4583, LM1, Loc. 704-1; MNA V4657, Rm1, Loc. 453-2; MNA V5260, Lm1, Loc. 453-2; MNA V5266, Rm1, Loc. 454-6; MNA V5274, LM1, Loc. 704-1; MNA V5288, LM1, Loc. 704-1; MNA V5306, Rm1, Loc. 704-1; MNA V5316, LM1, Loc. 704-1; MNA V5340, LM1, Loc. 1004-1; MNA V5342, RM1, Loc. 1004-1; MNA V7535, Rm1, Loc. 704-1; MNA V7537, Lm1, Loc. 704-1; OMNH 20008, Rm1, Loc. V5; OMNH 20009, LM1, Loc. V5; OMNH 20340, RM1, Loc. V5; OMNH 20350, Lm1, Loc. V5; OMNH 22295, RM1, Loc. V5; OMNH 22318, Rm1, Loc. V5; OMNH 22323, Rm1 (part), Loc. V5; OMNH 22834, LM1, Loc. V9; OMNH 24054, RM1, Loc. V61; UMNH VP5608, Lm1, Loc. 51; UMNH VP7631, Lm1, Loc. 108.

Distribution – Kaiparowits Formation of southern Utah, Campanian.

Diagnosis – Smallest species of *Cedaromys*; m1s (4-5:3) proportionally broader than species of *Paracimexomys*, *Bryceomys*, and *Dakotamys*; M1s (3-4:4:0-1) lacking an internal row or having a small, posteriorly placed, internal cusp.

Etymology – Named after Dr. J. Howard Hutchison, who has contributed enormously to our knowledge of Mesozoic and Tertiary vertebrates, has led me to many excellent microvertebrate localities on the Kaiparowits Plateau, and taught me the virtues of quarrying.

Description – m1. OMNH 20350 (figure 16A) has a formula of 4:3. The tooth broadens anteriorly; however, the cusp rows converge slightly anteriorly. There is an indentation on the labial wall of the tooth but none on the lingual side, so there is no “waist” in occlusal view. Cusps of the external row are well separated. The first two cusps of the internal row are joined together and only divided apically, and the second and third cusps are well separated. OMNH 20008 (figure 16B) has a formula of 5:3. The first cusp of the external row is erect and conical. The second cusp is larger than the other cusps, subcrescentic to conical in form, and the third cusp is linguobuccally compressed. The fourth and fifth cusps of the row are formed by a slight division of

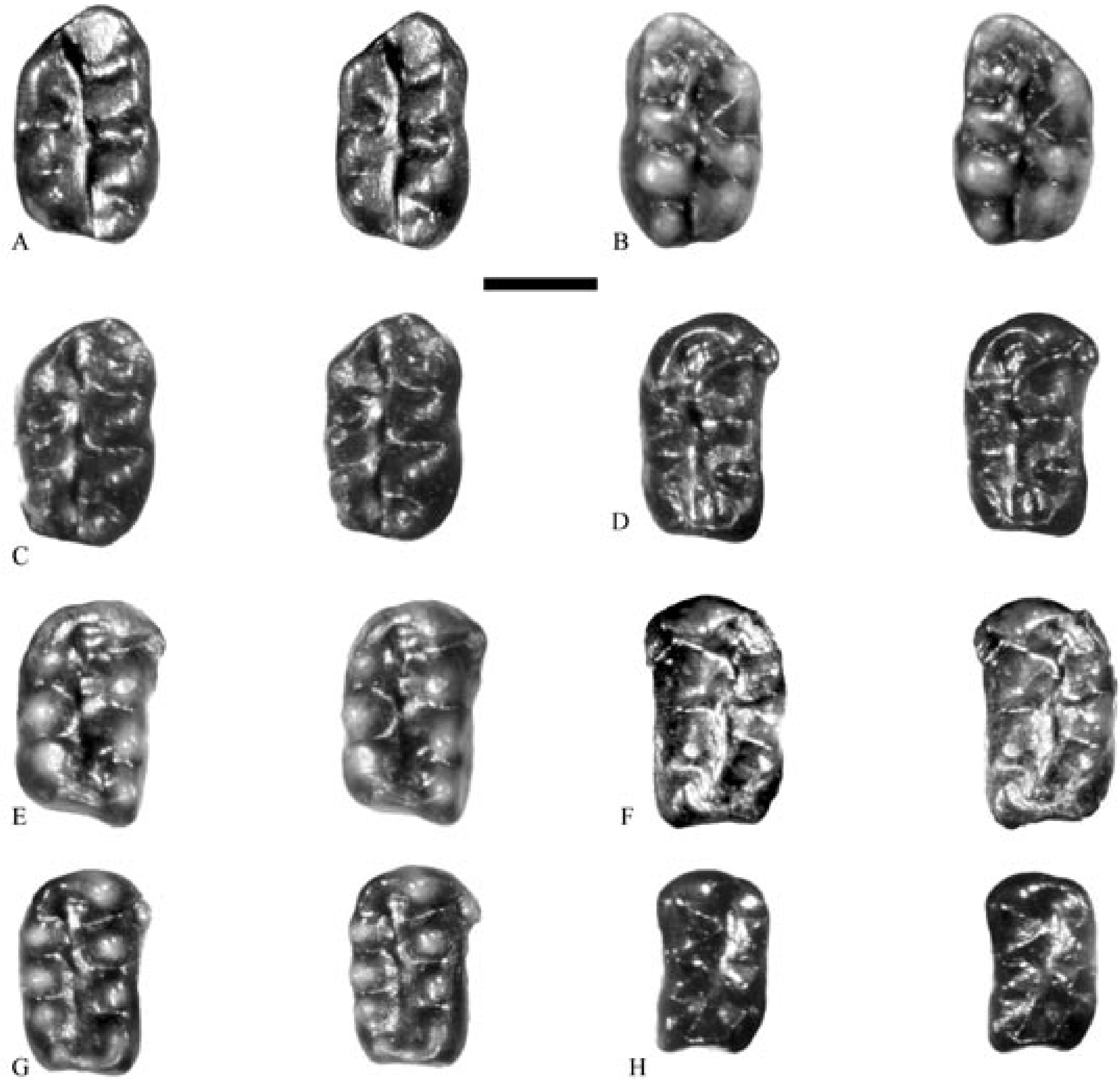

Figure 16. *Cedaromys hutchisoni* sp. nov.: A, (OMNH 20350), Lm1, stereo occlusal view; B, (OMNH 20008), Rm1, stereo occlusal view; C, (MNA V7537), Lm1, stereo occlusal view; D, (OMNH 22861), holotype, LM1, stereo occlusal view; E, (OMNH 20009), RM1, stereo occlusal view; F, (OMNH 20340), RM1, stereo occlusal view; G, (MNA V5340), LM1, stereo occlusal view; H, (OMNH 22295), RM1, stereo occlusal view. Scale bar = 1 mm.

a ridge that extends well posterior of the internal row. The first two cusps of the internal row are weakly separated, and the second and third are well separated. Cusps of both rows become lower anteriorly. MNA V7537 (figure 16C) also has a cusp formula of 5:3 and the central valley is sinuous. The first cusp of the external row is low, the second and third are equal sized and well separated, and the fourth and fifth cusps form a subdivided posterolabial ridge. The fifth cusp is the tallest cusp of the tooth. The labial cusp row is relatively high prior to wear compared to the lingual cusp row. Both MNA V7537 and OMNH 20008 have strong indentations on the labial wall of the tooth but lack an indentation on the lingual wall.

M1 – OMNH 22861 (holotype, figure 16D) has a formula of 3:4:1, which is the most common formula in this sample of M1s. The external row has three conical cusps that are completely separated from each other. There is a tiny cuspule at the anterior margin of the row that is not included in the cusp formula. The second cusp bears well-developed striae. The last cusp is connected to the last cusp of the medial row by a high wall that closes off the central valley. The central valley terminates posteriorly and appears to branch lingually between the third and fourth cusps of the medial row and continue to the single internal cusp. The medial row has four cusps that increase in width and height posteriorly. The cusps of the medial row are basically conical, well separated, and their apices lean anteriorly. The external and medial cusp rows appear to diverge slightly on this specimen, although on most of the M1s in this sample they do not. There is a single posteriorly placed cusp low on the lingual wall of the tooth. OMNH 20009 (figure 16E) shows the well-developed striae on cusps of the external row. OMNH 20340 (figure 16F) shows the strong convex labial side of the tooth (in occlusal view) that emphasizes the lack of a "waist" (opposite indentations on both sides of the tooth in occlusal view). On MNA V5340 (figure 16G) the cusp rows clearly do not diverge anteriorly, and this specimen differs from the other M1s in having a countable fourth cusp in the external row. OMNH 22295 (figure 16H) is the smallest tooth in the sample and is an example of an M1 that lacks an internal cusp. The external cusps are conical, coarsely striated, and well separated. The third cusp is lower and smaller than the first two cusps. The medial valley is oblique to the anteroposterior axis of the tooth. The cusps of the medial row are conical and broaden posteriorly. There is only a slight swelling in the position of the internal cusp.

Discussion – Many of the teeth here were assigned to *Paracimexomys* by Eaton (1987). This was prior to recognizing that retained primitive characters like small size and few cusps would doom about 50 million years of similar multituberculates to be lumped into a single genus, *Paracimexomys*. Since that time I have undertaken study of middle Cretaceous multituberculates (Eaton, 1995; Eaton and Cifelli, 2001) and I now believe that considerable generic diversity is present among small multituberculates with low cusp formulae (including *Dakotamys*, *Bryceomys*, *Cedaromys*, and *Janumys*).

The first lower molars of *Cedaromys hutchisoni* lack a waist in occlusal view, although some specimens have an indentation on the labial wall. A diagnostic character of *Paracimexomys* is the present of a waist on first molars (Archibald, 1982). The first molars assigned here to *Cedaromys* are broad relative to width (table 11), a character shared by other species of *Cedaromys*. These teeth are in many regards similar to those of *Eobaatar magnus*, Kielan-Jaworowska and others (1987), in having a convex lingual tooth wall (in occlusal view). The cusp formula for *E. magnus* was described as 4:2 by Kielan-Jaworowska and others (1987). Based on their plate 2, figure 2B, however, I interpret it as 4:3 with the first two cusps of the internal row being closely approximated as in this species of *Cedaromys*. Also note that the p4:m1 length ratio for *E. magnus* is very high (1.94), which is the condition found in species of *Cedaromys* and *Bryceomys*; it is significantly lower for *Paracimexomys* and *Dakotamys* (table 11).

The M1s are morphologically close to those of *Cedaromys* from the Cedar Mountain Formation, near the Albian-Cenomanian stage boundary, of central Utah described by Eaton and Cifelli (2001). The characteristic central valley that is lingually directed between cusps 3-4 of the medial row and the striae on the cusps of the external row are like the condition present in previously described species of *Cedaromys*. The cusps of the external row are better separated and less ridge-like than in previously described species of *Cedaromys*. The teeth are not similar to those of *Paracimexomys* as their cusp formulae differ, the internal and external rows of *Cedaromys* either diverge weakly or not at all anteriorly, and there is no waisting (indentation in occlusal view) of the molars. The M1s are quite distinct from those of *Dakotamys* in having greater width relative to length, conical cusps, and no reduction in height of external cusp row. The teeth are also similar to those of *Bryceomys*, a taxon possibly derived from *Cedaromys* (see Eaton and Cifelli, 2001). *Bryceomys* differs from *Cedaromys* principally in having a broad cuspate internal cusp row on M1. The similarity of M1s of *Cedaromys hutchisoni* and *Eobataar* is intriguing as they are similar in form, cusp formulae (3:4:1), and in having cusps, most markedly those of the external row, that bear striae. Cusps of the medial row of *Eobaatar magnus*, however, are pyramidal and deeply, but narrowly, separated unlike the anterior leaning conical cusps of the species described here.

cf. *Cedaromys* sp.
figures 17A-F

Referred Specimens – OMNH 20007, RP4, Loc. V5 (*Paracimexomys* n. sp. B in Eaton, 1987); OMNH 20479, RP4, Loc. V9.

Description – OMNH 20007 (figures 17A-C) is a relatively small P4 (AP=2.38; LB=1.13) with a cusp formula of 1:5. The tooth is low crested (CR=0.36), low crowned (H:AP=0.46), broad relative to length (LB:AP=0.48), and strongly waisted in occlusal view. There is a single small cusp anteriorly placed on the anteroexternal platform. The cusps of the medial cusp row are not well separated, which may reflect wear. The posterior basin is worn flat but appears to have lacked a deep pit at the posterior base of the tooth. OMNH 20479 (figures 17D-F) is significantly larger (AP=2.59; LB=1.40) than OMNH 20007, heavily worn, and appears to have a cusp formula of 1:4. The tooth is waisted in occlusal view with a broadly expanded anteroexternal platform (LB:AP=0.54) bearing one small, anteriorly placed cusp. The medial cusp row is well worn, and it is possible that a fifth cusp may have been completely removed by wear.

Discussion – These P4s may represent *Cedaromys* because of the low cusp formula (Cedar Mountain specimens have a formula of 4:2, Eaton and Cifelli, 2001) and low climb ratio of the medial cusp row. Cedar Mountain species of *Cedaromys* are weakly waisted and lack the broadly expanded anteroexternal platform of OMNH 20479. No P4s of *Paracimexomys* have been illustrated except for specimens questionably assigned to *Paracimexomys* (see Eaton and Cifelli, 2001) by Eaton and Nelson (1991) and Eaton (1995) that consistently have a cusp formula of 5:1. The P4 of cf. *P. robisoni* (see Eaton and Nelson, 1991: figure 2D-E; table 2) has strongly striated cusps, is not waisted in occlusal view, and has a larger less anteriorly placed cusp on the anteroexternal platform than on these specimens.

These specimens are similar in most regards to P4s of *Cedaromys* described by Eaton and Cifelli (2001) but are different from each other and cannot be confidently placed in *Cedaromys*. Also, comparison of the P4:M1 length ratio of these specimens with *C. hutchisoni* provides a value of 1.30, whereas previously described species of *Cedaromys* (see Eaton and Cifelli, 2001) have P4:M1 values between 1.03-1.13, indicating the P4 is only slightly larger than M1. If these P4s represent *Cedaromys*, it is unlikely that they belong to *C. hutchisoni*.

Dakotamys Eaton, 1995
Dakotamys magnus new combination (Sahni, 1972)
table 12, figures 17G-H

Cimexomys magnus Sahni, 1972

Paracimexomys magnus (Archibald, 1982)

Holotype – AMNH 77120, RM1.

Type Locality – Clambank Hollow Locality, Chouteau County, Montana.

Distribution – Judith River Formation of Montana, Kaiparowits Formation of southern Utah, Campanian.

Revised Diagnosis – Larger than any species of *Paracimexomys* and *Dakotamys*. M1 cusp formula of 5:5:1-2, greater than *Paracimexomys* and *Dakotamys malcolmi*. Internal cusp row short and cusps alternate position unlike *Cimexomys*; asymmetrical waist present in occlusal view.

Referred Specimens – MNA V5301, RM1, Loc. 1004-1; OMNH 20354, LM1, Loc. V5.

Description – M1. MNA V5301 (figure 17G) has a cusp formula of 5:5:2 or 3 and is large (AP=4.03; LB=2.62; LB:AP=0.65). The tooth has an asymmetric waist in occlusal view due to the lingual indentation present between cusps 3-4 and a more anterior indentation, between cusps 2-3, on the labial wall. The internal cusp row has two (or possibly three) small cusps that are well separated from the main body of the tooth. The medial row broadens posteriorly. The first three cusps are closely joined with only apices separated prior to wear. The fourth cusp is well separated and bears striae. The fifth cusp is the widest, and tallest cusp is the last of the row. The central valley is slightly oblique to the anteroposterior axis of the molar. The cusps of the external row are conical in form, deeply striated, and narrow posteriorly. The first cusp is low and small. The second cusp is the largest of the row and forms a bulge on the labial wall of the tooth. The cusps become smaller and less separated posteriorly. OMNH 20354 (figure 17H) clearly has a formula of 5:5:2 and is also large (AP=4.02*; LB=2.59; LB:AP=0.64*). This specimen clearly shows the pit present labial to cusps 1 and 2 of the external cusp row (also present on MNA V5301). The internal cusp row has two distinct cusps separated by a deep valley from the lingual wall of the medial cusp row.

Discussion – Sahni (1972) named a new species of *Cimexomys*, *C. magnus*. The molars described here are almost identical in size, morphology, and cusp formula to the type of *C. magnus* (AMNH 77120, AP=3.91; formula = 5:5:1). Archibald (1982, p. 111) recognized that the taxon did not fit in *Cimexomys* and tentatively transferred it to *Paracimexomys*. This species is not considered here to represent *Paracimexomys* because the medial and external cusp rows do not diverge anteriorly and the cusps are deeply ribbed. The species is included in *Dakotamys* as that genus was erected to include M1s with low cusp formulae, narrow internal cusp rows, parallel medial and external cusp rows, well-ribbed cusps, and an external row in which the cusps become smaller and more poorly defined posteriorly (Eaton, 1995; see revised diagnosis of *Dakotamys* in Eaton and Cifelli, 2001). Also, comparison of these specimens to M1s of *Dakotamys malcolmi* shows that they share the presence of a deep labial pit between the first two cusps of the external row, and the second cusp of that row is the largest and is deeply striated. The enlarged second cusp is reflected in the swelling on the labial side of the tooth; on *D. malcolmi* this results in a waist that is close to transverse to the anteroposterior axis. The elongation and addition of cusps in *D. magnus* results in the indentations being offset such that the resultant waist is oblique to the anteroposterior axis.

Relationships of Taxa from the Kaiparowits Formation

Most of the teeth described here are isolated and most of the attempts at taxonomy were directed toward separating what appear to be relatively closely related taxa. For this reason, the characters used to identify these taxa are virtually absent in multituberculate cladograms (e.g., Simmons, 1993; Rougier and others, 1996) and so this study provides little data for directly arguing or comparing larger-scale relationships. It would be desirable to collect more complete specimens so that dental associations can be made with more certainty and it would be ideal to be able to include cranial characteristics. Lacking these kinds of data, I hesitate to generate cladograms based on isolated teeth and find it frustrating that such attempts by me have yielded different results depending on the tooth position selected for analysis. This appears to lend some support for hypothesizing a mosaic-style evolution, at least in some multituberculate dental characteristics.

One potential relationship that may be emerging is that among *Cedaromys*, *Bryceomys*, and *Cimolomys*. This relationship is based on the similarity of lower first molars of these taxa, which have broad open valleys separating the pyramidal cusps of both rows. That is particularly the case if the m1 (UW 15535) Lillegraven and McKenna (1986) identified as *Cimolomys clarki* does belong to that genus. This suggests a transition from the erect pyramidal cusps seen in *Bryceomys* to the strongly crescentic cusps of Lancian species of *Cimolomys*. The lower incisor is not known in *Cimolomys*, which raises fundamental questions about the systematic relationships of that taxon. The lower incisor is also unknown with certainty for *Cedaromys* and *Bryceomys*.

MULTITUBERCULATE FAUNA FROM THE WAHWEAP FORMATION

Systematic Paleontology

Class MAMMALIA
Order MULTITUBERCULATA
Suborder CIMOLODONTA McKenna, 1975
Superfamily ?Ptilodontoidea Sloan and Van Valen, 1965
Family Neoplagiaulacidae Ameghino, 1890
Mesodma Jepsen, 1940
Mesodma sp. cf. *M. formosa* (Marsh, 1889) Clemens, 1964
table 13, figures 18A-G

Referred Specimens – MNA V4571, Rm2, Loc. 456-2; MNA V5241, Lm2, Loc. 456-2; MNA V5244, RM2, Loc. 456-2; MNA 5250, LM2, Loc. 456-2 (all of these second

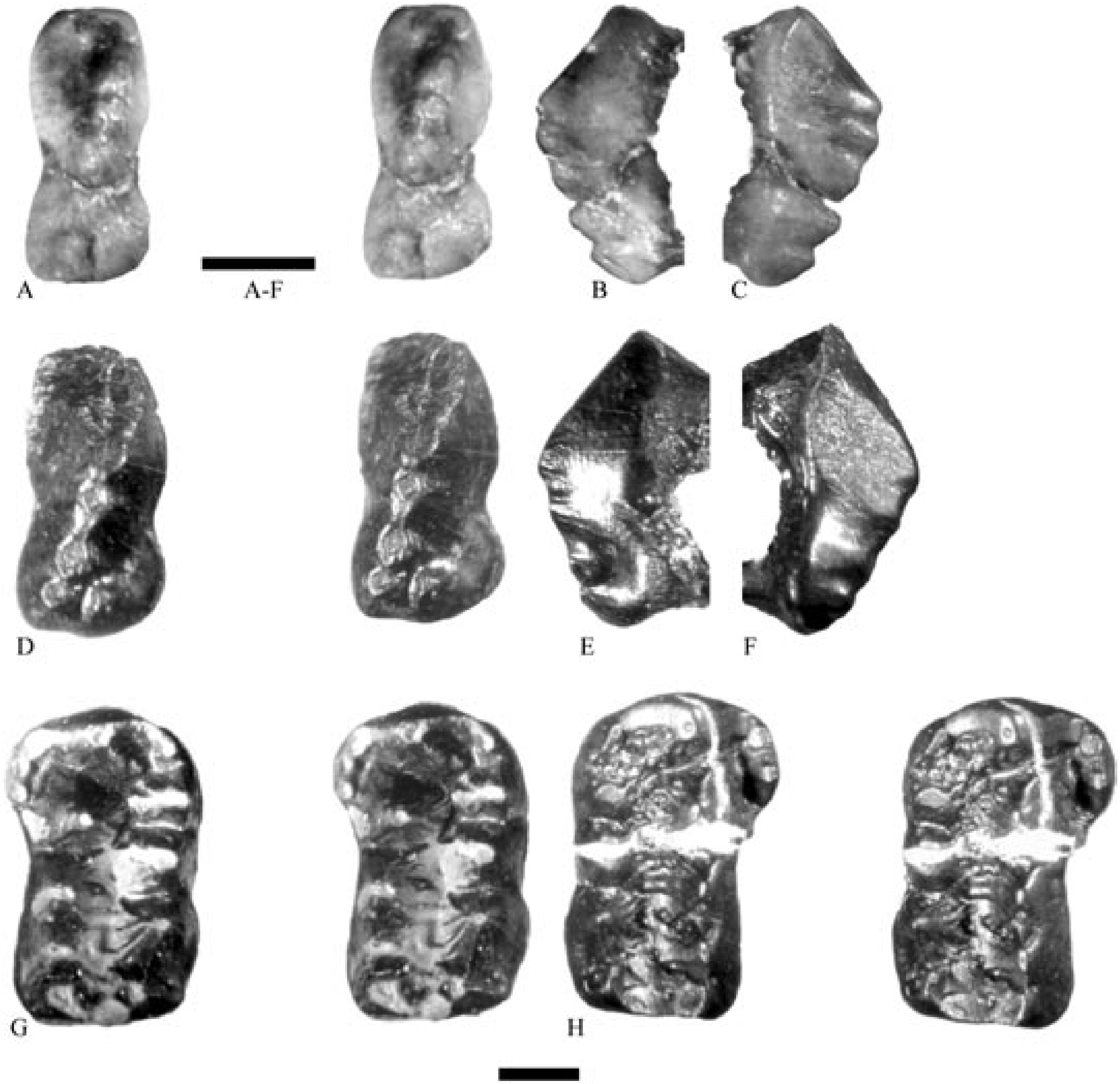

Figure 17. cf. *Cedaromys* sp.: A, (OMNH 20007), RP4, stereo occlusal view; B, labial view; C, lingual view; D, (OMNH 20479), RP4, stereo occlusal view; E, labial view; F, lingual view. *Dakotamys magnus*: G, (MNA V5301), RM1, stereo occlusal view; H, (OMNH 20354), LM1, stereo occlusal view. Scale bars = 1 mm.

molars were all assigned to *Cimexomys* or *Mesodma* sp. by Eaton, 1987); MNA V5254, RP4, 456-1;OMNH 20782, LM2, Loc. V11; OMNH 23340, Lm2, Loc. 707-2; UMNH VP7984, LM1 (part), Loc. 130; UMNH VP7989, Rm1, Loc. 130.

Description - m1. UMNH VP7989 (figure 18A) has a cusp formula of 6:5. The first cusp of the external row is small, three-sided, and leans anteriorly. The second cusp is pyramidal in form and leans slightly anteriorly. The third cusp is the largest of the tooth and is upright and pyramidal. The fourth and fifth cusps are equal in size and subcrescentic with their apices oriented posteriorly. The sixth cusp is a small erect cone with a concave lingual side. Cusps 1-5 have deep grooves at their lingual and labial bases. These grooves cross the pitted central valley that is closed posteriorly.

The first cusp of the internal row is small but distinct and is directly opposite the first cusp of the external row. The second cusp is taller than the first and essentially conical and erect. The third and fourth cusps are equal in size and taller than the second cusp. They are crescentic in form and lean posteriorly. Cusps 1-4 are well separated but to a depth higher than the central valley. The fourth and fifth cusps are more deeply divided by a valley that reaches the level of the central valley. The fifth cusp is elongate with a concave labial face. On this unworn specimen the cusps of both rows increase in height posteriorly.

m2 – MNA V5241 (figure 18B) has a cusp formula of 4:2. The apices of the cusps of the external row are separated labially. The cusps are separated lingually by deep grooves. The cusps decrease in length and increase in height posteriorly. The last cusp has a deep vertical groove on its lingual side. The central valley is sinuous with deep pits. The cusps of the internal row are about equal in size, although the second cusp is slightly longer than the first. The two cusps are well separated and no wear is apparent on either cusp.

MNA V4571 (figure 18C) also has a cusp formula of 4:2. The cusps of the external row broaden posteriorly and are about equal in height, rather than increasing in height posteriorly, probably reflecting wear. The apices of this worn cusp row are only separated at the apices labially and by deep grooves lingually. The anteromost groove crosses the pitted central valley. The first cusp of the internal row is much taller than the first cusp of the external row. It is worn apically and there is a deep groove on the wall of the cusp that faces the central valley. The second cusp is lower, unworn and not as long as the first cusp. There is a strong notch posterior of the second cusp.

P4 – MNA V5254 (figures 18D-F) has a cusp formula of 2:5. The anteroexternal platform is broad and the anterior width exceeds the posterior width of the tooth. The platform bears two cusps that are much lower than those of the central cusp row. The cusps are well striated. The cusps of the central row are deeply striated and have a moderate climb ratio such that the row reaches its apex at the subequal fourth and fifth cusps (although without wear it is likely that the fifth cusp would have been taller than the fourth). The posterior basin is poorly developed with a small, shallow basin.

M1 – UMNH VP7984 is the anterior part of an M1 with an estimated formula of 5:6:?. There are three well-striated conical cusps on the external row. The cusps of the medial row are crescentic and broaden posteriorly. The internal row is missing, but it attaches to the medial row below the third cusp, indicating the internal row exceeded half of the molar length.

M2 – OMNH 20782 (figure 18G) is a M2 with a formula of Ri:3:4. The external platform is moderately expanded and there is no evidence of cusps on the margin (ridge) of the platform. The first cusp of the medial row is weakly pyramidal and the same height as the second cusp. The second cusp has its apex oriented strongly anteriorly. The last cusp is small and well separated from the second cusp. The central valley is slightly sinuous and pitted. The first two cusps of the row are equal sized and closely positioned. The third cusp is slightly lower, has a deeper apical separation, with a deeper labial groove than between the first two cusps. The fourth cusp is the lowest of the row and is separated from the third cusp by a deep labial groove.

Discussion – The m1 is larger than the m1s of *M. hensleighi* and too small for those of *M. thompsoni* and *M. primaeva*. It is within the length range of Lillegraven's (1969) sample of *M. formosa* (table 13) but the width exceeds that of the specimens in Lillegraven's sample. The molar is at the lowest AP value for Archibald's (1982) sample of *M. garfieldensis*, and the width slightly exceeds that of Archibald's sample (table 13). No m1s are known for *M. senecta* (see Fox, 1971), but the size of the p4s indicates that taxon is close in size to *M. thompsoni*.

The basis for assigning these m2s to *Mesodma* is provided above under *Mesodma* sp. (large) described from the Kaiparowits Formation. The well-developed posterolingual notch is not found on figured specimens of *Cimexomys*, but the feature is absent on depicted specimens of *Mesodma*, except for *M. primaeva* (see Sahni, 1972, figure 10G). The pitting on these may also seem atypical for m2s of *Mesodma*, but the m1 included here is also pitted. These m2s (relative to the m1, UMNH VP7989) have an m2:m1 length ratio appropriate for *Mesodma* (table 13). Clemens (1964; p. 31) provided a cusp formula for *M. formosa* of 3:2, but Lillegraven (1969, figure 7-4a) illustrated a specimen of *M. formosa* with a formula of 4:3 which is characteristic of all of the m2s included here. The specimens are well within the size range of *M. formosa* and are in the lower part of the range of *M. garfieldensis* (table 13).

The P4 is very similar to that illustrated by Lillegraven (1969, figure8-1) as *Mesodma formosa* in the climb ratio of the medial cusp row, cusp formula, and the weakly developed posterior basin. The MNA specimen has a more broadly expanded anteroexternal platform. The specimen is below the size range of *M. garfieldensis* and is within the size range of *M. formosa* (table 13). The M1 is similar to M1s of *Mesodma* in terms of the length of the internal row exceeding half the molar length, the crescentic medial row cusps, and in that the cusps of the external and medial row are offset anteriorly but aligned transversely farther back on the tooth.

The M2s are similar to those from the Kaiparowits Formation assigned above to *Mesodma minor*, but they are larger and in the size range of *M. formosa* and *M. garfieldensis* (table 13).

It is difficult to distinguish this sample from among either of the similar-sized species *M. formosa* and *M. garfieldensis*. The P4 has fewer cusps and is smaller than those of *M. garfieldensis* (table 13). The molars are close to being within the range of both species. Archibald (1982, p. 47) distinguished *M. garfieldensis* from other species of *Mesodma* in that "M1 and m1 longer relative to M2 and m2, respectively, than in any Cretaceous species of *Mesodma* ... " The m2:m1 length ratio for *M. garfieldensis* is 0.56, whereas various samples of *M. formosa* range in value from 0.58-0.61 (table 13). The mean of the ratios of the m2s to the single m1 in this sample is 0.59 and is therefore slightly closer to the ratios of *M. formosa* than those of *M. garfieldensis*. This, coupled with the size and cusp formula of the single P4, suggests that this species is closer to *M. formosa* than to *M. garfieldensis*. However, the pits present in the molar valleys may indicate the presence of a species morphologically distinct from and more primitive than either *M. formosa* or *M. garfieldensis*.

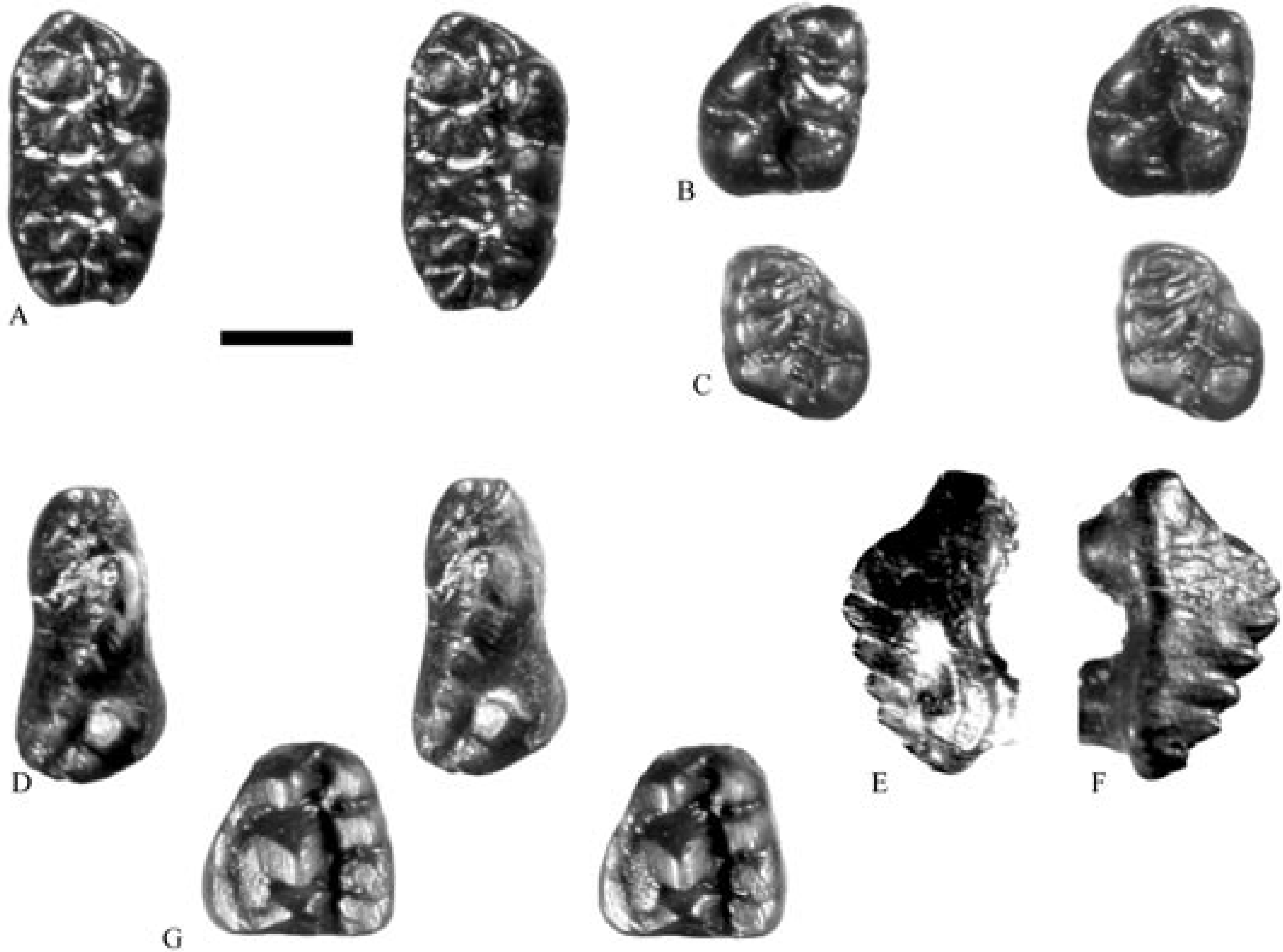

Figure 18. *Mesodma* sp. cf. *M. formosa*: A, (UMNH VP7989), Rm1, stereo occlusal view; B, (MNA V5241), Lm2, stereo occlusal view; C, (MNA V4571), Rm2, stereo occlusal view; D, (MNA V5254), RP4, stereo occlusal view; E, labial view; F, lingual view; G, (OMNH 20782), LM2, stereo occlusal view. Scale bar = 1 mm.

Family Cimolodontidae Marsh, 1889
Cimolodon Marsh, 1889
Cimolodon electus Fox, 1971
table 14, figures 19A-G

Referred Specimens – MNA V4613, Lm1, Loc. 455-1; MNA V5200, Rm2, Loc. 456-2 (*Cimolomys* n. sp. in Eaton, 1987); MNA V5234, RM1, Loc. 456-2 (*Cimolodon* sp. in Eaton, 1987); MNA V5273, Lm2, Loc. 455-1 (*Cimolomys* n. sp. in Eaton, 1987); MNA V5277, Lm1 (partial), Loc. 456-2; MNA V5280, RP4 (partial), Loc. 456-2; MNA V5282, LM1 (partial), Loc. 456-2; UMNH VP7562, Rm1, Loc. 82.

Description – m1. UMNH VP7562 (figure 19A) is from the base of the Wahweap Formation and has a cusp formula of 6:4. The first cusp of the external row is low and conical. The second cusp is taller and sub-pyramidal. Cusps 3 and 4 are well separated, pyramidal, and lean slightly posteriorly. Cusps 5 and 6 are small and conical, developed on the posteroexternal ridge. The central valley is slightly sinuous. The four cusps of the internal row are taller and larger than those of the external row. The first two cusps of the internal row are closely positioned. Deep valleys separate cusps 2-4. There is some weak grooving of the lingual and labial sides of cusps and a hint of a posteroexternal shelf. MNA V4613 (figure 14B) was recovered approximately 200 m higher in the section and, compared to UMNH VP7562, is more striated on the lingual and labial cusp walls, has an additional external cusp, and a better-developed posteroexternal shelf below cusps 6-7 of the external row.

m2 – MNA V5200 (figure 19C) has a cusp formula of 5:2. The external row is higher and broader and the cusps become more closely compressed posteriorly. The cusps of the row are narrowly separated. The first and second cusp appear to have been deeply divided prior to wear, but the valleys separating cusps 2-4 are progressively less deeply divided posteriorly and are mostly divided on the lingual wall of the cusp row. The central valley is deep and pitted and the cusp row walls are deeply grooved at their bases on both sides of the valley. The two cusps of the internal row are narrowly but deeply divided. There is a well-developed notch posterior of the second cusp.

P4 – MNA V5280 (figures 19D-F) is incomplete but clearly is part of a very high-crowned P4. The walls of the premolar are deeply striated. The posterior basin comprises a small part of the tooth. The basin is bounded by two cusps, the lingual being much lower than the labial.

M1 – MNA V5234 (figure 19G) has a cusp formula of 6:7:5. The first three cusps of the external row are striated and conical and are not deeply divided. The fourth cusp is slightly smaller than the third but is better separated, both anteriorly and posteriorly. Cusps 5 and 6 form a posterolabial ridge. The cusps of the row narrow slightly posteriorly due to the somewhat oblique nature of the central valley. The cusps of the medial row are strongly striated and crescentic, well worn on their labial side, and become better separated posteriorly. The valley between the internal and medial cusp rows is deeper than that of the central valley. The internal row is broad, and the cusps become larger and taller posteriorly.

Discussion – The m1s clearly belong to *Cimolodon* because of the isolated robust pyramidal cusps, the striated cusp walls, the largest of the internal row cusps occurring posteriorly, and the largest of the external row cusps occurring medially. They can be referred to *C. electus* because of their size (table 14), cusp formulae, pyramidal nature of the cusps, and the presence of a posterolabial cingulum. UMNH VP7562 (figure 19A), from near the base of the formation, may express primitive characters for this species in being weakly striated, having a low cusp formula, and in the weak development of the posterolabial cingulum. The partial P4 is remarkably similar to UA 5323, *C. electus* (see Fox, 1971, figure 4a-b). The M1 (MNA V5234, figure 19G) shown is similar to UA 5326 (Fox, 1971, figure 4d), *C. electus*, except for having one or two fewer cusps in each row (table 14) and a longer internal cusp row relative to the total length of the molar. The m2s are most similar to those of *Cimolodon* in that the cusps of the external row are not divided labially; however, other characters are less consistent. The broadening of the external cusp row posteriorly and the presence of a strong posterior notch are seen on m2s of *Cimolodon electus* (see Fox, 1971, figure 5b) but not on *C. nitidus* (see Clemens, 1964, figure 26-b; Lillegraven, 1969, figure 11-5b). The external cusp row broadens posteriorly also on m2s of *Cimolomys* (see Archibald, 1982, figure 23e; Lillegraven and McKenna, 1986, figure 7B), and the posterior notch is present on the m2 of *C. clarki* illustrated by Lillegraven and McKenna (1986) but not on the m2 of *C. gracilis* shown in Archibald (1982). A direct comparison of MNA V5200 (figure 19C) with UA 5336, *Cimolodon electus* (depicted by Fox, 1971, figure 5b), indicates that the specimens are almost identical except the two cusps of the internal row are less widely separated on the MNA 5200 than on the UA specimen. In this regard, MNA V5200 appears to be more similar to *Cimolomys clarki* (see Lillegraven and McKenna, 1986, figure 7B).

This sample appears to represent a slightly less cuspate population of *C. electus* than that described by Fox (1971), but in size, construction of the teeth, and details of morphology these teeth are almost identical to the Milk River sample. This broadens the definition of the species only by increasing the lower range of the cusp formulae.

Cimolodon similis Fox, 1971
table 14; figures 20A-H, 21A-F

Referred Specimens – MNA V4595, LP4, Loc. 455-1; MNA V5214, LP4 (part), Loc. 1015-1; MNA V5217, LP4, Loc. 1015-1; MNA V5221, RP4, Loc. 455-1; MNA V5245, Rm1, Loc. 456-2; UMNH VP7592, Rp4, Loc. 77; UMNH VP7980, Lm1, Loc. 130; UMNH VP7987, Rm1, Loc. 130; UMNH VP7989, Lm1 (part), Loc. 130; UMNH VP7990, Rm2, Loc. 130.

Description – p4. UMNH VP7592 (figures 20A-B) is a high crowned, symmetrically arched p4 with 11 serrations, 8 external, and 10 internal ridges. The anteroexternal lobe is deep and broad. External ridges descend from all but the most posterior serration and become more widely separated ventrally. The crest of the blade is reached at the fifth serration. Internal ridges 2-4 intersect anteriorly with the steeper ridge descending from the first serration. There is no internal ridge developed from the posteromost serration. The interior ridges maintain approximately the same separation ventrally, unlike the external ridges.

m1 – MNA V5245 (figure 20C) has a cusp formula of 6:4 and is waisted in occlusal view. The first three cusps of the external row are closely appressed and have little separation between the cusps. Cusps 3 and 4 are well separated, but the more posterior cusps of the row are less well separated. The central valley is lined with deep pits. The first two cusps of the internal row are closely positioned. The valley separating cusps 2-3 and cusps 3-4 are progressively more deeply divided compared to the valley separating the first two cusps. Cusps 2-3 are more pyramidal in form than the other cusps of the row as a result, in part, of their distinct separation.

UMNH VP7987 (figure 20D) is smaller than MNA V5245 (figure 20C) and has only a rudimentary cuspule in the position of the first cusp on the internal row, resulting in a cusp formula of 6:3. The first cusp of the external row is low and round. The second cusp is larger, taller, and weakly pyramidal in form. The third and fourth cusps are large, pyramidal in form, and well separated. The fifth and sixth cusps form a subdivided elongate ridge. The central valley is complexly pitted as a result of the presence of ribbing at the base of the cusps of both rows. On the internal row, there is a rudimentary anterior cuspule not counted in the cusp formula. The first cusp is tall, rounded anteriorly, flattened labially, and has a concave posterior face. The second cusp is similar but larger. The third cusp is squared anteriorly and rounded posterolingually.

m2 – UMNH VP7990 (figure 20E) has a cusp formula of 4:2. The external row is tall relative to the central valley of the tooth and rises higher posteriorly. The cusps are only separated at their apices and are divided lingually by narrow grooves. The central valley has a few pits. The cusps of the internal row are well worn apically. There is a basal vertical groove labially on the face of the first cusp. The first and second cusps are separated labially by a narrow groove. There is a well-developed notch posterior to the second cusp.

Figure 19. *Cimolodon electus*: A, (UMNH VP7562), Rm1, stereo occlusal view; B, (MNA V4613), Lm1, stereo occlusal view; C, (MNA V5200), Rm2, stereo occlusal view; D, (MNA V5280), partial RP4, stereo occlusal view; E, labial view; F, lingual view; G, (MNA V5234), RM1, stereo occlusal view. Scale bar = 1 mm.

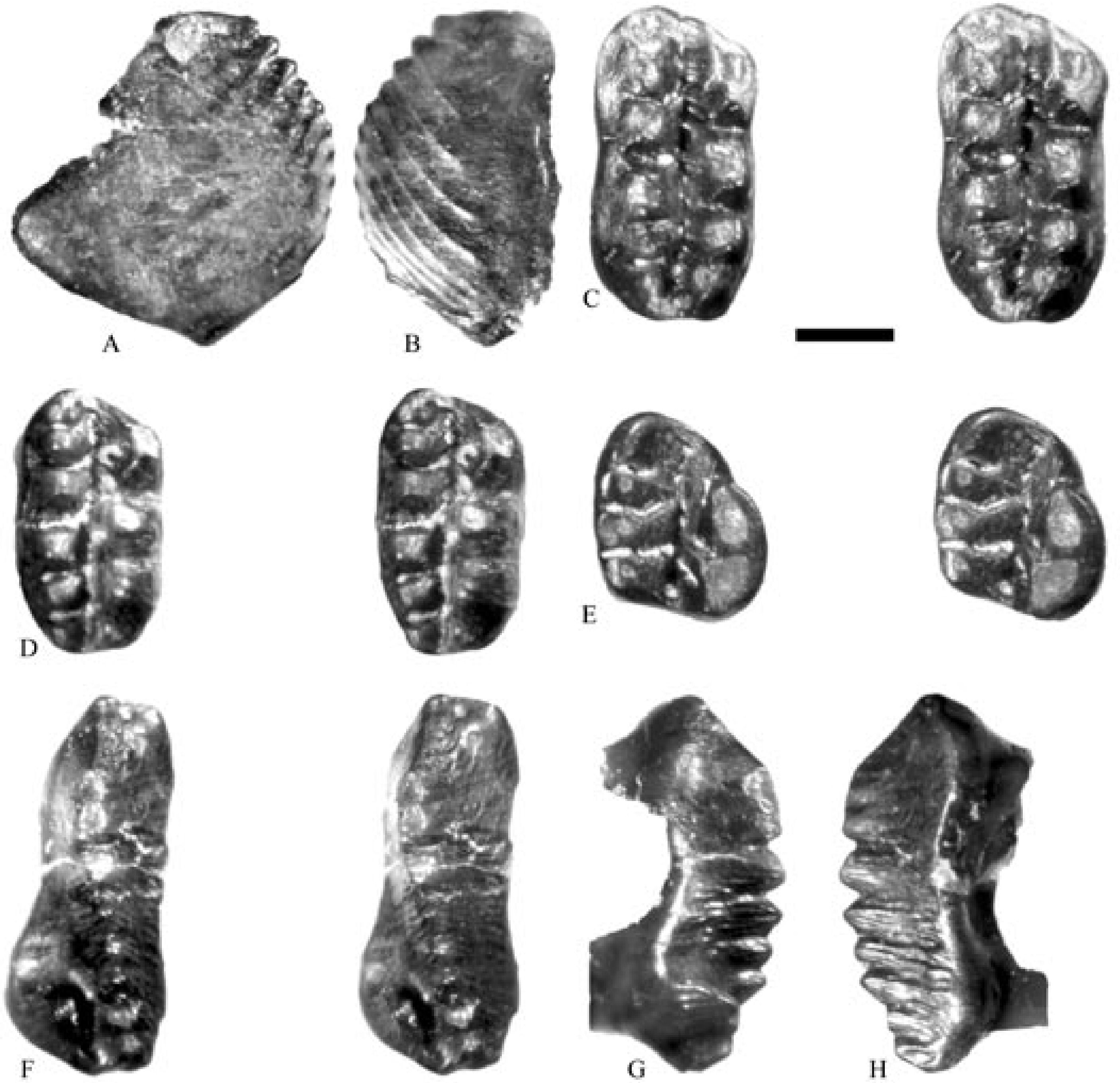

Figure 20. *Cimolodon similis*: A, (UMNH VP7592), Rp4, labial view; B, lingual view; C, (MNA V5245), Rm1, stereo occlusal view; D, (UMNH VP7987), Rm1, stereo occlusal view; E, (UMNH VP7990), Rm2, stereo occlusal view; F, (UMNH VP4595), LP4, stereo occlusal view; G, labial view; H, lingual view. Scale bar = 1 mm.

P4 – UMNH VP4595 (figure 20F-I) has a cusp formula of 1:8. It has a broadly expanded anteroexternal platform bearing one large cusp and a tiny, more anteriorly placed cuspule (not included in cusp formula). The medial row appears to have a low climb ratio, although this is not directly measurable due to wear on the last two cusps of the row. The posterior basin comprises a small part of the total length of the tooth (PL:AP = 0.28). The tooth is strongly striated on both sides. This specimen is almost identical in size, form, and cusp formula to those assigned by Fox (1971) to *C. similis* (table 14). MNA V5217 (figures 21A-C) has one more cusp on the anteroexternal platform, one less cusp in the medial row, and is smaller than MNA V4595 but in other regards similar. MNA V5221 (figures 21D-F) is similar in size to

MNA 5217 (table 14), but the last cusp in the medial row is subdivided, resulting in a cusp formula of 2:7. The anteroexternal platform is broadly expanded and bears one small and one large cusp. The cusps of the medial row have a low climb ratio (CR = 0.32), the sixth cusp is higher than the seventh, and the cusps are only separated at their apices. The wall posterior to the last cusp of the medial row is rugose. The posterior basin is short and has deep pits.

Discussion – The deep, wide anteroexternal lobe and high, symmetrical arch are characters of *Cimolodon* p4s (e.g. *C. nitidus*, Archibald, 1982, figure 18a). This specimen is about 11% smaller than that described by Fox (1971) as *C. similis* (table 14), a size difference also present in some of the P4s included here. The specimen is also similar in size to the p4s of *Cimolodon foxi* sp. nov. from the Kaiparowits Formation described earlier in this paper, but the p4 from the Wahweap Formation is less serrate than the p4s of *C. foxi*.

The m1 is considered to be *Cimolodon* because the cusps of both rows are pyramidal, the cusps of the external row are largest in the middle of the row, and the tooth is as broad anteriorly as posteriorly. The specimen compares almost identically with UA 5372 included by Fox (1971) in the hypodigm of *C. similis* and is within the size range of that species (table 14); however, one of the m1s (UMNH VP7987, figure 20D) is smaller than the range given by Fox (1971) for the species and is perhaps more primitive in having a lower cusp formula of 4:3. Another specimen from the same locality (UMNH VP7980, Loc. 130) is also smaller than the Milk River sample of *C. similis* but does have a better-developed first cusp such that its cusp formula is 6:4 as in *C. similis*. As such, although slightly smaller specimens having perhaps more primitive characters are present, designation of a new species is not warranted.

The P4s in this sample broaden both the size range and cusp formulae attributable to *C. similis*. The cusp formula in the diagnosis of the species (Fox, 1971) is 1:8-9. If the specimens described here are properly identified, the range of the cusp formula would be broadened to 1-2:6-9 and the anteroposterior range expanded to 3.6-4.1. MNA V4595 is certainly *C. similis*, and the other P4s included here are very similar to that specimen but are outside the range of size and cusp formula provided by Fox (1971). Fox's sample is small and the sample from the Wahweap Formation occurs considerably south of where Fox recovered his sample in Alberta, Canada. As such, it is not surprising that the sample described here is somewhat different. Alternatively, this sample could include two species, one in the size range of *C. similis* and a second smaller species. A much larger sample would be required to justify two species.

Cimolodon sp. cf. *C. nitidus* Marsh, 1889
table 14; figures 21G-I

Referred Specimens – UMNH VP7978, Lp3-4 (in partial mandible), Loc. 130; UMNH VP7988, Lp4 (in partial mandible), Loc. 130; UMNH VP7981, LM1, Loc. 130.

Description – p4. UMNH VP7978 (figures 21G-H) has 11 serrations with 9 external and 10 internal ridges. The arcuate crest reaches its apex at the fourth serration. On the labial wall of the blade the first ridge is nearly vertical, the second ridge is oriented posterodorsally-anteroventrally and the remaining ridges parallel the second. The posterior wall of the blade is well worn and an additional ridge may be obliterated. The orientation of the ridges on the lingual face of the tooth is very similar to the buccal side. A small single cusped p3 is positioned directly below the anterior face of the p4. Another p4 (UMNH VP7988) from the same locality as UMNH VP 7978 is almost identical.

M1 – UMNH VP7981 (figure 21I) was an extraordinarily well-preserved M1 but virtually exploded when touched by a tool during preparation (the specimens from this locality are extremely brittle). This description is limited by the extent to which the molar could be reconstructed. The cusp formula of the specimen is estimated to be 6?:7:5 or 6. The first cusp of the external row is small, low, and shifted slightly lingually. The second cusp is only slightly larger and about the same height as the first cusp (at least after wear). The third cusp is small, weakly pyramidal, and leans anteriorly. The fourth cusp is similar to the third in form but is much taller and longer. The fifth cusp is three-sided and slightly smaller than the fourth cusp. The part of the tooth possibly bearing the sixth cusp is missing. The central valley is complex and pitted due to the ribs formed at the bases of the cusps of the external and medial rows. The ribs cross the valley and connect to the cusps of the other row. Cusps of the medial row become larger and broader posteriorly. The first four cusps of the row are weakly pyramidal and cusps 2-4 lean anteriorly. The fifth and sixth cusps are pyramidal and the posteromost cusp is missing due to breakage. There are 5 distinct cusps in the internal row and a series of small swellings along the row. The valley between the medial and internal row is ribbed posteriorly. The internal row connects anteriorly just behind the second cusp of the medial row.

Discussion – The H:AP of these two p4s (0.60-0.61) is appropriate for p4s of *Cimolodon* (table 5) and generally greater than for p4s of *Mesodma* (table 1). The specimen is larger than those assigned to *C. similis* and smaller than those assigned to *C. electus* by Fox, 1971 (table 14). The specimens have fewer serrations (11) than does *C. electus* (15). The size of the specimens (table 14) is within the lower range of p4s assigned to *C. nitidus* by Archibald (1982) and Clemens (1964) but is below the size range of the sample described by Lillegraven (1969). The specimens have one fewer serration (11) than described for p4s of *C. nitidus*. The M1 is estimated to be larger than those of *C. electus* and within the lower range of length and upper range of width for the samples of *C. nitidus* described by Archibald (1982) and Clemens (1964). It is slightly shorter and narrower than the sample described by Lillegraven (1969).

It is likely that these specimens represent a new species of *Cimolodon* in which the molars are broader relative to width than those of *C. nitidus*. The proportions of these molars and premolars are different than in other species of *Cimolodon*, and there are fewer serrations on p4 (11) than on *C. nitidus*, *C. electus*, or *C. similis*. Had the M1 not shattered during preparation, it likely would have provided sufficient characters on which to base a new species. Lacking adequate data to establish a new species, the specimens are conferred to the closest of described species of *Cimolodon*, *C. nitidus*. All of the specimens were recovered from UMNH Locality 130 and nothing like them has been recovered from other Wahweap localities. This suggests that there can be very localized controls on the distributions of mammalian taxa.

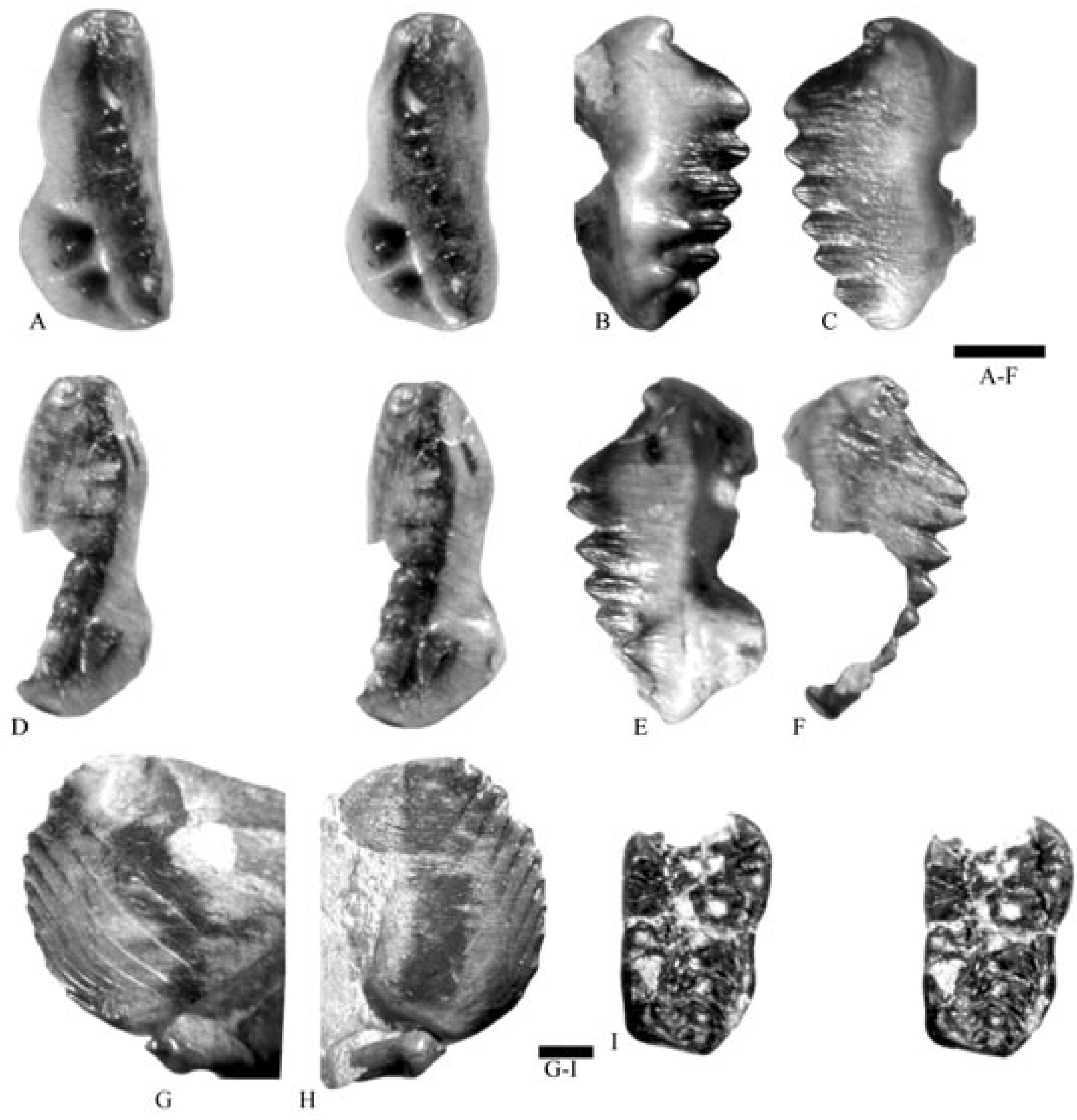

Figure 21. *Cimolodon similis*: A, (MNA V5217), LP4, stereo occlusal view; B, labial view; C, lingual view; D, (MNA V5221), partial RP4, stereo occlusal view; E, labial view; F, lingual view. *Cimolodon* sp. cf. *C. nitidus*: G, (UMNH VP7978), Lp3-4, labial view; H, lingual view; I, (UMNH VP7981), LM1, stereo occlusal view. Scale bars = 1 mm.

Cimolodon sp. (small)
table 14; figures 22A-C

Referred Specimens – MNA V4525, Rp4, Loc. 455-1 (*Cimexomys* sp. cf. *C. antiquus* in Eaton, 1987); MNA V4537, Lm2, Loc. 456-2 (?*Cimolodon* sp. in Eaton, 1987).

Description – p4. MNA V4525 (figures 22A-B; note that the bottom of the anteroexternal lobe is not shown as it is obscured by glue on the specimen) has 10 serrations and six internal and external ridges. The tooth forms a nearly symmetrical arch. The second serration is spaced far posterior to the first serration, and the remaining serrations are approximately equally spaced. The crest of the blade reaches its apex at the fourth serration slightly anterior to the midpoint of the blade. The posteroexternal pocket is low on the labial wall of the tooth and slopes anteroventrally. There are six closely spaced serrations on both sides of the blade and no serrations associated with the posteromost two cusps.

m2 – MNA V4537 (figure 22C) has a cusp formula of 4:2. The first cusp of the external row is anteroposteriorly narrow and broadly separated from the larger second cusp. Cusps 2 and 3 are separated slightly apically and by a deep groove lingually. There is little separation of cusps 3 and 4. The central valley is complexly pitted. The first cusp of the internal row is well separated from the smaller second cusp. There is a distinct notch posterior of the second cusp.

Discussion – This p4 was assigned to *Cimexomys* sp. cf. *C. antiquus* in Eaton, 1987. This choice reflects the small size of the tooth (very close to that of *C. judithae*, see table 9), the low number of serrations and ridges, and that the posteromost serrations were cusp-like and lacked ridges (as in *C. judithae*, Montellano, 1992, p. 32). However, the blade is high crowned and has a high H:AP ratio (0.65), much higher than that of any known species of *Cimexomys* (table 9). Also, the large gap between the first two serrations is not seen on either *Cimexomys* or *Mesodma* but is consistently present on p4s of *Cimolodon* (e.g., *C. similis*, Fox, 1971, figure 5; *C. nitidus*, Archibald, 1982, figure 18). However, it is somewhat difficult to access the relative position of the first two serrations on the figure of p4 of *C. gratus* (see Archibald, 1982, figure 37), as the anterior portion of the blade appears to be worn. Of species of *Cimexomys*, *C. gratus* has the most serrations (up to 10) and the highest H:AP ratio (0.52), but *C. gratus* is much larger than the MNA specimen and still has a significantly lower H:AP ratio (table 9). MNA V4525 is shorter and appears to be higher crowned than the partial p4 assigned above to *Cimolodon foxi* sp. nov. from the Kaiparowits Formation. The specimen is also similar to, but smaller than, a p4 (MNA V5870, figure 5C-D) described by Eaton (1995) as an indeterminate cimolodontid from the Dakota Formation. The blade is considered to represent *Cimolodon* because of its high H:AP ratio and the broad separation of the anteromost two serrations.

The cusps of the internal row of the m2 are not as narrowly divided and the external cusp row is less divided than in most illustrated m2s of *Cimolomys* (Sahni, 1972, figure 11E; Clemens, 1964, figure 35b; but less so than on the m2 illustrated in Archibald, 1982, figure 23e). Pitting and grooves are evident in specimens of both taxa. The specimen is smaller than described m2s of *Cimolodon* (or *Cimolomys*) and compares closest to the m2s of *Cimolodon foxi* sp. nov. from the Kaiparowits Formation described earlier in this paper. Taken together, these two specimens suggest the presence of a species of *Cimolodon* in the Wahweap Formation similar to *C. foxi* from the Kaiparowits Formation.

Superfamily unknown
Family Cimolomyidae Marsh, 1889
Meniscoessus Cope, 1882
Meniscoessus sp. cf. *M. intermedius* Fox, 1976
table 15; figures 22D-G

Referred Specimens – MNA V5281, LM1 (posterior part), Loc. 456-1; MNA V5287, RP4, Loc. 455-1.

Description – P4. MNA V5287 (figures 22D-F) has five cusps in the medial row. The first four cusps have a high climb ratio, and there is less difference between the height of the fourth and fifth cusps. The posterior face of the tooth is complexly crenulated with two cusps on the lingual side and one cusp on the labial side.

M1 – MNA V5281 (figure 22G) is the posterior portion of a large M1. The cusps of all three rows are pyramidal and the cusps of each row are deeply separated, almost to the depth of the anteroposterior valleys. The valleys that separate each cusp in the external and medial rows are aligned transversely. The cusps of the medial row broaden slightly posteriorly. The internal row has five cusps and joins the main body of the tooth just about at the position of the fifth from the last cusp.

Discussion – The P4 is unlike the P4 illustrated by Fox (1971, figure 8a, b) as *Meniscoessus ferox*. In overall form, the P4 looks more like that of the much larger *M. robustus* (e.g., Archibald, 1982, figure 29a, b). The P4 of *M. intermedius* is unknown. The number of cusps on the internal row of the M1 and the position the row meets the main body of the tooth are the same as in the M1 of *M. intermedius* (table 15), from the Oldman Formation (Judithian) of Canada (Fox, 1976). As there is only one M1 described for *M. intermedius*, it is not known if the specimen described here is within the size range for that taxon, or represents a smaller taxon. Of described species of *Meniscoessus*, *M. intermedius* is the closest in size and morphology to MNA V5218.

Genus *Cimolomys* Marsh, 1889
Cimolomys sp. cf. *C. trochuus* Lillegraven, 1969
table 16; figures 23A-C

Referred Specimens – MNA V4524, LP4 (part), Loc. 455-1 (*Cimolodon* sp. near *C. clarki* in Eaton, 1987; MNA V5326, LP4, Loc. 707-6 (*Cimolodon* sp. near *C. clarki* in Eaton, 1987); OMNH 23350, RP4, Loc. 702-2.

Description and Discussion – P4. MNA V5326 (figures 23A-C) has a cusp formula of 1:5 and has only a slight arch in occlusal view. The anteroexternal platform is moderately expanded and bears one large, ribbed cusp. The cusps of the medial row have a high climb ratio (CR = 0.58), are well separated, ribbed, and become larger posteriorly. The posterior wall that descends into the posterior basin from the last cusp of the medial cusp row is convex rather than flat. Two small cusps border the small posterior basin (PL:AP = 0.34).

These P4s are considered to represent *Cimolomys* because they have relatively few cusps, the cusps are large and distinct, and the cusps are ribbed. They are all near or with-

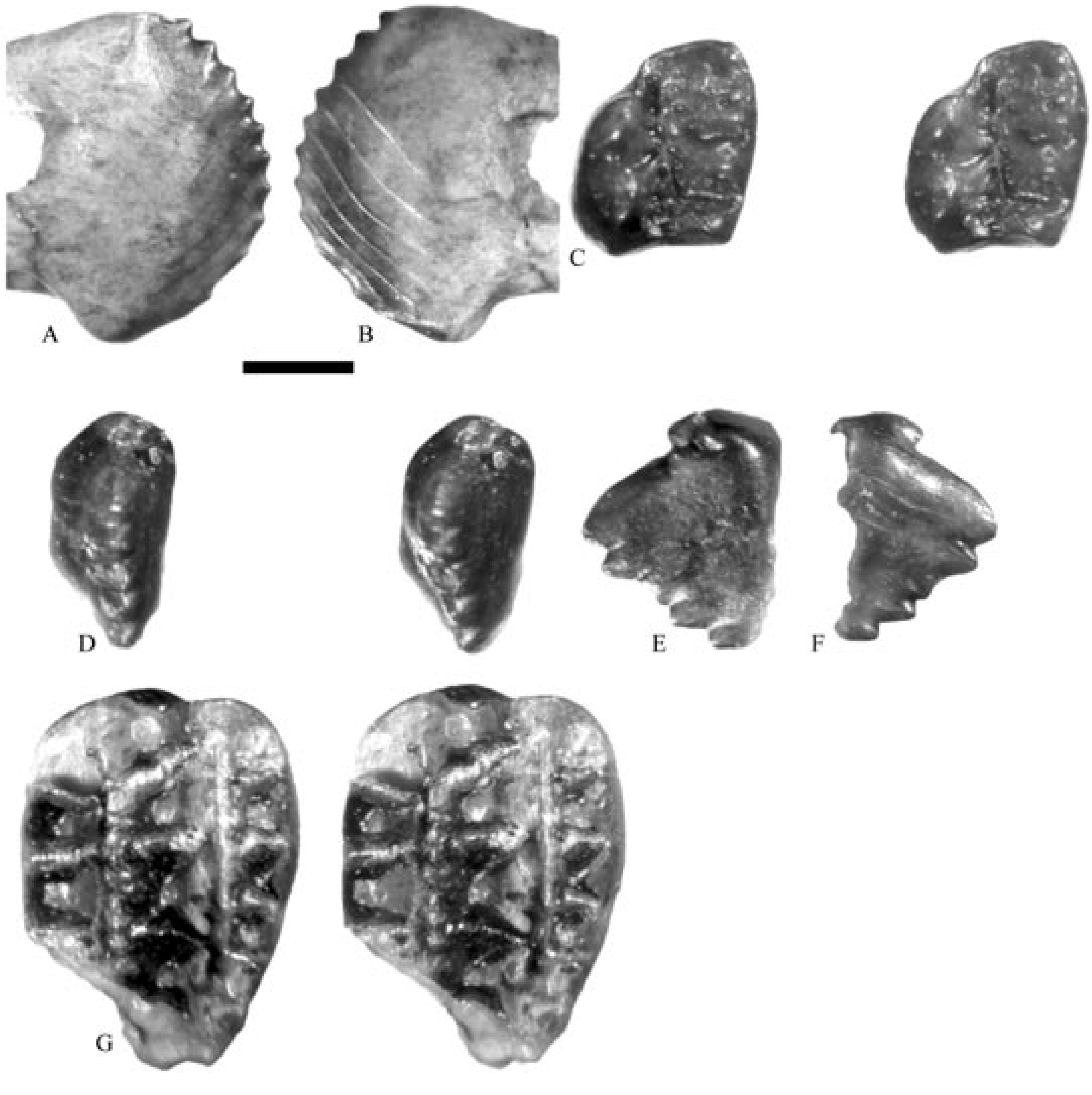

Figure 22. *Cimolodon* sp. (small): A, (MNA V4525), Rp4, labial view; B, lingual view; C, (MNA V4537), Lm2, stereo occlusal view. *Meniscoessus* sp. cf. *M. intermedius*: D, (MNA V5287), RP4, stereo occlusal view; E, labial view; F, lingual view; G, (MNA V5281), partial LM1, stereo occlusal view. Scale bar = 1 mm.

in the size range of P4s attributed to *C. clarki* by Sahni (1972) and Lillegraven and McKenna (1986) (table 16); however, Sahni (1972, p. 373) realized that these P4s were unusually large relative to the other teeth of *C. clarki*. Teeth of *C. clarki* are approximately 70% of the size of those of *C. gracilis*; however, the P4s assigned to *C. clarki* by Sahni (1972) and Lillegraven and McKenna (1986) are 25% larger than those of *C. gracilis* and are very close to the size of ?*Cimolomys* sp. A described in Fox (1971). Fox (1971) considered the P4 of ?*Cimolomys* sp. A to be in the size range of *C. trochuus* (a conclusion shared by Archibald, 1982, p. 122) for which P4s have not been described. It seems most likely that P4s assigned to *C. clarki* by Sahni (1972) and Lillegraven and McKenna (1986) belong to another, larger species of *Cimolomys*, possibly a taxon similar in size to *C. trochuus* (also see discussion above under *Cimolomys* sp. B cf. *C. clarki* from the Kaiparowits Formation). For this reason, the P4s described here are considered to be closer to *C. trochuus* than to *C. clarki*, even though these are close to the size of P4s previously assigned to *C. clarki*. These P4s are also too large to belong to ?*Cimolomys* sp. A or B, described below.

?*Cimolomys* sp. A
table 16; figure 23D

Referred Specimen – MNA V5218, Rm1, Loc. 455-1 (?Cimolomyid, gen. & sp. indet. in Eaton, 1987).

Description and Discussion – m1. MNA V5218 (figure 23D) has a cusp formula of 4:4. The tooth is broad relative to its width (LB:AP = 0.56), and the anteromost cusps of each row are closely positioned immediately adjacent to the central valley. The first cusp of the external row is low, small, and shifted lingually and is a three-faced pyramidal cusp. It is well separated from the second pyramidal cusp, which is the tallest of the row. A wide valley separates cusps 2 and 3. The third cusp is pyramidal and leans posteriorly. The posteromost cusp is lower than cusps 2 and 3, but not as low as the first cusp. There is a slight hint of a posteroexternal shelf.

The central valley is straight and lined with shallow pits. The corners of the pyramidal cusps 2-4 of each row meet in the central valley and may have crossed the central valley as ridges prior to wear. The first cusp of the internal row is a small projection rising from an anteriorly directed crest originating from the second cusp. The second cusp is subpyramidal and the tallest of the row. A wide, deep valley separates cusps 2 and 3. The third cusp is pyramidal and leans posteriorly. The fourth cusp is anteroposteriorly compressed.

The m1 (MNA V5218) is like those of *Bryceomys* in having cusp rows of equal width and having broad, U-shaped valleys separating the cusps of each row. The specimen is unlike *Bryceomys* in having a straight central valley and pyramidal cusps in both rows. The molar lacks the strongly crescentic cusps of *Cimolomys* gracilis, but is similar to the m1 of *C. clarki* depicted by Lillegraven and McKenna (1986, figure 7A, UW 15535) in having broadly separated pyramidal cusps. The specimen is also similar to a molar described from the Kaiparowits Formation earlier in this paper as ?*Cimolomys butleria* sp. nov. The m1 of ?*C. butleria* (UMNH 22837, figure 13A) is about the same size, has two more cusps in the external row, and is longer relative to width (LB:AP = 0.50) than MNA V5218. These two m1s are similar in having the anteromost cusps of each cusp row closely placed and in the shape and separation of the cusps. MNA 5218 (figure 23D) is also somewhat similar to ?*Cimolomys* sp. A described by Fox (1971) but appears to be more primitive in having two less cusps in the external row and less posterior protrusion of the external row.

It is likely that MNA 5218 represents a new genus intermediate between a taxon like *Bryceomys* and later crescentic-cusped forms of *Cimolomys*. It may also be possible that ?*Cimolomys butleria* sp. nov., ?*Cimolomys* sp. A (Fox, 1971), and possibly *C. trochuus* should be included in this new genus as the m1s of these taxa all have pyramidal cusps separated by broad, open valleys, cusp rows of equal width, cusp formulae of 4-6:4, and the two anteromost cusps of each row closely appressed. The species from the Wahweap Formation appears to be the most primitive.

A formal genus is not established due to lack of knowledge of other tooth positions, m1s of *C. trochuus* are unknown, and taxonomic uncertainty about the m1 attributed to *C. clarki* by Lillegraven and McKenna (1986) (see discussion above under ?*Cimolomys butleria* sp. nov. from the Kaiparowits Formation).

?*Cimolomys* sp. B
table 16; figures 22E-F

Referred Specimens – OMNH 23360, LP4 (part), Loc. 707-2; MNA V4529, LM2, Loc. 456-2 (*Cimolomys* n. sp. in Eaton, 1987); MNA 5206, LM2, Loc. 456-2 (*Cimolomys* n. sp. in Eaton, 1987); MNA V5320, RM2, Loc. 456-2 (*Cimolomys* n. sp. in Eaton, 1987); OMNH 20956, RM2, Loc. 455-2; UMNH VP7595, RM2, Loc. 77.

Description – P4. OMNH 23360 is the anterior part of a P4. The two striated cusps on the anteroexternal platform are closely appressed against the cusps of the medial cusp row and are only slight lower.

M2 - MNA V4529 (figure 23E) has a cusp formula of 2?:3:4. The specimen is worn, but there appear to have been two or three distinct cusps on the anteroexternal ridge. The anteroexternal platform has several distinct pits. The anterior face of the first cusp of the medial row leans posterodorsally. The cusp is narrow and well separated from the anterior-leaning subpyramidal, second cusp. The third cusp leans less anteriorly than the second and has deep grooves on its lingual side. The central valley is deep and lined on both sides by grooves on the internal and medial cusp row walls. Cusps of the internal row decrease in height posteriorly and are separated apically and by grooves on the labial wall. The cusps appear to have been slightly better separated posteriorly prior to wear.

MNA V5320 (figure 23F) has a formula of Ri:3:4. The anteroexternal ridge hints at having had one or two small cusps prior to wear. The anteroexternal platform is deeply pitted. The first cusp of the medial row is low and, despite the great amount of wear on the tooth, it lacks occlusal wear. The second cusp is large and pyramidal and leans anteriorly. The central valley is lined with deep pits, and grooves descend into it from the face of both the medial and internal cusp rows. Cusps of the internal row become larger posteriorly and are separated apically.

Discussion – The partial P4 appears to represent *Cimolomys*, as the cusps of the anteroexternal platform can be closely appressed to the cusps of the medial row in that genus (e.g. *C. gracilis*, Archibald, 1982, figure 23c). By contrast, in *Cimolodon* the cusps of the external row are separated from those of the medial row by a distinct valley (e.g., *C. nitidus*, Clemens, 1973, figure 30; Archibald, 1982, figure 20). Striations are more commonly seen on *Cimolodon* but can be present on *Cimolomys* (e.g., *C. clarki*, Lillegraven and McKenna, 1986, figure 7e).

These M2s have complex pitting, which makes them appear closest to the illustrated M2s of *Cimolodon electus* (see Fox, 1971, figure 5a). However, in *Cimolodon* the internal and medial cusp rows tend to parallel each other at an angle oblique to the anteroposterior axis of the tooth, and the internal row cusps are relatively narrow compared to the medial row (e.g., *C. electus*, Fox, 1971, figure 5; *C. nitidus*, Lillegraven, 1969, figure 11-5b). The M2 illustrated by Sahni (1972, figure 11F) as *C. clarki* had deeply separated cusps in the internal cusp row (which appear to be deepest between the first two cusps), very unlike the condition seen in these M2s. Similarly, the highly crescentic cusps of the M2 of *C. gracilis* depicted by Clemens (1964, figure 38b) are deeply separated; however, the specimens of *C. clarki* shown by Lillegraven and McKenna (1986, figure 7D) and *C. gracilis* illustrated by Archibald (1982, figure 23d) have the first two cusps relatively weakly divided with deeper division of the cusps posteriorly. There is some hesitance in assigning these M2s to *Cimolomys* because of the shallow separation of the cusps of the internal row. These specimens appear to be in the possible size range (estimated from teeth in other positions, table 16) of Fox's (1971) ?*Cimolomys* sp. A or *C. trochuus*, for which no M2s have been described.

?*Cimolomys* sp. C (large)
table 16; figure 23G

Referred Specimen – MNA V4559, LM2; Loc. 456-2 (*Cimolomys* sp. near *C. Clarki* in Eaton, 1987).

Description – M2. MNA V4559 (figure 23G) has a cusp formula of Ri:3:4. There is a strong anteroexternal ridge, but no distinct cusps are evident on this worn specimen. The first cusp of the medial row is low and worn. The second cusp is larger, pyramidal in form, and the third cusp is taller but slightly smaller at its base than the second cusp. The central valley is deep, straight, and aligned with the anteroposterior axis of the molar. The cusps of the internal row are better separated posteriorly.

Discussion – The internal cusps are well separated in depicted M2s of *Cimolomys clarki* (see Sahni, 1972, figure 11F) and *C. gracilis* (see Clemens, 1964, figure 38b), which could be a character diagnostic of the genus (see discussion above under ?*Cimolomys* sp. B). The cusps of the internal cusp are not deeply divided on this worn specimen, but cusp separation appears to be more complete than on M2s of *Cimolodon*. M2s of *Cimolodon* also tend to have more cusps in the medial row, and these cusps are narrow, anteroposteriorly compressed crescentic cusps (Clemens, 1964, figure 31b; Lillegraven, 1969, figure 11-5b) unlike the broad second cusp on MNA V4559. The central valley tends to be oriented with the AP axis of the molar in *Cimolomys* and somewhat obliquely to it in the few illustrated M2s of *Cimolodon*. Because of the weak separation of cusps of the internal row, this specimen is only tentatively referred to *Cimolomys*. It is within the size and cusp formula range for both *Cimolomys clarki* and *Cimolodon electus*.

Family indeterminate
Genus and species unknown
figures 23H-I

Referred Specimen – UMNH VP7599, Rp4 (partial), Loc. 77.

Description and Discussion - A single fragment (UMNH VP7599, figures 23H-I) of the posterior part of a large blade is present in the sample. The blade is distinctive in being very complex with striae oriented posteroventrally from the posteromost labial ridge. These striae terminate at the well-developed posterolabial cusp, which is positioned high on the labial wall. The p4 apparently has a high serration count, as this small portion of the blade has nine serrations.

The spacing of the serrations is similar to that of the p4s of *Cimolodon* sp. cf. *C. nitidus* described above (UMNH VP7978, figure 21G); however, the complex striated posterior wall of this specimen is different and is more similar to p4s of *C. electus* (see Fox, 1971, figure 3d-e). The posteroexternal cusp is relatively low compared to the crest of the tooth on all figured specimens of *Cimolodon* (e.g., Archibald, 1982, figure 18c; Fox, 1971, figure 3d, figure 5c). The posteroexternal cusp is positioned just below the last serration in *Mesodma* (e.g. Clemens, 1964, figure 10A), but the estimated size of this blade (5 mm) exceeds that known for *Mesodma*. In complexity and size, this blade is most like the unidentified large blade (UCMP 118576 – 5.92 mm) shown in Montellano (1992, figure 11).

Cimexomys Sloan and Van Valen, 1965
Cimexomys sp. cf. *C. antiquus* Fox, 1971
table 17; figures 24A-B

Referred Specimens – MNA V5205, LM1, Loc. 456-2; MNA V5247, Rm1 (damaged), Loc. 456-2; MNA V5324, Lm1, Loc. 455-1.

Description – m1. MNA V5247 (figure 24A) is a small m1 that narrows anteriorly and has a cusp formula of 5:4?. The cusps of the external row are separated by narrow valleys, and the last two cusps are poorly separated and ridge-like. The first cusp of the internal row is elongate. The last two (?) cusps of the internal row a re missing. Cusps on the specimen are worn but appear to be blocky. MNA V5324 was originally a better-preserved specimen than MNA V5247, but it was damaged while being prepared for illustration. MNA V5324 differs from MNA V5247 in having five or possibly six cusps on the external row and the first cusp of the external row is tiny and shifted lingually.

M1 - MNA V5205 (figure 24B) has a cusp formula of 4:6:2? (posteromost part of the tooth is missing). The cusps of the external row become markedly narrower posteriorly. There is a small cuspule (not counted in the formula) present along the anterior margin of the tooth in front of the first cusp. The first cusp is lower and smaller than the second cusp, and the two cusps are not deeply divided. The valley between cusps 2 and 3 is broader and deeper than the valley between the first two cusps, and it is deeper yet between

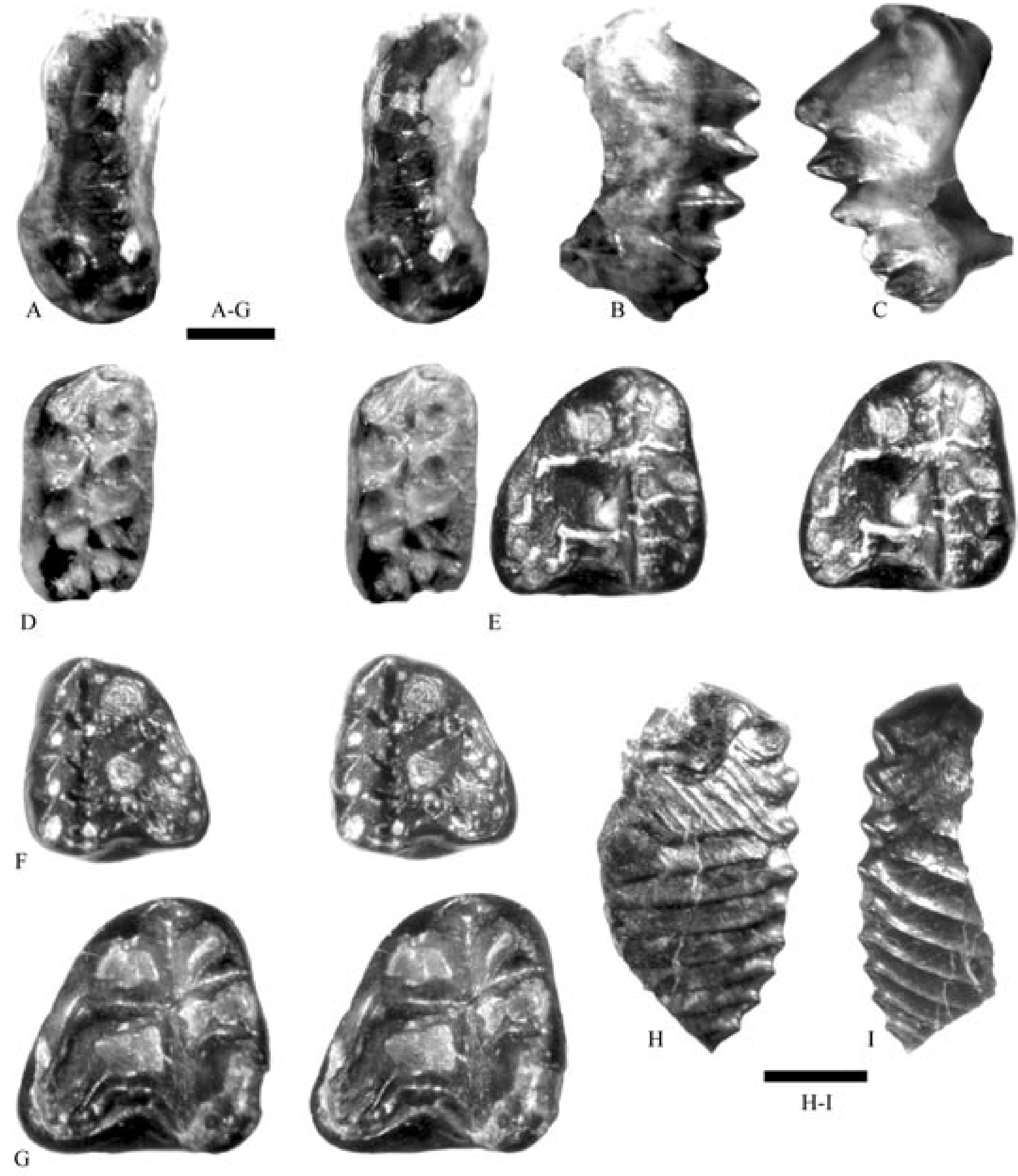

Figure 23. *Cimolomys* sp. cf. *C*. *trochuus*: A, (MNA V5326), LP4, stereo occlusal view; B, labial view; C, lingual view. ?*Cimolomys* sp. A: D, (MNA V5218), Rm1, stereo occlusal view. ?*Cimolomys* sp. B: E, (MNA V4529), LM2, stereo occlusal view; F, (MNA V5320), RM2, stereo occlusal view. ?*Cimolomys* sp. C (large): G, (MNA V4559), LM2, stereo occlusal view. Cimolodonta, Family indet., genus and species unknown: H, (UMNH VP7599), partial Rp4, labial view; I, lingual view. Scale bars = 1 mm.

cusps 3 and 4. The cusps have been worn to about the same height. The central valley is strongly oblique to the anteroposterior axis of the tooth. The cusps of the medial row are larger and broader posteriorly, and cusps 3-5 appear to have leaned anteriorly prior to wear. The internal row has two elongated cusps and joins the main body of the tooth between cusps 3 and 4 of the medial row.

Discussion – The M1 is similar to MOR 302 (*Cimexomys judithae*, Montellano and others, 2000, figure 1) in having a small first cusp on the external row, but the cusps are better divided on MOR 302 than on this specimen. The central valley is less oblique on MOR 302 but the cusps of the external row do narrow posteriorly and the cusps of the medial row broaden posteriorly as on this specimen. The cusps of MOR 302 are strongly aligned transversely, but UCMP 130504 (*Cimexomys judithae*, Montellano, 1992, figure 5) has cusps offset anteriorly and aligned posteriorly, with a strongly oblique central valley (as does *C. minor*, Archibald, 1982, figure 35). The MNA specimen is more like UCMP 130504.

The M1 (MNA V5205) is also similar in size to specimens referred to as cf. *Cimexomys* sp. by Montellano (1992). These specimens were identified on the basis of the length of the internal row being equal to or less than half the length of the tooth. This is probably not a certain diagnostic character of *Cimexomys* as it is not present on MOR 322, considered by Montellano (1992, figure 6) to represent *C. judithae*. Also, in *M. primaeva* (see Sahni, 1972, figure 10) the internal row of M1 is less than half the length of the tooth. One of the specimens (UCMP 131468) that Montellano (1992) referred to cf. *Cimexomys* sp. has a cusp formula (5:5:2?), close to that of the MNA M1 (4:6:2?). However, neither UCMP 131468 nor any of the other M1s referred to cf. *Cimexomys* sp. were illustrated by her.

MNA V5205 also was compared directly to the type of *C. antiquus*, UA 5640. The MNA specimen is similar in size and morphology except for having a more squared anterior margin and one less cusp in the external row. In cusp formula, size, and morphology, this specimen is closer to M1s of *C. antiquus* than to any other well-documented species of *Cimexomys* (this excludes cf. *Cimexomys* sp. of Montellano, 1992). In her differential diagnosis of *C. judithae* (see Montellano, 1992, p. 30), Montellano did not mention *C. antiquus*, and as such the assignment made here is not certain.

The m1s are of appropriate size to be included within either *C. antiquus* or *C. judithae* and are tentatively assigned here based on the M1. Both specimens are badly preserved, thus contributing to the uncertainty of their assignment.

Paracimexomys Archibald, 1982
cf. *Paracimexomys* sp. A
table 18; figures 24C-D

Referred Specimens – MNA V4567, Lm1, Loc. 456-2; MNA V4599, Lm1; Loc. 455-1; MNA V5233, LM2, Loc. 456-2; MNA V5240, RM1, Loc. 456-2; MNA V5325, Rm1, Loc. 455-1; OMNH 22544, LM2, Loc. V2; OMNH 24363, LM2, V11.

Description – m1. MNA V4599 has a cusp formula of 4:3. The specimen is very worn and poorly preserved (too poorly preserved to illustrate) as are many of the teeth in this sample of small multituberculates. The external cusp row is worn almost to its base. The central valley is worn, forming a broad open valley. The internal cusp row is less worn than the external, and the first two cusps of the internal row are closely appressed and not deeply divided. The second and third cusps are deeply divided. The tooth is relatively broad compared to its length (LB:AP = 0.66).

M1 – MNA V5240 (figure 24C) is an incompletely preserved M1 with a cusp formula of 4:4:1. The medial and internal cusp rows appear to be approximately parallel. The four cusps of the external row decrease in size posteriorly. A few of these cusps bear vertical striations, and more of them may have existed prior to wear. The central valley is deep and closed posteriorly and anteriorly. The cusps of the medial row increase in size and height posteriorly. The third cusp leans anteriorly. The internal row bears one small, low cusp. There is an indentation (seen in occlusal view) on the labial side of the tooth, but it is not determinable if there is one on the damaged lingual wall.

M2 – MNA V5233 (figure 24D) is a very worn specimen with a cusp formula of 1:2:3. The external platform is complex and pitted. The medial row has two well-formed cusps with the anteromost leaning forward and merging with the ridge on the anterior face of the tooth. The posterior wall of the cusp is concave and slopes posteriorly to the base of the second cusp, which is the largest and tallest of the tooth. The central valley is sinuous with deep anteroposteriorly oriented pits. The first two cusps of the internal row form a high ridge. The posteromost cusp is distinct, but not deeply divided from the more anterior cusps.

Discussion – Indeterminable characteristics of the poorly preserved m1s include whether the central valley was sinuous, the molar cusps were ribbed, or if the valleys were pitted. The m1s are tentatively assigned here as their size and what can be seen of their morphology appears to be appropriate for association with the single M1.

The M1 (MNA V5240, figure 24C) is morphologically similar to those of *Paracimexomys priscus* (see Archibald, 1982, figure 39a), but *P. priscus* is much larger (table 18) and lacks any hint of ribbing on the cusps (see discussion and the revised diagnosis of *Paracimexomys* in Eaton and Cifelli, 2001). The M2 tapers strongly posteriorly, and the central valley is very sinuous as in *P. priscus* (see Archibald, 1982, figure 39b). However, the strong pitting in the central valley is not seen in *P. priscus*.

Eaton and Cifelli (2001) restricted *Paracimexomys* to taxa lacking complex ribs or pitting and referred the rather wide morphologic range of taxa previously assigned to *Paracimexomys* to cf. *Paracimexomys*. This species (cf. *Paracimexomys* sp. A) would be the smallest assigned either to *Paracimexomys* or cf. *Paracimexomys* except for the similarly sized cf. *Paracimexomys perplexus* from the Cedar Mountain Formation (Eaton and Cifelli, 2001) and cf. *Paracimexomys* sp. from the Dakota Formation (Eaton, 1995, table 18).

cf. *Paracimexomys* sp. B
table 18; figure 24E

Referred Specimen – UMNH VP7982, Lm1-2, Loc. 130.

Description and Discussion – This specimen (figure 24E) is poorly preserved, and most of the molar enamel is missing. No cusp morphology is preserved, and the specimen is conferred to *Paracimexomys* based on the almost identical length of the m1 and m2, a characteristic of *Paracimexomys* (see Eaton and Cifelli, 2001). The length of these molars is too great for this specimen to be included in cf. *Paracimexomys* sp. A, described above.

Bryceomys Eaton, 1995
Bryceomys sp. cf. *B. fumosus* Eaton, 1995
table 18; figure 24F

Referred Specimen – MNA V7527, RM1, Loc. 455-1.

Description and Discussion – MNA V7527 (figure 24F) is a poorly preserved M1 with a cusp formula of 5?:4:2. The external and medial cusp rows are parallel and do not diverge anteriorly. The cusps of the external row descend in height posteriorly (the posteromost part of the tooth, possibly having a fifth cusp, is missing). The first cusp of the row is small and shifted lingually. The next three cusps are approximately equal in size and equally spaced, and they are all connected by a low ridge. The first two cusps of the medial row are elongate and poorly separated. The third cusp is more squared and deeply separated from both the second and fourth cusps. The last cusp of the medial row is the broadest and tallest of the tooth. The internal row is broad and has two distinct cusps on its lingual margin. The platform connects just posterior to the second cusp of the medial row.

The size (table 18) and morphology of this M1, particularly the very broadly expanded internal platform, are similar to that of the M1s of *Bryceomys fumosus* from the Smoky Hollow Member of the Straight Cliffs Formation (Turonian) described by Eaton (1995).

Cedaromys Eaton and Cifelli, 2001
Cedaromys sp.
table 18; figure 24G

Referred Specimen – MNA V7534, Rm1, Loc. 455-1.

Description and Discussion – MNA V5734 (figure 24G) is a worn m1 with a cusp formula of 4:3. The cusp rows converge anteriorly and the molar is strongly waisted in occlusal view. The first cusp of the external row is low and shallowly divided from the second cusp. The second and third cusps are larger than the first and a deep pit separates them. The third cusp is worn slightly lower than the second cusp. The fourth cusp is broad and flat. The central valley is sinuous. The first two cusps of the internal row are small, weakly divided, tall and conical cusps. Second and third cusps are well separated, but the separation does not reach the floor of the medial valley. The third cusp is larger and slightly taller than the first two cusps.

The robust appearance of this tooth is *Bryceomys*-like, but the molar cusps of *Bryceomys* are much better separated than those of *Cedaromys*. This molar is similar in morphology and size (table 18) to those of *Cedaromys hutchisoni* sp. nov., described from the Kaiparowits Formation earlier in this paper.

cf. *Cedaromys* sp.
table 18; figure 24H

Referred Specimen – MNA V4627, Lm1, Loc. 455-1 (*Paracimexomys* sp. in Eaton, 1987).

Description and Discussion – MNA V4627 (figure 24H) is an m1 with a cusp formula of 4:3. The cusps of the external row increase in height posteriorly. The first cusp is low and round. The second cusp is much larger and shallowly separated from the similar-sized third cusp, particularly along the labial wall. The fourth cusp is missing on this specimen. The central valley is only slightly sinuous. The cusps of the internal row decrease in height posteriorly. The first cusp is tall and essentially conical except for the worn flat surface facing the central valley. The first and second cusps are separated for about half their height. The second cusp is rounded anteriorly but is weakly squared at the posterior corners of the cusp. The third cusp is slightly elongated.

The cusps on this specimen are not as well separated as are those of m1s of *Bryceomys*, and the specimen lacks the pits separating the cusps in *Dakotamys*. The robust broad cusps of this specimen are closest to that seen on the m1s of *Cedaromys*, but they lack the closely paired first two cusps of the internal row that typifies *Cedaromys* (Eaton and Cifelli, 2001).

Genus and species unknown
table 18

Referred Specimens – MNA V5322, Rm2, Loc. 456-2 (*Paracimexomys* n. sp. in Eaton, 1987); OMNH 23362, Lm2, Loc. V16; UMNH VP7994, RM2, Loc. 130.

Description and Discussion – Three small second molars are present in the sample from the Wahweap Formation that are too small to fit with any of the taxa described earlier in this paper. MNA V5322 is small (AP=1.12; LB=0.94), it has a cusp formula of 3:2 and an ovate shape. An attempt was made to associate this specimen with the m1s described as cf. *Paracimexomys* sp. A, but the resultant m2:m1 ratio would be 0.71, too low for *Paracimexomys* (see Eaton and Cifelli, 2001) (table 18). If this specimen belongs with the m1s assigned to cf. *Paracimexomys* sp. A, then those m1s are incorrectly assigned.

Another small deeply worn m2 is present, OMNH 23362. Its length (AP=1.34) would be appropriate for cf. *Paracimexomys* sp. A, but the molar is not wide enough (LB=0.88) to belong with the m1s of that species (table 18). This m2 and MNA V5322 do not represent the same species, but they hint at the presence of greater diversity of small multituberculates in the fauna than can be accounted for on the basis of first molars.

UMNH VP7994 is a small M2 (AP=1.08*; LB=0.97*) with an unexpanded external platform expressed only by a narrow ridge. The external row has a narrow, sharp ridge anteriorly, but the ridge is too low to count as a cusp. The tooth is dominated by the first cusp of the external row, which is ribbed and the tallest and largest of the tooth. The second cusp is widely separated from, and smaller than, the first cusp. The central valley is slightly sinuous, unpitted, and open at both ends. The internal row has four cusps. The first is small, low, and closely joined to the larger second cusp. The second, third, and fourth cusps are separated by wide valleys formed by concave surfaces on the anterior and posterior faces of the cusps. The third cusp is the largest, and the apical separation between the third and fourth cusps is the deepest of the row. The large central cusp of the external row and the lack of an expanded external platform are similar to

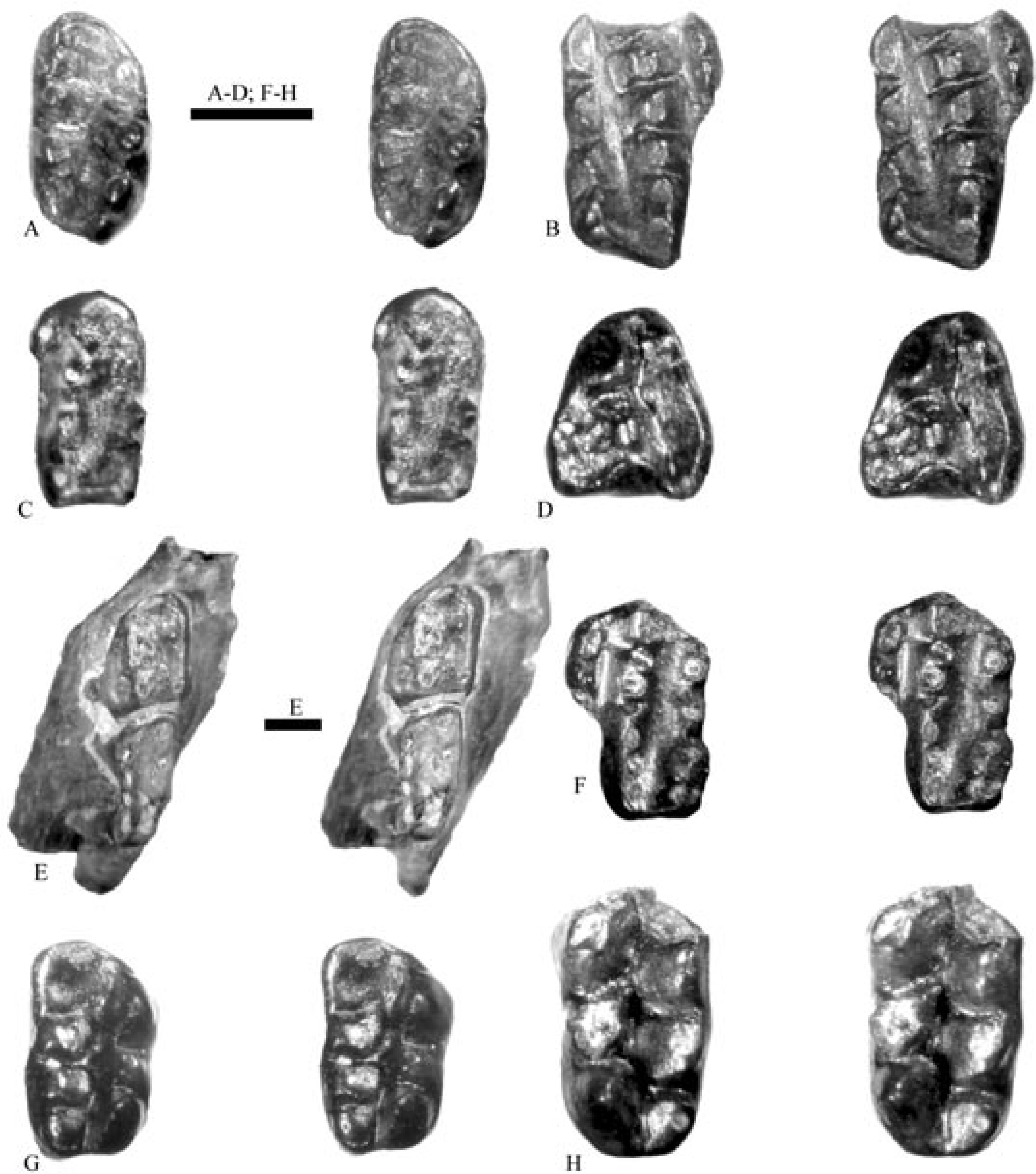

Figure 24. *Cimexomys* sp. cf. *C. antiquus*: A, (MNA V5247), Rm1, stereo occlusal view; B, (MNA V5205), incomplete LM1, stereo occlusal view. cf. *Paracimexomys* sp. A: C, (MNA V5240), RM1, stereo occlusal view; D, (MNA V5233), LM2, stereo occlusal view. cf. *Paracimexomys* sp. B: E, (UMNH VP7982), Lm1-2, stereo occlusal view. *Bryceomys* sp. cf. *B. fumosus*: F, (MNA V7527), incomplete RM1, stereo occlusal view. *Cedaromys* sp.: G, (MNA V5734), Rm1, stereo occlusal view. cf. *Cedaromys* sp.: H, (MNA V4627), incomplete Lm1, stereo occlusal view. Scale bars = 1 mm.

the condition seen in M2s of *Paracimexomys priscus* (see Archibald, 1982, 39b). This tooth possibly represents *Paracimexomys* or cf. *Paracimexomys*, and it is similar in size and proportions to MNA V5322 (m2). This supports the presence of a smaller species of *Paracimexomys* or cf. *Paracimexomys* in the fauna.

BIOSTRATIGRAPHIC IMPLICATIONS OF FAUNAS

Only two taxa from the Kaiparowits Formation described here are conspecific with previously described taxa (tables 19, 20). These include *Dakotamys magnus*, which was originally described by Sahni (1972) from the Judith River Formation and *Mesodma archibaldi*, which is the same taxon described by Montellano (1992) as *Mesodma* sp., also from the Judith River Formation. *Dakotamys magnus* was considered a unique occurrence in the Judithian by Lillegraven and McKenna (1986), as are most of the species to which taxa are conferred here: *Cimexomys* sp. cf. *C. judithae*; *Cimolomys* sp. A and B cf. *C. Clarki*; *Meniscoessus* sp. cf. *M. intermedius*; and *Meniscoessus* sp. cf. *M. major*. Only one conferred species, *Cimolodon* sp. cf. *C. nitidus*, is known from younger “Edmontonian” (and Lancian) localities, but the species described here appears to be morphologically more primitive than that species. *Mesodma* sp. (large) is most similar to *M. senecta* from the Aquilan, but the equivalency is difficult to establish as that species is poorly known. Both *Cimolodon foxi* and *Cimolodon* sp. cf. *C. similis* are closest to *C. similis*, an Aquilan taxon.

There is little doubt of the Judithian affinities of this multituberculate fauna, and this is consistent with data derived from therian mammals (Cifelli, 1994). Within the Judithian, this fauna may be slightly older than those from the type Judith River Formation based on some occurrences of taxa closer to Aquilan than to Judithian faunas and the sharing of four possibly conspecific taxa with the underlying Wahweap Formation (Aquilan) (see tables 18 and 19). The only taxon unique to a stratigraphic horizon is *Dakotamys magnus* from the stratigraphically highest well-sampled locality (TB8, MNA Loc. 1004-1; OMNH V5) in the Kaiparowits Formation (640 m above the base of the formation, Eaton, 1991). This may suggest a late immigration event of *Dakotamys magnus* into the area and perhaps indicate a basis on which to establish an approximate correlation with this part of the Kaiparowits Formation to the type Judithian.

Taxa described from the Wahweap Formation (tables 19, 20) include only two species identified with certainty, *Cimolodon electus* and *C. similis*, both of which are known from the Aquilan. One conferred species (*Cimexomys* sp. cf. *C. antiquus*) is close to an Aquilan taxon, as are two species questionably assigned to ?*Cimolomys* (sp. A and B). One conferred species (*Meniscoessus* sp. cf. *M. intermedius*) is closer to a Judithian member of the genus, and another conferred species (*Cimolodon* sp. cf. *C. nitidus*) is closest to an "Edmontonian" (and Lancian) species. Two other conferred species (*Cimolomys* sp. cf. *C. trochuus* and *Mesodma* sp. cf. *M. formosa*) are closest to Lancian species. Although there is little doubt of the Aquilan age of the Wahweap Formation, it contains a fauna significantly different from that of the Milk River Formation of Canada, the type fauna for the Aquilan. This may reflect latitudinal differences and/or the fauna from the Wahweap Formation may be somewhat older than the Milk River fauna based on some of the primitive characters present in species of both *Mesodma* (presence of pitting on molars) and *Cimolodon* (both *C. electus* and *C. similis* appear slightly more primitive than those species recovered from the Milk River Formation).

Refinement of North American Land Mammal "Ages" so that estimates of relative positions of faunas to the type "ages" can be achieved will require better sampling of mammalian faunas, more continuous latitudinal sampling, and the integration of data from other fossil groups (palynomorphs, ostracodes, lower vertebrates).

ACKNOWLEDGMENTS

Malcolm C. McKenna’s encouragement, both fiscally and spiritually, has allowed the research undertaken in the Cretaceous of southwestern Utah to bloom. Richard Cifelli and his crew collected, sacked, screen-washed, and picked more matrix than any sane people would consider and their efforts contributed greatly to the number of specimens available for this study. This research has been supported by various National Science Foundation and National Geographic Society grants to Richard L. Cifelli along with American Chemical Society Petroleum Research Fund grants 30989-GB8 and 34595-B8 to Eaton. The management of Grand Staircase-Escalante National Monument is thanked for its contributions to cover the costs of publishing this paper. The reviews of the manuscript by William A. Clemens and Jason A. Lillegraven are appreciated and the manuscript was greatly improved as a result of their efforts.

REFERENCES CITED

Archibald, J.D., 1982, A study of Mammalia and geology across the Cretaceous-Tertiary boundary in Garfield County, Montana: University of California Publications in Geological Sciences, v. 122, p. 1-286.

Cifelli, R.L., 1994, Therian mammals of the Terlingua local fauna (Judithian), Aguja Formation, Big Bend of the Rio Grande, Texas: Contributions to Geology, University of Wyoming, v. 30, p. 117-136.

Cifelli, R.L., Madsen, S.K., and Larson, E.M., 1996, Screenwashing and associated techniques for the recovery of microvertebrate fossils, *in* Cifelli, R.L., editor, Techniques for Recovery and Preparation of Microvertebrate Fossils: Oklahoma Geological Survey Special Publication 96-4, p. 1-24.

Clemens, W.A., 1964, Fossil mammals of the type Lance Formation, Wyoming, Part I, Introduction and Multituberculata: University of California, Publications in Geological Sciences, v. 48, p. 105 p.

Clemens, W.A., 1973, Fossil mammals of the type Lance Formation, Wyoming, Part III, Eutheria and summary: University of California, Publications in Geological Sciences, v. 94, 102 p.

Cope, E.D., 1882, Mammalia in the Laramie Formation: American Naturalist, v. 16, p. 830-831.

Eaton, J.G., 1987, Stratigraphy, depositional environments, and age of Cretaceous mammal-bearing rocks in Utah, and systematics of the Multituberculata (Mammalia): Ph.D. thesis, University of Colorado, Boulder, 308 p.

Eaton, J.G., 1991, Biostratigraphic framework for the Upper Cretaceous rocks of the Kaiparowits Plateau, southern Utah, *in* Nations, J.D., and Eaton, J.G., editors, Stratigraphy, depositional environments, and sedimentary tectonics of the western margin, Cretaceous Western Interior Seaway: Geological Society of America Special Paper 260, p. 47-63.

Eaton, J.G., 1995, Cenomanian and Turonian (early Late Cretaceous) multituberculate mammals from southwestern Utah: Journal of Vertebrate Paleontology, v. 15, p. 761-784.

Eaton, J.G., and Cifelli, R.L., 1988, Preliminary report on Late Cretaceous mammals of the Kaiparowits Plateau, southern Utah: Contributions to Geology, University of Wyoming, v. 26, p. 45-55.

Eaton, J.G., and Cifelli, R.L., 2001, Additional multituberculate mammals from near the Early-Late Cretaceous boundary, Cedar Mountain Formation, San Rafael Swell, Utah: Acta Palaeontologia Polonica, v. 46 (4), p. 453-518.

Eaton, J.G., Cifelli, R.L., Hutchison, J.H., Kirkland, J.I., and Parrish, J.M., 1999, Cretaceous vertebrate faunas from the Kaiparowits Plateau, south-central Utah, *in* Gillette, D.D., editor, Vertebrate Paleontology In Utah: Utah Geological Survey Miscellaneous Publication 99-1, p. 345-353.

Eaton, J.G., and Nelson, M.E., 1991, Multituberculate mammals from the Lower Cretaceous Cedar Mountain Formation, San Rafael Swell, Utah: Contributions to Geology, University of Wyoming, v. 29, p. 1-12.

Flynn, L.J., 1986, Late Cretaceous mammal horizons from the San Juan Basin, New Mexico: American Museum Novitates, no. 2845, p. 1-30.

Fox, R.C., 1971, Early Campanian multituberculates (Mammalia: Allotheria) from the upper Milk River Formation, Alberta: Canadian Journal of Earth Sciences, v. 8, p. 916-938.

Fox, R.C., 1976, Cretaceous mammals (*Meniscoessus intermedius*, new species, and *Alphadon* sp.) from the lowermost Oldman Formation, Alberta: Canadian Journal of Earth Sciences, v. 13, p. 1216-1222.

Fox, R.C., 1980, Mammals from the Upper Cretaceous Oldman Formation, Alberta, IV, *Meniscoessus* Cope (Multituberculata): Canadian Journal of Earth Sciences, v. 17, p. 1480-1488.

Jepsen, G.L., 1940, Paleocene fauna of the Polecat Bench Formation, Park County, Wyoming: American Philosophical Society Proceedings, v. 83, p. 217-340.

Kielan-Jaworowska, Z., Dashzeveg, D., and Trofimov, B.A., 1987, Early Cretaceous multituberculates from Mongolia and a comparison with Late Jurassic forms: Acta Palaeontologica Polonica, v. 32, p. 3-47.

Kielan-Jaworowska, Z., and Ensom, P.C., 1992, Multituberculate mammals from the Upper Jurassic Purbeck Limestone Formation of southern England: Palaeontology, v. 35, p. 95-126.

Kielan-Jaworowska, Z., and Hurum, J.H., 2001, Phylogeny and systematics of multituberculate mammals: Palaeontology, v. 44 (3), p. 389-429.

Kielan-Jaworowska, Z., and Sochava, A.V., 1969, The first multituberculate from the uppermost Cretaceous of the Gobi Desert (Mongolia): Acta Palaeontologica Polonica, v. 14, p. 355-371.

Lillegraven, J.A., 1969, Latest Cretaceous mammals of the upper part of Edmonton Formation of Alberta, Canada, and review of marsupial-placental dichotomy in mammalian evolution: Paleontological Contributions, University of Kansas, v. 50 (Vertebrata 12), p. 1-122.

Lillegraven, J.A., and McKenna, M.C., 1986, Fossil mammals from the "Mesaverde" Formation (Late Cretaceous, Judithian) of the Bighorn and Wind River basins, Wyoming, with definitions of Late Cretaceous North American Land-mammal "Ages": American Museum Novitates, no, 2840, p. 1-68.

Lofgren, D.L., 1995, The Bug Creek problem and the Cretaceous-Tertiary transition at McGuire Creek, Montana: University of California Publications in Geological Sciences, v. 140, 185 p.

Marsh, O.C., 1889, Discovery of Cretaceous mammals, part ii: American Journal of Science Series 3, v. 38, p. 177-180.

Montellano, M., 1992, Mammalian fauna of the Judith River Formation (Late Cretaceous, Judithian), north-central Montana: University of California, Publications in Geological Sciences, v. 136, p. 1-115.

Montellano, M., Weil, A., and Clemens, W.A., 2000, An exceptional specimen of *Cimexomys judithae* (Mammalia: Multituberculata) from the Campanian Two Medicine Formation of Montana, and phylogenetic status of *Cimexomys*: Journal of Vertebrate Paleontology, v. 20 (2), p. 333-340.

Novacek, M., and Clemens, W.A., 1977, Aspects of intrageneric variation and evolution of *Mesodma* (Multituberculata, Mammalia): Journal of Paleontology, v. 51, p. 701-717.

Rougier, G.W., Wible, J.R., and Novacek, M.J., 1996, Middle-ear ossicles of the multituberculate *Kryptobaatar* from the Mongolian Late Cretaceous: implications for mammaliamorph relationships and the evolution of the auditory apparatus: American Museum Novitates, no. 3187, 43 pp.

Sahni, A., 1972, The vertebrate fauna of the Judith River Formation, Montana: American Museum of Natural History Bulletin, v. 147, p. 321-412.

Simmons, N.S., 1993, Phylogeny of Multituberculata, *in* Szalay, F.S., Novacek, M.J., and McKenna, M.C., editors, Mammalian Phylogeny, Vol. 1, Mesozoic Differentiation, Multituberculates, Monotremes, Early Therians, and Marsupials: Springer-Verlag, New York, p. 146-164.

Sloan, R.E., and Van Valen, L., 1965, Cretaceous mammals from Montana: Science, v. 148, p. 220-227.

Weil, A.I., 1999, Multituberculate phylogeny and mammalian biogeography in the Late Cretaceous and earliest Paleocene Western Interior of North America: Ph.D. dissertation University of California, Berkeley, 243 p.

Table 1. Comparison of measurements, ratios, and cusp formulae of fourth premolars of Kaiparowits Formation species of *Mesodma* to other species. Boldface specimen numbers indicate specimens described in this paper; "*" indicates damaged specimen; "e" indicates measurement estimated from a depicted specimen; "?" indicates an uncertain value; "!" indicates an unusual value.

Tooth	Taxon	Source	S:ER:IR	AP	H	H:AP	AL:AP	p4:m1	P4:p4
p4	*M. hensleighi*	Lillegraven, 1969	11:8:9	2.70				1.50	0.66
	"	Archibald, 1982	9-10:7:7	2.66-2.89	1.04-1.39	0.45	0.47	1.49	0.64
	M. archibaldi	**MNA V7533**	9:6:7	2.90	1.52	0.52	0.48	1.57	
	M. formosa	Lillegraven, 1969		3.05-3.10				1.34	0.67
	"	Archibald, 1982	11:8:7	3.09	1.44	0.47			0.74
	M. thompsoni	Lillegraven, 1969		4.3				1.51	
	"	Archibald, 1982	12-13:10:9	4.55-4.61	1.96-2.21	0.45	0.43	1.67	0.56
	M. garfieldensis	Archibald, 1982	11-14:9-10:10	3.50-4.57	1.64-2.13	0.48	0.43	1.59	0.71
	M. primaeva	Sahni, 1972	11:?:?	4.7e		0.5e			
	"	Novacek & C., 1977		4.59-4.81		0.42			
	M. "*primaeva*"	Lilleg. & McK., 1986		3.48-3.47?					1.00!
	"	Montellano, 1992	11:?:?	3.71?					1.16!
	M. sp. (large)	**UMNH VP7642**	10:7:7	3.70	2.17	0.59	0.53*	1.47	0.7
	M. senecta	Fox, 1971	15:13:13	4.6		0.46e			0.6
	"	Novacek & C., 1977		4.18-4.54		0.44			
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**H:AP**	**PL:AP**	**P4:M1**
P4	*M. hensleighi*	Lillegraven, 1969	1:6	1.60-1.90	0.70-0.90	0.45	0.48e	0.39e	0.81
	"	Archibald, 1982	1-2:6	1.73-1.79	1.07-1.10	0.61			0.81
	M. formosa	Lillegraven, 1969	2:6	2.05	1.01	0.49	0.48e	0.31e	0.66
	"	Archibald, 1982	1-2:6-7	2.18-2.42	1.19-1.28	0.55			0.90
	M. thompsoni	Clemens, 1964	1-6:5-8	2.3-3.2	1.0-1.5	0.4	0.5e	0.54e	
	"	Archibald, 1982	2-5:6-7	2.51-2.56	1.36-1.58	0.57			0.78
	M. garfieldensis	Archibald, 1982	1-4:7-8	2.42-3.23	1.63-2.27	0.50	0.4-0.5e	0.32-0.35e	0.84
	M. senecta	Fox, 1971	1-2:6	2.7			0.5e	0.35e	
	M. sp. (large)	**MNA V5315**	2:6	2.79	1.47	0.53	0.63	0.37	
	"	**OMNH 20351**	1:6	2.38	1.15	0.48	0.55	0.34	
	"	**OMNH 20366**	3:6	2.62	1.32	0.50	0.55	0.34	
	"	**means**	1-3:6	2.60	1.32	0.51	0.58	0.35	
	M. primaeva	Sahni, 1972	2:6	4.0					
	"	Montellano, 1992	1-2:6-7	4.10-4.43				0.28e	
	M. "*primaeva*"	Lilleg. & McK., 1986	1:7	3.39-3.60	1.77-1.89	0.52	0.54e	0.28e	
	Mesodma sp.	Montellano, 1992	3-4:6-7	2.38-2.74				0.32e	1.05!

Table 2. Comparison of measurements, ratios, and cusp formulae of lower molars of Kaiparowits Formation species of *Mesodma* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurement estimated from a depicted specimen.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	M1:m1	m2:m1
m1	*Mesodma minor*	**UMNH VP5606**	6:4	1.56	0.80	0.53		
	"	**MNA V7538**	6:4	1.54	0.82	0.53		
	"	**means**	6:4	1.55	0.81	0.53	1.30	
	M. hensleighi	Lillegraven, 1969	6:5	1.70-1.95	0.75-0.85	0.43	1.22	0.57
	"	Archibald, 1982	6:4	1.70-1.97	0.72-1.00	0.43-0.50	1.22-1.31	0.57-0.60
	M. archibaldi	**MNA V5343**	6:4	1.79	0.84	0.47		
	"	**MNA V7531**	6:4	1.89	0.88	0.47		
	"	**MNA V7536**	6:4	1.70	0.86	0.51		
	"	**OMNH 20764**	6:5	1.87	0.85	0.46		
	"	**OMNH 22298**	6:5	1.80	0.80	0.44		
	"	**OMNH 22300**	6:4	1.88	0.92	0.49		
	"	**OMNH 22835**	6:4	1.99	0.97	0.49		
	"	**OMNH 24056**	6:4	1.85	0.86	0.47		
	"	**means**	6:4-5	1.85	0.87	0.48	1.35	0.63
	M. formosa	Lillegraven, 1969	6-7:4-5	2.10-2.50	1.00-1.40	0.47	1.36	0.61
	"	Archibald, 1982	6:4-5	2.05-2.55	0.90-1.35	0.44-0.47	1.24-1.36	0.58-0.61
	M. sp. (large)	**MNA V5338**	6:4	2.55	1.15	0.45		
	"	**OMNH 20356**	6:4	2.48	1.23	0.50		
	"	**means**	6:4	2.52	1.19	0.48		
	M. garfieldensis	Archibald, 1982	6-7:4-5	2.27-2.76	0.88-1.22	0.44	1.34	0.56
	M. thompsoni	Lillegraven, 1969	7:4	2.85	1.25	0.44		0.68
	"	Archibald, 1982	6-7:5	2.65-2.90	1.05-1.30	0.44	1.29	0.75
	M. primaeva	Sahni, 1972	5-6:4	3.15-3.60		0.4e	1.2	0.7
m2	*M. archibaldi*	**MNA V4502**	4:2	1.13	1.00	0.89		
	"	**MNA V5230**	3:2	1.09	0.98	0.90		
	"	**MNA V5303**	4:2	1.14	0.99	0.87		
	"	**MNA V7531**	4:2	1.23	0.94	0.76		
	"	**UMNH VP7643**	4:2	1.10	0.98	0.89		
	"	**OMNH 20518**	4:2	1.20	0.98	0.79		
	"	**OMNH 22868**	3?:2	1.27	1.10	0.80		
	"	**means**	3-4:2	1.17	1.00	0.84		
	M. hensleighi	Lillegraven, 1969	3:2	0.95-1.10	0.80-0.90	0.83		
	"	Archibald, 1982	3-4:2	0.95-1.23	0.80-1.07	0.83-0.86		
	M. formosa	Lillegraven, 1969	3-4:2	1.25-1.60	1.00-1.40	0.84		
	"	Archibald, 1982	3:02	1.25-1.60	1.00-1.40	0.84-0.88		
	M. sp. large	**MNA V5267**	4:2	1.64	1.33	0.81		
	M. thompsoni	Lillegraven, 1969	3-4:2	1.90-2.00	1.50-1.60	0.80		
	"	Archibald, 1982	4?:2	1.75-2.15	1.35-1.60	0.77-0.80		
	M. garfieldensis	Archibald, 1982	3-4:2	1.81	1.64	0.91		
	M. primaeva	Sahni, 1972	4:2	2.4	1.7e	0.8e		

Table 3. Comparison of measurements, ratios, and cusp formulae of upper molars of Kaiparowits Formation species of *Mesodma* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurements estimated from a depicted specimen; "?" indicates uncertain value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP		
M1	*M. archibaldi*	**MNA V7524**	5:6:4	2.41	1.26	0.53		
	"	**OMNH 20511**	5:6:4	2.42	1.24	0.51		
	"	**OMNH 24039**	5:6:4	2.64	1.27	0.48		
	"	**means**	5:6:4	2.49	1.26	0.51		
	Mesodma sp.	Montellano, 1992	5-6:6-7:3-5	2.30-2.81	1.17-1.41	0.52		
	M. cf. *archibaldi*	**MNA V5291**	5:6:5	2.21	1.39	0.63		
	Mesodma sp.	Lillegr. & M.,1986	5:6:3-5	2.36-2.43	1.41-1.44	0.59-0.61		
	?*Mesodma* sp.	Fox, 1971	6:7:5	2.3	1.1	0.5		
	M. primaeva	Sahni, 1972	6:7:5	4.0e	2.0e	0.5e		
	M. minor	**MNA V4503**		2.22	1.22	0.55		
	"	**MNA V5294**			1.08			
	"	**MNA V7525**	6:6:4	1.90	1.05	0.55		
	"	**UMNH VP7635**	5:6:5?	1.90	1.05	0.55		
	"	**OMNH 20369**	5:6:4	2.04	1.10	0.54		
	"	**OMNH 24045**	4:6?:4	2.03	1.24	0.61		
	"	**means**	4-6:6:4-5?	2.02	1.12	0.56		
	M. hensleighi	Lillegraven , 1969	6-7:8-9:4-5	2.10-2.30	1.00-1.10	0.46		
	"	Archibald, 1982	6:8:5	2.10-2.60	1.00-1.30	0.46-0.49		
	M. formosa	Lillegraven, 1969	8-9:9:6-7	3.10-3.15	1.25-1.40	0.44		
	"	Archibald, 1982		2.53-3.25	1.21-1.45	0.44-0.46		
	M. thompsoni	Archibald, 1982	7-8:9:4-6	3.15-3.70	1.35-3.70	0.44-0.49		
	M. garfieldensis	Archibald, 1982	6-8:8-11:4-5	3.09-3.65	1.31-1.65	0.45		
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**M2:M1**	**M2:m2**
M2	*M. minor*	**MNA V7529**	Ri:3:3	1.25	1.13	0.95		
	"	**OMNH 20011**	Ri:3:3	1.30	1.16	0.89		
	"	**OMNH 20364**	Ri:3:3	1.26	1.14	0.91		
	"	**OMNH 22296**	Ri:3:3	1.18	1.10	0.93		
	"	**OMNH 22302**	Ri:3:3	1.15	1.13	0.98		
	"	**means**	Ri:3:3	1.23	1.13	0.92	0.61	
	M. hensleighi	Lillegraven, 1969	1:3:3	1.00-1.15	1.00-1.15	0.99	0.50	1.07
	"	Archibald, 1982		1.00-1.22	0.97-1.17	0.97-0.99	0.50-0.53	1.02-1.06
	M. formosa	Lillegraven, 1969	1:3:3	1.30-1.60	1.25-1.50	0.95	0.46	1.02
	"	Archibald, 1982		1.21-1.75	1.23-1.65	0.95-0.98	0.46-0.56	1.02-1.12
	M. sp. (large)	**OMNH 24041**	2:3:4	1.65	1.63	0.99		1.01
	M. thompsoni	Lillegraven, 1969	1:3:3-4	1.85-1.90	1.65-1.80	0.92		0.96
	"	Archibald, 1982		1.85-2.15	1.60-1.80	0.85-0.92	0.61	0.96-1.14
	M. garfieldensis	Archibald, 1982	1:3:4	2.00	1.79	0.90	0.63	1.11
	M. primaeva	Sahni, 1972	1:3:4	2.1	1.6	0.8	0.5	0.9
	"	Montellano, 1992	1:3:4	2.24-2.36	1.86-1.95	0.83		
	Mesodma sp.	Montellano, 1992	1:3:3-4	1.31-1.69	0.94-1.40	0.86	0.63	

Table 4. Comparison of measurements, ratios, and cusp formulae of upper teeth of Kaiparowits Formation species of *Cimolodon* to other species. Boldface specimen numbers indicate specimens described in this paper; "*" indicates a damaged specimen; "e" indicates measurement estimated from a depicted specimen; "?" indicates uncertain value; "!" indicates an unusual value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	PL:AP	H:AP
P4	*C. foxi*	**UMNH VP7630**	4:5	3.18	1.48	0.47	0.31	0.46*
	"	**MNA V5270**	4:5	2.99	1.42	0.48	0.35	0.41*
	"	**MNA V5302**	4:6	2.98	1.32	0.44	0.34	0.44
	"	**MNA V5339**	4:6	3.22	1.65	0.51	0.41*	0.41*
	"	**means**	4:5-6	3.09	1.47	0.48	0.35	0.43
	C. cf. *nitidus*	**MNA V5337**	3:7	3.88	2.07	0.53	0.31	0.44
	C. nitidus	Clemens, 1964	3-6:5-8	3.7-5.3	1.75-2.6	0.48	0.7e	
	"	Lillegraven, 1969	3-4:5-7	4.35-5.00	1.85-2.70	0.50	0.5e	0.5e
	"	Archibald, 1982	3-4:5-?7	3.40-4.56	2.20-2.87	0.63	0.4e	0.34e
	C. similis	Fox, 1971	1:8-9	4.1	1.8-1.9	0.45		
	C. electus	Fox, 1971	1:7-9	4.3-4.5	1.8-2.0	0.43	0.3e	0.5e
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**P4:M1**	
M1	*C. foxi*	**MNA V4638**	?:??4		1.62			
	"	**OMNH 24038**	5:7:4	2.60	1.58	0.61		
	"	**OMNH 24040**	5:7:6	2.66				
	"	**OMNH 24326**	5:6:5	2.44	1.55	0.64		
	"	**means**	5-6:7:4-6	2.57	1.59	0.62	1.2	
	C. cf. *nitidus*	**OMNH 20477**	6:7:5	5.13	2.60	0.49	0.76!	
	C. nitidus	Clemens, 1964	5-7:7-8:3-5	3.1-5.1	1.7-2.7	0.56	1.1	
	"	Lillegraven, 1969	3-4:5-7	4.70-6.15	2.80-3.20	0.56	0.89	
	"	Archibald, 1982	5-6:?7-8:?4-6	4.31-4.66	1.88-2.64	0.57	0.91	
	C. electus	Fox, 1971	7:8:7	3.9-4.0	2.3-2.5	0.6	1.1	
	C. similis	Fox, 1971	5:7:4-5	3.3-3.4	2.1	0.6	1.2	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**M2:M1**	
M2	*C. foxi*	**MNA V4635**	Ri:3:4?	1.75	1.72	0.98		
	"	**OMNH 22316**	Ri:2:5	1.78	1.58	0.89		
	"	**OMNH 24043**	Ri:2:4?	1.54	1.41	0.92		
	"	**OMNH 24044**	Ri:2:5	1.78	1.64	0.92		
	"	**means**	Ri:2-3:4?-5	1.71	1.59	0.93	0.67	
	C. cf. *nitidus*	**OMNH 20477**	3:3:2	2.98	2.62	0.95	0.58	
	C. nitidus	Clemens, 1964	1-5:3-4:4-6	2.3-3.4	2.0-3.1	1.1	0.7	
	"	Lillegraven, 1969		3.00-3.60	2.80-3.15	0.9	0.63	
	"	Archibald, 1982	1-3:4:4-6	2.42-3.57	2.02-2.64	0.97	0.61	
	C. electus	Fox, 1971	1-2:3:5-6	2.9-3.3	2.8-3.0	0.9	0.8	
	C. similis	Fox, 1971	1:3:4-5	2.6-2.7	2.2-2.6	0.9	0.8	

Table 5. Comparison of measurements, ratios, and cusp formulae for lower teeth of Kaiparowits Formation species of *Cimolodon* to other species. Boldface specimen numbers indicate specimens described in this paper; "*" indicates damaged specimen; "e" indicates measurement estimated from a depicted specimen; "?" indicates an uncertain value.

Tooth	Taxon	Source	S:ER:IR	AP	H:AP	p4:m1	AL:AP
p4	*C. foxi*	**OMNH 20483**	12:10:9	3.70	0.61		0.40
	C. sp. cf. *similis*	**OMNH 20347**	12:9:9	4.30	0.55*		0.51*
	"	**OMNH 20484**	12:7:12	3.92	0.64		0.57*
	"	**OMNH 22313**	11:9:10	4.30	0.56		0.46
	"	**MNA V7532**	12:8:9	4.26	0.57		0.55
	"	**means**	11-12:7-9:9-12	4.20	0.58		0.52
	C. similis	Fox, 1971	12:9?:8?	3.9-4.6	0.6e	1.4	0.5e
	C. electus	Fox, 1971	15:9?:9?	5.8-6.2	0.6e	1.8	
	C. nitidus	Clemens, 1964	12-14:?:?	5.0-7.1		1.5	0.52e
	"	Lillegraven, 1969		6.00-6.88	0.6e		
	"	Archibald, 1982	12-14:?:?	5.11-6.30	0.55-0.60	1.28	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	
m2	*C. foxi*	**OMNH 20005**	4:2	1.94	1.64	0.85	
	"	**OMNH 20492**	?4:2	1.64	1.5	0.92	
	C. foxi?	**MNA V7540**	3?:2	1.75	1.48	0.85	
	C. similis	Fox, 1971	4:2	2.3	2	0.9	
	C. electus	Fox, 1971	4-6:2-3	2.5-3.2	2.2-2.5	0.8	
	C. nitidus	Clemens, 1964	4-6:2	2.3-3.5	1.7-2.6	0.7	
	"	Lillegraven, 1969		3.10-3.80	2.20-2.85	0.74	
	"	Archibald, 1982	4:2	2.49-3.11	1.74-2.38	0.75	

Table 6. Comparison of measurements, ratios, and cusp formulae of molars of *Kaiparomys cifellii* from the Kaiparowits Formation to selected species of *Mesodma* and *Cimolodon*. Boldface specimen numbers indicate specimens described in this paper.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	m2:m1
m1	*Kaiparomys cifellii*	**UCM 50420**	7:4	3.04	1.48	0.49	0.65
	Mesodma thompsoni	Lillegraven, 1969	7:4	2.85	1.25	0.44	0.68
	"	Archibald, 1982	6-7:4-5	2.65-2.90	1.05-1.30	0.44	0.75
	Cimolodon similis	Fox, 1971	6-7:4	3.0-3.2	1.6-1.8	0.6	0.7
	C. nitidus	Lillegraven, 1969		4.70-5.05	2.10-2.40	0.45	0.71
	"	Archibald, 1982	6-7:4	4.48-4.53	1.97-2.11	0.45	0.63

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	
m2	*Kaiparomys cifellii*	**UCM 50420**	4:2	1.96	1.66	0.85	
	"	**UCM 50384**	5:2	2.00	1.57	0.79	
	"	**OMNH 22842**	4:2	1.80*	1.53	0.85	
	"	**MNA V5264**	4:2	1.82	1.48	0.81	
	"	**means**	4-5:2	1.87	1.53	0.82	
	Mesodma thompsoni	Lillegraven, 1969	3-4:2	1.90-2.00	1.50-1.60	0.80	
	"	Archibald, 1982	4?:2	1.75-2.15	1.35-1.60	0.77-0.80	
	Cimolodon similis	Fox, 1971	4:2	2.3	2	0.90	
	C. nitidus	Lillegraven, 1969		3.10-3.80	2.20-2.85	0.74	
	"	Archibald, 1982	4:2	2.49-3.11	1.74-2.38	0.76	

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	
M2	*Kaiparomys cifellii*	**MNA V7530**	Ri:3:4	1.75	1.60	0.91	
	"	**OMNH 20362**	3:3:3	1.55	1.52	0.98	
	"	**OMNH 22325**	4:3:3	1.62	1.61	0.99	
	"	**means**	R-3-4:3:3-4	1.63	1.58	0.96	
	Mesodma thompsoni	Lillegraven, 1969	1:3:3-4	1.85-1.90	1.65-1.80	0.92	
	"	Archibald, 1982	1:3:4	1.85-2.15	1.60-1.80	0.85-0.92	
	Cimolodon similis	Fox, 1971	1:3:3-4	2.6-2.7	2.2-2.6	0.9	
	C. nitidus	Lillegraven, 1969		3.00-3.60	2.80-3.15	0.90	
	"	Archibald, 1982	1-3:4:4-6	2.42-3.57	2.02-2.70	0.82	

Table 7. Comparison of measurements, ratios, and cusp formulae of first molars of Kaiparowits Formation species of *Meniscoessus* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurements estimated from a depicted specimen; "?" indicates uncertain value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP
m1	*M.* cf. *intermedius*	**OMNH 20507**	6:4	4.67	2.12	0.45
	M. intermedius	Fox, 1976	7:4	5.3e	2.1e	0.4e
	M. major	Sahni, 1972	8:6	5.1e	2.5e	0.5e
	M. major	Fox, 1980	7:5	6.0-6.5	2.5-4.0	0.5
	M. robustus	Clemens, 1964	5:4	7.1-9.8	3.3-4.7	0.5
M1	*M.* cf. *intermedius*	**OMNH 20481**	?:?:6?		2.88	
	M. intermedius	Fox, 1976	7:8?:5	5.7	3.2	

Table 8. Comparison of measurements, ratios, and cusp formulae of teeth of Kaiparowits Formation species of *Cimolomys* and ?*Cimolomys* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurements estimated from a depicted specimen; "?" indicates uncertain value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP		
m1	?*C. butleria*	**OMNH 22837**	6:4	2.85	1.42	0.50		
	?*Cimolomys* sp. A	Fox, 1971	6:4	3.9-4.1	2.0-2.3	0.5		
	C. clarki	Lillegraven & M., 1986	6-7:4	4.24-4.35	1.76-2.22	0.46		
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**H:AP**	**PL:AL**
P4	*C.* sp. B cf. *clarki*	**MNA V4586**	1:5	4.28	2.06	0.48	0.51	0.53
	"	**MNA V7526**	1:5	4.12	2.1	0.51	0.54	0.52
	C. "*clarki*"	Sahni, 1972	2:5-6	4.0	1.5e	0.4e		0.63
	"	Lillegraven & M., 1986	3:6	3.99	1.56	0.39	0.53e	0.38
	?*Cimolomys* sp. A	Fox, 1971	1:5	4.2	1.7	0.4	0.58e	0.47
	C. gracilis	Clemens, 1964	1-2:5-6	2.9-3.1	1.3-1.4	0.4		0.67
	"	Archibald, 1982	1-2:5-6	2.68-2.88	1.46-1.50	0.53	0.42e	0.38
	?*C. butleria*	**MNA V5341**	1:5	2.63	1.23	0.47	0.48	0.34
	"	**OMNH 20010**	1:5	2.67	1.00	0.38	0.49	0.33
	"	**OMNH 22306**	1:5	2.70	1.20	0.44	0.44	0.30
	"	**means**	1:5	2.67	1.14	0.43	0.47	0.32
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**P4:M1**	
M1	?*C. butleria*	**MNA V5226**	4:6:5?	3.13	1.87	0.60	0.85	
	C. sp. A cf. *clarki*	**OMNH 24037**	5:6:7	3.22	2.01	0.62		
	C. sp. B. cf. *clarki*	**OMNH 24327**			1.88			
	C. clarki	Sahni, 1972	5:6:6	3.5e	2.0e	0.6e	1.1e?	
	"	Lillegraven & M., 1986	7:7:5	4.20-4.36	2.34-2.73	0.59	0.94?	
	C. trochuus	Lillegraven, 1969	5:6:7	4.70-4.80	2.90	0.62		
	C. gracilis	Clemens, 1964	5-8:7-10:4-6	4.3-6.0	2.1-3.1	0.7	0.6	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**M2:M1**	
M2	*C.* sp. A cf. *clarki*	**OMNH 24324**	3:3:4	2.24	2.26	1.01	0.70	
	C. clarki	Sahni, 1972	2:3:4	2.7e	2.7e	1.0e	0.8e	
	"	Lillegraven & M., 1986	1:3:3-4	2.74-3.30	2.60-2.90	0.93	0.71	
	C. gracilis	Clemens, 1964	2-3:3-4:4-7	3.1-3.8	2.7-3.0	0.8	0.7	
	"	Archibald, 1982	2:3:4	3.38-3.73	2.95-3.25	0.87		

Table 9. Comparison of measurements, ratios, and cusp formulae of fourth premolars of Kaiparowits Formation species of *Cimexomys* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates estimates made from a depicted specimen; "?" indicates uncertain value.

Tooth	Taxon	Source	S:ER:IR	AP	H:AP	AL:AP			p4:m1	
p4	*C.* cf. *judithae*	**MNA V5312**	9:8:7	3.10	0.50	0.47				
	"	**OMNH 22315**	10:6:7	3.02	0.51	0.46				
	"	**means**	9-10:6-8:7	3.06	0.51	0.47				
	C. judithae	Sahni, 1972	9:?:?	3.0						
	"	Montellano, 1992	9:6:5	3.18	0.51e	0.46				
	C. minor	Archibald, 1982	8-9:6:6	2.66-2.74	0.59	0.52			1.08	
	"	Lofgren, 1995		2.70-2.77					1.06	
	C. gratus	Archibald, 1982	9-10?:6:6	3.72-4.26	0.52	0.54			1.19	
	"	Lofgren, 1995		3.56-4.24					1.16-1.24	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**H:AP**	**PL:AP**	**P4:M1**	**P4:p4**
P4	*C.* cf. *judithae*	**MNA V4639**	2:5	2.34	1.11	0.47	0.44	0.36		
	"	**OMNH 20190**	4:6	2.25	1.03	0.46	0.41	0.36		
	"	**means**	2-4:5-6	2.30	1.07	0.47	0.43	0.36		0.75
	C. antiquus	Fox, 1971	2:5	2.1-2.2	0.7-1.0	0.4	0.52e	0.43	0.9	
	C. judithae	Sahni, 1972	3:5	2.4			0.4e		1.0	0.8
	"	Montellano, 1992	2:5	2.15	1.00	0.47	0.47e	0.37e	0.90	
	"	Montel. et al., 2000	3:5	2.21	0.63	0.29	0.56e	0.42e	0.97	0.7
	C. minor	Archibald, 1982	3:5	2.30-2.32	1.22-1.26	0.54	0.52e	0.39e	0.94	0.87
	"	Lofgren, 1995	3:5	2.09-2.25	1.13-1.25	0.55			0.87	0.80
	C. gratus	Archibald, 1982	3-4:5-6	3.05-3.44	1.65-1.73	0.52	0.41e	0.35e	0.97	0.80
	"	Lofgren, 1995	3-4:5-6	2.77-3.38	1.31-1.91	0.53-0.55			0.93-0.96	0.77-0.81

Table 10. Comparison of measurements, ratios, and cusp formulae of m1s and M2s of *Cimexomys* or *Mesodma* sp. from the Kaiparowits Formation to species of *Cimexomys*. Boldface specimen numbers indicate specimens described here; "*" indicates a damaged specimen; "?" indicates an uncertain value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	M1:M2
m1	*Cimexomys* or *Mesodma* sp.	**UMNH VP5604**	6:4	2.37	1.13	0.48	
	"	**UMNH VP5611**	7:4	2.55	1.16	0.46	
	"	**UMNH VP7640**	7:4	2.17	1.09	0.5	
	"	**MNA V5269**	6:4	2.31	1.18	0.51	
	"	**OMNH 20006**	6:4	2.26	1.08	0.48*	
	"	**OMNH 20359**	6:4	2.37	1.18	0.50	
	"	**OMNH 20494**	6:4	2.21	1.10	0.50	
	"	**OMNH 22314**	6:4	2.37	1.25	0.53	
	"	**OMNH 22847**	6:4	2.17	1.18	0.54	
	"	**OMNH 24053**	7:4	2.38	1.19	0.50	
	"	**OMNH 24055**	6:4	2.22	1.14	0.51	
	"	**means**	6-7:4	2.31	1.15	0.50	
	Cimexomys gratus	Lofgren, 1995		2.94-3.99	1.37-1.97	0.47	
	C. gratus	Archibald, 1982	6-7:4	3.35-3.58	1.46-1.62	0.46	
	C. antiquus	Fox, 1971	6:4-5	2.1-2.2	1.1	0.51	
	C. judithae	Montellano et al., 2000	6:4	1.97	0.88	0.45	0.62
M2	*Cimexomys* or *Mesodma* sp.	**OMNH 20343**	Ri:3:4?	1.72	1.59	0.92	
	"	**OMNH 20344**	Ri:2?:4	1.60	1.55	0.92	
	Cimexomys judithae	Montellano et al., 2000	1:3:3	1.30-1.59	1.34-1.35	0.96-1.03	

Table 11. Comparison of measurements, ratios, and cusp formulae of m1s of *Cedaromys hutchisoni* from the Kaiparowits Formation to m1s of *Eobaatar*, *Dakotamys*, *Paracimexomys*, *Janumys*, *Bryceomys*, and other species of *Cedaromys*. Boldface specimen numbers indicate specimens described in this paper; "*" indicates a damaged specimen; "!" indicates an unusual value.

Taxon	Source	Formula	AP	LB	LB:AP	p4:m1	m2:m1	M1:m1
Eobaatar magnus	Kielan-J. et al., 1987	4:2?	1.6-1.8	1.1	0.7	1.94	1.0	1.1
Cedaromys hutchisoni	**MNA V4657**	4:3	1.82	1.16	0.64			
"	**MNA V5260**	4:3	1.80	1.17	0.65			
"	**MNA V5266**	4:3	1.75	1.08	0.62			
"	**MNA V5306**	4:3	1.70	1.07	0.63			
"	**MNA V7535**	4:3	1.82	1.17	0.64			
"	**MNA V7537**	5:3	1.95	1.25	0.64			
"	**OMNH 20008**	5:3	2.06	1.27	0.62			
"	**OMNH 20350**	4:3	1.90	1.23	0.65			
"	**OMNH 22318**	4:3	2.06	1.34	0.65			
"	**UMNH VP5608**	4:3	1.84	1.23	0.67			
"	**UMNH VP7631**	4:3	2.10	1.34	0.64			
"	**means**	4-5:3	1.89	1.21	0.64			1.01
Cedaromys parvus	Eaton & Cifelli, 2001	4:3	2.02-2.28	1.32-1.43	0.68	1.78	0.93	1.13
Cedaromys bestia	Eaton & Cifelli, 2001	4:3	2.42-2.64	1.51-1.69	0.64	1.68	0.94	1.03
Bryceomys fumosus	Eaton, 1995	4:3	1.32-1.88	0.81-1.18	0.61	1.79	0.79	1.12
B. hadrosus	Eaton, 1995	5:3	2.64-2.71	1.60-1.61	0.61		0.79	1.01
B. intermedius	Eaton & Cifelli, 2001	4:3	1.79-1.93	1.10-1.25	0.62	1.51	0.71	1.12
Dakotamys malcolmi	Eaton, 1995	4:3	1.82-2.02	1.03-1.23	0.58	1.38	0.86	1.04
Janumys erebos	Eaton & Cifelli, 2001	4:3	1.14-1.46	0.66-0.84	0.60		0.97	1.13
Paracimexomys priscus	Lillegraven, 1969	4:3	2.60	1.60	0.61	1.46	0.92	1.23
"	Archibald, 1982	4:3	2.06*-2.31	1.30-1.41	0.61		0.93	1.08
cf. *P. robisoni*	Eaton & Nelson, 1991	4:3	2.0-2.1	1.2-1.3	0.6		0.78!	1.07

Table 12. Comparison of measurements, ratios, and cusp formulae of M1s of Kaiparowits Formation species of *Cedaromys* and *Dakotamys* to M1s of species of *Eobaatar*, *Janumys*, *Paracimexomys*, *Bryceomys*, and other species of *Cedaromys* and *Dakotamys*. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurement estimated from a depicted specimen; "?" indicates uncertain value.

Taxon	Source	Formula	AP	LB	LB:AP	M2:M1	P4:M1	M1:m1
Eobaatar magnus	Kielan-J. et al., 1987	3:4:1	1.7-1.9	1.0-1.3	0.64	0.9	0.9	1.1
Janumys erebos	Eaton & Cifelli, 2001	3-4:4	1.33-1.52	0.65-0.85	0.54		1.15	1.13
Paracimexomys priscus	Lillegraven, 1969	4:4:2	2.60	1.60	0.62			1.00
"	Archibald, 1982	4:4:2	2.21-2.58	1.34-1.60	0.60	0.89		1.08
"	Lillegraven & M., 1986	4:4:1	2.24	1.40	0.63			
"	Montellano, 1992	4:4:2	2.4	1.86	0.78e			
P. robisoni	Eaton & Nelson, 1991	4:4:1	2.1-2.3	1.3	0.6		0.9	1.1
Dakotamys malcolmi	Eaton, 1995	4:4:1-2	1.82-2.18	1.06-1.30	0.58	0.80	1.22	1.04
Dakotamys magnus	**MNA V5301**	5:5:2 or 3	4.03	2.62	0.65			
"	**OMNH 20354**	5:5:2	4.02*	2.59	0.64*			
Cedaromys bestia	Eaton & Cifelli, 2001	3:4	2.52-2.64	1.55-1.63	0.62	0.93	1.04	1.03
Cedaromys parvus	Eaton & Cifelli, 2001	3:4	2.32	1.39-1.48	0.63	0.94	1.08	1.13
Cedaromys hutchisoni	**MNA V4583**	3:4:1						
"	**MNA V5274**	3:4:1	1.77	1.19	0.67			
"	**MNA V5288**	3:4:1						
"	**MNA V5316**	3:4:0	1.90					
"	**MNA V5340**	4:4:1	1.80	1.17	0.65			
"	**MNA V5342**	3:4:1	2.15	1.35	0.63			
"	**OMNH 20009**	3:4:1	1.87	1.23	0.66			
"	**OMNH 20340**	3:4:1	2.03	1.28	0.63			
"	**OMNH 22861**	3:4:1	1.95	1.18	0.61			
"	**OMNH 22295**	3:4:0	1.65	1.07	0.65			
"	**OMNH 22834**	3:4:0	1.95	1.31	0.67			
"	**OMNH 24054**	3?:4:1	2.07	1.30	0.63			
"	**means**	3-4:4:0-1	1.91	1.23	0.64			
Bryceomys fumosus	Eaton, 1995	3-5:4:2-3	1.52-2.10	1.05-1.39	0.68	0.77	1.20	1.12
B. hadrosus	Eaton, 1995	3-5:4:2-3	2.68	1.63-1.87	0.65	0.83		1.01
B. intermedius	Eaton & Cifelli, 2001	3-4:4:2-3	2.10	1.43	0.68	0.64	1.09	1.12

Table 13. Comparison of measurements, ratios, and cusp formulae of m1s, m2s, P4s, and M2s of Wahweap Formation species of *Mesodma* to other species. Boldface specimen numbers indicate specimens described in this paper; "e" indicates measurement estimated from a depicted specimen; "?" indicates an uncertain value.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	m2:m1	
m1	*Mesodma* sp. cf. *M. formosa*	**UMNH VP7989**	6:5	2.27	1.26	0.56		
	M. formosa	Lillegraven, 1969	6-7:4-5	2.10-2.50	1.00-1.40	0.47	0.61	
	M. formosa	Archibald, 1982		2.05-2.55	0.90-1.35		0.58-0.61	
	M. garfieldensis	Archibald, 1982	6-7:4-5	2.27-2.76	0.88-1.22	0.44	0.56	
m2	*M.* sp. cf. *M. formosa*	**MNA V4571**	4:2	1.29	1.08	0.84		
	"	**MNA V5241**	4:2	1.47	1.21	0.83		
	"	**OMNH 23340**	4:2	1.29	1.12	0.87		
	"	**means**	4:2	1.35	1.14	0.84	0.59	
	M. formosa	Lillegraven, 1969		1.25-1.60	1.00-1.40	0.84	0.61	
	M. garfieldensis	Archibald, 1982	3-4:2	1.22-1.66	1.03-1.39	0.84	0.56	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**H:AP**	**PL:AP**
P4	*Mesodma* sp. cf. *M. formosa*	**MNA V5254**	2:5	2.22	1.13	0.51	0.49	0.39
	M. formosa	Clemens, 1964	1-4:5-7	1.90-2.80	0.85-1.20			
	"	Lillegraven, 1969		2.05	0.80-1.25	0.49	0.48e	0.31e
	M. garfieldensis	Archibald, 1982	1-4:7-8	2.42-3.23	1.63-2.27	0.5	0.4-0.5e	0.32-0.35e
M2	*Mesodma* sp. cf. *M. formosa*	**MNA V5244**	Ri:3:3?	1.40	1.27	0.91		
	"	**MNA V5250**	Ri:3:4	1.41	1.35	0.96		
	"	**OMNH 20782**	Ri:3:4	1.45	1.38	0.95		
	"	**means**	Ri:3:3?-4	1.42	1.33	0.94		
	M. formosa	Lillegraven, 1969		1.30-1.60	1.25-1.50	0.95		
	M. garfieldensis	Archibald, 1982	1:3:4	1.28-1.60	1.32-1.57	0.97		

Table 14. Comparison of measurements, ratios, and cusp formulae of teeth of Wahweap Formation species of *Cimolodon* to other species of *Cimolodon* and *Cimexomys* (for p4). Boldface specimen numbers indicate specimens described in this paper, "*" indicates a damaged specimen; "e" indicates measurement estimated from a depicted specimen; "?" indicates an uncertain value.

Tooth	Taxon	Source	S:ER:IR	AP	H:AP	AL:AP			
p4	*Cimolodon similis*	**UMNH VP7592**	11:8:10	3.46	0.63	0.52			
	"	Fox, 1971	12:8?:9:	3.9-4.6	0.6e	0.5e			
	C. sp. cf. *C. nitidus*	**UMNH VP7978**	11:9:10	5.19	0.61	0.51			
	"	**UMNH VP7988**	11:9:10	5.18	0.60	0.47			
	C. nitidus	Archibald. 1982	12-14:?:?	5.11-6.30	0.55-0.60				
	C. sp. (small)	**MNA V4525**	10:6:6	2.99	0.65	0.48			
	C. foxi	**this paper**	12:10:9	3.70	0.61	0.4			
	Cimexomys judithae	Montellano, 1992	9:?:?	3.18	0.51e	0.46e			
	"	Mont. et al., 2000	9:7:7	3.18	0.43e	0.56e			
	Cimexomys gratus	Archibald, 1982	9-10:6-5:5-6	3.72-4.26	0.52				
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**			
m1	*Cimolodon electus*	**MNA V4613**	7:4	3.52	1.95	0.55			
	"	**UMNH VP7562**	6:4	3.76	1.89	0.50			
	"	Fox, 1971	6-8:4	3.3-3.5	1.7-2.2	0.57			
	Cimolodon similis	**MNA V5245**	6:4	3.20	1.72	0.54			
	"	**UMNH VP7980**	6:4	2.80	1.56	0.56			
	"	**UMNH VP7987**	6:3	2.72	1.54	0.57			
	"	**UMNH VP7989**	?:4	2.84					
	"	Fox, 1971	6-7:4	3.0-3.2	1.6-1.7	0.55			
m2	*Cimolodon electus*	**MNA V5200**	5:2	2.60	2.38	0.92			
	"	**MNA V5273**	5:2	2.56	2.12*				
	Cimolodon electus	Fox, 1971	2-3:4-6	2.5-3.2	2.2-2.5	0.8			
	Cimolodon similis	**UMNH VP7990**	4:2	2.20	1.93	0.88			
	"	Fox, 1971	4:2	2.3	2.0	0.87			
	Cimolomys clarki	Lill. & McK., 1986	5:2	2.92	2.11	0.72			
	Cimolomys gracilis	Clemens, 1964	4-6:2-3	3.2-4.2	2.1-2.9	0.6-0.7			
	Cimolodon sp. (small)	**MNA V4537**	4:2	1.89	1.59	0.84			
	Cimolodon foxi	**this paper**	4:2	1.79	1.57	0.89			
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**PL:AP**	**H:AP**	**CR**
P4	*Cimolodon similis*	**MNA V4595**	1:8	3.93	1.72	0.44	0.28	0.45*	
	"	**MNA V5217**	2:6	3.62	1.75	0.48	0.30	0.53	0.27
	"	**MNA V5221**	2:7	3.71			0.32	0.44	0.32
	"	**means**	1-2:6-8	3.75	1.74	0.46	0.30	0.49	0.30
	"	Fox, 1971	1:8-9	4.1	1.8-1.9	0.45			
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**			
M1	*Cimolodon electus*	**MNA V5234**	6:7:5	3.76	2.43	0.65			
	"	Fox, 1971	7:8:7	3.9-4.0	2.3-2.5	0.61			
	Cimolodon. similis	Fox, 1971	5:7:4	3.3-3.4	2.1	0.63			
	C. sp. cf. *C. nitidus*	**UMNH VP7981**	6?:7:5?	4.58e	2.61e	0.60e			
	Cimolodon nitidus	Clemens, 1964	5-7:7-8:3-5	3.1-5.1	1.7-2.7	0.56			
	"	Lillegraven, 1969	6-7:7-8:6-8	4.70-6.15	2.80-3.20	0.56			
	"	Archibald, 1982	5-6:?7-8:?4-6	4.31-4.66	1.88-2.64	0.57			

Table 15. Comparison of measurements, ratios, and numbers of medial row cusps (P4) and internal row cusps (M1) of *Meniscoessus* sp. cf. *M. intermedius* from the Wahweap Formation to other species of *Meniscoessus*. Boldface specimen numbers indicate specimens described in this paper; "*" indicates a damaged specimen; "e" indicates a measurement estimated from a figured specimen.

Tooth	Taxon	Source	Medial Cusps	AP	H:AP	PL:AP
P4	*M*. sp. cf. *M. intermedius*	**MNA V5287**	5	2.11*	0.80*	0.48*
	Meniscoessus major	Sahni, 1972	4 or 5	3.3e		
	Meniscoessus robustus	Archibald, 1982	3-4	3.60-4.40		
	Meniscoessus ferox	Fox, 1971	4	4.5		
Tooth	**Taxon**	**Source**	**Internal Cusps**	**LB**		
M1	*M*. sp. cf. *M. intermedius*	**MNA V5281**	5	2.63		
	Meniscoessus intermedius	Fox, 1976	5	3.2		
	Meniscoessus major	Montellano, 1992	6	3.36-4.40		
	Meniscoessus robustus	Archibald, 1982	6-7	4.77-5.71		

Table 16. Comparison of measurements, ratios, and cusp formulae of teeth of Wahweap Formation species of *Cimolomys* and ?*Cimolomys* to other species. Boldface specimen numbers indicate specimens described in this paper; "?" indicates an uncertain value; "*" indicates a damaged specimen; "e" indicates a measurement estimated from a figured specimen.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP			
m1	?*Cimolomys* sp. A	**MNA V5218**	4:4	2.77	1.55	0.56			
	?*Cimolomys butleria*	**this paper**	6:4	2.85	1.42	0.50			
	?*Cimolomys* sp. A	Fox, 1971	6:4	3.9-4.1	2.0-2.3	0.50			
	Cimolomys clarki	Sahni, 1972	5-6:4	3.15?-3.6?					
	Cimolomys "*clarki*"	Lill. & McK., 1986	6-7:4	4.24-4.35	1.76-2.22	0.46			
	Cimolomys gracilis	Clemens, 1964	7-8:5-7	4.3-5.5	1.8-2.5	0.40			
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**H:AP**	**PL:AL**	**CR**
P4	*C*. sp. cf. *C. trochuus*	**MNA V5326**	1:5	3.85	1.71*	0.44*	0.55	0.34	0.58
	"	**OMNH 23350**	1:5	4.16	1.74	0.42	0.50*	0.33*	0.44*
	"	**means**	1:5	4	1.73	0.43	0.53	0.34	0.51
	?*Cimolomys* sp. A	Fox, 1971	1:5	4.2	1.7	0.4	0.58e	0.47	
	Cimolomys "*clarki*"	Sahni, 1972	2:5-6	4	1.5e	0.4e		0.63	
	"	Lill. & McK., 1986	3:6	3.99	1.56	0.39	0.53	0.38	
	Cimolomys gracilis	Clemens, 1964	1-2:5-6	2.9-3.1	1.3-1.4	0.4		0.67	
	"	Archibald, 1982	1-2:5-6	2.68-2.88	1.45-1.50	0.53	0.42e	0.38	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**			
M2	?*Cimolomys* sp. C (large)	**MNA V4559**	Ri:3:4	3.16	3.08	0.98			
	Cimolomys clarki	Lill. & McK., 1986	1:3:3-4	2.74-3.30	2.60-2.90	0.93			
	Cimolodon electus	Fox, 1971	1-5:3-4:4-6	2.9-3.3	2.8-3.0	0.9			
	?*Cimolomys* sp. B	**MNA V4529**	2?:3:4	2.58	2.47	0.96			
	"	**MNA V5206**	1:3:4	2.33	2.48	1.06			
	"	**MNA V5320**	1?:3:4	2.36	2.20	0.93			
	"	**OMNH 20956**	3:3:4?	2.64	2.37	0.90			
	"	**UMNH VP7595**	?	2.53	2.19	0.87			
	"	**means**	1-3:3:4?	2.49	2.34	0.91			
	Cimolodon similis	Fox, 1971	1:3:4	2.6-2.7	2.4-2.6	0.91			

Table 17. Comparison of measurements, ratios, and cusp formulae of first molars of Wahweap Formation species of *Cimexomys* to other species. Boldface specimen numbers indicate specimens described in this paper; "?" indicates and uncertain value; "*" indicates a damaged specimen.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP
m1	*Cimexomys* sp. cf. *antiquus*	**MNA V5247**	5:4?	1.72	0.92	0.54
	"	**MNA V5324**	?5:4	1.95	1.1	0.56
	Cimexomys antiquus	Fox, 1971	6:4-5	2.1-2.2	1.1	0.51
	Cimexomys judithae	Montellano et al., 2000	6:4	1.97	0.88	0.45
	Cimexomys gratus	Archibald, 1982	6-7:4	3.35-3.58	1.45-1.62	0.46
M1	*Cimexomys* sp. cf. *antiquus*	**MNA V5205**	4:6:2?	2.05*	1.29	0.63*
	Cimexomys antiquus	Fox, 1971	5:6:3-4	2.2-2.6	1.2-1.5	0.56
	Cimexomys judithae	Montellano et al., 2000	5:6:1+	2.29-2.39	1.12-1.20	0.50
	cf. *Cimexomys* sp.	Montellano, 1992	5-6:5-7:2	1.95-2.20	0.98-1.40	0.53

Table 18. Comparison of measurements, ratios, and cusp formulae of molars of Wahweap Formation species of cf. *Paracimexomys*, *Cedaromys*, cf. *Cedaromys*, *Bryceomys*, and genus and species unknown to other species. Boldface specimen numbers indicate specimens described in this paper; "*" indicates damaged specimen.

Tooth	Taxon	Source	Formula	AP	LB	LB:AP	m2:m1
m1	cf. *Paracimexomys* sp. A	**MNA V4599**	4:3	1.57	1.03	0.66	
	"	**MNA V4567**	4:3	1.50*	1.01	0.67*	
	"	**MNA V5325**	4:3	1.63	1.05	0.64	
	"	**means**	4:3	1.57	1.03	0.66	
	cf. *Paracimexomys perplexus*	Eaton & Cifelli, 2001	5:3	1.52-1.82	0.86-1.15	0.58	
	Paracimexomys priscus	Archibald, 1982	4:3	2.06-2.31	1.20-1.41	0.61	
	cf. *Paracimexomys* sp.	Eaton, 1995	4:3	1.32	0.98	0.74	
	cf. *Paracimexomys* sp. B	**UMNH VP7982**		2.05*	1.02*	0.50*	1.02*
	Cedaromys sp.	**MNA V7534**	4:3	1.73	1.09	0.63	
	Cedaromys hutchisoni	this paper	4-5:3	1.70-2.06	1.07-1.34	0.64	
	cf. *Cedaromys* sp.	**MNA V4627**	4:3	2.11*	1.28	0.61*	
m2	cf. *Paracimexomys* sp. B	**UMNH VP7982**		2.10*	1.38*	0.66*	1.02*
	genus & sp. unknown	**MNA V5322**	3:2	1.12	0.94	0.84	
	"	**OMNH 23362**	?	1.32	0.88	0.67	
Tooth	**Taxon**	**Source**	**Formula**	**AP**	**LB**	**LB:AP**	**M2:M1**
M1	cf. *Paracimexomys* sp. A	**MNA V5240**	4:4:1	1.73	0.91*	0.53*	0.88
	cf. *Paracimexomys perplexus*	Eaton & Cifelli, 2001	5:4:1-2	1.53-1.94	0.97-1.20	0.62	
	Paracimexomys priscus	Archibald, 1982	4:4:2	2.21-2.58	1.34-1.60	0.60	0.89
	cf. *Paracimexomys* sp.	Eaton, 1995	4:4:1	1.51-1.72	0.92-0.99	0.61	0.74
	Bryceomys sp. cf. *B. fumosus*	**MNA V7527**	5?:4:2	1.77	1.18	0.67	
	Bryceomys fumosus	Eaton, 1995	3-5:4:2-4	1.52-2.10	1.05-1.39	0.68	
M2	cf. *Paracimexomys* sp. A	**MNA V5233**	Ri:2:3	1.52	1.29	0.85	
	"	**OMNH 22544**	Ri:2:3	1.55	1.38	0.89	
	"	**OMNH 24363**	Ri:2:3	1.48	1.27	0.86	
	"	**means**	Ri:2:3	1.52	1.31	0.86	0.88

Table 19. Comparison of Wahweap and Kaiparowits Formation multituberculate species to those of the Aquilan, Judithian, "Edmontonian," and Lancian North American Land Mammal "Ages." Land Mammal "Age" faunas based on Lillegraven and McKenna (1986), Lofgren (1995), and Weil (1999). "X"- indicates conspecific occurrence; "cf." indicates conferred occurrence of species, and "?" indicates a possible conspecific occurence. Taxa with a “*” after them were considered unique occurrences within that "age" by Lillegraven and McKenna (1986).

Aquilan multituberculate taxa	**Wahweap Formation**	**Kaiparowits Formation**
*Mesodma senecta**		
*Cimexomys antiquus**	cf.	
*Paracimexomys magister**		
*Cimolodon electus**	X	
*Cimolodon similis**	X	cf.
?*Cimolomys* sp. A* (Fox, 1971)	?	
?*Cimolomys* sp. B* (Fox, 1971)		
*Meniscoessus ferox**		
Judithian multituberculate taxa		
*Mesodma primaeva**		
Mesodma archibaldi sp. nov.		X
*Cimexomys judithae**		cf.
*Dakotamys magnus**		X
*Cimolomys clarki**		cf.
*Meniscoessus intermedius**	cf.	cf.
*Meniscoessus major**		cf.
Paracimexomys priscus		
"Edmontonian" multituberculate taxa		
Mesodma cf. *M. thompsoni*		
Cimexomys sp. cf. *C. judithae*		
Kimbethohia campi		
Cimolodon nitidus	cf.	cf.
Cimolomys gracilis		
Meniscoessus robustus		
Lancian multituberculate taxa		
Mesodma formosa	cf.	
*Mesodma hensleighi**		
Mesodma thompsoni		
Cimolodon nitidus	cf.	cf.
?*Neoplagiaulax burgessi*		
*Cimexomys minor**		
*Cimolomys trochuus**	cf.	
Essonodon browni *		

Table 20. Multituberculate faunas from the Wahweap and Kaiparowits formations with known occurrences of similar species of North American Land Mammal "Ages." "X" indicates the occurrence of similar species and "?" indicates the presence of a possibly similar species. The "*" after some taxonomic names indicate that a similar species is shared by both the Wahweap and Kaiparowits formations.

	Aquilan	Judithian	"Edmontonian"	Lancian
Wahweap Formation				
Mesodma sp. cf. *M. formosa*				X
Cimolodon electus	X			
*Cimolodon similis**	X			
Cimolodon sp. cf. *C. nitidus**			X	X
Cimolodon sp. (small)*				
Meniscoessus sp. cf. *M. intermedius**		X		
Cimolomys sp. cf. *C. trochuus*				X
?*Cimolomys* sp. A	?			
?*Cimolomys* sp. B	?			
?*Cimolomys* sp. C (large)				
Family indeterminate		?		
Cimexomys sp. cf. *C. antiquus*	X			
cf. *Paracimexomys* sp. A				
cf. *Paracimexomys* sp. B				
Bryceomys sp. cf. *B. fumosus*				
Cedaromys sp.				
cf. *Cedaromys* sp.				
Genus and species unknown				
Kaiparowits Formation				
Mesodma archibaldi, sp. nov.		X		
Mesodma sp. cf. *M. archibaldi*, sp. nov.		?		
Mesodma minor, sp. nov.				
Mesodma sp. (large)	?			
Cimolodon foxi, sp. nov.*				
Cimolodon sp. cf. *C. nitidus**			X	X
Cimolodon sp. cf. *C. similis**	X			
Kaiparomys cifellii, gen. & sp. nov.				
Meniscoessus sp. cf. *M. intermedius**		X		
Meniscoessus sp. cf. *M. major*		X		
Cimolomys sp. A cf. *C. clarki*		X		
Cimolomys sp. B cf. *C. clarki*		X		
?*Cimolomys butleria*, sp. nov.	?	?		
Cimexomys sp. cf. *C. judithae*		X	?	
Cedaromys hutchisoni, sp. nov.				
cf. *Cedaromys* sp.				
Dakotamys magnus		X		