Additional Uintan and Duchesnean (Middle and Late Eocene) Mammals from the Sespe Formation, Simi Valley, California

Thomas S. Kelly¹ and David P. Whistler¹

ABSTRACT: A paleontologic resource impact mitigation program at the Simi Valley Landfill, Ventura County, California, is yielding new taxa and new geologic records of middle and late Eocene mammals from the middle member of the Sespe Formation. New Uintan taxa and new occurrences recorded from Simi Valley are Centetodon sp., cf. C. astecus; erinaceomorph, gen. and sp. undet.; Uintasorex sp., cf. U. montezumicus; Microparamys woodi n. sp.; Microparamys sp., cf. M. tricus; Micacis sp. undet.; and ?iscapotaphid, gen. and sp. undet. New Duchesnean taxa and new occurrences recorded from Simi Valley are Peradectes californicus; Leptotomus sp. undet.; ?Camelidae, gen. and sp. undet.; Simimeryx sp., aff. S. hudsonii; and Mammalia, gen. and sp. undet. Sespepectes singularis is now recorded from the Simi Valley Landfill Local Fauna, and this occurrence extends the geologic range of this species upward into the late Duchesnean. Additional specimens of the rare taxa Dyseodon pacificus, Griphomyx alecer, and Protyleopus robustus are now available and allow reevaluation of the intraspecific variation in the teeth of these species.

INTRODUCTION

The middle member of the nonmarine Sespe Formation, which is exposed along the northern side of Simi Valley, Ventura County, California, has yielded diverse middle and late Eocene land mammal assemblages (Stock, 1932; Golz, 1976; Golz and Lillegraven, 1977; Mason, 1988; Kelly, 1990, 1992; Kelly et al., 1991). Kelly et al. (1991) documented the preliminary results of a paleontologic resource impact mitigation program that is being conducted in the lower and middle members of the Sespe Formation at the Simi Valley Landfill. The program has yielded many new taxa and new geologic and geographic records from the Sespe Formation that were discussed only briefly by Kelly et al. (1991). Many of these new taxa and records are biostatistically significant and have not been adequately described. Kelly (1992) recently described the rodents of the families Eomyidae, Helisoconyidae, Simimyidae, and ?Zapodidae recovered during the program. The report herein describes additional new taxa and new specimens of poorly known taxa that were discovered during the program.

METHODS

All specimens were recovered from the middle member of the Sespe Formation by a process described by Kelly et al. (1991) that included wet screening of bulk matrix samples and heavy liquid separation of fossils. All specimens described herein are deposited in the Vertebrate Paleontology Collection of the Natural History Museum of Los Angeles County.

Measurements of large teeth were made to the nearest 0.1 mm with a vernier caliper, and those of smaller teeth were made with an AO optical micrometer to the nearest 0.01 mm. All teeth were measured at their greatest dimensions. Metric abbreviations and dental formulae follow standard usage.

All cladistic analyses were performed using Version 1.5 of the Hennig86 computer program (Farris, 1988) and run on a 386 personal computer. Cladograms were generated using the IE COMMAND that computes the most parsimonious cladograms by implicit enumeration. Weighting of characters was accomplished by using the XSTEPS W COMMAND that sets the character weights of the cladograms generated by the IE COMMAND by calculating the best fits of each character based on the product of the character consistency and character retention indices. The characters and character states used in the cladistic analyses are presented in Appendix A and the character state matrices for each group of taxa analyzed are presented in Appendices B, C, and D.

Institutional acronyms are as follows:

CIT—California Institute of Technology
LACM—Natural History Museum of Los Angeles County

¹ Vertebrate Paleontology Section, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007.
LACM (CIT)—California Institute of Technology locality, numbers and specimens now held by LACM
UCMP—University of California, Berkeley, Museum of Paleontology
UCMP-V—University of California, Berkeley, Museum of Paleontology, vertebrate fossil locality
UCR—University of California, Riverside, Department of Earth Sciences

Abbreviations are as follows:

A-P—Anteroposterior
ANT—anterior
Ar-Ar—argon-argon
C.V.—coefficient of variation
K-Ar—Potassium-argon
L—left
Ma—million years before present
N—number of specimens
O.R.—observed range
POST—posterior
R—right
S.D.—standard deviation
TR—transverse

SYSTEMATIC PALEONTOLOGY

Order Marsupialia Illiger, 1811
Family Didelphidae Gray, 1821
Tribe Peradectini Crochet, 1979
Genus Peradectes
Matthew and Granger, 1921

Peradectes californicus (Stock, 1936)

Figure 1

REFERRED SPECIMENS. L.M., LACM 130750; 2L.M.s, LACM 130831, 130832 4L.M.s, LACM 130830, 130835, 130837, 130838; RM., LACM 130839; RM., LACM 130829.

LOCALITIES. LACM 5661, 5857, 5866, 5869.

FAUNAS AND AGE. Tapo Canyon and Brea Canyon Local Faunas, late Uintan.

DESCRIPTION. Only one upper molar referable to Centetodon has been recovered during the impact mitigation program. The upper molar has a robust parastyle that is directed anterolabially. The large metastyle is directed posterolabially and positioned much farther labially than the parastyle. The paracone and metacone are conical cusps with sharp-tipped apices and are positioned relatively close together toward the midline of the tooth. The protocone is a well-developed cusp with the preprotocone and postprotocone extending to a very small protocone and metacone, respectively. The anterior cingulum is moderately developed and extends lingually from the middle of the anterior surface of the tooth to the anterolinguinal base of the protocone. The posterior cingulum is well developed and extends lingually from the posterior surface of the tooth, at the level of the metacone, to terminate in a distinct small bulge at the posterolinguinal base of the protocone. Although the roots are broken off near the base of the tooth, a single lingual root appears to have been present.

The lower molars are typical of those of Centetodon and are characterized by the following: (1) they have a basic tribosphenic pattern; (2) the an-
terior cingulid is well developed; (3) the paraconid is shelf-like; (4) the protoconid is the tallest cusp; (5) the cristid obliqua is usually medially concave; and (6) the entoconid and hypoconulid are positioned close together on the M₃.

**DISCUSSION.** The specimens of *Centetodon* from Simi Valley are very similar morphologically to those of *C. aztecus* of the Friars and Mission Valley Formations from the San Diego area, California, particularly with regard to the possession of a medially concave cristid obliqua on the lower molars. The mean measurements of the lower molars from Simi Valley are slightly larger than those of the sample of *C. aztecus* from the San Diego area. However, all of the Simi Valley lower molars fall within the observed range or within less than one standard deviation from the mean of those for *C. aztecus*. The M₁ from Simi Valley is smaller than any of those of *C. aztecus* from the San Diego area and is about three and one-half standard deviations from the mean of those of the San Diego sample. It is difficult to determine the significance of this size difference because only five M₃’s of *C. aztecus* are known and such a small sample is not expected to include the full range of intraspecific variation. Furthermore, the discrepancies in the comparative upper and lower molar sizes within the Simi Valley sample of *Centetodon* indicate that the sample either represents more than one species or a highly variable species. Until a larger sample from the Sespe Formation is available for adequate analysis and comparison with the San Diego sample, the Simi Valley teeth are herein referred to *C.* sp., cf. *C. aztecus*, recognizing that this taxon may represent more than one species.

**Suborder Erinaceomorpha**
Gregory, 1910

**Family Dormaaliidae** Quinet, 1964

**Subfamily Sespedectinae**
Novacek, 1985

**Genus Sespedectes** Stock, 1935c

*Sespedectes singularis* Stock, 1935c

**Figure 3**

**REferred Specimens.** Partial dentary with RM₁, LACM 132459; LM₁, LACM 132458.

**Locality.** LACM 5876.

**Fauna and Age.** Simi Valley Landfill Local Fauna, late Duchesnean.

**Discussion.** The two lower molars from LACM 5876 are morphologically indistinguishable from those of *S. singularis*. The measurements of LACM 132458 are 1.96 mm A-P, 1.35 mm ANT-TR, and 1.32 mm POST-TR, and those of LACM 132459 are 1.85 mm A-P, 1.51 mm ANT-TR, and 1.47 POST-TR.

These molars are significant because they represent the highest stratigraphic occurrence of *S. singularis* in the Sespe Formation and extend the geologic range of this species into the late Duchesnean.

*Sespedectinae* Novacek, 1985

erinaceomorph, gen. and sp. undet.

**Figure 4**

**REferred Specimens.** RP₁, LACM 131088; RM₁, LACM 131091.

---

**Table 1. Measurements (mm) of dentition of Centetodon sp., cf. C. aztecus.**

<table>
<thead>
<tr>
<th>N</th>
<th>Tooth/ dimension</th>
<th>O.R.</th>
<th>Mean</th>
<th>S.D.</th>
<th>C.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M¹ A-P</td>
<td>1.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ANT-TR</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>POST-TR</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>M₁ A-P</td>
<td>1.71-1.77</td>
<td>1.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ANT-TR</td>
<td>1.10-1.24</td>
<td>1.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>POST-TR</td>
<td>0.99-1.06</td>
<td>1.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>M₂ A-P</td>
<td>1.48-1.75</td>
<td>1.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ANT-TR</td>
<td>1.00-1.15</td>
<td>1.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>POST-TR</td>
<td>0.83-0.99</td>
<td>0.90</td>
<td>0.07</td>
<td>7.8</td>
</tr>
<tr>
<td>1</td>
<td>M₁ A-P</td>
<td>1.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ANT-TR</td>
<td>1.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>POST-TR</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.** *Centetodon* sp., cf. *C. aztecus* Lillegraven et al., A. RM₁, LACM 130750; B. LM₁, LACM 130835. All occlusal views. Scale = 1 mm.

**Figure 3.** *Sespedectes singularis* Stock, A. RM₁, LACM 132459; B. LM₁, LACM 132458. All occlusal views. Scale = 1 mm.
LOCALITY. LACM 5863.

FAUNA AND AGE. Brea Canyon Local Fauna, late Uintan.

DESCRIPTION. The P4 is subtriangular in occlusal outline and the labial surface is straight. The paracone is slightly compressed transversely and taller than the protocone. An incipient metacone is present posterior to the paracone along a sweeping posterior crest of the paracone (= metastylar crest). The parastyle is a small distinct cusp. The posteriorlingual cingulum extends posteriorly from the protocone and joins the posterior cingulum. The measurements of the P4 are 1.86 mm A-P and 1.89 mm A-NT-TR.

The partial M2 is missing the paracone, metacone, and part of the anterior cingulum. The paracone is smaller than the metacone and is connected to the protocone by the preprotocrista. The metacone is a prominent, relatively isolated cusp. The protocone is a tall, sharp-crested cusp with the postprotocrista extending postero-labially and terminating at the posterior aspect of the metacone. The hypocone is a well-developed cusp that is connected to the posterior and lingual cingulae. Although only partially represented, the anterior cingulum appears to have been robust. The only measurement that can be estimated for the partial M2 is the A-P, which is 1.9 mm.

DISCUSSION. The P4 and M2 from locality LACM 5863 are morphologically most similar to those of Sespedectes, Proterixoides Stock, 1935c, and Crypholestes (Novacek, 1976). The P4 and M2 are smaller than those of Proterixoides, slightly larger than those of Sespedectes, and about the same size as those of Crypholestes. They differ from those of Sespedectes by having the P4 less transversely elongated with a smaller metacone on the metastylar crest and more acute cusps (less bunodont), and the M2 with a less bunodont protocone, a much more robust precingulum, a weaker hypocone that is positioned further posteriorly, and a well-developed lingual cingulum between the hypocone and protocone. They differ from those of Proterixoides by having the M2 with a lingual cingulum present and sharper (less conical) primary cusps. They differ from those of Crypholestes by having the P4 less transversely elongated, the M2 metacone more isolated, and an M2 lingual cingulum present.

The P4 and partial M2 from locality LACM 5863 appear to represent a new species of Erinaceomorph insectivore most closely related to species of the Sespecidinae. However, due to the lack of adequate material, these specimens are referred to Erinaceomorph, gen. and sp. undet.

Order Primates Linnaeus, 1758
Family Omomyidae Trouessart, 1879
Genus Dyseolemur Stock, 1934a
Dyseolemur pacificus Stock, 1934a

REFERRED SPECIMENS. LP4, LACM 131087; RM2, LACM 131089; LP4, LACM 131090; partial RM4, LACM 130749.

LOCALITIES. LACM 5616, 5863.

FAUNA AND AGE. Brea Canyon Local Fauna, late Uintan.

DESCRIPTION. The P4 (LACM 131087), the first upper premolar from the Sespe Formation referred to D. pacificus, is only slightly worn. The paracone is a sharp tall cusp that is slightly compressed transversely. The labial margin of the tooth is convex. The posterolabial aspect of the tooth is swollen and larger than the antero-labial aspect. The preparacrista extends anteriorly from the paracone to the posterior aspect of the tooth and then turns labially to join the labial cingulum. The postparacrista extends posteriorly to the posterior cingulum and then turns labially to join the labial cingulum. A very small metastyle is present at the junction of the postparacrista and the labial cingulum. A small distinct para-style is present. The protocone is a conical cusp with a sharply pointed apex. A small short preprotocrista extends antero-labially from the.
protocone to the base of the paracone. The postproto- cristra is a weak crest that extends posteriorly down the posterior surface of the protocone, wherein it joins the posterior cingulum. A small bulge, which appears to represent an incipient hypocone, is present at the junction of the postproto- cristra and the posterior cingulum. The precingulum is a distinct crest that extends labially from the anterior base of the protocone to the parastyl. The posthypocone cristra is robust and extends labially from the incipient hypoconal bulge to the anterior base of the paracone, near the point where the preproto cristra turns labially. The labial cingulum is complete across the labial surface of the tooth but is distinctly thinner along the medial labial aspect. The measurements of the P4 are 1.81 mm A-P and 2.16 mm TR.

The M2 discovered during the program is well preserved and less worn than the two previously known M’s of D. pacificus. It differs from these M’s by the following characters: (1) the metaconule is better developed and slightly more isolated; (2) a connecting crest from the metaconule to the metacone is lacking; and (3) the hypocone is a distinct cusp on the posterior cingulum. The measurements of the M2 are 1.72 mm A-P and 1.44 mm TR, and those of the M2 are 2.03 mm A-P and 2.01 mm ANT-TR.

DISCUSSION. The impact mitigation program has resulted in the recognition of additional specimens of the rare primate D. pacificus, including the first P4 from the Sespe Formation referable to this species. Walsh (1987) assigned a P4 from the Mission Valley Formation in the San Diego area to D. pacificus, and a comparison of the description of this specimen with the newly discovered Simi Valley specimen appears to substantiate his assignment.

Szalay and Delson (1979) regarded Dyseolemur, Washakius Leidy, 1873, and Shoshonius Granger, 1810, as related because they shared the derived character of having mesostylids present on the lower molars. Szalay and Delson considered Dyseolemur more closely related to Washakius than to Shoshonius because the upper molars of Shoshonius possess mesostyles whereas in Washakius and Dyseolemur they lack mesostyles. Furthermore, Szalay and Delson noted that the shape of the M3 talonid notch of Dyseolemur and Washakius is nearly identical. A close relationship between Dyseolemur and Washakius is further supported because the Simi Valley P4 of Dyseolemur also exhibits greater morphological similarity to those of Washakius than to those of Shoshonius. In Shoshonius a distinct metacone is present on the P4, resulting in a reduction of the size of the paracone,

whereas in Dyseolemur and Washakius the metacone is lacking and the paracone is correspondingly larger. However, the P4 of Dyseolemur can be easily distinguished from those of Washakius by having a much weaker hypocone and better developed postprotoconal fold.

Order ?Primates
Family Microsyopidae
Osborn and Wortman, 1892
Subfamily Uintasoricinae
Szalay, 1969
Genus Uintasorex Matthew, 1909
Uintasorex sp., cf. U. montezumicus
Lillegraven, 1976
Figure 6

REFFERRED SPECIMEN. L.M., LACM 132461.
LOCALITY. LACM 5855.
FAUNA AND AGE. Tapo Canyon Local Fauna, late Uintan.

DISCUSSION. The L1, from locality LACM 5855 is morphologically very similar to those of U. montezumicus from the Mission Valley Formation, San Diego, California, including the following shared characters: (1) a vestigial paraconid that is positioned very close to the metaconid with the apices of these cusps separated by a very small gap; (2) a sharply curved cristid connecting the protoconid with the paraconid and a curved cristid connecting the protoconid with the metaconid; (3) an enclosed trigonid basin; (4) a small hypoconulid positioned close to the entoconid; and (5) a deeply basined and completely rimmed talonid. The measurements of LACM 132461 are 0.88 mm A-P, 0.51 mm ANT-TR, and 0.63 mm POST-TR.

The LM, from Simi Valley is assigned to U. sp., cf. U. montezumicus because it differs from those of U. montezumicus in its smaller size and by having the widths of the trigonid and talonid slightly smaller relative to the corresponding A-P lengths. The discovery of LACM 132461 represents the first record of Uintasorex from the Sespe Formation.

Figure 6. Uintasorex sp., cf. U. montezumicus Lillegraven, L.M., LACM 132461, occlusal view. Scale = 0.5 mm.
American rodents that provided many new insights into rodent phylogenetic relationships. In this report, Korth (1984) reviewed the taxonomy of Microparamys wherein he assigned two new species, M. scopaiodon and M. reginensis, to the genus. Korth noted that many species originally referred to Microparamy's are now assigned to other genera. He recognized seven North American species of Microparamys: M. minutus (Wilson, 1937), M. tricus (Wilson, 1940a), M. dubius (Wood, 1949), M. perfossus Wood, 1974, M. sp. D (= M. woodi n. sp., this paper), M. scopaiodon, and M. reginensis. In addition to these species, two informal taxa are referred to Microparamys: M. sp., cf. M. minutus from the Friars and Mission Valley Formations of the greater San Diego area of California (Lillegraven, 1977), and M. sp., cf. M. tricus from the Sespe Formation (this paper). Wood (1959) designated M. minutus from the Bridger Formation of Wyoming as the type species of Microparamys. The characters that define Microparamys have been expanded considerably with the addition of M. scopaiodon and M. reginensis to the genus. Korth noted that M. scopaiodon and M. reginensis also exhibit many similarities to the middle Eocene sciuravid Pauromys (family Sciuridae).

Korth (1984) revised the characters that define the Reithroparamyinae and included the following genera in this subfamily: Reithroparamys Matthew, 1920, Acritoparamys Korth, 1984, Apatosciuravus Korth, 1984, Lophiparamys Wood, 1962, and Microparas. Korth provided evidence that the reithroparamyines were directly derived from an Asian cricodontid rodent ancestor. In order to determine the phylogenetic relations of Microparamys to the other reithroparamyines and to determine if Microparas comprises a monophyletic clade, cladistic analyses were performed at the generic and specific levels using Version 1.5 of the Hennig86 computer program (Farris, 1988) run on a 386 personal computer. The characters and character states used in these analyses are presented in Appendix A. The Asian cricodontid rodent Coamos linghaensis Li, Chiu, Yan, and Hsieh, 1979, was selected as the outgroup because it is the most primitive rodent known, making it the best taxon available for determining the plesiomorphic character states used in the analyses. Coamos is well known from numerous specimens and has been described in detail by Li et al. (1989).

Korth (1984) assigned M. scopaiodon and M. reginensis to Microparas based on the following shared characters of these species with primitive ischyromyids and Microparas: (1) the M1 anterior cingulid is widely separated from the protoconid; (2) the lower molar anterior cingulid arises from the metaconid; (3) the lower molars lack a hypolophid that extends buccally from the entoconid; and (4) the mandibular masseteric fossa extends forward to a level about equal to those of Microparas. Korth also used the above characters to differentiate M. scopaiodon and M. re-

Order Carnivora Bowdich, 1758
Family Miacidae Cope, 1880
Genus Mic rais Cope, 1872
Micrais sp. undet.

Figure 7. Micrais sp. undet., RM2, LACM 130826, occlusal view. Scale = 1 mm.

REFFERED SPECIMEN. RM2, LACM 130826.
LOCALITY. LACM 5866.

FAUNA AND AGE. Brea Canyon Local Fauna, late Uintan.

DESCRIPTION. The trigonid of LACM 130826 is moderately elevated above the talonid indicating it is an M2. The trigonid shelf and the talonid basin are deep and the trigonid is open lingually. The cristid connecting the paraconid and protoconid possesses a distinct carnassial notch. A similar notch is present midway along the cristid that joins the metaconid and protoconid. The paraconid, protoconid, and metaconid are about equal in height. The entoconid and hypoconid are well developed, whereas the pre-entoconid, hypoconulid, and pre-hypoconid are only represented by very small cusps along the talonid cristid. The anterior and posterior labial cingulids are robust. A distinct periconid is present on the anterior labial cingulid. The measurements of LACM 130826 are 3.43 mm A-P, 2.74 mm ANT-TR, and 2.14 mm POST-TR.

DISCUSSION. The RM2 (LACM 130826) from Simi Valley is most similar to those of Micrais, and it is referred to Micrais sp. undet. It differs from previously known miacids of the Sespe Formation (Tapocony occidentalis, Stock, 1934b; Procoy dicis progressus Stock, 1935b); and Micrais bookway Stock, 1934b) by its much smaller size.

Order Rodentia Bowdich, 1821
Family Ischyromyidae Alston, 1876
Reithroparamyinae, Wood, 1962
Genus Microparamys Wood, 1959

DISCUSSION. In a very significant paper, Korth (1984) presented a comprehensive review of the early Tertiary evolution and radiation of North American rodents.
ginis) from Pauromys but recognized that most of these characters are just the plesiomorphic states for primitive ischyromyids. Korth cited the following similarities of M. scopaiodon and M. reginensis with Pauromys: (1) the lophs on the lower molars are of similar height; (2) the P₃ is very reduced; (3) the lower molar mesoconid is anteroposteriorly compressed; (4) the lower molar entoconid is separated from the posterolophid; and (5) the lower molar protoconid is isolated with the long arm of the protoconid extending to the base of the metaconid and paralleling the anterior cingulid. Of these characters, separation of the entoconid from the posterolophid is the plesiomorphic state observed in ctenodactyloid rodents and cannot be used to establish phylogenetic relationships.

In order to determine the phylogenetic relations of M. scopaiodon and M. reginensis to the sciuravid Pauromys and the reithroparamyines, a cladistic analysis including all of these taxa was performed. Character states were based primarily on those of the holotypes and topotypes of each genus. However, in order to avoid using characters that exhibit high levels of parallelism or reversals in the analyses, attempts were also made to consider the character states of the least derived species of each genus. The generic character states were determined from the following species: Reithroparamys ctenodactylops Korth, 1984, Reithroparamys delicatissimus (Leidy, 1871), Acritoparamys atavus (Jensen, 1937), Acritoparamys atucuteri (Loomis, 1907), Acritoparamys francesi (Wood, 1962), Lophiparamys musculus (Matthew, 1918), Lophiparamys woodi Guthrie, 1971, Apatosciuravus biflex Korth, 1984, Microparamys minutus, Microparamys scopaiodon, Microparamys reginensis, Pauromys perditus Troxell, 1923, and Pauromys sp. from Powder Wash, Utah, described by Dawson (1968).

Cladistic analysis of M. scopaiodon, M. reginensis, Pauromys, and the reithroparamyines was performed based on the character state matrix presented in Appendix B. The analysis resulted in four equally parsimonious cladograms with lengths of 60 steps and consistency indices of 66 using unweighted characters. The analysis was then repeated using successive weighting of characters, a procedure that has been shown to avoid the excessive weighting of multistate characters relative to binary characters and a means of basing groupings on more reliable characters without making prior decisions on weighting (Goldman, 1988; Farris, 1988). This procedure resulted in cladogram A of Figure 8 as the most parsimonious cladogram with a consistency index of 86. Therefore, cladogram A of Figure 8 is considered to most likely represent the correct relations of the taxa.

Based on cladogram A (Fig. 8), M. scopaiodon and M. reginensis are united by the following synapomorphies (node 6): (1) the M₁,₂ anterior cingulid is separated from the protoconid by a distinct groove in early wear that disappears with moderate wear to form a connection between the labial terminus of the anterior cingulid and the protoconid; (2) the M₁,₂ posterolophid is well developed; and (3) the M₁,₂ entoconid is isolated and separated from the posterolophid by a narrow distinct groove. In this analysis, Pauromys is the closest sister taxon to M. scopaiodon and M. reginensis, and these taxa are united by the following synapomorphies (Fig. 8, cladogram A, node 5): (1) the M¹⁻² metaconule is absent or very reduced; (2) the P₃ is extremely reduced relative to the lower molars; (3) a P₃ ectolophid is absent; (4) the M₁,₂ anterior cingulid is separated from the protoconid by a distinct groove or valley and the labial terminus of the anterior cingulid is not connected to the protoconid; (5) the M₁,₂ mesoconid is anteroposteriorly compressed; and (6) the M₁,₂ ectolophids are usually absent. These data indicate that M. scopaiodon and M. reginensis are more closely related to the sciuravid Pauromys than to the reithroparamyines and strongly imply that M. scopaiodon and M. reginensis are not referable to Microparamys (sensu stricto). Microparamys scopaiodon and M. reginensis are known only from fragmentary material and, until additional material is discovered that can provide a more complete analysis of these taxa, they cannot be confidently assigned to any genus or family and are herein referred to as "Microparamys," family incertae sedis. The analysis also indicates Apatosciuravus is the closest sister taxon to Pauromys. Korth (1984) noted that Apatosciuravus shares many characters with Microparamys and sciurids. Whether Apatosciuravus is a reithropamynine or sciuravid cannot be confidently determined based on the cladistic analysis presented here. Apatosciuravus is also known from fragmentary material and, until additional material of this taxon is discovered that can provide a more complete analysis, it is tentatively included in the Reithroparamyinae.

Based on the analysis presented above, the Reithroparamyinae comprises the following genera: Reithroparamys, Acritoparamys, Microparamys, Lophiparamys, and Apatosciuravus. Cladistic analysis was performed on these genera using the character state matrix presented in Appendix C with the characters unweighted and weighted. This analysis produced a single most parsimonious cladogram with a length of 43 steps and a consistency index of 83 using unweighted characters and 96 using weighted characters (Fig. 9). The analysis indicates that Reithroparamys, Apatosciuravus, and Acritoparamys are successive sister taxa to Microparamys and Lophiparamys. The reithroparamyines are united by the following synapomorphies (Fig. 9, node 1): (1) the posterior root of the zygoma is located in line with the anterior margin of the P¹ to the center of the P₃; (2) the M¹⁻² metaconule is lingually positioned; (3) the M¹⁻² hypocone is well developed; (4) the anterior termination of the masseteric fossa is located in line between the middle of the posterior half of the M₁,₂ to the middle of M₂; (5) the P¹ is
molariform with two buccal cusps (paracone and metacone) and a distinct hypocone; (6) the P$_4$ ectolophids are usually developed as complete cristids or almost complete cristids extending from the mesoconid to the protoconid and hypoconid; (7) the P$_1$ hypoconid is well developed; (8) the P$_2$ posterolophid is well developed; (9) the P$_3$ protoconid is usually absent or vestigial; and (10) the M$_1$, protoconid is connected or nearly connected to ectolophid, and the posterior arm of protoconid is short or if developed is usually directed towards the middle of the metaconid or further forward, and the posterior arm of the protoconid is not parallel with the anterior cingulid. Additional synapomorphies noted by Korth (1984) that may unite the reithroparamyines, but not included in the cladistic analysis because their character states are unknown for several genera, are: (1) the auditory bullae are enlarged and ossified with the skull and (2) the posterior margin of the nasal bones extends further posteriorly than that of the premaxillaries. In this analysis, *Microparamys* and *Lophitparamys* are closest sister taxa based on the putative synapomorphy (Fig. 9, node 4) of crenulated cheek teeth enamel. Based on the cladistic analysis, no autapomorphies can presently be identified for the reithroparamyines indicating they may represent a paraphyletic group. However, the lack of identifiable autapomorphies may also be due to the fact that many members of this group are poorly known.

Removal of "M." *scopaiodon* and "M." *reginensis* from *Microparamys* results in the following species assigned to the genus: *M. minutus*; *M.* sp.; cf. *M. minutus*; *M. dubius*; *M. tricus*; *M.* sp., cf.
M. tricus; M. perfoissus; and M. woodi n. sp. Cladistic analysis of these species was performed using the character state matrix presented in Appendix D with the characters unweighted and weighted. Two equally parsimonious cladograms were developed using unweighted characters with lengths of 53 steps and consistency indices of 77 (Fig. 10A–B). With weighted characters, cladogram A (Fig. 10) becomes the most parsimonious with a consistency index of 92.

Based on cladogram A (Fig. 10) the following suite of synapomorphies (node 1) are shared by the species of Microparanyms and characterize the genus: (1) the posterior margin of the anterior root of the zygoma is located in line with the anterior margin of the P4; (2) the anterior termination of the masseteric fossa is located in line with the middle of M1; (3) size is small; (4) the cheek teeth enamel is weakly to moderately crenulated; (5) the P4 metaconid is weakly developed; (6) a P4 ectolophid is present; (7) the P4 hypoconid is well developed; (8) the P3 posterolophid is well developed; (9) the M1,2 anterior cingulid is well developed as a long distinct cristid; (10) the M1,2 anterior cingulid is separated from the protoconid by a distinct groove or valley and the labial terminus of the anterior cingulid is not connected to the protoconid; (11) the M1,2 posterolophid is well developed; (12) the M1,2 hypoconulid is usually present as a moderately well-developed, often elongated, cuspule formed along the posterolophid; and (13) the M1,2 entoconid is isolated and separated from the posterolophid by a narrow distinct groove. The only autapomorphic characters identified that indicate Microparanyms is a monophyletic clade are the forward positioning of the zygoma and masseteric fossae and the distinct arrangement of the anterior cingulid and the protoconid (numbers 1, 2, and 9, above). Three species groupings are indicated by the analysis: (1) the minutus group, including M. minutus and M. sp., cf. M. minutus; (2) the woodi group, including M. woodi and M. perfoissus; and (3) the tricus group, including M. tricus, M. sp., cf. M. tricus, and M. dubius. The synapomorphies (node 2) that unite the minutus group is a strongly developed P3 mesoconid. The synapomorphies (node 4) that unite the woodi group are as follows: (1) the occlusal patterns in the M1,2 protoconid and hypoconid regions are U-shaped; (2) an M1 mesolophid is present as a distinct crest originating near the apex of the protoconid and extending lingually into the central basin of the tooth; (3) an M1,2 hypoconulid is lacking; and (4) the M1,2 entoconid is connected to the posterolophid. The synapomorphies (node 5) that unite the tricus group are: (1) the M1,2 postprotoconid is absent or poorly developed and (2) a small distinct cuspule is developed on the labial terminus of the M1,2 anterior cingulid.

The cladistic analyses presented here are regarded as preliminary because many of the taxa are poorly known, the sample sizes are small, and the intraspecific variation of certain characters is not adequately known, especially quantitative characters. However, whenever possible, an attempt was made not to use characters that have been shown by other investigators to be highly variable (e.g., Lillegraven, 1977). The analyses presented here help to clarify the characterization of the genus Microparanyms and provide a basis for future phyloge-
netic investigations of this little-known group of rodents.

**Microparamys woodi** new species

Figure 11, Tables 2 and 3

*Paramys* cf. *minutus* Wilson, 1940a:72, pl. 1, figs. 10-11.


**HOLOTYPE.** RM², LACM 130820.

**TYPE LOCALITY.** LACM 5857.

**HYPODIGM.** LdP³, LACM 133988; 3RP's, LACM 130821, 132415, 132463; LP³, LACM 132414; LM², LACM 130819; 2RM's, LACM 132422, 133989; 3LM's, LACM 132416, 132464, 132467; RM², LACM(CIT) 2153; LP², LACM 130822; 4RP's, LACM 130823, 132417, 132466, 133990; 2RM's, LACM 130818, 133991; 2LM's, LACM 132471, 132651; 2LM's, LACM 130824, 132472; RM², LACM(CIT) 2156; LM³, LACM 132468.

**DISTRIBUTION, FAUNAS, AND AGE.** Localities LACM 5661, 5855, 5857, 5860, 6081, locality LACM(CIT) 180; Tapo Canyon and Brea Canyon Local Faunas; late Uintan.

**ETYMOLOGY.** Named in honor of Albert E. Wood, formerly of the Amherst College, in recognition of his contributions to our understanding of *Microparamys*.

**DIAGNOSIS.** *Microparamys woodi* is distinguished by the following suite of characters: (1) small ischiorymid; (2) cheek teeth enamel crenulated; (3) upper cheek teeth with protolophs and metalophs usually complete, occusal patterns in the protoconal and hypoconal regions U-shaped, metalophs often doubled as two small cusps on metaloph, and tendency for development of small accessory crest originating from protoloph and extending anteriorly towards the anterior cingulum that occasionally results in division of valley between the anterior cingulum and protoloph into labial and lingual portions; (3) upper molars with mesostyles and from one to two mesolophs; (4) P₃ with moderately developed protoconid, weakly developed metaconid, and well-developed posteroloph; and (5) lower molars with metalophid complete, “mesolophids” present, posterolophid well developed and connected to entoconid, valley be-
between anterior cingulid and protoconid moderately developed with small accessory cristid extending across valley connecting protoconid and anterior cingulid, and hypoconulids absent. Differs from *Microparamys minutus* (Wilson, 1937) and *M.* sp., cf. *M. minutus* (Lillegraven, 1977) by having the following characters: (1) teeth larger; (2) M₁-₂ with mesostyles present, mesolops more strongly developed, and connection of anterior crest of hypocone to metaloph stronger; and (3) lower molar hypolophids more developed. Differs from *M. tricus* (Wilson, 1940a) by having the following characters: (1) teeth smaller; (2) M₁-₂ with relatively smaller mesostyles, less developed and bulbous protoconules and metaconules, less tendency for multiplication of metaconules, greater tendency for multiplication of mesolops, and greater tendency for development of an accessory crest uniting protoloph and anterior cingulum; and (3) lower molars with slightly less separation of protoconid and anterior cingulid. Differs from *M. dubius* (Wood, 1949) by having the following characters: (1) P₄ with better developed metaconule, a mesostyle, and larger hypocone; (2) M₁-₂ with lingually directed crests.
Table 2. Measurements (in mm) of upper dentition of *Microparamys woodi* new species.

<table>
<thead>
<tr>
<th>N</th>
<th>Tooth/ dimension</th>
<th>O.R.</th>
<th>Mean</th>
<th>S.D.</th>
<th>C.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dP* A-P</td>
<td>1.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ANT-TR</td>
<td>1.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>POST-TR</td>
<td>1.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>P* A-P</td>
<td>1.15-1.24</td>
<td>1.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ANT-TR</td>
<td>1.38-1.54</td>
<td>1.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>POST-TR</td>
<td>1.33-1.45</td>
<td>1.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>M* A-P</td>
<td>1.33-1.42</td>
<td>1.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ANT-TR</td>
<td>1.45-1.55</td>
<td>1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>POST-TR</td>
<td>1.40-1.47</td>
<td>1.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>M* A-P</td>
<td>1.35-1.48</td>
<td>1.42</td>
<td>0.05</td>
<td>3.5</td>
</tr>
<tr>
<td>5</td>
<td>ANT-TR</td>
<td>1.58-1.73</td>
<td>1.63</td>
<td>0.06</td>
<td>3.7</td>
</tr>
<tr>
<td>4</td>
<td>POST-TR</td>
<td>1.44-1.56</td>
<td>1.49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Measurements (in mm) of lower dentition of *Microparamys woodi* new species.

<table>
<thead>
<tr>
<th>N</th>
<th>Tooth/ dimension</th>
<th>O.R.</th>
<th>Mean</th>
<th>S.D.</th>
<th>C.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>P* A-P</td>
<td>1.24-1.41</td>
<td>1.34</td>
<td>0.07</td>
<td>5.5</td>
</tr>
<tr>
<td>5</td>
<td>ANT-TR</td>
<td>0.97-1.08</td>
<td>1.05</td>
<td>0.05</td>
<td>4.7</td>
</tr>
<tr>
<td>5</td>
<td>POST-TR</td>
<td>1.18-1.39</td>
<td>1.30</td>
<td>0.09</td>
<td>6.8</td>
</tr>
<tr>
<td>3</td>
<td>M* A-P</td>
<td>1.40-1.46</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ANT-TR</td>
<td>1.30-1.51</td>
<td>1.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>POST-TR</td>
<td>1.39-1.49</td>
<td>1.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>M* A-P</td>
<td>1.44-1.58</td>
<td>1.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ANT-TR</td>
<td>1.42-1.55</td>
<td>1.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>POST-TR</td>
<td>1.49-1.58</td>
<td>1.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>M* A-P</td>
<td>1.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ANT-TR</td>
<td>1.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>POST-TR</td>
<td>1.21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

from mesostyles and U-shaped protocones and hypocones; and (3) lower molars with “mesolophids” present and hypolophids that are less developed and posterolabially directed. Differs from *M. perrossus* Wood, 1974, by having the following characters: (1) P* and M* hypocones less separated from protocones; (2) M* 2 with better developed metalophs and greater tendency for multiplication of metaconules; (3) P, less anteroposteriorly elongated and protoconid smaller; and (4) lower molars with posterolabially directed hypolophids and lacking long cristid from entoconid toward hypoconid. Differs from “M.” ‘regimens’ Korth, 1984, by having the following characters: (1) teeth much larger; (2) lower molar lingual extension of mesoconid lacking and mesoconid not anteroposteriorly compressed; (3) occlusal outline of M*1, less rectangular; and (4) enamel more crenulated in basins. Differs from “M.” scopaiodon Korth, 1984, by having the following characters: (1) P* much larger, and larger relative to molars; (2) P, occlusal pattern more complex and protoconid more reduced; (3) lower molars with mesoconids not anteroposteriorly compressed, lacking a long posterior arm of protoconid extending to base of metaconid, and entoconids connected to posterolophids; and (4) enamel more crenulated in basins.

**DESCRIPTION.** Only one deciduous P* of *M. woodi* has been recovered from the Sespe Formation. The dP* is subtriangular in occlusal outline and moderately molariform. The protocone is the largest primary cusp, and the metacone and paracone are about equal in size. A thin crest is present along the labial aspect of the tooth that connects the metacone with the paracone. The preprourocrista extends anterolabially to form a protoloph and the postprotoocrista extends posterolabially to form a metaloph. Two small distinct metaconules are present along the crest of the metaloph. The anterior cingulum is robust. A very low accessory crest is present between the protoloph and the anterior cingulum that divides the valley separating these structures into labial and lingual portions. The posterior cingulum is well developed and extends lingually from the labial aspect of the metacone to the level of the protocone wherein it terminates in a well-defined bulge or hypocone.

The P* is subquadrate in occlusal outline with the protocone and hypocone separated by relatively deep valleys. A small distinct mesoisty is present between the paracone and metacone. One or two metaconules may be present as small cusps or bulges on the metaloph. The protoconid is usually a distinct small bulge on the protoloph. The protoloph is a complete crest except for a small cleft about midway along the protoloph at the point where a small accessory crest projects anteriorly from the protoloph towards the anterior cingulum. The metaloph is a low complete crest. The preprourocrista, postprotoocrista, and the protoconid form a U-shaped wear pattern in the protoconid region. A mesoloph is absent in all known P*’s. The anterior cingulum is well developed and a slight enlargement is present at the lingual terminus. The posterior cingulum is well developed and extends lingually from the posterolabial aspect of the metacone to terminate in a well-developed hypocone. A crest from the hypocone extends anterolabially to terminate just short of the middle of the metaloph and this crest along with the posterior cingulum and the hypocone results in a U-shaped wear surface in the hypoconal region. The enamel is moderately crenulated in the basins of the tooth.

The first two upper molars are similar in morphology to the P* except for the following differences. The occlusal outline is more quadrate in shape. The mesoisty has a small spur that extends lingually into the central basin of the tooth. The parastral region is larger or more inflated. Meso- lophes are always present and may vary from a single crest to two separate crests that extend labially from the apex of the protocone, between the preprourocrista and postprotoocrista, into the central basin to terminate about half way towards the labial as-
pect of the tooth. The anterior cingulum is more developed, and a lingual terminal bulge of the ante-
rior cingulum may be present or absent. The ac-
cessory crest that originates from the protoloph occasionally extends anteriorly to join with the an-
terior cingulum; this results in a division of the valley between the anterior cingulum and the pro-
toloph into labial and lingual portions. However, this accessory crest is more commonly absent, or it only forms a partial divider that extends anteriorly from the protoloph a very short distance into the intervening valley. The enamel is more crenulated in the basins of the first two upper molars.

The P$_4$ is subrectangular in occlusal outline. The metaconid is the largest and tallest cusp. A small cristid extends posteriorly from the apex of the metaconid towards the entoconid where it terminates just anterior to the entoconid. The proto-
conid is a low bunodont cusp and the smallest primary cusp. The metalophid is a small low cristid that connects the metaconid and protoconid. The mesoconid is weakly developed as a small rounded bulge or cusp, and a mesolophid is lacking. The entoconid is slightly taller than the hypoconid, and these cusps are connected by a complete, posteri-
orly convex posterolophid. The anterior cingulid is a convex cristid extending from the metaconid to the anterolabial aspect of the protoconid. The metalophid is a small cristid originating from the apex of the protoconid and extending anterolinguually towards the protoconid. The enamel is usu-
ally crenulated in the basins of the tooth.

The first two lower molars have rectangular oc-
clusal outlines. Incipient metastylids may be present as very small cusuples on the lingual cristid con-
necting the metaconid and entoconid. The metalo-
phid is a complete low cristid that connects the metaconid and protoconid. The mesoconids are well developed. "Mesolophids" are usually present and can vary from a single to as many as three low spurs extending lingually from the mesoconid into the central basin of the tooth. A small short spur is present that extends labially from the entoconid into the basin of the tooth. The hypolophid is usu-
ally a short posterolabially directed cristid. The an-
terior cingulid extends lingually from the base of the metaconid to the level of the protoconid and a moderately developed valley separates the ante-
rior cingulid from the protoloph and protoconid. A small accessory cristid extends from the protoloph across this valley to the anterior cingulid. The posterolophid is well developed and connects the hypoconid with the entoconid. The enamel is cren-
ulated in the basins of the tooth.

Only two M$_3$s of M. wooldi have been recovered during the impact mitigation program. The M$_3$s are morphologically very similar to the first two lower molars except that they have more robust and curved posterolophids. Both M$_3$s lack incipient mesostyl-
ids, but this may not be a diagnostic character for the M$_3$ because the occurrence of mesostylids is variable in the first two lower molars.

**DISCUSSION.** Wilson (1940a) referred two iso-
lated teeth, an upper and a lower molar, from the Sespe Formation at locality LACM(CIT) 180 to Paramys cf. minutus. Wood (1962) reevaluated the phylogenetic status of these two teeth and assigned them to an informal taxon, Microparamys sp. D, noting that they represented a very distinct species of *Microparamys.* Lillegraven (1977), in agreement with Wood, regarded the teeth of *M.* sp. D a new species but, like Wood, was reluctant to formally name a new taxon until a better sample was available from the Sespe Formation. The new material of *M.* sp. D discovered during the program at the Simi Valley Landfill has resulted in a better char-
acterization of this taxon and allows the assignment of this sample to the new species *M. wooldi.*

Because of the larger sample of *M. wooldi* now available, the intraspecific variation of the teeth can be evaluated. The two most variable characters of the teeth of *M. wooldi* are: (1) the degree of the development of an accessory crest extending from the protoloph to the anterior cingulum (= anterior cingulum–protoloph crest) and (2) the development of mesolophs and "mesolophids" in the upper and lower molars, respectively. The anterior cingulum–protoloph crest is usually absent or represented only by a partial crest extending anteriorly from the pro-
toloph part way across the transverse valley that separates the anterior cingulum from the proto-
loph. Occasionally, the anterior cingulum–proto-
loph crest is complete across the intervening valley and connects the anterior cingulum with the proto-
loph, resulting in a division of the valley into labial and lingual portions. Walsh (1987) also found the occurrence of anterior cingulum–protoloph crests to be highly variable in a sample of *Microparamys* teeth from the Mission Valley Formation of the San Diego area in California. In the upper molars, one or two mesolophs may be present, ex-
tending labially from the apex of the protocone into the central transverse valley. In the lower mo-
olars, from one to three "mesolophids" may be present as separate low cristids extending lingually from the mesoconid into the central basin of the tooth.

Many investigators have discussed in detail the probable relations of *M. wooldi* (= *M.* sp. D) to other species of *Microparamys* (Wilson, 1940a; Wood, 1962, 1974; Dawson, 1966, 1974; Lillegraven, 1977; Korth, 1984; Walsh, 1987). Wood (1974) regarded *M. wooldi* as most similar to *M. perfossus* of the Porven Local Fauna, Vieja–Oj-
naga area, Texas, wherein both species have U-shaped upper molar occlusal patterns in the proto-
conal and hypoconal regions. Additional shared characters of *M. wooldi* and *M. perfossus* indicating a close relationship are as follows: (1) the M$^1$ meso-
loph is well developed; (2) the M$_1$–entoconid is connected to the posterolophid; and (3) the M$_1$–entoconid is absent or vestigial. Even though the above synapomorphies unite *M. wooldi* and *M. perfossus* into a species group, *M. wooldi* can be easily distinguished from *M. perfossus* by the following
Figure 12. *Microparamys* sp., cf. *M. tricus* (Wilson), A. LM², LACM 130809; B. LM₃, LACM 130810; C. LM₄, LACM 130816; D. RM₃, LACM 130814. All occlusal views. Scale = 1 mm.

**Microparamys** sp., cf. *M. tricus* (Wilson, 1940)

**REFERRED SPECIMENS.** RM₁, LACM 130812; RM₂, LACM 130809; LM₁, LACM 130810; RM₃, LACM 130815; LM₄, LACM 130816; RM₅, LACM 130814.

**LOCALITIES.** LACM 5866, 5869.

**FAUNA AND AGE.** Brea Canyon Local Fauna, late Uintan.

**DISCUSSION.** The *Microparamys* teeth from localities LACM 5866 and 5869 are morphologically very similar to those of *M. tricus* from the early Duchesnean Pearson Ranch Local Fauna of the Sespe Formation. However, these teeth differ from those of *M. tricus* by having the following characters: (1) the teeth are smaller; (2) the M₁ postprotocristid is much more weakly developed and separated from the metaconal region by a labial continuation of the valley that separates the protocone from the hypocone; (3) the lingually directed crest from the mesostyle in the upper molars is slightly less developed; (4) the M₂ hypolophid is slightly less robust; (5) the M₃c anterior cingulid has a larger, more prominent cuspule at its labial termination; and (6) the M₄ postprotocristid is less developed. The teeth of *M. sp.*, cf. *M. tricus* are distinguished from those of *M. woodi* by having the following characters: (1) M₁⁻² with larger mesostyles, more bulbous protoconules and metaconules, a greater tendency for multiplication of the metaconules, less tendency for multiplication of mesolophs, and usually lacking the low crest that unites the protocone and the anterior cingulum and (2) lower molars with slightly greater separation of the protoconid and the anterior cingulid.

The samples of *Microparamys* teeth from the late Uintan Brea Canyon Local Fauna are slightly less derived, as indicated by their less developed postprotocristae, postprotocristids, mesostylar lingual crests, and hypolophids, than those of *M. tricus* and are therefore assigned to *M. sp.*, cf. *M. tricus*.

Lillegraven (1977) assigned 10 isolated teeth from the latest Uintan or earliest Duchesnean Camp San Onofre Local Fauna of the ?Santiago Formation, Camp Pendleton Marine Corps Base, California, to *M. tricus*. Lillegraven noted that even though the Camp San Onofre samples of *Microparamys* teeth are consistently smaller, they are indistinguishable morphologically from those of *M. tricus* from the Pearson Ranch Local Fauna. The teeth of *M. sp.*, cf. *M. tricus* are the same size as those of *M. tricus* from the Camp San Onofre Local Fauna but have less developed postprotocristae, postprotocristids, mesostylar lingual crests, and hypolophids. These character states indicate that *M. sp.*, cf. *M. tricus* is less derived than *M. tricus* from the Camp San Onofre Local Fauna. A single evolutionary lineage is probably represented by the *Microparamys* samples discussed above, wherein the late Uintan *M. sp.*, cf. *M. tricus* from the Brea Canyon Local Fauna was probably ancestral to the latest Uintan or earliest Duchesnean *M. tricus* from the Camp San Onofre Local Fauna, and the latter then gave rise to the larger early Duchesnean *M. tricus* from the Pearson Ranch Local Fauna.

**Genus Leptotomus Matthew, 1910**

*Leptotomus* sp. undet.

**REFERRED SPECIMEN.** LM₄, LACM 131465.

**LOCALITY.** LACM 5876.

**FAUNA AND AGE.** Simi Valley Landfill Local Fauna, late Duchesnean.

**DESCRIPTION.** The LM₁ is well worn, anteroposteriorly elongated, and the occlusal outline is subrectangular. The labial surface of the protoconid is missing. The anterior cingulid (= anterolophid) is a robust cusp that connects the metaconid with the protoconid. A small metalophid is present and projects lingually from the protoconid into the anterior basin of the tooth. The hypolophid is a continuous cuspid between the entoconid and the hypoconid. The ectolophid is complete and markedly curved. The posterior cingulid (= posterolophid) is robust and extends lingually from the posterolabial aspect of the tooth to the entoconid, where it is only separated from the entoconid by a small cleft. The measurements of LACM 131465 are 3.06 mm A-P, 2.66 mm ANT-TR (estimated), and 2.67 mm POST-TR.

**DISCUSSION.** The Simi Valley tooth (LACM 131465) appears most similar to those of *Leptotomus guildayi* Black, 1971, and *L. sp.*, near *L.
guildayi (Black, 1971) of the Badwater Localities 5, 6, and 15 from the ?Wagon Bed Formation of Wyoming by having the following shared characters: (1) the metalophid extends from the protoconid into the central basin of the tooth but does not connect with the metaconid; (2) the hypolophid is complete; (3) the posterolophid is prominent and separated only slightly from the entoconid; and (4) the ectlolophid is markedly curved. The Simi Valley tooth differs from those of L. guildayi and L. sp., near L. guildayi by its smaller size and by having a slightly less developed metalophid and a vestigial mesoconid.

The tooth from Simi Valley also exhibits some characters that are similar to those of species of *Rapamys*, including a prominent posterolophid, markedly curved ectlolophid, incomplete metalophid, and complete hypolophid. However, the Simi Valley tooth differs from those of *Rapamys* by lacking the wide separation of the posterolophid and the entoconid.

The Simi Valley specimen appears to be most closely related to *L. guildayi* and *L. sp.*, near *guildayi*. However, due to the lack of adequate material for species identification, it is herein assigned to *Leptotomus* species undetermined.

### Family ?lschyromyidae

**Genus Eohaplomys Stock, 1935a**

*Eohaplomys matutinus* Stock, 1935a

**Figure 14**

**REFERRED SPECIMENS.** RM¹, and partial RM², LACM 130827.

**LOCALITY.** LACM 5616.

**FAUNA AND AGE.** Brea Canyon Local Fauna, late Uintan.

**DISCUSSION.** Kelly et al. (1991) questionably assigned LACM 130827 to an undetermined dichobunid. Further preparation and examination of this specimen indicates that it is referable to *Eohaplomys matutinus*. The measurements of the RM¹ of LACM 130827 are 4.21 mm A-P and 4.88 mm TR.

**Superfamily Geomyoidea Weber, 1904**

**Family ?Geomyidae Gill, 1872**

**Genus Griphomys Wilson, 1940b**

*Griphomys alecer Wilson, 1940b*

**Figure 15, Tables 5 and 6**

**REFERRED SPECIMENS.** In addition to those referred elsewhere (Lillegraven, 1977); 2RdP's, LACM 130801, 132427; 2LdP's, LACM 130776, 132428; partial left maxilla with P⁴ and partial M¹, LACM(CIT) 2525; LP⁴, LACM 132432; 2RM's, LACM 130777; LACM(CIT) 2526; LM¹, LACM 130781; 3RM's, LACM 130778, 132425, 132429; 2LM's, LACM 130779, 132431; LM¹, LACM 132462; holotype, partial right dentary with P₂-M₁, LACM(CIT) 2522; partial right dentary with P₂ and M₂, LACM(CIT) 2524; 3RP's, LACM 130782, 130784, 130789; 2LP's, LACM 130783, 133993;

---

**Figure 13.** *Leptotomus* sp. undet., LM₉, LACM 131465, occlusal view. Scale = 1 mm.

**Figure 14.** *Eohaplomys matutinus* Stock, RM¹ and partial RM², LACM 130827, occlusal views. Scale = 1 mm.
RM, LACM 130785; 2LMs, LACM 130788, 132470; partial right dentine with M2, LACM(CIT) 2523; 4LMs, LACM 130774, 130775, 132424, 132426; 2RM2s, LACM 130780, 132430; 3RM2s, LACM 130786, 130787, 130790; LM, UCMP 79479.

LOCALITIES. Sespe Formation, LACM(CIT) 150, 202, 207, LACM 5612, 5616, 5661, 5855, 5857, 5859, 5860, 5866, 5868, 5869; Santiago Formation, UCMP V-72088.

FAUNAS AND AGE. Tapo Canyon, Brea Canyon, and Pearson Ranch Local Faunas, Simi Valley, and Camp San Onofre Local Fauna, Camp Pendleton Marine Corps Base, California; late Uintan to early Duchesnean.

DESCRIPTION. Four teeth (LACM 130776, 130801, 132427, 132428), tentatively assigned to dp’s, were recovered during the program from localities LACM 5616, 5661, and 5860. These teeth are morphologically very similar to the permanent upper check teeth except for being slightly smaller and relatively narrower transversely, and by having the anterior cingulum usually not extending as far lingually.

The permanent check teeth of *Griphomys alecer* have been well described by Wilson (1940b), Lindsay (1968), and Lillegraven (1977). However, due to the small number of teeth in the original samples of *G. alecer*, additional details on intraspecific variation are described below.

All of the upper molars have the central transverse valleys open labially and lingually, and all are lacking a preprotocrista. However, one upper molar has a very small mesostyle present between the paracone and metacone, but this cusp is not high enough to block the labial opening of the central transverse valley. A small anterocrista is usually present as a small cusp along and near the lingual termination of the anterior cingulum. The most variable character of the upper molars is the development of a protoloph spur, which usually comprises a small crest that originates along the posterior face of the protoloph near its connection with the protocone and extends posteriorly into

Figure 15. *Griphomys alecer* Wilson. A. RdP, LACM 132428; B. LP, LACM 132432; C. LM1, LACM 130781; D. RM2, LACM 130778; E. LM1, LACM 130779; F. LM2, LACM 132431; G. LM1, 132462; H. RP, LACM 130782; I. LP, LACM 130783; J. RP, LACM 130784; K. RM2, LACM 130785; L. LM2, LACM 130774; M. LM3, LACM 130775; N. RM3, LACM 130780; O. RM3, LACM 130787; P. RM3, LACM 130790. All occlusal views. Scale = 1 mm.
the central transverse valley of the tooth where it then turns labial for a short distance. Lillegren (1977) identified this structure as a low posterior protocrista. Whether this structure is homologous with a postprotocrista or an anterior ectoloph (= anterior mure) and a vestigial mesoloph is uncertain. Nevertheless, the following variations of this spur are exhibited by the Simi Valley upper molars of *G. alecer*: (1) the spur is completely lacking; (2) the spur is very small and only extends a very short distance posterolabially where it terminates at the posterior base of the protocone and does not extend into the central transverse valley; (3) the spur extends posterolabially from the protoloph about midway into the central transverse valley and resembles a vestigial mesoloph; and (4) the spur forms a small cristid that originates at the base of the protoloph, just labial to its connection with the protocone, and then extends posterolabially in a curved fashion into the central transverse valley resembling a small mesoloph. No distinct cusps or swellings are exhibited on any of the spurs that could be regarded as mesocones.

In the *P*, the most variable character is the development of the ectolophid and its associated mesoconid. Mesoconids, which may be represented by a distinct isolated cusp in the central transverse valley or by a distinct swelling at the middle of the ectoloph, are usually present. The mesoconid–ectolophid structure varies in the Simi Valley *P* as follows: (1) ectolophid incomplete, mesoconid absent, ectolophid represented by a small cristid or loph that projects anteriorly from the hypolophid into the middle of the central transverse valley and terminates about halfway across this valley; (2) ectolophid complete, mesoconid absent, ectolophid represented by a small cristid that projects anteriorly from the hypolophid across the central transverse valley and connects with the metalophid; (3) ectolophid complete, mesoconid present, ectolophid represented by a complete cristid extending anteriorly from the hypolophid across the central transverse valley where it is connected with the metalophid, and the mesoconid is a distinct bulge or swelling midway along the cristid; and (4) ectolophid absent, but an isolated well-developed, triangular-shaped mesoconid is present with one apex of the triangle connected to the middle of the anterior face of the hypolophid. The central transverse valley is usually open labially; however, in two premolars a slight bulge, which may represent a vestigial ectostyloid, is present midway along a weakly developed cristid at the labial aspect of the tooth between the protoconid and the hypoconid. This bulge does not represent a mesoconid because in both of these premolars a mesoconid is present in the central transverse valley.

The lower molars vary in the development of cristids and cusps in the central transverse valleys as follows: (1) cusps or cristids absent; (2) a distinct isolated cusp or mesoconid in the central transverse valley with cristids absent; and (3) an incomplete ectolophid, which may be a distinct cristid or very low indistinct cristid that originates on the anterior face of the hypolophid, lingual to the hypoconid, and extends midway anterolaterally or anteriorly into the central transverse valley. In the teeth exhibiting an incomplete ectolophid, a distinct mesoconid usually cannot be differentiated from the ectolophid. In one tooth (LACM 130774), two cristids originate on the anterior face of the hypolophid and extend anteriorly into the central transverse valley. The most labial cristid appears to represent a partial ectolophid with a small cusp or mesoconid at its termination. The lingual cristid does not exhibit a cusp, and this cristid may be a duplication of the ectolophid. Another lower molar (LACM 130775) is also distinctive in that it exhibits a small bulge or cusple (= ectostyloid) at the posterolabial base of the protoconid and a thin low cristid (= labial cingulid) that extends posteriorly from this

Note: Further details and data are provided in Tables 5 and 6, which detail the measurements in mm of the upper and lower dentition of *Griphomys alecer*.
cuspule to join with the anterolabial base of the hypoconid.

**DISCUSSION.** Many investigators have discussed the taxonomic relations of *Gripbomys* even though the fossil record of this genus was previously very sparse (Wilson, 1940b, 1949; Lindsay, 1968; Emry, 1972; Wood, 1974; Sutton and Black, 1975; Lillegraven, 1977; Black and Sutton, 1984). Wilson (1940b) described *Gripbomys alecer* and G. sp., near *alecer* on the basis of five specimens representing a total of nine teeth from the Sespe Formation of Simi Valley. Lillegraven (1977) assigned six specimens representing a total of six teeth from the Camp San Onofre Local Fauna, *Santiago Formation, Camp Pendleton Marine Corps Base, California, to G. alecer*. Lillegraven (1977) also assigned four isolated teeth from the *Santiago Formation to a second species of Gripbomys, G. toltecus*. Lindsay (1968) referred an LM1 from the Hartman Ranch Local Fauna of the Sespe Formation, north of the town of Ojai, California, to an undetermined species of *Gripbomys*. Golz and Lillegraven (1977) reported the occurrence of *Gripbomys* sp. from the Laguna Riviera Local Fauna, *Santiago Formation, Oceanside area, California. Sutton and Black (1975) questionably assigned an RM1, from the Pilgrim Creek Local Fauna, Colter Formation, Jackson Hole, Wyoming, to *Gripbomys*. Mary R. Dawson (pers. commun. in Sutton and Black, 1975) reported that *Gripbomys* may occur in the Badwater Faunas from the *Wagon Bed Formation of Wyoming. The above records represent the entire previously known occurrences of *Gripbomys* in the fossil record. Most investigators regard G. sp., near *alecer* to be synonymous with *G. alecer*, although none have presented new evidence to support this assumption (Lillegraven, 1977; Black and Sutton, 1984; Kelly, 1990; Kelly et al., 1991).

The impact mitigation program at the Simi Valley Landfill has resulted in the recovery of 30 additional teeth of *G. alecer* from 11 different stratigraphic levels in the Sespe Formation. The LM1, described by Lindsay (1968) from the Hartman Ranch Local Fauna can now be confidently assigned *G. alecer* because it is indistinguishable from the newly discovered M4s of this species from Simi Valley. A total of 46 teeth are now assigned to *G. alecer*.

The four teeth identified herein as deciduous P1s are only tentatively assigned to *G. alecer*. These teeth could represent a different species of *Gripbomys* because they are smaller than the permanent P1s of *G. alecer*. However, these teeth were recovered from three different localities that each yielded other teeth that were definitely assignable to *G. alecer*. Furthermore, these teeth are almost identical in structure to the other upper cheek teeth assigned to *G. alecer*, including the presence of small protoloph spurs and strongly bilophodont occlusal patterns.

The larger sample of *G. alecer* teeth allows for reevaluation of intraspecific variation and morphological change through time. Wilson (1940b) divided the specimens of *Gripbomys* into three taxa: *G. alecer* from locality LACM(CIT) 207, G. sp., near *alecer* from locality LACM(CIT) 202, and G. sp., near *alecer* from locality LACM(CIT) 150. These taxa were separated on the basis of the following characters: (1) slight differences in tooth size; (2) slight differences in the occlusal outlines of the P3s; (3) the presence or absence of vestigial mesoconids on the lower cheek teeth; (4) slight differences in the widths of the lower molar trigonids; and (5) the different stratigraphic occurrences of each taxon. Wilson noted that the teeth of *Gripbomys* from localities LACM(CIT) 202 and 207 were extremely similar and, considering the amount of individual variation present in other Eocene rodents, were probably conspecific. Wilson considered the sample of *Gripbomys* from locality LACM(CIT) 150 most likely to represent a different species because the lower cheek teeth lack vestigial mesoconids, whereas those of *G. alecer* and G. sp., near *alecer* from localities LACM(CIT) 202 and 207 possess vestigial mesoconids. The development of protoloph spurs and mesoconids on the teeth of *Gripbomys* does appear to vary somewhat depending upon the stratigraphic level from which they were collected. In ascending stratigraphic order, these variations are as follows: (1) from the level of locality LACM 5855 to that of locality LACM(CIT) 207, all upper cheek teeth have protoloph spurs and all lower cheek teeth have mesoconids present; (2) from the level of locality LACM(CIT) 202 to that of locality LACM 5866, the presence of protoloph spurs on the upper molars and mesoconids in the lower cheek teeth is highly variable; and (3) from the level of locality LACM(CIT) 150, all upper and lower cheek teeth lack protoloph spurs and mesoconids, respectively. Although there is an increase in the loss of protoloph spurs and mesoconids with decreasing geologic age, the cheek teeth that lack protoloph spurs and mesoconids from low in the section are otherwise indistinguishable from those of G. sp., near *alecer* from locality LACM(CIT) 150. Furthermore, the new teeth recovered during the impact mitigation program at the Simi Valley Landfill and those described by Lillegraven (1977) confirm that all of the characters that Wilson (1940b) used to separate species of *Gripbomys* are highly variable and not reliable for species identification. Therefore, all the specimens from the Sespe Formation of Simi Valley and those referred to *G. alecer* by Lillegraven (1977) from the *Santiago Formation can confidently be assigned to *G. alecer*.

*Gripbomys* is generally regarded as belonging to the superfamily Geomyoidea and questionably assigned to the Geomyidae because of the bilophodont structure of the molars (Wilson, 1940b, 1949; Lindsay, 1968; Sutton and Black, 1975; Wood, 1974; Black and Sutton, 1984). Wilson (1949) suggested that *Gripbomys* may have been derived from an ancestral sciuravine similar to the Bridgerian *Taxyomys* Marsh, 1872. Lillegraven (1977) speculated that *Gripbomys* may be derived from a "Nama-

Taxymys is a poorly known taxon and only the upper dentition is confidently assigned to this genus (Marsh, 1872; Wilson, 1938; Bown, 1982). The upper molars of Griphomys resemble those of Taxymys in their bilophodont structure. The major changes in the upper cheek teeth that would be required to derive Griphomys from a Taxymys-like sciuravine are as follows: (1) loss of the P₄; (2) development of a hypocene and metaloph on the P₄ with subsequent widening of the central transverse valley and molarization; and (3) in the upper molars, loss of the metacanules on the metalophs, development of the protoloph spurs, and extreme reduction or loss of the mesostylids. The major changes in the teeth that would be required to derive Griphomys from a "Namatomyss fantasma"-like comyid ancestor are as follows: (1) loss of the crests extending from the anterocone and anteroconid to the protoloph and metalophid, respectively; (2) loss of the posterior portion of the ectoloph and ectolophid; and (3) a slight increase in the height and development of the main loths and lophids (protoloph, metaloph, metalophid, and hypolophid) resulting in greater bilophodony. The development of the ectoloph, ectolophid, and the crests and cristids extending from the anterocone and anteroconid to the protoloph and metalophid, respectively, are derived characters for "Namatomyss" (Chimient, 1977) and would not be expected in a basal comyid ancestor. It appears that Griphomys is more easily derived from an ancestral comyid-like form, as suggested by Lillegraven (1977), than from a Taxymys-like sciuravid. Storer (1987) presented convincing evidence for the derivation of the early Uintan to late Duchesnean "Namatomyss" from an ancestral sciuravid resembling the Wasatchian Knightomyss. It is possible that Griphomys was derived from an ancestral "Namatomyss"-like eomyid during the intervening Bridgerian, making Griphomys a sister taxon of the eomyids. However, all of the above proposed evolutionary relationships are highly speculative. Details of the cranial and postcranial morphology of Griphomys, which would further clarify the phylogeny of the genus, are unfortunately unknown. Nevertheless, Griphomys is a distinctive taxon that exhibits affinities with both the Eomyidae and the Geomyoidea.

Order Perissodactyla Owen, 1848

Family Isectolophidae
Peterson, 1919

?isectionophid, gen. and sp. undet.

Figure 16

RECONCILED SPECIMEN. Right upper cheek tooth, LACM 133987.
LOCALITY. LACM 5616.
FAUNA AND AGE. Brea Canyon Local Fauna, late Uintan.

DESCRIPTION. The position of the upper cheek tooth from locality LACM 5616 within the dental arcade is uncertain; it could be a deciduous P₄ or a molar. The parastyle is a distinct cusp that is connected to the ectolophid and the protolophid. The labially positioned paracone is a robust bilobed cusp. The metacone is the tallest and most prominent cusp above the ectolophid. A small metacone rib is present. The posterior crest of the metacone extends posteriorly as a broadly curved crest and joins with the small metastyle. The anterior crest of the metacone extends anteriorly a very short distance where it then bifurcates into two crests, one leading anterolabially to join with the paracone and the other extending anteriorly to join with the para- style. The protocone and hypocene are prominent cusps separated by a central transverse valley that extends from the ectolophid to the lingual aspect of the tooth. The protolophid is a gently curved crest that extends from the protocone to join with the para- style. The metalophid is slightly less prominent than the protolophid and extends labially from the hypocene to join with the base of the ectolophid at a point about midway between the metacone and the meta- style. The anterior, lingual, and posterior cingulae are well developed, whereas a labial cingulum is lacking. The measurements of LACM 133987 are 7.5 mm A-P and 7.6 mm TR.

DISCUSSION. Kelly et al. (1991) questionably assigned the upper cheek tooth from locality LACM 5616 to an isectolophid perissodactyl, genus and species undetermined. This tooth exhibits characters that are similar to those of the Isectolophidae, including a prominent ectoloph with a well-developed para- style and paracone, a reduced metastyle, and a cross lophed occlusal pattern formed by the
protoloph and metaloph. However, the tooth is very distinctive and does not compare well with those of any previously described genus or species of isectolophid (Radinsky, 1963; Schoch, 1989). This tooth could represent a previously unrecognized deciduous premolar or a developmental anomaly of a known isectolophid. Until a better sample of this taxon is available and following Kelly et al. (1991), this tooth is very questionably assigned to the Isectolophidae.

Order Artiodactyla Owen, 1848
Family Oromerycidae Gazin, 1955
Genus Protylopus Wortman, 1898

Protylopus robustus Golz, 1976

Figure 17, Table 7

REFERRED SPECIMENS. Partial right maxilla with broken M1+2, LACM 131448; partial left dentary with P4-M3, LACM 131447.

LOCALITY. LACM 5616.

FAUNA AND AGE. Brea Canyon Local Fauna, late Uintan.

DISCUSSION. Golz (1976) described the rare oromerycid Protylopus robustus on the basis of two partial dentaries, the holotype (UCR 12833) from the Laguna Riviera Local Fauna of the Sespe Formation, Carlsbad area, California, and a referred specimen (LACM 26363) from the Brea Canyon Local Fauna of the Sespe Formation of Simi Valley. The holotype is well worn, and the referred specimen from the Sespe Formation is a poorly preserved partial left dentary with the M1 and a broken M2. The impact mitigation program at the Simi Valley Landfill has resulted in the discovery of the first upper molars of P. robustus and a well-preserved, slightly worn partial left dentary with P4-M1 (Kelly et al., 1991).

The upper molars of LACM 131448 are damaged with the M1 represented by the protocone and a partial paracone and metaconule, the M2 represented by a partial protocone and the metaconule, and the M3 represented by a partial protocone and metaconule. These molars exhibit the following characters: (1) crescentic labial cusps; (2) bifurcated postprotocristae; (3) moderately developed anterior and posterior cingulae; and (4) labial shelves between the protocones and metaconules.

The lower molars of P. robustus have been well described by Golz (1976). However, the teeth of the newly discovered dentary are less worn than those of the holotype and exhibit the following differences: (1) the P4 metaconid is slightly more developed; (2) the metaconid in the lower molars
Table 7. Measurements (in mm) of teeth of Protylopus robustus.

<table>
<thead>
<tr>
<th>Tooth/dimension</th>
<th>LACM 131449</th>
<th>LACM 131448</th>
</tr>
</thead>
<tbody>
<tr>
<td>M¹ A-P</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>8.6 (estimated)</td>
<td>—</td>
</tr>
<tr>
<td>M² A-P</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>M² A-P</td>
<td>11.5 (estimated)</td>
<td>TR</td>
</tr>
<tr>
<td>TR</td>
<td>10.6 (estimated)</td>
<td>—</td>
</tr>
<tr>
<td>P₁ A-P</td>
<td>8.1</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>4.2</td>
<td>—</td>
</tr>
<tr>
<td>M₁ A-P</td>
<td>8.1</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>6.4</td>
<td>—</td>
</tr>
<tr>
<td>M₁ A-P</td>
<td>9.5</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>7.5</td>
<td>—</td>
</tr>
<tr>
<td>M₁ A-P</td>
<td>16.6</td>
<td>—</td>
</tr>
<tr>
<td>TR</td>
<td>8.3</td>
<td>—</td>
</tr>
<tr>
<td>M₁-M₁</td>
<td>34.3</td>
<td>—</td>
</tr>
</tbody>
</table>

is not connected to the co-joined cristids from the protoconid and hypoconid; and (3) the M₁ hypoconulid basin has a small cuspule at the anterior labial corner near the termination of the posterior cristid of the metaconid.

Family Camelidae Gray, 1821

Protoceratidae gen. and sp. undet.

Figure 18

REFERRED SPECIMEN. Partial RM², LACM 130828.

LOCALITY. LACM 5876.

FAUNA AND AGE. Simi Valley Landfill Local Fauna, late Duchesnean.

DESCRIPTION. The only specimen referable to this taxon is a well-worn, partial RM² that is missing the mesostylar region, the paracone, the anterolabial portion of the preprotocrista, and part of the anterior cingulum. The tooth appears to have been transversely elongated with a rectangular occlusal outline. The partial ectoloph, which extends from the metastyle to the anterior aspect of the metacone, is relatively straight. The metastyle is very small and the rib on the labial surface of the metacone is weakly developed. The protocone is deeply worn. The partial preprotocrista extends anterolabially and, presumably, was connected with the missing paracone. The postprotocrista is rounded with wear and is separated from the anterior crest of the metaconule by a narrow valley between the protocone and metaconule. The anterior crest of the metaconule extends anterolabially wherein it joins the posterior crest of the paracone and the anterior crest of the metacone. The posterior crest of the metaconule extends posterolabially and joins with the metastyle and the posterior crest of the metacone. The metacone and metaconule are crescentic and, even in their worn state, exhibit a moderate degree of selenodonto. The anterior cingulum is moderately well developed and a small lingual cingulum is present between the protocone and metaconule, whereas labial and posterior cingulids are lacking. The measurements of LACM 130828 are as follows: 5.0 mm (estimated) A-P, 7.6 mm (estimated) ANT-TR, and 6.6 mm POST-TR.

DISCUSSION. The partial M² from Simi Valley differs from those of other middle to late Eocene selenodont artiodactyls, including Protoreodon Scott and Osborn, 1887, Diplolimnops Peterson, 1919, Protylopus Wortman, 1898, Oromeryx Marsh, 1894, Eotylopus Matthew, 1910, Malaguerstinae Gazin, 1955, Camelodon Granger, 1910, Leptoclymodon Wortman, 1898, Leptotragulus Scott and Osborn, 1887, Paebromylus Peterson, 1931, Orenus gazin Black, 1978, Siminimyx Stock, 1934c, and Leptomeryx Leidy, 1853, by having a much less developed metastyle and an apparently straighter ectoloph. It further differs from those of species of the Oromerycidae by lacking a bifurcated postprotocrista and having a weaker developed rib on the metacone.

The Simi Valley tooth is most similar to those of Poebrodon kaiy Gazin, 1955, from the Uinta Formation of Utah. These similarities include a relatively straight ectoloph, a very small metastyle, a weakly developed rib on the metacone, a crescentic metaconule, and a tendency for the anterior crest of the metaconule to join with the posterior crest.

Figure 19. Siminimyx sp., aff. S. hudsoni Stock, A. RM², LACM 130869; B. RM¹, LACM 130868. All occlusal views. Scale = 1 mm.
of the paracone with wear. The missing paracone, parastyle, and mesostyle in the Simimeryx tooth do not allow a comprehensive comparison with species of Poebrodon. However, it differs from those of Poebrodon by being more transversely expanded and having greater development of the anterior and labial cingula.

The Simi Valley tooth appears to belong to a taxon that is most closely related to the middle Eocene Poebrodon, but, because of the incomplete nature of the Simi Valley specimen, it is hereinquestionably referred to the Camelidae.

Family Hypertragulidae Cope, 1879

Genus Simimeryx Stock, 1934c

Simimeryx sp., aff. S. hudsoni Stock, 1934c

Figure 19

Simimeryx n. sp. Kelly et al., 1991:8.

REFERRED SPECIMENS. Partial RM1 and partial RM2, LACM 130867; RM2, LACM 130869; RM3, LACM 130868.

LOCALITY. LACM 5876.

FAUNA AND AGE. Simi Valley Landfill Local Fauna, late Duchesnean.

DESCRIPTION. The upper molars of Simimeryx sp., aff. S. hudsoni are represented by a partial M2 that is missing the paracone and protocone, a partial M3 that is missing the ectoloph, and a complete M4. The paracone is a rounded conical cusp. The paraconid is robust and positioned at the anterolabial corner of the tooth. The metaconules are well developed and crescentic. The posterior crest of the metaconule extends anterolabially where it joins the posterior cingulum. The anterior crest of the metaconule extends posterolabially to the anterolabial base of the paracone where it turns lingually towards the posterior crest of the protocone. The labial cingulum is reduced on the upper molars so that it is distinct anteriorly, posteriorly, and between the paracone and metacone, but barely discernable along the labial surfaces of the paracone and metacone. The anterior and lingual cingulae are moderately well developed, but the posterior cingulum varies from a moderately distinct crest to absent. The measurements of the only complete upper molar are 5.6 mm A-P, 6.6 mm ANT-TR, and 6.0 mm POST-TR.

The M1 is anteroposteriorly elongated and moderately well worn. The paraconid and entoconid are conical and somewhat bunodont cusps, whereas the protoconid and metaconid are crescentic. The parastylid is a distinct cistid that extends labially from the termination of the preprotoconid wherein it turns posteriorly to join the mediolabial surface of the paraconid. The anterior and lingual cingulids are moderately developed. A robust hypoconulid is present. The measurements of the M1 are 8.8 mm A-P and 4.7 mm TR.

DISCUSSION. The teeth from locality LACM 5876 are referred to Simimeryx because the upper molars lack mesostyles and have robust parastyles, postprotoconid cingulae that are posterolabially directed, and lingual cingulae. Also, the morphology of the M2 hypoconulid is more like those of Simimeryx than those of other hypertragulids.

Two species of Simimeryx are currently recognized: S. hudsoni of the Pearson Ranch Local Fauna, Sespe Formation, California, and S. minutus Peterson, 1931, of the Lapont Fauna, Duchesne River Formation, Utah. Fossils of Simimeryx hudsoni are well represented in the collections from the Sespe Formation, whereas S. minutus is known only from fragmentary material. The samples of Simimeryx teeth from locality LACM 5876 differ from those of S. hudsoni by having the following characters: (1) the teeth are slightly larger and slightly more selenodont; (2) the parastyle and parastylid are more labially positioned and the parastyle is slightly more reduced; (3) the anterior crest of the metaconule extends further posterolabially to the anterolabial base of the paracone where it turns lingually towards the posterior crest of the protocone; (4) the upper molar anterior, posterior, and lingual cingulae are less developed; (5) the upper molar labial cingulum is much less developed; and (6) the M1 hypoconulid is proportionately larger. It is difficult to compare the Simimeryx teeth from locality LACM 5876 with those of S. minutus because of the lack of comparative material, but the measurements of the Simi Valley teeth are much larger. The teeth from locality LACM 5876 are more derived than those of S. hudsoni, as indicated by their greater selenodonty, slightly more reduced cingulae and reduced parastyles in the upper molars, and relatively larger M1, hypoconulid, and appear to represent a new species. However, until an adequate sample of this taxon is available, these teeth are assigned to S. sp., aff. S. hudsoni.

Most investigators regard Simimeryx as a member of the Hypertragulidae (Stock, 1934c; Gazin, 1955; Golz, 1976). However, Emry (1978) hesitated to include Simimeryx in this family because Simimeryx differs from the more typical hypertragulids, Hypertragulus Cope, 1873, and Parviragulus Emry, 1978, by having (1) the protocones and metaconules of the upper molars in different positions relative to Simimeryx and (2) a very distinctive M1, hypoconulid morphology. The teeth of S. sp., aff. S. hudsoni exhibit some similarities with those of Parviragulus and Hypertragulus, such as the reduced molar cingulae and cingulids. The M1, hypoconulid of S. sp., aff. S. hudsoni is also proportionally larger than those of S. hudsoni and possesses a deeper central basin that is intermediate to those of S. hudsoni and those of other hypertragulids. The teeth of S. sp., aff. S. hudsoni differ from those of Parviragulus and Hypertragulus by having the following characters: (1) larger and less hypsodont molars; (2) less transversely compressed upper molars; (3) much less developed paracone and metacone ribs; (4) a greatly reduced metacone; (5) a more posteriorly directed postprotoconid; and (6) a rel-
atively smaller M, hypoconulid. The teeth of S. sp., aff. S. hudsoni appear to be morphologically intermedaiate to those of S. hudsoni and those of the more typical hypertragulids, suggesting, contrary to Emry (1978), that Simimeryx should be included with the Hypertragulidae.

Mammalia
gen. and sp. undet.

**Figure 20**

**REFERRED SPECIMEN.** Partial right upper cheek tooth, LACM 130865.

**LOCALITY.** LACM 5876.

**FAUNA AND AGE.** Simi Valley Landfill Local Fauna, late Duchesnean.

**DESCRIPTION.** The partial tooth (LACM 130865) is missing part of the metaconule and posterior cingulum, and the metacone. The occlusal outline appears to have been subtriangular in shape. A small metastyle is present. The protocone and metacone are tall conical cusps, with the protocone larger than the metacone. The protocone exhibits a postprotoconulid fold that extends posterolabially towards the posterior cingulum and a very vestigial postprotoconulid that extends between the protocone and the metacone. The preprotoconulid is a complete crest forming a protoloph that extends anterolabially from the protocone to join with the protocone. The protocone exhibits an oval wear pattern and appears to be smaller than the metacone. Only about half the metacone is present, and it also appears to have had an oval wear pattern. The anterior cingulum is robust and extends lingually from the metastyle to about half way along the anterior face of the protocone. The labial cingulum is moderately developed across the labial surface of the metacone. A small distinct cusp (= hypocone) is present along the anterior cingulum near its lingual termination. The partial posterior cingulum is robust and a small cusp (= hypocone) is present near its lingual termination. The measurements of LACM 130865 can only be estimated as follows: 3.7 mm A-P and 4.6 mm TR.

**DISCUSSION.** The partial upper cheek tooth (LACM 130865) from Simi Valley is perplexing because its ordinal and familial assignment is uncertain. Kelly et al. (1991) assigned this tooth to an undetermined omomyine primate based on the presence of a postprotoconulid fold. Further preparation and examination of this specimen makes this assignment questionable. Because of the incomplete nature of the specimen, it is herein assigned to Mammalia, gen. and sp. undet.

**CONCLUSIONS**
The paleontologic resource impact mitigation program at the Simi Valley Landfill has yielded large samples of superposed middle to late Eocene small mammal assemblages. New taxa and additional specimens of poorly known taxa were recovered during the program. Prior to this report, many of these taxa were inadequately described because they were represented by fragmentary specimens or very small samples.

The discovery of the following Uintan taxa from the middle member of the Sespe Formation is documented: Canidetodon sp., cf. C. aztecum; erinaceomorph, gen. and sp. undet.; Uintasorex sp., cf. U. montezumicus; Microparamys woodi n. sp.; Microparamys sp., cf. M. tricus; Miaciis sp. undet.; and sectolophid, gen. and sp. undet. Also, the discovery of the following Duchesnean taxa from the middle member of the Sespe Formation is documented: Peradectes californicus; Leptotomys sp. undet.; Camelidae, gen. and sp. undet.; Simimeryx sp., aff. S. hudsoni; and Mammalia, gen. and sp. undet.

The impact mitigation program at the Simi Valley Landfill has resulted in larger samples of the teeth of the primate Dyseodens pacificus, the rodent Griphomys alector, and the artiodactyl Protylopus robustus. The new specimens of D. pacificus described herein include the first P3 and the third M3 of this species recovered from the Sespe Formation. Among the known teeth of D. pacificus, the M3 appears to exhibit the greatest variation in morphology. In the teeth of G. alector, the most variable characters are the development of the upper molar protoloph spurs and the lower molar mesoconids. The teeth of G. alector exhibit similarities with those of the Eomyidae and the Geomyidae, and Griphomys may have originated from a "Namatomys"-like comyid ancestor. The new specimens of P. robustus described herein include the first upper molars referable to this species and a well-preserved partial left dentary with P1-M3.
Centetodon sp., cf. C. azteca and Microparahyops are now known to have a geologic range from the early late Uintan Tapo Canyon Local Fauna to the late Uintan Brea Canyon Local Fauna. Spermophyllum, Jaywilsonomyx, Mesohippus, aff. S. Russeti, Brachyhyops, Menops, Poabromylus, chyrotomus, neodus, nops, Mammalia, the by Adjidaumo, Hyaenodon, first daumo, appearances with 5876 of thwhistleri of P. "of Locality extends the by the Fauna into the Valley Landfill, presented the by the Duchesnean of the Minnesota, Aulolithomys, Hyracodon, and Aclistomycter, appearances of the Simimys, Hesquiat, Mesomylodon, and Aegialototypospis, Mesohippus, Trigonias, Subhyracodon, Toxotherium, Brachyhydrs, Archaeotherium, Agriocboerus, Podabromylus, Eotylopus, Acistomyceter, Heteromyxus, Hendryomyxus, Leptomeryx, and Hypertragulus and the last appearances of Protevixoides, Spermophyllum, Simiedeets, Chumashius, Pareumyx, Rapamyx, Gripphyx, Myotonyx, Ischyrotonyx, Hessolestes, Harpagolesus, Duchesneodus, Amynodontopsis, Triplous, Eophippus, Protoreodon, Leptoreodon, Hypopsodus, Diplobonops, and Simimeryx (Wilson, 1986; Kelly, 1990; Kelly et al., 1991; Walsh, 1991; Lucas, 1992). Additional first appearances that can now be confidently recorded in the Duchesnean are Paradjidaumo, Heliscomys, and Simiarctomyx. Additional last appearances recorded in the Duchesnean are "Namatomyx" and Simimylyx.

Based on the taxa that constitute the Simi Valley Landfill Local Fauna, this fauna can be compared with other key Duchesnean North American land mammal faunas as follows: (1) it is younger than the Pearson Ranch Local Fauna from the Sespe Formation of California, the Skyline Local Fauna from the Agua Fria–Green Valley area of Texas, Lapoint Fauna from the Duchesne River Formation of Utah, and the faunal assemblages of the Badwater Locality 20 and the Wood and Rodent Localities from the Wagon Bed Formation of Wyoming; (2) it is older than the Porvenir Local Fauna from the Vieja–Ojinaga area of Texas; and (3) it is probably a correlative of the Lac Pelletier Lower Fauna from the Cypress Hills Formation of Saskatchewan.

Prothero et al. (1992) recently reported that the Simi Valley Landfill Local Fauna occurs within the latter part of a reversed magnetozone, which they interpret as Chron C17R. Based on K-Ar radiometric calibration, Berggren et al. (1985, 1992) regard Chron C17R to occur between about 41 and 41.5 Ma. However, revised Ar-Ar radiometric calibration presented by Prothero and Swisher (1992) places Chron C17R between about 38.7 and 39 Ma. Based on the data presented by Prothero and Swisher (1992) and Prothero et al. (1992), the age of the Simi Valley Landfill Local Fauna is about 37.5 to 38.8 Ma. Prothero and Swisher (1992) also provided revised Ar-Ar dates of 39.74 ± 0.07 Ma for the Lapoint tuff that occurs below the Lapoint Fauna between the Lapoint and Dry Gulch Creek Members of the Duchesne River Formation and 37.8 ± 0.06 Ma for the Buckshot Ignimbrite of the Vieja–Ojinaga area that underlies the Porvenir Local Fauna. In addition, Prothero and Swisher (1992) questioned the validity of a K-Ar date of 42.3 ± 1.4 Ma (Black, 1969) for a biotite-bearing unit underlying the faunal assemblage from Badwater Locality 20 because it contains older detrital biotite. The age of this biotite-bearing unit has been used by other investigators as a lower age limit for the Duchesnean (e.g., Krishikalka et al., 1987; Kelly, 1990; Lucas, 1992). Furthermore, Prothero and Swisher (1992) and Prothero et al. (1992) have presented the following additional magnetostatigraphic correlations: (1) the Duchesnean Pearson Ranch Local Fauna occurs throughout most of Chron C18N, estimated between about 40.5 and 39 Ma; (2) the Duchesnean Lapoint Fauna occurs in the latter part of Chron C18N, estimated to be younger than about 39.7 Ma; (3) the latest Uintan Strathern Local Fauna, which underlies the Pearson Ranch Local Fauna, occurs in the latter part of Chron C18R, estimated to be about 40.5 Ma; and (4) the late Uintan Tapo Canyon and Brea Canyon Local Faunas occur from Chron C19N to the lower half of Chron C18R, estimated between about 42 and 40.5 Ma. The new Ar-Ar calibration of the magnetic time scale would place the Duchesnean between about 40.5 and 37 Ma (Prothero and Swisher, 1992; Prothero et al., 1992), whereas the K-Ar calibration would place the Duchesnean between about 42 and 39 Ma (Berggren et al., 1985, 1992). Lucas (1992) recently redefined the Duchesnean and regarded Duchesnean faunas as occurring from about 37 Ma to as old as 42 Ma, which he correlated with Chron C18 to part of Chron C16. Irregardless of whether the new Ar-Ar or the K-Ar calibrations of the magnetic time scale are correct, it appears that the early Duchesnean faunas occur within Chron C18N, the late Duchesnean faunas occur within Chrons C17R to C17N, and the Uintan–Duchesnean boundary occurs between Chrons C18N and C18R. All of the
above data support the biostratigraphic evidence that the Simi Valley Landfill Local Fauna is younger than the Lapoint Fauna, older than the Porvenir Local Fauna, and late Duchesnean in age.

ACKNOWLEDGMENTS

We are indebted to the Simi Valley Landfill and Recycling Center (SVLRC), a division of Waste Management of California, Inc., for providing financial support of the Paleontological Resource Impact Mitigation Program that has led to the recovery of the specimens described in this study. Special thanks is given to E. Bruce Lander and Mark A. Roeder of Paleo Environmental Associates, Inc. and the LACM for their direction of the extensive fieldwork at the Simi Valley Landfill, which resulted in the discovery of the new specimens described herein. We would also like to thank Mike Williams of SVLRC and Kim Uhlich and Scott Ellison of the Ventura County Resource Management Agency Planning Division for their support and recognition of the scientific significance of the paleontological resources of the Simi Valley Landfill.

LITERATURE CITED


Szalay, F.S. 1976. Systematics of the Omomyidae (Tar-


Received 15 December 1992; accepted 20 May 1993.

APPENDIX A

CHARACTERS AND CHARACTER STATES USED IN CLADISTIC ANALYSES

1. Position of posterior margin of anterior root of the zygoma. Three states are recognized: 0, located in line between P4 and M1; 1, located in line with center of P3; 2, located in line with anterior margin of P4.

2. Position of anterior termination of massecetid fossa. Six states are recognized: 0, located in line with the trigonid of M3; 1, located in line between the posterior half to middle of M3; 2, located in line with the middle of M3; 3, located in line with center of anterior half of M3; 4, located in line between the anterior end of M, to posterior root of M3; 5, located in line with the middle of M1.

3. Number of mental foramina on mandibular rami. Two states are recognized: 0, single foramen present; 1, two foramina present.

4. Cheek teeth crenulations. Three states are recognized: 0, not crenulated; 1, weakly to moderately crenulated; 2, extremely crenulated.

5. Size. Based on A-P length of M2. Four states are recognized: 0, medium 1.40-1.60 mm; 1, small 1.25-1.40 mm; 2, very small <1.25 mm; 3, large <1.60 mm.

6. P1. Two states are recognized: 0, present; 1, absent.

7. P2. Two states are recognized: 0, non-molariform with single buccal cusp (paracone) and hypocone absent or rudimentary; 1, molariform with two buccal cusps (paracone and metacone) and distinct hypocone.

8. M1-M2 occlusal patterns in hypoconal and protoconal regions. Two states are recognized: 0, occlusal pattern not U-shaped; 1, occlusal pattern U-shaped.

9. M1-M2 metaconule and protoloph development and occlusal shape. Two states are recognized: 0, both lophs well developed and complete forming general V-shaped occlusal pattern; 1, one or both lophs incomplete and do not form a V-shaped occlusal pattern.

10. M1-M2 protoconule development. Three states are recognized: 0, protoconule well developed as single large conical cusp; 1, protoconule moderately reduced as elongated cusp; 2, absent or vestigial.

11. M1-M2 metaconule development. Six states are recognized: 0, single unreduced metaconule usually present as large conical cusp; 1, single moderately reduced metaconule usually present as a relatively distinct cusp; 2, two metaconules (doubled) usually present as small reduced cuspsules; 3, two metaconules (doubled) usually present as well-developed cuspsules; 4, single very reduced metaconule usually present; 5, metaconule absent or vestigial.

12. M1-M2 metaconule position. Two states are recognized: 0, metaconule positioned labially and in close association with metacone; 1, metaconule positioned lingually and not in close association with metacone.

13. M1-M2 postprotocrista development. Two states are recognized: 0, absent or poorly developed; 1, moderately well to well developed.

14. M1-M2 hypocone development. Two states are recog-
nized: 0, moderately developed cusp; 1, well-developed cusp.
15. M2 mesolophid. Defined as spur or loph originating near apex of protocone that extends lingually into the central basin of the tooth. Two states are recognized: 0, absent or weakly developed; 1, present as a distinct cristid or loph.
16. P, size relative to lower molars. Defined as ratio of mean M, A-P length to mean P, A-P length. Four states are recognized: 0, moderately reduced (ratio = 0.75–0.90); 1, slightly reduced (ratio = 0.90–0.98); 2, very reduced (ratio = 0.65–0.75); 3, extremely reduced (ratio = <0.65).
17. M, mesoconid. Three states are recognized: 0, absent; 1, present, weakly developed; 2, present, strongly developed.
18. P, ectolophids. Two states are recognized: 0, absent; 1, usually developed as a complete cristid connecting the protoconid, mesoconid, and hypoconid or two almost complete cristids extending from mesoconid towards protoconid and hypoconid, respectively.
19. P, hypoconid. Two states are recognized. 0, small and poorly developed; 1, well developed.
20. P, posterolophid. Two states are recognized: 0, absent or very weakly developed; 1, present, well developed.
21. P, protoconid. Two states are recognized: 0, usually present as a distinct cusp; 1, usually absent or vestigial.
22. Complexity of lower molar occlusal patterns. Two states are recognized: 0, simple to moderately simple; 1, very complex with abundant small cristids and lophs present throughout the talonid.
23. M, trigonid size. Two states are recognized: 0, equal or subequal in size to talonids; 1, markedly narrower than talonids.
24. M, mesoconid shape. Two states are recognized: 0, not anteroposteriorly compressed; 1, anteroposteriorly compressed.
25. M, anterior cingulid development. Two states are recognized: 0, weakly developed as short low cristid; 1, well developed as long, distinct cristid.
26. M, anterior cingulid connection with protoconid. Four states are recognized: 0, anterior cingulid separated from protoconid by small, shallow valley and labial terminus of anterior cingulid connected to protoconid; 1, anterior cingulid separated from protoconid by distinct groove or valley and labial terminus of anterior cingulid not connected to protoconid; 2, anterior cingulid separated from protoconid by narrow groove in early wear that disappears with moderate wear to form connection between labial terminus of anterior cingulid and protoconid; 3, anterior cingulid separated from protoconid by distinct groove or valley and connected to protoconid by small but relatively persistent thin cristid originating from near labial terminus of anterior cingulid.
27. M, anterior cingulid connection with metaconid. Three states are recognized: 0, anterior cingulid is weakly developed as low, short cristid connected to base of metaconid; 1, anterior cingulid moderately to well-developed cristid connected to the metaconid; 2, anterior cingulid moderately developed as a distinct cristid along anterior margin of tooth and separated from metaconid by distinct gap or groove.
28. M, development of cusp on labial terminus of anterior cingulid. Two states are recognized: 0, not cuspidate; 1, cuspidate.
29. M, trigonid. Two states are recognized: 0, trigonid usually open posterolingually; 1, trigonid usually closed posterolingually.
30. M, protoconid. Two states are recognized: 0, protoconid not isolated, but connected or nearly connected to ectolophid and posterior arm of protoconid short or if developed usually directed towards middle of metaconid or further forward, and posterior arm is not parallel with anterior cingulid; 1, protoconid relatively isolated cusp with posterior arm of the protoconid extending to or nearly to the posterior labial base of metaconid, and posterior arm of protoconid nearly parallel with anterior cingulid.
31. M, hypolophid development. Two states are recognized: 0, incomplete, absent or rudimentary cristid is present that originates from the entoconid and is labially directed a short distance into the central basin of tooth; 1, complete cristid present, connecting entoconid with hypoconid resulting in a distinct enclosed valley between the hypolophid and posterolophid.
32. M, posterolophid development. Two states are recognized: 0, posterolophid weakly developed; 1, posterolophid well developed.
33. M, “mesolophids.” Defined as small spurs or cristids generally directed lingually from the mesoconid into the central basin of the tooth. Two states are recognized: 0, absent or rudimentary; 1, present as one to three small spurs.
34. M, hypoconulid development: Four states are recognized: 0, present as well-developed isolated cusp; 1, present as moderately well-developed, often elongated, cuspule formed along posterolophid; 2, incipient hypoconulid present as a widening along posterolophid; 3, absent.
35. M, entoconid isolation. Four states are recognized: 0, M, entoconid isolated and well separated from posterolophid by well-developed wide gap; 1, M, entoconid isolated and separated from posterolophid by narrow distinct groove; 2, M, entoconid connected to posterolophids; 3, M, entoconid isolated from posterolophid by narrow groove, whereas M, entoconid connected to posterolophid.
36. M, ectolophids. Defined as cristids extending from mesoconid to or near protoconid and hypoconid forming anteroposteriorly directed loph along labial aspect of tooth. Two states are recognized: 0, usually present with one or both cristids complete or nearly complete; 1, usually absent.
APPENDIX B
Character state matrix for following group of taxa: *Cocomys* (outgroup), *Reithroparamys*, *Apatosciuratus*, *Acritoparamys*, *Microparamys*, *Lophiparamys*, “*Microparamys*” *reginensis*, “*Microparamys*” *scopaiodon*, and *Pauromys*. Characters and character states are defined in Appendix A.

| Characters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| *Cocomys*  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Reithroparamys* | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apatosciuratus* | 2 | 1 | 1 | 0 | 1 | 2 | 4 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Acritoparamys* | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| *Microparamys* | 2 | 5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 |
| *Lophiparamys* | ? | 2 | 0 | 2 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| “M.” *reginensis* | ? | 4 | 0 | 0 | ? | ? | ? | ? | ? | ? | ? | ? | ? | 1 | 1 | ? | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| “M.” *scopaiodon* | ? | 4 | 0 | 0 | ? | ? | ? | ? | ? | ? | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| *Pauromys* | 2 | 5 | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 1 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 2 | 0 |

APPENDIX C
Character state matrix for *Cocomys* (outgroup) and reithroparamyne genera. Characters and character states are defined in Appendix A.

| Characters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| *Cocomys*  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Reithroparamys* | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apatosciuratus* | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Acritoparamys* | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| *Microparamys* | 2 | 5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 |
| *Lophiparamys* | ? | 2 | 0 | 2 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |

APPENDIX D
Character state matrix for *Cocomys lingchaensis* (outgroup) and species of *Microparamys*. Characters and character states are defined in Appendix A.

| Characters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| *Cocomys*  | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *lingchaensis* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *M. minutus* | 2 | 5 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 1 |
| *M. sp., cf. M. minutus* | ? | ? | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 1 |
| *M. dubius* | ? | ? | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *M. sp., cf. M. tricus* | ? | ? | 1 | 3 | 2 | 0 | 1 | 3 | 0 | ? | ? | ? | ? | ? | ? | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 1 |
| *M. tricus* | 2 | 5 | 1 | 3 | 1 | 0 | 1 | 3 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 2 | 1 |
| *M. woodi* | ? | ? | 1 | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 0 | 1 | 0 | 1 | 1 | 3 | 2 |
| *M. perROSSUS* | 5 | 1 | 0 | 1 | 1 | 4 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | ? | 0 | 0 | 1 | 0 | 3 | 2 |