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

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Abstract.—A paleontologic impact mitigation program being conducted at the Simi Valley Landfill in southern California is yielding new species and new geologic and geographic occurrences of middle and late Eocene rodents representing the families Eomyidae, Heliscomyidae, Simimyidae, and ?Zapodidae from the middle member of the continental Sespe Formation. These rodents include “*Namatomys*” sp., cf. “*N.*” *fantasma* Lindsay, “*Namatomys*” sp., *Paradjidaumo reynoldsi* new species, *Heliscomys* sp., *Simimys landeri* new species, and *Simiacritomys whistleri* new genus and species.

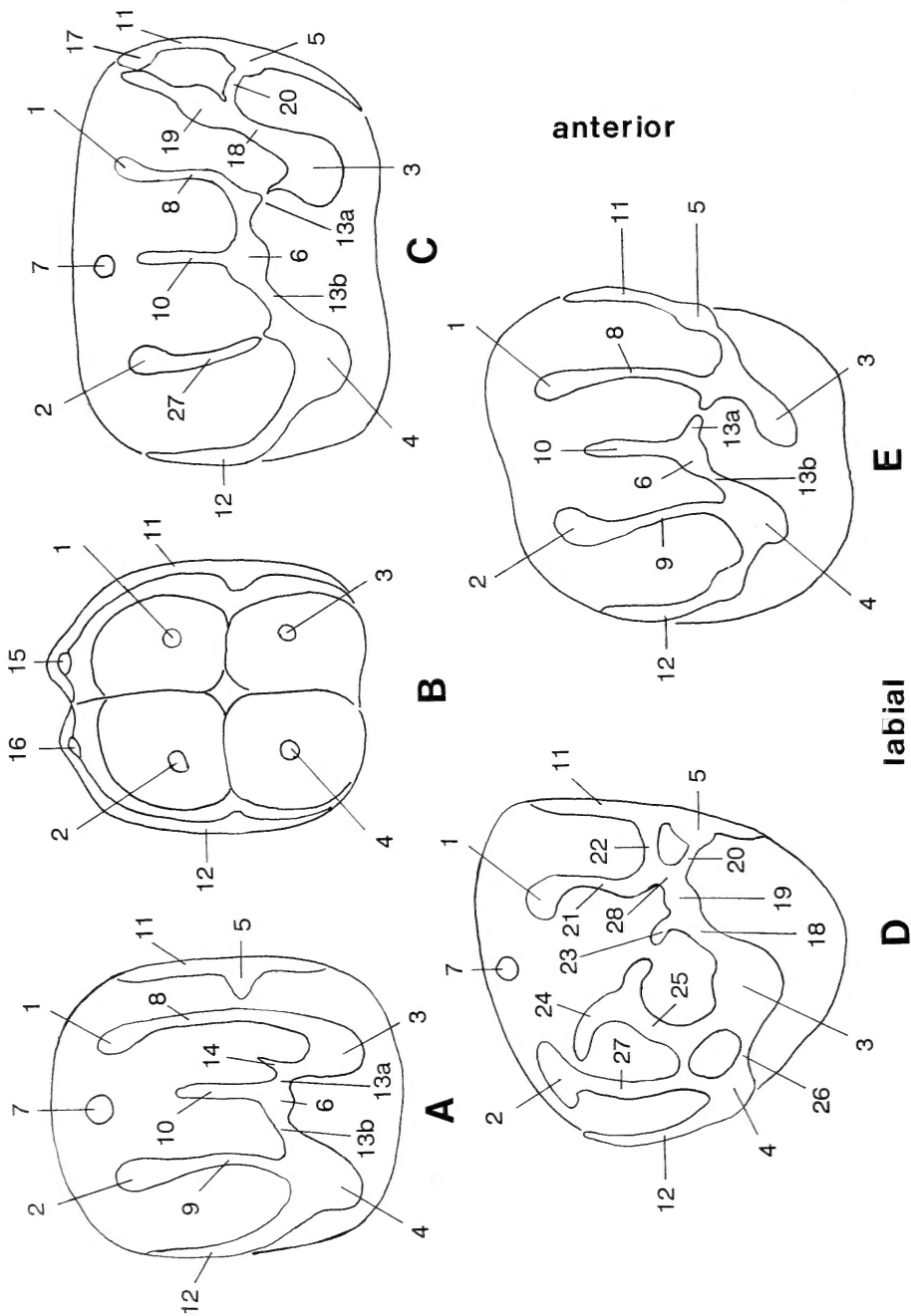
Mason (1988) and Kelly (1990) described the mammalian paleontology and biostratigraphy of the continental Sespe Formation along the northern side of Simi Valley, Ventura County, California. Kelly (1990) recognized four superposed middle Eocene local faunas from the middle member of the Sespe Formation. In ascending stratigraphic order, these faunas include the Tapo Canyon Local Fauna (early late Uintan age), the Brea Canyon Local Fauna (late Uintan age), the Strathern Local Fauna (latest Uintan or earliest Duchesnean age), and the Pearson Ranch Local Fauna (early Duchesnean age).

Kelly and others (1991) reported 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. They recognized a fifth local fauna, the Simi Valley Landfill Local Fauna of middle or late Duchesnean age, from the uppermost part of the middle member and an unnamed assemblage from the uppermost part of the lower member. The program has yielded many new taxa and geologic and geographic records from the Sespe Formation that were only briefly discussed by Kelly and others (1991). These new taxa are biostratigraphically significant, especially those of the Simi Valley Landfill Local Fauna. This report describes the rodents of the families Eomyidae, Heliscomyidae, Simimyidae, and ?Zapodidae discovered during the program.

Materials and Methods

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

All measurements were made with an AO optical micrometer to the nearest 0.01 mm, and all teeth were measured at their greatest dimensions. Measurements



of the first two upper molars for some species were grouped, as were those for the first two lower molars because of the difficulty in unequivocally assigning isolated teeth to their correct positions in the dental arcade. All metric abbreviations and dental formulae follow standard usage. Dental terminology used herein is presented in Figs. 1 and 2.

Institutional acronyms are as follows: LACM, Natural History Museum of Los Angeles County; SBCM, San Bernardino County Museum. Abbreviations for anatomical terms are as follows: A-P, anteroposterior; Ant, anterior; L, left; Post, posterior; R, right; TR, transverse. Other abbreviations are as follows: CV, coefficient of variation; Loc., locality; N, number of specimens; OR, observed range; SD, standard deviation.

Systematic Paleontology

Class Mammalia Linnaeus, 1758

Order Rodentia Bowdich, 1821

Family Eomyidae Deperet and Douxami, 1902

"*Namatomys*" sp., cf. "*N.*" *fantasma* Lindsay, 1968

Figure 3, Table 1

Specimens.—RM^{1or2}, LACM 130792; RM^{1or2}, LACM 130793; RM^{1or2}, LACM 130795; RM^{1or2}, LACM 134684; RM^{1or2}, LACM 130800; LM^{1or2}, LACM 130797; LM^{1or2}, 130791; LM^{1or2}, LACM 130798; LM^{1or2}, LACM 130799; RP₄, LACM 130808; RM_{1or2}, LACM 130804; LM₁?, LACM 130807; LM_{1or2}, LACM 130805; RM₃, LACM 130803; LM₃, LACM 130806.

Distribution and age.—LACM Locs. 5857 and 5859, Tapo Canyon Local Fauna, early late Uintan; LACM Loc. 5869, Brea Canyon Local Fauna, late Uintan.

Description.—The occlusal surfaces of the upper molars are subquadrate in shape. The anterior cingulum (=anteroloph) is well-developed and extends from the labial aspect of the tooth to the lingual aspect. A distinct anterocone is connected by a small accessory crest to the protoloph near the protocone. The paracone, protocone, metacone, and hypocone are distinct low-crowned cusps with protoloph and metaloph usually forming complete crests that are much lower than the cusps. The posterior arm of the protocone is usually developed labially as a distinct crest and it is commonly forked by additional small spurs. A small mure is present that projects anterolabially from the hypocone towards the posterior arm of the protoloph, but rarely connects with this arm. In five molars, the mesostyle is present as a small distinct cusp. A small spur on the mesocone is commonly present and extends lingually. The posterior cingulum (=posteroloph) is a well-developed, robust crest that extends from the posterolabial base of the metacone to the apex of the hypocone.

←

Fig. 1. Dental terminology in upper cheek teeth of A—"Namatomys" and *Paradjidaumo*, B-*Heliscomys*, C-*Simimys* M¹⁻², D-*Simimys* M³, and E-*Simiacritomys*: 1, paracone; 2, metacone; 3, protocone; 4, hypocone; 5, anterocone; 6, mesocone; 7, mesostyle; 8, protoloph; 9, metaloph; 10, mesoloph; 11, anterior cingulum; 12, posterior cingulum; 13, mure (=entoloph in *Simiacritomys*), a—anterior, b—posterior; 14, posterior arm of protocone; 15, hypostyle; 16, protostyle; 17, parastyle; 18, preprotocrista; 19, protoconule; 20, anteroconal spur; 21, paralophule; 22, cingular-preprotoconular connection; 23, postprotoconular wing; 24, anterior metalophular spur; 25, postprotocrista; 26, postprotoconular crest; 27, metalophule; 28, preprotoconular wing.

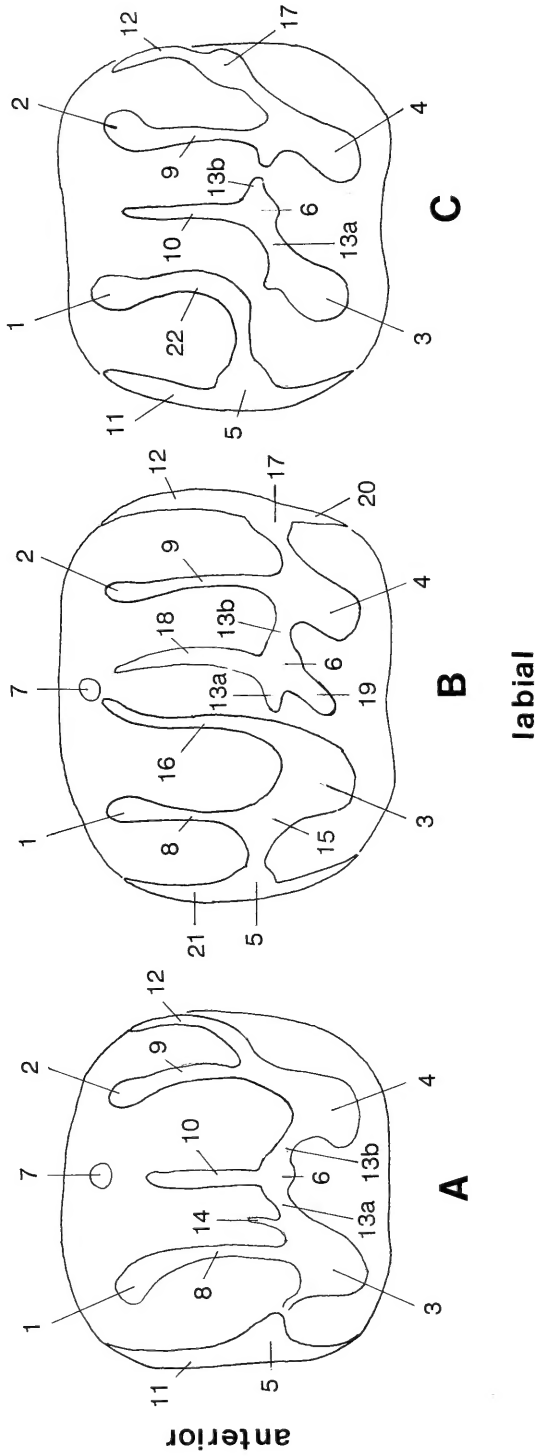


Fig. 2. Dental terminology in lower cheek teeth of A.—*Namatomys* and *Paradjidaumo*, B.—*Simimys*, and C.—*Simiacritomys*: 1, metaconid; 2, entoconid; 3, protoconid; 4, hypoconid; 5, anteroconid; 6, mesoconid; 7, mesostylid; 8, metalophid; 9, hypolophid; 10, mesolophid; 11, anterior cingulid; 12, posterior cingulid; 13, mure (=ectolophid in *Simimys* and *Simiacritomys*), a— anterior, b— posterior; 14, posterior arm of protoconid; 15, preprotocristid; 16, postprotocristid; 17, hypoconulid; 18, lingual mesolophid; 19, labial mesolophid; 20, labial extension of posterior cingulid; 21, anterolabial cingulid; 22, labial projection of metaconid.

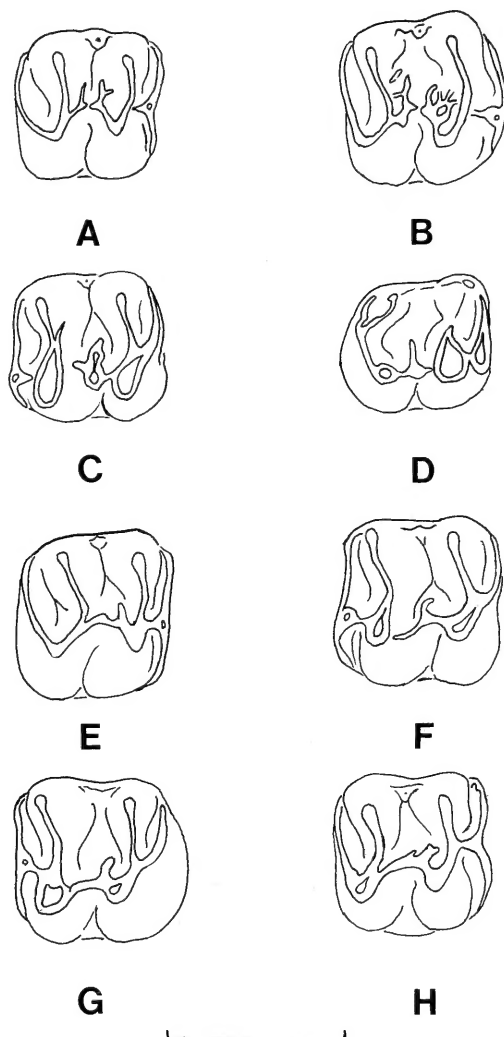


Fig. 3. "*Namatomys*" sp., cf. "*N.*" *fantasma* Lindsay (A-D) and "*Namatomys*" sp. (E-H). "*Namatomys*" sp., cf. "*N.*" *fantasma*. A, RM^{1or2}, LACM 130793. B, RM^{1or2}, LACM 130792. C, LM^{1or2}, LACM 130805. D, LM₃, LACM 130806. "*Namatomys*" sp. E, RM^{1or2}, LACM 131044. F, LM_{1?}, LACM 131057. G, LM^{1or2}, LACM 131058. H, RP⁴, LACM 131040. All occlusal views; D reversed. Scale = 1 mm.

The P₄ is transversely narrowed and anteroposteriorly elongated. A distinct anteroconid is present. The metaconid and protoconid are positioned close together near the anterior midline of the tooth and are connected by a small complete metalophid. The posterior arm of the protoconid is a low, moderately developed crest that extends posterolabially into the central basin of the tooth. The entoconid and hypoconid are distinct cusps connected by a thin hypolophid (=entolophid). A small posterior cingulid is present that extends from the entoconid to the middle of the tooth, where it connects to the hypolophid. A thin crest is present that connects the metaconid with the entoconid.

Table 1. Measurements (in mm) for teeth of "*Namatomys*" sp., cf. *N. fantasma* Lindsay from Tapo Canyon and Brea Canyon Local Faunas.

N	Tooth	Dimension	OR	Mean	S.D.	CV
9	M ^{1 or 2}	A-P	.85-1.05	.98	.08	8.3
9		ANT-TR	.97-1.15	1.05	.07	6.9
9		POST-TR	.97-1.06	1.02	.04	3.4
1	P ₄	A-P	.98			
1		ANT-TR	.77			
1		POST-TR	.50			
3	M _{1 or 2}	A-P	1.02-1.08	1.05		
3		ANT-TR	.91-.95	.94		
		POST-TR	.86-1.00	.94		
2	M ₃	A-P	1.04-1.15	1.10		
2		ANT-TR	.90-.97	.94		
2		POST-TR	.90-.93	.92		

The first two lower molars are slightly elongated anteroposteriorly and their occlusal outlines are subrectangular in shape. The anterior cingulid is a robust crest with a distinct anteroconid that is connected to the labial aspect of the metalophid by a small accessory crest. The metaconid, protoconid, entoconid, and hypoconid are distinct cusps. The metalophid and hypolophid are usually complete crests, especially in well worn teeth, and are much lower than the primary cusps. The mure is incomplete anteriorly. A short bifurcated mesolophid is present that extends from the mesoconid into the central basin of the tooth. The mesoconid is connected to the hypoconid by a posterior mure. A small mesostylid is usually present. The posterior cingulid is a well-developed crest extending from the entoconid to the midline of the tooth, where it connects with the hypolophid.

The M₃ is anteroposteriorly elongated and slightly narrower in width posteriorly. The anterior cingulid is a well-developed crest with a small anteroconid that is represented by a bulge at the middle of this crest. In unworn teeth, a small valley separates the anterior cingulid from the protoconid at the anterolabial aspect of the tooth. The metaconid is a sharp cusp that is taller than the moderately well-developed protoconid. The hypoconid is smaller and shorter than the metaconid and protoconid. The entoconid is the smallest of the primary cusps and is positioned towards the posterolingual corner of the tooth, along a crest that connects to the metaconid. The metalophid is a low crest that connects the metaconid with the protoconid. The mesolophid is a moderately distinct crest that extends lingually into the central basin of the tooth. The hypolophid is a thick crest that curves posteriorly from the hypoconid to the entoconid. A small low posterior cingulid is present in one M₃ at the posterolingual aspect of the tooth.

Discussion.—Lindsay (1968) described a new species of eomyid rodent, *Namatomys fantasma* of the Hartman Ranch Local Fauna from the Sespe Formation exposed along upper Sespe Creek, north of Simi Valley. Other investigators (Chiment 1977; Storer 1984, 1987; Korth 1989) concluded that this new species represented a different genus and should not be assigned to *Namatomys* Black (1965). Chiment (1977), in an unpublished Master's thesis, proposed a new generic name, which he and W. W. Korth will publish in a forthcoming report (pers. comm.). Presently all investigators recognize this genus as "*Namatomys*."

Table 2. Measurements (in mm) for teeth of "*Namatomys*" sp. from Simi Valley Landfill Local Fauna.

N	Tooth	Dimension	OR	Mean	S.D.	CV
4	P ⁴	A-P	1.04-1.15	1.08		
4		ANT-TR	1.05-1.16	1.10		
4		POST-TR	1.06-1.14	1.08		
6	M ^{1 or 2}	A-P	1.03-1.13	1.08	.04	3.4
4		ANT-TR	1.17-1.28	1.23		
4		POST-TR	1.10-1.15	1.13		
6	M _{1 or 2}	A-P	1.07-1.20	1.14	.05	4.8
6		ANT-TR	1.05-1.18	1.09	.07	6.3
6		POST-TR	1.06-1.19	1.12	.04	4.0

"*Namatomys*" sp., cf. "*N.*" *fantasma* is morphologically very similar to "*Namatomys*" *fantasma*, but differs in having much smaller teeth. It differs from "*N.*" *fugitivus* Storer (1984) of the Swift Current Creek Local Fauna from the Cypress Hills Formation in Saskatchewan by having the following characters: smaller teeth; posterior protoloph-paracone connection in the upper molars less common; and the mesolophid is not strongly forked. It is similar in size to "*N.*" *lacus* Storer (1987) of the LacPelletier Lower Fauna from the Cypress Hills Formation in Saskatchewan, but differs from this species by having the following characters: the connection of the anterocone with the protoloph in the upper molars slightly more labially positioned, resulting in a longer lingual extension of the anterior cingulum from the anterocone; the mure in the upper molars is much less complete; and the ectolophids of the M₁ and the M₂ are more complete. It differs from "*N.*" sp. (see below) from LACM Loc. 5876, which occurs stratigraphically much higher in the section at the Simi Valley Landfill, by having the following characters: smaller teeth with lower crown height; the crests (lophs) are lower and less prominent; the posterior arm of the protocone is commonly bifurcated; and the mesoloph is slightly more complex with additional small spurs present. It is similar in size to an unnamed species of "*Namatomys*" described by Chiment (1977) from the Santiago Formation in the San Diego area of California.

The "*Namatomys*" material from the Tapo Canyon and Brea Canyon Local Faunas appears to represent a new species most closely related to "*Namatomys*" *fantasma*. However, until Chiment and Korth publish a formal description of the unnamed species from the San Diego area and comparisons with that species can be made, the Simi Valley species is herein assigned to "*N.*" sp., cf. "*N.*" *fantasma*.

"*Namatomys*" sp.

Figure 3, Table 2

Specimens.—RP⁴, LACM 131040; RP⁴, LACM 132438; LP⁴, LACM 131451; LP⁴, LACM 132448; RM^{1 or 2}, LACM 131032; RM^{1 or 2}, LACM 131044; RM^{1 or 2}, LACM 130849; RM^{1 or 2}, LACM 131033; LM^{1 or 2}, LACM 131055; partial RM^{1 or 2}, LACM 132653; RM₁?, LACM 131045; RM^{1 or 2}, LACM 131046; RM_{1 or 2}, LACM 131060; LM_{1 or 2}, LACM 131057; LM_{1 or 2}, LACM 131058; LM_{1 or 2}, LACM 131059.

Distribution and age.—LACM Loc. 5876, Simi Valley Landfill Local Fauna, late Duchesnean.

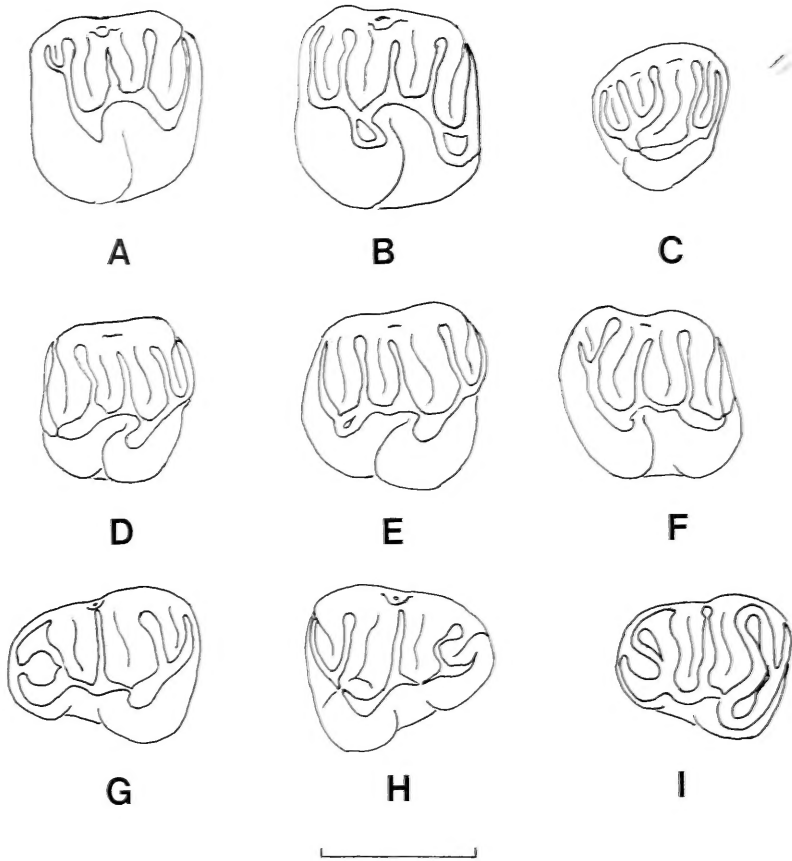


Fig. 4. *Paradjidaumo reynoldsi* new species. A, LP⁴, LACM 131036. B, LM^{1or2}, LACM 131078. C, RM³, LACM 131449. D, LM^{1or2}, LACM 130846. E, LM^{1or2}, LACM 131048. F, LM²?, LACM 131028. G, RP₂, LACM 131052. H, Holotype, RP₂, LACM 131042. I, LP₂, LACM 131064. All occlusal views; A, B, C, and F reversed. Scale = 1 mm.

Description.—The occlusal outline of the P⁴ is almost square. The anterior cingulum is robust with a small crest connecting it to the middle of the protoloph. The protoloph is a complete crest and usually well connected to the paracone. In one tooth, the protoloph is only weakly attached to the paracone. The metaloph is a complete crest connecting the metacone with the hypocone. The protoloph and the metaloph are much lower than the primary cusps. The paracone, protocone, metacone, and hypocone are tall slender cusps that have increased crown height. This increase in crown height is the result of an increase in cusp height alone, whereas the base of the crown remains low. The mure is complete, connecting the mesocone with the protocone and the hypocone. The posterior arm of the protocone is a distinct crest that connects to the posterolabial base of the paracone. The mesoloph varies from a very small spur to a moderately developed, thin, short crest. A distinct mesostyle is present. The posterior cingulum is a robust crest extending from the metacone to the hypocone.

The first and second upper molars are similar in morphology to the P⁴, but exhibit the following differences. They are more transversely expanded. The an-

terocone is slightly more robust and positioned further labially. The protoloph and metaloph are complete low crests that are slightly more developed. The mesoloph is usually absent, but, when present, is a very small short spur. The posterior arm of the protocone is usually not present, but, when present, it is a very short crest extending labially, but not joining the paracone. The mesostyle is present as a smaller cusp.

The lower molars are represented by the M_1 and M_2 and exhibit the following characters. The anterior cingulid is well-developed and connected to the protoconid. The metaconid, protoconid, entoconid, and hypoconid are distinct tall slender cusps. The protolophid and metalophid are complete and lower in height than the primary cusps. The mure is usually a complete crest connecting the mesoconid with the protoconid and the hypoconid. The protoconid of one tooth, presumably M_1 , has a well-developed posterior arm that extends to and connects with the posterolabial aspect of the metaconid. Apparently the posterior arm of the protoconid is not present in the M_2 . The mesolophid is a simple, thick crest that projects a short distance labially from the mesoconid and then turns posteriorly towards the metalophid. The mesostylid is absent or sometimes present as an incipient cusp on the crest between the metaconid and entoconid. The posterior cingulid forms a thick crest that extends labially from the posterolingual corner of the entoconid to the midline of the tooth, where it connects with the metalophid.

Discussion. — “*Namatomys*” sp. of the Simi Valley Landfill Local Fauna differs from “*N.*” sp., “*N.*” *fantasma* of the Tapo Canyon and Brea Canyon Local Faunas by having larger teeth, increased height of the primary cusps, greater development of the crests, and a simpler mesoloph. The increase in crown height and the more prominent crests indicate that “*N.*” sp. is more derived than “*N.*” sp., cf. “*N.*” *fantasma*. The material of “*Namatomys*” from LACM Loc. 5876 probably represents a new species, but until a better sample is available from the Sespe Formation and this sample can be adequately compared with the samples of “*Namatomys*” from the greater San Diego area to be described by Chiment and Korth, it is herein assigned to an unnamed species of “*Namatomys*.”

Paradjidaumo Burke, 1934

Paradjidaumo reynoldsi new species

Figure 4, Table 3

Paradjidaumo n. sp. Kelly and others, 1991:7, 12.

Holotype. — RP₄, LACM 131042.

Type locality. — LACM Loc. 5876.

Diagnosis. — Differs from *Paradjidaumo trilophus* (Cope, 1873) (= *P. nasutus* Cope and *P. minor* Douglass), *P. spokaneensis* White (1954), *P. hansonorum* Russell (1972), *P. hypsodus* Setoguchi (1978), and *P. validus* Korth (1980) by having smaller teeth (averaging 12%, 22%, 15%, 10%, 29% smaller, respectively). Further differs from *P. trilophus* by having P_4 less molariform and mesolophids with less tendency to join entoconids with wear. Further differs from *P. spokaneensis* by having the following characters: P^4 smaller relative to molars; P_4 more anteroposteriorly elongated; and mesolophid of M_2 and M_3 not connected to entoconid. Further differs from *P. alberti* Russell (1954) by having the following characters: P_4 longer, wider posteriorly, and larger relative to molars; P_4 mesoconid connected by mure to hypoconid; and lower molars less elongated anteroposteriorly, resulting

Table 3. Measurements (in mm) for teeth of *Paradjidaumo reynoldsi* new species from Simi Valley Landfill Local Fauna.

N	Tooth	Dimension	OR	Mean	S.D.	CV
5	P ⁴	A-P	1.10–1.25	1.19	.06	5.4
5		ANT-TR	1.10–1.24	1.18	.07	5.9
5		POST-TR	1.08–1.24	1.16	.06	4.9
11	M ^{1 or 2}	A-P	1.17–1.32	1.25	.06	4.9
10		ANT-TR	1.17–1.47	1.38	.11	7.6
8		POST-TR	1.25–1.45	1.36	.06	4.4
5	M ³	A-P	.95–1.01	.95	.05	5.3
5		TR	.99–1.11	1.05	.05	5.1
5	P ₄	A-P	1.16–1.36	1.26	.09	7.3
5		ANT-TR	.83–1.03	.88	.09	9.6
5		POST-TR	1.08–1.30	1.22	.09	7.6
15	M _{1 or 2}	A-P	1.07–1.37	1.24	.07	5.9
11		ANT-TR	1.00–1.26	1.13	.09	8.0
13		POST-TR	1.07–1.29	1.20	.07	6.0
3	M ₃	A-P	1.17–1.35	1.27		
3		ANT-TR	1.10–1.28	1.15		
3		POST-TR	1.16–1.17	1.16		

in squarer occlusal outlines. Further differs from *P. hansonorum* by having P₄ not square in occlusal outline, but with anterior width much smaller relative to posterior width. Further differs from *P. hypsodus* by having the following characters: P₄ wider transversely relative to anteroposterior length; and cheek teeth with lower crowns, valleys between cusps and crests shallower, and cusps more prominent relative to crests. Further differs from *P. validus* by having the following characters: P₄ less molariform; greater development of cingulids in lower molars; and lack of accessory lophid joining mesolophid and hypolophid on P₄ through M₂.

Etymology. — Named in honor of Robert E. Reynolds, Curator of Earth Science, San Bernardino County Museum, in recognition of his extensive work in the recovery of fossil microvertebrates from southern California and his contributions to the Simi Valley Landfill Paleontologic Resource Impact Mitigation Program.

Referred specimens. — RP⁴, LACM 131041; RP⁴, LACM 131036; LP⁴, LACM 131038; LP⁴, LACM 131037; LP⁴, LACM 131079; RM^{1 or 2}, LACM 130843; RM^{1 or 2}, LACM 130844; RM^{1 or 2}, LACM 130847; RM^{1 or 2}, LACM 131034; RM^{1 or 2}, LACM 131035; RM^{1 or 2}, LACM 131068; RM^{1 or 2}, LACM 131078; RM^{1 or 2}, LACM 131031; RM^{1 or 2}, LACM 131456; RM^{1 or 2}, LACM 132437; LM^{1 or 2}, 130842; LM^{1 or 2}, LACM 130848; LM^{1 or 2}, LACM 131027; LM^{1 or 2}, LACM 132444; LM^{1 or 2}, LACM 132457; RM³, LACM 130840; RM³, LACM 131077; RM³, LACM 131450; LM³, LACM 131449; LM³, LACM 131463; RP₄, LACM 131052; RP₄, LACM 132443; RP₄, LACM 132446; LP₄, LACM 131064; LP₄, LACM 131051; LP₄, LACM 131053; LP₄, LACM 132435; RM_{1 or 2}, LACM 131056; RM_{1 or 2}, LACM 130845; RM₁, LACM 130850; RM₁, LACM 131039; RM₁, LACM 131049; LM₁, LACM 130846; RM₂, LACM 131043; RM_{1 or 2}, LACM 130851; RM_{1 or 2}, LACM 131054; partial RM_{1 or 2}, LACM 131063; LM_{1 or 2}, LACM 131048; LM_{1 or 2}, LACM 131061; LM_{1 or 2}, LACM 131453; LM_{1 or 2}, LACM 131454; LM_{1 or 2}, LACM 131455; LM₃, LACM 130841; LM₃, LACM 131028; LM₃, LACM 131050.

Distribution and age.—LACM Loc. 5876, Simi Valley Landfill Local Fauna, late Duchesnean.

Description.—The occlusal outline of the P⁴ is almost square. The anterior cingulum is a low and weakly developed crest that usually connects with the lingual aspect of the protoloph. The anterior cingulum is not a distinct loph on the occlusal surface because of its small size and low height, and gives the tooth a four-crested pattern. The paracone, protocone, metacone, and hypocone are rounded cusps that have increased crown height through an increase in the height of the crown base. The protoloph and metaloph are complete, thick, high crests that connect the paracone with the protocone, and the metacone with the hypocone, respectively. The mesoloph is usually a long, high, well-defined crest extending to the lingual aspect of the tooth. The mure is a complete high crest. The posterior cingulum is a well-developed, high crest that extends from the metacone to the hypocone.

The first two upper molars are similar to the P⁴ except for the following differences. They are expanded transversely and have a strong five-crested occlusal pattern. The anterior cingulum is well-developed forming a robust, high crest that extends lingually from anterolabial aspect of the paracone to the midline of the tooth, where it connects with the protoloph. The mesostyle is present as a small cusp in five molars.

The occlusal outline of the M³ is subtriangular, with the posterior aspect transversely narrowed. The anterior cingulum is a well-developed crest that extends lingually from the anterolabial aspect of the paracone to the midline of the tooth where it connects with the protoloph. The five-crested occlusal pattern is usually well-developed. The paracone is the tallest primary cusp. The protocone is a thick, rounded cusp that is positioned towards the center of the lingual aspect of the tooth. The protocone usually is connected to the hypocone. A small mesostyle is sometimes present. The protoloph and metaloph are complete, thick, high crests. The mesoloph is a high, distinct crest extending to the labial aspect of the tooth. The posterior cingulum is a distinct crest.

The P₄ is transversely narrowed and anteroposteriorly elongated. A small anterior cingulid is present that connects to the protoconid. The protoconid and metaconid are positioned medially and connected posteriorly by a complete metalophid. The hypolophid usually is a complete, high crest that connects the entoconid with the hypoconid, except in one tooth, wherein the hypolophid is divided by a shallow cleft that is labial to the connection of the posterior cingulid and the hypolophid. The mesolophid usually is a long, well-developed crest that extends lingually to a distinct but small mesostylid. The posterior cingulid is a well-developed, thick crest that extends labially from the posterolingual corner of the entoconid to the midline of the tooth, where it connects with the center of the metalophid.

The M₁ and M₂ are slightly anteroposteriorly elongated and their occlusal outlines are subquadrate to subrectangular. The anterior cingulid extends labially from the anterolingual corner of the tooth and connects with the anterolabial corner of the protoconid. The metaconid, protoconid, entoconid, and hypoconid are conical cusps that have increased crown height through an increase in the height of the crown base. The metaconid and entoconid are taller than the protoconid and hypoconid. The metalophid and hypolophid are complete, high crests.

The mure is a high, complete crest connecting the mesoconid with the protoconid and hypoconid. The mesolophid is usually a long, high, well-defined crest that extends to or near the lingual aspect of the tooth. The posterior cingulid is a moderately high crest that extends labially from the posterolingual aspect of the entoconid to the midline of the tooth where it connects with the center of the hypolophid.

Three teeth are questionably considered M_3 s. These teeth are similar to the M_1 and M_2 , except for the following differences. The hypolophid is a more rounded crest and the posterior cingulid is smaller and lower in height.

Discussion.—Burke (1934) named and described *Paradjidaumo* and documented the unique attachment of the anterior cingulid to the anterolabial aspect of the protoconid in the lower molars of this genus. The teeth described above can be confidently assigned to *Paradjidaumo* because they exhibit the following characters: well-developed crests (=lophs) that are nearly as high as the primary cusps; the mesolophs and mesolophids of the molars are high and complete, and form a five-crested occlusal pattern; and the lower molars possess the unique attachment of the anterior cingulid to the protoconid.

Paradjidaumo is primarily known from faunas of Chadronian to Orellan age. The only previous record of the genus from the Duchesnean was documented by Russell (1954), who described *P. alberti* from the Kishenehn Formation of British Columbia. *Paradjidaumo reynoldsi* can be easily distinguished from *P. alberti* by its relatively larger P_4 that has the mesoconid connected by the mure to the hypoconid and its squarer lower molars. *Paradjidaumo reynoldsi* is restricted to the Simi Valley Landfill Local Fauna and this occurrence represents the first record of the genus from the Sespe Formation and the second record of the genus in the Duchesnean.

Family Heliscomyidae Korth, Wahlert, and Emry, 1991

Heliscomys Cope, 1873

Heliscomys sp.

Figure 5

Specimens.—RM¹, LACM 131452; LM², LACM 132456.

Distribution and age.—LACM Loc. 5876, Simi Valley Landfill Local Fauna, late Duchesnean.

Description.—The two upper molars are the only teeth of *Heliscomys* thus far recovered during the impact mitigation program. They are well preserved and only slightly worn. The measurements of LACM 131452 are 0.70 mm A-P, 0.56 mm ANT-TR, and 0.59 mm POST-TR, and those of LACM 132456 are 0.82 mm A-P, 0.73 mm ANT-TR, and 0.81 mm POST-TR. The occlusal outlines of the upper molars are square. Each tooth has six cusps arranged in two rows of three cusps each. The paracone, metacone, protocone, hypocone are well-defined conical cusps. The paracone and the metacone are slightly taller than protocone and hypocone. Moderately deep valleys separate the cusps and the lingual cingulum from the hypocone and protocone. The median transverse valley is open lingually. The hypostyle (=entostyle of Black, 1965) is a distinct cusp on the lingual cingulum, lower than the hypocone, and separated from the protostyle by a small cleft that is an extension of the median transverse valley. The protostyle is weakly expressed as a small incipient cusp on the lingual cingulum. The anterior

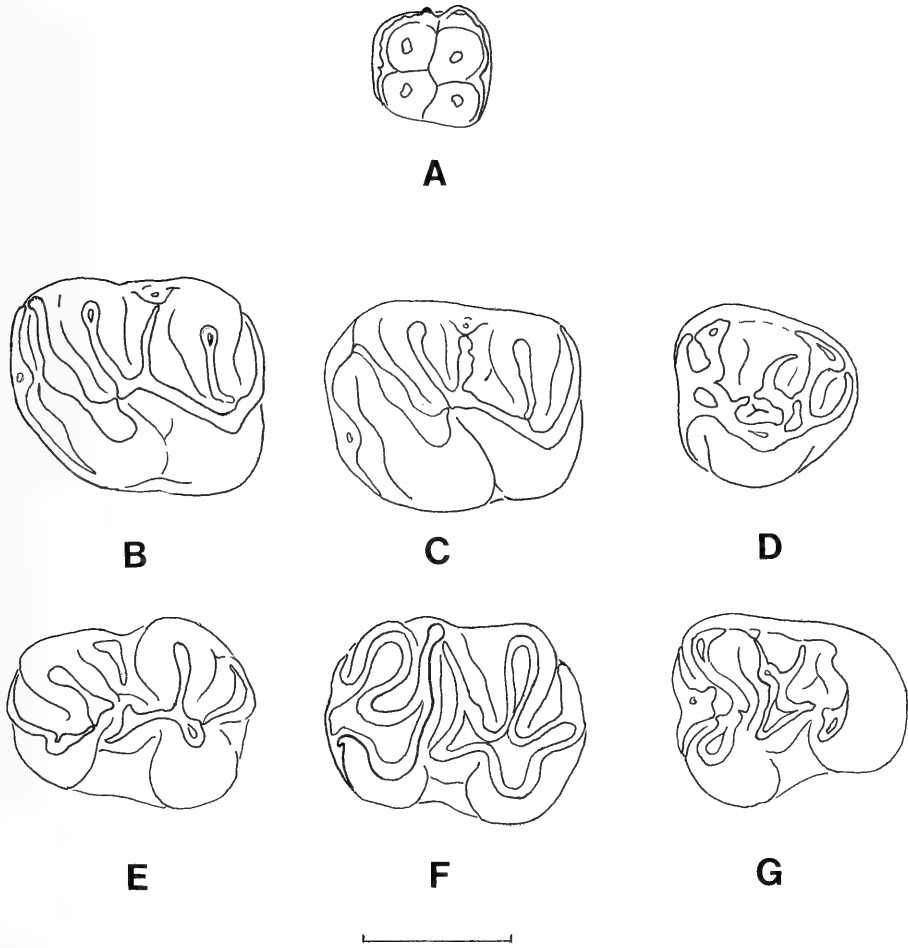


Fig. 5. *Heliscomys* sp. (A) and *Simimys landeri* new species (B-G). *Heliscomys* sp. A, RM¹, LACM 131452. *Simimys landeri*. B, Holotype, RM¹, LACM 131062. C, RM², LACM 130759. D, RM³, LACM 131458. E, RM₁, LACM 130771. F, RM₂, LACM 130765. G, LM₃, LACM 130767. All occlusal views; A-F reversed. Scale = 1 mm.

cingulum is a thin crest separated from the paracone and the protocone by a shallower valley than the median transverse valley, and is continuous with the lingual cingulum. The posterior cingulum is moderately developed with a very small incipient cusp in the center of the cingulum, and it is separated from the metacone and the hypocone by a shallower valley than the median transverse valley.

Discussion.—The upper molars from Simi Valley are assigned to *Heliscomys* because of the presence of six cusps that are positioned in two transverse rows of three cusps each, the square shape of the occlusal surface, and the conical shape of the primary cusps, which are separated by distinct valleys.

The *Heliscomys* teeth from Simi Valley are very similar to those of *H. sp.*, cf. *H. vetus* Cope (1873) from the Pipestone Springs Local Fauna (Black 1965) of the Renova Formation in Montana (Chadronian age) and the Pilgrim Creek Local

Fauna (Sutton and Black 1975) of the Jackson Hole area in Wyoming (Chadronian age). It differs from *H. sp.*, cf. *H. vetus* and all other species of *Heliscomys* by having the following characters: the M^{1-2} are slightly smaller; the primary cusps are subequal in height; the protostyle and the hypostyle are lower in height than the primary cusps; the posterior cingulum is slightly more developed with an incipient cusp present; the median transverse valley is slightly shallower; the valley between the anterior cingulum and the paracone and the protocone is slightly shallower; and the valley separating the posterior cingulum and the metacone and the hypocone is slightly shallower. Although the sample of *H. sp.* consists of only two teeth, all of the above characters indicate *H. sp.* is less derived than the other species of *Heliscomys*, as would be expected considering its earlier occurrence in the Duchesnean. Storer (1988) described a premolar, which he assigned to *Heliscomys sp.*, from the Lac Pelletier Lower Fauna (late Duchesnean age) of Saskatchewan. It is difficult to compare the Simi Valley teeth of *Heliscomys* with that from Saskatchewan because they represent different teeth. The Simi Valley teeth probably represent a new species, but, until a larger sample is available, they are assigned to an unnamed species of *Heliscomys*.

Heliscomys sp. is restricted to the Simi Valley Landfill Local Fauna and this occurrence is the first record of the genus and the family Heliscomyidae from the middle member of the Sespe Formation. Furthermore, the specimens of *H. sp.* from Simi Valley represent in the second record of the genus in the Duchesnean.

Family Simimyidae Wood, 1980

Simimys Wilson, 1935a

Simimys landeri new species

Figure 5, Table 4

Simimys n. sp. Kelly and others, 1991:7, 12.

Holotype.—RM¹, LACM 131062.

Type locality.—LACM Loc. 5876.

Diagnosis.—Differs from other species of *Simimys* by having the following characters: larger (15% to 41% in tooth measurements); cheek teeth with less development of small accessory crests and stylids; M³ hypocone more prominent; and M₃ lingual metalophid bifurcated at lingual aspect with one end connecting to metastylid and other to base of entoconid.

Etymology.—Named in honor of E. Bruce Lander of Paleo Environmental Associates, Inc. and the Natural History Museum of Los Angeles County, in recognition of his efforts directing the Simi Valley Landfill Paleontologic Resource Impact Mitigation Program that resulted in the recovery of large samples of microvertebrates from the Sespe Formation.

Referred specimens.—RM¹, LACM 130760; RM¹, LACM 130762; RM¹, LACM 130769; LM¹, 130772; LM², LACM 130773; RM², LACM 130759; RM², LACM 130761; RM², LACM 134685; RM³, LACM 131458; LM³, LACM 131459; LM³, LACM 132439; LM³, LACM 130768; LM₁, LACM 131070; RM₁, LACM 130771; RM₁, LACM 132434; partial RM₁, LACM 132454; RM₂, LACM 130765; LM₂, LACM 130766; LM₂, LACM 132453; RM₂, 130763; LM₃, LACM 130767; LM₃, LACM 132450; LM₃, LACM 132455; RM₃, LACM 130770.

Distribution and age.—Type locality, Simi Valley Landfill Local Fauna, late Duchesnean.

Table 4. Measurements (in mm) for teeth of *Simimys landeri* new species from Simi Valley Landfill Local Fauna.

N	Tooth	Dimension	OR	Mean	S.D.	CV
5	M ¹	A-P	1.70-1.94	1.81	.11	5.8
5		ANT-TR	1.43-1.58	1.49	.06	4.2
5		POST-TR	1.47-1.66	1.56	.07	4.8
4	M ²	A-P	1.76-1.81	1.79		
4		ANT-TR	1.56-1.64	1.60		
4		POST-TR	1.49-1.58	1.52		
4	M ³	A-P	1.24-1.31	1.28		
4		TR	1.15-1.24	1.21		
3	M ₁	A-P	1.76-1.85	1.80		
3		ANT-TR	1.05-1.14	1.10		
4		POST-TR	1.24-1.40	1.32		
4	M ₂	A-P	1.75-1.91	1.85		
4		ANT-TR	1.28-1.50	1.40		
4		POST-TR	1.40-1.56	1.46		
4	M ₃	A-P	1.52-1.64	1.58		
4		ANT-TR	1.23-1.34	1.29		
4		POST-TR	1.04-1.18	1.13		

Description.—The M¹ is slightly elongated anteroposteriorly and the occlusal outline is subrectangular in shape. The paracone, metacone, protocone, and hypocone are well-developed cusps. The mure is complete and connected to the protocone and the hypocone. The protoloph is a well-developed crest joining the mesocone with the paracone. The mesoloph is a complete crest that extends from the mesocone to the mesostyle. The mesostyle is usually weakly expressed, but in some teeth, it is a small distinct cusp. The metalophule is absent or expressed as a thin crest. The parastyle is represented by a small bulge on the labial aspect of the anterior cingulum. The anterocone is a distinct cusp on lingual aspect of the anterior cingulum. In unworn teeth, the protoconule is a distinct and well-developed cusp that is positioned along the crest between the protocone and paracone. The anteroconal spur is absent to moderately developed. The paralophule, postmesoconal spur, and enterostyle are absent.

The M² is anteroposteriorly elongated and the occlusal outline is subrectangular. The anterocone is a small distinct cusp. An anteroconal spur is absent to well-developed. The parastyle is a moderately to well-developed cusp. In unworn teeth, a cleft is present that separates the parastyle and the anterior cingulum, except near the base of the crown. The protoconule is a distinct cusp. The protoloph is a distinct crest that joins the mesocone with the paracone. The mesoloph is a distinct crest that extends lingually to the mesostyle. The metalophule usually is well-developed. A small accessory cusp sometimes is present on the mesoloph near the mesostyle. The anterior and posterior cingulae are robust. The paralophule, postmesoconule spur, and enterostyle are absent.

The M³ has a subtriangular occlusal outline. The protocone is a well-developed cusp. The metacone is a moderately well-developed cusp. The hypocone is posteriorly positioned and moderately developed as a distinct expansion on the posterolingual aspect of the tooth. The protoconule is small. The paralophule is well-developed. The metalophule is a well-developed thick crest in moderately

worn teeth. The mesostyle is weakly developed. The cingular-preprotoconular connection is strongly developed. The anterocone is a distinct cusp with a complete anteroconal spur that connects the anterocone with the preprotocrista. A small postprotoconular wing extends posteriorly a short distance towards the postprotocrista. The postprotocrista extends anterolingually into the central basin of tooth and a small anterolabial bifurcation is present about half-way along the postprotocrista that is directed towards, but does not connect with, the postprotoconular wing. The anterior metalophular spur connects the metalophule with the postprotocrista. Small depressions are present in the enamel of the central basin of the tooth.

The M_1 is anteroposteriorly elongated and the occlusal outline is subrectangular in shape. The anteroconid (=preprotoconid of Lillegraven and Wilson 1975) is usually weakly developed, but in one tooth it is a distinct cusp. A preprotocristid is present that connects the protoconid with the anteroconid. The protoconid is connected to the metaconid by the postprotocristid. A small cusp-like swelling is present in the center of the postprotocristid. The entoconid and the hypoconulid are well-developed cusps. The mesoconid is robust with short, but distinct, labial and lingual mesolophids present. The hypolophid is a well-developed crest that connects the entoconid with the hypoconid. The mesostylid is well-developed and a labial extension of mesostylid is present. The posterior ectolophid connects the hypoconid with the mesoconid. The posterior cingulid is a well-developed crest that extends from the posterolingual aspect of the entoconid to the hypoconid. There is no labial extension of the posterior cingulid.

The M_2 is anteroposteriorly elongated and the occlusal outline is subrectangular. The protoconid, metaconid, entoconid, and hypoconid are well-developed cusps. The mesoconid is large and robust. The hypoconulid is well-developed and attached to the prominent posterior cingulid. The lingual mesolophid is robust and extends to base of the mesostylid. The labial mesolophid is developed as a rounded projection extending from the mesoconid. The postprotocristid is a single crest with no bifurcation and joins the mesostylid with wear. The metalophid is a complete crest extending between the preprotocristid and the metaconid. A distinct anterolabial cingulid is present. The premetastylid is absent.

The M_3 is anteroposteriorly elongated, posteriorly narrowed, and the occlusal outline is subrectangular. The protoconid, metaconid, entoconid, and hypoconid are well-developed cusps. The labial mesolophid is short and does not extend below the hypoconid. In some teeth, a very small cross-crest is sometimes present on the labial mesolophid. The lingual metalophid is bifurcated at its lingual end, with one spur of the bifurcation connecting to the mesostylid and the other spur to the base of the entoconid. The ectostylid is absent.

Discussion.—Wilson (1935a) described two rodents from the Sespe Formation as *Eusmysops simplex* and *E. vetus*. Wilson (1935b) then amended the generic name to *Simimys* for these two species. Wilson (1949) named a third species, *S. murinus*, from the Sespe Formation and described additional material, including a partial skull. Lillegraven and Wilson (1975) and Walsh (1987) proposed synonymizing *S. vetus* and *S. murinus* with *S. simplex*. The impact mitigation program at the Simi Valley Landfill has yielded many large superposed samples of *S. simplex*, and analysis of these samples will be described in a separate paper. *Simimys landeri* can be easily distinguished from *S. simplex* by its much larger

teeth. The observed ranges of all tooth measurements for *S. landeri* do not overlap those for *S. simplex*. Furthermore, most of the tooth measurements for *S. landeri* are five or more standard deviations away from the means of the respective tooth measurements for *S. simplex*. The teeth of *S. landeri* also appear to be less complex than those of *S. simplex*, with a reduction in the number of small crests and stylids. *Simimys landeri* further differs from *S. simplex* by having a better developed M^3 hypocone and a bifurcated M_3 metalophid that connects lingually to the metastylid and entoconid. *Simimys landeri* is only known from the Simi Valley Landfill Local Fauna (late Duchesnean age) at LACM Loc. 5876, whereas *S. simplex* is known from the Tapo Canyon, Brea Canyon, Strathern, Pearson Ranch, and Simi Valley Landfill Local Faunas (late Uintan to late Duchesnean).

Lillegraven and Wilson (1975) analyzed a large sample of *S. simplex* from the Camp San Onofre Local Fauna of the Santiago Formation in the Oceanside area, California, and found that almost all dental characters studied were highly variable and unreliable for separating species of *Simimys*. They found this to be particularly true for the following characters: the amount of metaconid development in the lower molars; the development of mesostylids in the lower molars; the presence of a mesolophid connection to the protoconid; the anterior ectolophid connection to the protoconid; and the morphology of M^3 and M_3 . The characters used herein to separate *S. simplex* from *S. landeri* were not discussed by Lillegraven and Wilson (1975) and presumably are diagnostic. However, even if future study indicates some of these characters are taxonomically unreliable for species diagnosis, the much larger size of *S. landeri* still warrants specific separation from *S. simplex*.

The ambiguous nature of the morphological characters in *Simimys* has resulted in different familial assignments. Klingener (1964) and Lindsay (1968) suggested *Simimys* exhibited muroid characters and may belong to the Cricetidae, whereas Wood (1937), Stehlin and Schaub (1951), Klingener (1963), and Lillegraven and Wilson (1975) questionably assigned *Simimys* to the Zapodidae. Wood (1974, 1980) considered *Simimys* to be too derived to be ancestral to later zapodids and assigned *Simimys* to the superfamily Dipodoidea, family Simimyidae, whereas Emry (1981) referred *Simimys* to the superfamily Muroidea, family *incertae sedis*. Emry and Korth (1989) considered the loss of the P^4 in *Simimys* to possibly warrant its assignment to a separate family closely related to the Zapodidae and under the Dipodoidea. Wood (1980) presented the most convincing evidence that *Simimys* represents a distinct family of the Dipodoidea and this systematic assignment is followed here.

Family ? Zapodidae Coues, 1875

Simiacritomys new genus

Type species. — *Simiacritomys whistleri* new species.

Range. — Late Eocene (late Duchesnean) of southern California.

Diagnosis. — Molars five-lophed with robust, rounded cusps; deep median transverse valley that divides tooth into anterior and posterior sections usually present in first two upper and lower molars; anterocone well-developed; M^1 and M^2 protoloph usually divided, midway along its length, by cleft; M_1 and M_2 metalophid divided, midway along its length, by deep valley separating metaconid and protoconid; hypolophid thick, prominent crest connecting hypoconid and ento-

conid; mesoloph and mesolophid usually long, high, well-developed crests strongly connected to mesocone and mesoconid, respectively; anterior entoloph small anteriorly directed crest not connecting with protoloph; posterior entoloph thick, high, well-developed crest connecting hypocone with mesocone; ectolophids incomplete; distinct hypoconulid present; and cheek tooth enamel thick.

Referred species.—Type species only.

Etymology.—*Simi*, in reference to its occurrence in Simi Valley; *acritos*, Greek for mixed or confused; *mys*, Greek for mouse.

Discussion.—The familial relations of *Simiacritomys* are uncertain. The teeth of *Simiacritomys* exhibit similarities to those of eomyid and zapodid rodents. The molars are similar to eomyids by having a five-crested occlusal pattern with a similar positioning of the crests and cusps. However, they differ from all eomyid genera by having the following characters: the first two upper and lower molars are divided into anterior and posterior portions by deep transverse valleys; the protoloph usually divided, midway along its length, by a cleft that separates the paracone from the protocone; and the metalophid is divided or not developed because of a deep valley between the metaconid and the protoconid. The cheek teeth of *Simiacritomys* are similar to those of the zapodids *Plesiosminthus* Viret (1926) and *Megasminthus* Klingener (1966) by having a five-crested occlusal pattern, the mesoloph and the mesolophid usually long and well-developed, and the presence of a hypoconulid on the lower molars. In particular, the upper molars of *Plesiosminthus grangeri* (Wood, 1935) figured by Green (1977, p. 1001, Figs. 3E, 3G) are strikingly similar to those of *Simiacritomys*, especially with regard to the presence of deep transverse valleys that separate these teeth into anterior and posterior portions. *Plesiosminthus* differs from *Simiacritomys* by having complete protoloph and metalophids, more complete entolophs and ectolophids, and more anteroposteriorly elongated lower molars. *Megasminthus* differs from *Simiacritomys* by having cheek teeth with mesostyles and mesostylids, less anteriorly directed metalophs, less isolated metaconids, and more complete ectolophids.

The molar occlusal patterns of *Simiacritomys* exhibit some similarities to those of the Bridgerian ?zapodid *Elymys* Emry and Korth (1989) and to those of the simimyid *Simimys*. The molars of *Simiacritomys* differ from those of *Elymys* by having squarer occlusal outlines, mesoloph and mesolophids, and incomplete protoloph, metalophids, entoloph and ectolophids. The teeth of *Simiacritomys* differ from those of *Simimys* by having molars with more quadrate (less anteroposteriorly elongated) occlusal outlines, a central transverse valley dividing the molars into anterior and posterior portions, upper molars with transversely oriented (less oblique) crests and lacking the W-shaped occlusal pattern, the anterior cingulum in the upper molars does not project lingually from the anterocone, no protoconules or mesostyles, and a valley present that separates the metaconid from the protoconid.

Storer (1988, p. 98, Fig. 4) described and figured an upper molar of an undetermined genus and species of rodent from the Lac Pelletier Lower Fauna of Saskatchewan (late Duchesnean age). This tooth is similar to those of *Simiacritomys* in having a five-crested occlusal pattern, a transverse valley dividing the tooth, the anterior cingulum connected with the protocone and extending to the anterolingual corner of the tooth, and the hypocone strongly connected to the mesoloph. The upper molars of *Simiacritomys* differ from this tooth by having

a divided protoloph, a complete well-developed metaloph, and no mesostyle. Storer (1988) noted the similarity of the tooth from Saskatchewan with those of *Plesiosminthus* and with an upper molar described by Dawson (1966, p. 113) from Duchesne River Formation in the Uinta Basin of Utah (Randlett Fauna, Uintan age). Dawson (1966) assigned the tooth from Utah to “?sciuravid or myomorph sp.” and noted some similarities between this tooth and those of *Sciuravus* Marsh (1871) and *Simimys*. The teeth of *Simiacritomys* are similar to this tooth by having the protocone and the hypocone separated by a distinct valley, a long mesoloph, an incomplete entoloph that projects anteriorly from the mesocone but does not connect with the protoloph, a central transverse valley dividing the tooth into anterior and posterior portions, and a similar arrangement of the posterior cingulum, which extends from the posterolabial corner of the tooth to the hypocone. The teeth of *Simiacritomys* differ from this tooth by having no lingual projection of the anterior cingulum, an anterior cingulum that is connected with the protoloph near midline rather than labially, and no mesostyle. The indeterminate rodent teeth described by Storer (1988) and Dawson (1966) appear to represent taxa that are related to *Simiacritomys*. However, their generic assignments will remain uncertain until larger samples of these taxa are available.

The teeth of *Simiacritomys* are morphologically most similar to those of the sicistine zapodid *Plesiosminthus*. This similarity suggests *Simiacritomys* is a member of the family Zapodidae. Definitive familial assignment of *Simiacritomys* requires knowledge of the morphology of the skull and the mandible, which are presently unknown.

Simiacritomys whistleri new species

Figure 6, Table 5

?zapodid, new genus and species Kelly and others, 1991:6, 13.

Holotype.—LM₂, LACM 131462.

Type locality.—LACM 5876.

Diagnosis.—Same as for genus.

Referred specimens.—RM^{1or2}, LACM 130854; partial RM^{1or2}, LACM 130852; RM^{1or2}, LACM 130853; LM^{1or2}, LACM 130855; LM³, LACM 131075; LM³, LACM 131457; LM³, LACM 132451; RM₂, LACM 130857; RM₂, LACM 131461; LM₂, LACM 131065; LM₂, LACM 130856; LM₂, LACM 130858; LM₂, LACM 130861; RM₃, LACM 131460; LM₃, LACM 130860; LM₃, LACM 131069.

Etymology.—Named in honor of David P. Whistler of the Vertebrate Paleontology Section of the Natural History Museum of Los Angeles County for his work on the Paleontologic Resource Impact Mitigation Program on the Sespe Formation at the Simi Valley Landfill.

Description.—The first two upper molars exhibit the following characters. The occlusal outline is subquadrate. The teeth have a five-crested or lophed occlusal pattern. The anterior cingulum is a thick, well-developed crest that extends from the anterolabial base of the paracone to the protoloph, and has no lingual extension. The anterocone is usually represented by a small distinct cusp along the anterior cingulum near its connection with the protocone. The paracone, metacone, protocone, and hypocone are well-developed conical cusps. A central transverse valley completely divides the tooth into anterior and posterior portions,

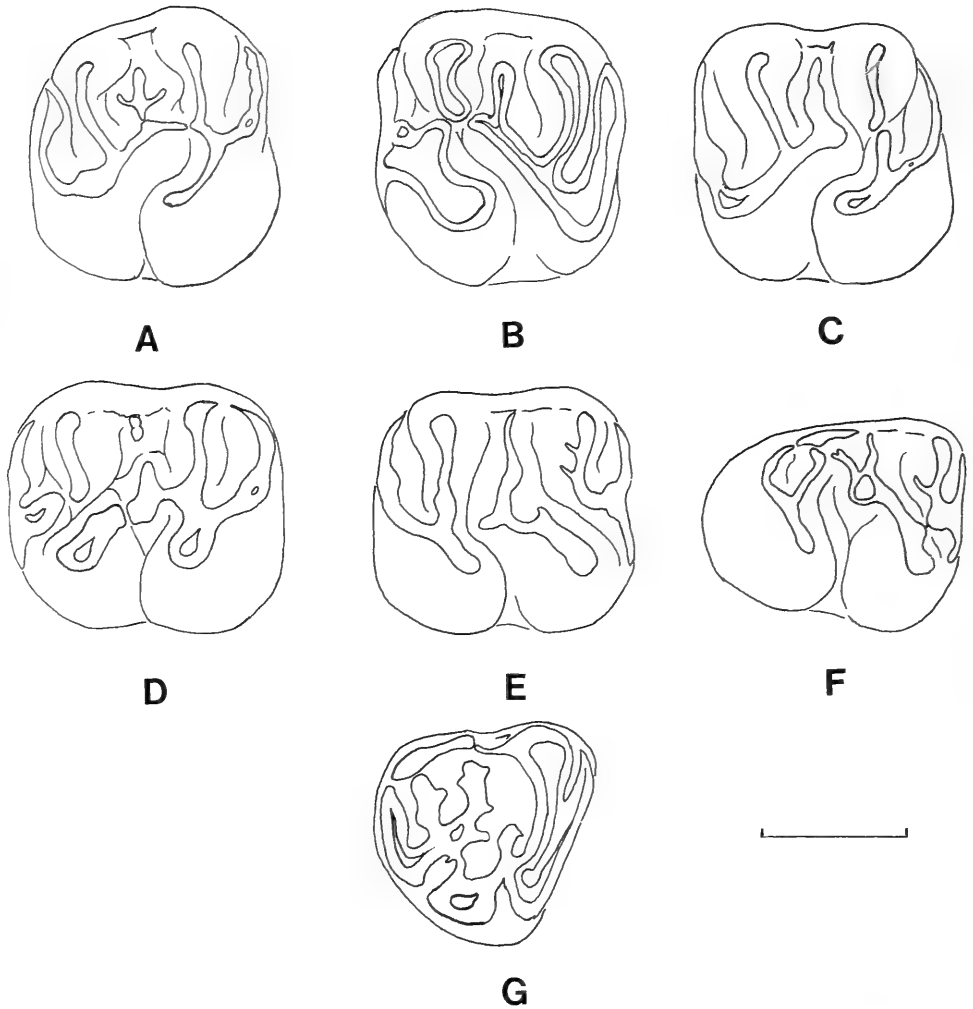


Fig. 6. *Simiacritomys whistleri* new genus and species. A, RM^{1or2} , LACM 130854. B, RM^{1or2} , LACM 130853. C, LM^{1or2} , LACM 130855. D, RM_2 , LACM 130857. E, Holotype, RM_2 , LACM 131462. F, RM_3 , LACM 130460. G, LM^3 , LACM 131075. All occlusal views; D reversed. Scale = 1 mm.

and is open labially and lingually. The other valleys between the primary cusps and crests are deep. The protoloph is usually divided, midway along its length, by an obliquely directed valley that persists even in extreme wear. In one tooth (LACM 130854), the protoloph is a complete crest across this valley and connects the protocone with the metacone. A mesostyle is not present. The metaloph is a thick, well-developed crest connecting the metacone and hypocone. The mesoloph is a moderately long, thick, high crest. In one tooth (LACM 130854), the mesoloph has two accessory spurs, one directed anterolabially, the other, posterolabially. The posterior entoloph (=posterior mure) is a thick crest connecting the mesocone and hypocone. The anterior entoloph (=anterior mure) is a crest that extends anteriorly from the mesocone, but does not connect with the protoloph because

Table 5. Measurements (in mm) for teeth of *Simiacritomys whistleri* new genus and species from Simi Valley Landfill Local Fauna.

N	Tooth	Dimension	OR	Mean	S.D.	CV
4	M ¹ or 2	A-P	1.68-1.82	1.73		
3		ANT-TR	1.79-1.90	1.83		
4		POST-TR	1.65-1.70	1.65		
3	M ³	A-P	1.30-1.38	1.34		
3		TR	1.45-1.55	1.50		
6	M ₂	A-P	1.72-1.90	1.82	.08	4.6
6		ANT-TR	1.50-1.72	1.67	.10	5.7
6		POST-TR	1.59-1.90	1.71	.09	5.0
3	M ₃	A-P	1.55-1.92	1.74		
3		ANT-TR	1.42-1.61	1.50		
3		POST-TR	1.24-1.42	1.34		

of the presence of the central transverse valley. The posterior cingulum is well-developed and a small incipient cusp (posterocone?) is present along this cingulum.

The M³ exhibits the following characters. The occlusal outline is subtriangular, with the posterior aspect narrowed transversely. The anterior cingulum extends lingually from the anterolabial corner of the tooth to the protoloph. The protoloph appears to be a complete crest with a small, lingually directed spur (?metalophid II of Green, 1977). The protocone is a well-developed cusp that is situated slightly posteriorly of the midline along the labial aspect of the tooth. The hypocone is a transversely elongated cusp that is positioned posterolabially. A complete entoloph connects the protocone and hypocone with the mesocone. The mesoloph and metaloph are thick, moderately long crests that extend lingually from the mesocone and posterior entoloph, respectively. The metacone is an elongated cusp at the posterolabial corner of the tooth.

There is no tooth in the sample that can be positively identified as an M₁. The M₂ exhibits the following characters. The occlusal outline is slightly elongated anteroposteriorly, resulting in a subrectangular shape. The M₂ has a five-crested or lophed occlusal pattern with deep valleys between the cusps and the crests. The anterior cingulid is moderately well-developed. A distinct anteroconid is present along the anterior cingulid that sometimes connects with the base of the labial projection of the metaconid. A median transverse valley is usually present and divides the tooth into anterior and posterior portions. The metaconid, protoconid, entoconid, and hypoconid are large, rounded cusps. A deep valley divides the metalophid, midway along its length, and separates the metaconid from the protoconid. The mesoconid is a distinct cusp in the center of the ectolophid (=mure). The mesolophid is usually a long well-developed crest that is strongly connected to the mesoconid. The ectolophid is usually incomplete. A mesostylid is not present. The hypolophid is a thick, well-developed crest that connects the entoconid with the hypoconid. The posterior cingulid is a tall, well-developed crest that extends from the posterolingual aspect of the entoconid to the hypolophid, where it connects near the posterolingual aspect of the hypoconid. A hypoconulid is present as a distinct bulge or cusp along the posterior cingulid.

The M₃ is anteroposteriorly elongated and the occlusal outline is subrectangular. The anteroconid is a small distinct cusp along the anterior cingulid that is con-

nected to the labial projection of the metaconid. The anterior cingulid is smaller than those of the M_2 and it extends labially a short distance beyond the anteroconid. The metaconid and protoconid are well-developed cusps. The valley that divides the metalophid in the M_2 is usually interrupted in the M_3 by a more completely developed metalophid that usually forms a thin complete crest across this valley. The anterior ectolophid is a thick, complete crest that connects the protoconid to an indistinct mesoconid, whereas a posterior ectolophid is absent. The mesolophid is usually a long, thin crest that extends to the lingual aspect of the tooth. Short accessory spurs sometimes are present on the mesolophid. The hypolophid is a complete crest connecting the well-developed hypoconid with a very small entoconid. The posterior cingulid is a short distinct crest at the posterolingual aspect of the tooth.

Discussion.—Two teeth, an upper molar (LACM 130854) and a lower molar (LACM 130857), differ in the development of the crests and their connections relative to those of other molars assigned to *Simiacritomys*. In LACM 130854 (Fig. 6A), the anterior entoloph extends across the deep transverse valley, almost connecting with the protoloph, and the protoloph is complete. In LACM 130857 (Fig. 6D), the posterior ectolophid extends across the central transverse valley and connects with the hypolophid, whereas the anterior ectolophid is divided, midway along its length, by a deep valley. It could be argued that these variations are taxonomically significant and these specimens should not be referred to *S. whistleri*. However, these differences are regarded as intraspecific variation because, in other rodent species where large samples of teeth are available, a high degree of variability is observed (for example, see Lillegraven and Wilson 1975, and Green 1977). Furthermore, all the specimens were recovered from one locality and these molars, except for the characters noted above, have the same basic morphology as the other molars assigned to *S. whistleri*.

Simiacritomys whistleri is of uncertain affinities and is restricted to the late Duchesnean Simi Valley Landfill Local Fauna. As noted above in the discussion of the genus, *S. whistleri* is morphologically similar to the middle Arikareean to early Hemingfordian sicistine zapodid *Plesiosminthus grangeri* from South Dakota.

Conclusions

This report documents the discovery of new species and new geologic and geographic occurrences of middle and late Eocene rodents from the middle member of the Sespe Formation recovered during the Simi Valley Landfill Paleontologic Resource Impact Mitigation Program. The taxa discovered during the program are “*Namatomys*” sp., cf. “*N.*” *fantasma* Lindsay, “*Namatomys*” sp., *Paradjidaumo reynoldsi* new species, *Heliscomys* sp., *Simimys landeri* new species, and *Simiacritomys whistleri* new genus and species. New records from the middle member of the Sespe Formation in Simi Valley include “*Namatomys*,” *Paradjidaumo*, *Heliscomys*, and *Simiacritomys*. The occurrence of *Paradjidaumo* in the Simi Valley Landfill Local Fauna represents the second record of this genus in the Duchesnean. The occurrence of *Heliscomys* in the Simi Valley Landfill Local Fauna represents the second record of the genus and the family Heliscomyidae in the Duchesnean.

The results of this study and those summarized by Kelly and others (1991)

allow reevaluation of the Simi Valley Landfill Local Fauna. A revised faunal list for this fauna includes: *Sespedectes singularis* Stock (1935); *Proterixoides davisi* Stock (1935); *Leptotomus* sp. undetermined; “*Namatomys*” sp.; *Paradjidaumo reynoldsi* n. sp.; *Heliscomys* sp.; *Simimys simplex*; *Simimys landeri* n. sp.; *Simiacritomys whistleri* n. gen. and sp.; Camelidae, gen. and sp. undetermined; *Simimeryx* sp.; and Mammalia, gen. and sp. undetermined. The Simi Valley Landfill Local Fauna from LACM Loc. 5876 is characterized by the restricted stratigraphic ranges of the following taxa: “*Namatomys*” sp.; *Paradjidaumo reynoldsi*; *Heliscomys* sp.; *Simimys landeri*; *Simiacritomys whistleri*; and *Simimeryx* sp. The shared occurrences of *Sespedectes*, *Proterixoides*, “*Namatomys*,” *Paradjidaumo*, *Heliscomys*, *Simimys*, and *Simimeryx* indicate that the Simi Valley Landfill Local Fauna is late Duchesnean in age.

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A Newly Adventive Ant of the Genus *Pheidole* in Southern California (Hymenoptera: Formicidae)

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Abstract.—This paper records, for the first time, in the United States the presence of *Pheidole teneriffana*, a species originally described from the Canary Islands. Colonies are established in Long Beach, Los Angeles County. The species is briefly characterized and the worker subcastes illustrated. A key is included to facilitate the separation of *P. teneriffana* from native *Pheidole* species in the Los Angeles basin.

Insects accidentally introduced into southern California from other parts of the world are a common occurrence. There are probably many more such introductions than we realize because, more often than not, the insect does not become established. Some of those that do successfully colonize here may become conspicuous as pests and others may be unobtrusive and, hence, undiscovered for years.

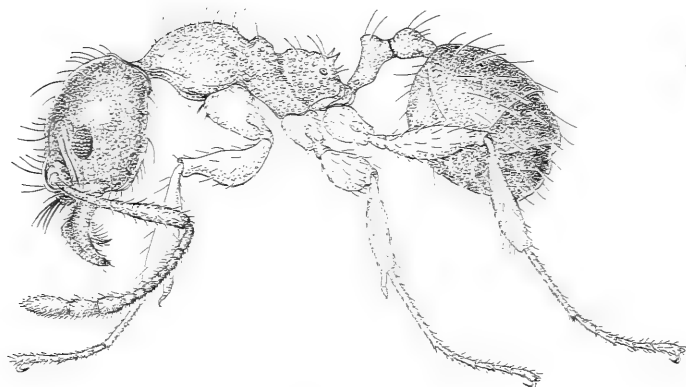
Several non-native ant species are present and firmly established here, but none has yet proven to be anything other than a nuisance. The most well known of these species is, of course, the common Argentine Ant, *Iridomyrmex humilis* (Mayr) (from South America), a conspicuous nuisance species in urban areas. Other introduced ant species in California, all from various parts of the Old World, include *Tetramorium caespitum* (Linné) ("Pavement Ant"), *Monomorium pharaonis* (Linné) ("Pharaoh Ant"), *Cardiocondyla ectopia* Snelling (no common name), and *Paratrechina longicornis* (Latreille) ("Crazy Ant").

An additional species that must be placed among those exotic ants now established in California is the myrmicine species *Pheidole teneriffana* Forel. In an error-laden note, Martinez (1992) first reported the presence of this ant in California. There are no prior records of this species in the United States, although it was recorded from Cuba by Aguayo (1932). *Pheidole teneriffana* was originally described by Forel (1893) from Teneriffe in the Canary Islands, but is now known to occur across North Africa at least as far east as Egypt.

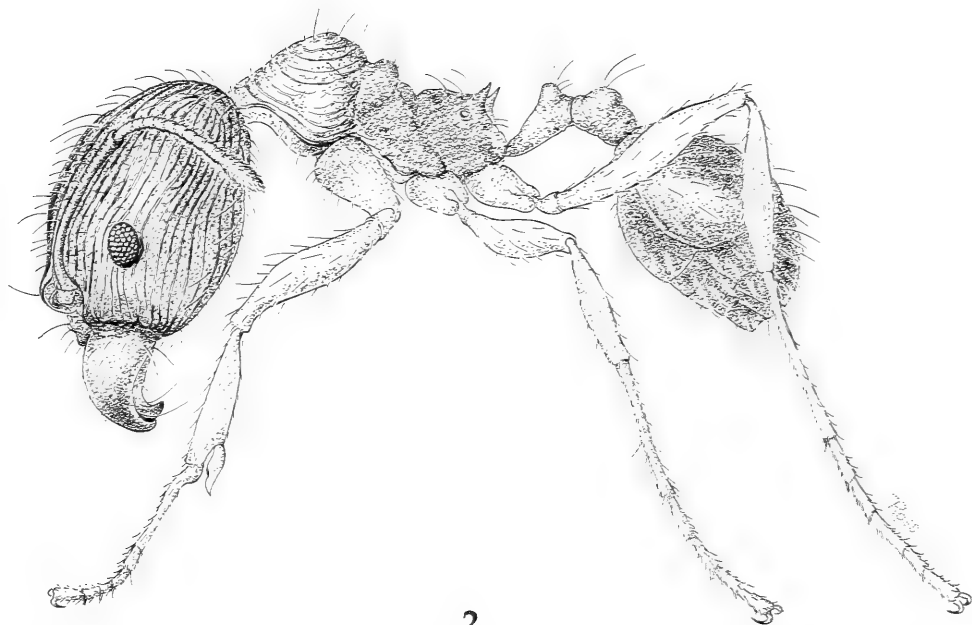
At present, its known occurrence in California is limited to colonies found in Long Beach, Los Angeles County, by Mr. Mike Martinez, an employee of the Long Beach Parks Department. Several colonies are mature and have produced winged reproductives.

Many native species of *Pheidole* occur in California, and *P. teneriffana* shares with these the characteristic presence of two distinctly different subcastes of workers ("soldier" and "worker"). The "soldier" subcaste is larger and more robust than the "workers" and has a disproportionately larger and more massive head.

The most recent key for the separation of *Pheidole* species in the United States is that of Gregg (1958). In that key *P. teneriffana* goes to the set of couplets



1

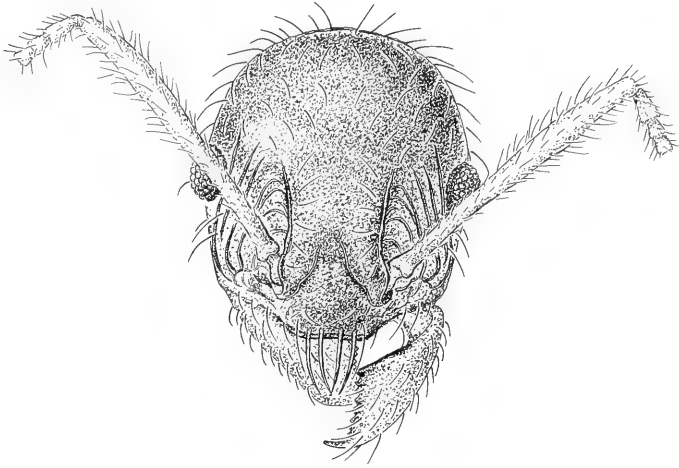


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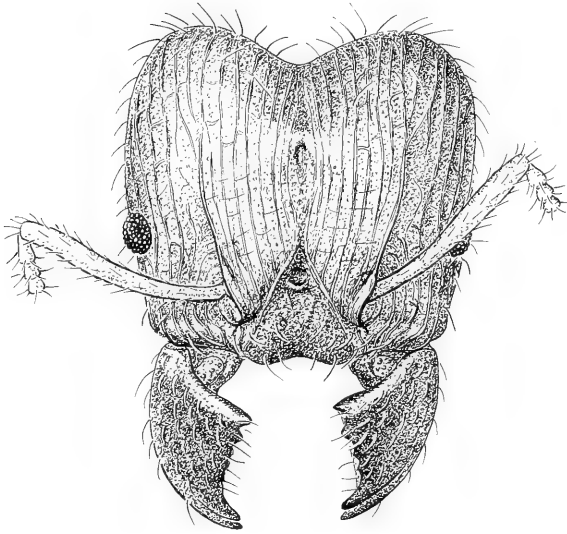
Figs. 1, 2. *Pheidole teneriffana*, minor worker (1) and major worker (2), lateral view. Figures by Tina Ross.

separating the several forms of *P. sitarches* and keys most often to *P. sitarches sitarches* Wheeler, an ant that does not occur in California.

The major worker ("soldier") (Figs. 2 and 4) of *P. teneriffana* differs from all known California species by the following combination of morphological features: head width 1.38–1.52 mm; antennal scape evenly curved and not flattened at base, extending about $\frac{3}{4}$ of distance between antennal sockets and top of vertexal lobe; margins of frontal lobes extending dorsad to base of vertexal lobes; frontal area of head with conspicuous, widely spaced longitudinal rugae that extend to



3



4

Figs. 3, 4. *Pheidole teneriffana*, minor worker (3) and major worker (4), frontal view of head. Figures by Tina Ross.

vertex lobes, the interspaces shiny and mostly smooth; vertex strongly concave between prominent vertex lobes; pronotum without distinct humeral angles and strongly convex in profile; mesonotum in profile strongly convex; propodeal spines present and about as long as distance between their bases; pronotum anteriorly with a few transverse rugae; mesepisternum and side of propodeum contiguously punctate and with some longitudinal rugae (most conspicuous on propodeum); postpetiole mostly smooth and shiny, lateral margins angulate at about midlength; total length 3.8–4.0 mm.

Minor workers (Figs. 1 and 3) are much more difficult to characterize, but the following combination of characters should separate them from those of other species in southern California: head smooth and shiny, quadrate in frontal view, with dorsolateral angles broadly rounded and vertex convex across middle; antennal scape extending beyond vertex by about $\frac{1}{3}$ its length; pronotum almost entirely smooth and shiny; mesepisternum and propodeum contiguously punctate and dull; mesonotum distinctly angulate in profile; propodeal spines short, slender and acute; total length 2.25–2.60 mm.

The following key will serve to separate the worker subcastes of *P. teneriffana* from those of other *Pheidole* known to occur in the Los Angeles basin.

Key to *Pheidole* of Los Angeles Area

- 1a. *Major* (=“soldier”): sculpture of front of head various, but not consisting of continuous longitudinal rugae that extend from base of clypeus to vertex—*Minor*: head shape various, but if top of head is convex, *then* scape and tibiae bear many long, suberect to erect hairs and longest hairs of pronotum are clearly longer than greatest eye diameter 2
- b. *Major* (Figs. 2, 4): sculpture of front of head consisting of coarse longitudinal rugae that extend continuously from level of base of clypeus to top of vertex. *Minor* (Figs. 1, 3): head broadly rounded in frontal view; scape and tibiae with sparse suberect to erect hairs, those of scape limited to frontal face; longest hairs of pronotum about as long as greatest eye diameter *P. teneriffana* Forel
- 2a. *Major*: tops of vertexal lobes with transverse rugae or fine striae: antennal scape not extending more than one-half distance between antennal socket and top of vertex. *Minor*: head quadrate in frontal view, vertex transverse and abruptly rounded at sides and antennal scape extending beyond vertex by less than one-fifth its length 3
- b. *Major*: tops of vertexal lobes dull to slightly shiny, devoid of striations or rugae, but with scattered punctures; apex of scape extending more than four-fifths of distance between antennal sockets and tops of vertexal lobes. *Minor*: vertex either rounded in frontal view or prolonged into short, narrow “neck”; antennal scape extending beyond vertex by at least one-fifth its length 4
- 3a. *Major*: top of vertex crossed by coarse transverse rugae; postpetiole node without lateral connules. *Minor*: head and pronotum smooth and shiny *P. clementensis* Gregg
- b. *Major*: top of vertex with fine, close striae which may be partially effaced; postpetiole node with sharp lateral connules. *Minor*: head and pronotum slightly shiny and distinctly shagreened, at least in large part *P. pacifica* Wheeler
- 4a. *Major*: base of antennal scape broad and flattened *and* apex not extending beyond vertexal lobes. *Minor*: vertex broadly rounded in frontal view *P. hyatti* Emery
- b. *Major*: base of antennal scape narrow and rounded *and* apex extending well beyond vertexal lobes. *Minor*: vertex strongly and evenly narrowed into short “neck” *P. vistana* Forel

The potential importance of this ant as a pest species is unknown, but I suspect low. It is likely that this species is primarily a seed-harvester and general scavenger, as are most species of *Pheidole* in temperate regions. In urban areas, at least, it will have to compete against *I. humilis*, a notoriously successful urban pest species. An additional competitor will be the native fire ant, *Solenopsis xyloni*, one of the few native species that seems to be able to withstand the Argentine ant in disturbed habitats. Between them, these two ants utilize the same resources that *P. teneriffana* might be expected to exploit.

Voucher specimens from the Long Beach population are deposited in the collections of the California Department of Food and Agriculture, Los Angeles County Museum of Natural History, Museum of Comparative Zoology, and National Museum of Natural History.

Acknowledgments

My thanks go to Mike Martinez for bringing this ant to my attention and to E. O. Wilson for resolving its identity. The figures were prepared by Tina Ross.

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Distinguishing the Endangered Stephens' Kangaroo Rat (*Dipodomys stephensi*) from the Pacific Kangaroo Rat (*Dipodomys agilis*)

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Abstract. — Efforts to conserve the endangered Stephens' Kangaroo Rat have been complicated by its morphological similarity to the sympatric Pacific Kangaroo Rat. We used discriminant analysis of a variety of morphometric characters to develop a protocol for distinguishing these two species in the field. The species differ significantly in skull, hair, and external metric characters measured on live specimens. Discriminant analysis indicated that the two species can be distinguished more successfully on the basis of weight, ear length, and head shape than on the basis of hair characters alone. We outline a simple and effective protocol for identifying live-captured specimens using ear length and postorbital head width.

Efforts to develop plans for conserving Stephens' Kangaroo Rat [*Dipodomys stephensi* (Merriam)], listed as rare by the State of California in 1972 (Leach and Fisk 1972) and federally listed as endangered in 1988 (Kramer 1988), are complicated by its morphological similarity to the Pacific Kangaroo Rat (*Dipodomys agilis* Gambel), with which it often coexists on a fine spatial scale (Price et al. 1991). Indeed, Grinnell (1922:65) remarked that "*stephensi* has been caught in the same trap-line with *agilis* without any notion on the part of the trapper that two species were represented." This similarity has led to uncertainty over the accuracy of species identifications based on live-trapping studies performed by relatively inexperienced workers and, hence, to uncertainty over the exact spatial distribution of *D. stephensi* within its range in southwestern San Bernardino, western Riverside, and northern San Diego counties, California.

Published descriptions of Stephens' Kangaroo Rat do exist for characters of the skull, pelage, and baculum, as well as for standard characters recorded for museum specimens such as ear length and weight (Grinnell 1922; Lackey 1967a, b; Bleich 1977; Homan and Genoways 1978). Although some of these papers compare *D. stephensi* with *D. agilis*, to our knowledge no paper has focused on devising a simple, quantitative method for discriminating the two species in the field.

In this paper we use discriminant analysis of characters that are easily measured on live animals to suggest a simple protocol for distinguishing Stephens' from Pacific Kangaroo Rats. We also analyse characters that might be of use for identifying skull material.

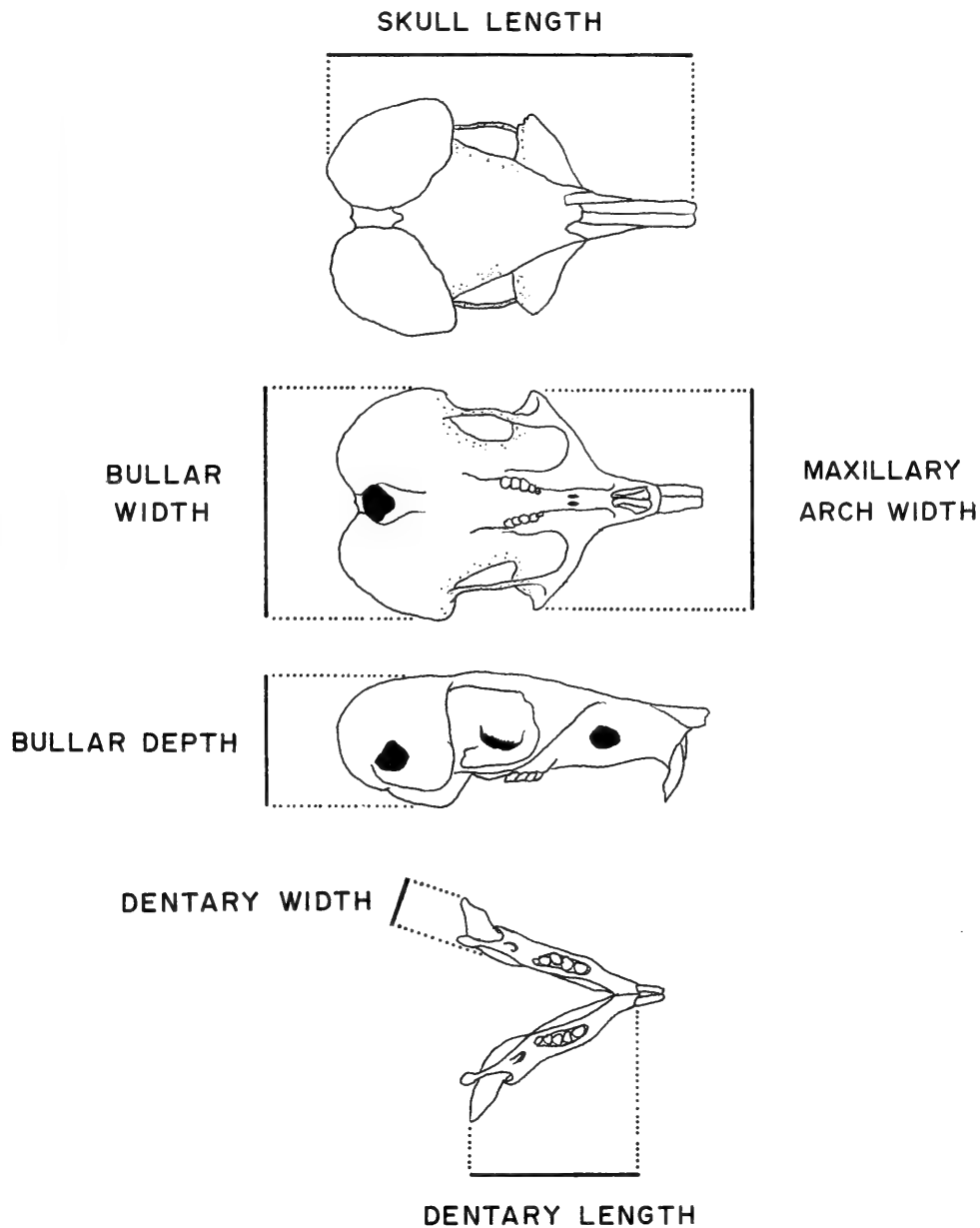


Fig. 1. Six skull characters measured on museum specimens.

Methods

Skull Characters

Six skull characters (Fig. 1) were measured by a single observer, using Helios dial calipers, on a total of 173 specimens from the Museum of Vertebrate Zoology at University of California, Berkeley, and the Natural History Museum of Los Angeles County. Virtually all specimens were adults from western Riverside County, California.

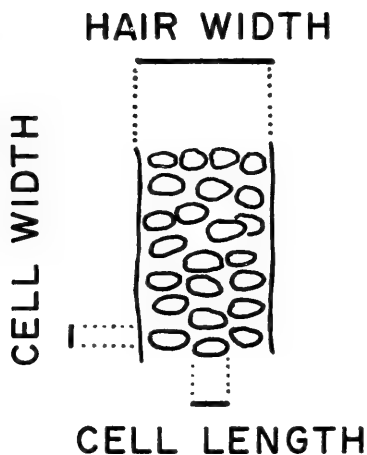


Fig. 2. Three characters of guard hairs.

Hair Characters

Five guard hairs were clipped from the back, approximately 2 cm above the tail, of each of 155 specimens from Riverside County. Some were from specimens housed in the Natural History Museum of Los Angeles County, and some were from specimens live-captured at two sites, the University of California Motte Rimrock Reserve (Steele Peak Quadrangle: T4S,R4W,S24) and the San Jacinto Wildlife Area (Lakeview Quadrangle: T3S,R2W,S32). All hair samples were from adult animals.

The five hairs were mounted in permount on microscope slides and covered with glass cover slips, following standard methods described in Homan and Genoways (1978). Preparations were measured at $\times 400$ magnification, using a compound microscope equipped with an ocular micrometer. Four variables were measured at the widest point of the hair: hair width, length and width of the central medullary cell, and number of columns of medullary cells (Fig. 2). Averages, calculated over replicate hairs for each specimen, were used in subsequent analyses.

Characters of Live Specimens

We measured five characters on a representative sample of live-captured residents, mostly adults, of our permanent study sites on the Motte Reserve and San Jacinto Wildlife Area. Body mass was measured with a 100-gram Pesola spring scale. Ear length was measured, from notch to tip, with a flexible plastic ruler, and length, preorbital and postorbital breadth of the head were measured with calipers gently closed until they pressed against the skull (Fig. 3). Hair samples were taken from a subset of these individuals.

Analytical Methods

Differences between males and females within species, and between the two species, were assessed separately for characters of skull, hair, and live specimens using univariate analysis of variance, canonical discriminant analysis, and discriminant analysis (Procedures ANOVA, CANDISC, and DISCRIM, respectively,

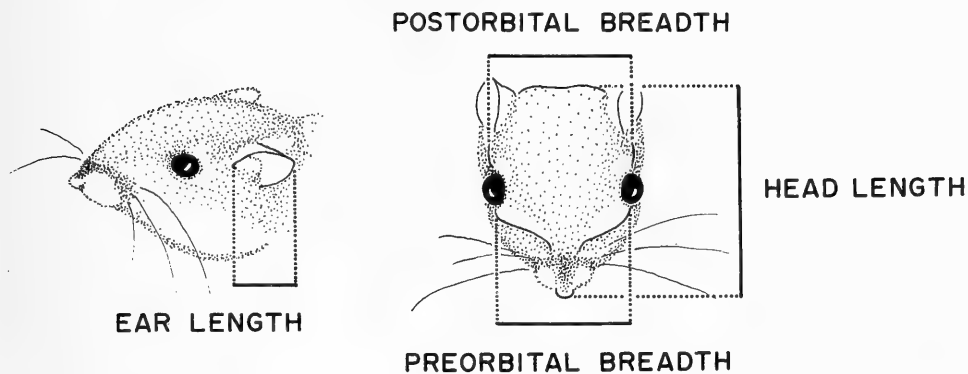


Fig. 3. Head characters measured on live specimens.

SAS Institute, Inc. 1985; also see Klecka 1980). These analyses were repeated for hair data combined with live-capture data, using the subset of live specimens for which we had both types of data, to determine whether discrimination was improved when hair data were included. Finally, the set of variables included in the analysis was pruned using stepwise discriminant analysis (Procedure STEPDISC, SAS Institute, Inc. 1985) to arrive at a minimum set of variables that produces good separation of *D. stephensi* and *D. agilis*.

Results

Skull Characters

Males and females differed significantly in three skull characters for *D. agilis* and one character for *D. stephensi* (Table 1). When all characters were considered together, males differed significantly from females for both species (Wilks' lambda = 0.64, 0.68; $P = 0.001, 0.03$ for *D. agilis* and *D. stephensi*, respectively).

The two species differed significantly, whether comparisons were made by sex, or with sexes pooled. Table 1 presents means for pooled sexes, with approximately equal sample sizes of males and females within species. ANOVA indicated significant interspecific differences for all characters except skull length and dentary width, and canonical discriminant analysis revealed highly significant overall differences between species (Table 1; Wilks' lambda = 0.477, $df = 6, 105$, $P < 0.001$). The squared canonical correlation, an indicator of the percentage of the total variation in discriminant function scores that is accounted for by species differences, was 52%.

Canonical coefficients indicated that the species differ primarily in skull length relative to maxillary arch width, bullar depth, and dentary length; *D. agilis* has a skull that is narrow and shallow relative to that of *D. stephensi*. The single variable having the greatest correlation with species was maxillary arch width (total canonical structure coefficient = 0.74).

The value of these skull characters for classifying specimens can be assessed with discriminant analysis; the misclassification frequency indicates how well the centroids of the two species are separated relative to the spread of individuals of each species around its centroid. Discriminant analysis correctly classified 58 of 70 *D. agilis* specimens and 37 of 42 *D. stephensi*, for an overall error rate of 15.2%.

Table 1. Mean values for skull characters, by sex and by species, and mean discriminant scores ("Disc. score") by species. Asterisks indicate characters whose means differ significantly ($P < 0.05$) between sexes within species. Species means with different superscript letters differ significantly ($P < 0.05$). \bar{x} = mean; S.D. = standard deviation; N = sample size. Sample sizes for combined sexes include only specimens with complete data. The canonical coefficients refer to unstandardized coefficients in the canonical discriminant function that provides maximal separation between species.

Species	Sex	Var.	Skull length	Bullar width	Bullar depth	Max. arch width	Dentary length	Dentary width	Disc. score
<i>D. agilis</i>	M	\bar{x}	36.90*	24.54*	13.09*	20.64	18.01	7.84	
		S.D.	0.95	0.73	0.34	1.12	0.58	0.58	
		N	43	43	42	44	40	39	
<i>D. stephensi</i>	F	\bar{x}	36.44*	24.23*	12.92*	20.86	18.06	7.64	
		S.D.	0.76	0.71	0.36	1.22	0.67	0.51	
		N	41	42	41	42	39	38	
<i>D. stephensi</i>	M	\bar{x}	36.48	24.79	13.22	22.21	18.72*	7.80	
		S.D.	1.05	0.65	0.35	1.19	0.86	0.50	
		N	34	39	36	38	30	30	
<i>D. agilis</i>	F	\bar{x}	36.26	24.71	13.10	22.28	18.32*	7.65	
		S.D.	1.15	0.72	0.37	0.99	0.51	0.37	
		N	40	40	35	36	26	25	
<i>D. agilis</i>	M + F	\bar{x}	36.75 ^a	24.44 ^a	13.02 ^a	20.83 ^a	18.06 ^a	7.75 ^a	-6.59
		S.D.	0.86	0.73	0.36	1.20	0.62	0.56	1.10
		N	70	70	70	70	70	70	70
<i>D. stephensi</i>	M + F	\bar{x}	36.46 ^a	24.83 ^b	13.21 ^b	22.27 ^b	18.61 ^b	7.76 ^a	-4.42
		S.D.	0.96	0.60	0.31	0.83	0.70	0.46	0.84
		N	42	42	42	42	42	42	42
Canonical Coefficient			-1.27	0.03	0.87	0.80	0.82	-0.50	

Table 2. Mean values for four characters of guard hairs, and for the discriminant score. Hair data are in ocular micrometer units (one unit = 0.00556 mm). \bar{x} = mean; S.D. = standard deviation; N = number of individuals; P = probability that the two species have the same mean value.

Species		Maximal hair width	Medullary cell number	Medullary cell length	Medullary cell breadth	Disc. score
<i>D. agilis</i>	\bar{x}	14.81	3.13	5.59	2.97	10.76
	S.D.	1.70	0.26	0.66	0.29	1.16
	N	57	57	57	57	57
<i>D. stephensi</i>	\bar{x}	12.39	2.84	4.77	2.85	9.00
	S.D.	1.29	0.26	0.66	0.30	0.90
	N	98	98	98	98	98
	P	0.0001	0.0001	0.0001	0.0124	
Canonical Coefficient		0.51	0.78	0.46	-0.61	

Hair Characters

Males and females did not differ significantly in hair characters for either species; species comparisons therefore were performed with pooled data. *Dipodomys agilis* and *D. stephensi* differed significantly in all four characters tested individually (Table 2), as well as when all characters were considered together in a canonical discriminant analysis (Wilks' lambda = 0.58, df = 4,150, $P < 0.001$). Species accounted for 42.3% of total variation in discriminant function scores. *Dipodomys agilis* had wider hairs, larger medullary cells, and more columns of cells than *D. stephensi* (Table 2).

Maximal hair width was the variable with the highest correlation with species (total structure coefficient = 0.96). Indeed, the discrimination with only this variable was nearly as good as with all variables entered, as the squared canonical correlation only dropped to 39.3% (Wilks' lambda = 0.61, df = 1,153, $P < 0.0001$).

We used a split-sample discriminant analysis to assess the value of hair characters alone in classifying specimens. When hair from the 105 live-captured specimens was used as the basis for classifying the 47 museum specimens, 5/23 *D. agilis* and 3/24 *D. stephensi* were misclassified, for an overall misclassification rate of 17%. This misclassification rate was similar to that (19%) for live-captured specimens classified according to a discriminant function derived from the live-capture hair data.

Characters of Live Specimens

Males and females did not differ significantly for any individual variable in *D. agilis*, but did vary in body mass, preorbital breadth, and head length for *D. stephensi* (Table 3). For both species, sexes were significantly different when all variables were considered together: males were heavier and had longer heads than females.

Although the sexes differed for both species, the significance of between-species differences was not substantially higher when discrimination was performed separately for each sex. We therefore report results of an analysis with pooled sexes. The two species differed significantly for all individual variables except head length (Table 3), and they differed overall (Wilks' lambda = 0.215, df = 5,81, $P < 0.0001$).

Table 3. Mean values for characters measured on live specimens, reported by sex and by species, and mean discriminant score, by species. Asterisks indicate characters whose means differ significantly ($P < 0.05$) between sexes within species. Species means with different superscript letters differ significantly ($P < 0.05$). \bar{x} = mean; S.D. = standard deviation; N = sample size. Sample sizes for combined sexes include only specimens with complete data. Canonical coefficients refer to unstandardized coefficients in the canonical discriminant function that provides maximal separation between species, with sexes pooled. Weight is reported in grams, other characters in mm.

Species	Sex		Weight	Ear length	Preorbital breadth	Postorbital breadth	Head length	Disc. score
<i>D. agilis</i>	F	\bar{x}	53.7	16.4	21.5	23.6	40.1	
		S.D.	12.7	1.5	1.7	1.3	2.9	
	M	\bar{x}	14	14	14	14	14	
		S.D.	51.9	16.7	21.7	24.2	39.5	
<i>D. stephensi</i>	F	\bar{x}	13.9	2.0	1.8	1.3	3.1	
		S.D.	23	23	23	23	23	
	M	\bar{x}	55.6*	14.8	23.3*	25.3	39.9*	
		S.D.	7.7	0.7	1.1	0.5	1.1	
<i>D. agilis</i>	M + F	\bar{x}	22	22	22	22	22	
		S.D.	64.1*	15.0	24.3*	25.3	41.3*	
	M + F	\bar{x}	5.7	0.6	0.8	0.8	0.9	
		S.D.	27	29	29	29	29	
<i>D. stephensi</i>	M + F	\bar{x}	52.6 ^a	16.6 ^a	21.6 ^a	24.0 ^a	39.7 ^a	15.85
		S.D.	13.3	1.8	1.7	1.3	3.0	1.11
	M + F	\bar{x}	38	38	38	38	38	38
		S.D.	60.3 ^b	14.8 ^b	23.8 ^b	25.2 ^b	40.6 ^a	19.66
Canonical Coefficient	M + F	\bar{x}	7.8	0.6	1.0	0.7	1.2	0.90
		S.D.	49	49	49	49	49	49
	Canonical Coefficient	\bar{x}	-0.038	-0.995	0.673	0.555	0.166	—
		S.D.						

Dipodomys agilis weighed less than *D. stephensi* and had longer ears and a narrower head. The discriminant function explained 78.5% of the total variation, much more than that explained by hair data alone, or skull data alone. Indeed, a discriminant analysis performed with characters taken from live specimens correctly classified 36 of 38 *D. agilis* and 48 of 49 *D. stephensi*, for a very low misclassification rate of 3.4%. The misclassified individuals were not juveniles (individuals weighing less than 50 g).

Judging from total structure coefficients, preorbital breadth (0.71), ear length (-0.63), and postorbital skull breadth (0.61) were most highly correlated with the score on the discriminant function, and stepwise discriminant analysis selected these three variables as the most useful for discriminating the two species, whether forward or backward selection protocols were used. Species differences with a discriminant function based on these three variables alone accounted for 77.8% of the total variation, nearly as much as with all five variables (78.5%).

Analysis of Hair Plus Live-Capture Data

When hair data were combined with overall morphological information for the live-captured individuals having complete data (15 *D. agilis* and 11 *D. stephensi*), the degree of discrimination was improved somewhat (percent of variation in discriminant scores explained by species differences increased to 87.1% from 78%, and misclassification rate from a discriminant analysis was virtually identical to the 3.6% misclassification rate based on live-capture data—1/15 *D. agilis* and 0/11 *D. stephensi* were misclassified, for an error rate of 3.8%).

Total structure coefficients indicate that maximum hair width and ear length were the two variables having greatest correlation with the discriminant function (0.75 and 0.68, respectively). Stepwise discriminant analysis entered these two variables first; they, along with postorbital breadth, explained 82.6% of the total variation, not much less than that (87.1%) explained by all nine variables. Discriminant analysis based on these three variables correctly classified 25 of 26 individuals, for an error rate of 3.8%.

Discussion

Our data agree with previous reports that *D. stephensi* differs from *D. agilis* in a number of morphometric characters. *Dipodomys stephensi* weighs more and has thinner guard-hairs, a broader skull, deeper auditory bullae, longer dentary, and shorter ears than *D. agilis* (Grinnell 1922; Lackey 1967a; Bleich 1977; Homan and Genoways 1978).

The two species can be discriminated with reasonable precision using subsets of these characters. Skull characters provided 85% correct classification of the museum specimens we measured and should be of some utility for identifying prepared museum material. Characters of the head have the greatest value for discriminating live-captured specimens. Including guard-hair characters improves the discrimination based on ear and head characters, but hair characters alone provide inferior discrimination of the two species.

On the basis of our analyses, we recommend two methods for distinguishing live-captured *D. stephensi* from *D. agilis*, depending on the availability of hair data. If hair data are not available, then good discrimination can be obtained by measuring ear length and postorbital breadth of the head. If hair samples and a

Table 4. a) Unstandardized canonical discriminant coefficients for functions based on two variables (ear length, postorbital breadth) or three variables (ear length, postorbital breadth, maximal hair width). Rsquare is the squared canonical correlation. b) Mean discriminant scores, by species, for two- and three-variable discriminant functions.

		Two-variable function	Three-variable function
a) Discriminant Function Coefficients			
	Hair Width	—	-36.251
	Ear Length	-1.049	-0.951
	Postorbital Breadth	1.473	1.291
	Rsquare	0.808	0.826
b) Mean Discriminant Scores			
<i>D. agilis</i>	\bar{x}	12.32	18.04
	S.D.	1.09	1.10
	N	15	15
<i>D. stephensi</i>	\bar{x}	16.55	22.03
	S.D.	0.86	0.84
	N	11	11

microscope are available, then slightly better discrimination can be obtained by including maximal hair width along with the other two variables.

Table 4 gives the unstandardized canonical coefficients for these two methods of discrimination. A "score" on the two- or three-variable discriminant axis can be calculated for each specimen by multiplying each measurement (in mm) by the canonical coefficient associated with it, and summing the products over the two or three variables. For example, if individual #F2485 has postorbital breadth of 25.3 mm and ear length of 15 mm, its two-variable discriminant score is

$$1.473 \times (25.3) - 1.049 \times (15) = 21.532.$$

Figure 4 shows the distribution of scores on two- and three-variable discriminant axes for *D. stephensi* and *D. agilis*. The small region of overlap in the distributions of scores for the two species reflects the probability of misclassifying a specimen, which is 3.8–6.7% (depending on which data set is used) for the two-variable discriminant function and 3.8% for the three-variable discriminant function.

Once a discriminant score has been calculated for a specimen, as described above, a *t*-test can be used to assess the probability that the specimen belongs to a sample of *D. stephensi* or of *D. agilis*, and the specimen can be assigned to species on the basis of these probabilities. The *t*-statistic is calculated by subtracting the mean discriminant score of a species (given in Table 4 for our calibration sample) from the discriminant score of the specimen, and then dividing the difference by $s[(n-1)/n]^{1/2}$, where *s* is the standard deviation for the species' sample and *n* is the number of individuals on which that sample is based. This value of *t* is compared, using 1-tailed probabilities, with a *t*-distribution having (*n* - 1) degrees of freedom, to determine the probability that the specimen was taken from the distribution for that species. Values for the mean discriminant scores, standard deviations, and sample sizes for our samples are given in Table 4.

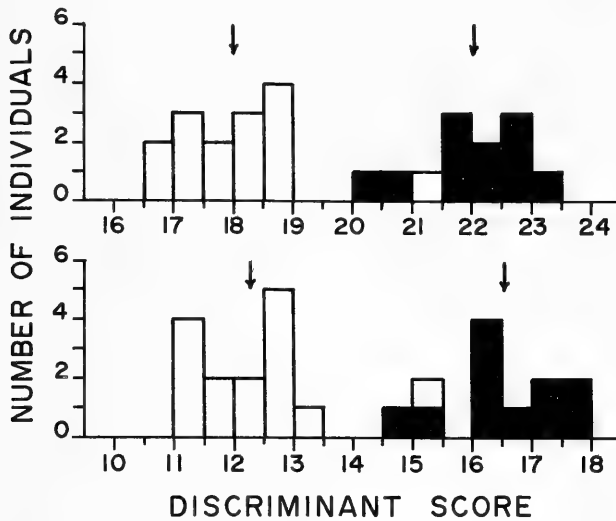


Fig. 4. Distributions of scores on discriminant axis for *D. agilis* (open bars) and *D. stephensi* (filled bars). Top = scores based on two characters (ear length and postorbital breadth). Bottom = scores based on three characters (ear length, postorbital breadth, and hair width). Arrows indicate mean scores for each species.

When individual #F2485 described above is compared with our sample of *D. stephensi*, $t = -0.564$, $df = 10$, and 1-tailed probability that it belongs to that sample lies between 0.24 and 0.45. When the specimen is compared with our *D. agilis* sample, $t = 3.079$, $df = 14$, and $0.005 < P < 0.01$. Because the specimen has a much higher probability of belonging to *D. stephensi* than to *D. agilis*, we would assign the specimen to *D. stephensi*. For specimens that have approximately equal probability of belonging to both species, additional qualitative pelage characters (Bleich 1977) could be used for identification.

We used this protocol to classify 14 *D. agilis* and 13 *D. stephensi* that were captured at the Motte Reserve and San Jacinto Wildlife Area, but which were not included in the "calibration" sample used to calculate the discriminant function presented in Table 4. The individuals were assigned to species prior to measuring ear length and postorbital breadth, using the suite of qualitative characters that is often used to distinguish these two species (e.g., darkness of the hairs on soles of the hind feet, dorsal tail stripe, and tail tuft; baculum shape in males; weight; calmness when handled; "richness" of the brown pelage coloration; width and distinctness of the lateral tail stripe; Bleich 1977). All 27 specimens were correctly classified by the two-variable discriminant function; this is less than the misclassification rate for the calibration data set.

Field workers are urged to collect and report standard measurements on live-captured specimens to provide documentation for their identifications in cases where an endangered species is similar morphologically to a sympatric, nonendangered congener. Our discrimination procedure, based solely on ear length and postorbital head breadth, provides a standardized identification protocol for *D. stephensi* and *D. agilis*, with low probabilities of misclassification.

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The Status of *Neotoma anthonyi* (Rodentia, Muridae, Cricetinae) of Todos Santos Islands, Baja California, Mexico

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Abstract.—The present conservation status of the Todos Santos Islands packrat (*Neotoma anthonyi*) was determined through live trapping, search for evidence and interviews with local inhabitants. It is concluded that this species is either extinct or very close to extinction. This was likely caused by the introduction of domestic cats.

The packrat *Neotoma anthonyi* is a species endemic to Todos Santos Islands, off the coast from Ensenada, Baja California. These are two islets located at the mouth of Todos Santos Bay (Fig. 1). The south island has a surface area of approximately 100 ha and maximum elevation of 95 m; the north island has 30 ha and rises 45 m (Secretaría de Marina 1974). The southern part of the south island is formed by rounded hills with steep cliffs; the northern part of this island and the north island are low plateaus; the shorelines are rocky and precipitous (Nelson 1921). The islands, which are an extension of the Punta Banda peninsula, lie 5 km to the northwest of it. The islands are separated from each other by a narrow channel. Vegetation is Californian coastal scrub (Pase and Brown 1982), and includes open herbaceous areas dotted with clumps (a few meters in diameter) of *Encelia californica*, *Bergerocactus emoryi*, and *Opuntia prolifera*. This vegetation is typical for flat areas, including most of the north island, but is absent at the lighthouse and dwellings on the north island, and on hilltops, in the valleys and on low plateaus of the south island. These clumps of shrubs were probably important for the packrats, as they are to the mainland *N. lepida* and other species elsewhere (*N. albigula*; Rangel and Mellink *in press*). These islands also harbor the endemic subspecies of deer mouse *Peromyscus maniculatus dubius*.

The Todos Santos Islands packrat was described by J. A. Allen from five specimens collected on 11 May 1897 by A. W. Anthony (Allen 1898). Between its first collection and 1910 at least 45 additional specimens were collected. Their identifications were verified by E. A. Goldman (1910). Neither Allen (1898) nor Goldman (1910) reported a measure of abundance for these packrats, but Nelson (1921) indicated that *N. anthonyi* was "extremely numerous" on the islands (implying it was found on both landmasses). None of these authors reported preferred habitats.

Methods

Five trips to the Todos Santos Islands to determine the status of this packrat were made. These visits were on 8 March, 29-31 March, 12-14 June and 3-5

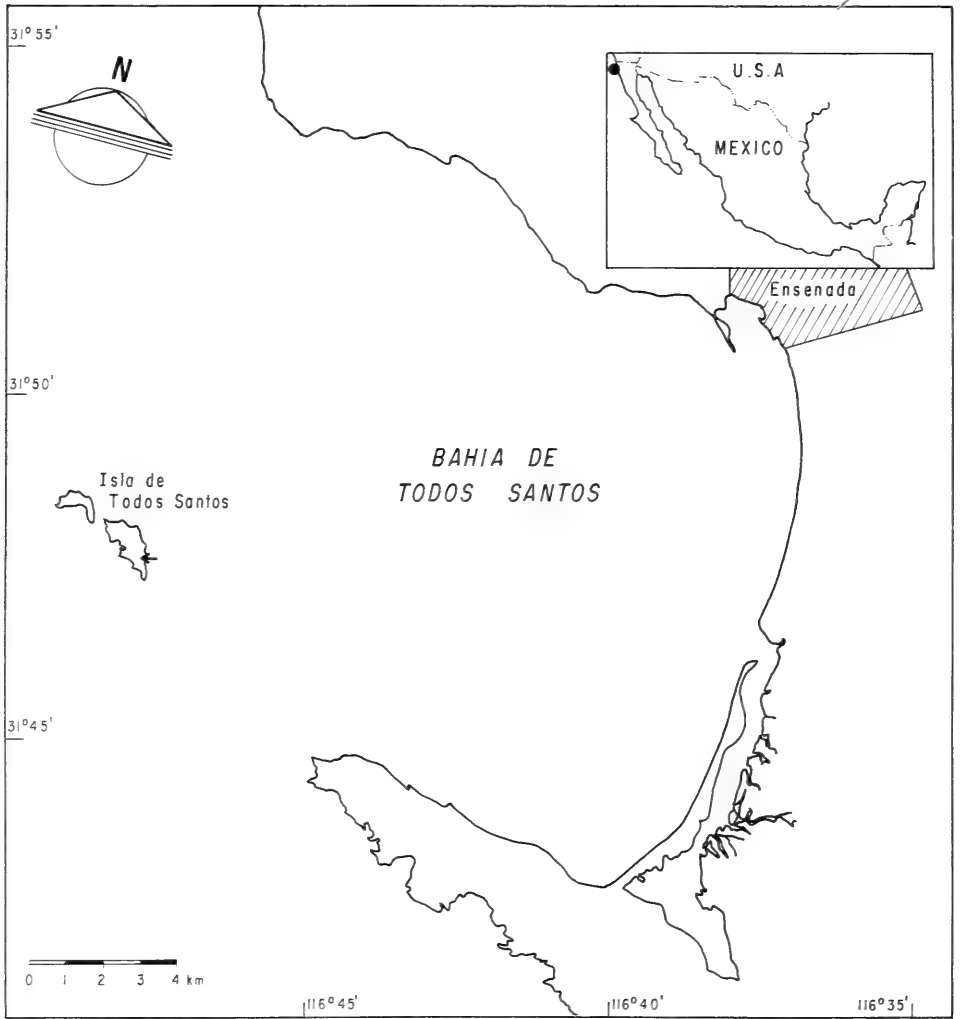


Fig. 1. Location of Islas de Todos Santos, Baja California. An arrow marks the area where a packrat skull and midden-type material were found.

October of 1989 to the south island, and 22–24 March 1990 to the north island. On these visits I searched for evidence of packrats in almost all cracks and shrub clumps of both islands, and trapped rodents during the last four trips (80, 160, 160 and 160 night traps, respectively). During four of the island visits, and at Ensenada, local fishermen and the lighthouse keeper were interviewed regarding the presence of the species or of its houses. The trapping regime utilized 80 Sherman traps, baited with rolled oats, and checked early in the morning and in the afternoon (to make them all available at night, since deer mice proved to be active during the day).

Traps were placed favoring the best sites, and using different areas on each trip. When the cliffs were sampled, traps were set mainly next to cracks. Whenever the traps were set in flats (either on top of the hills or in the low areas), they were

set in transects with 15, 20, 30, or 40 traps, with a 10 m spacing between traps. The transects ran through different habitat variations, but favored shrub clumps and rock outcrops (the most favorable habitat for packrats). Some traps were also set next to a housing development of the north island, since packrats have been known to use certain parts of abandoned buildings (E. Mellink pers. obs.).

This survey was probably adequate since most of the suitable spots were inspected, and trapping transects were set in all areas of the islands and most shrub clumps and rock outcrops were included. Similar surveying efforts on the mainland and Cedros island, which have low packrat populations, have rendered positive results. In Cedros island (E. Mellink accepted), trapping success for *Neotoma bryanti* varied from 2.5 to 7.5% in areas occupied by the species.

Results and Discussion

The only evidence of recent presence of packrat has been a skull of *N. anthonyi* that I found on the first visit in a crack of the eastern cliffs on the south island. The skull is undatable, but probably is not more than a decade old. I have not found any packrat nests or feces, but I found midden-type material in some small caves (less than 1 m deep). Trapping success was high, but restricted to deer mouse (*P. maniculatus dubius*). The oldest fisherman, who started living on the islands in the early 1950s, does not remember any packrats or evidence of them, but another one remembers having seen a "pile of debris" in the past (date unspecified). Based on my information, it can be concluded that *N. anthonyi* is either extinct or very close to extinction.

The most plausible explanation for the disappearance of the packrats is extirpation by domestic cats, which were introduced prior to 1950. (I have been unable to find any collector's field notes to check if cats had already been introduced.) *Neotoma anthonyi* would presumably be very susceptible to predation, since it evolved in the absence of mammalian predators (nocturnal birds of prey are not resident on the islands).

Feral domestic rabbits also existed on the south island. It is unknown whether they competed with the packrats. The fishermen and lighthouse keeper stated that the populations of both cats and rabbits increased to "high" numbers about 15 years ago. Rabbits have almost been extirpated, allegedly by cats and humans. Only cats are now present, in low numbers. The large rabbit population might have stimulated a population increase in cats, but decline of the rabbits would have imposed a great predation pressure on the packrat population (probably an easier prey than the deer mouse, and providing a greater food return per capture), if still present. The deer mouse would be less susceptible than packrat because of its smaller size, larger populations, and higher reproductive rates (based on the life histories of other packrats and other subspecies of the deer mouse). Also deer mouse would probably be inadequate to sustain the high cat populations left over from the rabbit high.

Cats may have caused other extinctions. The Todos Santos Island Rufous-crowned Sparrow (*Aimophila ruficeps sanctorum*) is an endemic bird that nests on the ground or close to it. Eduardo Palacios and myself searched the southern island for it, with the aid of recordings of the species, on 15 April 1991. We were unable to obtain any response or see any individuals. I had not recorded it on any of my former visits, although those trips were not aimed at this species in

particular. Similarly, Everett (1989) indicated that both the Xantus' murrelet (*Synthliboramphus hypoleucus*) and Cassin's auklets (*Ptychoramphus aleuticus*) historically nested on Todos Santos Islands, with only the prior species doing so currently. Current lack of nesting on the island by the latter species could be also an effect of the cats.

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Holmes, T. Jr., and S. Speak. 1971. Reproductive biology of *Myotis lucifugus*. J. Mamm., 54:452–458.

Brattstrom, B. H. 1969. The Condor in California. Pp. 369–382 in Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii + 635 pp.

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