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## Archaeological Evidence for the Recent Extinction of Three Terrestrial Mammals on San Miguel Island

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### INTRODUCTION

In this paper, evidence is presented concerning the recent extinction on San Miguel Island of western spotted skunks (*Spilogale gracilis*), ornate shrews (*Sorex ornatus*), and a large insular species of deer mouse (*Peromyscus nesodytes*). Skeletal remains from these species are present in a faunal collection made by Charles Rozaire during the excavation of two archaeological middens (4-SMI-261 and 4-SMI-261A) on the northeast coast of the island.

SMI-261 is a small coastal cave located east of Bay Point. The faunal remains from this site were obtained by excavating most of the cave's interior and a 5-ft (1.5 m) wide trench extending 15 ft (4.6 m) into the talus at the mouth of the cave (Fig. 1). The SMI-261A site is located at the bottom of a vertical fissure in the cliff, a few meters below SMI-261. Both sites were excavated in arbitrary 6-inch (15.2 cm) levels and all faunal remains retained by a quarter-inch screen were collected. These deposits contained disc-shaped beads made by grinding the wall portion of purple olive shells (*Olivella biplicata*). *Olivella* beads of this type are characteristic of Middle Period (ca. 400 B.C. to 300 A.D.) occupations of the Santa Barbara Channel mainland (Gibson 1975).

Stratigraphic profiles indicate that SMI-261 is composed of a complex series of well-defined, more or less horizontal, interbedded strata (C. Rozaire, pers. comm.). According to Rozaire, the SMI-261A midden is comparatively homogeneous and lacks the obvious stratification that characterizes SMI-261. It is evident from this dissimilarity in midden structure that differences exist in the depositional histories of the two sites.

Human skeletal remains were present in the sites and it is probable that both middens were disturbed prehistorically by intrusive burial pits. Apparently, additional mixing of deposits occurred due to recent digging by grave robbers. This is evidenced by the concentration of highly fragmented, completely disarticulated human skeletons on the surface and in the zero to 6-inch levels of SMI-261 and SMI-261A (Table 1).

### SPECIES ACCOUNTS

#### *Peromyscus nesodytes* and *Peromyscus maniculatus* (Deer Mice)

The faunal collections from SMI-261 and SMI-261A contain numerous remains of *Peromyscus nesodytes* (Fig. 2), a large species of deer mouse previously reported only from late Pleistocene deposits on Santa Rosa Island (Wilson 1936, White 1966). *P. nesodytes* is larger than any modern *Peromyscus* from the United States (White 1966). The mean molar row length of the Santa Rosa Island specimen is 5.95 mm (Table 2). This value does not differ significantly from those of *P. nesodytes* from either SMI-261 ( $x = 6.06, t = 1.21, P > 0.50$ ) or SMI-261A ( $x = 5.75, t = 0.753, P > 0.50$ ). Mean mandibular molar row dimensions of the San Miguel Island *P. nesodytes* do differ significantly from those of *P. anyapahensis*, a small species of extinct deer mouse from late Pleistocene deposits on Anacapa Island ( $t = 7.41, P < 0.05$ ).

In addition to *Peromyscus nesodytes*, the archaeological collections also contain bones of *Peromyscus maniculatus* that are, in most respects, comparable to *P. m. streator*, the only

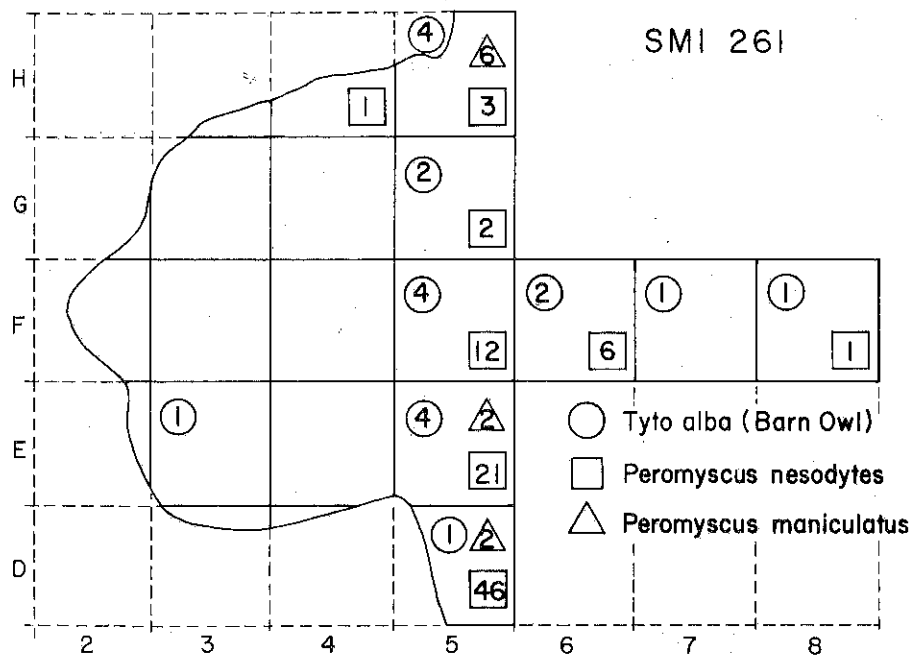


FIGURE 1. Map of SMI-261 showing distribution of Barn Owl, *Peromyscus nesodytes*, and *Peromyscus maniculatus*.

TABLE 1. Distribution of human skeletal remains in SMI-261 and SMI-261A.

Site number	Excavation unit	Levels in inches						
		Surface	0-6	6-12	12-18	12-36	18-24	24-30
SMI-261	—	5	—	—	—	—	—	—
"	D-5	1	—	—	—	—	—	—
"	E-3	—	—	—	1	1	—	—
"	F-5, 6, 7	—	—	—	—	—	—	—
"	G-4	—	—	1	—	—	—	1
"	H-5	—	—	—	—	—	1	—
SMI-261A	First room	2	8	—	—	—	—	—
"	Test pit #1	—	—	—	—	—	1	—

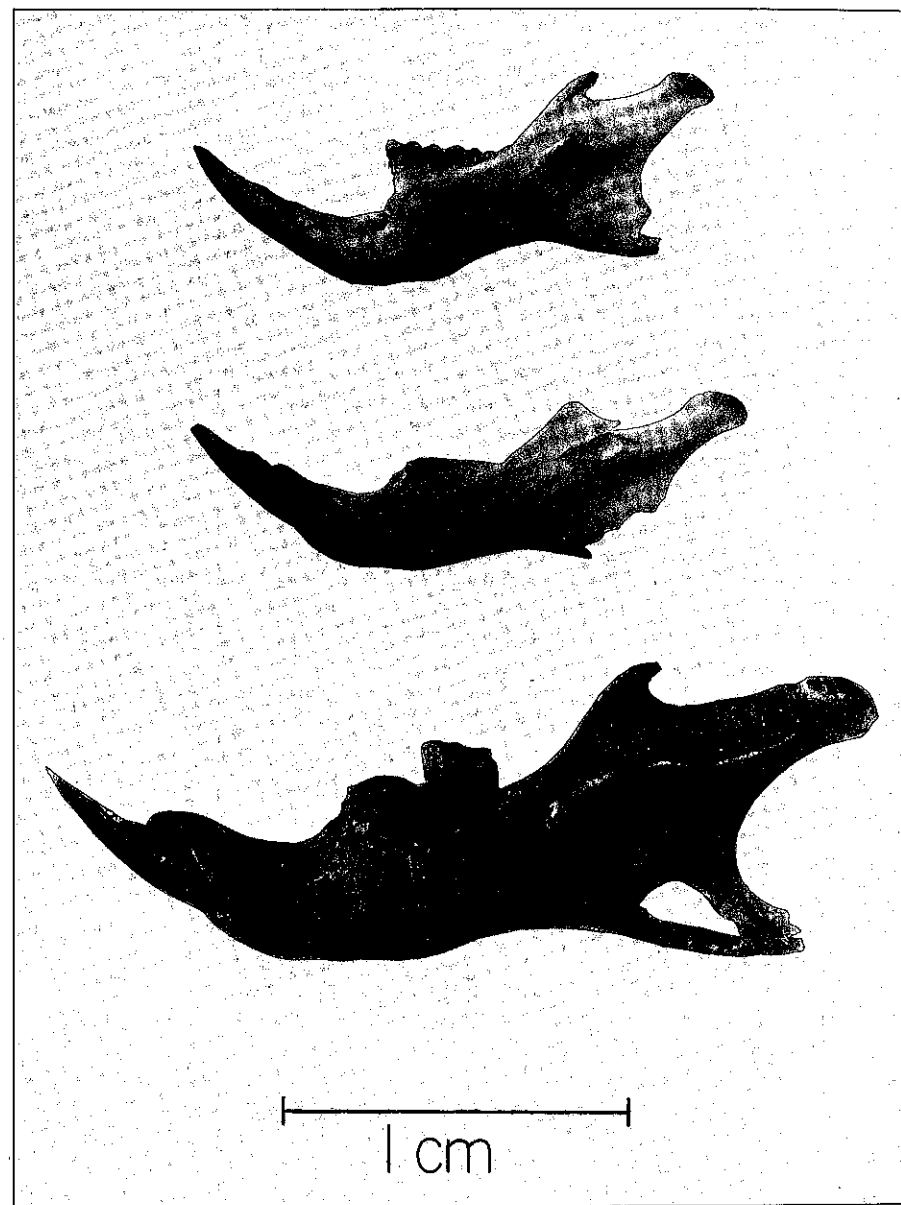


FIGURE 2. Lateral view of hemimandibles of: (top) *Peromyscus nesodytes* from SMI-261A; (center) *Peromyscus maniculatus streator*; and (bottom) *Peromyscus nesodytes* from San Miguel Island.

TABLE 2. Dental dimensions of deer mice from the Northern Channel Islands.

Species	Origin of specimens	Dating	Alveolar length of mandibular molar row†			Mesiodistal width of mandibular incisors		
			$\bar{X}$	S.D.	$n$	$\bar{X}$	S.D.	$n$
<i>Peromyscus maniculatus streator</i>	San Miguel Island; specimens were trapped at various localities	1939	3.88	0.20	12	0.57	0.07	12
<i>Peromyscus maniculatus</i>	San Miguel Island; SMI-261 & SMI-261A	Middle period (400 B.C.-300 A.D.?)	4.12	0.11	3	0.65	0.09	3
<i>Peromyscus nesodytes</i>	San Miguel Island; SMI-261 & SMI-261A	Middle period (400 B.C.-300 A.D.?)	6.00	0.17	10	0.95	0.06	10
<i>Peromyscus nesodytes</i> *	Santa Rosa Island; deposits	Late Pleistocene	5.95	0.16	7	—	—	—
<i>Peromyscus anyapahensis</i> *	Santa Rosa Island; deposits	Late Pleistocene	5.51	0.14	7	1.09	0.04	7

\* Data from White (1966). White's measurements are estimated to the nearest 0.01 mm. All other measurements are estimated to the nearest 0.05 mm.  
 † Measurement as defined by White (1966).

endemic form of rodent previously reported from San Miguel Island (Nelson and Goldman 1931).

At least 99 *P. nesodytes* and 28 *P. maniculatus* individuals are represented in the collections from the archaeological sites. These figures are based on counts of the most frequently occurring unique (*i.e.*, from one side of the body) skeletal remains from each excavation unit. The deer mouse bones from SMI-261 and SMI-261A are well preserved and do not exhibit burning, cut marks, or other obvious evidence of processing by humans. *Peromyscus* bone is not evenly distributed in the archaeological middens. Instead, it tends to be concentrated at only a few levels of each excavation unit (Table 3). Levels containing high densities of deer mouse bone were probably produced during periods when the SMI-261 cave was not occupied by humans and was therefore available as a roosting place for owls. In this site there is a negative association between deer mouse remains and artifacts. Although shell artifacts occurred in 32 of the 6-inch levels excavated at SMI-261, only two of these artifact-bearing levels also contained deer mouse bone. The role of owls in the deposition of *Peromyscus* at SMI-261 is also indicated by the presence of barn owl (*Tyto alba*) remains in units that also contained deer mouse bone and by the presence of high densities of *Peromyscus* bone at the lateral margin of the cave's mouth near potential owl roosts (Fig. 1 and Table 3). Even though owl remains occur in SMI-261A (Guthrie 1980), these predators may not be responsible for all of the *Peromyscus* in the deposit. Both ends of the SMI-261A fissure are blocked and the site could have functioned as a natural trap during part of its depositional history (C. Rozaire, pers. comm.).

#### Fusion of Long-bone Epiphyses

Differences exist between the *P. nesodytes* and *P. maniculatus* samples with respect to epiphyseal fusion. Eight per cent of the *P. nesodytes* femora from the archaeological collections have completely fused proximal and distal epiphyses (Table 3). The *P. maniculatus* material, in contrast, contains many more femora with completed epiphyseal union (40 per cent). In *P. nesodytes* 18 per cent, and in *P. maniculatus* 5 per cent of the femora recovered from the archaeological sites belonged to young individuals lacking any fused epiphyses. Differences in age structure of the two species cannot be inferred from these data since the bones of relatively small immature *P. maniculatus* pass through quarter-inch mesh screen and are lost at a higher rate than are the bones of larger immature *P. nesodytes*. Additional biases may have been introduced by the disproportionate preservation and recovery of denser, relatively resistant adult bones.

#### Coronoid Process Morphology

A significant difference in mandibular morphology exists between the *P. maniculatus* preserved in the archaeological middens and modern *P. maniculatus streator* trapped on San Miguel Island. The coronoid processes of *P. maniculatus* jaws from SMI-261 and SMI-261A are relatively small and have little or no posterior recurve. *P. m. streator* collected on the island during the 1930s contrast with these specimens by frequently exhibiting prominent, markedly recurved coronoid processes (Fig. 3). Seven of the 11 *P. maniculatus* hemimandibles from SMI-261 were determined to have intact coronoid processes after careful examination with a dissecting microscope. The absence of recurved coronoid processes in the archaeological collection is not, therefore, explained by low preservation rates of processes with recurved morphology.

Modifications in coronoid process shape have been produced in laboratory rats by feeding them experimental diets of contrasting consistencies (Whiteley, Kendrick, and Matthews 1966). Rats fed a diet of hard food items that required vigorous mastication developed prominent coronoid processes that extended to the level of, or superior to, the zygomatic arches. Animals fed the same food after it had been ground to a fine powder and mixed with water developed comparatively short coronoid processes that never extended to the level of the

TABLE 3. *Peromyscus* remains (SMI-261 and SMI-261A).

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Species	Bone	Grid	0-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42-48"	48-54"	54-60"	60-66"	66-72"
SMI-261														
<i>P. maniculatus</i>	R.Mandible	D-5	1											
"	L.Femur	D-5	1						2					
"	R.Tibia	D-5	1						1					
"	L.Mandible	E-5						1						
"	R.Mandible	E-5	1											
"	L.Femur	E-5						2						
"	R.Femur	E-5						2						
"	L.Tibia	E-5						2						
"	R.Tibia	E-5						2						
"	R.Mandible	G-5						1						
"	L.Femur	H-4							1					
"	L.Mandible	H-5						5						
"	R.Mandible	H-5						2						
"	L.Femur	H-5						2						
"	R.Femur	H-5						6						
"	L.Tibia	H-5						3						
"	R.Tibia	H-5						5						
"	L.Pelvis	H-5						3						
<i>P. nesodytes</i>	L.Mandible	D-5	8											
"	R.Mandible	D-5	10											
"	R.Maxilla	D-5	1											
"	L.Femur	D-5	46											
"	R.Femur	D-5	45											
"	L.Humerus	D-5	5											
"	R.Humerus	D-5	4											
"	L.Radius	D-5	1											
"	R.Ulna	D-5	1											
"	L.Pelvis	D-5	8											
"	R.Pelvis	D-5	17											
"	Sacrum	D-5	2											
"	L.Mandible	E-5								2				
"	R.Mandible	E-5								2		3		
"	R.Maxilla	E-5										1		
"	L.Femur	E-5								10		11		
"	R.Femur	E-5								8		5		
"	R.Pelvis	E-5								1		2		
"	Sacrum	E-5										2		
"	L.Mandible	F-5												2
"	R.Mandible	F-5											1	2
"	L.Tibia	F-5											5	4
"	R.Tibia	F-5											5	7
"	L.Pelvis	F-5											2	4
"	R.Pelvis	F-5											2	2
"	L.Femur	F-6							5				1	
"	R.Femur	F-6							1				3	
"	L.Tibia	F-6											1	
"	R.Tibia	F-6											1	
"	R.Humerus	F-6										1		
"	L.Pelvis	F-6										1		
"	R.Pelvis	F-6										1		
"	L.Pelvis	F-8				1								
"	L.Mandible	G-5									1			
"	R.Mandible	G-5									1			
"	L.Maxilla	G-5									1			
"	R.Maxilla	G-5									1			
"	L.Femur	G-5									2			
"	L.Humerus	G-5									1			
"	R.Pelvis	G-5									2			

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TABLE 3. (Cont.)

Species	Bone	Grid	0-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42-48"	48-54"	54-60"	60-66"	66-72"
"	R. Femur	H-4					1							
"	L. Femur	H-5									1			
"	R. Fem	H-5									3			
"	L. Tibia	H-5									1			
"	R. Tibia	H-5									2			
SMI-261A														
<i>P. maniculatus</i>	L. Mandible	TP1	18	1										
"	R. Mandible	TP1	12											
"	L. Femur	TP1	12											
"	R. Femur	TP1	6											
"	L. Tibia	TP1	19											
"	R. Tibia	TP1	16											
"	L. Pelvis	TP1	1	2										
"	R. Pelvis	TP1	2											
<i>P. nesodytes</i>	L. Mandible	TP1	1	5								10		
"	R. Mandible	TP1	1	5								5		
"	R. Maxilla	TP1		2	4							2		
"	R. Femur	TP1	2											
"	L. Tibia	TP1	1											
"	R. Tibia	TP1	3											
"	L. Humerus	TP1	2											
"	R. Humerus	TP1	2											
"	L. Ulna	TP1		2										
"	R. Ulna	TP1		2										
"	L. Pelvis	TP1	4											
"	R. Pelvis	TP1	4											
"	Sacrum	TP1	1											

Abbreviations: L. = left; R. = right; TP1 = Test pit 1.

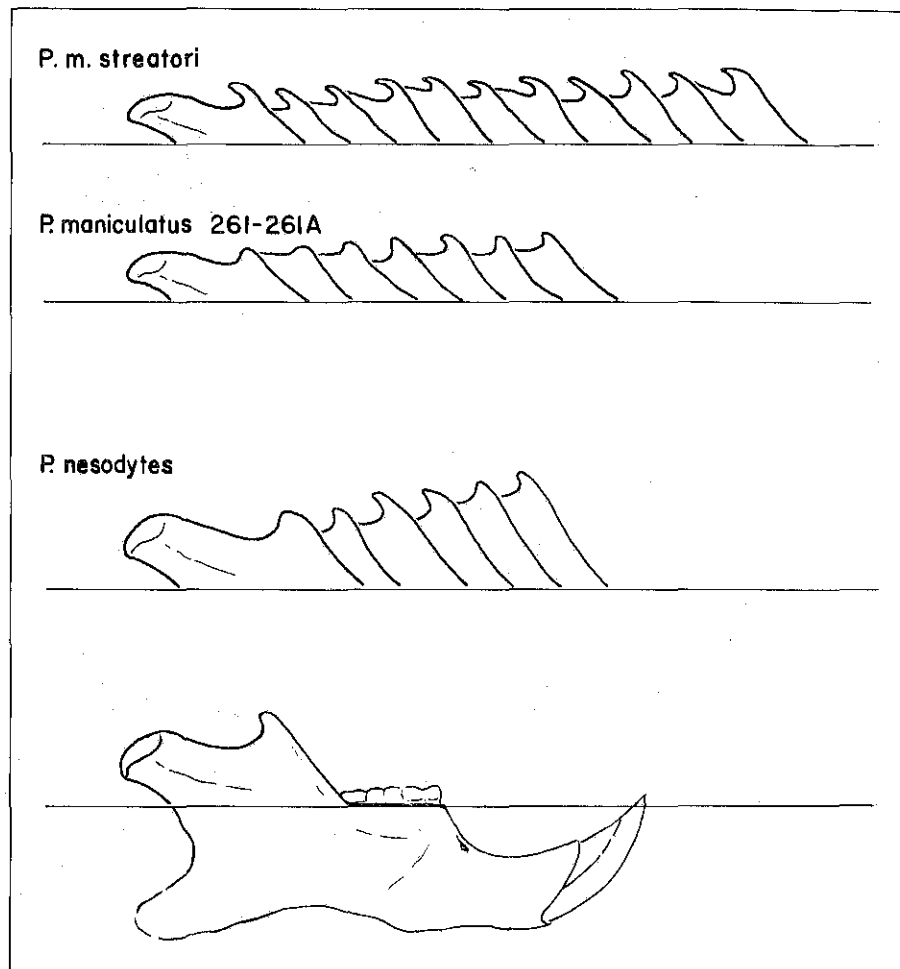


FIGURE 3. Lateral view of coronoid processes of *Peromyscus* from San Miguel Island. The upper three figures show series of processes arranged from lowest to highest—mandibles are oriented parallel to the superior edge of the alveolus (see bottom figure).

zygomatic arch. These experiments suggest the possibility that the morphological differences observed in the jaws of deer mice from San Miguel Island are the result of dietary rather than genetic factors.

#### Habitat Preferences

*P. m. streator* is morphologically (Nelson and Goldman 1931) and biochemically (Gill 1976) distinct from other Channel Island races of *Peromyscus*. Presumably, this subspecies of deer mouse has been isolated on San Miguel Island for a considerable period of time. From data on post-Pleistocene sea-level changes and bathymetric readings of the San Miguel passage, it can be inferred that San Miguel Island has existed as a discrete geographical unit for about ten thousand years (Orr 1967). Recent landscape evolution on the island has been characterized by

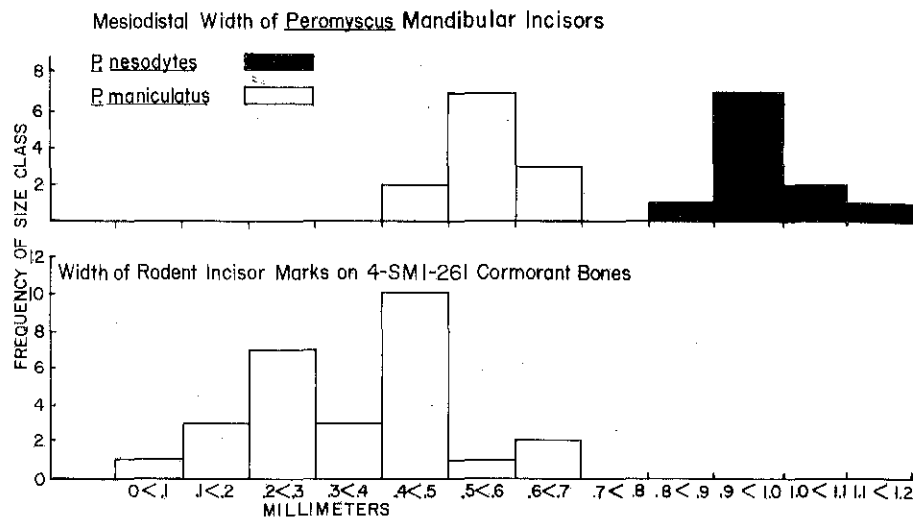


FIGURE 4. Illustration comparing width of rodent incisor marks on bird bones and mesiodistal diameters of *Peromyscus* mandibular incisors.

overgrazing and large-scale wind and water erosion. This modern episode of catastrophic vegetation stripping began when sheep overgrazed the island during a severe drought in the 1860s (Johnson 1972, 1980). The extinction of *P. nesodytes* may have resulted from the loss of habitat associated with this recent transformation of much of the island into defoliated sand dunes. The occurrence of *P. nesodytes* and *P. maniculatus* in the same archaeological sites is circumstantial evidence that these species lived on the island contemporaneously. It cannot be assumed that both species occupied coastal habitats in the vicinity of the archaeological sites since *Peromyscus* bones could have been transported from the interior of the island by owls. Occupancy of the SMI-261 cave by deer mice is indicated by incisor marks on gnawed bird bones from this deposit. Polyvinyl alcohol surface replicas (Walker 1976, Walker and Long 1977) were used to examine these bones microscopically. Many of the grooves on the gnawed bones have diameters that fall within the range of variation of *P. maniculatus* incisor widths (Fig. 4). The inference that prehistoric *P. maniculatus* occupied coastal habitats in the vicinity of SMI-261 is consistent with reports that modern *P. m. streatori* occur at highest densities in coastal areas (Gill 1976, D. Johnson, pers. comm.).

#### *Sorex ornatus* (Ornate Shrew)

A damaged *Sorex* cranium is present in the faunal remains from SMI-261A (Test pit 1, 6 to 12-inch level). The only shrew previously reported from the Channel Islands is a single specimen discovered on Santa Catalina Island in 1941 and originally described by von Bloeker (1941) as a new species, *Sorex willetti*. Von Bloeker (1967) subsequently demoted the specimen to subspecific status (*i.e.*, *Sorex ornatus willetti*). *S. o. willetti* differs from mainland races in its slightly larger size, longer cranium, and darker pelage (von Bloeker 1967). Comparisons of cranial measurements of the *S. o. willetti* type specimen, *S. ornatus* specimens from mainland localities, and the SMI-261A cranium (Table 4) indicate that the SMI-261A specimen and the Santa Catalina Island shrew both have larger cranial dimensions than shrews from the mainland. It is possible that the SMI-261A specimen represents a race of San Miguel Island shrews.

TABLE 4. Cranial dimensions of *Sorex ornatus* from the Santa Barbara Channel area.

Species	Locality	n	Molar length	Interorbital breadth	Maxillary breadth
<i>Sorex ornatus willetti</i> *	Santa Catalina Island	1	4.00	3.40	4.30
<i>Sorex ornatus cf. willetti</i>	San Miguel Island	1	3.80	3.50	4.80
			$\bar{X}$ S.D.	$\bar{X}$ S.D.	$\bar{X}$ S.D.
<i>Sorex ornatus</i> *	Mainland	5	3.71 0.17	3.07 0.21	3.90 0.51

\* Los Angeles County Museum of Natural History (LACM) specimens.

An alternative explanation is that the SMI-261A *Sorex* was captured on the mainland by a raptorial bird that subsequently roosted at the island site. This possibility is suggested by the presence of barn owl remains in the excavation unit containing the shrew cranium (Guthrie 1980) and by reports of mainland rodent species in owl pellets discovered in a cave on one of Los Coronados Islands, situated approximately eight miles (13 km) from the mainland (Banks 1965). Arguing against transportation by owls is the relatively great distance, 30 miles (48 km), between the Santa Barbara mainland and San Miguel Island.

#### *Spilogale gracilis* (Western Spotted Skunk)

Test pit 1 at SMI-261A contained a fragmentary cranium (6 to 12-inch level) and a complete right femur (zero to 6-inch level) from *Spilogale gracilis*. Western spotted skunks do not inhabit the island at present and have not previously been reported from either archaeological or paleontological contexts on San Miguel Island. The only other record of skunks on San Miguel Island is in the unpublished field notes of C. D. Voy, who visited the island sometime around 1893 (Johnson 1972). Voy reported that a small species of skunk was caught in a trap some years prior to his visit.

Cranial dimensions of the San Miguel Island specimen are small compared with those of *S. gracilis amphialus* from the other Channel Islands (Table 5). For most dimensions, the San Miguel Island spotted skunk falls outside the range of variation of the female Santa Cruz Island and Santa Rosa Island spotted skunks measured by van Gelder (1959). If this specimen is not a recently extinct endemic form, its relatively small dimensions suggest affinities with *S. g. phenax* on the mainland rather than with the larger *S. g. amphialus* subspecies from the Channel Islands.

Large abscesses perforate the frontal sinuses of the San Miguel Island spotted skunk cranium. Lesions of this sort result from infection by metastrongylid sinus worms of the genus *Skrjabinogylus* (Hill 1939, Duncan 1976). Similar frontal sinus abscesses are present on almost all the available prehistoric and recent *S. g. amphialus* crania from the Channel Islands (Walker and Collins in prep.).

The western spotted skunk femur from SMI-261A has a maximum length of 43.5 mm. This dimension is close to the mean length of 14 right femora I recovered from a dry cistern on Santa Cruz Island ( $\bar{X} = 43.07$ ,  $S.D. = 2.74$ , range = 38.21-47.79 mm).

#### HUMANS AS DISPERSAL AGENTS

American Indians may have had an important role in transporting animals to the Channel Islands. The historic Chumash Indians living in the Santa Barbara Channel area possessed a specialized maritime economy that involved the trade of natural resources and manufactured goods among villages on the Northern Channel Islands and on the mainland (King 1971, Hudson, Timbrook, and Rempe 1978). Descriptions of historic Chumash canoe trips suggest numerous occasions for the inadvertent dispersal of small animals across the channel: "When going to sea to trade, they make ready all that they will need. Four men begin by going to the place where *tomol* (plank canoe) is stored, situated in much tule and removing the boat. They keep it there shaded and in water so that the tarring does not get soft and the boards will not shrink if they should get dry" (informant cited in Hudson, Timbrook, and Rempe 1978:131). Ornate shrews inhabit coastal and inland marshes (Hall and Kelson 1959) and could have boarded canoes stored in these habitats. Contrary to popular belief, shrews are capable of fasting (Hamilton 1930) and could easily survive the half-day canoe trip across the channel (Hudson, Timbrook, and Rempe 1978).

Beached canoes would have been attractive to deer mice as nesting places and sources of food. Indians living on the Santa Barbara mainland traded seeds, acorns, and chia to people on

TABLE 5. Cranial dimensions of western spotted skunks (*Spilogale gracilis*) from the Northern Channel Islands and Los Angeles County.

Cranial dimension*	Origin of specimen	Sex	n	Measurement	
				or mean	S.D.
Interorbital breadth	San Miguel Island: SMI-261	U	1	13.90	—
		Santa Rosa Island†	M	20	16.53
	F		8	15.19	0.50
	Santa Cruz Island	M	4	16.34	0.79
		F	2	15.51	0.08
	Los Angeles Co.†	M	7	15.68	0.45
		F	8	13.69	0.68
	Postorbital breadth	San Miguel Island: SMI-261	U	1	15.20‡
Santa Rosa Island†			M	20	16.60
		F	7	15.89	0.63
Santa Cruz Island		M	4	15.94	0.69
		F	2	15.60	0.04
Los Angeles Co.†		M	7	16.11	0.63
		F	8	14.69	1.01
Palatal length		San Miguel Island: SMI-261	U	1	19.70
	Santa Rosa Island†		M	22	21.66
		F	8	19.81	0.62
	Santa Cruz Island	M	4	20.67	0.70
		F	2	20.05	0.56
	Los Angeles Co.†	M	7	21.32	0.45
		F	8	18.88	0.37
	Height of cranium	San Miguel Island: SMI-261	U	1	15.50
Santa Rosa Island†			M	21	18.27
		F	7	17.18	0.35
Santa Cruz Island		M	4	17.36	0.41
		F	2	17.60	0.52
Los Angeles Co.†		M	6	17.42	0.69
		F	7	16.69	0.72
Length of molar row		San Miguel Island: SMI-261	U	1	16.90
	Santa Rosa Island†		M	22	18.59
		F	8	17.63	0.47
	Santa Cruz Island	M	4	18.12	0.52
		F	2	17.58	0.31
	Los Angeles Co.†	M	7	18.61	0.38
		F	8	17.06	0.66

Abbreviations: U = unknown; M = male; F = female.

† Measurements were made according to the definitions of van Gelder (1959).

\* Data from van Gelder (1959).

‡ Measurement estimated.



the islands in exchange for items such as fish, shell beads, and abalone shell (King 1971, Hudson, Timbrook, and Rempe 1978). Considering the nesting and feeding opportunities provided by the plant foods traded to the islands, it is probable that *Peromyscus* occasionally crossed the Santa Barbara Channel secreted in baskets of cargo.

### CONCLUSIONS

The substantial quantity of *P. nesodytes* bone in the SMI-261 and SMI-261A middens is convincing evidence that this species survived on San Miguel Island at least until approximately 2,000 years ago. Deer mice have been trapped extensively on the island during the past few years and there is little doubt that *P. nesodytes* is extinct. It is conceivable that the extinction of *P. nesodytes* was caused by changes American Indians produced in San Miguel Island's floral and/or faunal communities. It is more likely, however, that *P. nesodytes* became extinct due to recent, large-scale habitat destruction caused by wind erosion, water erosion, and overgrazing (Johnson 1980).

The evidence for the presence of *Sorex* and *Spilogale* populations on the island is equivocal. In the absence of additional specimens, it remains possible that the *Sorex* and *Spilogale* bones from SMI-261A represent isolated individuals that reached San Miguel Island with the aid of humans, or by some other means.

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