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Subfossil remains of *Peromyscus stirtoni* (Mammalia: Rodentia) from Costa Rica

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Abstract: Preliminary sampling of near-surface sediments from Caverna Ojos Verdes, Barra Honda National Park, Costa Rica, yielded remains of the white-footed mouse, *Peromyscus stirtoni,* which was not reported previously from this country. Remains of other animals recovered from the cave sediments include fish, amphibians, reptiles, birds, and fourteen taxa of mammals. The mammalian fauna is dominated by forest species. The environment which existed when the remains of these animals were deposited in the cavern was probably dry tropical forest, similar to that which occurs on Cerro Barra Honda today. Actual age of the sediments in unknown, but tiny fragments of pottery in some levels suggests middle to late Holocene. The occurrence of *P. stirtoni* probably represents a pre-Columbian distribution in a dry forest habitat which has since been mostly lost due to clear-cutting for agriculture.

Caverna Ojos Verdes is a solution cavern in the Tertiary Barra Honda Limestone. It caps the 400+ meter high Cerro Barra Honda in Barra Honda National Park on the Nicoya Peninsula, Guanacaste Province, Costa Rica. Surface and near-surface sediments in this cave were sampled in June 1985 to test for the presence of fossil animal remains. Microvertebrates, especially small mammals, have proven to be sensitive indicators of climatic and vegetational changes (*e.g.,* Lundelius *et. al.* 1983), and remains of these animals were sought to provide information about the poorly known development of the flora and fauna of northwestern Costa Rica.

COLLECTION METHODS

Surface accumulations of bone in Caverna Ojos Verdes were collected in the east and west chambers of the cave (Figure 1.). In addition, two test excavations were made to determine the presence of bone in the cave sediments. One of these (Test Excavation A – Figure 1), in the south corner of the central chamber, was a 50 x 50 cm square excavated in six nine–cm levels to a depth of approximately 55 cm. Each of these levels was assigned a number in sequence, with level 1 being the closest to the surface. A second area, below a surface accumulation of bone in the east chamber (Test Excavation B Figure 1), was excavated to a depth of 10 cm. The bottom of the deposit was not reached in either site. The exact age of the sediments sampled is unknown, but is probably middle to later Holocene, based on the shallow depth of burial and the presence of tiny fragments of pottery in some levels.

Samples were washed twice through 1.5 mm screen to remove the sediment matrix following techniques outlined by Hibbard (1949). After drying, the residue was picked for vertebrate remains. Some remains were treated by soaking for six to twelve hours in 5 % glacial acetic acid to remove calcium carbonate coatings. Mammal remains were identified using comparative specimens from the collection of modern mammals in the University of Kansas Museum of Natural History.

PEROMYSCUS REMAINS

Identification of the *Peromyscus* remains is based on length and width measurements and

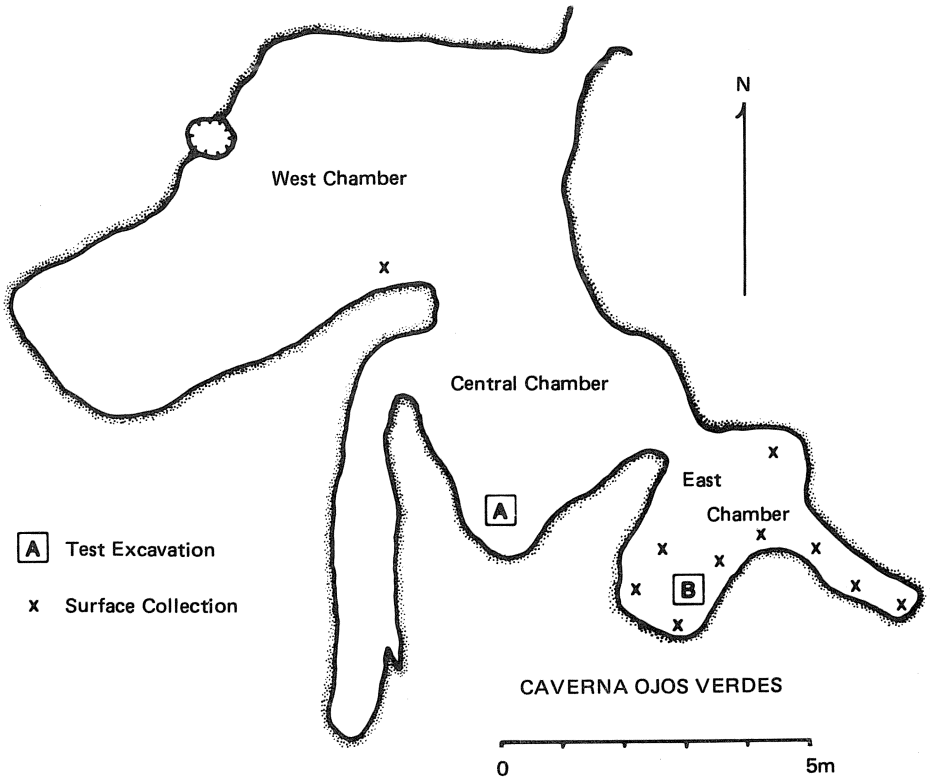

Fig. 1. Plan view of Caverna Ojos Verdes locating Test Excavations A and B, and areas where surface collections of bone were made (after National Speleological Society, 1982).

tooth morphology. Specimens of four species from Costa Rica and Nicaragua were used for comparison: *P. gymnotis* (24 specimens from Granada Department, Nicaragua), *P. mexicanus* (24 specimens from Matagalpa Department, Nicaragua), *P. nudipes* (two groups: 24 specimens from Cartago Province and 17 specimens from San José Province, Costa Rica), and *P. stirtoni* (4 specimens from Boaca, Managua, and Matagalpa departments, Nicaragua).

It must be noted that the systematics of Costa Rican *Peromyscus* is not well understood. Hall (1981) gives both *P. mexicanus* and *P. nudipes* as occurring in Costa Rica. Huckaby (1980) synonymizes *P. nudipes* with *P. mexicanus.* McPherson (1985) shows only *P. nudipes* in Costa Rica, suggesting that the southern range limit of *P. mexicanus* is in Nicaragua. R. M. Timm (pers. comm. 1987) suggests that as many as three species of *Peromyscus* (*P. gymnotis, P. mexicanus,* and *P. nudipes*) may occur in Costa Rica, but that the limits of their ranges are not well defined. I have attempted to avoid systematic problems by using specimens of *P. mexicanus* from Nicaragua and by using two populations of *P. nudipes* from Costa Rica. The specimens of *P. nudipes* from Cartago were originally identified in the collections of the University of Kansas Museum of Natural History as *P. mexicanus saxatilis,* and those from San José were identified as *P. nudipes nudipes.* It should be noted that there is a clear difference in size between the molars of these two groups (Figures 2 and 3).

A left first upper molar (LM1) and right lower second molar (Rm2) of *Peromyscus stirtoni* were encountered in sediments from 35 to 45 cm below the surface of the cave (level 5). Molars of *P. stirtoni* are much smaller than those of the other three species of *Peromyscus* (Figures 2 and 3). They are morphologically distinct as well. A weakly developed anteroloph and mesoloph characterize the upper first molars of *P. stirtoni,* while in the other *Peromyscus*

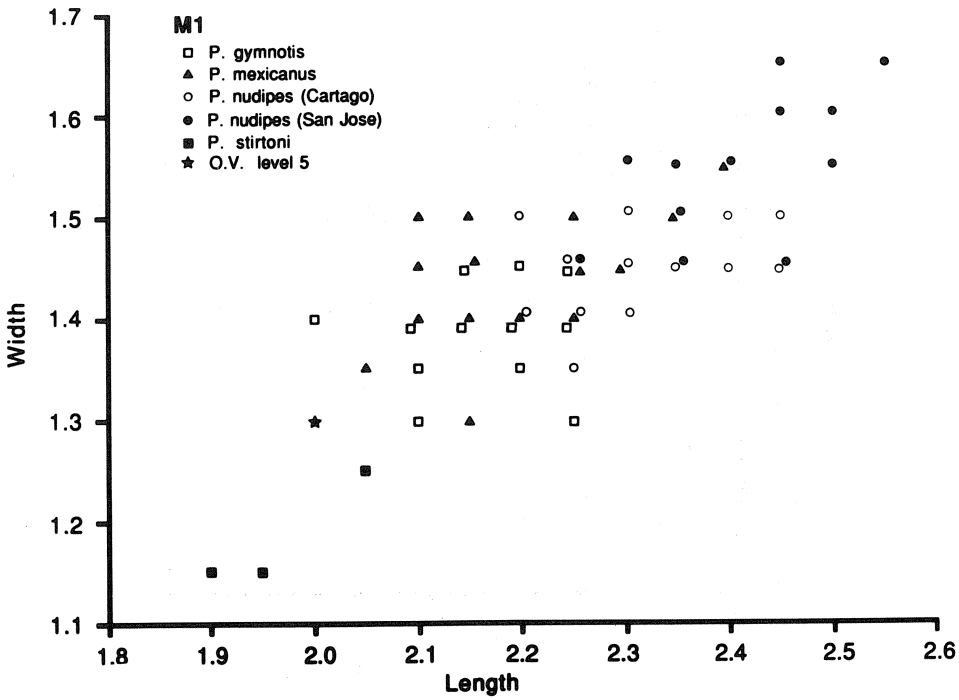

Fig. 2. Graph of length vs. width measurements of upper first molars (Ml) of four modern species of *Peromyscus* and specimen from level 5 in Caverna Ojos Verdes. Modern specimens of the same size and from the same species are represented by only one plot.

studied these lophs are normally very strongly developed. An anteromedian flexus varies from absent to very strongly developed in recent specimens of all four species. The LM1 from Caverna Ojos Verdes possesses a poorly developed anteroloph and mesoloph as in *P. stirtoni.*

Lower second molars of *P. gymnotis, P. mexicanus,* and *P. nudipes* normally possess a moderate to well developed mesolophid or entolophulid in the main lingual valley. In the four specimens of *P. stirtoni,* all such structures were absent. The Rm2 from Ojos Verdes has a fine, weakly developed entolophulid which would appear to equivocate its identification as *P. stirtoni.* The small size of the specimen, however, precludes its belonging to any of the other three species (Figure 3), and the sample size of modern *P. stirtoni* is insufficient to discount the development of all accessory cuspids and lophids in this species.

Peromyscus stirtoni is the only small mammal in the fauna from Ojos Verdes which is not presently known from Costa Rica. The current range of *P. stirtoni* is from southern Guatemala and eastern El Salvador to west–central Nicaragua, where it occurs in dry lowland forests and brush (Jones and Yates 1983). It is possible that this mouse may occur in northern Guanacaste Province, Costa Rica, but it has yet to be reported there. Alternatively, the ramains from Ojos Verdes may reflect a former, pre–Columbian range from which the white–footed mouse has been excluded by clear–cutting of forests and the introduction of agriculture.

In addition to the remains identified as *P. stirtoni* from level 5, a single left lower second molar (Lm2) of *Peromyscus* was discovered in level 2 of Test Excavation A. This specimen is the same size as Lm2s of modern *P. gymnotis, P. mexicanus.* and *P. nudipes* from Cartago Province (Figure 3). The subfossil molar is too large for *P. stirtoni* and possesses a strong mesolophid/entolophulid, characteristic of *P. gymnotis, P. mexicanus,* and *P. nudipes.* The molar probably belongs to one of these three species, but is too small for the *P. nudipes* from San José Province.

Peromyscus gymnotis inhabits dry deciduous forests, semievergreen forests, and secondary

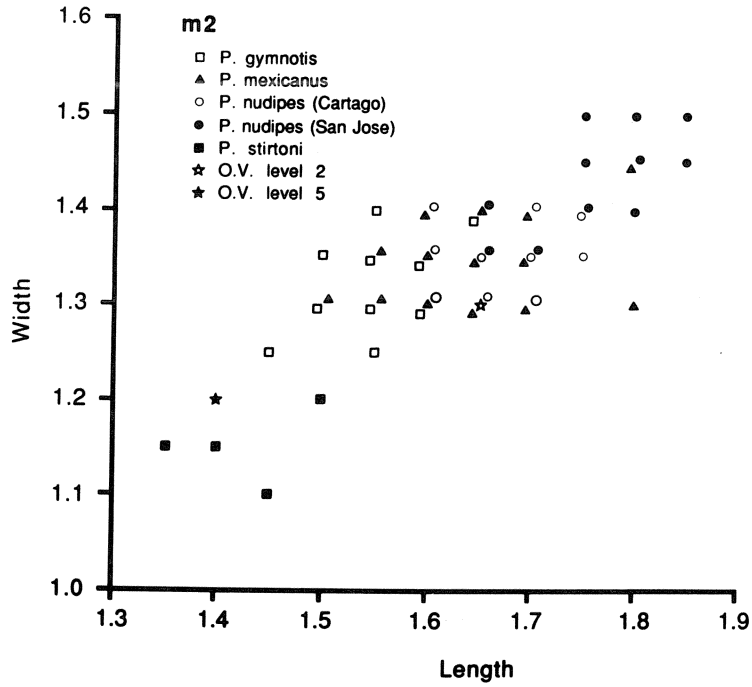

Fig. 3. Graph of length vs. width measurements of lower second molars (m^2) of four modern species of *Peromyscus* and two specimens from levels 2 and 5 in Caverna Ojos Verdes. Modern specimens of the same size and from the same species are represented by only one plot.

growth in lowlands along the Pacific Coast of Central Americ from Chiapas, Mexico, to southern Rivas Department, Nicaragua (Jones and Yates 1983). Considering the dry, tropical forest animals with which the remains occur in Ojos Verdes, it is likely that the tooth from level 2 represents *P. gymnotis.* However, specimens of *P. nudipes,* a humid forest animal, were taken from the 500 +m high Cerros de San Juan on the Nicoya Peninsula (Harris 1943) in vegetation which may be similar to that on Cerro Barra Honda and the nearby 500+ m high Cerro Corralito. This mouse may exist or may have existed near Ojos Verdes in association with dry forest animals.

Peromyscus mexicanus, normally an inhabitant of middle and high elevation forests, is the least likely identification for the Lm2 from level 2. It is known as far south in the Central Cordillera as Boaca Department, Nicaragua, and occurs on isolated volcanoes on Ometepe Island in Lake Nicaragua (Jones and Yates 1983).

ASSOCIATED FAUNA

Animal whose remains occur with those of *Peromyscus* in Caverna Ojos Verdes include *Didelphis sp., Dasypus novemcinctus, Liomys salvini, Ototylomys phyllotis, Reithrodontomys* sp., *Sigmodon hispidus, Coendou mexicanus,* and unidentified remains of bats, birds, amphibians, reptiles, and fish. A list of the vertebrates recovered from Caverna Ojos Verdes is given in Table 1. The minimum number of individuals (MNI) for each taxon was calculated for the entire site and separately for each level (Table 1) by determining the smallest number of individual animals which could be represented by the identified remains. This is determined by counting the most abundant single element for each taxon, for example, right tibias or LM1s.

While the mammalian fauna of Barra Honda has not been thoroughly studied, most of the mammals recovered from Ojos Verdes are known in the modern fauna of Guanacaste and the Nicoya Peninsula (McPherson 1985, Wilson 1983), and they are probably present in Barra

TABLE 1

Minimum numbers of individuals (MNI) of species recovered from Caverna de Ojos Verdes, Parque Nacional Barra Honda, Costa Rica, in June 1985. MNI was calculated both for each excavation level and for the entire site

Taxon	Surface Collection	Test Excavations A 1	2	3	4	5	6	B	MNI by Level	Site MNI
Osteichthyes					1				1	1
Amphibia & Reptilia		X	X	X	X	X	X	X	X	X
Aves						1		1	2	1
Mammalia										
Didelphis sp.			1						1	1
Chiroptera			X	X	X	X	X	X	X	X
Micronycteris schmidtorum	1								1	1
Dasypus novemcinctus							1		1	1
Liomys salvini		1	1	2	1	1	2	1	9	2
Ototylomys phyllotis		1	1	1	1		3	2	9	6
Reithrodontomys sp.							1		1	1
Peromyscus sp.			1						1	1
P. stirtoni						1			1	1
Sigmodon hispidus		1	3	1	2	1	2	1	11	6
Rattus sp.	1								1	1
Coendou mexicanus	1	1						1	3	2
Agouti paca	2								2	2
Dasyprocta punctata								1	1	1
Dicotyles tajacu							1		1	1
TOTAL									46	27

X – MNI not calculated for this taxon

Honda National Park or its immediate surroundings. One exception to this is the genus *Reithrodontomys,* represented in Caverna Ojos Verdes by a single, small, distinctively grooved upper incisor from sediments between 50 and 55 cm below the cave surface (level 6). The modern distribution of *Reithrodontomys* in Costa Rica is poorly understood, and presently the genus is represented in northwestern Costa Rica by a single specimen of *R. gracilis* from a cloud forest locality at 975 m about 70 km north of Barra Honda (Hall 1981:649; Harris 1943). I have also recovered remains of *R. gracilis* from modern owl pellets in the Dr. Rafael Lucas Rodríquez Caballero (Palo Verde) Wildlife Refuge (Woodman, manuscript). The specimen from Caverna Ojos Verdes indicates that *Reithrodontomys* occurred on or near Cerro Barra Honda in the past, and it may still survive there.

Other subfossil occurrences of extirpated mammals in Guanacaste were reported by Grady (1982), who discovered remains of *Marmosa mexicana* in Chorotega Cave on Cerro Barra Honda and remains of *Orthogeomys* sp. from Skull Cave near the town of Nicoya, less than 10 km west of Barra Honda. Both were surface or near-surface finds associated with pottery (McGrosky 1982), yet neither animal is presently known from the Nicoya Peninsula of Costa Rica.

The mammalian fauna of Ojos Verdes is dominated by forest-dwelling species, especially of the dry lowlands. The presence of *Liomys salvini, Ototylomys phyllotis,* and *Peromyscus*

stirtoni indicates that the local vegetation was predominantly dry, lowland tropical forest. Remains of *Sigmodon hispidus* testify to the presence of some open areas. Studies of barn owl pellet accumulations from the Rodríquez Caballero Refuge, a modern environment similar to that at Barra Honda, show a clear dominance of *Sigmodon hispidus* over all other taxa, including *Liomys salvini* and *Ototylomys phyllotis* (Vaughan and McCoy 1982; Woodman, manuscript). This in part reflects the abundance of open habitat in Palo Verde (Vaughan *et al.* 1982), the large population densities common to *Sigmodon hispidus* (Baker 1983), and the preference of the barn owl for hunting in open areas (Prestt and Wagstaffe 1984). In Ojos Verdes, the numbers of individuals of *Sigmodon, Liomys,* and *Ototylomys* are approximately equal. This suggests that the amount of open area relative to forest was less at the time that the remains accumulated. However, the habitat cannot be exactly reconstructed, in part because the means by which the remains accumulate in Caverna Ojos Verdes cannot be determined by these limited excavations.

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RESUMEN

En un muestreo preliminar de sedimentos superficiales de la Caverna Ojos Verdes, en el Parque Nacional Barra Honda, Costa Rica, aparecieron restos subfósiles del "ratón de patas blancas", *Peromyscus stirtoni,* el cual no ha sido informado anteriormente para este país. Otros animales representados por restos subfósiles en Caverna Ojos Verdes incluyen *Didelphis* sp. (zorro pelón), *Dasypus novemcinctus* (armadillo), *Liomys salvini* (ratón semiespinoso), *Ototylomys phyllotis* (rata arborícola), *Reithrodontomys* sp. (ratón de las cosechas), *Peromyscus* sp. (ratón de patas blancas), *Sigmodon hispidus* (rata algodonera), *Coendou mexicanum* (puercoespín), *Agouti paca* (Tepescuintle), *Dasyprocta punctata* (guatusa), *Dicotyles tajacu* (saíno), y restos no identificados de murciélagos, pájaros, reptiles, anfibios y peces. La fauna subfósil de mamíferos colectada en la caverna es dominada por especies del bosque. El ambiente existente cuando esta fauna se acumuló en la caverna fue bosque tropical seco, similar al que actualmente se encuentra en el Cerro Barra Honda. Aún cuando no fue posible obtener, mediante la técnica del radio-carbón, la edad de los sedimentos en donde fueron encontrados los restos, la presencia de pequeños fragmentos de cerámica en algunos niveles sugiere que pertenecen al Holoceno medio o tardío. La presencia de *P. stirtoni* probablemente refleja su distribución en el habitat de bosque seco en la época precolombina, que posteriormente fue modificada por efecto de la agricultura.

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