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MAMMALS OF THE COSIGÜINA PENINSULA OF NICARAGUA

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ABSTRACT: Nicaragua's Cosigüina Peninsula, located at the northwestern tip of the country, is one of the most poorly studied biotic regions in Central America. The peninsula has been occupied for millennia because the climate of the region supported human habitation and because of its strategic position along the rich Pacific coast. The combination of long-term occupancy by humans and the cataclysmic eruptions of Volcán Cosigüina have produced a heavily impacted landscape. During the 1960s, the University of Kansas conducted multiyear field surveys of the terrestrial mammals on the peninsula and the adjacent mainland to quantify species diversity, relationships, abundances, habitat use, and reproduction.

The mammalian fauna of the peninsula contains at least 39 species of terrestrial mammals, which includes 7 orders and 17 families. These include Didelphimorphia (2 species)—Didelphidae, 2; Chiroptera (22)—Emballonuridae, 2; Noctilionidae, 1; Mormoopidae, 1; Phyllostomidae, 12; Vespertilionidae, 3; Molossidae, 3; Carnivora (4)—Procyonidae, 1; Mustelidae, 1; Felidae, 2; Perissodactyla (1)—Tapiridae, 1; Artiodactyla (1)—Cervidae, 1; Rodentia (8)—Sciuridae, 1; Heteromyidae, 1; Muridae, 5; Dasyproctidae, 1; Lagomorpha (1)—Leporidae, 1. We provide new information on distributions, systematics, morphometrics, and natural history of the species of terrestrial mammals on the Cosigüina Peninsula, including a number of new records for the peninsula. We document that diversity and abundances of mammals can be substantial in a heavily impacted landscape. In comparison with five other mammalian faunas in Nicaragua, the Cosigüina fauna is most similar in size and diversity with those from elsewhere in the Pacific lowlands. The fauna from the Cordillera los Maribios, which is composed of the volcanic peaks along the eastern edge of the Pacific Lowlands, has the lowest number of species recorded for any of the six faunas with only 21 species recorded; however, this fauna may be under sampled or the unstable environments offered by these active volcanoes may not support a large or diverse mammalian fauna. The mammalian faunas from the remaining two physiographic regions of Nicaragua—Central Highlands and Atlantic Lowlands—have larger, more diverse faunas than that of the Cosigüina Peninsula and elsewhere in the Pacific lowlands. Three reserves in Nicaragua's Sistema Nacional de Áreas Protegidas now protect more than one-fourth of the peninsula.

Key words. Biogeography. Coefficients of similarity. Dry forest. Mammalia. Neotropics. Nicaragua.

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INTRODUCTION

The Cosigüina Peninsula lies on the extreme northwest of the Central American country of Nicaragua (**Fig. 1**). The Gulf of Fonseca to the east and northeast and the Pacific Ocean to the west and northwest form the peninsula. The peninsula is dominated by Volcán Cosigüina, a 872 m cone-shaped dormant volcano, which last erupted in 1859. Volcán Cosigüina is the northwesternmost of Nicaragua's series of northwest to southeast trending volcanoes near the Pacific coast. It is separated from its nearest neighbor Volcán San Cristobal by approximately 60 km of Pacific coastal lowlands. Galindo (1835) described in detail the last major explosive eruption of the volcano in 1835. The Cosigüina Peninsula is part of the Central American Pacific lowlands, much of which is classified as dry forest in the Holdridge Life Zone system (Holdridge 1967).

From a biological and conservation perspective, it has become increasingly important to determine the diversity and relationships of species occurring in an area, especially if the fauna is isolated geographically. Biological surveys form baseline data for comparing geographic similarity over regional areas, monitoring faunal composition over time, and monitoring environmental and catastrophic impacts on the fauna. These measures of diversity and community composition can be used in sustainable management, including the conservation of biodiversity by identifying species vulnerable to extirpation and contribute to the national protected-areas systems. Nicaragua's Cosigüina Peninsula is one of a number of physiographic areas in Central America that deserve detailed study to determine uniqueness of its mammalian fauna.

During the 1950s and 1960s, the University of Kansas conducted multiyear field surveys of the terrestrial mammals in Nicaragua to quantify species diversity, systematic relationships, abundances, habitat use, and natural history. To assess the amount of isolation of the mammals occurring on the Cosigüina Peninsula, field parties conducted research there in 1967 and 1968.

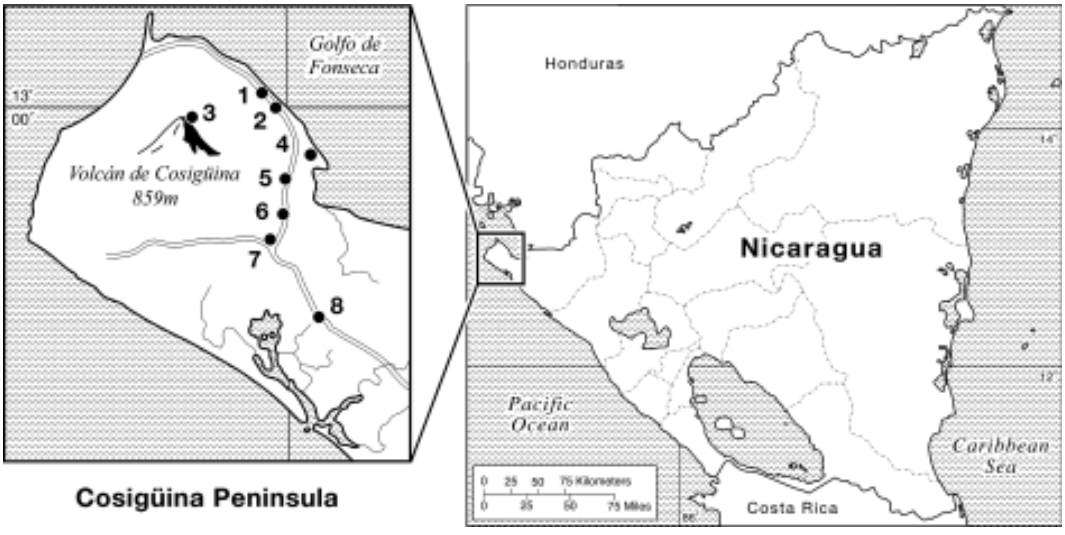

Fig. 1. Map of the Central American country of Nicaragua indicating the position of the Cosigüina Peninsula and our work sites on the peninsula. These sites are 1) Potosí, 5 m; 2) 1 km SE Potosí, 15 m; 3) slopes of Volcán Cosigüina; 4) 6 1/2 km N, 1 km E Cosigüina, 10 m; 5) 4 1/2 km N Cosigüina, 15 m; 6) El Paraíso, 1 km N Cosigüina, 20 m; 7) Hacienda Cosigüina; 8) 7 km S, 1 km E Cosigüina.

METHODS AND MATERIALS

Study area

The Cosigüina Peninsula lies in the Pacific lowlands of extreme northwestern Nicaragua's Provincia de Chinandega (ca. 12°55'N, 87°30'W). The first detailed description of the area was undertaken by B. W. Taylor (1963) as part of a United Nations assistance program. Taylor classified the peninsula as occurring in the Pacific physiographic region of Nicaragua, with two other regions being recognized—Central Highland Region and Atlantic Region. Today, we consider this area part of the Pacific lowland tropical dry forest, the most endangered forest type in all of Central America. The original vegetation of the peninsula was "Semi-evergreen Rain Forest" according to Taylor (1963), but no significant primary stands of this vegetation type remain in Nicaragua. Taylor (1963:50-51) described the successional communities on the peninsula as:

> Around Vulcan Cosiguena the vegetation now includes open pastureland, bushland scrub and low woodland, with some forest communities on low-lying sites, and there are fairly extensive areas of derived savanna. It is apparent that scrub, dominated by *Lippia cardiostegia* Benth., 3 m in height, would cover most of the coarse sand deposits if fire and grazing were prevented, but much of this area is now covered by a low bushland, less than 1 m in height, with *Hyptis suaveolens* […] and *Baltimora recta* […] dominant and with *Sida acuta* [...], *S. spinosa* [...], *Waltheria americana* and *Lantana camara* common. In places this bushland is replaced by a mixed pasture sward with *Eragrostis ciliaris*, *Oplismenus burmanii* […] and *Andropogon brevifolius* the most common species.
>
> In small areas where there has been some accumulation of finer material a low woodland occurs, 5–8 m in height with the most common trees being *Karwinskia calderonii* […] *Stemmadenia obovata* […], *Pithecolobium dulce*, *Acacia farnesiana*, *Pisonia macranthocarpa* […], *Tecoma stans* and *Achatocarpus nigricans* […]; but more usually this is replaced by a derived savanna with *Coccoloba floribunda* and *Pithecolobium dulce* abundant in the tree layer. Forests occur in areas where there has been a considerable accumulation of fine material washed from higher slopes, coupled with a supply of sub-surface water. Mostly these forests are 15–20 m in height and of mixed composition with *Lysiloma seemanni*, *L. kellermannii*, *Bursera simaruba*, *Gyrocarpus americanus*, *Cecropia peltata*, *Sapium thelocarpum*, *Bombacopsis quinatum* and *Caesalpinia eriostachys* common. In areas with short seasonal flooding the forests are taller with *Guarea excelsa* and *Enterolobium cyclocarpum* abundant in the upper layer.

The area around Potosí, where much of our fieldwork was concentrated, was *Acacia* woodland where the tallest trees were about 10 m. A small area of mangrove swampland, primarily red mangrove (*Rhizophora*), borders the Gulf of Fonseca, where some of the edge trees may exceed 20 m because of the additional moisture available. The surface geology of the peninsula consists primarily of young soils of recent volcanic origin that are subject to heavy, intermittent leaching. The soils of the basal region of the peninsula are primarily alluvial. The volcanic ash and sand soils on the peninsula can be loose in places to the depth of one-third m. The resulting dust covers nearly all of the vegetation during the dry season. As is typical for the Pacific lowlands of Central America, the climate is strongly seasonal, with a significant, harsh dry season. Rainfall averages 1500 to 2000 mm, with six dry months between November and April.

Techniques

Trapping for small mammals was conducted using Sherman live traps and snap-type traps. Medium-sized and large mammals were obtained with the use of 16 gauge shotguns. Bats were collected with mist nets set over bodies of water and across other flyways. All specimens were prepared in the field as skins with skulls, skulls only, or preserved in fluid. Each individual was examined for ectoparasites, which were preserved in 70% ethanol. All mammalian specimens (**Table 1**) obtained during this research are deposited in the Natural History Museum, University of Kansas, Lawrence (KU). One additional specimen deposited in the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley, was examined in this study.

Measurements

Cranial measurements for all specimens except the tapir were taken with digital calipers accurate to 0.1 mm; the tapir was measured with calipers accurate to 1.0 mm. All measurements given in the species accounts are in mm unless otherwise noted. All weights are in grams. Cranial measurements of bats are given in the following sequence: greatest length of skull (including incisors), condylobasal length, zygomatic breadth, postorbital constriction, mastoid breadth, length of maxillary toothrow, and breadth across upper molars. Cranial measurements of rodents are given in the following order: greatest length of skull, condylobasal length, zygomatic breadth, interorbital constriction, mastoid breadth, length of nasals, palatal length, and length of maxillary toothrow. External measurements are those

Table 1

Summary of mammalian species found to be occurring on the Cosigüina Peninsula of Nicaragua and the sites where they were recorded.

Orders, families, and species	6 1/2 km N, 1 km E Cosigüina	4 1/2 km N Cosigüina	El Paraiso, 1 km N Cosigüina	Potosí	Other
Didelphimorphia					
Didelpidae					
Didelphis virginiana	+		+		
Philander opossum	+				
Chiroptera					
Emballonuridae					
Saccopteryx bilineata	+		+		
Saccopteryx leptura			+		
Noctilionidae					
Noctilio leporinus				+	
Mormoopidae					
Pteronotus parnellii	+				
Phyllostomidae					
Artibeus jamaicensis	+	+			
Artibeus phaeotis	+	+			
Carollia perspicillata		+		+	
Carollia subrufa	+	+		+	
Centurio senex		+			
Chiroderma villosum	+	+			
Desmodus rotundus		+			
Glossophaga soricina		+			
Platyrrhinus helleri	+	+		+	
Sturnira lilium	+	+		+	
Uroderma bilobatum	+	+			
Uroderma magnirostrum		+			
Vespertilionidae					
Eptesicus furinalis	+			+	
Myotis nigricans	+				
Rhogeessa tumida	+				
Molossidae					
Eumops bonariensis				+	
Molossus molossus				+	
Molossus rufus		+	+	+	
Carnivora					
Procyonidae					
Nasua narica			+		
Mustelidae					
Mephitis macroura			+		
Felidae					
Leopardus pardalis					+
Panthera onca					+
Perissodactyla					
Equidae					
Tapirus bairdii				+	
Artiodactyla					
Cervidae					
Odocoileus virginianus	+		+		+

(Table 1, cont.)

Orders, families, and species	6 1/2 km N, 1 km E Cosigüina	4 1/2 km N Cosigüina	El Paraiso, 1 km N Cosigüina	Potosí	Other
Rodentia					
Sciuridae					
Sciurus variegatoides	+	+	+	+	
Heteromyidae					
Liomys salvini		+	+		
Muridae					
Oligoryzomys fulvescens		+	+		
Oryzomys alfaroi		+			
Oryzomys couesi	+	+	+		
Ototylomys phyllotis			+		
Sigmodon hirsutus		+			
Dasyproctidae					
Dasyprocta punctata	+				
Lagomorpha					
Leporidae					
Sylvilagus floridanus			+		

recorded by the field collector and are presented in the following order: total length; length of tail; length of hind foot; length of ear from notch. All testis measurements are of greatest length and measurements of embryos are crown–rump.

The common name(s) for each species is listed in English and then in Spanish. Spanish names listed herein are those that are used within the Cosigüina Peninsula region of Nicaragua. As non-mammalogists cannot distinguish most of the many species of bats, there are few local common names in Spanish, other than murciélagos, for most bats. Hence, we have not included a Spanish name for most of the bats. The conservation status for species recognized in Nicaragua as in need of protection are those reported on Nicaragua's official list (MARENA, 1999).

Analyses

Similarity among Nicaraguan mammalian faunas were determined using Jaccard's coefficient of similarity calculated by

$$\text{Percent Similarity} = [a/(a + b + c)] \times 100 \quad [1]$$

where a = number of species in common between both faunas, b = number of species present only in the first fauna, and c = number of species present only in the second fauna (Dobson and Wright, 2000; Rahel, 2000, 2002; Lim and Engstrom, 2001; Olden and Poff, 2003). The percent similarity values were used to construct a table of similarities among the six mammalian faunas. The data for the other mammalian faunas from Nicaragua are based on material deposited in the Natural History Museum of the University of Kansas collected by the same field parties that worked on the Cosigüina Peninsula using the same techniques. These localities (**Table 2**) are—**Pacific Lowlands:** San Antonio combined with Hacienda San Isidro, Chinandega, and 13 km S, 14 km E of Finca Amayo combined with vicinity of San Juan del Sur, Rivas; **Cordillera los Maribios:** Hacienda Bellavista, Volcán Casita, Chinandega combined with 4 km WNW of Puerto Momotombo, Leon; **Central Highlands:** Finca Tepeyac, 10.5 km N, 9 km E of Matagalpa combined with Santa María de Ostuma, Matagalpa; and **Atlantic Lowlands**: vicinity of El Recreo, Atlántico Sur.

Table 2

Species composition of six mammalian faunas from Nicaragua used in computation of Jaccard's Coefficients of Similarity. The geographic origins of the faunas are detailed in the Methods and Materials.

Orders, families, and species	*Cosigüina Peninsula, Chinandega*	*Pacific Lowlands-Chinandega*	*Cordillera los Maribios*	*Pacific Lowlands-Rivas*	*Central Highlands*	*Atlantic Lowlands*
Didelphimorphia						
Didelphidae						
Caluromys derbianus		+	+	+	+	+
Chironectes minimus						+
Didelphis marsupialis		+			+	+
Didelphis virginiana	+	+	+	+	+	
Marmosa mexicana		+	+			
Philander opossum	+	+		+	+	+
Xenarthra						
Bradypodidae						
Bradypus variegatus					+	+
Megalonychidae						
Choloepus hoffmanni					+	+
Dasypodidae						
Dasypus novemcinctus				+	+	+
Myrmecophagidae						
Tamandua mexicana						+
Chiroptera						
Emballonuridae						
Rhynchonycteris naso						+
Saccopteryx bilineata	+			+		
Saccopteryx leptura	+					
Noctilionidae						
Noctilio albiventris				+		+
Noctilio leporinus	+			+		
Mormoopidae						
Pteronotus parnellii	+					+
Phyllostomidae						
Artibeus intermedius			+			
Artibeus jamaicensis	+	+	+	+	+	+
Artibeus lituratus				+	+	+
Artibeus phaeotis	+	+	+	+		
Artibeus toltecus					+	
Artibeus watsoni						+
Carollia sowelli					+	+
Carollia castanea						+
Carollia perspicillata	+	+	+	+	+	+
Carollia subrufa	+	+			+	
Centurio senex	+	+				+
Chiroderma villosum	+	+	+			
Choeroniscus godmani		+			+	
Chrotopterus auritus					+	
Desmodus rotundus	+	+		+	+	+
Glossophaga commissarisi		+		+	+	+
Glossophaga leachii				+		
Glossophaga soricina	+	+	+	+	+	+

(Table 2, cont.)

Orders, families, and species	*Cosigüina Peninsula, Chinandega*	*Pacific Lowlands-Chinandega*	*Cordillera los Maribios*	*Pacific Lowlands-Rivas*	*Central Highlands*	*Atlantic Lowlands*
Lichonycteris obscura						+
Macrophyllum macrophyllum				+		
Phyllostomus discolor		+	+	+		+
Phyllostomus hastatus						+
Platyrrhinus helleri	+		+		+	+
Sturnira lilium	+	+		+	+	+
Uroderma bilobatum	+	+		+		+
Uroderma magnirostrum	+	+				
Vampyressa nymphaea						+
Vampyrodes caraccioli						+
Vespertilionidae						
Eptesicus furinalis	+	+				
Myotis nigricans	+	+				
Rhogeessa tumida	+					
Natalidae						
Natalus stramineus						+
Molossidae						
Eumops bonariensis	+					
Molossus molossus	+					
Molossus rufus	+	+	+			
Molossus sinaloae				+		+
Primates						
Cebidae						
Alouatta palliata				+	+	
Ateles geoffroyi				+		+
Cebus capucinus			+			+
Carnivora						
Canidae						
Urocyon cinereoargenteus			+			
Procyonidae						
Bassaricyon gabbii					+	
Nasua narica	+					+
Potos flavus				+	+	+
Procyon lotor				+		
Mustelidae						
Conepatus mesoleucus			+			
Eira barbara						+
Lutra longicaudis						+
Mephitis macroura	+	+		+		
Mustela frenata					+	
Spilogale putorius		+	+			
Felidae						
Leopardus pardalis	+					
Panthera onca	+					
Perissodactyla						
Equidae						
Tapirus bairdii	+					+

(Table 2, cont.)

Orders, families, and species	Cosigüina Peninsula, Chinandega	Pacific Lowlands-Chinandega	Cordillera los Maribios	Pacific Lowlands-Rivas	Central Highlands	Atlantic Lowlands
Artiodactyla						
Cervidae						
Odocoileus virginianus	+					
Rodentia						
Sciuridae						
Sciurus deppei					+	
Sciurus richmondi						+
Sciurus variegatoides	+	+	+	+	+	+
Heteromyidae						
Heteromys desmarestianus					+	
Liomys salvini	+	+	+	+	+	
Muridae						
Baiomys musculus					+	
Melanomys caliginosus						+
Nyctomys sumichrasti		+	+		+	
Oligoryzomys fulvescens	+	+			+	+
Oryzomys alfaroi	+				+	+
Oryzomys couesi	+	+		+	+	+
Oryzomys dimidiatus						+
Oryzomys melanotis				+	+	
Ototylomys phyllotis	+	+	+		+	
Peromyscus gymnotis		+	+	+		
Peromyscus mexicanus					+	
Reithrodontomys brevirostris					+	
Reithrodontomys fulvescens				+		
Reithrodontomys gracilis		+				
Reithrodontomys mexicanus					+	
Reithrodontomys sumichrasti					+	
Sigmodon hirsutus	+	+		+	+	+
Erethizonidae						
Coendou mexicanus		+		+	+	
Dasyproctidae						
Dasyprocta punctata	+				+	+
Echimyidae						
Hoplomys gymnurus						+
Proechimys semispinosus						+
Lagomorpha						
Leporidae						
Sylvilagus brasiliensis				+	+	+
Sylvilagus floridanus	+			+		
Total species	39	34	21	35	43	50

RESULTS

SPECIES ACCOUNTS

Didelphis virginiana californica Bennett
Common opossum, Zarigüeya

Specimens examined (2) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114458); El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 114459).

Gardner (1973), in a systematic revision of the genus *Didelphis* in North and Middle America, studied all available specimens then known from Nicaragua including our two individuals from the Cosigüina Peninsula. He assigned the name *Didelphis virginiana californica* to the common opossums occurring from the central United States through Nicaragua. Wilson et al. (2002) subsequently reported that *D. v. californica* also occurs in northwestern Costa Rica. Two common opossums from the peninsula were collected on 4 March at localities having dense, low scrub vegetation. At El Paraíso, where *D. virginiana* was observed on several occasions and one obtained, a few tall scattered trees also were present. An adult male and a subadult female had the following external measurements, respectively: 870, 675; 418, 357; 70, 58; 60, 48. Cranial measurements of the adult male are: greatest length of skull, 126.2; condylobasal length, 120.8; zygomatic breadth, 65.3; interorbital breadth, 26.6; length of nasals, 54.3. The dentition of the male was complete, whereas M4 and p3 of the female were just erupting and the basisphenoid suture not ossified. A third *Didelphis* was obtained on 3 March at El Paraíso and subsequently discarded. Genoways recorded in his field notes that "*Didelphis* was commonly seen on the peninsula" (8 March 1968).

Philander opossum fuscogriseus (J.A. Allen)
Gray four-eyed opossum, Zarigüeya ocelada

Specimen examined (1) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114492).

The only representative of the gray four-eyed opossum known from the peninsula is a subadult male captured in a trap baited with the body of a squirrel on 6 March near a stream coming from hot springs surrounded by dense, low scrub vegetation. This male weighed 411.5 g and had testes that measured 19 mm in length. There are no signs of molt. External measurements are 525, 276, 39, 33. Cranial measurements are as follows: greatest length of skull, 68.1; condylobasal length, 67.4; zygomatic breadth, 35.5; interorbital breadth, 11.5; length of nasals, 31.7. We follow Hall (1981) in assigning all gray four-eyed opossums from Nicaragua to the subspecies *P. o. fuscogriseus*, which was originally described from Greytown in the southeastern part of the country.

Saccopteryx bilineata (Temminck)

Specimens examined (2) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114632); El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 114633).

An adult female and a young adult male were collected in the vicinity of Cosigüina. The male, obtained on 1 March, weighed 7.4 g and had testes 2 mm in length. The female was taken on 5 March and weighed 6.8 g. There is no molt evident in either specimen. Length of forearm and cranial measurements of the male and female, respectively, are: 43.1, 45.4; 15.8, –; 13.9, –; 9.9, 10.0; 2.6, –; 8.2, 8.2; –, –; –, –; 6.3, 6.3. The greater white-lined bat is considered to be monotypic.

At 6 1/2 km N, 1 km E of Cosigüina, white-lined bats were obtained with 11 other species, but *Saccopteryx bilineata* was collected with only *Saccopteryx leptura* and *Molossus rufus* at El Paraíso. The specimen from El Paraíso was shot while foraging at a yard light about 1830 hr. Another individual was shot at Potosí, but subsequently discarded.

Saccopteryx leptura (Schreber)

Specimens examined (2) — El Paraíso, 1 km N Cosigüina, 20 m, 2 (KU 114642–43).

Two adult females were collected on 1 March; both females weighed 4.7 g and showed no signs of molt. One of the females was car-

rying a single embryo, with a crown-rump length of 8 mm. Length of forearm and cranial measurements of these individuals are as follows: 38.6, 40.7; 13.4, 13.2; 11.6, 11.4; 8.4, 8.3; 2.2, 2.1; 6.8, 6.9; 5.0, 4.7; 5.6, 5.5. The lesser white-lined bat is considered to be monotypic. At El Paraíso, this species was collected with *Saccopteryx bilineata* and *Molossus rufus*.

Noctilio leporinus mastivus (Vahl)

Specimens examined (2) — Potosí, 5 m, 2 (KU 114755–56).

Two adult female fishing bats were collected on 6 March in a net set across a small pool only a few hundred meters from the Pacific Ocean. One of the females, which weighed 68.9 g, was carrying a single embryo measuring 30 mm in crown-rump length. The other female, which was not visibly pregnant, weighed 58.0 g. Neither specimen shows signs of molt. Length of forearm and cranial measurements of these individuals are as follows: 82.7, 80.0; 26.4, 26.0; 23.3, 22.9; 18.5, 18.3; 6.9, 6.8; 16.9, 16.4; 9.9, 9.7; 12.3, 12.4. Davis (1973), in his systematic revision of this species, assigned all specimens from Mexico, Central America, northern South America, and the Caribbean to *N. l. mastivus* based on the large size of individuals and we concur.

Fishing bats were netted at the same site at Potosí as *Artibeus jamaicensis*, *Carollia subrufa*, *Sturnira lilium*, *Eptesicus furinalis*, *Eumops bonariensis*, *Molossus molossus*, and *M. rufus*. One of the two female *N. leporinus* collected was found to be serving as host to larval ticks belonging to the *Ornithodoros hasei* group.

Pteronotus parnellii mesoamericanus J. D. Smith

Specimen examined (1) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114076).

The only representative of a mustached bat from the peninsula was a 18.8 g pregnant adult female collected on 6 March that carried a single embryo with a crown-rump length of 18 mm. The female did not have any signs of molt. Length of forearm and cranial measurements are as follows: 58.5; 22.0; 20.6; 12.3; 4.3; 11.7; 9.1; 7.9. Smith (1972) cited this specimen in his systematic revision of the family Mormoopidae, assigning it to a newly described subspecies *Pteronotus parnellii mesoamericanus*. Specimens from the Pacific lowlands and Central Highlands of Nicaragua were assigned to this subspecies, whereas those from eastern Nicaragua were placed in *P. p. rubiginosus.*

Pteronotus parnellii was netted with *Artibeus phaeotis*, *Chiroderma villosum*, and *Platyrrhinus helleri* at 6 1/2 km N, 1 km E of Cosigüina.

Artibeus jamaicensis paulus Davis

Specimens examined (6) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 3 (KU 115020–22); 4 1/2 km N Cosigüina, 15 m, 3 (KU 115023–25).

Four adult male *Artibeus jamaicensis* were collected between 2 and 5 March in the vicinity of Cosigüina. Average weight of these individuals was 36.3 g (33.0-37.9) and testes measurements averaged 6.3 mm (5-7). One female obtained on 5 March at 6 1/2 km N, 1 km E of Cosigüina weighed 39.0 g and was carrying a single embryo that had a crown–rump length of 4 mm. Another female, captured on 2 March at 4 1/2 km N of Cosigüina, which was not pregnant, weighed 36.0 g. There were no signs of molt on any of the specimens examined.

Length of forearm and cranial measurements of two adult males and two adult females, respectively, are as follows: 56.2, 58.6, 57.0, 55.7; 27.4, 28.0, 27.9, 27.6; 16.5, 17.4, 16.9, 17.1; 7.3, 7.1, 7.1, 6.7; 14.4, 14.9, 14.7, 14.4; 9.6, 9.7, 9.6, 9.6; 12.0, 12.2, 11.6, 11.8. Davis (1970b) proposed the name *A. jamaicensis paulus* for populations occurring from the dry Pacific Coast of Chiapas, Mexico, to the Guanacaste of Costa Rica, and we concur that the Pacific coastal populations are noticeably distinct from the populations of the Caribbean lowlands and mid-elevational slopes.

Although *A. jamaicensis* shared collecting localities with many species of bats, it always was taken in close associated on the peninsula with *Artibeus phaeotis*, *Carollia subrufa*, and *Sturnira lilium*.

Artibeus phaeotis palatinus Davis

Specimens examined (10) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 6 (KU 115074–79); 4 1/2 km N Cosigüina, 15 m, 4 (KU 115080–83).

Between 2 and 6 March, seven adult male *Artibeus phaeotis* were collected in the vicinity of Cosigüina. Average weight of seven adult males was 10.1 g (8.8–11.5) and testes measurements averaged 5 mm (4–7) in length. Average weight of three adult females was 10.2 g (9.7–10.8). The 9.7 g adult female aborted a single embryo (crown–rump length 27 mm) shortly after it was captured on the evening of 5 March. Other females examined were not pregnant. Only one individual, a male from 4 1/2 km N of Cosigüina, showed signs of molt. A patch of older hair in the middle of the back appeared to be a remnant of the past molting period.

Length of forearm and cranial measurements of two adult males and two adult females, respectively, are as follows: 35.9, 35.8, 35.8, 37.8; 18.3, 18.8, 18.3, 18.5; 16.1, 16.2, 16.1, 16.7; 11.0, 11.8, 11.3, 11.0; 4.6, 4.7, 4.7, 4.6; 9.9, 10.1, 9.5, 9.3; 5.6, 5.9, 5.9, 5.9; 7.6, 7.9, 7.6, 7.6. Davis (1970a) described *A. p. palatinus* based on its smaller size and paler coloration, and restricted its geographic range to the coastal plains of the Pacific versant from the Isthmus of Tehuantepec in Mexico to Puntarenas in Costa Rica. This tent-making bat is widely distributed, although never abundant, in Central America (Timm, 1985).

In the vicinity of Cosigüina, *A. phaeotis* was captured regularly in areas having water and relatively dense vegetation. It was captured with all bat species known from the peninsula except *Noctilio leporinus*, *Eumops bonariensis*, and *Molossus molossus*—all of which were obtained only from Potosí—and *Saccopteryx leptura* taken only at El Paraíso.

Carollia perspicillata azteca Saussure

Specimens examined (2) — 4 1/2 km N Cosigüina, 15 m, 1 (KU 114885); Potosí, 5 m, 1 (KU 114907).

Two specimens of the short-tailed fruit bat were taken on the peninsula, an adult male captured on 4 March and a young female captured on 6 March. The male weighed 15.9 g and had a testes length of 7 mm. There was no evidence of molt on either specimen. Length of forearm and cranial measurements of the male are as follows: 42.9; 23.3; 21.1, –, 5.4; 11.3; 8.0; 8.4. Pine (1972) assigned all specimens of this species from Mexico and Central America to the subspecies *Carollia perspicillata azteca*.

At Potosí and at 4 1/2 km N of Cosigüina, this species was taken along with the congeneric smaller species *Carollia subrufa*. Other bat species taken in the same nets include *Artibeus jamaicensis*, *A. phaeotis*, *Chiroderma villosum*, *Desmodus rotundus*, *Platyrrhinus helleri*, *Sturnira lilium*, and *Uroderma magnirostrum*.

Carollia subrufa (Hahn)

Specimens examined (11) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114912); 4 1/2 km N Cosigüina, 15 m, 4 (KU 114913–16); Potosí, 5 m, 6 (KU 114905–06, 114908–11).

Between 2 and 6 March, five males and six females of the poorly known *Carollia subrufa* were collected. Males had an average weight of 14.4 g (13.1–15.5). Average testes length of four males was 6.5 mm (6–8). Weight for six females averaged 13.2 g (11.9–14.5). There was no gross reproductive activity found among the females, except one adult female obtained on 4 March from 4 1/2 km N of Cosigüina had a single young born in the holding bag. The newborn bat had a crown–rump length of 27 mm and weighed 2.4 g. Another female from Potosí was carrying a young bat at the time of capture. The juvenile bat weighed 3.1 g and had a forearm length of 22 mm. Molt was not evident on any specimens, except for one female from Potosí that showed signs of molt on the neck.

Length of forearm and cranial measurements of two males and two females from Potosí, respectively, are as follows: 38.6, 37.6, 36.8, 40.4; 21.3, 21.1, 21.0, 22.5; –, –, –, –; 5.3, 5.4, 5.3, 5.3; 10.5, 10.7, 10.0, 10.0, 10.6; 6.6, 6.7, 6.8, 7.2; 7.5, 7.5, 7.5, 7.6. Pine (1972), in his revision of bats of the genus *Carollia*, treated this species as monotypic and we concur.

Based on collecting efforts on the peninsula, *C. subrufa* was a relatively common bat that was collected in most areas. This abundance also is reflected in the fact that *C. subrufa* was captured at the same localities as 21 other species of bats on the peninsula (**Table 1**). The bat species most commonly associated with *C. subrufa* on the peninsula include *Artibeus jamaicensis*, *A. phaeotis*, and *Sturnira lilium*.

Centurio senex senex Gray

Specimen examined (1) — 4 1/2 km N Cosigüina, 15 m, 1 (KU 115105).

The wrinkled-faced bat is represented on the peninsula by a single pregnant adult female captured on 2 March. She weighed 18.8 g, carried a single embryo that had a crown-rump length of 17 mm, and showed no signs of molt.

Length of forearm and cranial measurements of this individual are as follows: 42.7; 19.3; 15.1; 15.1; 5.7; 12.3; 5.2; 10.8. Paradiso (1967) reviewed members of this genus and assigned populations from Mexico, Central America, and northern South America to the nominate subspecies.

At 4 1/2 km N of Cosigüina *Centurio senex* was taken in nets that also captured *Artibeus jamaicensis*, *A. phaeotis*, *Carollia subrufa*, *Glossophaga soricina*, *Platyrrhinus helleri*, and *Sturnira lilium*.

Chiroderma villosum jesupi J. A. Allen

Specimens examined (9) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 2 (KU 115006–07); 4 1/2 km N Cosigüina, 15 m, 7 (KU 115008–14).

Five males and four females were collected in the vicinity of Cosigüina between 4 and 6 March. The males had an average weight of 19.1 g (18.0-22.4). Testes measurements averaged 3.6 mm (3-5). Three of the four females were carrying single embryos that measured 25, 25, and 29 mm. Corresponding weights of the three pregnant females are 24.5, 21.5, and 28.6 g. The weight of the female that was not pregnant was 22.7 g. Molt was not found on any of the specimens examined.

Length of forearm and cranial measurements of two adult males and two adult females, respectively, from 4 1/2 km N Cosigüina are as follows: 44.6, 41.4, 45.0, 44.0; 24.5, 23.6, 24.5, 23.7; 21.8, 21.2, 22.1, 21.3; 15.5, 14.7, 15.9, 15.2; 5.6, 5.5, 5.8, 5.6; 12.1, 11.3, 12.2, 11.7; 8.3, 8.1, 8.7, 8.1; 11.1, 10.7, 11.0, 10.8. The taxon *Chiroderma villosum jesupi*, originally described from Colombia, is applied to all populations in Central America and Mexico (Hall, 1981).

This species was found at two localities where it was always taken in association with *Artibeus phaeotis*. Seventeen other species of bats were recorded from these two areas (**Table 1**).

Desmodus rotundus murinus Wagner
Common vampire bat, Vampiro

Specimen examined (1) — 4 1/2 km N Cosigüina, 15 m, 1 (KU 115115).

The only specimen of *Desmodus rotundus* from the peninsula was an adult female that weighed 34.7 g; she was not pregnant and showed no signs of molt. Length of forearm and cranial measurements are as follows: 60.1; 24.3; 21.6; 12.0; 5.4; 12.1; 3.3; 5.5. All Mexican and Central American populations of common vampires, as well as those in adjacent South America, are assigned to *D. r. murinus* (Hall, 1981); however, Koopman (1994) did not recognize subspecies in this widely distributed and often extremely abundant vampire. The common vampire was obtained on 4 March with *Artibeus jamaicensis*, *A. phaeotis*, *Carollia perspicillata*, *C. subrufa*, *Chiroderma villosum*, *Glossophaga soricina*, *Platyrrhinus helleri*, *Sturnira lilium*, and *Uroderma magnirostrum*.

Glossophaga soricina handleyi
Webster and Jones

Specimens examined (7) — 4 1/2 km N Cosigüina, 15 m, 7 (KU 114843–49).

Although this widespread and often abundant species was collected on three different nights (2, 4, and 5 March) on the peninsula, it was obtained at only one locality. Two males with weights of 8.6 and 9.1 g had corresponding testes measurements of 1 and 2 mm, respectively. Weights of five females averaged 9.2 g (8.8–9.9). None of the females were pregnant. All of the specimens examined, except for one female, were molting along the shoulder or mid-back region. Length of forearm and cranial measurements of two males and two females, respectively, are as follows: 34.5, 35.7, 36.6, 37.2; 19.3, 19.5, 19.7, 19.9; 9.3, 9.4, 9.3, 9.4; 4.5, 4.6, 4.6, 4.5; 8.9, 8.7, 8.9, 9.2; 6.9, 7.1, 7.5, 7.4; 5.4, 5.3, 5.4, 5.5. Webster (1993) cited these specimens in his systematic revision of the genus *Glossophaga* assigning them to *G. s. handleyi*, a subspecies occurring on the mainland of southern Mexico, throughout Central America, and into northern South America.

Although *G. soricina* has been collected with a wide variety of bat species (**Table 1**), only *Artibeus phaeotis* and *Platyrrhinus helleri* were caught on each of the nights that *G. soricina* was obtained.

Platyrrhinus helleri (Peters)

Specimens examined (5) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114989); 4 1/2 km N Cosigüina, 15 m, 3 (KU 114990–92); Potosí, 5 m, 1 (KU 114988).

All specimens of this species were collected in the vicinity of Cosigüina between 2 and 6 March. Males, collected on 4 and 6 March, weighed 12.8 and 12.2 g and had testes that were 5 and 6 mm in length, respectively. Weight for three adult females averaged 14.7 g (14.1-15.5). None of the females examined were pregnant; however, one adult female collected at 4 1/2 km N of Cosigüina on 2 March was lactating. Another female from the same area had enlarged mammae when it was collected on 5 March. Molt is not readily evident on most specimens examined; however, two individuals have remnants of the past molt in the form of patches of older hair occurring in the middle of the back.

Length of forearm and cranial measurements of an adult male and two adult females, respectively, are as follows: 37.7, 37.1, 37.4; 21.8, 21.7, 21.3; 19.4, 19.2, 19.0; 12.1, 11.8, 11.8; 5.4, 5.2, 5.1; 10.6, 10.3, 10.2; 7.4, 7.6, 7.7; 7.6, 7.6, 7.7. This species is treated as monotypic.

Platyrrhinus helleri was taken at three locations on the peninsula in nets in association with *Pteronotus parnellii*, *Artibeus jamaicensis*, *A. phaeotis*, *Carollia perspicillata*, *C. subrufa*, *Centurio senex*, *Chiroderma villosum*, *Desmodus rotundus*, *Glossophaga soricina*, *Sturnira lilium*, and *Uroderma magnirostrum*.

Sturnira lilium parvidens Goldman

Specimens examined (22) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 2 (KU 114933–34); 4 1/2 km N Cosigüina, 15 m, 16 (KU 114935–50); Potosí, 5 m, 4 (KU 114929–32).

Six males and 16 females were collected between 2 and 6 March; the series includes both mature adults and young adults with incomplete fusion of the phalangeal epiphyses. Average weight of four adult males was 15.9 g (14.1-17.6). Testis measurements of 6 males averaged 3.7 mm (2-5 mm). None of the 16 females captured during the same time period were pregnant. Average weight of 14 females was 13.8 g (11.6 and 16.3). Molt was not found on any of the specimens examined.

Length of forearm and cranial measurements of two adult males and two adult females, respectively, from 4 1/2 km N of Cosigüina are as follows: 38.3, 37.5, 38.0, 37.0; 21.9, 21.7, 21.2, 20.9; 19.2, 18.9, 18.4, 18.3; 12.9, 12.5, 12.6, 12.7; 5.5, 5.3, 5.2, 5.4; 11.3, 11.2, 10.9, 11.2; 6.5, 6.0, 6.0, 5.8; 6.7, 6.4, 6.2, 6.5. Hall

(1981) assigned all Mexican and Central American populations of this species to *Sturnira lilium parvidens*.

Based on collecting efforts on the peninsula, *S. lilium* was one of the more common bat species; it was represented at three collecting localities, and was taken at the same locations as 21 other species of bats (**Table 1**). Although *S. lilium* was collected with most other bat species on the peninsula, it was most commonly collected with *Artibeus jamaicensis*, *A. phaeotis*, and *Carollia subrufa*.

Uroderma bilobatum convexum Lyon

Specimens examined (2) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 114970); 4 1/2 km N Cosigüina, 15 m, 1 (KU 114971).

Two adult males collected on 5 March represent the only records known for the tent-making bat on the Cosigüina Peninsula. These males weighed 14.7 and 16.8 g, and had corresponding testes measurements of 6 and 7 mm. Neither had signs of molt.

Length of forearm and cranial measurements of these individuals are as follows: 42.5, 42.5; 23.0, 22.5; 20.4, 20.5; 12.9, 13.0; 5.3, 5.3; 10.8, 11.0; 8.2, 7.8; 7.4, 7.2. This chromosomally complex species has been studied extensively in Central America (Davis, 1968; Baker et al., 1972, 1975; Baker, 1981; Greenbaum, 1981). The name *Uroderma bilobatum convexum* is being applied to populations along the Pacific Coast of Central America from Nicaragua southward into northern South America.

Tent-making bats were taken at only two locations on the peninsula and *Artibeus phaeotis* and *Chiroderma villosum* were the only species taken in all the sets of nets where *U. bilobatum* was taken. In Costa Rica's dry forest, Timm and Lewis (1991) documented that both male and female *U. bilobatum* are found in dry forest during the breeding season—the rainy season—but that only a small number of males are in the dry forest during the dry season. The females and most males migrate to better feeding areas away from the dry forest during the dry season. We suspect that the small number of *U. bilobatum* obtained on the Cosigüina Peninsula and the fact that both are males in our dry season surveys reflects a similar seasonal migration out of the area by females and most males.

Uroderma magnirostrum Davis

Specimen examined (1) — 4 1/2 km N Cosigüina, 15 m, 1 (KU 114987).

The only specimen obtained of this uncommon tent-making bat is an adult female that was taken on 4 March. This fully mature adult was carrying a single embryo with a crown-rump length of 28 mm, she weighed 21.4 g, and shows no signs of molt. Length of forearm and cranial measurements are as follows: 45.1; 23.9; 21.8; 13.1; 5.8; 11.0, 8.2; 9.1. Davis (1968) first recognized this species in 1968 based on material ranging from southern Mexico to northern Bolivia, and treated *Uroderma magnirostrum* as monotypic.

Our single individual was captured in a net that was set across water and an adjacent clearing where the following species also were captured: *Artibeus jamaicensis*, *A. phaeotis*, *Carollia perspicillata*, *C. subrufa*, *Desmodus rotundus*, *Glossophaga soricina*, *Platyrrhinus helleri*, and *Sturnira lilium*.

Eptesicus furinalis gaumeri J. A. Allen

Specimens examined (2) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 115136); Potosí, 5 m, 1 (KU 115135).

An adult female and male *Eptesicus furinalis*, collected on 5 and 6 March, respectively, are the only representatives of the species from the peninsula. The male, from Potosí, weighed 6.5 g and had testes that were 7 mm in length. The female from 6 1/2 km N, 1 km E of Cosigüina weighed 8.1 g and was not obviously pregnant, however, it did have an enlarged uterus. No molt was evident on either specimen.

Length of forearm and cranial measurements of the male and female, respectively, are as follows: 37.6, 38.6; 15.0; 15.0; 13.7, 14.1; 9.8, 10.0; 3.8, 3.7; 7.9, 7.9; 5.5, 5.6; 5.9, 6.2. Davis

(1965, 1966) assigned specimens from Mexico, Central America except eastern Costa Rica, and northern South America to the taxon *E. f. gaumeri*.

Eptesicus furinalis was taken at two locations on the peninsula with *Carollia subrufa* and *Sturnira lilium*, the only species of bats obtained in the same nets at both sites. The female was carrying ticks of the genus *Ornithodoros*.

Myotis nigricans nigricans (Schinz)

Specimen examined (1) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 115133).

The only specimen of the black myotis known from the peninsula is a pregnant adult female obtained on 5 March. She weighed 4.2 g and was carrying a single embryo that had a crown-rump length of 7 mm. Length of forearm and cranial measurements of this individual are as follows: 34.8; 13.6; 12.7; 8.1; 3.4; 6.9; 4.9; 5.1. LaVal (1973) reviewed the Neotropical representatives of the genus *Myotis* and assigned our specimen to *Myotis nigricans nigricans*, which was found to be distributed from Tamaulipas, Mexico, to Paraguay.

Rhogeessa tumida H. Allen

Specimens examined (3) — 6 1/2 km N, 1 km E. Cosigüina, 10 m, 3 (KU 115145–47).

A male and two adult females collected on 5 March weighed 3.1, 3.6, and 3.2 g, respectively. Both females had swollen uteri, but were not obviously pregnant. Molt was not found among any of the specimens.

Length of forearm and cranial measurements of the male and the two females are as follows: 27.9, 27.6, 28.0; 11.8, 12.0, 11.6; 8.0, 8.2, 7.6; 3.0, 2.9, 2.9; 6.6, 6.6, 6.4; 4.0, 4.4, 4.2; 5.0, 5.3, 5.0. There currently are 10 species recognized in the chromosomally complex genus *Rhogeessa*. The appropriate scientific name for the 2n = 34 populations occurring along the Atlantic versant of Mexico (except the Yucatan Peninsula) southward to Honduras on both Pacific and Atlantic versants and finally along the Pacific versant of Nicaragua and into arid areas of northwestern Costa Rica is *R. tumida* (Bickham and Baker, 1977; Baker, 1984; Baker et al., 1985; Ruedas and Bickham, 1992; Audet et al., 1993; Genoways and Baker, 1996; Timm et al., 1999). A distinct species, *R. io*, occurs in eastern Nicaragua southward into South America.

Larvae of the bat tick, *Ornithodoros hasei*, were collected from one of the females.

Eumops bonariensis (Peters)

Specimen examined (1) — Potosí, 5 m, 1 (KU 114142).

A single adult male *Eumops bonariensis* was obtained on 6 March; it weighed 10.3 g, had testes that were 5 mm in length, and represents the only record known for the country of Nicaragua. Although no molt was evident, the fur deviated from normal coloration by having white spots on the back.

Length of forearm and cranial measurements of this individual are as follows: 38.8; 16.8; 15.7; 4.0; 9.8; 6.5; 7.1. Jones et al. (1971:21) in their checklist of the bats of Nicaragua reported this specimen under the name *Tadarida laticaudata* (= *Nyctinomops laticaudatus*). However, based on our study of this specimen, we conclude that it is actually *Eumops bonariensis*. The checklists of Baker and Jones (1975) and Jones and Owen (1986) also reported *T. laticaudata* as occurring in Nicaragua, citing Jones et al. (1971), and failed to include *E. bonariensis* as occurring in the country. Eger (1977) also made no mention of *E. bonariensis* occurring in Nicaragua in her revision of the genus *Eumops*. Based on our reidentification of this individual, Hall (1981) however, included this specimen in his marginal records of *E. bonariensis*, thus becoming the first published record for the country. We know of no specimens of *Nyctinomops laticaudatus* from Nicaragua, thus we must now regard this species as almost surely occurring in the country, but having yet to be documented there despite the previous reports.

Our single specimen of *E. bonariensis* was collected at Potosí in close association with *Noctilio leporinus*, *Carollia subrufa*, *Sturnira*

lilium, *Eptesicus furinalis*, *Molossus molossus*, and *M. rufus*. The specimen was a host to larval ticks of the *Ornithodoros hasei* group.

Molossus molossus (Pallas)

Specimen examined (1) — Potosí, 5 m, 1 (KU 114140).

On 6 March, a pregnant adult female, with no evidence of molt and weighing 11.4 g, was obtained. The single embryo had a crown-rump length of 5 mm.

Length of forearm and cranial measurements of this individual are as follows: 36.8; 16.4; 14.6; 10.6; 3.4; 9.6; 5.8; 7.1. According to Dolan (1989), the most recent reviewer of this species in Central America, there is not a subspecific name available for Mesoamerican populations. She did recognize two small species of *Molossus* occurring in Nicaragua, with *M. molossus* occurring in the lowlands of the Pacific versant and *M. aztecus* being found in the Central Highlands.

Our single specimen was obtained at Potosí in the same net with *Noctilio leporinus*, *Carollia subrufa*, *Sturnira lilium*, *Eptesicus furinalis*, *Eumops bonariensis*, and *Molossus rufus*.

Molossus rufus nigricans Miller

Specimens examined (40) — 4 1/2 km N Cosigüina, 15 m, 2 (KU 114098–99); El Paraíso, 1 km N Cosigüina, 20 m, 17 (KU 114100–16); Potosí, 5 m, 21 (114087–97, 115149–58).

Between 1 and 6 March, 10 male and 30 female *Molossus rufus* were collected on the peninsula; the series includes both mature adults and young adults with incomplete fusion of the phalangeal epiphyses. Average weight of nine adult males was 32.9 g (29.3-35.1). Testes measurements for 10 males averaged 5.7 mm (2-7). Sixteen of 30 females were pregnant, each carrying a single embryo. Weights for 12 females that were not pregnant averaged 29.7 g (26.1-36.0), whereas six pregnant females had an average weight of 30.8 g (28.4-36.5). Crown-rump length of embryos averaged 16.9 mm (7-22).

Length of forearm and cranial measurements of two males and two females, respectively, from Potosí are as follows: 50.9, 50,5, 48.2, 47.1; 22.9, 22.8, 21.5, 21.6; 20.1, 20.2, 18.9, 18,8; 14.3, 14.1, 13.3, 13.7; 4.4, 4.0, 4.3, 4.5; 13.9, 14.0, 12.8, 13.0; 8.0, 8.3, 7.6, 7.8; 9.5, 9.8, 9.4, 9.6. We use the species name *M. rufus* following Carter and Dolan (1978) and Dolan (1989). The name *M. r. nigricans* is applied to all populations of this species in Mexico, Central America, and northern South America (Hall, 1981).

Coloration of *M. rufus* from the peninsula consisted primarily of two phenotypes—light rust color and a dark brown color. Of 30 skins available for study, 12 individuals had the lighter coloration and 18 the darker. Three of the specimens with lighter coloration were showing signs of molt on the neck and back. Apparently these individuals were starting to molt into the darker color. There was no relationship found between coloration and collecting locality, but the evidence may indicate that the lighter color is the result of fading or bleaching of the darker color by some agent, such as ammonia, in the roost.

Based on our work, *M. rufus* was the most common bat species on the peninsula. It was collected in several different types of habitats throughout the peninsula. At El Paraíso, 11 specimens were shot on 1 March along a road that was being used as a flyway. On 4 March, six additional specimens were collected at the same place. The primary flight period at this locality occurred between 18:00 and 18:30 hr. Ectoparasites obtained from *M. rufus* included larval ticks (*Orithodoros stageri*) as well as larvae of an unidentified species in the same genus.

Nasua narica narica (Linnaeus)
White-nosed coati, Pizote

Specimen examined (1) — El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 115604).

Local residents reported that pizotes were common throughout the area. A male *Nasua narica* was obtained from local residents on 3 March. Cranial measurements of this individual are as follows: greatest length of skull, 133.7**;** condylobasal, 126.8; zygomatic breadth, 64.4; postorbital constriction, 31.1; mastoid breadth, 45.6; length of maxillary toothrow, 49.9; breadth across upper molars, 35.8. We follow Decker (1991) in using the species name *Nasua narica* for the North American white-nosed coati and Hall (1981) in assigning populations from southern Mexico and Central America to the nominate subspecies. Coatis were included as occurring on the Cosigüina Peninsula by de la Rosa and Noche (2000).

Mephitis macroura richardsoni Goodwin
Hooded skunk, Zorro hediondo

Specimen examined (1) — El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 115617).

Mephitis macroura is seemingly uncommon on the Cosigüina Peninsula as the KU field parties saw only a single individual, a young adult male, which was obtained on 1 March. All teeth are fully erupted and cusps sharp and unworn; the basisphenoid suture is not completely ossified. The testes measured 15 mm in length. Markings on the male consisted of lateral stripes, which ran from the shoulder to the hip. The external measurements are 584, 294, 59, and 30. Cranial measurements are as follows: greatest length of skull, 63.2; condylobasal, 58.5; zygomatic breadth, 39.0; postorbital constriction, 17.9; mastoid breadth, 33.6; length of maxillary toothrow, 22.7; breadth across upper molars, 22.9. Historically, it was believed that *M. m. richardsoni* was confined to Nicaragua with a type locality at Matagalpa, Matagalpa. Hall (1981) reported the specimen from Matagalpa as the southern-most population of the species; however, Janzen and Hallwachs (1982), Wilson (1983), and Wilson et al. (2002) correctly report skunks from Costa Rica's Provincia de Guanacaste. The Cosigüina Peninsula was included in the present day distribution of the hooded skunk by de la Rosa and Noche (2000).

Leopardus pardalis aequatorialis (Mearns)
Ocelot, Tigrillo or Ocelote

Local residents reported that tigrillos (*Leopardus pardalis*) were common throughout the area. On 1 March, a single ocelot was observed by the KU field party on the slopes of Volcán Cosigüina. We follow Hemmer (1978) and Kratochvíl (1982) in the use of the generic *Leopardus* for the ocelot, which is treated in the genus *Felis* by other authors. Because we do not have a specimen at hand, we simply follow Murray and Gardner (1997) in assigning the subspecies *L. p. aequatorialis* to this sighting. The Cosigüina Peninsula was included in the present day distribution of the ocelot by de la Rosa and Noche (2000). *Leopardus pardalis* is on Nicaragua's CITES Appendix I list as a species in danger of extinction.

Panthera onca centralis (Mearns)
Jaguar, Tigre

Specimen examined (1) — Hacienda Cosigüina, 1 (KU 71940).

Local residents reported to Genoways that jaguars were still present on the peninsula in 1968. *Panthera onca* is known from the peninsula by the cranium of an adult obtained by Albert A. Alcorn from a hunter in June 1956. Cranial measurements of this unsexed individual are as follows: greatest length of skull, 224.1; condylobasal, 199.2; zygomatic breadth, 151.2; postorbital constriction, 43.1; mastoid breadth, 90.3; length of maxillary toothrow, 80.9; breadth across upper molars, 73.5. We follow Hemmer (1978) and Groves (1982) in using the generic name *Panthera* for the jaguar, which traditionally has been placed in genus *Felis* by other authors. Seymour (1989) suggested some reductions in the number of subspecies, but does not present an analysis; therefore, we follow Hall (1981) in placing nearly all Central American populations of

jaguar in *F. o. centralis*. The Cosigüina Peninsula was included in the present day distribution of the jaguar by de la Rosa and Noche (2000); however, if any do remain in this region of Nicaragua the numbers must be so low as to not represent a viable population. Significant numbers of jaguars are still present in the Caribbean lowlands of Nicaragua. *Panthera onca* is on Nicaragua's CITES Appendix I list as a species in danger of extinction.

Tapirus bairdii (Gill)
Baird's tapir, Danto

Specimen examined (1) — Cosigüina Peninsula (MVZ 98896).

Local residents reported to Jones that "danto" were present on the peninsula (late 1960s), but he questioned that in his field notes. Certainly, historically *Tapirus bairdii* was present throughout the Pacific lowlands of Nicaragua. A subadult male *T. bairdii* (MVZ 98896) labeled as from the Cosigüina Peninsula only was obtained by Milton Hildebrand from a Mr. Raun, a Dane who lived in San Miguel, El Salvador, and ran a drug store. Mr. Raun was a big game hunter. He presented the skin and skull of a tapir that he had shot early in 1941 on the Cosigüina Peninsula to Hildebrand as a gift when Hildebrand visited him in San Miguel. Raun told Hildebrand that there were no more tapirs remaining in El Salvador at that time (1942) so he went to Nicaragua to obtain one for his collection where they were still found. Tapirs were considered rare throughout the region and Raun appreciated that the animal he had obtained was of value as a scientific specimen.

The specimen is preserved as a pelt and complete, well-cleaned skull. The animal was a large subadult when killed. The greatest length of skull is 396 mm and zygomatic breadth 174 mm. The incisors and premolars are fully erupted but unworn. The first upper and lower molars are fully erupted, the second partially erupted through the bone, and the third had not yet erupted through the bone.

Tapirus bairdii is on Nicaragua's CITES Appendix I list as a species in danger of extinction.

Odocoileus virginianus truei (Merriam)
White-tailed deer, Venado cola blanca

Specimens examined (5) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 115626); El Paraíso, 1 km N Cosigüina, 20 m, 3 (KU 115627–29); 1 km SE Potosí, 15 m, 1 (KU 115625).

Local residents reported to Jones that venado were present in abundance on the peninsula; they were so abundant there in the 1960s that hunters from other areas of Nicaragua came there to hunt deer. While the KU field party was staying at Hacienda El Paraíso, hunters from the community of León were there specifically to hunt deer. On the night of 29 February-1 March, they shot three deer, the skulls of which were given to the KU field party. The field party obtained two others, one on 2 March and one on 4 March. Thus, we are able to study five *Odocoileus virginianus* from the peninsula, four males (1 adult and 3 subadults) and one subadult female. The adult male has fully erupted adult dentition and polished, short spikes for antlers; the left antler has a short tine typical of the Central American forms. The three subadult males were just erupting second and third molars and the basisphenoid sutures were not ossified; antler development on these individuals was restricted to an unexposed button on one, an exposed button on one, and a small velveted spike on the third. The second and third molars were erupting on the female; the second was exposed through the gum, but the third was still within the mandible and the basisphenoid suture not fully ossified. Greatest length of skull for the single adult male with fully erupted teeth and the two older subadult males and the subadult female with molars not fully erupted are 225.4, 199.2, 194.4, and 207.5 and these same individuals have a zygomatic breadth of 89.2, 79.7, 74.4, and 83.7, respectively. The external measurements for the adult male are: 1485, 184, 391,

and 142. Smith observed two deer on Volcán Cosigüina on 1 March.

Based on the current literature, it is not possible to determine whether these specimens should be assigned to *O. v. nelsoni* or *O. v. truei* and our specimens are not informative because only one is a mature adult. We assigned the specimens to *O. v. truei* solely on geographic grounds. Geographic variation in the Central America white-tailed deer needs to be reassessed using modern techniques as C. Hart Merriam typically described new subspecies and species of mammals based on a single individual with little regard for geographic, sexual, or age variation.

Odocoileus virginianus from the peninsula served as host to a variety of ectoparasites including the hippoboscid fly *Lipoptena mazamae* and the ixodid ticks *Amblyomma cajennense* (adult female), two species of *Amblyomma* sp. (nymphs), *Amblyomma* sp. (larvae), *Boophilus macroplus* (adult male and female), and *Boophilus* sp. (nymphs).

Sciurus variegatoides adolphei (Lesson)
Variegated squirrel, Ardilla común

Specimens examined (14) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 7 (KU 115239–45); 4 1/2 km N Cosigüina, 15 m, 2 (115246–47); El Paraíso, 1 km N Cosigüina, 20 m, 3 (KU 115248–50); 7 km S, 1 km E Cosigüina, 10 m, 2 (110304–05).

The variegated squirrel was common locally in the taller forest along streams on the peninsula. On 19 August, two males were collected 7 km S, 1 km E of Cosigüina. The specimens weighed 472.2 and 610 g and had a testes measurement of 8 and 27 mm. Between 1 and 6 March, 12 additional specimens were obtained from the peninsula. Testes measurements and corresponding weights of four males are 20, 30, 31, and 34 and 576.4, 615.8, 642.2, and 673.3. Examination of six females revealed no pregnant individuals. Weights of two lactating females were 740.5 and 761.7. The remaining females had weights of 490.0, 656.0, 668.8, and 699.9. The lack of pregnant females in our series of adults suggests that reproduction occurs primarily during the rainy season. Cranial measurements of two adult males and two adult females, respectively, are as follows: 61.2, 61.6, 63.0, 62.6; 56.6, 55.6, 57.3, 57.6; 35.7, 34.4, 35.8, 35.7; 20.1, 19.9, 21.1 20.3; 25.4, 24.7, 25.6, 26.8; 21.3, 21.3, 22.4, 21.2; 19.8, 20.3, 20.0, 20.1; 12.1, 12.4, 11.7, 12.2. This species exhibits a high degree of morphological variation particularly in pelage color and pattern. Harris (1937) recognized *Sciurus variegatoides adolphei* from a limited area in the lowlands of northwestern Nicaragua, with a type locality at El Realejo near Chinandega, and we attribute the populations on the Cosigüina Peninsula to this subspecies.

We found the variegated squirrel on Cosigüina Peninsula to be highly variable in pelage coloration and patterns; however, much of the variation can be attributed to molt. Multiple molt lines, having differences in distinctness and regularity, contribute to the variable appearance among individuals. Although molt does not always begin in the same area, it usually begins anteriorly and proceeds posteriorly. Single molt lines usually extend more posteriorly on the dorsal side than on the lateral surfaces. No molt lines were observed on the ventral surface.

Sciurus variegatoides was obtained at most collecting localities on the peninsula. Field collectors noted that higher concentrations occurred in those areas that had tall evergreen trees growing along hot springs; however, in one case, an adult was shot while it was foraging in a mimosa tree (*Albizia* sp.).

Liomys salvini vulcani (J. A. Allen)
Spiny pocket mouse, Rata

Specimens examined (13) — 4 1/2 km N Cosigüina, 10 m, 9 (KU 115338–47); El Paraíso, 1 km N Cosigüina, 20 m, 4 (KU 115348–51).

The spiny pocket mouse is the most abundant rodent on the peninsula and is especially common in acacia woodlands and grasslands. At 4 1/2 km N of Cosigüina, two individuals

were collected in an area where the vegetation had been cleared. In the same area, another specimen was captured near a log that was lying about two or three meters from a stream. Other specimens were obtained in tall grass and elephant-ear-type plants. One female was pregnant, an adult captured on 2 March had three embryos each 22 mm in crown-rump length. An adult male captured on 1 March had testes measuring 18 mm. Other species of rodents that were collected with *Liomys salvini* include *Oligoryzomys fulvescens* and *Oryzomys couesi*.

Genoways (1973), in a revision of the genus *Liomys*, assigned these specimens to *L. s. vulcani*, which is confined to the lowlands of western Nicaragua and associated highland areas such as the volcanoes of the Cordillera Los Maribios.

Ectoparasites collected on *L. salvini* include the sucking louse, *Fahrenholzia fairchildi*, and larvae of the tick, *Amblyomma* sp.

Oligoryzomys fulvescens costaricensis (J. A. Allen)
Pygmy rice mouse, Ratón

Specimen examined (1) — El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 115432).

This species is known from the peninsula based on a single adult male collected on 1 March at El Paraíso. This male weighed 11.7 g, has adult pelage with a molt line starting on the head, and a testis length of 5 mm. Cranial measurements are as follows: 20.7, 18.1, 11.0, 3.6, 9.1 8.1, 3.6, 3.5, 2.9.

We follow Carleton and Musser (1989) in the use of the generic name *Oligoryzomys*. Jones and Engstrom (1986) recognized two well-defined forms of *Oligoryzomys fulvescens* in Nicaragua, which they assigned to two subspecies—the larger, more darkly colored, highland and eastern lowlands race being *O. f. nicaraguae* and the smaller, paler, western race being *O. f. costaricensis*. They suggested, however, that the *O. fulvescens* from the Pacific lowlands might represent an intergradation between *O. f. pacificus* to the north and *O. f. costaricensis* to the south. Carleton and Musser (1995) documented a significant north-south increase in average size in *O. fulvescens* in Central America with *O. f. costaricensis* being the largest form.

At El Paraíso, this species was collected in a mesic habitat that bordered piles of debris near a corral. *Liomys salvini* and *Oryzomys couesi* were the only species captured with *Oligoryzomys fulvescens*.

Oryzomys alfaroi alfaroi (J. A. Allen)
Alfaro's rice rat, Ratón

Specimen examined (1) — 4 1/2 km N Cosigüina, 15 m, 1 (KU 115431).

A single specimen of *Oryzomys alfaroi* is known from all of northwestern Nicaragua, a juvenile male (third molars not erupted, basisphenoid suture not ossified) captured by J. K. Jones, Jr., on 2 March 1968 in "lush vegetation at warm springs" (J. K. Jones, Jr., field notes). Jones and Engstrom (1986) assigned all specimens of this species in Nicaragua to the nominate subspecies, *O. o. alfaroi*, and remarked that it appeared to be nowhere common in the country. *Liomys salvini* and *Oryzomys couesi* were the only species captured with *Oryzomys alfaroi*.

Oryzomys couesi couesi (Alston)
Ratón

Specimens examined (15) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 2 (KU 115440–41); 4 1/2 km N Cosigüina, 15 m, 11 (115442–53); El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 115454).

Eight male and seven female *Oryzomys couesi* were collected on the peninsula between 1 and 5 March. Five adult or near-adult males had an average weight of 51.4 g (40.7-67.2) and the average length of testes was 11.0 mm (10-12). Weights of two subadult males and one juvenile male are 26.8, 31.5, and 18.5 g, respectively, with corresponding testes lengths of 9, 5, and 4 mm. Four of the seven females collected were pregnant. Two of the pregnant females had sets of two embryos that had crown-rump measurements of 10 and 20 mm, whereas the other two pregnant females had sets of four embryos that had crown-rump

measurements of 2 and 9 mm. In the latter females, there were two embryos in each uterine horn. Weights of pregnant females averaged 48.3 g (37.9-55.2). Two grown females that were not pregnant and a juvenile female weighed 36.4, 39.7, and 18.5 g, respectively. All of the specimens examined had adult pelage except for a young male and female, from 4 1/2 km N of Cosigüina, in juvenile pelage. There was no indication of molt on any of the specimens examined.

Cranial measurements of two adult males and two adult females, respectively, are as follows: 30.1, 31.0, 29.1, 30.1; 28.4, 28.4, 26.5, 28.0; 15.8, 16.0, 15.2, 15.4; 4.7, 5.0, 4.6, 5.0; 12.0, 12.1, 11.4, 11.8; 13.2, 12.9, 11.8, 12.3; 5.4, 5.5, 5.1, 5.6; 4.3, 4.3, 4.3, 4.3. We follow Jones and Engstrom (1986) in assigning our specimens to the nominate subspecies, which has a broad distribution from Costa Rica northward to Veracruz in eastern Mexico.

This species typically was collected in habitats that were mesic in nature and often included dense shrubbery and tall grass growing along streams. At 4 1/2 km N of Cosigüina, six *O. couesi* were collected in tall grass and elephant-ear-type plants, which were growing at the edge of a cleared area. Another individual was obtained along piles of debris near a corral. *Oryzomys couesi* was collected with *Liomys salvini*, *Oligoryzomys fulvescens*, and *Sigmodon hirsutus*.

Emerson (1971) reported the sucking louse, *Hoplopleura oryzomydis*, occurring on a specimen of *Oryzomys couesi* (reported by him under the name *O. palustris*) from El Paraíso that was collected by our field party.

Ototylomys phyllotis phyllotis Merriam
Big-eared climbing rat, Ratón

Specimens examined (2) — El Paraíso, 1 km N Cosigüina, 20 m, 2 (KU 115479–80).

Two male big-eared climbing rats were collected on 2 March. One specimen, weighing 15.0 g and having juvenile pelage (second molars partially erupted, third molars not erupted, basisphenoid suture not ossified), was obtained in a scrub forest in a trap that was set in a tree hole. An older specimen was shot along a wooded fencerow. This specimen weighed 90.0 g and had adult pelage with a molt line on the neck. The greatest length of skull of the smaller individual was 27.3; the cranium of the larger male is broken. Lawlor (1969) assigned all *Ototylomys* from Nicaragua to the nominate subspecies.

Sigmodon hirsutus griseus J. A. Allen
Cotton rat, Ratón

Specimen examined (1). 4 1/2 km N Cosigüina, 15 m, 1 (KU 115573).

The Central American cotton rat is known from the peninsula based on a single adult male that was captured on 4 March. It weighed 96.8 g, had testes that measured 18 mm in length, and no signs of molt. The specimen was collected with *Oryzomys couesi* along low bushes and tall grass that grew around the edge of a clearing near a stream. Cranial measurements of this individual are as follows: 34.9, 33.3, 18.8, 5.2, 14.0, 13.8; 6.0; 8.0. We follow Peppers and Bradley (2000) and Peppers et al. (2002) in using the specific name *hirsutus* for cotton rats found in Nicaragua in place of *hispidus* as it has been in previous literature. The subspecific name *S. h. griseus*, based on a holotype from the dry lowlands east of Lago de Nicaragua, Chontales, seems to be the most appropriate name for cotton rats from western Nicaragua.

The sucking louse, *Hoplopleura hirsuta*, was reported on this specimen by Emerson (1971). The lice of the *H. hirsuta* species group should be reexamined now that molecular systematic studies have demonstrated that several biological species of *Sigmodon* are represented in what was previously considered the wide ranging more northern species *S. hispidus*.

Dasyprocta punctata punctata Gray
Agouti, Guatuza

Specimen examined (1) — 6 1/2 km N, 1 km E Cosigüina, 10 m, 1 (KU 115597).

Local residents reported that agoutis were common on the peninsula. A single young adult

male agouti was obtained on 5 March. There was no sign of molt on this specimen, and testis length of this individual was 10 mm. External measurements are as follows: 490; 23; hind foot, 120; 40. Cranial measurements are as follows: 97.8; 89.9; 44.1; 26.8; 31.3; 38.0; –; –. Our specimen is best assigned to the nominate subspecies with a restricted type locality at El Realejo, Chinandega, Nicaragua (Goodwin, 1946: 417). This form occurs along the Pacific coast of Central America from southwestern Guatemala to northwestern Costa Rica (Hall, 1981). *Dasyprocta punctata* is on Nicaragua's CITES Appendix III list as a species in danger of extinction.

Sylvilagus floridanus costaricensis Harris
Cottontail rabbit, Conejo

Specimen examined (1) — El Paraíso, 1 km N Cosigüina, 20 m, 1 (KU 115225).

In a systematic review of the genus *Sylvilagus* in Nicaragua, Yates et al. (1979) found that the cottontails from Nicaragua averaged larger in most measurements than did those from either Costa Rica or Honduras. They concluded that the subspecies *Sylvilagus floridanus costaricensis* was the only form found in the country occurring throughout central and western Nicaragua.

An adult female cottontail rabbit that was shot in the acacia scrub forest near a clearing on 1 March had two embryos (20 mm in crown–rump length) both in the right uterine horn. External measurements are as follows: total length, 403; length of tail, 35; length of hind foot, 87; length of ear, 62; mass, 1265 g. Cranial measurements include greatest length of skull 74.5, condylobasal length 64.1, zygomatic breadth 34.0, interorbital constriction 14.4, mastoid breadth 27.9, length of nasals 32.6, palatal length 7.7, and length of maxillary toothrow 13.0.

Additional species

Dasypus novemcinctus. Local residents reported to Genoways that cusuco (*Dasypus novemcinctus*) were present on the peninsula, but none was observed by our field parties. The "armadillo común" or nine-banded armadillo is the armadillo to be expected on the peninsula (Genoways and Timm, 2004).

Ateles geoffroyi. Local residents reported that "mono areña" (*Ateles geoffroyi*) were present on the peninsula, but none was observed by our field parties. The black-handed spider monkey is the species historically found throughout Nicaragua, but its abundance and distribution are now considerably reduced. The other member of the order Primates that historically should have been found on the peninsula is the mantled howler monkey, "mono congo" (*Alouatta palliata*). The lack of observations of primates by the KU field parties in 1968 is of interest and perhaps indicative of low populations of both species. Spider and howler monkey populations may not have recovered in this region from the yellow fever epidemic that swept through Central America in the early 1950 decimating primate populations (Timm and LaVal, 2000). Albert A. Alcorn recorded in his field notes (June 20, 1956) that he was told by a hunter working for his father, J. A. Alcorn, in the Managua area that "3 years ago there were hundreds of monkeys but yellow fever killed almost all of them" (KU archives). Both spider and howler monkeys are on Nicaragua's CITES Appendix I list as species in danger of extinction.

Canis latrans. Local residents reported to Genoways that coyotes (*Canis latrans*) were present on the peninsula but none were observed by our field parties. De la Rosa and Noche (2000) include the Cosigüina Peninsula in the present day and historical distribution of coyotes in Nicaragua.

Urocyon cinereoargenteus. Local residents reported to Genoways that "gato ostoches" (*Urocyon cinereoargenteus*) were present on the peninsula but none were observed by our field parties in 1968. De la Rosa and Noche (2000) include the Cosigüina Peninsula in the present day distribution of gray foxes in Nicaragua.

Eira barbara. Local residents reported to Jones that "culumucos" (*Eira barbara*) were common on the peninsula. De la Rosa and Noche (2000) include the Cosigüina Peninsula

in the present day distribution of tayras. *Eira barbara* is on Nicaragua's CITES Appendix III list as a species threatened with extinction.

Spilogale putorius. Local residents reported to Genoways that spotted skunks (*Spilogale putorius*) were present on the peninsula, although none were observed by our field parties. The Pacific lowlands are not shown within the range of spotted skunks by Reid (1997), but we suspect that they are or were found there as the species is widely distributed in the Pacific lowlands of northwestern Costa Rica.

Pecari tajacu. Local residents reported to Genoways that "sahino" or "jabalí de collar"—collared peccaries (*Pecari tajacu*) were present on the peninsula but none were observed by our field parties. Collared peccaries are on Nicaragua's CITES Appendix II list as a species threatened with extinction.

DISCUSSION

When the Spaniards arrived in the New World, there were perhaps 550 000 km^2 of dry forest on the Pacific side of lowland tropical Mesoamerica. The Central American dry forests have been heavily impacted by timber harvest, first by the several groups of Native Americans that lived in the region, then by the Spaniards and other European colonists. Fire was used historically, and continues to be used, as a management tool for clearing forest and improving pasturelands for cattle (Taylor, 1963). Cattle production, small farms, and now crop production on a large scale for such crops as sugarcane and cotton, have reduced the dry forest to less than 1% of its original extent. Dry forests, originally more extensive than the Central American wet forests, are now the most endangered habitats in Central America (Janzen, 2004; Stoner and Timm, 2004; Timm and McClearn, in press).

We document that the mammalian fauna of the dry forests of the Cosigüina Peninsula contains at least 39 species of terrestrial mammals. In this fauna, 7 orders and 17 families of mammals are represented as follows: Didelphimorphia (2 species)—Didelphidae, 2; Chiroptera (22)—Emballonuridae, 2; Noctilionidae, 1; Mormoopidae, 1; Phyllostomidae, 12; Vespertilionidae, 3; Molossidae, 3; Carnivora (4)—Procyonidae, 1; Mustelidae, 1; Felidae, 2; Perissodactyla (1)—Tapiridae, 1; Artiodactyla (1)—Cervidae, 1; Rodentia (8)—Sciuridae, 1; Heteromyidae, 1; Muridae, 5; Dasyproctidae, 1; Lagomorpha (1)—Leporidae, 1.

Our survey of the taxonomic relationships of the mammals occurring on the Cosigüina Peninsula revealed no truly endemic taxa. The Cosigüina fauna falls into three broad categories—species with widespread geographic ranges throughout the Neotropics; species occurring throughout southern Mexico, Central America, and into northern South America; and species occurring along the dry Pacific Lowlands of southern Mexico and Central America. None of the taxa, with the possible exception of *Liomys salvini vulcani*, appears to be restricted even to the Pacific lowlands of Nicaragua and northwestern Costa Rica. Thus, at a taxonomic level, the Cosigüina mammalian fauna does not appear to have any unique elements.

In **Table 3**, Jaccard's coefficients of similarity (Dobson and Wright, 2000; Rahel, 2000, 2002; Lim and Engstrom, 2001; Olden and Poff, 2003) are presented comparing six mammalian faunas from Nicaragua to evaluate how the composition of the fauna from the Cosigüina Peninsula is related to those of other areas in the country. In comparison with five other mammalian faunas in Nicaragua, the Cosigüina fauna is most similar in size and diversity with those from elsewhere in the Pacific Lowlands—vicinity of San Antonio and Hacienda San Isidro (**Table 2**; 34 species; 46% similarity), Chinandega, about 70 km to the southeast, and vicinity of Finca Amayo and San Juan del Sur (35 species; 30.4% similarity), Rivas, nearly 300 km southeast near the Costa Rican border.

The Cosigüina fauna shares lower and nearly equal similarity coefficients (22.4% to 25.4%) with the remaining three faunas, which is probably driven by sharing of widespread Neotropical species of mammals. Most interesting here is the low similarity value (22.4%) between the Cosigüina fauna and the fauna from the

Table 3

A matrix of Jaccard's Coefficients of Similarity comparing six mammalian faunas from Nicaragua. The geographic origins of the faunas are detailed in the Methods and Materials.

Faunas	*Cosigüina Peninsula, Chinandega*	*Pacific Lowlands-Chinandega*	*Cordillera los Maribios*	*Pacific Lowlands-Rivas*	*Central Highlands*
Pacific Lowlands-Chinandega	46.0				
Cordillera los Maribios	22.4	41.0			
Pacific Lowlands-Rivas	30.4	38.0	21.7		
Central Highlands	25.4	35.1	18.9	32.2	
Atlantic Lowlands	23.9	23.5	12.7	30.8	32.9

geographically relatively close Cordillera los Maribios, which is composed of the chain of active volcanoes just to the east of the source of the Chinandega Lowland fauna. The fauna from the Cordillera los Maribios has the lowest number of species recorded for any of the six faunas with only 21 species identified; however, this fauna may be under sampled or the unstable and relatively recent environments offered by these active volcanoes may not support a large or diverse mammalian fauna. The 41% similarity between the Chinandega Lowland fauna and adjacent Cordillera los Maribios fauna is the second highest found in our study and clearly demonstrates the proximity of these faunas. The Rivas and Chinandega lowland faunas have a similarity of 38% indicating a sharing of a considerable number of species between these two lowland sites.

The mammalian faunas from the remaining two physiographic regions of Nicaragua—Central Highlands, vicinity of Finca Tepeyac and Santa María de Ostuma, Matagalpa (43 species; 25.4% similarity); Atlantic Lowlands, vicinity of El Recreo, Atlántico Sur (50 species; 23.9% similarity)—have larger, more diverse faunas than that of the Cosigüina Peninsula and elsewhere in the Pacific lowlands. Their values with the Cosigüina fauna are well below their shared similarity value of 32.9%. Thus, our conclusions from the similarity indices are that there is a definable Pacific Lowland mammalian fauna and that the fauna of the Cosigüina Peninsula is typical of this region with little geographic isolation from other Pacific lowland faunas.

The Cosigüina Peninsula has been occupied for millennia because the climate of the region supported human habitation and because of its strategic position along the resource rich Pacific coast. This combination of long-term occupancy by humans and the cataclysmic eruptions of Volcán Cosigüina (and neighboring volcanoes) resulted in a recent and heavily impacted landscape on the peninsula. This region also is one of the most poorly studied in Central America in terms of biotic diversity, perhaps because biologists often choose to work in regions that they deem less impacted by humans and those with the most diverse floras and faunas. Herein, we document that mammal diversity and abundances can be substantial in a heavily impacted landscape. There is a diverse array of bats, especially those species that are seed dispersers and thereby critical to forest regeneration. Interestingly, no predaceous bats of the subfamily Phyllostominae were captured on the peninsula, whereas KU field parties captured a number of species on the mainland. It has been suggested by several

authors that the phyllostomines might be good indicator species of habitat disturbance (Fenton et al., 1992; also see critique by Timm and McClearn, in press).

Although there is a definable Pacific Lowland mammalian fauna in Nicaragua, little remains of the dry forest and little of it is protected as is true throughout much of Central America. Nicaragua's system of protected areas has expanded rapidly however in recent years. Three biotically unique areas on the Cosigüina Peninsula are now designated as "Reserva Natural" in the Sistema Nacional de Areas Protegidas (SINAP). These include Reserva Natural Volcán Cosigüina (13 168 ha), encompassing much of the old volcanic cone; Reserva Natural Delta del Estero Real (55 000 ha), which includes the estuary, delta, and the surrounding lowlands at the mouth of Río Tecolapa and headwaters of Golfo Fonseca; and Reserva Natural Estero Padre Ramos (9157 ha), which encompasses the inlet and surrounding lowlands on the southern fifth of the peninsula along the Pacific coast. These three reserves now protect more than one-fourth of the peninsula. As in most countries, additional trained professionals are needed to protect, manage, and develop these protected areas; however, the first steps toward conservation are taken, protecting the biotically interesting areas. Additional information on Nicaragua's Ministerio del Ambiente y los Recursos Naturales including background information on some reserves may be found at: www.marena.gob.ni.

The Pacific lowland dry forests of Central America are able to regenerate when protected from fire and other anthropomorphic disturbances (see Frankie et al., 2004; Timm and McClearn, in press for recent reviews). The mammals of the tropical dry forest are among the most poorly known of any of the bioclimatic life zones. If the native mammals of Central America's tropical dry forests are to be conserved, additional efforts must be made to protect the forest that remains and allow natural succession to recreate mature stands. Conservation measures for this endangered forest type and fauna should include economic alternatives for local residents, sustainable development, and expanded research.

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