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A preliminary biological survey of Cerro Piedra Larga, Oaxaca, Mexico: Birds, mammals, reptiles, amphibians, and plants

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Resumen. Cerro Piedra Larga es una montaña aislada en el este de Oaxaca, justo al oeste del Istmo de Tehuantepec. En virtud de que en esta sierra no se ha conducido ningún inventario biológico, un estudio preliminar puede ser de interés. Durante varias semanas de trabajo en las partes altas de la sierra, desarrollamos inventarios preliminares para aves, mamíferos, reptiles, anfibios y plantas. Geográficamente, las afinidades de la biota de la sierra parecen constituir una mezcla entre la Sierra Madre Oriental y la Sierra Madre del Sur, lo cual sugiere una origen por medio de colonización y no por medio de conexiones históricas.

Palabras clave: inventario biológico, faunística, florística, Cerro Piedra Larga, Oaxaca, México.

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Abstract. Cerro Piedra Larga is an isolated mountain massif in eastern Oaxaca, lying just west of the Isthmus of Tehuantepec. No previous biological inventories had assessed this range, making even a preliminary assessment of interest. During several weeks of work in the higher portions of the mountain range, we assembled such preliminary inventories for birds, mammals, reptiles, amphibians, and plants. Geographically, the affinities of the highland biota of Cerro Piedra Larga appear to be mixed between the Sierra Madre Oriental and the Sierra Madre del Sur, suggesting that the biota likely originated by colonization, rather than via historical connections.

Key words: biological inventory, faunistics, floristics, Cerro Piedra Larga, Oaxaca, México.

Introduction

Mexico, located at the conjunction of two great biogeographic realms, is considered a megadiverse country, one of the storehouses of biodiversity at a global scale (Mittermeier *et al.* 1998). Although Mexico has seen attention from students of biodiversity over more than two centuries (Ramamoorthy *et al.* 1993), the survey of its biodiversity remains incomplete (Peterson *et al.* 1998). Many areas remain unsurveyed, and incompletely known as to species composition and communities of animals and plants.

Cerro Piedra Larga is an isolated mountain massif in eastern Oaxaca (Figs. 1, 2), lying less than 100 km west of the Isthmus of Tehuantepec, a major biogeographic barrier that divides the heart of Mexico from northern Central America. The montane habitats of the Cerro are isolated from the Sierra de los Mixes and the Zempoaltepec massif to the north by the dry lowlands of the Río Tehuantepec and from the Sierra de Miahuatlán to the south and west by a low, dry valley that holds the highway from Oaxaca City to the Isthmus. Hence, the Cerro represents an island of montane habitat separated from larger sierras by dry lowland valleys, and at the extreme of a major biogeographic realm. In spite of its intriguing geographic situation, Cerro Piedra Larga has seen no organized biological survey, and in fact has seen effectively no collecting whatsoever in the high montane portions (Binford 1989).

Initial surveys of Cerro Piedra Larga by small plane revealed a surprise in its vegetation. Whereas most interior mountain massifs in Mexico simply hold arid and humid pine-oak forest, Cerro Piedra Larga appeared to hold patches of cloud forest in high-elevation sheltered canyons. This observation motivated on-the-ground fieldwork, and was indeed confirmed by our field studies. This patch of cloud forest is clearly one of the most isolated in all of Mexico, and for that reason is of considerable biological interest.

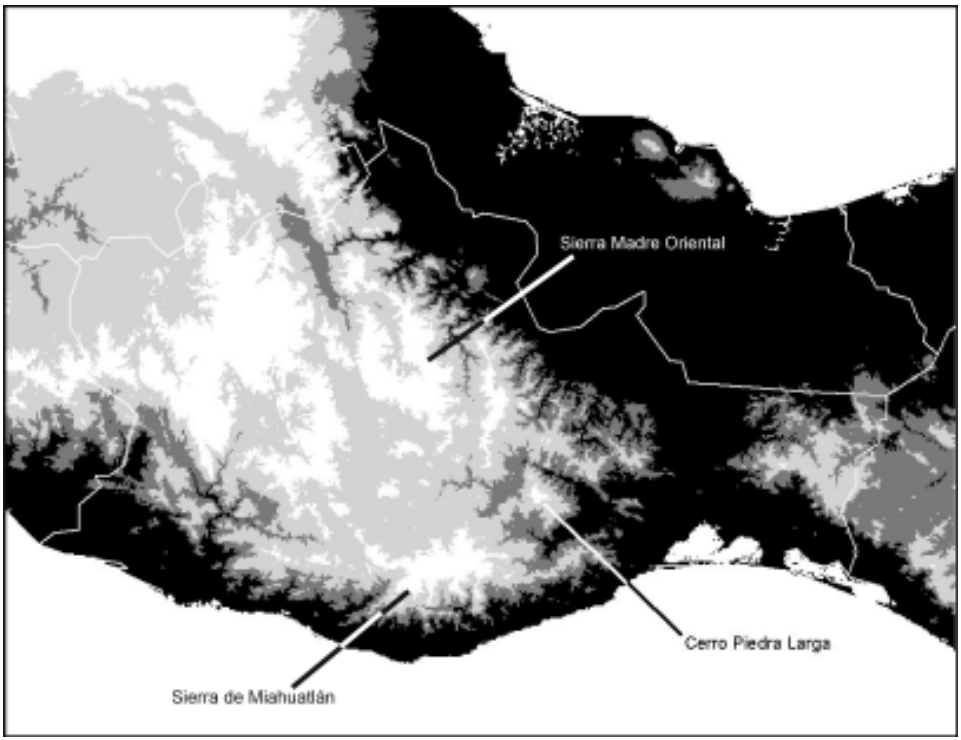

Fig. 1. Map of southern Mexico, showing elevational variation (white-to-black scale indicates elevations in 500 m intervals) and the location of Cerro Piedra Larga.Fig. 3. Species

Cerro Piedra Larga is a mass of Mesozoic origin located just west of the Isthmus of Tehuantepec, northwest of Juchitán, in the area bordered by the coordinates 16º 31' and 16º 37' N latitude, and 95º 45' and 95º 51' W longitude. The massif rises from a base at about 600 m to elevations of about 2700 m, and has a roughly oblong shape.

The present contribution is intended as a multi-taxon approach to a first-pass documentation of the biological diversity of Cerro Piedra Larga. A team of investigators and students from the Universidad Nacional Autónoma de México and the Field Museum of Natural History surveyed the high montane portions of the Cerro in March, April, and August of 1993. Herein, we present preliminary inventories for plants, reptiles and amphibians, birds, and mammals.

Inventories for each taxon are clearly preliminary. Species accumulation curves for the three vertebrate taxa (Fig. 3) indicate that inventories for birds are likely complete. Mammals, although presenting a flat accumulation curve, were sampled in a small area, and the true fauna is doubtless larger. Reptiles and amphibians,

which present a steeply ascending species accumulation curve, are only partly sampled, and will certainly reveal many additional forms with further study.

Methods

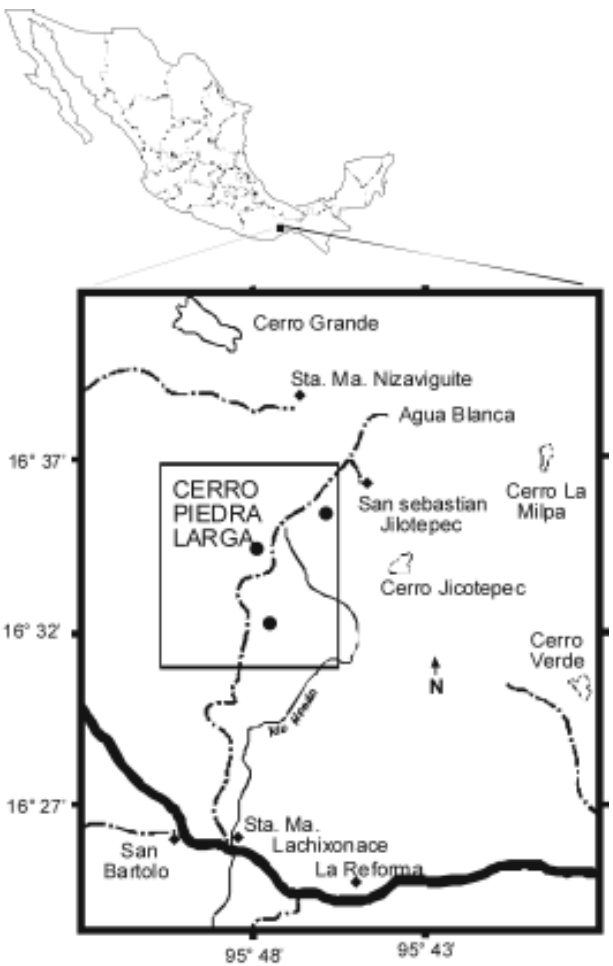

Fig. 2. Map of the region of Cerro Piedra Larga, showing principal access roads, and study sites (as large black dots).

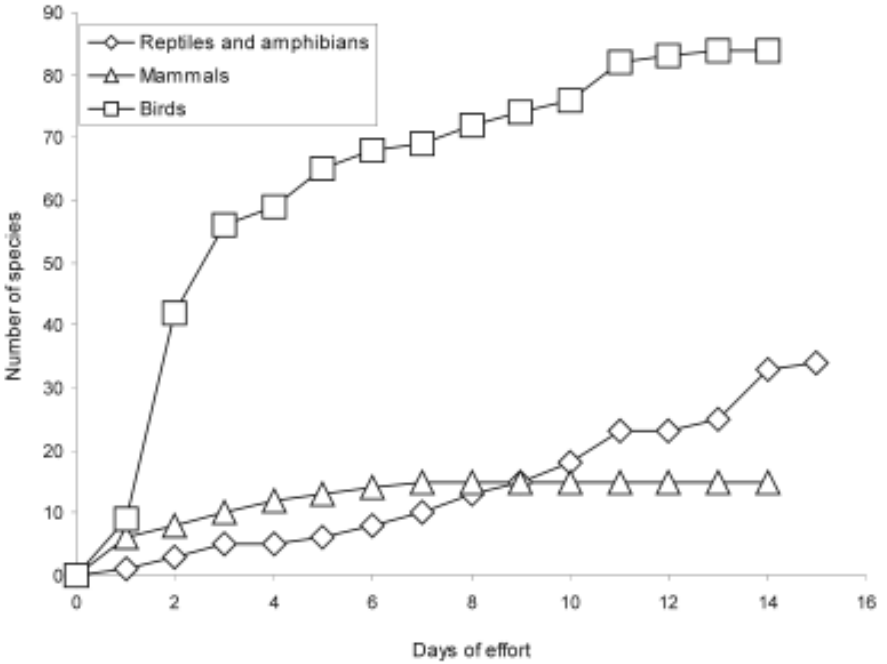

Fig. 3. Species accumulation curves showing the progress of each inventory (birds, mammals, and reptiles and amphibians).

Diverse methods were employed to assemble inventories of species for plants, reptiles and amphibians, birds and mammals. As such, the information (or the depth of information) available for the different taxonomic groups varies in completeness and detail. In general, our studies were carried out by multiple investigators per taxon, during 15-day periods in 1993.

Plants. Field work and collections were made on Cerro Piedra Larga in April and August 1993, each visit lasting 15 days by three botanists. We made systematic sweeps through the areas surrounding the study sites, focusing on the best-preserved vegetation patches, and collecting specimens of plants that were either flowering or fruiting. Appropriate data on date, locality, and habitat were noted to permit proper documentation and identification in the herbarium.

We developed a vegetation profile based on a representative area with a well-preserved pine forest. We delimited an area of 5 x 50 m, and censused all trees with DBH of Æ3.18 cm: we recorded total height (m), circumference at breast height (cm), crown coverage (m) via measurement of major and minor perpendicular

diameters, identification and position within the study area via coordinates in a set of 5 x 5 m cells.

Reptiles and amphibians. Field work and collections were made on Cerro Piedra Larga in April and August 1993, each visit lasting 15 days by three herpetologists. Daily activities included following line transects during approximately 9 hr, beginning late in the morning, and including the afternoon, evening, and part of the night. These efforts were designed to include hours of peak activity of most amphibian and reptile species. In each daily transect, we inspected each microhabitat represented, attempting each day to include different vegetation types and altitudinal zones. Two principal vegetation types —pine-oak forest and tropical deciduous forest (hereafter "dry forest")— were worked most intensively (Fig. 1).

Specimens were collected for the purpose of vouchering identification and permitting additional study. Collections were made by traditional capture techniques (Casas-Andreu *et al.* 1996), complemented by the use of drift-fences and pitfall traps (Vogt & Hine 1982). For each specimen collected, we recorded locality, date, hour of capture, elevation, vegetation type, microhabitat, sex, age, coloration, and activities observed. Specimens were preserved according to accepted herpetological techniques (Pisani & Villa 1974), and were deposited in the Colección Herpetológica, Museo de Zoología "Alfonso L. Herrera," Facultad de Ciencias, Universidad Nacional Autónoma de México (MZFC).

Birds. Four experienced observers and two assistants inventoried the birds of Cerro Piedra Larga from 31 March to 13 April 1993. Two camps were established in mixed humid pine-oak and cloud forest near Aserradero El Aguacate, near San Sebastián Jilotepec, Municipio de Nejapa de Madero, Distrito de Yautepec, Oaxaca, at 2520 m (16° 36.469' N: 95° 48.045' W). Geographic coordinates were determined with a precision of better than 100 m using a Trimble Ensign geographic positioning system.

Ten to 17 mist nets were set in lines of 4-10, crossing each major microhabitat type (humid pine-oak forest, cloud forest, edge habitats). Lines were run for 3-7 days, and then shifted in position, for a total of 169 net-days. Additional records were accumulated by visual observations and by selective hunting. Specimens resulting from these collections were deposited in the Museo de Zoología, Facultad de Ciencias, UNAM, the Field Museum, and the Natural History Museum, University of Kansas.

Mammals. Two experienced mammalogists inventoried the mammals of Cerro Piedra Larga from 31 March to 13 April 1993. Two camps were established in mixed humid pine-oak and cloud forest near Aserradero El Aguacate, near San Sebastián Jilotepec, Municipio de Nejapa de Madero, Distrito de Yautepec, Oaxaca: (1) Aserradero El Aguacate (16° 36.469' N: 95° 48.045' W, 2520 m, pine-oak forest; 7-13 April 1993), and (2) Agua Fría (16° 36.750' N: 96° 48.750' W, 2100-2300 m,

pine-oak forest with isolated patches of cloud forest; 31 March-7 April 1993). Geographic coordinates were determined with a precision of better than 100 m using a Trimble Ensign geographic positioning system. Work was carried out near the end of the dry season (< 100 mm per month), so seed and fruit production were minimal at the time of the study.

Methods employed were the traditional inventory approaches for small-and medium-sized mammals. Ten 12 m nylon mist nets were opened from 18:00-05:00 hr daily, and were checked every 2 hr, for a total of approximately 5000 net-hr of sampling in each habitat. Bats captured were kept in cloth bags in shade until they could be identified and prepared as specimens, and to obtain a sample of their excretions.

We set 160 Sherman traps baited with oatmeal and vanilla along two transects of 80 traps each. We also set two transects of pitfall traps, with 11 buckets buried every 5 m to create a 50 m sampling transect; the buckets were connected via a barrier of plastic that was buried a few centimeters into the soil to guide shrews into the pitfall traps. Medium-sized species were captured using Tomahawk traps baited with sardines. Specimens resulting were deposited in the Museo de Zoología de la Facultad de Ciencias (MZFCUNAM) y en la Colección Nacional de Mamíferos, Instituto de Biología (CNM-IBUNAM), both in the Universidad Nacional Autónoma de México.

Results

Plants. The lower parts of the Cerro are covered with deciduous tropical scrub (Rzedowski 1978). This community is typical of seasonal climates, and is characterized by floristic elements that loose foliage during the dry season. It is dominated by trees that average 5-8 m tall, with some emergents reaching 12 m. Among dominant families are Burseraceae, Leguminosae, Anacardiaceae, and Euphorbiaceae. The shrub layer is 0.5-2 m tall, and is quite diverse, including many species of Leguminosae, Euphorbiaceae, and Verbenaceae. Principal tree species include *Bursera bicolor*, *B. bipinnata*, *Haematoxylum brasiletto, Ceiba parvifolia*, *Acacia farnesiana, A. cochliacantha*, *A. pennatula*, *Alvaradoa amorphoides*, *Stemmadenia obovata*, *Guazuma ulmifolia*, *Lysiloma divaricata*, *Euphorbia schlechtendalii*, *Leucaena esculenta*, *Gyrocarpus jatrophifolius*, *Caesalpinia esclerocarpa*, and *Bucida wigginsiana*.

Between 1800 and 2200 m, a pine-oak forest dominates, with trees 12-25 m tall, and varying in species composition by aspect and by substrate characteristics. On southeast-facing rocky slopes, it is common to encounter *Pinus lawsonii*, *P. pringlei*, and *P. oocarpa*, associated with *Quercus crassifolia*, *Q. acutifolia*, *Q. scytophylla*, *Arbutus xalapensis*, *Nolina longifolia*, *Iresine celosia*, and others. This zone has seen frequent forest fires started for creating pastures and facilitating extraction of wood. For this reason, large open areas in the process of regeneration are common, often with many individuals of *Pinus* spp. 5-10 m tall and a few taller adult examples.

Flowering plants include some orchids, a few Piperaceae, Ericaceae such as *Xolisma squamulosa*, *Arctostaphylos pyrifolia*, Bromeliaceae such as *Pitcairnia* sp., and others.

At 2200-2600 m, on protected northwestern slopes, and in valleys, a forest almost purely of *Pinus* is present, with individuals 15-30 m tall. Among the most important species are *Pinus maximinoi*, *Pinus douglasiana* and *P. ayacahuite*. In more open areas, these species intermingle with *Quercus scytophylla*, *Q. candicans*, *Q. laurina*, *Alnus* spp., *Arbutus xalapensis*, *A. glandulosa*, *Styrax argenteus*, *Myrica cerifera*, *Rapanea juergensenii*, and *Clethra macrophylla*. The shrub and herbaceous layers include species such as *Satureja macrostema*, *Salvia lavanduloides*, *Salvia mexicana*, *Litsea glaucescens*, *Arctostaphylos pyrifolia*, *Vaccinium confertum*, *Xolisma squamulosa*, *Orthrosanthus monadelphus*, *Lotus repens*, and *Lobelia laxiflora*. Fig. 4 shows a diagram of a typical profile of this sort of forest.

The cloud forest is well-developed only in canyons and on humid northwest-facing slopes, between 2200 and 2600 m. This habitat does not occupy a great area, and is restricted to disjunct patches of variable floristic composition. It has two arboreal strata, the taller being made up of 20-30 m trees including *Pinus ayacahuite*, *P. maximinoi*, *Quercus uxoris*, *Q. laurina*, and *Q. candicans*. The lower stratum includes 12-18 m trees, and is dominated by *Cornus disciflora*, *C. excelsa*, *Garrya laurifolia*, *Fuchsia arborescens*, *Styrax argenteus*, *Hedyosmum mexicanum*, *Myrica cerifera*, *Alnus* spp., *Budleia crotonoides*, *Clethra licanioides*, *Senecio aspatensis*, *Inga* sp., *Cleyera theaeoides*, and *Saurauia scabrida*. The shrub and herbaceous layers are rich in tropical species, including *Litsea glaucescens*, *Salvia gracilis*, *Eugenia oerstediana*, *Solanum pubigerum*, *Psychotria* sp., *Palicourea padifolia*, and *Lycianthes* sp. Also common are vines such as *Solandra* sp., *Passiflora sexflora*, *Passiflora membranacea*, *Smilax regelii*, *Mikania pyramidata*, *Marsdenia macrophylla*, and *Sarcostemma* sp. Epiphytes are another important element, including members of the families Bromeliaceae (e.g., *Tillandsia* spp.), Orchidaceae (e.g., *Lemboglossum cervantesii*), and Piperaceae (e.g., *Peperomia* sp.).

Reptiles and amphibians. In all, 34 species were encountered on Cerro Piedra Larga, including eight amphibians of five genera and four families, and 26 reptiles of 21 genera and 12 families (Table 1, Appendix 2). Of species collected, five were taxa endemic to the state of Oaxaca: *Abronia oaxacae*, *Phyllodactylus muralis*, *Tantilla striata*, *Micrurus ephippifer*, and *Ctenosaura oaxacana*. Hence, Oaxaca endemics represented 14.7% of the total fauna.

Species detected were fairly evenly divided between the two habitats (Table 2). Pine-oak forest held 15 species, including snakes (six species) for 40% of the fauna, lizards (five species) 33.3 %, anurans (three species) 20%, and a salamander (6.6%). All species detected in this habitat were diurnal, except the crepuscular *Rhadinaea fulvivittis*. Several species were tree living, including *Abronia oaxacae*, *Sceloporus grammicus*, and *Leptophis diplotropis*; *Chiropterotriton* sp. was found in a bromeliad.

In dry forest, 21 species were found, including lizards (five species) at 23.9% of the fauna, anurans (six species) 28.5%, and snakes (five species) 23.8%. Of species

Table 1. Taxonomic diversity of reptiles and amphibians detected in biotic inventories on Cerro Piedra Larga, Oaxaca.

Taxonomic group	*Families*	*Genera*	*Species*	*% of total species*
Salamanders	1	1	1	2.9
Anurans	3	4	7	20.0
Lizards	7	10	15	42.8
Snakes	4	10	10	31.4
Turtles	1	1	1	2.9
Totals	16	26	34	100.0

encountered, *Phyllodactylus muralis* was nocturnal, and *Bufo canaliferus* was found both in daytime and nighttime. *Trimorphodon biscutatus* was found in daytime in molt, but its activity is usually nocturnal.

Of the 34 species encountered on Cerro Piedra Larga, 27 were restricted to single habitat types (Table 3). The area representing the ecotone between the two

Table 2. Percentages of representation of taxa of amphibians and reptiles divided by vegetation type. Percentages given in columns are relative to the column totals, whereas those given with the column totals refer to the overall total of species encountered.

Taxonomic group	*Pine-oak forest*	*Dry forest*	*Ecotone*
Salamanders	1 (6.6%)	.	.
Anurans	3 (20.0%)	6 (28.5%)	.
Lizards	5 (33.3%)	7 (47.6%)	2 (50.0%)
Snakes	6 (40.0%)	5 (23.8%)	1 (25.0%)
Turtles	.	.	1 (25.0%)
Total	15 (44.1%)	21 (61.7%)	4 (11.7%)

habitats held only four species, of which three were also found in dry forest, and two in pine-oak forest; only the turtle *Rhinoclemmys rubida* was detected solely in the ecotone.

Many species were found on Cerro Piedra Larga only within limited elevational ranges (Table 3, Fig. 5). For example, the lizards *Sceloporus formosus* and *S. grammicus* were found in pine-oak forest, but only below 2620 m. The lizard *Anolis quercorum* was found only at 1850-2095 m. Similarly, in dry forest, the lizard *Sceloporus siniferus* was found only at 900-1765 m. Numerous such examples were obtained, in which a species' elevational range was less than that of its habitat.

The distribution of species among different microhabitats is of special interest to understanding the structure of the community in which they live. Reptile and

amphibian species were found to use four principal microhabitats on Cerro Piedra Larga, including on and below the forest floor, in trees, and on rock walls (Table 4). Twenty species inhabited the forest floor, on and under rocks, on or below fallen logs, in leaf litter, in fenceposts, in grass, or among magueys. Some species, such as *Sceloporus siniferus*, were observed to use numerous niches on the forest floor. Among arboreal species, the salamander *Chiropterotriton* sp. was found in a bromeliad; other species were reptiles found in shrubs, in trees, or on fenceposts. Fossorial species included several snakes, which were found typically beneath rocks and trunks; finally, the lizard *Urosaurus bicarinatus* used rock walls extensively, in addition to the forest floor.

It is important to point out that Cerro Piedra Larga was visited only twice for herpetological studies, owing in large part to the difficulty of access to the higher

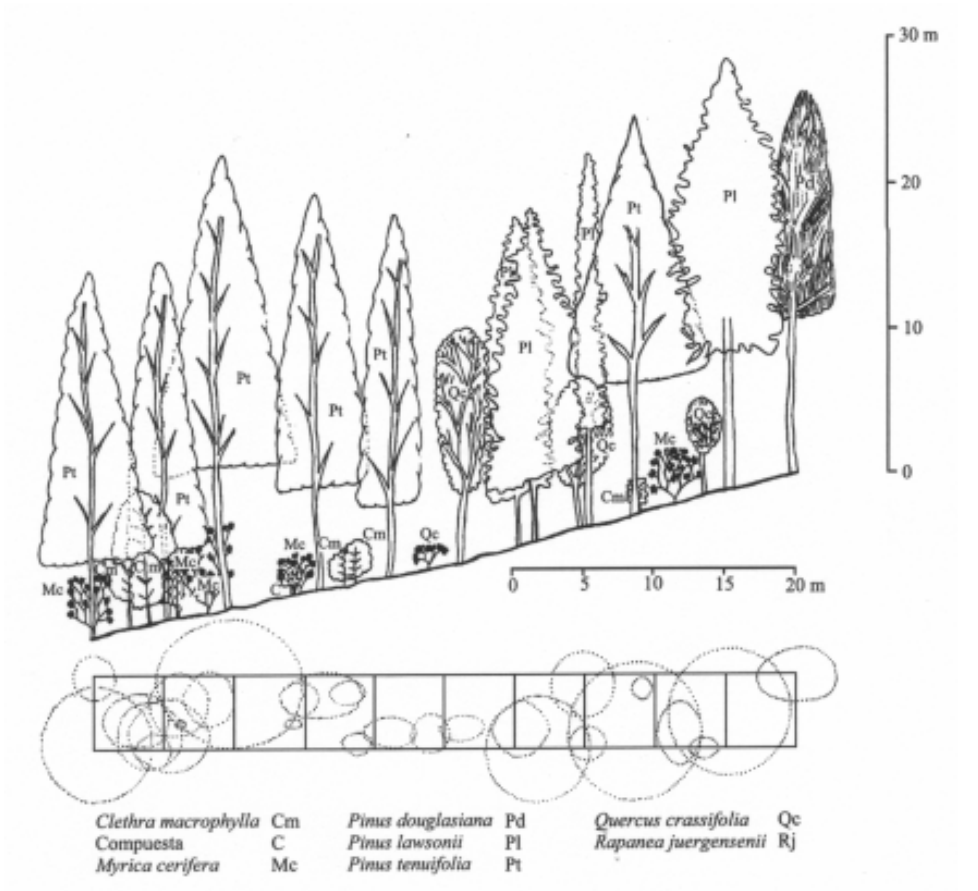

Fig. 4. Vegetation profile of Cerro Piedra Larga. See text for explanation.

portions of the mountain. The total of 34 species detected thus compares favorably with 26 species in the vicinity of San Cristóbal de las Casas (Hernández M. 1992), and 37 species in Omiltemi, Guerrero (Flores V. & Muñoz 1993). Although this comparison indicates that the zone is probably herpetologically quite rich, the preliminary nature of the inventory reported herein must be emphasized.

Three of the species documented herein represent extensions to known geographic distributions. The snake *Tantilla striata* was previously known from a single locality 61 km NE of Cerro Mixtequilla, Oaxaca (Wilson 1990). The record of the frog *Hyla bistincta* may represent the southernmost record of the species, which is otherwise known from localities in the northern highlands of Oaxaca (Duellman 2001). Finally, the presence of the lizard *Abronia oaxacae* on Cerro Piedra Larga represent an eastward extension of the species' known distribution, the nearest known localities being Santo Domingo Chontecomatlán, in the Sierra Madre del Sur, and Sierra de Juárez, in northern Oaxaca (Cambell & Frost 1993).

No plethodontid salamander of the genus *Chiropterotriton* was indicated for the Cerro Piedra Larga region in the most recent taxonomic revision (Darda 1994), probably for lack of material for study from the area. The individual collected on Cerro Piedra Larga belongs to the "Southern Group" (Darda 1994). Previous Oaxaca records included the southern extreme of the Sierra Madre Oriental, and a probable population in the Sierra Madre del Sur. Because the relationships and taxonomic

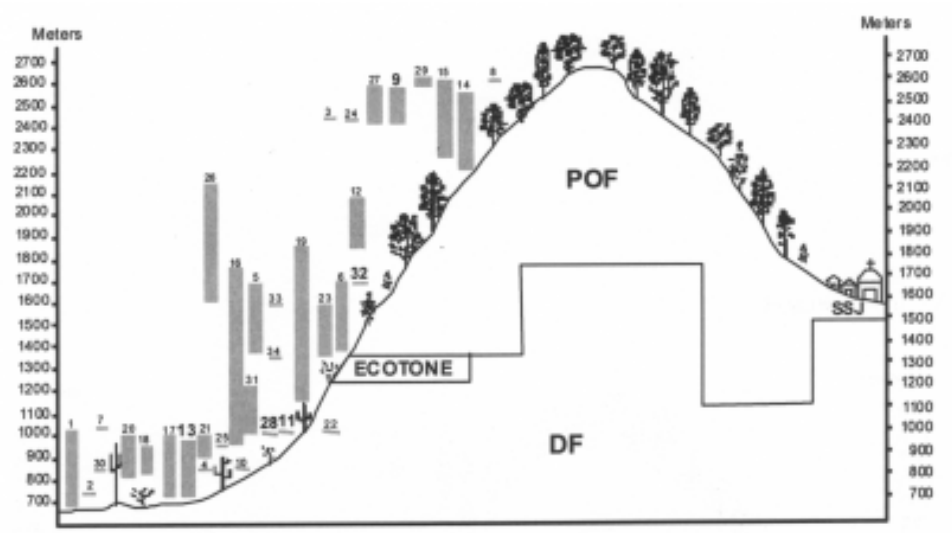

Fig. 5. Elevational distribution of reptile and amphibian species on Cerro Piedra Larga, Oaxaca. Numbers refer to species in Appendix 2. Oaxaca endemic species are indicated with bold numbers. DF = dry forest, POF = pine-oak forest, SSJ = San Sebastián Jilotepec.

status of these populations remains problematic, the specific identification of the individual collected on Cerro Piedra Larga must await more detailed study.

Some reptile and amphibian species on Cerro Piedra Larga were found only in the pine-oak forest, and others principally in the dry forest; one was found only in the ecotone between the two habitats. These patterns clearly are the product of sets of causal factors, including both biotic factors (e.g., vegetation characteristics, competitive and mutualistic interactions with other species) and abiotic factors (e.g., altitude, humidity, etc.).

An excellent example of the effect of these ecological restrictions is that of the *Chiropterotriton* salamanders, which are typically found only in situations of high humidity in forests with abundant epiphytes. Wake (1987) indicated that most of these salamanders inhabit bromeliads, probably because of abundant food resources, egg deposition sites, and buffering against extremes of temperature and humidity. In contrast, *Abronia oaxacae* is usually considered restricted to pine-oak forests (Bogert & Porter 1967). As for dry forest, several species were found that appear restricted to arid zones, including *Urosaurus bicarinatus* and *Sceloporus siniferus* (Duellman 1966, Sánchez & López-Forment 1988).

Because the pine-oak forest on Cerro Piedra Larga is surrounded by dry forest, it is effectively an island, probably isolated during the climatic fluctuations related to glaciations in the Pleistocene. The pine-oak forests in the area are distinct from the surrounding habitats, suggesting differentiation of the faunas of the habitats. Hence, we consider the fauna of the pine-oak forests of Cerro Piedra Larga to represent an isolated montane fauna.

Twelve of the 15 species found in this habitat were not found in the adjacent dry forest (including an unidentified *Hyla* tadpole and a shed *Senticolis triapis* skin). Of these, five are from the mountains both to the north and to the south of the isolated Cerro Piedra Larga, (*Chiropterotriton* sp., *Abronia oaxacae*, *Sceloporus formosus*, *Eumeces brevirostris*, and *Thamnophis godmani*). Five are known only from the mountains to the north (*Hyla bistincta*, *Sceloporus grammicus*, *Anolis quercorum*, *Rhadinaea fulvivittis*, and *Crotalus ravus*), whereas the other three are known only from the mountains to the south. Hence, the montane herpetofauna of Cerro Piedra Larga shows affinities to both mountain systems. For this reason we can not say Cerro Piedra Larga represents a characteristic local fauna. It is worth mentioning that the *Chiropterotriton* may represent an undescribed species and that in all likelihood the populations from the mountains north of Cerro Piedra Larga are specifically distinct from those to the south.

The herpetofauna of the dry forest shows strong influence of the Isthmus of Tehuantepec. Indeed,of the 21 species found in that habitat, 13 are also found on the Isthmus (Hartweg & Oliver 1940). Most likely, the dry valley of the Río Tehuantepec acts as a dispersal corridor for these faunas, whereas the long and complex series of habitat types connecting the area to the Oaxaca Valley may serve as an effective filter barrier to dispersal.

In total, five species endemic to the state of Oaxaca were detected in the area: three in dry forest, and two in pine-oak forest. For example, *Abronia oaxacae* is restricted to the pine-oak forests of the Sierra Madre del Sur (Bogert & Porter 1967). *Ctenosaura oaxacana* is a recently described species for the Isthmus of Tehuantepec, but was long referred to *C. quinquecarinata* by many herpetologists (Bailey 1928, Gicca 1983, de Quieroz 1995).

Ecotones between two habitats can hold both mixtures of the faunas of each, or can possess distinct faunal elements (Cox & Moore 1980, Pianka 1982). In the ecotonal zone on Cerro Piedra Larga, we encountered only four species, three of which were also found in dry forest (*Sceloporus siniferus*, *Lepidophyma smithi* and *Leptotyphylops goudoti*). One species, the turtle *Rhynoclemys rubida*, was found only in the ecotone, although the species has been found at a nearby locality (El Camarón) in dry forest, suggesting that the species would also be found in that habitat near Cerro Piedra Larga.

Altitudinal distributions of species tend to follow particular patterns in Mexico (Wake & Lynch 1976, Flores V. 1993, Peterson *et al.* 1993), such as that species richness declines with elevation. This pattern was present, although not marked, in the Cerro Piedra Larga herpetofauna. Twenty-one species were found in the low-elevation dry forest, whereas 15 species were found in the high-elevation pine-oak forest. Because inventory intensity was greatest in the pine-oak forest, we suspect that this pattern would be even more pronounced if the inventories were completed.

The diversity of microhabitats present in an area, or spatial heterogeneity, is an important factor in determining how many species may live in an area (Cox & Moore 1980). Within the broad category of ground surface microhabitats, for example, the lizard *Sceloporus siniferus* was found in seven distinct microhabitats, which is probably why this species is found across a broad swath of elevations. Others are much more specific, such as the plethodontid salamander *Chiropterotriton* sp., which was found only in bromeliads, as is usual for the group (Wake 1987).

Birds. A total of 84 species was encountered in the humid montane forests on Cerro Piedra Larga (Appendix 3). Of these, 59 probably breed on the mountain, and the remaining 25 are passage migrants or winter residents. Faunal accumulation curves (Fig. 3) leveled off after 11 days, indicating that the inventory effort was more or less complete.

By far the dominant species, both in mist nets and in observations, was the nightingale-thrush *Catharus occidentalis*; other common species included the hummingbird *Hylocharis leucotis*, the jay *Cyanocitta stelleri*, the warbler *Basileuterus belli*, and the brush-finch *Atlapetes brunneinucha*. The list for the site also includes several rare and poorly known species (Binford 1989), such as the Maroon-fronted Ground-dove *Claravis mondetoura*, the Military Macaw *Ara militaris*, and the Northern Saw-whet owl *Aegolius acadicus*.

Cerro Piedra Larga, therefore, represents the last island of humid montane forest before the lowland barrier of the Isthmus of Tehuantepec. Cerro Piedra

Larga, at 95 48' W longitude, lies isolated between two mountain ranges, one to the north and one to the south (Fig. 1). Hence, this island is both marginal and isolated between the two coastal mountain ranges, and Cerro Piedra Larga records of many montane forest species represent considerable range extensions south and east towards the Isthmus of Tehuantepec (*e.g.*, *Cyrtonyx montezumae*, *Dendrortyx macroura*, *Otus flammeolus*, *Aegolius acadicus*, *Catharus occidentalis*, and *Ridgwayia pinicola*, among others).

Cerro Piedra Larga's avifauna includes most of the species typical of humid montane forests in southern Mexico (Binford 1989, Navarro-Sigüenza 1992, Torres-Chávez 1992, Hernández-Baños *et al.* 1995). Species occurring in similar habitats on other mountain ranges west of the Isthmus of Tehuantepec in Oaxaca, but not detected on Cerro Piedra Larga, include *Otus trichopsis*, *Glaucidium gnoma*, *Strix varia*, *Amazilia beryllina*, *Eupherusa* spp., *Tilmatura dupontii*, *Atthis heloisa*, *Anabacerthia variegaticeps*, *Automolus rubiginosus*, *Xiphocolaptes promeropirhynchus*, *Xiphorhynchus flavigaster*, *Empidonax affinis*, *E. difficilis*, *E. fulvifrons*, *Cyanolyca* spp., *Catharus aurantiirostris*, *Dendroica graciae*, *Myioborus miniatus*, *Piranga flava*, *P. erythrocephala*, *Chlorospingus ophthalmicus*, *Icterus graduacauda*, *Loxia curvirostra*, and *Carduelis notata*. Of these species, several are rare and often difficult to detect (*e.g. Tilmatura dupontii*, *Strix varia*) or show seasonal movements (*e.g. Amazilia beryllina*, *Carduelis notata*); others perhaps require the existence of humid forests at adjacent lower elevations (*e.g. Anabacerthia variegaticeps*, *Eupherusa* spp.). However, our failure to detect several species almost certainly reflects their absence from the humid montane forests of Cerro Piedra Larga: *Xiphorhynchus flavigaster*, *Myioborus miniatus*, and most notably *Chlorospingus ophthalmicus*, all of which are common and easily detectable when present in an area.

Two peculiar features of the avifauna of Cerro Piedra Larga deserve further comment. First, very few representatives of the neotropical families Dendrocolaptidae (only *Lepidocolaptes affinis*) and Furnariidae (none) were found; even the neotropical flycatchers (Tyrannidae) seemed less common than on other mountain ranges in Oaxaca. This imbalance has also been noted on other islands of humid montane forest isolated amid dry forest (Morales-Pérez & Navarro-Sigüenza 1991).

Second, the relative abundances of the nightingale-thrushes *Catharus occidentalis* and *C. frantzii* were strikingly uneven. We netted *C. occidentalis* 69 times, and *C. frantzii* but twice, a 35-fold difference. These two species were for many years confused by systematists, and often occur syntopically (Phillips 1969), but their abundances seem rarely to be balanced. We have detected no obvious feature of vegetation or habitat type associated with which species is dominant, so further study of the habitat use and ecological requirements of this species pair will be necessary to understand factors affecting their relative abundances.

The position of Cerro Piedra Larga intermediate between the mountains of eastern and western Mexico was the reason that we chose the mountain for careful study. The arid pine-oak forest connection to the eastern end of the Sierra de

Miahuatlán (Fig. 1), led us to expect affinities with the Sierra Madre del Sur of southern Oaxaca and Guerrero. However, our study of the specimens resulting from the inventory did not support this prediction.

For seven species, it was possible to determine the subspecific affinities and distinguish between eastern and western origins of the Cerro Piedra Larga populations. The quail *Cyrtonyx montezumae* is known in Oaxaca only from the Sierra Madre del Sur and the mountains of the interior (Binford 1989), and hence is of western affinities. The quail-dove *Claravis mondetoura*, although not previously known from Oaxaca, has been recorded in Mexico only in Chiapas and southern Veracruz (Howell 1992), and hence has decidedly eastern affinities. The owl *Aegolius acadicus* is known in Oaxaca reliably only from the vicinity of Cerro San Felipe in the northern interior of the state (Binford 1989), a forest island belonging to the interior-western group identified by Hernández-Baños *et al.* (1995). For the hummingbird species complex *Lampornis amethystinus*, which is represented by forms with pink or blue throats distributed in a mosaic across southern Mexico (Phillips 1966), we collected examples of both forms from the same net line, providing the first evidence of sympatry of the two forms (Torres-Chávez *et al.* in prep.), and indicating the presence of populations of western (*L.* [*a.*] *margaritae*) and of largely eastern (*L.* [*a.*] *amethystinus*) affinity. The toucanet *Aulacorhynchus* [*prasinus*] *prasinus* of the east, separable at the species level from the western Mexican populations *A.* [*p.*] *wagleri* (Navarro-Sigüenza *et al.* 2002), was identified on the basis of remains in the posession of local residents. Finally, the antpitta *Grallaria* [*guatimalensis*] *ochraceiventris* of the west, separable at the species level from the eastern *G.* [*g.*] *guatimalensis* (Navarro-Sigüenza *et al.* in prep.) was collected. Therefore, in all, we encountered four forms with affinities in the west or interior of Oaxaca, and three forms with affinities to eastern Oaxaca, and the avifauna of Cerro Piedra Larga is seen to consist of a mixture of the two avifaunas.

The discovery and documentation of the avifauna of Cerro Piedra Larga as a mixture of eastern and western avifaunas changes considerably the picture of isolated insular (montane) faunas (Hernández-Baños *et al.* 1995). Formerly, the two faunas were almost without exception thought to be allopatric, and any isolated peak would be quickly determinable as "eastern" or "western," on the basis of a few records. Cerro Piedra Larga, however, combines elements of both faunas, probably owing to random colonization from mountains to the north and south across the dry, lowland barriers. For the first time, then, montane avifaunas in Mexico are seen to show mobility and ability to colonize remote regions, and form novel faunistic combinations.

Mammals. We recorded 15 species of four orders, nine families and 16 genera (Appendix 4). Bats were the most diverse group, with eight species, followed by rodents (four species), artiodactyls (two species), and insectivores (one species).

Both localities sampled showed a mixture of pure pine-oak forest with restricted patches of cloud forest. In all, ten species were of nearctic distribution, being

distributed principally to the north of Cerro Piedra Larga (*e.g.*, *Cryptotis mexicana*, *Neotoma mexicana*, *Pteronotus parnelli*, *Mormops megalophylla*), whereas three (*Dermanura azteca*, *Carollia perpicilliata*, *Sturnira lilium*) are of neotropical distribution (Goodwin 1969). Overall, the mammal fauna at Cerro Piedra Larga showed a similar pattern of mixture of nearctic and neotropical affinities, as in other mountain ranges (Briones *et al.* 2001, Sánchez-Cordero 2001).

Discussion and conclusions

We present herein a preliminary biotic inventory of Cerro Piedra Larga, an isolated massif in Oaxaca, southern Mexico. This massif, which had not previously seen any detailed floristic or faunistic study, resulted quite interesting for a number of reasons. Concerted study of several taxonomic groups made the results all the more intriguing.

The first surprise was the existence of patches of cloud forest at high elevations on such an isolated interior mountain massif. This habitat, which includes a number of floristic elements characteristic of cloud forests elsewhere, is otherwise restricted in Oaxaca to the Sierra Madre Oriental, the Sierra Madre del Sur, and a few isolated mountains in northern Oaxaca (Rzedowski 1978, Binford 1989). Hence, the discovery of cloud forest patches on Cerro Piedra Larga provides a fascinating isolated example of this habitat.

Perhaps most interesting was the pattern of geographic affinities of the high-elevation faunas on Cerro Piedra Larga. Among birds, reptiles, and amphibians, we were able to distinguish a series of species that have clear affinities to eastern Mexico (northern Oaxaca) or western Mexico (southern Oaxaca). The usual understanding of cloud forest biogeography emphasizes vicariance, with areas relatively continuous in the Pleistocene being subdivided under warmer climate regimes during interglacial periods. This scenario would predict previous connection of mountain masses over the past several tens of thousands of years, and would suggest sharing of faunas with the regions with which connections were most recently shared (Hernández-Baños *et al.* 1995).

The pattern of affinities observed on Cerro Piedra Larga, however, did not fit this pattern. The quite-distinct faunas of the Sierra Madre Oriental *versus* the Sierra Madre del Sur each have contributed species to the fauna of this massif, and the mountain's faunas are seen to be a mixture of the two faunas. This result indicates a new process in montane vertebrate biogeography: colonization across dry lowland barriers.

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Appendix 1. List of plant species encountered on Cerro Piedra Larga, Oaxaca, Mexico.

Species	*BPQS*	*BPQH*	*BMM*
Actinidaceae			
Saurauia scabrida Hemsl.			X
Amaranthaceae			
Iresine celosia L.		X	X
Alstroemeriaceae			
Bomarea hirtella (Kunth) Herb.			X
Aquifoliaceae			
Ilex discolor Hemsl.			X
I. quercetorum I.M. Johnst.			X
Araliaceae			
Oreopanax xalapensis (Kunth) Decne. et Planch.			X
Asclepiadaceae			
Gonolobus sp.			X
Marsdenia macrophylla (Humb. et Bonpl. ex Schult.) E. Fourn.		X	X
Sarcostemma sp.		X	X
Asteraceae			
Calea scabra (Lag.) B.L. Rob.			X
Erigeron karvinskianus DC.		X	X
Eupatorium chiapense B.L. Rob.		X	
Eupatorium cremastum B.L. Rob.			X
Eupatorium mairetianum DC.			X
Eupatorium pycnocephalum Less.		X	
Eupatorium pazcuarense Kunth		X	X
Eupatorium sp.			X
Gnaphalium americanum Mill.	X	X	
Gnaphalium attenuatum DC.		X	X
Gnaphalium roseum Kunth		X	X
Hieracium irazuense Benth.		X	
Hieracium sp.			X
Mikania pyramidata Donn. Sm.			X
Rumfordia attenuata B.L. Rob.			X
Schistocarpha seleri Rydb.			X
Senecio aspatensis (Coult.) Greenm.			X
Senecio jurgensenii Hemsl.		X	X
Senecio polypodioides Greene		X	
Stevia triflora DC.	X	X	
Verbesina nelsonii B. L. Rob. et Greenm.		X	X
Begoniaceae			
Begonia fusca Liebm.			X

BPQS = arid pine-oak forest, BPQH = humid pine-oak forest, and BMM = cloud forest.

Appendix 1. *Continues.*

Species	*BPQS*	*BPQH*	*BMM*
Betulaceae			
Alnus acuminata Kunth subsp. *arguta* (Schltdl.) Furlow		X	X
Alnus jorullensis Kunth		X	X
Bromeliaceae			
Catopsis sp.		X	X
Pitcairnia sp.	X		
Buddlejaceae			
Buddleia crotonoides A. Gray		X	
Cactaceae			
Aporocactus flagelliformis (L.) Lem.			
Caprifoliaceae			
Viburnum discolor Benth.			X
Caryophyllaceae			
Arenaria lanuginosa (Michx.) Rohrb.		X	X
Stellaria cuspidata Willd. ex Schltdl.		X	
Chloranthaceae			
Hedyosmum mexicanum C. Cordem.			X
Clethraceae			
Clethra licanioides Standl. et Steyerm.			X
Clethra macrophylla M. Martens et Galeotti		X	X
Cornaceae			
Cornus disciflora DC.			X
Cornus excelsa Kunth			X
Crassulaceae			
Sedum sp.			X
Cucurbitaceae			
Cyclanthera ribiflora (Schltdl.) Cogn.			X
Cistaceae			
Helianthemum pringlei S. Watson	X		
Dryopteridaceae			
Dryopteris pseudofilix-mas (Fée) Rothm.			X
Phanerophlebia macrosora (Baker) Underw.			X
Polystichum distans E. Fourn.			X
Ericaceae			
Arbutus glandulosa M. Martens et Galeotti		X	
Arctostaphylos aff. *longifolia* Benth.			X
A. pyrifolia (Donn. Sm. ex Loes.) Standl. et Steyerm.	X	X	
Gaultheria odorata Bredem. ex Willd.		X	X
Vaccinium confertum Kunth	X		
Xolisma squamulosa (M. Martens et Galeotti) Small			X
Fagaceae			
Quercus candicans Née		X	X
Q. crassifolia Humb. et Bonpl.	X	X	

Appendix 1. *Continues.*

Species	*BPQS*	*BPQH*	*BMM*
Q. laurina Bonpl.		X	X
Q. scytophylla Liebm.		X	X
Q. uxoris McVaugh			X
Garryaceae			
Garrya laurifolia Hartw. ex Benth.			X
Gesneriaceae			
Moussonia deppeana (Schltdl. & Cham.) Hanst.			X
Iridaceae			
Orthrosanthus monadelphus Ravenna		X	
Lamiaceae			
Salvia gracilis Benth.		X	X
S. lavanduloides Kunth		X	X
S. mexicana L.			X
S. aff. *recurva* Benth.			X
Satureja macrostema (Benth.) Briq.		X	X
Stachys repens M. Martens et Galeotti			X
Lauraceae			
Litsea glaucescens Kunth			X
Leguminosae			
Astragalus guatemalensis var. *brevidentatus* (Hemsl.) Barneby		X	
Crotalaria mollicula Kunth		X	
Inga sp.			X
Lotus repens (G. Don.) Sessé et Moc. ex Standl. et Steyerm.		X	
Lupinus sp.		X	
Lentibulariaceae			
Pinguicula moranensis Kunth			X
Lobeliaceae			
Lobelia gruina Cav.		X	X
L. laxiflora Kunth			
Melastomataceae			
Miconia glaberrima (Schltdl.) Naudin			X
M. mexicana (Bonpl.) Naudin			X
Tibouchina galeottiana (Triana) Cogn.			X
Myricaceae			
Myrica cerifera L.		X	X
Myrsinaceae			
Ardisia nigropunctata Oerst.			X
Rapanea juergensenii Mez			X
Myrtaceae			
Eugenia oerstediana O. Berg			X
Nolinaceae			
Nolina longifolia (Karw. ex Schult. f.) Hemsl.	X		
Onagraceae			
Fuchsia arborescens Sims			X

Appendix 1. *Continues.*

Species	*BPQS*	*BPQH*	*BMM*
Fuchsia sp.	X	X	
Lopezia racemosa Cav.			X
Orchidaceae			
Isochilus unilateralis B.L. Rob.	X		
Lemboglossum maculatum (La Llave et Lex.) Halb.		X	X
Lemboglossum cervantesii (La Llave et Lex.) Halb.			X
Passifloraceae			
Passiflora membranacea Benth.			X
P. sexflora Juss.			X
Pinaceae			
Pinus ayacahuite C. Ehrenb. ex Schltdl.		X	X
P. douglasiana Martínez		X	
P. lawsonii Roezl ex Gordon		X	
P. maximinoi H. E. Moore		X	X
P. oocarpa Schiede ex Schltdl.	X	X	
Piperaceae			
Peperomia sp.			X
Piper amalago L.			X
P. scabrum Sw.			X
Polygalaceae			
Monnina xalapensis Kunth			X
Ranunculaceae			
Anemone mexicana Kunth		X	
Rosaceae			
Holodiscus argenteus (L.f.) Maxim.		X	X
Prunus brachybotrya Zucc.			X
P. salasii Standl.		X	
Rubiaceae			
Galium mexicanum Kunth			X
Hoffmannia conzattii B.L. Rob.			X
Nertera granadensis (Mutis ex L. f.) Druce		X	
Palicourea padifolia (Willd. ex Roem. et Schult.) C.M. Taylor et Lorence			X
Psychotria pubescens Sw.			X
Relbunium hypocarpium (L.) Hemsl.		X	
Saxifragaceae			
Heuchera sp.		X	
Scrophulariaceae			
Calceolaria mexicana Benth.			X
Smilacaceae			
Smilax regelii Killip et C.V. Morton		X	
Solanaceae			
Cestrum anagyris Dunal			X
Cestrum sp.			X

Appendix 1. *Continues.*

Species	*BPQS*	*BPQH*	*BMM*
Lycianthes amatitlanensis (J.M. Coult. et Donn. Sm.) Bitter			X
Physalis amphitricha (Bitter) Standl. et Steyerm.			X
P. philadelphica Lam.		X	X
Solandra sp.			X
Solanum aligerum Schltdl.	X		
S. appendiculatum Kunth ex Dunal		X	
S. lanceolatum Cav.		X	X
S. pubigerum Dunal		X	
S. nigricans M. Martens et Galeotti		X	
S. tacanense Lundell			X
Styracaceae			
Styrax argenteus C. Presl.			X
S. polyneurus Perkins			X
Theaceae			
Cleyera theaeoides (Sw.) Choisy		X	X
Urticaceae			
Myriocarpa longipes Liebm.			X
Valerianaceae			
Valeriana palmeri A. Gray		X	X
Violaceae			
Viola guatemalensis W. Becker			X

Appendix 2. Distribution of species of amphibians and reptiles by vegetation type, altitudinal interval, and use of microhabitat types on Cerro Piedra Larga, Oaxaca.

Species	*Microhabitat*	*Pine-oak*	*Dry forest*	*Ecotone*	*Elevation (m)*
Bufonidae					
Bufo canaliferus	Ff		x		670-1005
B. marinus	Ff		x		725
Hylidae					
Hyla bistincta	Ff	x			2425
H. sumichrasti			x		850
H. sp.		x	x		1375-1670
Ptychohyla leonhardschultzei		x	x		1375-1670
Leptodactylidae					
Eleutherodactylus pipilans	Ff		x		1020-1030
Plethodontidae					
Chiropterotriton sp.	A	x			2600
Anguidae					
Abronia oaxacae	A	x			2405-2580
Eublepharidae					
Coleonyx elegans	A		x		850
Gekkonidae					
Phyllodactylus muralis	Ff		x		1005
Iguanidae					
Anolis quercorum	Ff, A	x			1850-2095
Ctenosaura oaxacana	A		x		725-980
Sceloporus formosus	Ff, A	x			2200-2540
S. grammicus	A	x			2285-2610
S. siniferus	Ff		x	x	950-1765
S. smithi	Ff		x		725-1000
Urosaurus bicarinatus	Ff		x		840-945
Scincidae					
Eumeces brevirostris	Ff	x			1140-1855
Teiidae					
Aspidoscelis deppii	Ff		x		830-1005
A. guttata	Ff		x		920-1000
A. motaguae	Ff		x		1005
Xantusiidae					
Lepidophyma smithi	Ff		x	x	1350-1590
Colubridae					
Senticolis triapis		x			2425
Enulius flavitorques	Ff		x		950
Leptophis diplotropis	A	x	x		1605-2145
Rhadinaea fulvivittis	Ff	x			2405-2580

Ff= Forest floor; A= Arboreal; F= fossorial

Appendix 2. *Continues.*

Species	*Microhabitat*	*Pine-oak*	*Dry forest*	*Ecotone*	*Elevation (m)*
Tantilla striata	Ff		x		1000
Thamnophis godmani	Ff	x			2580-2610
Trimorphodon biscutatus			x		845
Leptotyphlopidae					
Leptotyphlops goudoti	Ff		x	x	1005-1225
Elapidae					
Micrurus ephippifer	Ff	x			1610
Viperidae					
Crotalus ravus	Ff	x			1590
Bataguridae					
Rhynoclemmys rubida	Ff			x	1351

Appendix 3. Bird species recorded in humid montane forests on Cerro Piedra Larga, Oaxaca, 31 March - 13 April 1993. Species likely to breed on the mountain are indicated in the "Breeds" column.

Species	*Breeds*	*Mar 31*	*Apr 1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Accipiter striatus	?	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Aegolius acadicus	Y	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Aeronautes saxatalis	Y	0	0	1	1	0	0	1	0	0	0	0	1	1	0
Ara militaris	Y	0	0	0	0	0	1	1	1	1	1	1	1	1	0
Atlapetes brunneinucha	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
A. pileatus	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Aulacorhynchus prasinus	Y	0	1	1	1	1	1	0	0	1	0	0	0	0	0
Basileuterus belli	Y	0	1	1	1	1	1	1	1	1	1	1	0	0	0
Bombycilla cedrorum	N	0	1	1	1	0	1	1	0	0	1	1	1	1	0
Buteo brachyurus	Y	0	0	0	0	1	0	0	0	0	0	0	1	0	0
B. jamaicensis	Y	0	0	1	1	1	1	0	1	0	1	0	1	1	0
Buteogallus anthracinus	Y	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Caprimulgus vociferus	?	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Cardellina rubrifrons	N	0	0	1	0	0	1	0	0	1	0	0	0	0	0
Cathartes aura	Y	0	1	1	1	1	1	1	0	1	0	1	1	1	0
Catharus frantzii	Y	0	1	1	1	1	1	0	0	0	0	0	0	0	0
C. guttatus	N	0	0	0	0	1	1	1	0	0	1	1	0	1	0
C. occidentalis	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Catherpes mexicanus	Y	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Certhia americana	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Chaetura vauxi	?	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Claravis mondetoura	?	0	0	0	0	0	0	0	0	1	0	1	1	0	0
Colaptes [auratus] cafer	Y	0	1	1	1	1	1	0	0	0	1	0	0	0	0
Colibri thalassinus	Y	0	0	0	0	0	0	0	1	0	1	0	0	1	0
Columba fasciata	Y	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Contopus pertinax	Y	1	1	1	1	1	0	0	0	0	0	0	0	0	0
C. sordidulus	N	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Coragyps atratus	Y	0	1	0	0	1	0	0	1	1	0	0	1	0	0
Corvus corax	Y	0	1	0	0	1	0	0	0	0	0	0	0	0	0
Cyanocitta stelleri	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cyrtonyx montezumae	Y	0	0	0	0	0	1	1	1	1	1	1	1	1	0
Dendroica auduboni	N	0	1	1	1	0	1	0	0	0	1	1	1	1	0
D. occidentalis	N	0	1	1	1	1	1	1	1	1	1	1	1	1	0
D. townsendi	N	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Dendrortyx macroura	Y	0	0	1	1	1	0	0	0	0	1	1	0	0	0
Diglossa baritula	Y	0	1	0	0	1	0	0	0	0	0	0	0	0	0
Empidonax sp.	?	0	1	0	0	1	1	1	0	0	0	1	1	1	0

Appendix 3. *Continues.*

Species	*Breeds*	*Mar 31*	*Apr 1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Ergaticus ruber	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Eugenes fulgens	Y	0	0	0	0	1	0	0	1	0	0	0	1	0	0
Geococcyx velox	Y	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Grallaria guatimalensis	Y	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Hirundo pyrrhonota	N	0	0	0	0	0	0	0	0	0	0	1	0	0	0
H. rustica	N	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Hylocharis leucotis	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Icterus [galbula] bullockii	N	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Junco phaeonotus	Y	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Lampornis amethystinus	Y	0	0	0	0	0	0	0	1	1	1	1	1	1	0
L. margaritae	Y	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Lepidocolaptes affinis	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Leptotila verreauxi	Y	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Melanerpes formicivorus	Y	0	0	1	1	1	1	1	0	0	0	0	0	1	0
Melanotis caerulescens	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Micrastur semitorquatus	Y	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Mitrephanes phaeocercus	Y	0	0	1	1	1	1	0	0	1	1	1	1	1	0
Myadestes occidentalis	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Myiarchus tuberculifer	Y	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Myioborus pictus	Y	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Oporornis tolmiei	N	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Otus flammeolus	Y	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Parula superciliosa	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Peucedramus taeniatus	Y	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Pheucticus ludovicianus	N	0	0	0	0	0	0	0	0	0	0	0	0	1	0
P. melanocephalus	Y	0	0	0	0	0	0	1	0	0	0	1	1	1	0
Picoides villosus	Y	0	0	1	1	1	1	1	1	1	1	1	1	1	0
Pipilo ocai	Y	0	0	0	1	1	0	1	0	0	0	0	0	1	0
Piranga ludoviciana	N	0	0	1	0	0	0	1	0	0	1	1	0	1	0
Ptilogonys cinereus	Y	0	0	1	1	1	1	0	0	0	1	1	1	1	0
Regulus calendula	N	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Ridgwayia pinicola	Y	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Sphyrapicus varius	N	0	1	1	0	0	1	0	0	0	1	0	1	0	0
Stelgidopteryx serripennis	?	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Streptoprocne zonaris	Y	0	0	0	0	0	0	0	0	1	0	1	1	1	0
Tachycineta thalassina	N	0	0	1	0	0	1	0	0	1	0	1	0	0	0
Troglodytes brunneicollis	Y	0	1	0	1	0	1	0	1	1	1	1	1	1	0
Trogon mexicanus	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	0

Appendix 3. *Continues.*

Species	*Breeds*	*Mar 31*	*Apr 1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Turdus infuscatus	Y	0	1	1	1	1	1	1	1	1	1	1	1	1	1
T. migratorius	Y	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Vermivora celata	N	0	0	1	0	1	0	0	0	0	0	0	0	0	0
V. ruficapilla	N	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Vireo huttoni	Y	0	0	0	0	1	0	0	0	1	1	1	1	1	0
V. solitarius	N	0	1	1	0	0	0	0	0	1	0	0	0	1	0
Wilsonia pusilla	N	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Zonotrichia lincolnii	N	0	1	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 4. List of mammal species encountered on Cerro Piedra Larga, Oaxaca, México.

ORDER INSECTIVORA

Cryptotis mexicana (Coues, 1877)

ORDER CHIROPTERA

Pteronotus parnelli (Gray, 1843)
Glossophaga soricina (Pallas, 1766)
Dermanura azteca (K. Andersen, 1906)
Carollia perspicillata (Linnaeus, 1758)
Sturnira lilium (E. Geoffroy, 1810)
Tadarida brasilensis (I. Geoffroy, 1824)
Mormops megalophylla (Peters, 1864)
Myotis vellifer (Kaup, 1929)

ORDER RODENTIA

Reithrodontomys fulvescens (J.A. Allen, 1894)
Oryzomys alfaroi (J.A. Allen, 1891)
Neotoma mexicana (Baird, 1855)
Sciurus aureogaster (F. Cuvier, 1829)

ORDER ARTIODACTYLA

Odocoileus virginianus (Zimmermann, 1815)
Pecari tayacu (Linnaeus, 1758)