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BIODIVERSITY VIEWPOINT

Conservation priorities in Mexico: moving up in the world

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Abstract. Elevational patterns of species richness and endemism in birds, mammals, reptiles, amphibians, and butterflies, in two mountain ranges in southern Mexico are analysed. In all five taxonomic groups and both mountain ranges, although species richness is concentrated in the lowlands, endemism is concentrated at intermediate and high elevations. If conservation efforts are to focus on the preservation of biotic elements unique to Mexico, efforts should be focused on highland habitats instead of on the highly diverse lowlands.

Key words. Species richness, endemism, altitudinal transects, conservation priorities.

INTRODUCTION

Recent conservation efforts in Mexico have concentrated in lowland rain forest habitats, although most of the country is covered by montane or desert habitats. Lowland rain forests reach their northernmost extreme in central eastern Mexico, and hold, in many taxonomic groups, highly diverse faunas. Hence, conservationists have worked towards the preservation of lowland tropical rain forest habitats in several regions, such as the Lacandon region of eastern Chiapas, Sian Ka'an of the Yucatan Peninsula, and the Calakumul Biosphere Reserve in Campeche.

While applauding these efforts, we are concerned about the biogeographic understanding on which such conservation decisions are based: in Mexico, many other habitats hold diverse and unique floras and faunas (e.g. cloud forest, pine-oak forest, semideciduous tropical forest; Flores-Villela & Geréz 1988). Many of these habitats are as endangered or more so than tropical rain forests in the region, and relatively little area has been set aside for preservation.

In this essay, we argue that conservation efforts in Mexico should take on a much more eclectic orientation, focusing on preservation of the diversity of habitats in the region, and that this orientation should be founded on studies of biogeographic patterns in the region itself rather than on extrapolations from other regions. We present a summary of patterns of species richness and endemism in four vertebrate classes (birds, mammals, reptiles, and amphibians) and one insect order (Lepidoptera) in two mountain ranges in southern Mexico, and discuss its implications for the design and focus of conservation efforts in the country.

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METHODS

For all five taxonomic groups, detailed studies of elevational distributions of species have been conducted with comparable methods in two biogeographically distinct mountain ranges in southern Mexico. The first is the southern slopes of the Sierra Madre del Sur above the Pacific coastal plain in southern Guerrero; habitats at the base of the range are deciduous tropical scrub and semideciduous tropical forest, and higher habitats are cloud forest, humid pine-oak forest, pine forest, fir forest, and on the interior slopes, arid pine-oak forest. The second is the northern slopes of the Sierra de Juárez above the Atlantic coastal plain in northern Oaxaca; the elevational sequence of habitats is from lowland rain forest up through cloud forest, humid pine-oak forest, pine forest, fir forest, and on the interior slopes, arid pine-oak forest. Hence, although differing in the habitats at the lowest elevations, the two mountain ranges present similar habitat sequences at higher ones.

Data presented herein are based on 10 years (1980–9) of intensive study in the Sierra Madre del Sur of Guerrero by members of the Museo de Zoología, concentrating in the Sierra de Atoyac along an altitudinal transect from Atoyac de Alvarez to Cerro Teotepec (the highest point in the range) and in the vicinity of Omiltemi west of Chilpancingo. This information is supplemented by less intensive work in the Sierra de Taxco to the north and the Sierra Madre del Sur above Zihuatanejo west of Acapulco. Primary taxonomic and distributional works resulting from these surveys in Guerrero are as follows: birds—Navarro-Sigüenza (1986, 1992) and Morales-Pérez (1989); mammals—Jiménez-Almaraz (1991), León-Paniagua (unpubl.); reptiles and amphibians—Flores-Villela & Muñoz-Alonso (in review), Hernández-García & Flores-Villela (in prep.), and Flores-Villela (1991); and Lepidoptera—Llorente-Bousquets, Luis-Martínez & Vargas-Fernández (1990) and Vargas-Fernández, Llorente-Bousquets & Luis-Martínez (1991, in press). Members of the Museo de Zoología have conducted studies in the Sierra de Juárez from 1985 to the present, concentrating on the humid northern slope between Cerro Pelón (the highest point) and Valle Nacional, supplemented by visits to the nearby Cerro Zempoaltépetl. Publications summarizing the results of these studies include the following: birds—Peña and Torres-Chávez (Torres-Chávez, 1992); mammals—León-Paniagua (unpubl.); reptiles and amphibians—Flores-Villela (1991), Flores-Villela & Geréz (1988), and Hernández-García & Flores-Villela (in prep.); and Lepidoptera—Luis Martínez, Vargas-Fernández & Llorente-Bousquets (1991).

Endemism is discussed at the national level. We considered as endemic species restricted to Mexico and a limited portion of southeastern Arizona, southwestern New Mexico, and western Texas, as these areas hold the northernmost extremes of the uniquely Mexican pine-oak woodland habitats. We also examined endemism in a nonpolitical manner by analysing richness of species of restricted range, and by analysing average latitudinal range widths of species in different habitats and at different altitudes. Determination of rare and local distributions are based on published descriptions, and on our own field experience. Data on latitudinal ranges of bird and mammal species are based on range summaries in AOU (1983), Hall (1981), and Eisenberg (1989), with latitudinal limits estimated to the nearest 2°. Taxonomic sources are AOU (1983) and Hall (1981) for birds and mammals, respectively.

PATTERNS OF DISTRIBUTION, SPECIES RICHNESS, AND ENDEMISM

Species richness in all five groups is clearly concentrated in lowland habitats (Fig. 1). In general, lowland rain forest or semideciduous tropical forest holds the greatest number of species. Species richness declines rapidly with elevation, reaching a low of 6–43% of the rain forest total in fir forest (Fig. 1). For example, 238 bird species are known from the tropical rain forest at the base of the Sierra de Juárez, 124 from the cloud forest immediately above, and 108, 91, and 55 species in the pine-oak, pine, and fir forests, respectively. Hence, species richness is consistently highest in lowland tropical habitats and reduced in montane habitats.

Endemism, however, shows a very different altitudinal pattern, being low in lowland tropical forests in both mountain ranges, and increasing rapidly with altitude (Fig. 1). Percentage endemism is 6–51% in the lowlands, but rises to 22–100% in montane forests. For example, in birds, only four of 238 species (1.7%) in the lowland rain forest at the base of the Sierra de Juárez are endemic to Mexico. However, seven of 124 cloud forest bird species (5.6%), eighteen of ninety-one pine forest bird species (18.7%), and twelve of fifty-five fir forest species (21.8%) are endemic to Mexico. These elevational changes in levels of endemism mirror closely patterns documented in other taxonomic groups and regions (e.g., Patterson, 1982). As is evident from Fig. 1, species richness and endemism show opposite trends along the altitudinal transects in both mountain ranges. These trends are similar when the number of endemic species, rather than percentage endemism, is examined.

Species of restricted distribution or of extremely spotty occurrence are a much more heterogeneous grouping, and their distributional patterns are more complex (Fig. 2). However, all five taxa/regions for which data are available (birds and butterflies in both, and mammals in Oaxaca) have higher frequencies of geographically restricted or rare species in cloud forest as compared with lowland forests (sign test, $P < 0.05$). In fact, all eight curves in Fig. 2 show highest frequencies of rare species in montane forests as opposed to lowland forests.

In order to demonstrate more quantitatively the more restricted nature of the geographic ranges of montane forest faunas, we analyse two examples in more depth: birds and mammals of the Sierra de Juárez. A summary of the average latitudinal extent of ranges of bird and mammal species along the Sierra

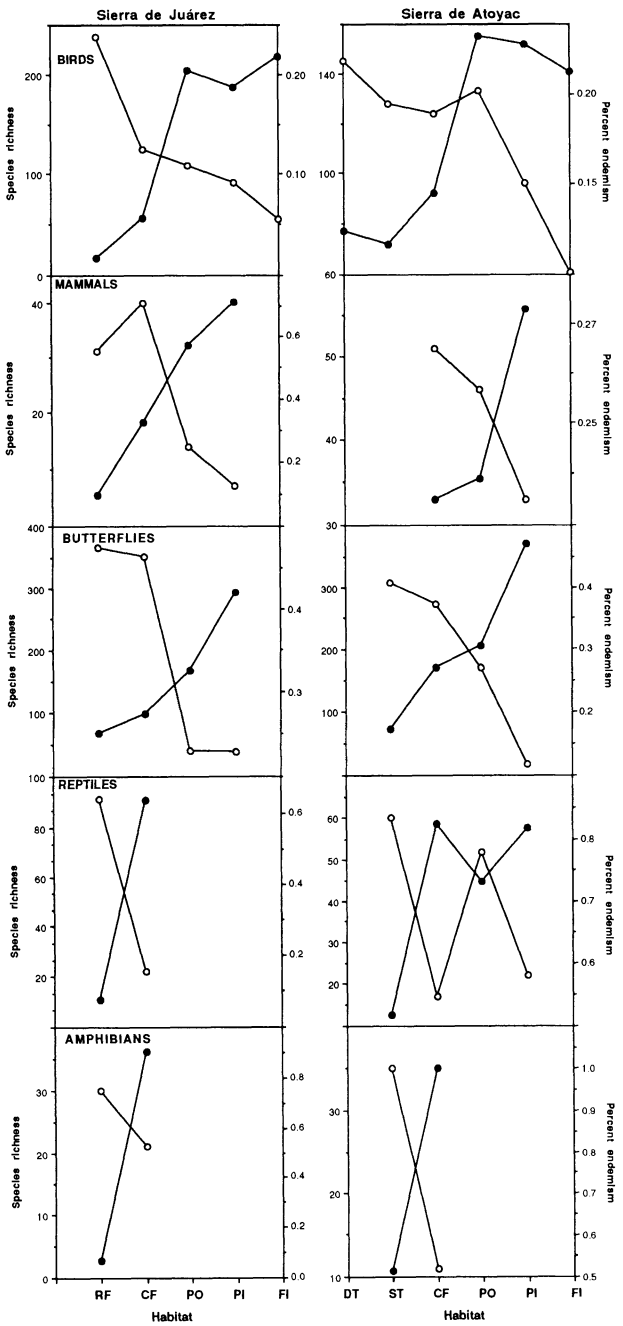

Fig. 1. Species richness (open circles) and percent endemism (closed circles) in four taxonomic groups in the Sierra de Atoyac of Guerrero and the Sierra de Juárez of Oaxaca. Habitats are abbreviated as follows: RF=lowland rain forest, DT=deciduous tropical scrub, ST=semideciduous tropical forest, CF=cloud forest, PO=pine-oak forest, PI=pine forest, and FI=fir forest.

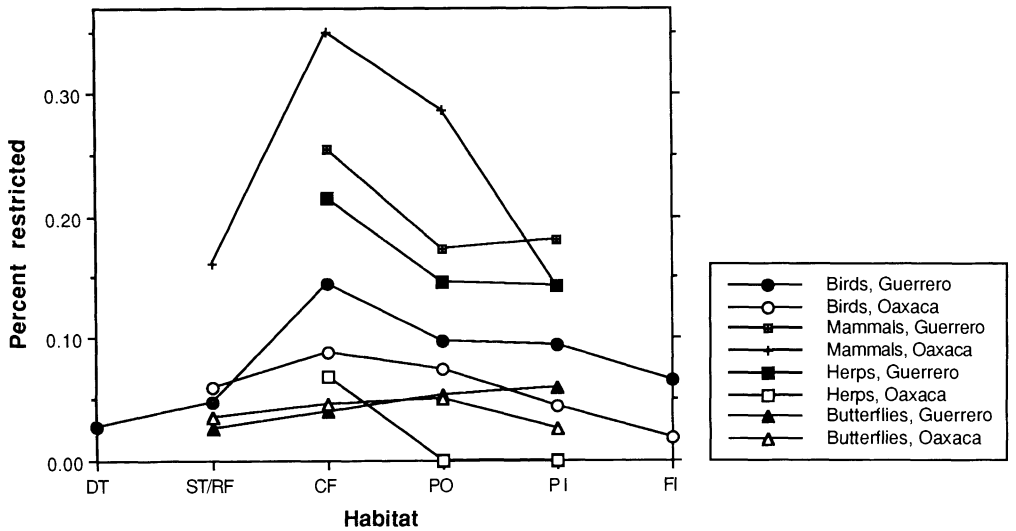

Fig. 2. Patterns of altitudinal distribution of species with restricted ranges, shown as percent of total numbers of species. Habitat abbreviations follow caption of Fig. 1.

de Juárez (Fig. 3) reveals an interesting pattern: species with most restricted ranges geographically are found chiefly at middle and high elevations (Mann-Whitney *U*-tests comparing species occuring and not occurring in tropical rain forest, $P<0.0001$ and $P< 0.0024$, for birds and mammals, respectively). The median latitudinal range of birds of tropical rain forest is 32°, that of cloud forest birds is 25°, and those of pine-oak and pine forest are 18° and 20°, respectively; a parallel decrease in latitudinal range is shown by mammal species. Range width increases again in birds in the highest-elevation fir forest, reflecting a predom-

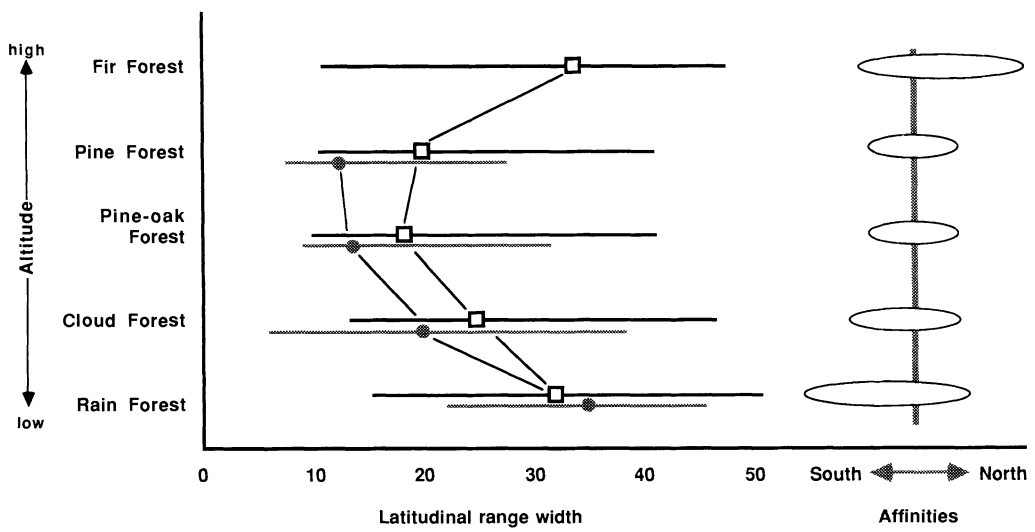

Fig. 3. Latitudinal range widths (median, 25th, and 75th percentiles) of the bird fauna (solid lines) and mammal faunas (stippled lines) of five altitudinal zones in the Sierra de Juárez of Oaxaca, with a diagrammatic interpretation of the observed patterns of affinities at the species level.

inance of species with northern affinities, many of which range as far north as Canada and Alaska; no data are available on the mammal fauna of the fir forests of the Sierra de Juárez. In general, however, latitudinal range width is significantly lower in species of montane forests than in those of lowland tropical forests.

DISCUSSION

Our data demonstrate a striking contrast between patterns of species richness and endemism in two mountain ranges in southern Mexico. Species richness is concentrated in lowland habitats, whereas endemic species, species with limited geographic ranges, and species that are rare or locally distributed are found chiefly in montane habitats (Flores-Villela, 1991).

The design of conservation strategies depend critically on the scale and goals of the overall effort. For example, in the United States, much effort is invested in preserving examples of each native habitat type throughout its range (e.g. the efforts of the Nature Conservancy), whereas in Madagascar, desperate attempts are being made to save whole vertebrate families from extinction. In the present case, if the goal is to preserve biological diversity in Mexico, then conservation efforts should be aimed at lowland tropical habitats. If, however, a larger-scale objective is adopted, and the purpose of conservation efforts in Mexico is to preserve biological diversity in the world, concentration would be modified to include montane habitats (in Mexico, cloud forest and pine-oak forest), where many uniquely Mexican taxa of plants and animals are found.

We see the preservation of biological diversity on a global scale as a primary objective of modern conservation efforts. Hence, we suggest that the focus of conservation efforts in Mexico and Central America be adjusted to concentrate on preservation of taxa unique to the region. Lowland tropical forest habitats in Mexico typically harbour few endemic forms; many lowland species have distributions that are virtually continuous into northern South America. On the other hand, endemics are concentrated in other habitats, such as montane forests and deserts and dry forest (Escalante, Navarro, and Peterson, 1993; Rzedowski, 1991, in press; Flores-Villela, 1991). This paper is but one example of how species richness and endemism in other habitats must also be taken into account in conservation planning.

A diversity of patterns

The patterns of species richness and endemism in five animal groups described above provide an interesting view of the utility of well-known groups such as birds or mammals as indicators of patterns in other taxonomic groups. Conservation decisions are unavoidably based on incomplete information. Yet, is a rapid survey of one taxonomic group, for example, birds, sufficient to identify areas as priorities for conservation action? In other words, the indicator group concept is useful only to the extent that patterns of species richness and endemism in different groups coincide.

The taxonomic groups examined in this survey show strikingly similar patterns of altitudinal distribution in the two mountain ranges treated herein. In both mountain ranges, in all five taxonomic groups, species richness declines and endemism increases steadily with altitude. Although other groups are known to show contrasting patterns (e.g. lowland rain forest trees in the Chimalapas region of Mexico, Wendt, 1989; fleas, Ponce-Ulloa, 1991), patterns of species richness and endemism in potential groups such as birds and butterflies appear to have some generality.

Number and size of reserves

From the standpoint of preservation of biological systems, the best reserves would contain entire watersheds extending from the lowlands to the highest peaks, thus preserving processes that affect the natural habitats on a regional scale (e.g. hydrology, climate). However, very few areas remain in which whole drainages are undisturbed and available for possible conservation action. Hence, conservation biologists are forced to make decisions regarding the size, shape, and spatial distribution of systems of reserves for optimizing preservation of biological diversity in a region.

The altitudinal patterns of range width described above (Figs 2 and 3) suggest that the number and size of reserves should be adjusted based on biological information. Mexican lowland tropical forest species tend to have broad geographic ranges, whereas montane species often do not. Endemic species that are rare or have restricted distributions are concentrated in montane habitats. Furthermore, species with large home ranges and correspondingly large minimal reserve areas for viable populations, such as large eagles (e.g. *Harpia harpyja*, *Spizaetus* spp.) and cats

(e.g. *Panthera onca*), appear to be found chiefly in the lowlands. The only species with enormous spatial requirements in montane habitats in Mexico is the Mountain Lion (*Felis concolor*), with most other species able to maintain viable populations in much smaller forest patches. Hence, smaller, carefully planned reserves may be very effective in preserving the most unique parts of the biological diversity of Middle America.

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