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Local migrations of insectivorous birds in western Mexico: implications for the protection and conservation of their habitats

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Summary

In this study I present data suggesting altitudinal movements of some species of foliage-gleaning insectivorous birds and related species of an oak–pine woodland of western Mexico. These movements can be regarded as short-distance or local migrations because the species involved breed in the woodlands and forests of the Sierra Madre Occidental highlands and winter in the tropical forests of the Pacific lowlands. Nine species of insectivorous birds out of 17 breed at the study site in the mountains of southern Durango and move to the lowlands in the winter; these can be regarded as short-distance or local migrants. In Mexico tropical deciduous and semi-deciduous forests are distributed mostly in the Pacific lowlands in the states of Sinaloa, Durango, Nayarit and Jalisco. Tropical forests of the Pacific lowlands are very important as wintering grounds for both North American and local west-Mexican migrants; however, there is only one protected area in western Mexico which to some degree includes these two types of tropical forests, and it is not located in the Sierra Madre Occidental, the most important mountain range in Mexico in terms of length and area covered. In addition, these tropical forests are the northern limit of the range for many tropical species. At present, these habitats are not threatened seriously by human activities (mainly forestry and cattle-raising) but this might change at any moment. At the study site the temperate highlands of southern Durango are already under the protection of "La Michilía" Biosphere Reserve, but a proposal to enlarge the area of the reserve to include the valley of the Río Mezquital and the western slope of the valley will increase the diversity of habitats, both temperate and tropical. As a consequence more bird species, as well as other taxa, will be protected in their natural environments. Such a proposal must be supported by field evidence on actual habitat use both during the breeding and wintering season, by local and long-distance migrants, in order to assess accurately the importance of this area as a representative place of western Mexico.

En este estudio se presentan datos que sugieren la existencia de movimientos altitudinales en algunas especies de pájaros insectívoros que buscan su alimento entre el follaje de árboles y arbustos, así como de otras especies de pájaros

insectívoros relacionadas en cuanto a sus hábitos de forrajeo, de un bosque mixto de encino–pino del occidente de México. Estos movimientos altitudinales pueden ser considerados como migraciones locales debido a que las especies implicadas en este fenómeno se reproducen en los bosques de las partes altas de la Sierra Madre Occidental e invernan en los bosques tropicales de las tierras bajas de la costa del Pacífico. Nueve especies de pájaros insectívoros, de un total de 17 que se reproducen en las montañas del sur del Estado de Durango, realizan movimientos estacionales hacia las tierras bajas de la costa durante el invierno; éstas pueden ser consideradas como especies migratorias locales o de corta distancia. En México, los bosques tropicales deciduos y semideciduos se encuentran distribuidos principalmente en las tierras bajas de la costa del Pacífico en los estados de Sinaloa, Durango, Nayarit y Jalisco. Estos bosques tropicales de la costa del Pacífico son muy importantes como áreas de invernada tanto para los pájaros migratorios de América del Norte como para los migratorios locales del occidente de México; sin embargo, sólamente hay un área protegida en el occidente de México que incluye de alguna manera estos dos tipos de bosques tropicales, pero ésta no se encuentra localizada en la Sierra Madre Occidental, a pesar de ser la cadena montañosa más larga y extensa de todo México. Además, estos bosques tropicales constituyen el límite norteño del área de distribución de muchas especies tropicales. En la actualidad estos hábitats no se encuentran amenazados seriamente por las actividades humanas (principalmente aprovechamientos forestales y cría de ganado) pero esta situación puede cambiar en cualquier momento. En el área de estudio las tierras altas, en el sur del Estado de Durango, ya se encuentran bajo la protección de la Reserva de la Biosfera "La Michilía", pero una propuesta para incrementar el área de la reserva e incluir el Valle del Río Mezquital y su ladera occidental aumentaría considerablemente la diversidad de hábitats, tanto templados como tropicales. En consecuencia, más especies de pájaros, así como de otros taxa, serían protegidos en sus ambientes naturales. Una propuesta de tal naturaleza deberá estar apoyada por evidencia de campo sobre el uso real de los diferentes hábitats durante el invierno por pájaros migratorios de larga distancia, provenientes de América del Norte, y por pájaros migratorios locales del occidente de México, y durante la época de reproducción por los residentes tropicales. Sólo de esta manera se podría evaluar acertadamente la importancia de esta área como un lugar representativo del occidente de México.

Introduction

Migration is an adaptation evolved to cope with changes in space and time of the physical and biotic characteristics of the environment; food availability is regarded as a key factor in the evolution of migratory patterns (Gauthreaux 1982). First attempts to study bird migration focused on the physiological causes of restlessness in migratory birds. It was not until the work of David Lack (1954) that a distinction was made between proximate (physiological) and ultimate (evolutionary) factors responsible for bird migration. He also noted the importance of ultimate factors in the modelling of migratory patterns from a cost–benefit approach.

The traditional and widespread idea of bird migration as long-distance movement, although not completely wrong, fails to emphasize the diversity of

migratory movements between breeding and wintering grounds in response to strong annual cycles (Gauthreaux 1982). The strongest annual cycle known from higher latitudes, i.e. the cycle with the highest variation, is certainly that of changes in weather; however, such cycles are predictable and environmental conditions change accordingly.

When environmental conditions become harsher through large geographic areas and at all localities, birds are forced to migrate over considerable distances to find suitable wintering areas. This is especially true for bird species known as long-distance migrants, breeding in northern temperate areas and wintering in the tropical–subtropical belt. However, when such environmental changes occur through a large geographic area but not homogeneously, birds can cope with these changes by moving to nearby localities. Short-distance migrants are bird species that breed and winter in the same geographic region and move between different habitats. These movements of birds or local migrations usually involve changes in elevation from the highlands to the lowlands in winter and back to the highlands in the spring to breed.

In contrast to the long history of studies on long-distance migrants (see, e.g., Moreau 1972, Keast and Morton 1980, Rappole *et al.* 1983) there is relatively little knowledge about short-distance or local migrations; however, currently it seems that this situation is changing (Pearson 1980 and papers in this issue by Stiles, Levey and Stiles, and Ramos and Rappole). In tropical Middle America differences in weather conditions change abruptly from cool temperate highlands to warm tropical lowlands. Environmental changes, mostly in temperature and precipitation, can control the heterogeneity of habitats within a large area, and can also influence the time and rate of movements within those habitats (Gauthreaux 1982).

The importance of western Mexico as a wintering area for most passerines breeding in western North America has been remarked by Hutto (1980, 1989). Here I present data on the seasonal and annual fluctuations of insectivorous bird densities from an oak–pine woodland of western Mexico. I also assess the importance of nearby coastal lowlands as potential wintering grounds not only for long-distance migrants but for short-distance or local migrants as well.

Study area

This study was carried out at the "Estación Piedra Herrada" (23°23'N 104°15'W, elevation 2,480 m) in "La Michilía" Biosphere Reserve (Figure 1).

The study site is located in the southern part of the Mexican state of Durango, on the eastern slope of the Sierra Madre Occidental that faces inward to the Mexican Plateau. Over an elevational gradient, vegetation structure ranges from rather open woodlands with savanna-like appearance to pine forests. At an elevation of 2,400 m there is an extensive plain crossed by deep ravines with mixed woodlands as the dominant vegetation type. Depending on the slope, exposure and soil type, different oak and pine species grow together resulting in several types of mixed woodlands and forests (González-Elizondo *et al.* 1993).

Weather is temperate with summer rains and a well-defined dry season lasting from February to late May. Mean annual rainfall is 790 mm, mostly between June and October and with 20% of winter rains. Mean annual temperature is

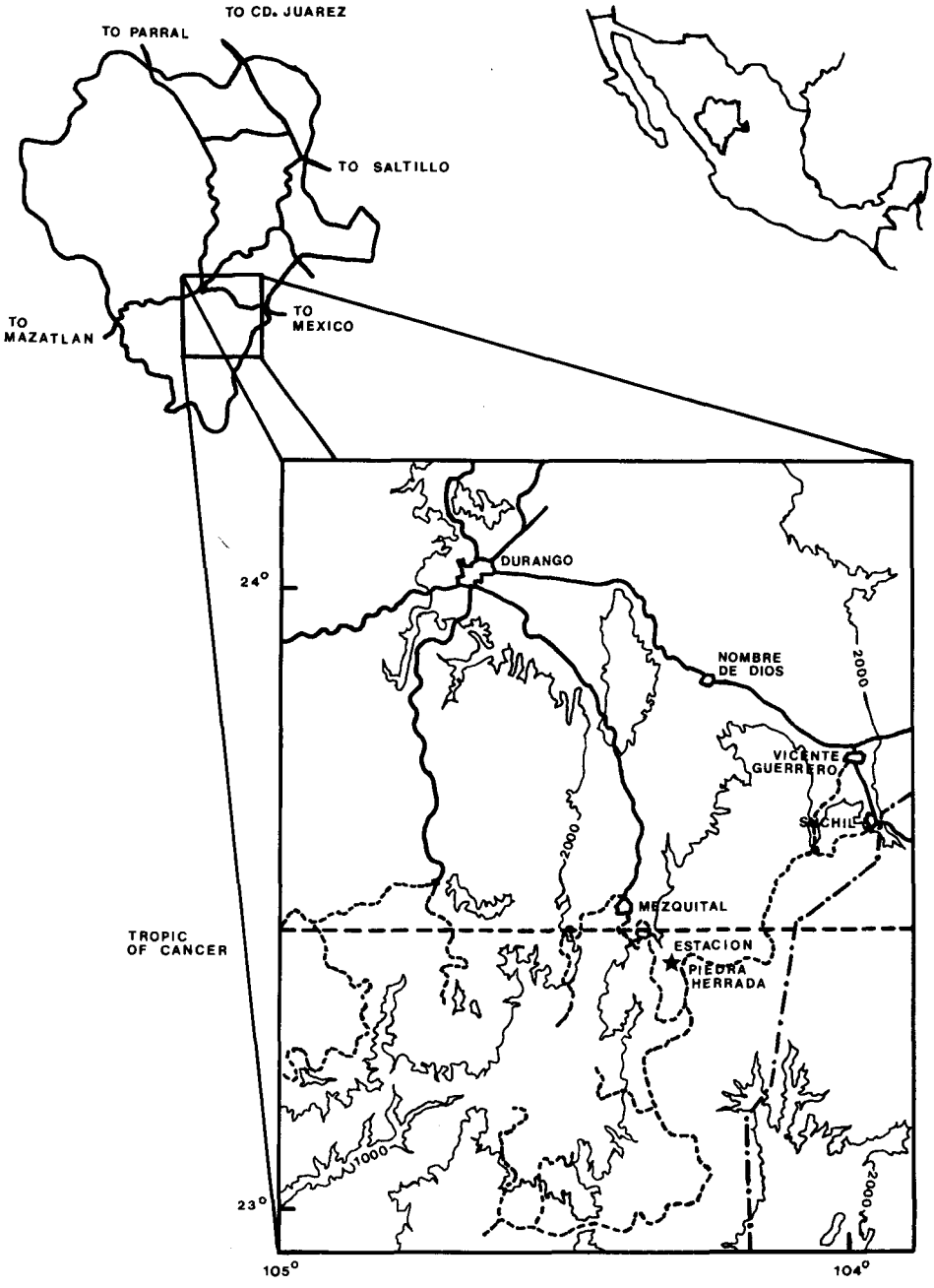

Figure 1. Map of the study region in south-eastern Durango, Mexico. The position of the state within Mexico is shown top right, and the position of the study region within the state is shown top left. Contour lines (1,000 and 2,000 m) indicate topography; paved roads (unbroken line), unpaved roads (broken line) and state limits (dotted line) are also shown.

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11.6 °C, with mean monthly temperatures ranging from 15.9 °C in June to 5.9 °C in January. Snowstorms occur approximately once every 20 years and when they occur the winter conditions are much harsher, as in winter of 1986–1987.

Vegetation is characterized by the dominance of oaks, with species such as *Quercus durifolia*, *Q.* aff. *hartwegii*, *Q. eduardii* and *Q. sideroxyla*; oak species drop their leaves in the dry season (March–May), although not all at the same time. Pines substantially increase habitat heterogeneity in both canopy height and foliage type. The commoner pine species are *Pinus leiophylla*, *P. cooperi*, *P. engelmanii* and *P. teocote*. Habitat heterogeneity is also increased by topography such as rocky outcrops surrounded by even terrain with deeper soils. Oak clumps develop in the rocky outcrops as dense patches of short trees with undergrowth species such as *Pithecellobium leptophyllum*, *Caeonothus buxifolius* and *Erythrina montana*. Other important trees and shrubs are madrones (*Arbutus tessellata*, *A. arizonica* and *A. xalapensis*), junipers (*Juniperus deppeana*) and manzanita (*Arctostaphylos pungens*). During the rainy season there is a bloom of annual and perennial plants resulting in a woodland with a totally different aspect. Among grasses, the more important species are *Panicum bulbosum*, *P. hians*, *Piptochaetium fimbriatum* and *Bromus anomalus*.

Methods

In a 175 ha plot I censused the bird community, both in summer and winter, from 1983 to 1989 (at least 100 censuses for each of the two seasons). Bird censuses were carried out from sunrise to noon during five to six days using the variable circular plot method as described by Ramsey and Scott (1979, 1981) and Reynolds *et al.* (1980). Each plot was divided into concentric rings of the following widths: six of 5 m each (5–30 m), two of 10 m each (30–50 m) and two of 25 m each (50–100 m). For each bird I estimated the distance to the centre of the plot and its height. Distance data were plotted into a frequency histogram for each species in order to find out the basal region of consistent detectability, i.e. the region where all the birds are detected. I used the formula of Ramsey and Scott (1979) for an estimate of the density (D) as:

$$D = \Sigma_{i=1}^{n} n_i \, (w_i/a)$$

where n_i is the number of birds detected in the ith day within the basal region, w_i is the proportion of censuses of the i^{th} day, n is the number of days censused, a is the total area effectively surveyed.

Species richness is the number of bird species and diversity (BSD: bird species diversity) was computed as the inverse of Simpson's index (Simpson 1949, Hill 1973):

$$BSD = 1/(\Sigma^{s}_{i=1} p_i^2)$$

where p_i is the proportion of birds of the i^{th} species and s is the number of bird species.

Results

A complete species list is presented in Appendix 1, and density data of foliage-gleaning insectivorous birds and related species are shown in Appendix 2A.

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Table 1. Guild structure of foliage-gleaning insectivorous birds and related species of an oak–pine woodland of western Mexico. Bird censuses in the summer of 1983 and 1984 were carried out in mid-August (S = summer, W = winter). For guild groups, see Appendix 2B.

GUILD GROUPS	S'83	W'84	S'84	W'85	S'85	W'86
Permanent residents						
Flycatchers	1.6	2.3	3.1	2.2	3.4	1.2
Acrobatic gleaners	32.4	50.4	69.7	57.0	56.1	52.0
Foliage gleaners	4.5	7.5	4.9	5.0	5.6	7.4
Understorey gleaners	0.5	0.2	0.1	—	—	—
Summer residents						
Flycatchers	2.9	0.1	3.3	—	6.9	—
Foliage gleaners	0.4	—	0.3	—	0.6	—
Foliage strikers	1.0	0.9	1.9	—	2.9	0.2
Nearctic migrants						
Foliage gleaners	1.4	13.2	1.4	14.0	—	23.7
Overall density[1]	44.7	74.6	84.7	78.2	75.5	84.5
Species richness[2]	16	14	16	9	13	10
Species diversity[3]	4.13	3.76	3.24	3.83	3.08	4.10
GUILD GROUPS	S'86	W'87	S'87	W'88	S'89	W'89
Permanent residents						
Flycatchers	2.2	0.9	3.6	2.1	1.1	3.9
Acrobatic gleaners	26.7	27.7	65.4	38.6	30.7	37.3
Foliage gleaners	3.8	5.0	7.2	3.8	6.3	5.1
Understorey gleaners	0.4	0.2	2.1	1.3	0.3	1.9
Summer residents						
Flycatchers	4.4	—	7.8	6.6	0.2	7.0
Foliage gleaners	1.3	—	0.9	0.8	—	3.4
Foliage strikers	1.7	0.2	2.0	2.3	0.1	4.2
Nearctic migrants						
Foliage gleaners	—	10.0	—	—	16.4	—
Overall density[1]	40.5	44.0	89.0	55.5	55.1	62.8
Species richness[2]	18	10	17	17	12	18
Species diversity[3]	5.80	3.77	4.42	4.36	4.35	6.70

[1] Birds/10 ha.
[2] Number of species.
[3] Inverse of Simpson's index.

For a global analysis species were grouped into guild categories in order to show species affinities in residency status combined with foraging abilities (Appendix 2B). Table 1 shows this grouping, and fluctuations in density through time.

Permanent residents are those species that breed and spend the winter season at the study site. Summer residents or summer visitors are those species that arrive at the study site in early spring to breed and leave the area in fall to winter elsewhere in the mountains of western Mexico. Nearctic migrants are those species that breed in northern temperate areas of western North America and spend the winter at the study site.

Flycatching species show a strong seasonal pattern of higher densities in summer, when more species are breeding at the study site (Table 1). The Western Flycatcher *Empidonax difficilis* is the only permanent resident and depends more on foliage-hovering than on sallying as a foraging technique during winter

(J.N. unpublished data). Summer residents leave the area during winter, although sometimes the Painted Redstart *Myioborus pictus*, a flycatching warbler, remains in low numbers. This pattern of low winter densities is not an unexpected one since food availability for species depending on flying insects is very low.

Foliage gleaners are represented by several species in all three categories based on residency status. Acrobatic gleaners are all-year residents with species such as the Mexican Chickadee *Parus sclateri*, Bridled Titmouse *Parus wollweberi* and the Bushtit *Psaltriparus minimus*; this category is the most important component of the whole guild, with percentages ranging from 59.1% to 82.3% of the guild in summer and from 55.7% to 72.9% in winter. Acrobatic gleaners show a pattern of high densities in winter decreasing in summer owing to territorial behaviour and spacing of breeding pairs. The heavy snowstorm of the winter of 1987 lasted more than two days, densities remained very low, and the usual increase in density from the previous summer (breeding season) owing to recruitment of young was not evident (Table 1). These data also show affinities with northern temperate forests of North America where parids show a definite dominance in terms of species abundances.

Foliage gleaners are those species that more commonly use the energetically inexpensive foraging technique of gleaning prey from leaves and twigs as they move through the foliage. Some species less frequently sally after prey flushed from the foliage and some others hover to pick up prey from otherwise inaccessible foraging substrates.

Typical foliage gleaning all-year residents are Hutton's Vireo *Vireo huttoni* and Olive Warbler *Peucedramus taeniatus*; these species show a pattern of higher winter densities probably due, as in the acrobatic gleaners, to the recruitment of young from the previous breeding season. Hutton's Vireo is more abundant and has less variable densities than the Olive Warbler, probably owing to its greater versatility in foraging techniques. The Olive Warbler was relatively stereotyped in its foraging behaviour (J.N. unpublished data).

Foliage gleaners arriving in late spring to breed at the study site have extremely low densities (Table 1). Possible explanations for the relative scarcity of species in this category are: (i) the Crescent-chested Warbler *Parula superciliosa* is more abundant in cool, wet ravines and occasionally breeds in the more xeric woodland, and (ii) Grace's Warbler *Dendroica graciae* has a high affinity for pure pine forests and restricts most of its foraging activities to pine foliage (J.N. unpublished data).

Understorey-dwelling gleaners show no definite pattern of seasonal fluctuation, although there was a slight upward trend in both their density and constancy in the habitat after the snowstorm of the winter of 1987 (Table 1). Their increase in breeding density, especially that of the House Wren *Troglodytes aedon*, was due to an increase in foraging substrate, i.e. mostly dead oak branches broken by snow accumulation. Such selective damage occurred in oaks more frequently than in pines (J.N. unpublished data).

Species referred to as strike gleaners are large-bodied and slow-moving insectivorous birds compared to typical foliage gleaners. They are characterized by feeding mostly on large-bodied insects, which are rather scarce in winter (J.N. unpublished data) and, consequently, their winter densities are extremely

low. Only one species, the Hepatic Tanager *Piranga flava*, is abundant enough to show up in bird censuses.

Nearctic migrants are breeding species of western North America that spend the winter at the study site. As expected, migrants are present only during winter; however, there are density data for some migrants in the summer of 1983 and 1984 (Table 1) because bird censuses were carried out in mid-August when early migrants had already arrived and were passing through. The Yellow-rumped Warbler *Dendroica coronata* is both a breeding species, very localized at the study site, and a Nearctic migrant, although it is commoner as a transient species during the spring and fall migration (J.N. unpublished data). The most important Nearctic migrant is the Ruby-crowned Kinglet *Regulus calendula*, which is very constant, i.e. occurring every winter, and very abundant; it might be regarded as the key species to show the effects of winter harshness, as during the 1987 snowstorm with the lowest density (9.6 birds/10 ha) ever recorded in this study (Appendix 2A).

Species richness, as expected, was higher in summer (Table 1) because more species take advantage of the relaxed environmental conditions to breed and rear their young when resources are plentiful. Diversity (BSD) did not show any definite pattern through time, although there is a slight tendency to greater BSD during summer with two exceptions (1984, 1985), times when the Mexican Chickadee was very abundant and accounted for 49.8% and 53.4% of the whole guild, respectively. Diversity measured as the inverse of Simpson's index is also a measure of dominance and in this context the dominance of the Mexican Chickadee is shown accurately.

Discussion

Local migrants in western Mexico

Differences in migratory movements between years as shown by some local migratory species are probably related, as suggested by Gauthreaux (1982), to individual differences in tolerance. So if environmental changes do not exceed the tolerance limits of a population, then some individual birds might remain in the area.

As defined before, local migrants are those species that breed in one type of habitat and spend the winter in a different habitat within the same geographic region. Several species at the study site fulfil these requirements, i.e. breed in the temperate highlands and winter in the tropical lowlands. Species included in this category are: Elegant Trogon *Trogon elegans*, Greater Pewee *Contopus pertinax*, Buff-breasted Flycatcher *Empidonax fulvifrons*, Solitary Vireo *Vireo solitarius*, Grace's Warbler, Painted Redstart, Crescent-chested Warbler, Hepatic Tanager and Black-headed Grosbeak *Pheucticus melanocephalus*. These are nine species out of 17 present during the breeding season (Appendix 2B) that spend the winter in the adjacent Pacific lowlands, indicating that 50% of the regular breeding species of an oak–pine woodland are exposed seasonally to environmental changes. There are more highland breeding species that move to the Pacific lowlands in winter; these species breed only in cool moist ravines such as the Eared Trogon *Euptilotis neoxenus*,

Table 2. Balance of migratory and resident insectivorous birds in selected west-Mexican habitats (Hutto 1980). Data from the study site in southern Durango are not included because of differences in species allocation into groups. Numbers refer to localities in the states of Nayarit[1], Sinaloa[2], Jalisco[3] and Michoacán[4]

Vegetation type	Elevation (m)	Insectivorous birds	
		Residents	Migrants
Tropical semi-deciduous forest	20[1]	20 (54.1%)	17 (45.9%)
Tropical deciduous forest	30[2]	10 (55.6%)	8 (44.4%)
	30[3]	12 (66.7%)	6 (33.3%)
Pine–oak woodland	915[3]	16 (61.5%)	10 (38.5%)
	1,340[3]	17 (65.4%)	9 (34.6%)
	1,980[4]	26 (70.3%)	11 (29.7%)
	2,135[3]	17 (56.7%)	13 (43.3%)
	2,315[4]	11 (55.0%)	9 (45.0%)

Tufted Flycatcher *Mitrephanes phaeocercus*, Dusky-capped Flycatcher *Myiarchus tuberculifer*, Red-faced Warbler *Cardellina rubrifrons* and Slate-throated Redstart *Myioborus miniatus*. Overall there are 14 highland breeding species that require wintering habitat in the Pacific lowlands; if changes occur on the wintering grounds, mostly by habitat destruction, this group of species can be seriously threatened, not to mention the whole array of western North American migrants that spend the winter in western Mexico north of the Tehuantepec Isthmus (Hutto 1980).

Tropical forests of western Mexico

Two types of tropical forest might be of great concern as wintering habitats for both long-distance and local migrants. The more widespread habitat, extending over most of the Pacific lowlands, is the tropical deciduous forest characterized by short, clumped trees. Not as extensive but probably more important for migratory birds is the semi-deciduous tropical forest, confined to the cooler and more humid canyons of the western slope of the Sierra Madre Occidental.

Tropical deciduous forest is characteristic of the Pacific lowlands, covering uninterrupted extensions from southern Sonora and south-west Chihuahua southwards to Chiapas (Rzedowski 1978). This type of forest covers approximately 8% of the Mexican mainland between sea level and 1,900 m in elevation, but more frequently below 1,500 m. Currently it is not affected by human activities to a large extent and the only important activity is cattle-raising.

Tropical semi-deciduous forest is more widespread in the Pacific than in the Gulf lowlands. It is patchily distributed in western Mexico from central Sinaloa to coastal Chiapas (Rzedowski 1978). This type of forest covers some 4% of Mexico between sea-level and 1,300 m in elevation. Forestry can restrict its distribution, but at present this forest type is not greatly affected by human activities.

Environmental conditions are less variable in semi-deciduous than in deciduous tropical forests. Insects and other arthropods are more constantly abundant where evergreen vegetation is available, so we might expect that semi-deciduous tropical forests found in the Sierra Madre Occidental can host a high number of bird species. Data from Hutto (1980) support this idea, although proportions of resident and migrant species are very similar (Table 2).

Habitat protection and conservation

An analysis of the distribution of the main vegetation types in Mexico and their associated vertebrate fauna (Flores and Gerez 1988) showed that the tropical deciduous and semi-deciduous forests of western Mexico have a high species richness and also a great number of endemic species. The analysis also showed that almost half (44.4%) of the total cover of tropical deciduous forest is distributed in western Mexico in the states of Sonora (12.2%), Sinaloa (13.9%), Durango (5.1%), Nayarit (4.3%) and Jalisco (8.9%). Similarly, about two-thirds (71.7%) of the total cover of tropical semi-deciduous forests are distributed in the states of Sinaloa (6.0%), Durango (1.5%), Nayarit (38.8%) and Jalisco (25.4%). These data reveal the importance of western Mexico as a region of great biological diversity.

In spite of this evidence and of the extent of tropical deciduous and semi-deciduous forests in western Mexico, there is only one protected area in the region, namely the "Sierra de Manantlán" Biosphere Reserve, in the state of Jalisco. Large patches of tropical deciduous and semi-deciduous forests are distributed in most of the canyons of the western slope of the Sierra Madre Occidental, in the states of Chihuahua and Durango; at present these forest are not threatened (Rzedowski 1978), although the timber industry might change this status suddenly.

West of the study site is the Río Mezquital (Figure 1), the only river rising in the Mexican Plateau and flowing all the way through the Sierra Madre Occidental into the Pacific lowlands. On the eastern slope of the valley of the Río Mezquital there is an abrupt change in vegetation from the oak–pine and oak woodlands of the highlands to deciduous tropical forest, with tree species of *Ipomoea* and *Ceiba* at the bottom of the valley. On the western slope of the valley there is a more diverse vegetation gradient; in addition to the vegetation types occurring on the eastern slope, there are Douglas fir and pine forests.

The temperate highlands of the Sierra Madre Occidental in southern Durango are already under the protection of biosphere reserves promoted by UNESCO's Man and Biosphere (MAB) Program (Halffter 1978). However, more banding and bird censusing will show the need for the protection of the tropical forests as an important wintering ground for a large array of both North American long-distance and west-Mexican local migrants.

A proposal to increase the area of "La Michilía" Biosphere Reserve, in southern Durango, to include the valley of the Río Mezquital and its western slope, a natural biogeographical corridor for plants and animals, should be supported by field data to emphasize the importance of the whole area for both resident and migratory birds. Such an action would increase the diversity of habitats within the reserve and, consequently, the protection and conservation of more species depending on those habitats.

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Appendix 1. Species list of foliage-gleaning insectivorous birds and related species of an oak–pine woodland of western Mexico (* = occasional species). Nomenclature and taxonomic sequence follow AOU (1983).

Family Trogonidae
- Elegant Trogon *Trogon elegans*
- Eared Trogon *Euptilotis neoxenus* *

Family Tyrannidae
- Tufted Flycatcher *Mitrephanes phaeocercus* *
- Greater Pewee *Contopus pertinax*
- Grey Flycatcher *Empidonax wrightii* *
- Western Flycatcher *Empidonax difficilis*
- Buff-breasted Flycatcher *Empidonax fulvifrons*
- Dusky-capped Flycatcher *Myiarchus tuberculifer* *
- Cassin's Kingbird *Tyrannus vociferans* *

Family Paridae
- Mexican Chickadee *Parus sclateri*
- Bridled Titmouse *Parus wollweberi*

Family Aegithalidae
- Bushtit *Psaltriparus minimus*

Family Sittidae
- Pygmy Nuthatch *Sitta pygmaea* *

Family Troglodytidae
- Bewick's Wren *Thryomanes bewickii*
- House Wren *Troglodytes aedon*

Family Muscicapidae: Subfamily Sylviinae
- Ruby-crowned Kinglet *Regulus calendula*
- Blue-grey Gnatcatcher *Polioptila caerulea* *

Family Vireonidae
- Solitary Vireo *Vireo solitarius*
- Hutton's Vireo *Vireo huttoni*
- Warbling Vireo *Vireo gilvus* *

Familiy Emberizidae: Subfamily Parulinae
- Crescent-chested Warbler *Parula superciliosa*
- Yellow-rumped Warbler *Dendroica coronata*
- Black-throated Grey Warbler *Dendroica nigrescens*
- Townsend's Warbler *Dendroica townsendi* *
- Hermit Warbler *Dendroica occidentalis* *
- Grace's Warbler *Dendroica graciae*
- Red-faced Warbler *Cardellina rubrifrons* *
- Painted Redstart *Myioborus pictus*
- Slate-throated Redstart *Myioborus miniatus* *
- Olive Warbler *Peucedramus taeniatus*

Family Emberizidae: Subfamily Thraupinae
- Hepatic Tanager *Piranga flava*

Family Emberizidae: Subfamily Cardinalinae
- Black-headed Grosbeak *Pheucticus melanocephalus*

Appendix 2A. Structure and composition of the guild of foliage-gleaning insectivorous birds of an oak–pine woodland of western Mexico. (S = summer, W = winter, ** = less than 0.1 bird/ 10 ha). Occasional species are not included (see Appendix 1).

SPECIES	S'83	W'84	S'84	W'85	S'85	W'86
Elegant Trogon	0.1	—	0.1	—	0.5	—
Greater Pewee	0.9	—	0.7	—	1.5	—
Western Flycatcher	1.6	2.3	3.1	2.2	3.4	1.2
Buff-breasted Flycatcher	0.3	—	1.2	—	3.4	—
Mexican Chickadee	18.4	33.5	42.2	33.4	40.3	31.2
Bridled Titmouse	10.8	12.9	17.0	15.3	12.9	10.8
Bushtit	3.2	4.0	10. 5	8.3	2.9	10.0
Bewick's Wren	—	0.1	0.1	—	—	—
House Wren	0.5	0.1	—	—	—	—
Ruby-crowned Kinglet	—	11.7	—	12.6	—	22.8
Solitary Vireo	0.6	0.8	1.3	—	2.0	—
Hutton's Vireo	2.0	5.1	4.0	3.7	3.6	3.1
Crescent-chested Warbler	—	—	—	—	—	—
Yellow-rumped Warbler	0.5	0.6	0.4	0.8	—	0.3
Black-throated Grey Warbler	0.9	0.9	1.0	0.6	—	0.6
Grace's Warbler	0.4	—	0.3	—	0.6	—
Painted Redstart	1.6	0.1	1.3	—	1.5	—
Olive Warbler	2.5	2.4	0.9	1.3	2.0	4.3
Hepatic Tanager	0.4	0.1	0.6	—	0.9	0.2
Black-headed Grosbeak	—	—	—	—	—	—

SPECIES	S'86	W'87	S'87	S'88	W'89	S'89
Elegant Trogon	0.3	—	**	0.3	—	0.2
Greater Pewee	0.4	—	2.9	0.6	—	1.2
Western Flycatcher	2.2	0.9	3.6	2.1	1.1	3.9
Buff-breasted Flycatcher	3.3	—	2.2	3.8	—	4.5
Mexican Chickadee	11.8	19.2	31.7	23.6	18.3	17.7
Bridled Titmouse	5.7	5.6	8.1	6.7	4.5	7.0
Bushtit	9.2	2.9	25.6	8.3	7.9	12.6
Bewick's Wren	0.2	0.2	1.1	0.3	0.3	0.8
House Wren	0.2	—	1.0	1.0	—	1.1
Ruby-crowned Kinglet	—	9.6	—	—	16.1	—
Solitary Vireo	0.8	—	1.6	0.8	—	1.6
Hutton's Vireo	2.7	2.6	3.1	3.0	3.6	3.0
Crescent-chested Warbler	1.0	—	0.4	0.5	—	2.9
Yellow-rumped Warbler	0.2	0.4	—	—	0.2	0.2
Black-throated Grey Warbler	—	—	—	—	0.1	—
Grace's Warbler	0.3	—	0.5	0.3	—	0.3
Painted Redstart	0.4	—	2.7	1.9	0.2	1.1
Olive Warbler	0.9	2.4	4.1	0.8	2.7	2.1
Hepatic Tanager	0.7	0.2	0.3	0.7	0.1	1.5
Black-headed Grosbeak	0.2	—	0.1	0.8	—	1.1

Appendix 2B. Guild categories of foliage-gleaning insectivorous birds and related species of an oak–pine woodland of western Mexico based on residency status and foraging behaviour.

PERMANENT RESIDENTS
Flycatchers: Western Flycatcher
Acrobatic gleaners: Mexican Chickadee, Bridled Titmouse, Bushtit
Foliage gleaners: Hutton's Vireo, Olive Warbler
Understorey gleaners: Bewick's Wren, House Wren
SUMMER RESIDENTS
Flycatchers: Elegant Trogon, Greater Pewee, Buff-breasted Flycatcher, Painted Redstart
Foliage gleaners: Crescent-chested Warbler, Grace's Warbler
Foliage strikers: Solitary Vireo, Hepatic Tanager, Black-headed Grosbeak
NEARCTIC MIGRANTS
Foliage gleaners: Ruby-crowned Kinglet, Yellow-rumped Warbler, Black-throated Grey Warbler

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