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# Relationship Between Bird Diversity and Habitat along a Pine-Oak Successional Forest in Southern Mexico

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## Abstract

Few studies have related bird species richness and abundance with vegetation structure at different successional stages in pine-oak forests of Mexico. We studied changes in the bird community across three successional stages of pine-oak forest: early, intermediate, and mature. Also, we related bird community attributes—including generalist and specialist birds—with vegetation variables. We analyzed the vegetation and estimated bird abundances in 10-min-count periods in 10 circular plots per successional stage. We recorded a total of 71 bird species: 21 were specialists and 50 were generalists. The completeness of species richness was between 79 and 88% in the sampled habitats. Diversity profiles were consistently larger in the intermediate stage, except for its species richness that was not different between this and the early stage. We found a more richness and a higher number of individuals of generalist in the early and intermediate stages. The abundance of specialists was higher in the mature forest. An ordination analysis showed that generalists were associated to different variables. This suggests that these species can adapt to different forest conditions. Some specialist birds were more abundant in sites with high dominance of trees. Our results confirm the importance of maintaining not only mature forests but also young successional stages in order to conserve the species typical of secondary pine-oak forest bird species.

**Keywords:** succession, temperate forests, bird community, species richness, change land use

## 1. Introduction

The composition and the structure of vegetation influence the abundance and the distribution of birds in different environments [1–4]. In temperate forest ecosystems of Mexico and other parts of the world, many anthropogenic activities (i.e., agriculture, overharvesting, and fires) have increasingly modified the composition and structural characteristics of vegetation [5, 6]. As a consequence, many of these landscapes are currently characterized by secondary forest intermixed with scrublands, grasslands, and farmlands [7]. In these landscapes, vegetation in later successional stages is usually taller and has greater biomass, higher number of vertical structural components, and higher number of tree species [7, 8]. Due to their complexity, these habitats often provide a variety of food and nesting sites for specialist birds, in particular [3, 9]. Earlier stages, on the other hand, have a well-developed low layer and thicker vegetation. Thus, bird species richness and abundance vary across forest successional stages [10]. Many bird species, for example, are favored from disturbed sites that are often found in early successional stages, as these may have more habitats available for generalist species (i.e., species that use a relatively wide set of habitat resources [11–13]). On the other hand, Connell [14] suggests that species richness is greater in sites in the intermediate phase of succession because species characteristic of both early and mature forests (i.e., generalists and specialists) can coexist.

The presence of bird species across forest chronosequences (i.e., sequential changes in the structure of the community spatially and temporally reflected) can help in reverting fragmentation processes, as bird species participate in various ecological interactions (e.g., pollination, seed dispersal, and nutrient cycling). For example, in a montane oak forest in Costa Rica, Wilms and Kappelle [15] found that numerous birds that forage on the fruits of mature forest trees also forage for resources in pastures. Thus, birds may serve as key dispersal agents, transporting tree seeds from mature, closed forests to non-forested secondary scrublands or pastures.

Several studies have shown the relationship between bird communities and vegetation structure in temperate forests [10, 16, 17]. However, few studies have related bird species richness and abundance with vegetation structure at different successional stages in pine-oak forests in the Americas, and these have mainly evaluated changes in bird communities throughout post fires succession following fires in Canada and the United States [18]. In Mexico, there are some studies that have described changes in bird structure in sites of pine-oak forest with different levels of disturbance [19–21]. These studies have found a general pattern of a greater number of bird species in the undisturbed forests than in the disturbed forests, but there are no reports on the response of bird communities to plant succession in temperate ecosystem.

Our main goal was to evaluate the relationships between the richness and abundance of the bird community and the vegetation structure of three successional stages of a pine-oak forest (early, intermediate, and mature forests) in southern Mexico. In addition, we evaluated these relationships between vegetation and generalist and specialist birds. We hypothesized that bird species richness and abundance would rise in the intermediate stage (according to intermediate disturbance hypothesis [14]), due to the presence of both generalist and specialist birds. We also expected a greater presence of specialist bird in mature forest and an increase of generalist birds in the early stage. The results of this research can contribute toward improving the management policies of this ecosystem in the region, which has been continuously affected by anthropogenic disturbances.

## 2. Methods

### 2.1. Study area

This study was carried out in the locality of Xocomanatlan in the state of Guerrero between 17°33′21″ and 17°31′30″ N and 99°41′02″ and 99°38′16″ W (**Figure 1**). This area corresponds with the biotic province of the Sierra Madre del Sur which presents a high concentration of endemic species. The study area has an average elevation of 1900 m.a.s.l.

### 2.2. Sampling sites

Three sites of pine-oak forest in different successional stages were selected: early (last disturbance approximately 5 years ago), intermediate (last disturbance approximately 20 years ago), and mature (last disturbance approximately 40 years ago). At the mature forest site, large-scale agricultural activities have been largely impeded by the topography (inclination >45 grades) and the rocky substrate of the zone. The tenants have partially logged trees to obtain forest timber, although elements of the original flora are retained. The early and the intermediate successional sites were cleared by the traditional slash and burn method to plant corn and, to a lesser extent, peach, pear, apple, and hawthorn (*tejocote* in Spanish) orchards. The date of the last major disturbance and the type of management at each site were obtained from informal interviews with farmers.

### 2.3. Vegetation sampling

At each selected site, we randomly delimited 10 plots of 0.78 ha (**Figure 1**). Within each plot, we traced two perpendicular lines, oriented to the four cardinal points, with ropes. The taxonomic identity of all trees and shrubs with branches intersecting the ropes and with diameters at breast height (DBH) ≥ 10 cm was determined. The foliage cover of each of these plants was
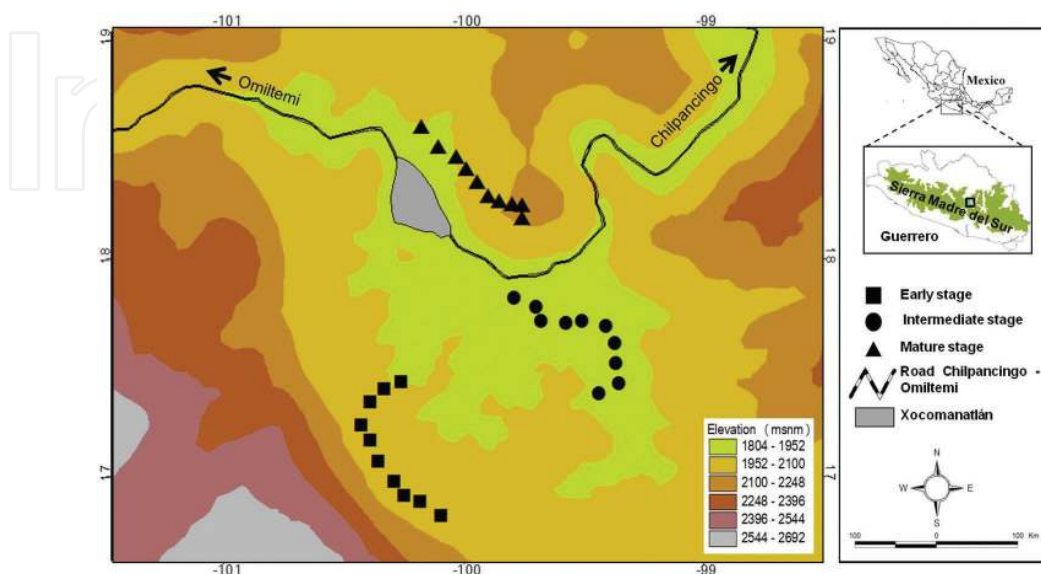


**Figure 1.** Location of the study area in the state of Guerrero in southern Mexico, showing the sampling plots in three successional stages of a pine-oak forest.

estimated by the ellipse formula, using the length of the maximum and the minimum diameters of the foliage [22]. Foliage stratification is a measure that reflects the foliage density and was estimated using an optical square marked with two perpendicular axes [23]. The square has three mirrors arranged so that an observer can look horizontally through the device and assess the height of objects above. In each plot, we recorded foliage height and the number of times that foliage touched the point of intersection of the two axes. This procedure was repeated every 50 cm along the two transects, resulting in a total of 50 observational data points. Foliage heights were estimated with the electronic clinometer Haglöf HEC and were grouped in 1 m intervals. With this data, we evaluated the foliage height diversity (FHD) using the Shannon-Wiener index. Detailed vegetation analyses for these sites are described in Almazán-Núñez et al. [7].

Plants were identified by consulting botanical specimen collections, and plants were deposited at the Herbarium of the Chemistry and Biological Sciences Faculty of the Autonomous University of Guerrero.

### 2.4. Bird survey

Birds were surveyed from October 2013 to April 2014 in the same plots where vegetation was sampled. The bird censuses were performed during the hours with the highest bird activity in the morning (07:00 to 11:00 h) and the afternoon (16:00 to 19:30 h). We used the point count method with a fixed radius of 50 m (10 point counts per site for a total of 30 points). This radius was selected because the vegetation structure of the three successional stages allowed observations to be performed at this distance. Each point count was separated by 200 m to avoid pseudoreplication. All individuals seen or heard within a 10-min period at each point were recorded. This time lapse is long enough to allow most birds present, including rare species, to be counted, and short enough to minimize the probability of counting the same bird more than once [24]. Each site was visited 30 times (for a total of 90 visits to all successional stages). The abundance of each species was the average number resulting from all visits. Raptors and vultures were excluded, as our point count sampling method was not designed to effectively sample these bird groups. Each observed bird species was categorized into two groups based on Stotz et al. [11] and personal observations: (1) specialist (i.e., birds inhabiting the forest interior that are rarely found in other habitat types) and (2) generalist (i.e., birds that use a variety of habitats including the forest interior, secondary forest, forest edges, and open areas).

### 2.5. Data analysis

We calculated the average and the standard error of the abundance and the richness of birds and of structural parameters (e.g., foliar cover, FHD) and of the plant community (e.g., richness and abundance of trees and shrubs) based on the vegetation data collected in the three successional stages. These variables were compared with a one-way analysis of variance (ANOVA) and multiple comparisons with Tukey's HSD. The Chao2 estimator was used to assess the comprehensiveness of the bird species survey. This nonparametric species richness estimator has been found to give reasonable approximations at small-grain-size sample units

(i.e., circular plots [25]). Calculations were done with the software EstimateS version 9 [26]. To compare bird richness and diversity between seral stages, we used the number of effective species, which is the number of species of equal abundance expected in a community, and three levels of diversity ($^0D$, $^1D$, and $^2D$, respectively) were calculated. The first index corresponds to species richness and does not consider abundance ($^0D$). In the second index, species are weighted according to observed abundances ($^1D$). The third index ($^2D$) gives more weight to the dominant species [27, 28]. For this analysis, an estimated diversity profile was performed by using an analytical method to obtain accurate, continuous, and low-bias diversity especially for $q \leq 1$ [29]. In these comparisons, 200 replicate bootstrapping and confidence intervals at 84% were used, which are appropriates for inference equivalent to $P < 0.05$ [30]. This profile was calculated in the R package iNEXT [31].

Both the richness and abundance of the generalist and specialist bird species in each successional stage were compared and analyzed using a Kruskal-Wallis (K-W) test and an ANOVA, respectively. The significant differences were contrasted with a Mann-Whitney U test (in the case of K-W test) and multiple comparisons of Tukey's HSD (for the ANOVA). To evaluate the relationship between the abundance of specialist and generalist birds and the 10 habitat variables, a canonical correspondence analysis (CCA) was used. CCA is a multivariate ordination technique for associating species abundance data with multiple environmental factors [32]. From an initial examination of the correlation matrix of the 10 habitat variables, we eliminated several from the analysis that were redundant with other variables. Then, the CCA was executed using the uncorrelated variables. We eliminated bird species with less than three observed individuals from the CCA, as very low numbers can reflect random observations [33]. This analysis was performed in MVSP package v. 3.22 [34].

## 3. Results

### 3.1. Vegetation sampling

Tree richness and abundance were significantly highest in mature forest in comparison to the early and the intermediate stages (**Table 1**), while shrub richness and abundance did not show significant differences between the three successional stages (**Table 1**). The structural variables were significantly highest in the mature forest in comparison to the other two stages, except for plant density, which was greater in the intermediate stage, although this difference was not significant (**Table 1**).

### 3.2. Richness, abundance, and diversity of birds

We recorded a total of 71 species corresponding to 25 families (Appendix). Among these, 53 species were residents and 18 were migrants. Also, 21 species were classified as specialists and 50 as generalists (Appendix). In the intermediate successional stage, 47 species were recorded, in the early stage 45 species, and in the mature stage 36 species. The Chao2 richness estimator showed that the 79, 84, and 88% of the total expected richness, respectively, to the early, intermediate and mature stages were recorded.
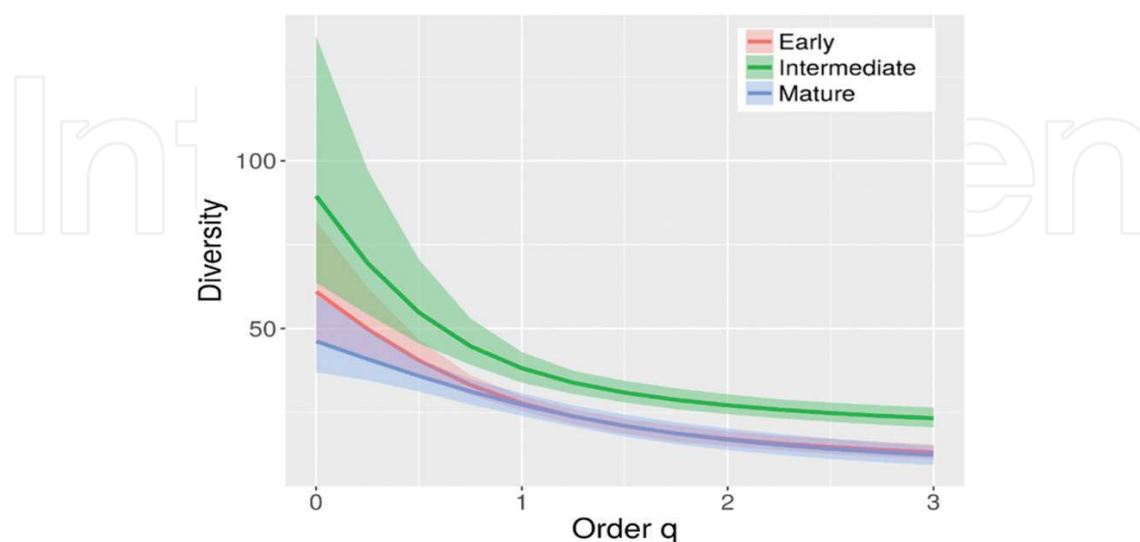
| Variables | Successional stage | | |
|---|---|---|---|
| | ES | IS | MS |
| Tree richness | 1.7 ± 0.26a | 2.7 ± 0.30b | 3.9 ± 0.31c |
| Shrub richness | 2.3 ± 0.33a | 2.6 ± 0.56a | 1.9 ± 0.43a |
| Tree abundance | 5.5 ± 0.82a | 11 ± 1.55b | 17.2 ± 1.46c |
| Shrub abundance | 11.9 ± 1.86a | 9.6 ± 2.47a | 7.1 ± 1.26a |
| Shannon-Wiener index | 1.1 ± 0.08a | 1.3 ± 0.14a | 1.4 ± 0.09a |
| Simpson dominance | 0.4 ± 0.03a | 0.4 ± 0.05a | 0.3 ± 0.03a |
| Foliar cover ($m^2$) | 249.1 ± 67.77a | 539.1 ± 73.13b | 659.3 ± 86.25b |
| Foliage height diversity (FHD) | 1.7 ± 0.17a | 2.1 ± 0.10b | 2.3 ± 0.05b |
| Plant density | 42.3 ± 6.90a | 47.1 ± 7.93a | 43.7 ± 4.38a |
| Total height | 16.7 ± 1.19a | 20.0 ± 0.70ab | 22.8 ± 1.03b |

Different letters denote significant differences ($P < 0.05$) according to Tukey's HSD tests. ES, early stage; IS, intermediate stage; and MS, mature stage.

**Table 1.** Average values (± SE) of habitat variables in three successional stages of pine-oak forest in southern Mexico.

The intermediate successional stage showed a higher diversity profile than the mature stage and was higher in the order q1 and q2 (abundance and dominance, respectively) than early stage, but not in q0 (richness), as confidence intervals overlapped. Diversity in the intermediate and early stages was not different (**Figure 2**).

The richness of specialist birds was not significantly distinct between the three successional stages (**Figure 3A**). The richness of generalist species was highest in the early and intermediate



**Figure 2.** Estimated diversity profiles of bird assemblages across three successional stages, early, intermediate, and mature, in a secondary pine-oak forest in southern Mexico. Shaded polygons denote the 84% confidence intervals.
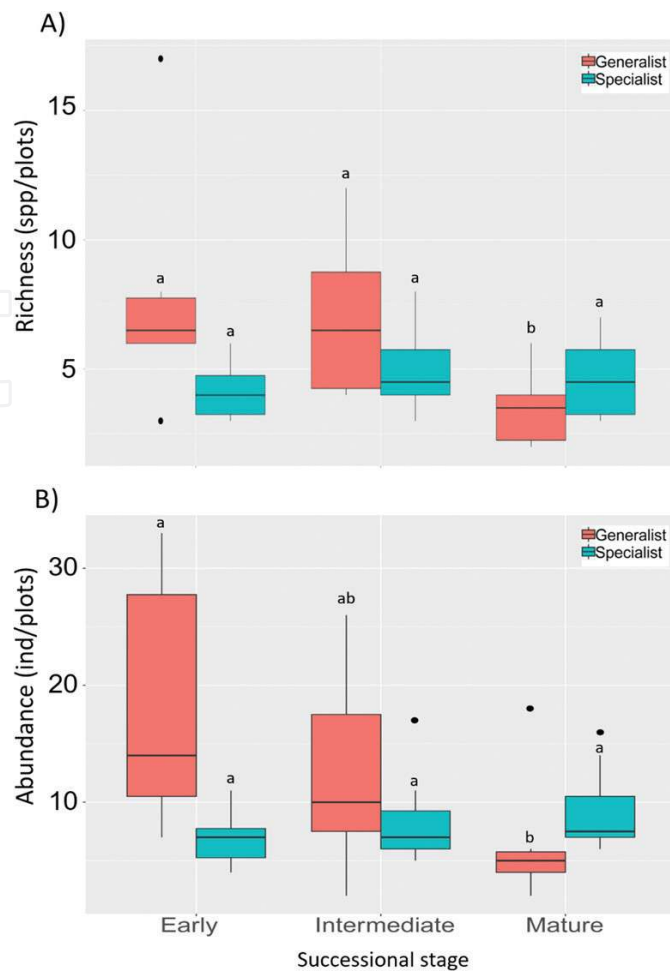
**Figure 3.** Boxplot of (A) richness and (B) bird abundance of generalist and specialist birds across three successional stages of a pine-oak forest in southern Mexico. Different letters indicate significant differences ($P < 0.05$) among successional stages, according to Mann-Whitney U test (richness of generalists) and Tukey's HSD (abundance of generalists). Within boxes, horizontal line indicates the median; box boundaries indicate interquartile range; whiskers indicate minimum, and maximum values and black dots are *outliers.*

stages, and the lowest species richness was found in the mature stage (**Figure 3A**). These differences were significant between successional stages ($X^2 = 7$, $df = 2$, $P = 0.030$; **Figure 3A**). The average abundance of specialist birds between the three successional stages was not significant (**Figure 3B**). Meanwhile, the abundance of generalist species was higher in the early stage and lower in the mature stage ($F = 5.32$, $P = 0.01$).

### 3.3. Relationship between distribution of generalist and specialist birds and habitat variables

The first two canonical axes of the CCA explained 85.5% (first axis = 56.8%; second axis = 28.7%) of the total explainable variation in the relationship between the distribution of generalist birds and habitat variables. The three main groups were revealed by this ordination analysis of generalist birds (**Figure 4A**). The first group is formed by species that forage in the foliage and that are associated with the height of plants and FHD, including warblers, such as

*Setophaga ruticilla*, *S. townsendii*, *Oreothlypis superciliosa*, and *Mniotilta varia*; vireos, such as *V. gilvus* and *V. solitarius*; and other migrants such as *Pheucticus melanocephalus* and *Polioptila caerulea*. The second group was formed by species associated with tree abundance and the diversity of plants (Shannon-Wiener index), including *Mithrephanes phaeocercus*, *Setophaga petechia*, *S. coronata*, *Cardellina pusilla*, and *Junco phaeonotus*. Finally, the third group was formed by *Aphelocoma coerulescens*, *Columbina inca*, *Catharus ustulatus*, *Sialia sialis*, and *Turdus migratorius* as well as the hummingbirds *Amazilia beryllina* and *Hylocharis leucotis* that were associated with shrub abundance (**Figure 4A**).
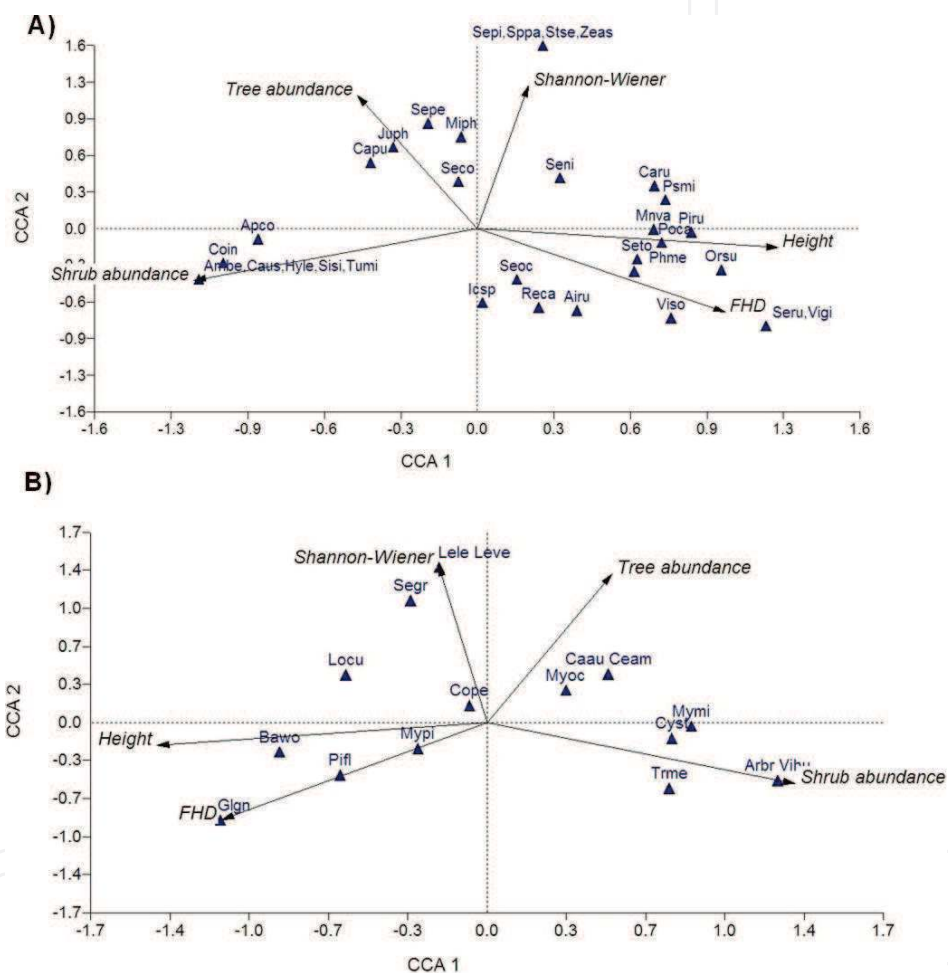


**Figure 4.** Canonical correspondence analysis of generalist (A) and specialist species (B) along the successional gradient of a pine-oak forest in southern Mexico. Variables: FHD, foliage height diversity; height, total height of the plants. Species: Airu, *Aimophila rufescens*; Ambe, *Amazilia beryllina*; Apco, *Aphelocoma coerulescens*; Arbr, *Arremon brunneinucha*; Bawo, *Baeolophus wollweberi*; Capu, *Cardellina pusilla*; Caru, *Cardellina rubrifrons*; Caau, *Catharus aurantiirostris*; Caus, *Catharus ustulatus*; Ceam, *Certhia americana*; Coin, *Columbina inca*; Cope, *Contopus pertinax*; Cyst, *Cyanocitta stelleri*; Glgn, *Glaucidium gnoma*; Hyle, *Hylocharis leucotis*; Icsp, *Icterus spurius*; Juph, *Junco phaeonotus*; Leaf, *Lepidocolaptes affinis*; Lele, *Lepidocolaptes leucogaster*; Leve, *Leptotila verreauxi*; Locu, *Loxia curvirostra*; Mefo, *Melanerpes formicivorus*; Miph, *Mitrephanes phaeocercus*; Mnva, *Mniotilta varia*; Myoc, *Myadestes occidentalis*; Mymi, *Myioborus miniatus*; Mypi, *Myioborus pictus*; Orsu, *Oreothlypis superciliosa*; Phme, *Pheucticus melanocephalus*; Pifl, *Piranga flava*; Piru, *Piranga rubra*; Poca, *Polioptila caerulea*; Psmi, *Psaltriparus minimus*; Reca, *Regulus calendula*; Seco, *Setophaga coronata*; Segr, *Setophaga graciae*; Seni, *Setophaga nigrescens*; Seoc, *Setophaga occidentalis*; Sepe, *Setophaga petechia*; Sepi, *Setophaga pitiayumi*; Seru, *Setophaga ruticilla*; Seto, *Setophaga townsendi*; Sisi, *Sialia sialis*; Sppa, *Spizella passerina*; Stse, *Stelgidopteryx serripennis*; Trme, *Trogon mexicanus*; Tumi, *Turdus migratorius*; Vigi, *Vireo gilvus*; Vihu, *Vireo huttoni*; Viso, *Vireo solitarius*; Zeas, *Zenaida asiatica*.

On the other hand, the CCA of the specialist birds explained 92.1% (first axis = 60.5%; second axis = 31.6%) of the total explainable variation. The distribution of some specialists, including woodcreepers, such as *Lepidocolaptes leucogaster*, the dove *Leptotila verreauxi*, and the warbler *Setophaga graciae*, were associated with the diversity of plants (Shannon-Wiener index; **Figure 4B**). Moreover, species as *Glaucidium gnoma*, *Piranga flava*, and *Baeolophus wollweberi* were associated with FHD and the height of plants. Other species such as *Arremon brunneinucha*, *Vireo huttoni*, and *Trogon mexicanus* were associated with shrub abundance, while *Myadestes occidentalis*, *Catharus aurantiirostris*, and *Certhia americana* were associated with tree abundance to a lesser extent (**Figure 4B**).

## 4. Discussion

Our results showed that bird diversity profile was higher in the intermediate successional stage than the other stages, except for its species richness that was not different to the early stage. These results support partially the intermediate disturbance hypothesis [14], which states that within a broad range of environmental disturbance levels, species diversity is maximized at an intermediate level of anthropogenic and natural disturbances, because competitively inferior, disturbance-tolerant species and competitively dominant, disturbance-sensitive species coexist when disturbances are neither too rare nor too frequent [35]. We also found less bird species in mature forest than in young secondary forests. This result coincides with those found by other authors along successional gradients in different types of vegetation in the Neotropics of Mexico [36, 37], Costa Rica [15, 38], and Ecuador [12, 39]. In addition, land-use history can influence the type of vegetation that regenerates after a disturbance. Gaps in the canopies of disturbed forests, for instance, promote an increase in the productivity of the lower vegetation strata [7, 38]. As a consequence, secondary successional habitats can provide a complex mosaic of microhabitats that can attract many bird species, such as *Junco phaeonotus*, *Mitrephanes phaeocercus*, and *Myadestes occidentalis*, which are favored of the open canopies to foraging. In our study area, pine tree richness was highest in the early successional stage, while pine tree abundance increased in the intermediate successional site [7]. This can explain the high richness of birds in the first successional stages that use these trees as foraging sites, such as warblers (*Cardellina pusilla*, *C. rubrifrons*, *Setophaga pitiayumi*, *S. striata*, *S. coronata*, and *S. townsendii*). In addition, recent studies have suggested that birds associated with mature forest might actually prefer early-successional habitat to mature forest during the post-fledging period to replenish energy [40]. Although this aspect was not evaluated in this study, it is probable that some birds, such as *Trogon mexicanus*, *Contopus pertinax*, *Cyanocitta stelleri*, and *Catharus aurantiirostris*, can move during the post-fledging period to the early stages in search of resources, as it has been observed in this stage.

In our study area, the higher diversity of birds at the early and intermediate stages was also likely due to the presence of peach, pear, apple, and hawthorn orchards, which may provide a diversified food supply for birds during certain periods of the year [41, 42]. On the other hand, there was a high dominance in the early and mature stages compared to the intermediate stage. Different studies showed that in the early stage this is a typical pattern, where species associated to this stage reach high abundance values in relation to other species [43], as it was the case of the resident species *Aphelocoma coerulescens* and a migratory

one, *Regulus calendula*. In mature forest, the dominance is not a common pattern, but in our study area, this result can be explained by the presence of resident species that were observed actively during the nesting period (March–April), such as *Trogon mexicanus* and *Myioborus pictus*.

On the other hand, the higher richness of generalist species in the intermediate and the early stages resulted to a large extent from the presence of Neotropical migrants that can readily use such habitats in the first stages of succession [12, 13]. In fact, there was an increase in the richness and abundance of generalist birds in these stages, which differed with the mature stage, something that is not occurred with the specialist birds whose presence was the same in the three successional stages. Moreover, the ordination analysis showed that the generalist birds were associated to different variables such as height of plants, FHD, and tree and shrub abundance. These correspondences are based according to their behavior and feeding habits, demonstrating that these species can adapt to different forest conditions [4, 44]. Particularly, species such as *A. coerulescens*, *Columbina inca*, *Catharus ustulatus*, *Amazilia beryllina*, *Hylocharis leucotis*, *Sialia sialis*, and *Turdus migratorius* were more abundant in sites with predominance of shrubs. These species have been associated with open areas with scattered trees [45]. Also, other bird groups (i.e., *Oreothlypis superciliosa*, *Polioptila caerulea*, *Piranga rubra*, *Mniotilta varia*, *Setophaga townsendi*, *Setophaga ruticilla*, *Vireo gilvus*, *V. solitarius*) were more associated with total height of the plants and foliar height diversity or FHD, because their habitat uses and foraging behavior include branches and leaves [46]. Specialist birds' abundance increased in the mature forest, which coincides with previous studies that showed that specialization in bird communities generally increases in the course of forest succession [47]. Some specialist birds such as woodcreepers (*Lepidocolaptes leucogaster*) were related to the abundance of trees and Shannon-Wiener index (giving more weight to plant richness), as these birds need trees to make their nests in cavities and forage on trunks and bryophytes [48]. On the other hand, other specialist birds were associated with shrub abundance and corresponded to their ecological needs. Particularly, shrub dwellers such as *Myioborus miniatus* and *Vireo huttoni* use low strata in vegetation in search for food and even for cover, since they are ground foragers like *Arremon brunneinucha*.

## 5. Conclusions

Our results demonstrate the importance of maintaining not only the mature forest but also young successional stages for conservation of secondary pine-oak forest bird species. According to this, the forest policies and management planners must take into account how land and forest are used in pine-oak ecosystems of southern Mexico, in order to improve landscape heterogeneity and multiply different habitat and foraging site opportunities for bird species.

## Acknowledgements

## A. Appendix

Composition of bird species in three successional stages of pine-oak forest in southern Mexico. *Seasonality*: R, resident; M, migratory. *Bird groups*: G, generalist; S, specialist. *Successional stage*: ES, early stage; IS, intermediate stage; MS, mature stage. The relative abundance of bird species per successional stage is presented

| Family | Species | Seasonality | Bird groups | Successional stage | | |
|---|---|---|---|---|---|---|
| | | | | ES | IS | MS |
| Columbidae | *Columbina inca* | R | G | 0.015 | 0.004 | |
| | *Leptotila verreauxi* | R | S | | 0.009 | |
| | *Zenaida asiatica* | R | G | | 0.009 | |
| Cuculidae | *Piaya cayana* | R | G | 0.008 | | |
| Trochilidae | *Lampornis clemenciae* | R | G | | 0.009 | |
| | *Archilochus alexandri* | R | G | 0.008 | 0.009 | |
| | *Amazilia beryllina* | R | G | 0.008 | | |
| | *Hylocharis leucotis* | R | G | 0.030 | | |
| Strigidae | *Glaucidium gnoma* | R | S | | | 0.013 |
| Trogonidae | *Trogon mexicanus* | R | S | 0.019 | 0.040 | 0.138 |
| Picidae | *Melanerpes formicivorus* | R | G | | | 0.031 |
| | *Picoides scalaris* | R | G | | 0.004 | |
| | *Picoides villosus* | R | S | | 0.004 | 0.006 |
| Furnariidae | *Lepidocolaptes leucogaster* | R | S | | 0.022 | |
| | *Lepidocolaptes affinis* | R | S | | 0.004 | |
| Tyrannidae | *Mitrephanes phaeocercus* | R | G | 0.049 | 0.084 | 0.006 |
| | *Contopus pertinax* | R | S | 0.026 | 0.044 | 0.038 |
| | *Empidonax fulvifrons* | R | G | 0.004 | | |
| Vireonidae | *Vireo huttoni* | R | S | | 0.004 | |
| | *Vireo solitaries* | MI | G | 0.004 | | 0.019 |
| | *Vireo gilvus* | R | G | | | 0.013 |
| Corvidae | *Cyanocitta stelleri* | R | S | 0.053 | 0.018 | 0.006 |
| | *Aphelocoma coerulescens* | R | G | 0.162 | 0.026 | |
| Hirundinidae | *Stelgidopteryx serripennis* | R | G | | 0.022 | |
| Paridae | *Baeolophus wollweberi* | R | S | | 0.022 | 0.069 |
| Aegithalidae | *Psaltriparus minimus* | R | G | | 0.048 | 0.038 |
| Certhiidae | *Certhia americana* | R | S | 0.011 | 0.013 | |

| Family | Species | Seasonality | Bird groups | Successional stage | | |
|---|---|---|---|---|---|---|
| | | | | ES | IS | MS |
| Troglodytidae | *Thryomanes bewickii* | R | G | 0.004 | | |
| | *Troglodytes aedon* | R | G | | | 0.006 |
| Polioptilidae | *Polioptila caerulea* | MI | G | 0.004 | 0.022 | 0.025 |
| Regulidae | *Regulus calendula* | MI | G | 0.094 | 0.040 | 0.069 |
| Turdidae | *Sialia sialis* | R | G | 0.023 | | |
| | *Myadestes occidentalis* | R | S | 0.056 | 0.066 | 0.019 |
| | *Catharus aurantiirostris* | R | S | 0.015 | 0.018 | 0.019 |
| | *Catharus ustulatus* | T-MI | G | 0.011 | | |
| | *Turdus migratorius* | R | G | 0.023 | | |
| Mimidae | *Melanotis caerulescens* | R | G | 0.004 | 0.004 | |
| Ptiliogonatidae | *Ptiliogonys cinereus* | R | G | 0.004 | 0.004 | 0.031 |
| Peucedramidae | *Peucedramus taeniatus* | R | S | | | 0.013 |
| Fringillidae | *Euphonia elegantissima* | R | G | 0.004 | | |
| | *Loxia curvirostra* | R | S | | 0.022 | 0.019 |
| | *Spinus notatus* | R | G | 0.008 | | |
| Passerellidae | *Arremon brunneinucha* | R | S | 0.008 | | |
| | *Atlapetes pileatus* | R | S | | | 0.013 |
| | *Aimophila rufescens* | R | G | 0.004 | | 0.006 |
| | *Melozone albicollis* | R | G | 0.011 | | |
| | *Spizella passerina* | MI | G | 0.015 | 0.026 | |
| | *Junco phaeonotus* | R | G | 0.064 | 0.070 | |
| Icteridae | *Icterus spurius* | MI | G | 0.004 | | 0.025 |
| | *Icterus bullockii* | MI | G | | 0.004 | |
| Parulidae | *Mniotilta varia* | MI | G | 0.008 | 0.031 | 0.031 |
| | *Oreothlypis superciliosa* | R | G | | 0.004 | 0.013 |
| | *Setophaga ruticilla* | T | G | | | 0.006 |
| | *Setophaga pitiayumi* | R | G | | 0.013 | |
| | *Setophaga petechia* | MI | G | 0.004 | 0.009 | |
| | *Setophaga striata* | T | G | | 0.013 | |
| | *Setophaga coronata* | MI | G | 0.053 | 0.057 | 0.013 |
| | *Setophaga graciae* | R | S | | 0.035 | 0.006 |
| | *Setophaga nigrescens* | MI | G | 0.004 | 0.018 | 0.006 |
| | *Setophaga townsendi* | MI | G | 0.015 | 0.018 | 0.031 |
| | *Setophaga occidentalis* | MI | G | 0.026 | 0.004 | 0.019 |
| | *Cardellina pusilla* | MI | G | 0.015 | 0.013 | |
| | *Cardellina rubrifrons* | MI | G | | 0.013 | 0.006 |
| | *Myioborus pictus* | R | S | 0.060 | 0.066 | 0.156 |
| | *Myioborus miniatus* | R | S | 0.011 | 0.004 | |

| Family | Species | Seasonality | Bird groups | Successional stage | | |
|--------|---------|-------------|-------------|-----|-----|-----|
| | | | | ES | IS | MS |
| Cardinalidae | *Piranga flava* | R | S | 0.011 | 0.013 | 0.069 |
| | *Piranga rubra* | MI | G | | 0.004 | 0.006 |
| | *Piranga bidentata* | R | G | 0.004 | | |
| | *Pheucticus melanocephalus* | R | G | 0.004 | 0.004 | 0.013 |
| Thraupidae | *Diglossa baritula* | R | G | 0.004 | 0.004 | 0.013 |
| | *Sporophila torqueola* | R | G | 0.045 | | |

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