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DISTINCT SUMMER BIRD ASSEMBLAGES IN TWO FRAGMENTS OF *POLYLEPIS* FORESTS IN THE SOUTHERN YUNGAS OF ARGENTINA

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Resumen. – Distintos ensambles de aves en época estival en dos fragmentos de bosques húmedos de *Polylepis* de las Yungas Australes de Argentina. – Los bosques de *Polylepis* son considerados uno de los ecosistemas Neotropicales más amenazados. La avifauna de los bosques de *Polylepis* de los Andes tropicales ha sido relativamente bien estudiada en Bolivia y Perú. Sin embargo, en los Andes de Argentina esta información es muy escasa. En este trabajo caracterizamos y comparamos los ensambles de aves en dos fragmentos de bosques de *Polylepis* de las Yungas Australes: *P. australis* y *P. hieronymi*, y proporcionamos la primera lista exhaustiva de aves de bosque de *P. hieronymi*. El trabajo de campo se realizó en dos cadenas montañosas de la provincia de Jujuy con bosques de *Polylepis* dominados por las distintas especies. Registramos un total de 391 aves pertenecientes a 43 especies. La riqueza, abundancia relativa y diversidad de especies fueron mayores en bosques de *P. australis* que en bosques de *P. hieronymi*. Hubo un marcado recambio en la composición de especies entre comunidades (índice de similitud de Sørensen = 23%). Las especies características de cada tipo de bosque fueron el Chingolo (*Zonotrichia capensis*, VI = 90%) en *P. australis* y el Fiofío silbón (*Elaenia albiceps*; VI = 70%) en el bosque de *P. hieronymi*. Los gremios de uso de hábitat mostraron una abundancia mayor de especies de aves generalistas y de áreas abiertas o borde en bosques de *P. australis* que en bosques de *P. hieronymi;* pero no detectamos diferencias entre las especies de aves de bosque. La ausencia de registros de especies de aves altamente asociadas a bosques de *Polylepis* podría estar relacionada con la actual retracción de estos bosques y a la simplificación estructural debido a disturbios antrópicos. Por lo tanto, para garantizar la conservación de las comunidades de aves de *Polylepis* se deberían ampliar los límites del Parque Nacional Calilegua para incluir a bosques de *P. australis,* y de la Reserva Provincial Las Lancitas para incluir a los bosques de *P. hieronymi*.

Abstract. – *Polylepis* forests are considered one of the most threatened Neotropical ecosystems. The tropical Andes avifauna of *Polylepis* forests has been relatively well studied in Bolivia and Peru; however, in Argentina this information is scarce. In this study, we characterize and compare bird assemblages in two humid *Polylepis* forests fragments of the Southern Yungas, *P. australis* and *P. hieronymi*, and provide the first exhaustive bird list for *P. hieronymi* forest. Fieldwork was carried-out in two mountain ranges in Jujuy Province with *Polylepis* forest dominated by the different species. We recorded a total of 391 birds belonging to 43 species. Bird richness, relative abundance, and diversity were higher in *P. australis* than in *P. hieronymi* forest. There was a high turnover in species composition between communities (Sørensen similarity index = 23%). Indicator species of each forest type were Rufous-collared Sparrow (*Zonotrichia capensis*, IV = 90%) in *P. australis* and White-crested Elaenia (*Elaenia albiceps*; IV = 70%) in *P.*

hieronymi forest. Habitat use guilds showed a significantly higher bird abundance of generalist and forest edge or open areas in *P. australis* than in *P. hieronymi* forest, but there was no difference between abundance of forest bird species. The absence of bird species highly associated with *Polylepis* forests could be related to the retraction of current *Polylepis* forests and to their structural simplification caused by anthropogenic disturbances. Therefore, the boundaries of Calilegua National Park should be broadened to include *P. australis* and of Las Lancitas Provincial Reserve to include *P. hieronymi* to ensure the conservation of *Polylepis* forest bird assemblages. *Accepted 22 July 2014.*

Key words: Argentina, hotspots, mountain forest, *Polylepis australis, Polylepis hieronymi*, Yungas.

INTRODUCTION

Neotropical montane forests are of particular conservation concern because they are biodiversity hotspots mainly for bird species (Fjeldså & Kessler 1996, Sánchez-González *et al.* 2008). Many bird species are highly restricted to specific habitats, such as *Polylepis* forests (Kessler 2000, Kessler *et al.* 2001, Fjeldså 2002, Jácome *et al.* 2007). Trees of the genus *Polylepis* characterize the upper montane forests of South America and form the highest tree-line in the world (Fjeldså & Kessler 1996). *Polylepis* forests also provide numerous ecosystem services, such as water regulation and supply, protection from soil erosion, and carbon sequestration (Fjeldså & Kessler 1996, Cingolani *et al.* 2008, Renison *et al.* 2010). *Polylepis* forests are currently distributed in small and isolated patches in landscapes dominated by grasslands, and are mainly restricted to ravines and rocky outcrops (Fjeldså & Kessler 1996, Renison *et al.* 2006, Gareca *et al.* 2010). This patchy distribution is primarily the result of centuries of human activities, including logging (Fjeldså & Kessler 1996, Renison *et al.* 2006), fire (e.g., Renison *et al.* 2002, Cingolani *et al.* 2008), overgrazing (e.g., Cingolani *et al.* 2008, Giorgis *et al.* 2010), and soil degradation (Renison *et al.* 2010). *Polylepis* forests are considered one of the most threatened Neotropical vegetation types (Jameson & Ramsay 2007). Therefore, conservation, monitoring, and restoration of *Polylepis* forest remnants are extremely important (Gareca *et al.* 2010).

Forest bird communities are very sensitive to forest loss and degradation (Watson *et al.* 2004, O'Dea & Whittaker 2007, Zurita & Zuleta 2009, Albanesi *et al.* 2014); hence, analyses of avian diversity patterns can be indicative of ecosystem integrity. Bird communities of tropical Andes *Polylepis* forests have been relatively well studied (e.g., Fjeldså 1993, Fjeldså 2002, Herzog *et al.* 2003, Cahill & Matthysen 2007; Lloyd 2008a, 2008b; Lloyd & Marsden 2008, 2011). However, information about birds in subtropical *Polylepis* forests in Argentina is scarce. To our knowledge, the only three studies addressing bird communities of *Polylepis* forests are focused on *P. australis*, primarily located on the Sierras Grandes of central Argentina (García *et al.* 2008, Bellis *et al.* 2009, 2010; Bellis *et al.* in prep.). There are no studies available on bird communities of others *Polylepis* species on the subtropical montane forests or Southern Yungas of north-western Argentina (e.g., *P. hieronymi*). This is particularly critical since the Southern Yungas is one of the world's biodiversity hotspots (Myers *et al.* 2000), with less than 5% of its forest protected in Argentina (Brown *et al.* 2006). Information is crucial for the management and recovery of the small *Polylepis* forest patches that still remain (Lloyd 2008b), and because several Important Bird Areas (IBAs) include *Polylepis* forests with globally threatened bird species (Di Giácomo 2005).

Argentina harbors five of the c. 26 described *Polylepis* species (Kessler & Schmidt-Lebuhn 2006). *P. tarapacana* and *P. tomentella* are found in dry environments of the Puna region; *P. crysta-galli* and *P. hieronymi* are distributed in the Southern Yungas; and *P. australis* is the southernmost species and dominates forests in the upper Southern Yungas and Sierras Grandes of central Argentina (Córdoba province), covering a latitudinal extension of 1200 km (Kessler & Schmidt-Lebuhn 2006, Renison *et al.* 2013). Within *Polylepis*, there is a well-defined ecological and morphological gradient from tall trees growing at the upper limits of humid cloud forests, to successively smaller species growing at lower elevation and in drier habitats (Schmidt-Lebuhn *et al.* 2010). As an example, in the Southern Yungas of Argentina, forests of *P. hieronymi* show several differences with *P. australis* forests. *Polylepis hieronymi* trees are substantially smaller than *P. australis* and occur at lower altitude, on very steep slopes which probably have very shallow soils that do not permit persistence of taller trees (Herzog *in litt.*). Moreover, *P. hieronymi* does not form continuous forest rather it is restricted to small patches, since it is a pioneer species that colonizes open areas and then is surpassed by taller trees of the Southern Yungas such as *Alnus acuminata* (Fjeldså & Kessler 1996, Renison *et al.* 2013). Consequently, *P. australis* and *P. hieronymi* forests are structurally different, and hence bird communities may differ between them. To test this hypothesis we compare bird species richness, abundance, and species turnover between *P. hieronymi* and *P. australis* forests of the Southern Yungas of north-western Argentina, and identify the bird species that characterizes each forest type (using an indicator species analysis, ISA). We also used a guild approach to evaluate the collective association of species to changes in the different forest types.

METHODS

Study area. Fieldwork was conducted in two forest fragments of *P. australis* and *P. hieronymi* located in the very steep eastern slopes (≤ 45º) of the Andes, Jujuy province, north-western Argentina. Both fragments belong to the upper cloud forest of the Southern Yungas. Annual vertical precipitation reaches 1500 mm and is mainly concentrated in the austral summer (December–March). Fog and horizontal precipitation can be equivalent to vertical precipitation or even exceed this volume (Hunzinger 1995).

The *P. australis* fragment studied (50 ha) is located in Alto Calilegua (between 2200–2500 m a.s.l.), in Calilegua mountain range (23º37'S, 64º54'W). Alto Calilegua is situated on continuous tracks of Southern Yungas forest that extends toward Bolivia. *P. australis* trees were found in humid, protected, and steep ravines surrounded by highland grasslands or *Alnus acuminata* forest patches of up to 6 m of height. *P. australis* trees had c. 50 cm of diameter at breast height (DBH) and 4–6 m of height (with some individuals reaching up to 16 m; Rivera & Politi pers. observ., Renison *et al.* 2013); forest patch was structurally rich, with *P. australis* trees associated with plants such as vines, ferns and bromeliads (Rivera & Politi pers. observ., Bellis *et al.* 2009). The trees of *P. australis* do not form dense patches in this fragment; rather they had an open canopy.

The *P. hieronymi* fragment (30 ha) is located in Santa Bárbara mountain range (24º6'S, 64º27'W) at an elevation that ranged from 2000– 2300 m a.s.l.. Santa Bárbara mountain range is situated on a small outlying mountain range that is about 80 km in length, separated to the East from the main continuous forest area. Santa Bárbara is separated 70 km by a low valley (ca. 400–500 m a.s.l.) of seasonally dry forest from Alto Calilegua. Trees of *P. hieronymi* were found on ravines, but also outside ravines. *P. hieronymi* trees had 20 cm DBH, a height ≤ 3 m and individuals that unusually had 8 m height (Rivera & Politi pers. observ., Renison *et al.* 2013), this forest patch had lower structural and botanical complexity than *P. australis* patch (Rivera & Politi pers. observ.). In this fragment, trees form dense pure patches surrounded by highland grasslands or *A. acuminata* of up to 6 m of height.

Bird survey. Bird data were collected during the austral summer (January to March 2006), when bird richness is highest due to the arrival of migrants. Moreover, differences in bird communities are easier to detect during the summer due to the birds' territorial behavior compared to their aggregated distribution in winter, when large mixed flocks are formed (Ordano 1996, García *et al.* 2008). Bird species and abundance were quantified using 10-minute point counts randomly distributed in each *Polylepis* forest (Bibby *et al.* 1992, Lee & Marsden 2008). In each fragment, we located 30 survey points separated by at least 150 m to avoid double-counts between neighboring points. At each point, the surveyor waited 5 min as a settling down period before starting the counts (Bibby *et al.* 1992). Birds occurring within a 50-m fixed-radius of each point were recorded visually or aurally. Point count stations were surveyed twice (and total abundance was added) in favorable weather conditions within a 3-hour period after sunrise. Nocturnal species and species that only overflew the forest were not considered. Birds were taxonomically identified following Gill & Donsker (2013).

Data analysis. As a measure of relative abundance we calculated encounter rates (ER) per bird species recorded at each point count. ER was expressed as the mean number of detections per point (10 min and 0.78 ha) for each species recorded. Richness and Simpson's diversity index (1/D, Magurran 2004) of bird communities were calculated using EstimateS v.8.0 software (Colwell 2006). Due to problems inherent to traditional diversity indices, such as the loss of information associated with limited sampling (Feinsinger 2004), species richness was estimated from the sample-based rarefaction curves (Mau Tau, Sobs) (Magurran 2004, Mao *et al.* 2005) using EstimateS (Colwell 2006). Rarefaction analysis allowed us to compare richness and diversity after standardizing differences in abundance among samples (Magurran 2004). Changes in avian composition between forest fragments (beta diversity) were tested with the Sørensen similarity index (Magurran 2004).

We also calculated the Indicator Value (IV) index (Dufregne & Legendre 1997) to find species significantly associated with a particular type of forest fragment within the bird assemblage following the formula:

$$IVij = Aij \times Bij \times 100,$$

where Aij is the mean abundance of species i in the treatment of group j compared to all groups in the study. Bij is the relative frequency of occurrence of the species i in the sites of groups j. An IV of 100% shows that a species is a perfect indicator for a given habitat type (for details, see Dufrene & Legendre 1997). Indicator values were tested for significance with Monte Carlo (based on 1000 permutations, Quinn & Keough 2002).

Functional groups were established according to habitat use of species as determined from the literature (Fjeldså & Kessler 1996, Dardanelli *et al.* 2006). Groups were classified as: forest species (FS: species that use mainly understory, ground, medium stratum or canopy); forest edge or open-area species (EO: species that primarily use forest edges, shrublands or open areas); and neutral species (N: habitat generalists). Here we defined habitat in the narrow sense of vegetation structure rather than as the full array of biotic and abiotic factors in the environment. We tested changes in bird communities (diversity and relative abundance) and habitat use groups (relative abundance) between forest types with Mann Whitney *U*-test (Quinn & Keough 2002).

RESULTS

We recorded a total of 391 birds belonging to 43 species, 22 bird species were recorded in *P. hieronymi* and 27 in *P. australis* fragments. Composition of bird communities was clearly different between forest fragments (Table 1). There was a high turnover in species composition between forest fragment bird assemblages (Sørensen index = 23% similarity). Six species were shared between forest fragments: Stripe-crowned Spinetail (*Cranioleuca pyrrhophia*), White-throated Tyrannulet (*Mecocerculus leucophrys),* Rusty-browned Warbling-Finch (*Poospiza erythrophrys),* Red-tailed Comet (*Sappho sparganura*), Chiguanco Thrush (*Turdus chiguanco*), and Rufous-collared Sparrow (*Zonotrichia capensis*) (Table 1). *P. australis* forest fragment had higher bird abundance (Mann-Whitney U-test, $U = 1211.5$, $P < 0.0001$) and Simpson's diversity (Mann-Whitney U-test, $U = 745.5$, $P = 0.01$) than *P. hieronymi* (Table 1). Rarefaction analysis also indicated higher bird species richness in *P. australis* than in *P. hieronymi* forest fragment (Mann-Whitney U-test, $U = 6395.5$, $P < 0.0001$; Table 1).

In the Indicator species analysis (ISA) nine bird species were selected as significant (Monte Carlo test; $P < 0.05$) indicators of (or species closely associated with) a particular forest type and one bird species was marginally significant ($P = 0.05$; Table 2). Only one bird species was a good indicator of *P. hieronymi* forest fragment: the White-crested Elaenia (*Elaenia albiceps*, IV = 70%), whereas the Rufous-collared Sparrow was the best indicator species (IV = 90%, Table 2) of *P. australis.*

Relative bird abundance per functional group also showed variation between forests (Fig. 1). The bird community of *P. australis* forest had a significantly higher abundance of neutral species and forest edge and open-areas species than *P. hieronymi* forest (Mann-Whitney U-test, $U = 1193$, $P < 0.001$; $U = 1044$, $P = 0.018$, respectively; Fig. 1). However, no difference in abundance for forest bird species was detected (Mann-Whitney U-test, $U = 907.5$, $P = 0.91$; Fig. 1).

DISCUSSION

This study represents the first approach to compare bird assemblages in two humid *Polylepis* forests in the Southern Yungas of Northwestern Argentina. In accordance with our hypothesis the two types of humid *Polylepis* forests have distinct avian communities, sharing only 23% of their bird species. There are several factors that may explain this results; according to our field observations, the greater diversity and abundance of birds found in *P. australis* forest might be associated with greater forest structural complexity (*P. australis* trees were associated with other plants such as vines, ferns, and bromeliads; Rivera & Politi pers. observ.) that offers more resources for avifauna. Habitats with a complex architecture support more species than habitats with a simple architecture because they provide more resources and/or opportunities for microhabitat segregation (MacArthur & MacArthur 1961, Fjeldså 1993, Luoto *et al.* 2004, Cherkaoui *et al.* 2009, Albanesi *et al.* 2014). It is well demonstrated that structural complexity is positively associated with *Polylepis* bird diversity (Sevillano-Ríos *et al.* 2011, Tinoco *et al.* 2013). Differences in bird species composition might respond to variations in the quality within the *Polylepis* fragments, since the number of *Polylepis* specialists is mainly dependent of habitat attributes (Fjeldså 1993, Bellis *et al.* 2009). For instance, in the Peruvian Andes the *Polylepis*-dependent species were strongly associated to habitat complexity such as density of large trees, vegetation cover and plant diversity (Fjeldså & Kessler 1996; Lloyd 2008a, b). Besides forest quality, the surrounding vegetation may exert a significant influence on avifauna composition (Lloyd 2008a). In this study, neighbouring

TABLE 1. Bird species list, bird relative abundance (ER, expressed as encounter rates, i.e., mean number of detections per 10-min sampled period at each point), diversity and bird-habitat association recorded in *Polylepis hieronymi* and *P. australis* forests in northwestern Argentina. FS: forest species, EO: edge-open land species, and N: neutral species. (+) Species closely associated with *Polylepis* forests according to Fjeldså & Kessler (1996). (§) Migrant birds. (*) Significant differences between forest fragments (*P* < 0.05).

Bird list	English name	Forest type		Habitat use group
		P. hieronymi	*P. australis*	
Cracidae				
Penelope dabbenei	Red-faced Guan	0	0.06	FS
Falconidae				
Caracara plancus	Southern Crested Caracara	0	0.02	N
Columbidae				
Patagioenas fasciata §	Band-tailed Pigeon	0.02	0	EO
Psittacidae				
Aratinga mitrata	Mitred Parakeet	0	0.59	EO
Psilopsiagon aurifrons	Mountain Parakeet	0	0.25	EO
Trochilidae				
Sappho sparganura	Red-tailed Comet	0.41	0.58	N
Colibri coruscans	Sparkling Violetear	0	0.08	EO
Picidae				
Colaptes rubiginosus	Golden-olive Woodpecker	0.06	0	FS
Furnaridae				
Cinclodes fuscus	Buff-winged Cinclodes	0	0.06	EO
Cranioleuca pyrrhophia	Stripe-crowned Spinetail	0.04	0.06	FS
Synallaxis frontalis	Sooty-fronted Spinetail	0.02	0	FS
Leptasthenura fuliginiceps	Brown-capped Tit-Spinetail	0	0.13	FS
Phacellodomus striaticeps+	Streak-fronted Thornbird	0	0.06	FS
Phacellodomus maculipectus	Spot-breasted Thornbird	0	0.04	EO
Syndactyla rufosuperciliata	Buff-browed Foliage-gleaner	0.04	0	FS
Rhinocryptidae				
Scytalopus superciliaris	White-browed Tapaculo	0.13	0	FS
Tyranidae				
Elaenia albiceps §	White-crested Elaenia	0.98	0	FS
Knipolegus signatus	Andean Tyrant	0	0.02	FS
Ochthoeca leucophrys	White-browed Chat-Tyrant	0	0.04	EO
Myiotheretes striaticollis	Streak-throated Bush Tyrant	0	0.13	FS
Mecocerculus leucophrys	White-throated Tyrannulet	0.06	0.11	FS
Tityridae				
Pachyramphus validus	Crested Becard	0.08	0	EO
Troglodytidae				
Troglodytes solstitialis	Mountain Wren	0.02	0	FS
Turdidae				
Turdus nigriceps §	Andean Slaty Thrush	0.02	0	EO
Turdus chiguanco	Chiguanco Thrush	0.19	0.34	N
Motacillidae				
Anthus hellmayri §	Hellmayr's Pipit	0.02	0	EO

TABLE 1. Continuation.

Bird list	English name	Forest type		Habitat use group
		P. hieronymi	*P. australis*	
Thraupidae				
Chlorospingus flavopectus	Common Bush Tanager	0.02	0	EO
Thraupis bonariensis	Blue-and-yellow Tanager	0	0.13	EO
Pipraeidea melanonota	Fawn-breasted Tanager	0.02	0	FS
Thlypopsis sordida	Orange-headed Tanager	0	0.04	EO
Emberizidae				
Arremon torquatus	White-browed Brush Finch	0.02	0	FS
Atlapetes fulviceps	Fulvous-headed Brush Finch	0	0.15	FS
Atlapetes citrinellus	Yellow-striped Brush Finch	0.06	0	FS
Phrygilus unicolor+	Plumbeous Sierra Finch	0	0.23	FS
Zonotrichia capensis	Rufous-collared Sparrow	0.23	2.05	N
Poospiza erythrophrys	Rusty-browed Warbling Finch	0.23	0.04	FS
Compsospiza baeri+	Tucuman Mountain Finch	0	0.04	FS
Cardinalidae				
Saltator aurantiirostris	Golden-billed Saltator	0	0.02	FS
Pheucticus aureoventris	Black-backed Grosbeak	0.06	0	FS
Parulidae				
Myiothlypis signata	Pale-legged Warbler	0.02	0	FS
Fringillidae				
Spinus atrata+	Black Siskin	0	0.13	FS
Spinus uropygialis	Yellow-rumped Siskin	0	0.06	EO
Spinus magellanica	Hooded Siskin	0	0.04	EO
ER mean (SE)		0.28 (0.03)	0.56 (0.05) *	
Number of individuals		131	260	
Species richness (Mau Tau; S obs, SE)		22 (2.24)	27 (2.97) *	
Simpson diversity (SE)		2.49 (0.31)	3.23 (0.21) *	

vegetation was similar in both forest patches, suggesting that structural complexity might be the main driver of bird diversity and species turnover between *Polylepis* forests.

Other factors that could contribute to the differences in the bird assemblages of these forest fragments, but that were not assessed in this study, could be patch size and biogeography. It is well known that the increase in species richness and abundance is largely dependent of the patch area (MacArthur & Wilson 1967) and this pattern has been recorded in *Polylepis* forests of Ecuador (Tinoco *et al.* 2013), although *Polylepis* forests of Peruvian Andes show no a clear pattern (Lloyd 2008b). Biogeography might be related to the mountain ranges isolation that results in a discontinuous distribution of species (Brown *et al.* 2001). Therefore, some bird species found in *P. australis* forest might have not been able to colonize *P. hieronymi* forests in the eastern mountain range. More specific studies of species–area relationships and biogeographic patterns are required to clarify their effects on bird communities.

A limitation of our study is the difficult to extrapolate our results beyond the areas surveyed since, due to logistical and economic

TABLE 2. Indicator species analysis showing bird species significantly associated to *Polylepis* forest of north-western Argentina. The best indicator species are shown in bold.

Forest type	Bird species	Indicator value (%)	*P* value
Polylepis hieronymi	***Elaenia albiceps***	70	0.001
	Scytalopus superciliaris	20	0.03
Polylepis australis	***Zonotrichia capensis***	90	0.001
	Aratinga mitrata	23	0.008
	Phrygilus unicolor	27	0.003
	Atlapetes fulviceps	20	0.02
	Myiotheretes striaticollis	20	0.02
	Thraupis bonariensis	20	0.02
	Spinus atrata	17	0.05
	Leptasthenura fuliginiceps	17	0.04

constraints, the surveys were only conducted in a single fragment of each forest type and only during summer season. However, as the study area is typical of other *Polylepis* forests in the region, we consider that the results might be representative of other areas. In addition, accumulations of local studies often are the only approach to obtain general patterns (Blake 2005).

Overall, our results show that the avifauna of both *Polylepis* forests is mainly composed of bird species from the neighboring vegetation (i.e., cloud forests of the Southern Yungas). Similar results were found in *Polylepis* forest of Peru, where avifauna composition was significant influenced by the matrix (Lloyd 2008a, b). Surrounding matrix can exert a strong effect on the processes occurring inside fragments (Metzger *et al.* 2009) affecting bird richness, abundance and assemblage composition (Lindenmayer & Fisher 2006). Literature often shows that small forest fragments are dominated by ecological generalists and open areas' species that use the surrounding habitat matrix (Antongiovanni & Metzger 2005). In agreement with this idea, indicator species of each forest type were birds with low or moderate sensitivity to habitat degradation. The generalist species Rufous-collared Sparrow was the best indicator species (IV = 90%) in the *P. australis* assemblage and it is considered an opportunistic species that uses forest edges (Estades & Temple 1999). In addition, Rufous-collared Sparrow has been found associated with *Polylepis* matrix (Lloyd & Marsden 2008, Lloyd 2008b) and in disturbed *Polylepis* forests. Bird species that were poor indicators of this forest type (IV ≤ 23%) included forest species, such as Fulvous-headed Brush-finch (*Atlapetes fulviceps*), Streak-throated Bush-tyrant (*Myiotheretes striaticollis*), Black Siskin (*Spinus atrata*), and Brown-capped Tit-Spinetail (*Leptasthenura fuliginiceps*), but also species that use edge and open areas, such as Mitred Parakeet (*Aratinga mitrata)* and Blue-and-yellow Tanager (*Thraupis bonariensis*), and Puna grasslands, such as the Plumbeous Sierra-finch (*Phrygilus unicolor*).

The species characteristic or indicator of *P. hieronymi* forest was the White-crested Elaenia (IV = 70%), a typical bird species that uses the upper understory, midstory, and canopy strata of the forest. However, the White-crested Elaenia has a wide distribution, and also was recorded as a dominant species in the Andean Patagonic forests of Argentina

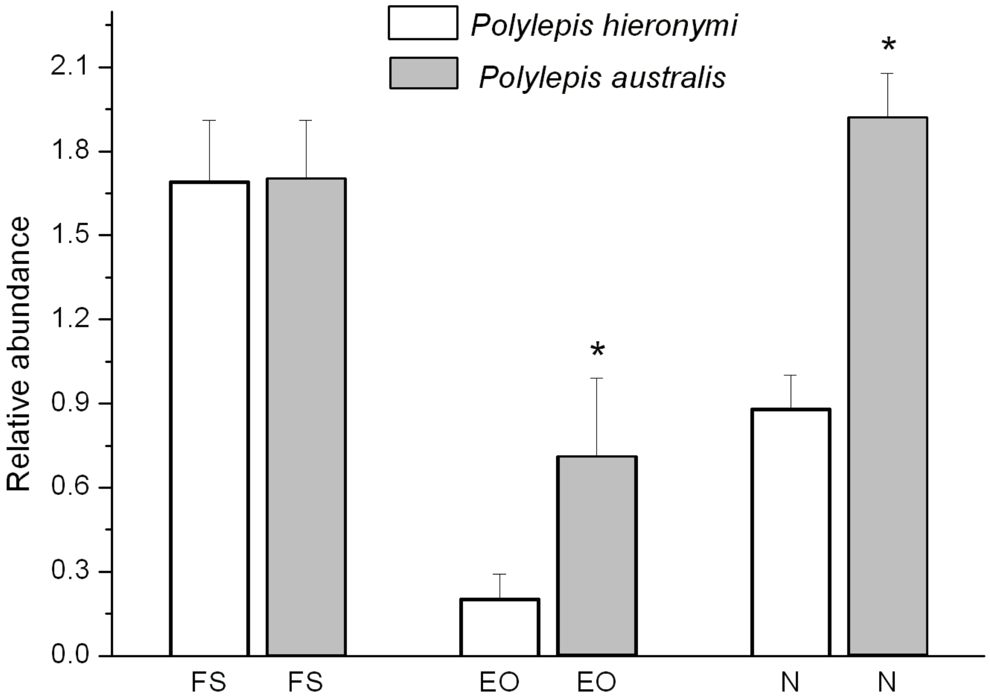

FIG. 1. Relative mean abundance (expressed as encounter rates, i.e., number of detections per 10-min sampled period at each point ± Standard error) of birds recorded in the different habitat use groups. FS: forest species, EO: edge-open land species, and N: neutral species. (*) Significant differences between *Polylepis* forest fragments ($P < 0.05$).

(Lantschner & Rusch 2007) and in temperate forests of Southern Chile (Rozzi *et al.* 1996). The White-browed Tapaculo (*Scytalopus superciliaris)* was the second forest species recorded as characteristic of *P. hieronymi* forest but with a very low indicator value (IV = 20%).

Although bird diversity in *P. australis* forests is greater than *P. hieronymi* ones, neither studied forest presented *Polylepis* bird specialists, such as Tawny Tit-spinetail (*Leptasthenura yanacensis*), Thick-billed Siskin (*Carduelis crassirostris*), and Giant Conebill (*Oreomanes fraseri*) mentioned for Northwestern Argentina (Di Giácomo 2005), Bolivia, or Peru (Fjeldså 1993, Fjeldså & Kessler 1996, Fjeldså 2002, Herzog *et al.* 2003, Cahill & Matthysen 2007, Lloyd 2008a & 2008b; Lloyd & Mardsen 2008). Only four species listed as closely associated with *Polylepis* forests (Fjeldså & Kessler 1996, Fjeldså 2002) were recorded in *P. australis* forest: Black Siskin, Streak-fronted Thornbird (*Phacellodomus striaticeps),* Tucuman Mountain-finch (*Poospiza baerii*), and Plumbeous Sierra-Finch. The scarcity of birds typically associated with *Polylepis* forest could respond to human induced disturbances, such as fire, logging, and grazing, which strongly contribute to forest degradation and drives structural habitat simplification (Renison *et al.* 2013). Fjeldså (1993) suggested that low quality forests usually exhibit low or no *Polylepis* bird specialists and a bird community with similar species composition than the surrounding vegetation. In Northwestern Argentina, this situation becomes worrying considering that *Polylepis* forests are inadequately represented in protected areas (Renison *et al.* 2013). Therefore, to ensure the conservation of *Polylepis* avifauna it is necessary to include these forests fragments as protected areas broadening the borders of Calilegua National Park and Las Lancitas Provincial Reserve to conserve *P. australis* and *P. hieronymi* forests, respectively (Renison *et al.* 2013).

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