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ANNUAL VARIATION OF ABUNDANCE AND COMPOSITION IN FOREST BIRD ASSEMBLAGES ON NAVARINO ISLAND, CAPE HORN BIOSPHERE RESERVE, CHILE

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Resumen. – Variación intra-anual de la abundancia y la composición del ensamble de aves de bosque en la Isla Navarino, Reserva de la Biósfera Cabo de Hornos, Chile. – La estructura y dinámica de las comunidades de aves en los bosques templados del sur de Sudamérica han sido estudiadas generalmente sólo durante la época reproductiva (Noviembre–Marzo); por lo tanto, los estudios sobre variaciones estacionales y comportamiento migratorio son casi inexistentes. Este trabajo se enfoca en la variación intra-anual de la abundancia y la composición del ensamble de aves forestales en los bosques más australes del mundo, en el Parque Etnobotánico Omora dentro de la Reserva de la Biósfera del Cabo de Hornos, Chile (55°S). Combinando los datos obtenidos a través de censos en estaciones de escucha, capturas con redes de niebla y listas de especies, registramos un total de 34 especies de aves pertenecientes a 20 familias. Dieciocho de éstas fueron Passeriformes y, entre las especies residentes las más abundantes fueron el rayadito (*Aphrastura spinicauda*) y el cometocino (*Phrygilus patagonicus*). Entre las aves migratorias, las especies más abundantes fueron el fío-fío (*Elaenia albiceps*) y el chercán (*Troglodytes musculus*). Tanto la riqueza de especies como la abundancia disminuyen durante el invierno; sólo un tercio del ensamble de aves de los bosques subantárticos se ausenta durante el invierno. Esta proporción es menor que la documentada para los bosques de *Nothofagus* de menor latitud. Nuestros datos no mostraron que los patrones intra-anuales de la estructura de la comunidad de aves se vea afectada significativamente por el sendero turístico del Parque Etnobotánico Omora. El monitoreo de patrones estacionales de la riqueza, abundancia y migraciones de las aves del bosque templado chileno es necesario para comprender más integralmente los ecosistemas boscosos más australes e implementar estrategias de conservación efectivas y prácticas sustentables de ecoturismo.

Abstract. – The structure and dynamics of avian communities in the temperate forests of southern South America have been generally studied during the breeding season (November–March), and reports about seasonal variations and migratory behavior of species are almost lacking. This study examined intra-annual variations on a monthly basis in bird species composition and abundance in the world's

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southernmost forested ecosystems, found in the Cape Horn Biosphere Reserve, Chile (55°S). Combining data obtained through point-count surveys, mist-netting, and checklist methods, we recorded a total of 34 bird species belonging to 20 families. Eighteen of these species were Passeriformes, and the most abundant year-round resident species were Thorn-tailed Rayadito (*Aphrastura spinicauda*) and Patagonian Sierra-Finch (*Phrygilus patagonicus*). The most abundant seasonal migrants species were White-crested Elaenia (*Elaenia albiceps*) and Southern House Wren (*Troglodytes musculus*). Point-count and mist-netting methods showed a reduction in species richness and abundance during winter, with one third of the bird assemblage absent. This proportion was lower than that documented for more northern *Nothofagus* forests. Additionally, our data provided no evidence that intra-annual patterns of avian community structure were significantly affected by a recently implemented tourism trail through the Omora Park. We believe that understanding seasonal patterns of richness, abundance, and migratory status of Chilean temperate forests birds will help to better understand the world's southernmost forest ecosystem, implement effective conservation, facilitate sustainable ecotourism, and lead to new ecological and evolutionary research. *Accepted 14 April 2009*.

Key words: Forest birds, subantarctic forests, Chile, Cape Horn, point-count surveys.

INTRODUCTION

The temperate forests of southwestern South America extend from approximately 30°–56°S along Chile and Argentina. The most Austral portion of this biome, known as the Magellanic subantarctic forest (48°–56°S), is dominated by broadleaf trees from the genus *Nothofagus* (Armesto *et al.* 1996). Compared to the Northern Hemisphere, the avian communities that inhabit the southern temperate forests are characterized by a higher degree of endemism and relatively fewer migratory species (Rozzi *et al.* 1996a), a combination that arises from the region's biogeographic isolation and the influence of glacial events that reached their maxima 15,000 years ago (Armesto *et al.* 1996, Vuilleumier 1998). Following the general rule of decreasing species diversity with increasing latitude (Alekseev 1982, Gaston *et al.* 1995), bird species richness in the Magellanic subantarctic forests is less than at lower latitudes farther north, such as Chiloé Island (42°S) (Rozzi *et al.* 1996b, Anderson & Rozzi 2000).

Bird community structure, however, is dynamic within and among years (Holmes *et al.* 1986, Holmes 1988, Rozzi *et al.* 1996a), and may vary among habitat types (Maia-Gouvea *et al.* 2005), successional stages (Stiles 1980), or with the degree of anthropogenic disturbance (Newmark 2006). To detect and describe the fluctuations and patterns of avian diversity, long-term and year-round studies are needed (Holmes 1988). Nonetheless, most ornithological field studies are conducted over short time periods, usually in the breeding season (Karr & Freemark 1983). This pattern applies in the southern South America temperate forest biome as well, and even basic information is often lacking about seasonal patterns of bird species occurrence, abundance and diversity.

For the breeding season, short-term studies have described bird assemblages for South American temperate forests at latitudes extending from the Cape Horn Biosphere Reserve (55–56°S) to Fray Jorge National Park (30°S) (e.g., Sielfeld 1977, Venegas 1981, 1991, Jaksic & Feinsinger 1991, Willson *et al.* 1994, Rozzi *et al.* 1996b, Cofré 1999, Estades & Temple 1999, Anderson & Rozzi 2000, Anderson *et al.* 2002, Cornelius *et al.* 2000, Figueroa Rojas *et al.* 2000, Reid *et al.* 2002, Becerra Serial & Grigera 2005, Díaz 2005, Díaz *et al.* 2005). While most of these studies have been descriptive accounts of the breeding season avifauna, some point-count surveys have shown a reduction in abundance and species diversity in winter (García 1982,

Sabag 1993, Cornelius 2000, Becerra Serial & Grigera 2005). On Chiloé Island (41°S), both abundance and diversity showed a marked increase when fruits and flowers were available for the arrival of migratory birds in spring (Smith-Ramírez & Armesto 1994, Rozzi *et al.* 1996a). In the remnant forest patches at the northern end of the Chilean temperate forest's range (30ºS), which were isolated from the main expanse of temperate forest following incremental aridization during the Quaternary period (Núñez-Avila & Armesto 2006), birds exhibit much less pronounced seasonal patterns (Reid *et al.* 2002).

To investigate intra-annual variability in the structure of bird assemblages in the southernmost forests, we initiated a year-round study at the Omora Ethnobotanical Park (55ºS) on Navarino Island in the Cape Horn Biosphere Reserve. These are the world's southernmost forests, and the archipelago is considered one of the most pristine wilderness areas remaining on the planet (Mittermeier *et al.* 2002). Nonetheless, portions of Navarino Island and adjacent areas in Tierra del Fuego have been subjected to anthropogenic impacts since the late 1800s, including disturbance associated with the introduction of cattle, horses, feral dogs, cats, and the invasive North American beaver (*Castor canadensis*; Anderson *et al.* 2006a). Recently, the American mink (*Mustela vison*), an invasive exotic predator, has also extended its range from Tierra del Fuego to several smaller islands south of the Beagle Channel, including Navarino and Hoste islands, where bird assemblages evolved without significant terrestrial mammalian predators (Rozzi & Sherriffs 2003, Anderson *et al.* 2006a). As a result, the effects of mink are expected to significantly affect the reproductive success of native ground-nesting songbirds and waterbirds. Tourism is also increasing in the Cape Horn Biosphere Reserve, often without sufficient planning, which has the potential to cause negative effects on birds as seen elsewhere (Cornelius *et al.* 2001, Reid *et al.* 2002, Laiolo 2004). We believe that a better understanding of the seasonal avian community patterns will aide authorities in the management of these forests, as birds can be useful indicators of habitat disturbance (Newmark 2006). In addition, such baseline information will prove useful in the planning of long-term ecological and evolutionary research on subantarctic ecosystems. Therefore, in this study, we set out to characterize the monthly variation in forest bird assemblages over the course of a year in the Cape Horn Biosphere Reserve, Chile. We examined temporal abundance patterns, described variations in the use of different micro-habitats within the forest, and tested for an impact of tourism by comparing the bird assemblages found near and far from the interpretive trails in the Omora Ethnobotanical Park.

METHODS

Study area. This research was conducted as part of the long-term forest bird mist-netting program conducted in the Omora Ethnobotanical Park (54º57'S; 67º39'W). The data presented here were taken from November 2002 to December 2003. The Omora Park is located 3 km west from the town of Puerto Williams on the north coast of Navarino Island (Fig. 1). Precipitation in the area reaches approximately 450 mm per year, and the mean annual temperate is 6°C, ranging from 2°C in winter (July) to 10°C in summer (January) (Rozzi *et al.* 2006b). Within the study area, habitat types include secondary and primary *Nothofagus* forests and anthropogenic shrubland, composed of *Berberis buxifolia*, *Chiliotrichum diffusum*, *Ribes magellanicum*, and *Embothrium coccineum*. *Nothofagus* forests can be subdivided further into evergreen stands (*N. betuloides* and *Drimys winteri*) and deciduous

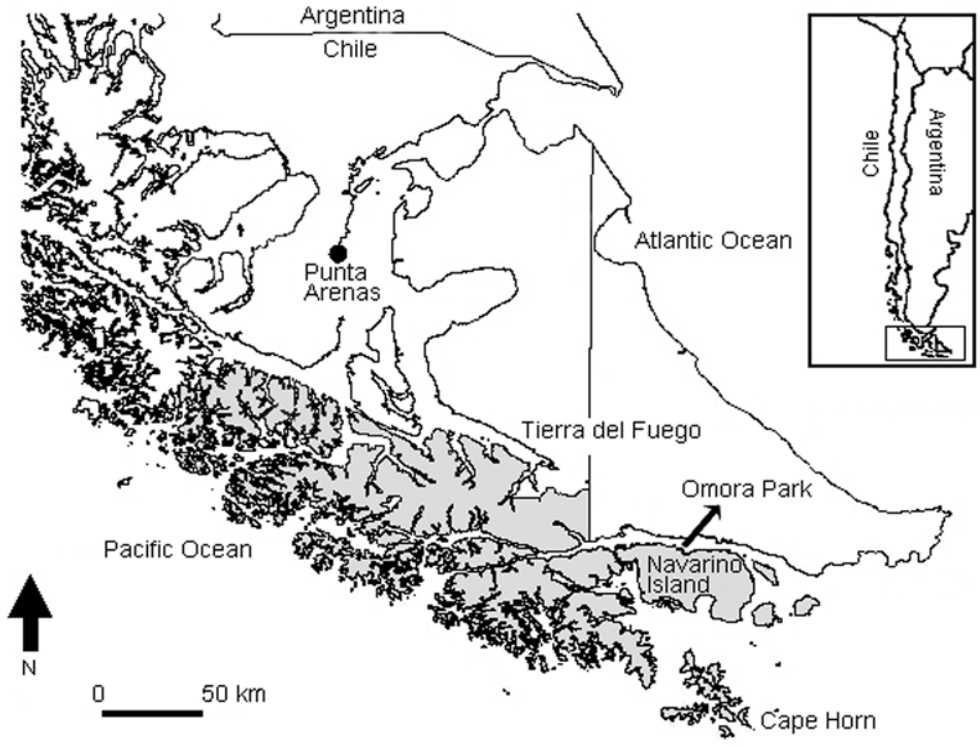

FIG. 1. Map showing the study area in the Omora Ethnobotanical Park on the north coast of Navarino Island in the Cape Horn Biosphere Reserve (shaded area), Chile (55°S).

forests (*N. pumilio* and *N. antarctica*) (for more details see Rozzi et al. 2006a).

Characterizing the forest bird community. Bird assemblages were described using point-counts, mist-netting, and checklists of all birds seen and heard while working in the field. These three methods were complementary and can help to more fully describe the species composition of forest birds than could any one technique alone (Anderson & Rozzi 2000). The observer had previous experience identifying forest birds; nevertheless, pre-sample point-counts were done to standardize the protocol and to calculate the real time consumed in moving from one point to another.

Point-counts were conducted at 20 stations, all at least 150 m apart, and grouped into two transects. Ten stations were located along the visitors' trail that runs through the Omora Park ("near stations"), while a second transect of ten stations was located a minimum of 150 m from the trail in similar habitats ("far stations"). The appropriate radius of point-counts and general methods for birds surveys have been the subject of numerous studies (e.g., Emlen 1971, Reynold *et al.* 1980, Ralph *et al.* 1993, 1995, Jiménez 2000, Simons *et al.* 2007). In choosing our method, we considered characteristics of the habitat of Magellanic subantarctic forests to select the parameters of the survey protocol. In contrast with more northern temperate forests in Chile, such as the rainforests of Chiloé (Jiménez 2000), these forests are relatively

open and unstratified with a very sparse understory and a higher proportion of deciduous trees. Therefore, SI conducted all counts, and recorded all birds within a radius of 50 m for 6 min at each station (Reynolds *et al.* 1980, Ralph *et al.* 1993), with counts starting upon the observer's arrival at the station (Ralph *et al.* 1995, Jiménez 2000). Surveys were conducted during the morning in the second half of each month from December 2002 to November 2003. We could not conduct surveys at six stations in April due to a severe snowstorm. Given the climate of the area, counts were sometimes conducted during light rain, with clouds and slight wind, as well as during good weather.

Three to five mist-nets were deployed monthly (6–12 m x 2.6; 3 x 3 cm mesh) at fixed locations in two habitats (44 days in forests and 46 days in shrublands/forest edge) for a total of three days per site each month from May 2003 to November 2003. During the remaining months, we sampled birds for a minimum of seven days (January = 7, February = 12, March = 13 and April = 11), except in December 2003 when there were only four capturing days. From January 2003 to September 2003, the habitat immediately around each net was classified as either interior forest, shrubland, forest edge, or open, and this subclassification of habitat was used only to evaluate habitat use by the four most captured species: Thorn-tailed Rayadito (*Aphrastura spinicauda*), Patagonian Sierra-Finch (*Phrygilus patagonicus*), White-crested Elaenia (*Elaenia albiceps*), and Black-chinned Siskin (*Carduelis barbata*). Each day, mist-nets were opened for a minimum of 5 h and checked every 15 to 30 min. Each captured bird was banded with a uniquely numbered ring (see Anderson & Rozzi 2000, Anderson *et al.* 2002), and the concerning habitat was recorded. Additionally, within the sampled habitats we recorded all birds seen or heard during visits to the Omora Ethnobotanical Park from December 2002 to December 2003. This method was also used to register the first and last sightings of migratory species.

Data analysis. The average number of individuals detected at points along the two transects were calculated for each month. Methods to correct for detection errors were not used here because their assumptions were not matched due to the study conditions (e.g., distance methods; see also Elphick 2008) or logistical constraints (e.g., multiple observer methods), respectively. Mean species richness for each transect was determined as the average number of species detected in each month (with points as replicates) and averaged throughout the year to compare the near and far transects. Relative abundance was estimated as the percentage of individuals of each species relative to the total number of individuals. To standardize mist-netting sample effort, we calculated the product of the net area (m^2) and the time the nets were open (h), to give the number of birds per m^2 and h for each day (Anderson & Rozzi 2000).

Point-count data (number of individuals and number of species per transect and month) were analyzed with a repeated-measures analysis of variance (ANOVA), using "near" and "far" as the between factor and months as the within subject factor. A post-hoc Tukey test for multiple comparisons was conducted on the significant results of the ANOVA (Quinn & Keough 2002). While normality was not obtained (Shapiro-Wilks test, $P < 0.05$), both homoscedasticity (Levene test) and sphericity (Maunchley sphericity test) assumptions were met. ANOVA is robust to non-normality, especially when there is a balanced design (Sokal & Rohlf 1995), so we used the parametric test. Because some stations could not be visited in April due to heavy snow, this month was eliminated from all analysis of point-count data. Mist-netting

data were analyzed using the non-parametric Kruskal-Wallis and Mann-Whitney *U*-tests to compare variation in the number of species and the number of individuals among months and between forest and shrubland habitats, respectively (Siegel & Castellan 1988), as these data failed a Shapiro-Wilk test for normality and Levene test for homocedasticity ($P < 0.05$). The STATISTICA 6.0 software package was used for all analyses and significance was considered with a $P < 0.05$.

RESULTS

Subantarctic forest avian assemblage. Combining the data obtained from all methods, we recorded a total of 34 bird species from 20 families (Table 1). Eighteen species were Passeriformes, and eight were birds of prey (Falconiformes and Strigiformes). Twenty-four (71%) of these species nest and/or forage principally in the forest interior (Table 1). The most speciose families were Furnariidae (five species), Tyrannidae (four), Falconidae, Anatidae, and Strigidae (three each) (Table 1). Most families (65%) were represented in this community by only one species.

Point–count transects and the effects of tourism trail and season on community structure. During the point–count surveys we recorded 1596 birds belonging to 24 different species and 16 families (Table 1). At stations near the trail, we made 743 observations of 22 species, while 853 observations of 20 species were made at the stations farther from the trail. The mean monthly richness was 9.5 (± 2.8 SD) and 9.0 (± 1.7 SD) for the near and far transects, respectively. When data from both transects were combined, the lowest species richness was observed in March (9 species), and the highest in October and December (15 species each). Species richness varied significantly among months ($F_{10, 180} = 10.90$, $P < 0.00001$), but not between transects ($F_{1, 18} = 0.77$, $P = 0.39$) (Fig. 2), with richness peaking in midsummer (November–January; Fig. 2a). Abundance also varied significantly among months ($F_{10, 180} = 3.211$, $P = 0.0008$) with most birds in summer (October–February; Fig. 2b). Abundance at point-count stations near the tourism trail did not differ significantly from those on the transect farther away ($F_{1, 18} = 1.972$, $P = 0.177$; Fig. 2b). Moreover, there was no significant correlation between the month and trail proximity variables for either species richness ($F_{10, 180} = 0.874$, $P = 0.559$) or abundance ($F_{10, 180} = 1.260$, $P = 0.257$).

Mist-net data. During the year-round mist-netting program, we captured 639 individuals belonging to 19 species and 13 families (Table 1). In addition, there were 123 recaptures (16% of all captures). Species richness ($H = 25.0$, $P = 0.0093$) and avian abundance ($H = 29.7$, $P = 0.0018$) varied significantly among months; both were lowest during winter (June–August) and highest during the Austral summer (November–February) (Fig. 3).

We found no differences in species richness ($U = 854$, $P = 0.2021$) when comparing forest and shrubland habitats, but abundance was significantly greater in shrublands ($H = 749$, $P = 0.0337$). Mist-netting also showed that shrubland and forest edge plots had greater abundance than forest interior or open sites for the four most common captured species (Thorn-tailed Rayadito, Patagonian Sierra-Finch, White-crested Elaenia, Black-chinned Siskin) (Fig. 4).

Migratory status of subantarctic forest birds. Based on the pattern of presence and absence of each species throughout the year, we identified eight forest species (33%) as probable migrants (Table 2). Of these, Black-faced Ibis (*Theristicus melanopis*), Rufous-collared Sparrow (*Zonotrichia capensis*), Blue-and-white Swallow (*Pygochelidon cyanoleuca*), Chilean Swallow (*Tachycineta meyeni*), and White-crested Elaenia

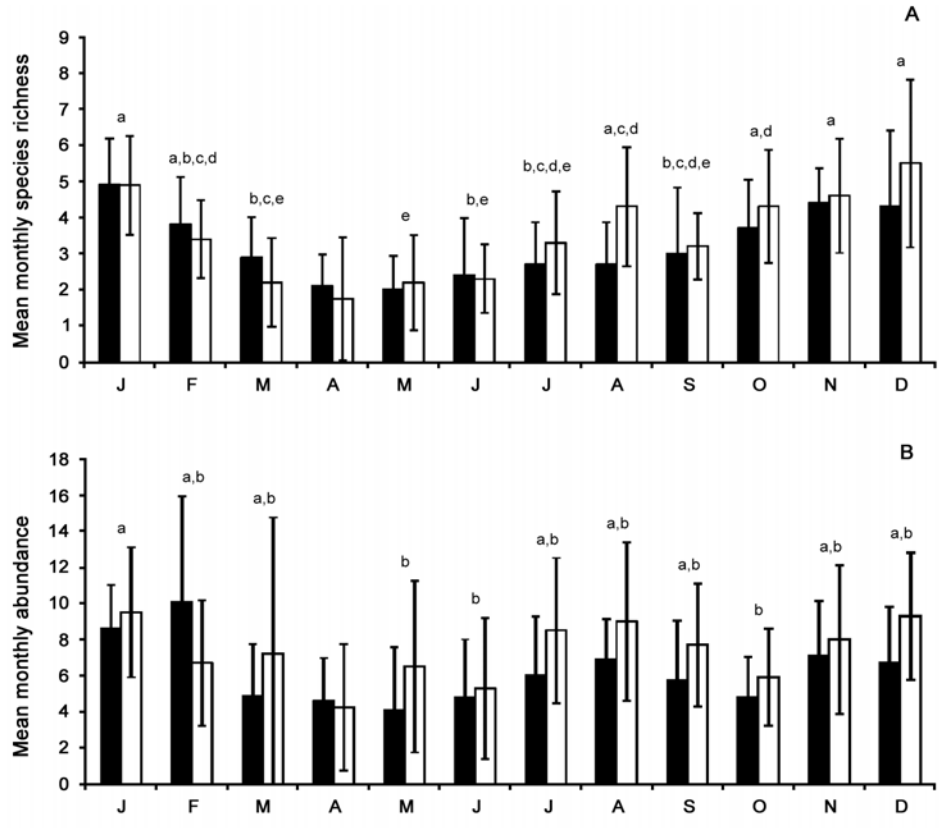

FIG. 2. Mean (± SD) monthly species richness (A) and abundance (B) of forest birds counted at stations "near" (0–5 m; black columns) and "far" (> 150 m; open columns) from the visitor's trail in the Omora Park. Point-counts were conducted from December 2002 to November 2003. In April, only four "far" stations could be visited due to inclement weather. Small letters above columns indicate significant differences (post-hoc Tukey test) in richness or abundance, respectively, among months.

are categorized as migratory in southern Chile by Jaramillo (2003). Green-backed Firecrown (*Sephanoides sephaniodes*) and Southern House Wren (*Troglodytes musculus*) were previously classified as resident species in Navarino Island (Jaramillo 2003). However, we detected Southern House Wren only in spring and summer, and the hummingbird was recorded only in late summer. Patagonian Tyrant (*Coloramphus parvirostris*) was an uncommon species during our study, making it impossible to properly determine its migratory status. Three other species not generally considered forest species - Upland Goose (*Chloephaga picta*), Ashy-headed Goose (*Chloephaga poliocephala*), and Southern Lapwing (*Vanellus chilensis*) - were found sometimes to use forested habitat but can be regarded as migrants.

On the other hand, Fire-eyed Diucon (*Xolmis pyrope*) was present in our study area throughout the year, despite having been cited as an Austral summer migrant in the south of Chile (Jaramillo 2003) and Tierra del Fuego (54°S) (Schlatter 2004). Overall, the most abundant species were year-round residents

TABLE 1. Bird species recorded through mist-netting, point-count surveys, and checklists in the Omora Ethnobotanical Park from November 2002 to December 2003. Migratory status was taken from Jaramillo (2003) and complemented with data from the present study. Abbreviations: M = migrant; R = resident; [1] = scarce information, possibly a portion of the population migrate; [B] = information from bibliography.

Species	Family	Mist-net	Census	Checklist	Migratory status
Ashy-headed Goose	Anatidae		X	X	M
Upland Goose	Anatidae		X	X	M
Black-crowned Night-Heron	Ardeidae			X	R
Black-faced Ibis	Threskiornithidae		X	X	M
Chilean Hawk	Accipitridae			X	R[B]
American Kestrel	Falconidae			X	R[B]
Chimango Caracara	Falconidae	X	X	X	R
Southern Caracara	Falconidae		X	X	R
Southern Lapwing	Charadriidae		X	X	M
Austral Parakeet	Psittacidae		X	X	R
Barn Owl	Tytonidae			X	R[B]
Magellanic Horned Owl	Strigidae			X	R[B]
Austral Pygmy-Owl	Strigidae	X	X	X	R
Rufous-legged Owl	Strigidae			X	R[B]
Green-backed Firecrown	Trochilidae	X		X	M
Magellanic Woodpecker	Picidae	X	X	X	R
Thorn-tailed Rayadito	Furnariidae	X	X	X	R
Bar-winged Cinclodes	Furnariidae	X		X	M[B]
Grey-flanked Cinclodes	Furnariidae			X	M[B]
Dark-bellied Cinclodes	Furnariidae		X	X	R
White-throated Treerunner	Furnariidae	X	X	X	R
Magellanic Tapaculo	Rhinochryptidae	X	X	X	R
Tufted Tit-Tyrant	Tyrannidae	X	X	X	R
Patagonian Tyrant	Tyrannidae	X	X	X	R[1]
White-crested Elaenia	Tyrannidae	X	X	X	M
Fire-eyed Diucon	Tyrannidae	X	X	X	R
Blue-and-white Swallow	Hirundinidae			X	M
Chilean Swallow	Hirundinidae	X	X	X	M
Southern House Wren	Troglodítidae	X	X	X	M
Austral Thrush	Turdidae	X	X	X	R
Rufous-collared Sparrow	Emberizidae	X	X	X	M
Austral Blackbird	Icteridae	X	X	X	R
Black-chinned Siskin	Fringillidae	X	X	X	R
Patagonian Sierra-Finch	Fringillidae	X	X	X	R
	Total	**19**	**24**	**34**	

and included Thorn-tailed Rayadito, Patagonian Sierra-Finch, and Black-chinned Siskin, which together accounted for 60 % of the average total counts in the subantarctic forest avian community across the year (Table 2).

DISCUSSION

Seasonal patterns in the subantarctic bird community structure. It is well-known that species richness diminishes with latitude for numerous taxa of

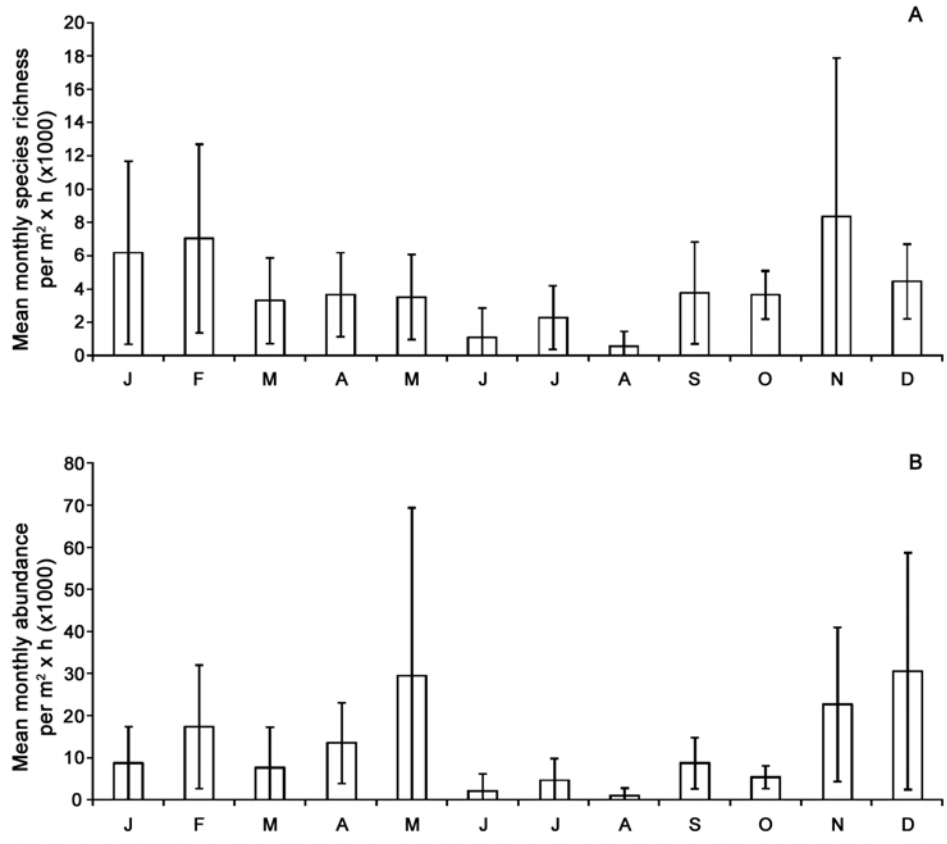

FIG. 3. Mean (±SD) monthly species richness (A) and abundance (B) of forest birds based on captures with mist-nets.

woody plants, invertebrates, and vertebrates (Alekseev 1982, Rosenzweig 1992, Gaston *et al.* 1995, Williams *et al.* 1997), even though the non-vascular flora in Chile provides a significant exception (Rozzi *et al.* 2008). Regarding birds in the temperate forests of South America, the predominant species are common throughout the latitudinal range of *Nothofagus* forests (33–56°S), but there is still a tendency for a decreasing number of species with increasing latitude (Anderson & Rozzi 2000). Our results also indicate that in high latitude, subantarctic forests, a higher percentage of the bird community are year-round residents than in similar forests farther north. In the Cape Horn Biosphere Reserve, migratory species comprised one third of the forest bird assemblage, whereas about half of the species in forests farther north in Chile were found to be migrants (Jaksic & Feinsinger 1991). Therefore, our data suggested that not just the total number of migrants, but their proportion of the total assemblage also decreases with latitude, perhaps as a consequence of such barriers as marine channels and mountains (Henningsson & Alerstam 2005) or a more benign than expected maritime, subantarctic climate.

It was expected that during the winter avian abundance and richness would be lower

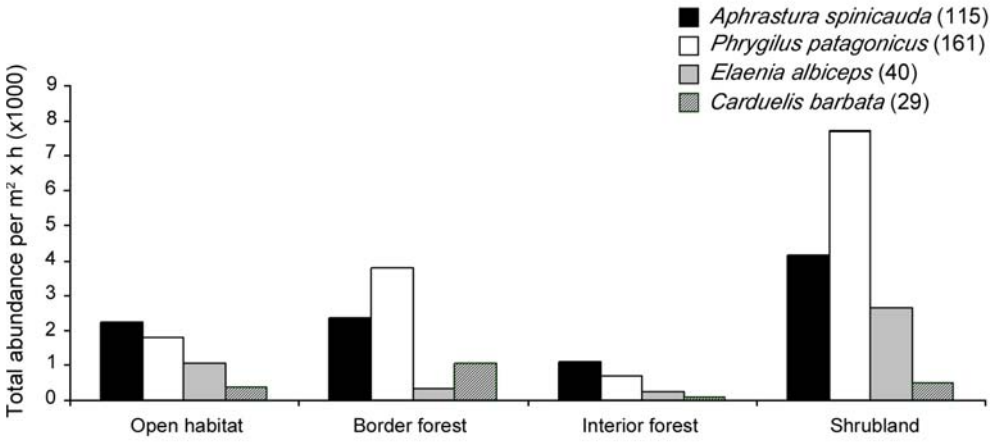

FIG. 4. Abundance of the four most captured species in four different microhabitats based on data from January 2003 to September 2003.

than in summer, due to migration. However, there was only a moderate monthly variation throughout the year, differing from lower latitude *Nothofagus pumilio* forests (41°S) where 63% of the forest bird species were absent in winter (Becerra Serial & Grigera 2005). At the northern end of the Chilean temperate forests, in a relict forest stand at Fray Jorge National Park (30°S), many species that were absent from our study area in winter were residents (e.g., Green-backed Firecrown, Southern House Wren, Rufous-collared Sparrow, Chilean Swallow) (Cornelius *et al.* 2000). Because results of the present research include only one year and only one place (i.e., Omora Park), it is possible that migration of some species involves only a portion of the entire population or movements among different habitats inside the island.

While the four most abundant birds (Thorn-tailed Rayadito, Patagonian Sierra-Finch, Black-chinned Siskin, Austral Thrush *Turdus falcklandii*) in our study were resident species, two migratory species became seasonally important in summer (Southern House Wren, White-crested Elaenia). In other temperate forest sites at lower latitudes in Chile, short-term studies conducted during the summer months have found that Green-backed Firecrown and Thorn-tailed Rayadito were the most abundant species on Chiloé Island (42°S) (Sabag 1993, Rozzi *et al.* 1996a, b), in the northernmost Chilean temperate forest at Fray Jorge (Cornelius *et al.* 2000), and at Santa Inés (32°S) (Reid *et al.* 2002). However, because recent studies have detected high levels of overestimation for bird populations with point-counts of 50 m of radius (Simons *et al.* 2007), caution is appropriate when our results are compared with those of other studies.

Compared to earlier works, our year-round study allowed us to detect a greater number of forest bird species for the Cape Horn Biosphere Reserve. While previous reports accounted for a total of 19 (Anderson & Rozzi 2000) to 20 "forest" species (Venegas 1991, 1994), excluding raptors, we surveyed a total of 34 species, including eight raptors. In our study, the additional bird species using forest ecosystems were registered only through the point-count surveys and included: Ashy-headed Goose, Upland Goose, Black-faced Ibis, Southern Lapwing,

TABLE 2. Relative abundance (%) of forest bird species surveyed with point-counts in each of the seasons of the year between December 2002 and November 2003 in the Omora Ethnobotanical Park, Chile (55°S), with species listed from most to least abundant. N = number of individuals recorded.

Species	Percentage (%)				
	Year	Summer (Dec21–Mar20)	Fall (Mar21–Jun20)	Winter (Jun21–Sep20)	Spring (Sep21–Dec20)
Thorn-tailed Rayadito	28.5	19.6	30.7	40.5	26.0
Patagonian Sierra-Finch	16.9	13.4	19.7	17.5	18.6
Black-chinned Siskin	14.6	17.1	23.8	15.6	3.6
Austral Thrush	8.6	5.7	12.1	8.1	10.5
Southern House Wren	7.3	12.6	0.0	0.0	13.3
White-crested Elaenia	6.8	14.1	0.0	0.0	9.4
Rufous-collared Sparrow	3.0	1.4	0.0	3.0	7.4
Austral Parakeet	2.4	7.1	0.0	0.5	0.3
Chimango Caracara	2.3	1.4	4.5	2.7	1.5
White-throated Treerunner	1.8	1.4	2.1	3.2	0.5
Magellanic Woodpecker	1.6	0.8	2.4	2.2	1.5
Tufted Tit-Tyrant	1.4	0.2	0.7	3.5	1.3
Chilean Swallow	0.9	2.4	0.0	0.0	0.5
Black-faced Ibis	0.8	0.6	0.0	0.0	2.3
Fire-eyed Diucon	0.7	0.4	1.4	1.2	0.0
Magellanic Tapaculo	0.4	0.6	0.3	0.2	0.3
Austral Blackbird	0.4	0.0	0.7	0.0	1.0
Southern Caracara	0.3	0.0	0.0	1.0	0.3
Patagonian Tyrant	0.1	0.0	0.7	0.0	0.0
Cinclodes spp.	0.1	0.0	0.0	0.2	0.3
Dark-bellied Cinclodes	0.1	0.0	0.0	0.2	0.0
Upland Goose	0.1	0.0	0.0	0.0	0.5
Ashy-headed Goose	0.1	0.2	0.0	0.0	0.0
Austral Pygmy-Owl	0.1	0.0	0.0	0.2	0.0
Southern Lapwing	0.1	0.0	0.0	0.0	0.3
Unidentified species	0.8	1.2	1.0	0.0	0.8
Total N	**1596**	**509**	**290**	**405**	**392**

Chimango Caracara (*Milvago chimango*), Southern Caracara (*Caracara plancus*), Austral Pygmy-Owl (*Glaucidium nanum*), Dark-bellied Cinclodes (*Cinclodes patagonicus*), and Blue-and-white Swallow. Aquatic and semi-aquatic species, namely geese, lapwings, and cinclodes, are uncommon in the forest, but may use such habitats when they are close to freshwater or coastal ecosystems. This greater species richness for forest sites in our study was a direct consequence of the year-long survey that provided a better detection of species without conspicuous behavioral or song characteristics, such as owls, or of those that use the forest only occasionally or specialize in rare microhabitats (e.g., freshwater edges).

Factors affecting forest bird assemblages in the Cape Horn Biosphere Reserve. The habitat with the highest avian abundance was shrubland, which differs from findings on Chiloé Island where more individuals were recorded at for-

est edges (Rozzi *et al.* 1996b). On Navarino Island, however, shrubland ecosystems are rather discrete habitat patches, surrounded by forests, whereas on Chiloé shrublands tend to be larger because of the more intensive history of agricultural and livestock activities on this island. As a result, the landscape of Chiloé is much more fragmented and shrublands perhaps less suitable for birds due to the longer distances between forest fragments. In Navarino, both resident (Thorn-tailed Rayadito and Patagonian Sierra-Finch) and migratory (White-crested Elaenia and Southern House Wren) species are more abundant in shrublands than in forests. However, while the Southern House Wren is also common in forests on Navarino Island, on Chiloé Island this species prefers open habitat and is not found in the forest interior (Rozzi *et al.* 1996b, Díaz *et al.* 2005, SI pers. obs.). At the same time, White-throated Treerunner (*Pygarrhichas albogularis*) is the only passerine species that is an obligate inhabitant of the forest interior, being totally absent from shrubland and open habitats.

Regarding tourism, we did not find a significant impact of the tourist trail in the Omora Park in 2003. Species richness and abundance was equivalent near and far from the trail, throughout the year. However, given the limited scope of our analysis with only one trail studied, additional monitoring of bird assemblages will be required in order to evaluate the long-term impact of increasing tourism and plans for its anticipated growth in the archipelago.

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