The native and exotic avifauna of Easter Island: then and now

La avifauna nativa y exótica de Isla de Pascua: antes y ahora

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Abstract: The Polynesian colonization of islands in the south Pacific led to one of the greatest extinctions of birds in Earth's history. An important case study of the historic and prehistoric effects of human activity comes from Easter Island, which has lost most of its native terrestrial biota. We studied the abundance and diversity of the terrestrial (all exotic) and seabird (all native) populations of Easter Island in 2001 and 2003. To assess whether populations have remained stable over ecological time (30 years) we compared our results with published accounts of the island's historic and prehistoric avifauna. Terrestrial species were quantified using 100 x 100 m quadrat counts and by walking surveys. All known seabird colonies were surveyed from shore or accessed by boat. Five terrestrial exotic species were common, yet they varied 77-fold in abundance. We observed 10 seabird species, of which seven were breeding. We present the first reports of Sharp-tailed Sandpiper, Henderson and Phoenix petrels, as well as anecdotal evidence of egrets and shorebird species previously unknown from the island. Breeding populations of both exotic and native species have remained relatively constant over the last three decades. Native seabird populations remain low and concentrated to several small cliffs and islets. We discuss the importance of our findings in light of conserving the remaining native populations of seabirds on Easter Island.

Resumen: La colonización de las islas en el Pacífico sur por Polinesios causó a una de las extinciones más grandes de aves en la historia de la tierra. Uno de los casos más importantes de los efectos históricos y prehistóricos de la actividad humana viene de la isla de Pascua, que ha perdido la mayor parte de su biota terrestre nativa. Estudiamos la abundancia y diversidad de poblaciones terrestres (todas exóticas) y de aves marinas (todas autóctonas) en la isla de Pascua en el 2001 y 2003. Para determinar si las poblaciones permanecieron estables en tiempo ecológico (30 años) comparamos nuestros resultados con los registros publicados de la avifauna histórica y prehistórica de la isla. La abundancia de especies terrestres fue cuantificada usando cuadrantes de 100 x 100 m, contando aves en forma estandardizada. Las colonias conocidas de aves marinas fueron visitadas por lancha, para verificar su presencia y nidificación. Cinco especies terrestres exóticas fueron las más comunes, siendo la más común 77 veces más abundante que la más escasa. Observamos 10 especies de aves marinas, de las cuales siete se encontraban nidificando. Presentamos los primeros registros de *Calidris acutipenis*, y *Pterodroma atrata* en Chile, y nuevas observaciones de *Pterodroma alba*, así como la evidencia anecdótica de presencia de garzas y aves playeras en la isla. Las poblaciones residentes de especies exóticas y nativas se han mantenido relativamente constantes durante las últimas tres décadas. Las poblaciones nativas de aves marinas siguen siendo bajas y se encuentran concentradas en acantilados e islotes pequeños. Se discute la importancia de nuestros resultados a la luz de conservar las poblaciones nativas restantes de aves marinas en la isla de Pascua.

Keywords: Easter Island, Rapa Nui, Avifauna, populations.

It is commonly acknowledged that we are in the midst of an anthropogenic extinction crisis, especially with respect to the biodiversity of isolated islands (Wilson 2001). Easter Island is unique in terms of its isolation and in the picture it provides of the process and effects of human activity on island ecosystems. Easter Island has experienced the classic trio of anthropogenic stressors: habitat alteration, resource exploitation, and invasion of exotic species. The effects of prehistoric human activity on the island's indigenous flora and fauna were dramatic and well documented (Routledge 1957, Metraux 1974, Flenley and Bahn 2003). For these reasons, Easter Island serves as an important case study for the global extinction crisis.

Easter Island underwent an ecological meltdown as a result of prehistoric human exploitation of the island's resources (Flenley et al. 1991). Humans have lived on the island since Polynesians first colonized it 1000-1300 years ago (Milberg and Tyrberg 1993). The proceeding human history is both complex and incompletely known (Routledge 1957), but it is agreed that the island underwent a cascading ecological collapse, followed by a decline in the human civilization in the mid to late 1700s. This downward spiral is thought to be due to several non-exclusive factors. First, the forests that once covered the island were harvested and largely destroyed by the late 1600s (Flenley and King 1984), which is believed to have lead to the erosion and denutrification of arable land (Flenley et al. 1991). Second, the Polynesians brought rats (*Rattus exulans*) (Roberts 1991), which are thought to have hindered forest recruitment through granivory, as well as consumed birds, an important food source for prehistoric islanders (Steadman et al. 1994). The lack of wood intensified the civilization's plight because of the lack of fuel for fires and the inability to make canoes for offshore fishing. It has also been suggested that a change in climate contributed to the forest's decline (Flenley and Bahn 2003), but this apparent drying of the land may have been directly related to the loss of forests. Today, there remains no indigenous forest on the island and three-quarters of the extant flora (ca. 200 species) is non-native (Flenley et al. 1991, Rauch et al. 1996).

Easter Island's ecological collapse and subsequent trajectory to its present status are reflected in changes in its avifauna. The island had a rich prehistoric avian fauna, with an estimated 30 breeding seabird and terrestrial species (see Table 2, Steadman 1995). Although the terrestrial avifauna went extinct after the Polynesian colonization, seabirds were reported on and around the island into the 1900s (Routledge 1957), but they too were affected (Steadman 1995). It is believed that seabirds commonly nested on the main island but are now mostly restricted to several small islets (motus) off the south-west coast (Johnson et al. 1970, Steadman 1995). Following the decline of the native fauna, five exotic land birds were introduced between 1885 and 1928 (Johnson et al. 1970), and another between 1968 and 1987 (Schlatter 1987). There are no published reports of whether these populations have remained stable for the past three decades, yet such information is important because of the negative consequences that exotic bird species can have for naturally colonizing species (Case 1996).

Steadman (1995) proposed that the extinction crisis among Polynesian avifauna has all but run it course. As discussed, Easter Island experienced a severe loss of biodiversity due to prehistoric extinctions, but extirpation of native avifauna remains a concern because small populations of nesting seabirds remained on and around the island until at least 35 years ago (Johnson et al. 1970**.** To assess whether Easter Island is still losing native species, while supporting exotic ones, we conducted the island's first quantitative surveys of native and exotic birds. Several questions were addressed. First, do terrestrial species differ in abundance, and is this variation predicted by habitat characteristics? Secondly, are populations of exotic species stable over time? And last, has the diversity and distribution of nesting seabirds changed in the last three decades?

MATERIALS AND METHODS

Study Area

Easter Island ("Rapa Nui" in the Polynesian language and "Isla de Pascua" in Spanish) is the most remote inhabited island in the world, lying in the south Pacific (27° 8′ 24″S, 109° 20′ W) 3600 kilometres west of South America and 2100 kilometres southeast of the Pitcairn group, its nearest inhabited neighbour. It is small (171 square kilometres) and completely volcanic in origin, rising from the sea to 510 m at its highest point. The island's climate is temperate, with most precipitation (776 mm of total 1118 mm) occurring between March and Sept (Flenley and Bahn 2003).

The topography is dominated by four heights of land, the largest being Mt. Teravaka in the north, followed by Rano Kao, Poike (Mt. Puakatike), and Rano Raraku. Rano Kao and Rano Raraku are large volcanic craters in the southwest and eastern parts of the island, respectively. The other prominent feature is the only town on the island, Hanga Roa, situated along the western coast on the flats north of Rano Kao. As a whole, the island is largely devoid of trees (<10% cover), having only a few large contiguous stands of introduced *Eucalyptus* spp. and several other less common species. Volcanic boulder fields, short and tall grasses and extensive shrub-guava thickets cover the island. Cattle, horses and sheep commonly wander and graze inland paddocks. The craters of Rano Raraku and Rano Kao are both water filled; a small lake exists in the former crater while the latter is a bog-like wetland with scattered open water surrounded by exposed peat mats, *Scirpus californicus*, *Cyperus* sp., *Polygonum* cf. *acuminatum*, and *Thelypteris* sp. (M. Johnson and C. Rothfels, Pers Obs.). Precipitous cliffs skirt the island at three locations: in the southwest around Rano Kao, in the east around the Poike peninsula, and on the northern slope of Mt. Teravaka. Several tiny islands are also situated around the coast, but the largest two (Motu Nui and Motu Iti), south-southwest of Rano Kao, are the most famous for their association with the Birdman Cult (Routledge, 1957).

Sampling

We studied the birds of the island on two separate occasions. The first visit was November 3-9, 2001, while the second was March 3-6, 2003. In 2001, we intensively sampled both terrestrial and seabird species. In 2003, both groups of birds were again surveyed, but emphasis was placed on estimating seabird diversity and canvassing island residents for anecdotal reports of island birds.

Terrestrial Species

In 2001, we conducted 17 surveys on haphazardly selected hectare plots. Plots were spread throughout the island with the exception of the urban area of Hanga Roa and the extreme northwest corner of the island (west of Anakena and north of Anakeve). For each survey, we paced out the boundaries of the hectare and one observer slowly walked along three transects (20 m in from the edge; 50 m in; and 70 m in, respectively) so that the entire area was covered. We counted all birds seen in or over the plot, plus we counted Chilean Tinamous that were heard, if not seen. Because the island exhibits variation in its physical characteristics and vegetational composition over relatively small geographic areas, we investigated whether several habitat characteristics predicted variation in the abundance of different bird species. We quantified habitat variation by visually estimating the percent area covered by: a) shrubs, b) herbaceous plants, and c) boulders, within every 100 x 100 m plot. We also categorized the presence or absence of volcanic bombs, which are large black volcanic projectile deposits prominent over much of Easter Island.

To estimate the relative abundance of terrestrial bird species around the hub of human activity, we conducted six relevé surveys (Krebs 1999) in and just outside Hanga Roa. These surveys involved counting all birds seen along one transect; we calculated relative abundance by summing the absolute abundance of an individual species among the six surveys and dividing by the total number of individuals counted of all species.

To test whether species differed in abundance in the one-hectare survey data, we used Friedman's nonparametric method for randomized blocks, where each one-hectare survey was treated as a separate block and species were designated as "treatment" effects. This method is analogous to the parametric Analysis of Variance randomized complete block design for comparing means, but is superior for non-normal data (Sokal and Rohlf 1995). A-posteriori pairwise comparisons between species were done using Wilcoxon's Signed-rank Test for two groups.

We examined whether habitat characteristics correlated with species' abundances using a combination of multivariate approaches. For shrubs, herbaceous plants, and boulder cover, we reduced the data using a correlation extraction method employed using Principal Components Analysis (PCA), while stipulating the Varimax method for variable loadings (Tabachnick and Fidell 2001). We performed Spearman rank correlations between the PC axes and the abundance of each species, and boot-strapped with 1000 simulations to construct 95% confidence intervals. If the 95% confidence intervals overlapped zero, we concluded there was no relationship between the habitat variable and a species' abundance. To examine how the presence or absence of volcanic bombs affected abundance, we performed Multivariate Analysis of Variance (MANOVA) with the five widespread exotic terrestrial species (Table 1) designated as dependent variables. All analyses were performed using SYSTAT (vers. 9, SPSS Inc.).

Pelagic Species

Seabirds were surveyed in 2001 and 2003 along the coast by watching for individuals flying and by searching for breeding areas on islets and along cliff faces at Poike, Rano Kao, and on a small islet west of Anakeve. We censused all known off-shore and cliff face breeding habitats (small islets), with the exception of the north facing cliff of Mt. Teravaka. In 2003, the outer cliff faces of Rano Kao, Motu iti and Motu Kao Kao were surveyed by boat on one occasion. The largest islet, Moto Nui, was also surveyed on foot for breeding seabirds. In all cases, we estimated the total number of individuals present and the general stage in the breeding cycle.

RESULTS

Exotic Terrestrial Species

We found five exotic terrestrial bird species on Easter Island (Table 1). Common Diuca-Finch (*Diuca diuca*) and House Sparrow (*Passer domesticus*) were the most common species detected in surveys, followed by Rock Pigeon (*Columba livia*), Chimango Caracara (*Milvago chimango*), and Chilean Tinamou (*Nothoprocta perdicaria*) (Fig. 1). Chickens (*Gallus gallus*) were also observed but never outside of domestic settings. All species could be easily seen during the course of a day hike, but there was substantial variation in their abundance (Friedman's $\chi_4 = 12.01$, $P = 0.017$). The largest difference was seen between the Chilean Tinamou and the Common Diuca-Finch; the finch was 77 times more abundant than the tinamou (Fig. 1). All species except for Rock Pigeon were significantly more abundant than the tinamou. Additionally, Common Diuca-Finch was 3.1-fold more abundant than the caracara, a difference that was weakly significant ($Z = 1.88$, $P = 0.059$).

Although habitat characteristics varied substantially, we detected no association between habitat variation and species abundances. There was large variation in the percent cover of shrubs (range = 0-70%; mean = 18.2, SE = 1.4), herbaceous plants (range = 0-100%; mean =

62.0, SE = 1.6), and boulders (range = 0-40%; mean = 14.1, SE = 0.8) between replicate survey locations. Based on this data, we retained the first two habitat PCA axes, which explained 49.8% and 36.2% of the habitat variation (Table 2). The first axis described variation in vegetative cover, with loadings being positive for herbaceous cover and negative for shrub cover. The second axis was primarily associated with boulder cover, which had a negative loading (Table 2). Vegetative (PC1) and boulder cover (PC2) were not significantly associated with the abundance of any species as the 95% CI of all Spearman correlations overlapped 0. Likewise, the presence of volcanic bombs, which were present in 12 of the 17 plots, did not appear to influence species abundances (Wilk's $\lambda = 0.36$, $F_{5,11} = 1.02$, $P = 0.45$).

The results of the relevé surveys of the birds in and around Hanga Roa were quantitatively and qualitatively similar to the island-wide quadrat surveys (Fig. 2).

Native Seabird Species

SAMPLING 2001: In November 2001 we observed four pelagic species and one vagrant shorebird (Table 1), and detected nesting evidence for three of the four seabird species. Masked Booby (*Sula dactylacta*) was the most common seabird with 71 individuals observed and an estimated 18 nests on the islands of Motu Nui, Motu Iti, and Motu Kao Kao. More than 20 Brown Noddy (*Anous stolidus*) were on a small pillar of land rising at the base of the cliff face 500 m NW of Rano Kao; six pairs had begun to construct nests. A lone Red-tailed Tropic Bird (*Phaethon rubricauda*) nested on a cliff face on the south side of the Poike peninsula, with a total of 12 birds counted flying in this area. At least six individual Great Frigatebirds (*Fregata minor*) were seen but they did not appear to be nesting. We saw and photographed a Sharp-tailed Sandpiper (*Calidris acuminata*) feeding at a puddle along a road 2 km north of Hanga Roa (Fig. 3). This sighting represents the first record of this species for Easter Island and the Chilean territory.

SAMPLING 2003: The seabird fauna was more diverse in March, with 10 seabird species seen (Table 1). Breeding was confirmed for Kermadec Petrel (*Pterodroma neglecta*; 30 individuals, one nest with one egg), Christmas Island Shearwater (*Puffinus nativitatis*; 10 individuals, three nest scrapes, one with a full grown juvenile), and Masked Booby (40 individuals, ca. 10 nests on Motu Iti and Motu Nui, with nearly full grown young). Many of the Kermadec Petrels were landing in inaccessible sites on cliffs, where nests may have been present. The onset of primary moult in many of the Kermadec Petrels suggests that these were at the end of their breeding cycle. Breeding was suspected for Herald Petrel (*Pterodroma arminjoniana heraldica*; 100 individuals, many displaying and landing on apparent nest scrapes), Phoenix Petrel (*Pterodroma alba*; four over Motu Nui in evening and some displaying), Red-tailed Tropicbird (four on cliffs SE of Poike Peninsula; one on cliff south of Hanga Roa near Punta Baquedano), and Brown Noddy (24 individuals on rocks south of Hanga Roa). Given their behaviour and apparent lack of eggs, it appeared that Herald Petrels were just starting to breed in March. Several other seabirds were observed but without breeding evidence. These included Great Frigatebird (2 – 20 per day; 35 roosted at Motu Nui including immatures, adult males and females), and Grey Ternlet (*Procelsterna cerulea*; three on north-facing cliffs of Motu Nui). Finally, a dark *Pterodroma* petrel was observed and photographed over Motu Nui, which was identified as the recently split Henderson Petrel (*Pterodroma atrata*) (Brooke and Rowe 1996). This taxon is only known to breed on Henderson Island, Pitcairn Group, and it represents another species previously unknown from Easter Island and Chilean waters (Fig 4).

Anecdotal Reports

Island residents and park rangers reported that Sooty Terns (*Sterna fuscata*, Manutara in the native language) arrive in September and breed on Motu Nui. The locals do not differentiate between the Sooty Tern and the Grey-backed Tern (*Sterna lunata*) and the latter may be present on Motu Nui, as it is historically known from the islands (Johnson et al. 1970, Carr 1980). Islanders who frequent the Anakena beach, reported occasional sightings of "white little birds" running in groups of 2-4 along the sand; their observations are most consistent with Sanderling (*Calidris alba*). A bird-watching tour visiting in October 2003 described seeing a shorebird they believed to be a Wandering Tattler (*Heteroscelus incanus*) (Tony Pym, Pers. Comm., 2003). Island residents also described occasional inland sightings of white herons, which apparently were seen standing on the backs of cattle. We believe these birds to be Cattle Egrets (*Bubulcus ibis*).

DISCUSSION

Easter Island is one of the world's starkest examples of how humans can severely impact natural ecosystems, yet relatively little is know about the contemporary avian community of the island, and how the community has changed through recent time. Our results represent the first quantitative description of the contemporary avifauna on Easter Island, and raise the total number of species known from the island to 49. We show that there are presently five common exotic terrestrial species, and although these species vary in abundance, this variation was not predicted by variation in habitat characteristics. We also observed ten seabird species, seven of which showed evidence of breeding. It is known that a mass extinction of birds followed Polynesian colonization, and we show that in recent decades the exotic and native avifauna has remained relatively stable. Conservation efforts are still needed, however, as existing seabird nesting sites are small and few in number.

Terrestrial exotic species

The exotic terrestrial species common on the island substantially varied in abundance (Fig. 1), whereby the rank-abundance of these species was approximately inversely related to body mass, a common phenomenon in animal communities (Elton 1960). We predicted that variation in vegetation (shrub and herbaceous plant cover) and volcanic debris (volcanic bombs and boulders) would explain variation in the abundance of the different bird species. Surprisingly, habitat variation did not predict the abundance of any of the bird species. In general, all species could be found throughout the island, in both urban and non-urban settings (Fig. 2). This suggests extensive overlap in habitat use and mechanisms of coexistence that we were unable to detect. These species certainly utilize other types of resources in different ways, especially food and nesting sites, which can be an important mechanism of coexistence. Also, theory predicts that coexistence can be maintained when intraspecific competition is greater than competition between species (Chesson 2000), which may also help to explain the maintenance of the limited diversity of exotic species on the island, even if species do not specialize on particular habitat resources.

Previous research reviewed the human introductions of five species to Easter Island, one of which (Long-tailed Meadowlark, *Sturnella loyca*) has not been reported since 1942 (Johnson et al. 1970). In their study, they described House Sparrow and Chimango Caracara as abundant, while Common Diuca-Finch and Chilean Tinamou were common. Four of the five exotics found in our study overlapped with Johnson et al.'s (1970) and can still be described as common, in that all can be easily seen in the course of a day. This congruency between studies shows that the populations of these four species have remained approximately stable over the last 35 years. One species found in our study, Rock Pigeon, represents an additional successful introduction since 1968 (Schlatter 1987).

Changes through time

The diversity and abundance of seabirds has changed dramatically since Polynesians colonized Easter Island. It is commonly believed that there were at least 25 breeding seabird species prehistorically (Steadman 1995). If we accept Steadman's estimate of 25 species, seabird diversity was reduced to one-third of its original level by historic times. In addition, only 60% of the species breeding in historic times overlapped with prehistoric breeders (Table 1). This massive reduction and overturn in biodiversity was likely brought about by both direct and indirect influences of human activity. Direct influences would have included the consumption of birds by the island inhabitants (Steadman et al. 1994), while indirect effects would have been caused by the introduction of rats by Polynesians and Europeans (Roberts 1991), as well as by the alteration and degradation of breeding habitats through deforestation (Flenley and Bahn 2003).

Despite early changes, the seabird community on Easter Island has remained relatively constant over the last three decades (Johnson et al. 1970). We confirmed breeding for seven seabird species, only one fewer than historically reported (Johnson et al. 1970, Carr 1980, Milberg and Tyrberg 1993). There appears to have been small changes in the composition of the seabird community, for example, neither Johnson et al. (1970) nor Schlatter (1987) reported seeing Masked Booby nesting, yet we observed them nesting in both November and March. This suggests that this species may have established colonies in the last two decades. Likewise, our report of Phoenix Petrel represents the first evidence of this species from Easter Island. Sooty Tern was notably absent in our surveys. Island residents claimed that this species arrives to nest on the islets in September, and Johnson et al. (1970) reported "several hundred" in December 1968. Therefore, if this species were still breeding on the islets around Easter Island, we would have expected to see it in November 2001. The possibility of a recent extirpation of Sooty Tern is of cultural significance because of its past role in the Birdman cult (Routledge 1957). Our observations of Great Frigatebirds concur with Johnson et al.'s reports, as do our observations of nesting Red-tailed Tropicbirds, although we found them to be nesting on the Poike peninsula in addition to Rano Kao.

Vagrants, Migrants and Natural Colonization of Birds

Despite the remoteness of Easter Island, vagrants and potential colonists are frequent. A combination of our observations, published notes, and anecdotal reports identify at least four shorebird species and two egrets that have visited the island in recent times (Table 1). These observations suggest that Easter Island serves as a refuge for vagrants, if not as a stop-over for long distance migrants. The fact that no terrestrial bird species has naturally colonized and established a population on Easter Island in recent history (Steadman 1995), demonstrates the extremely low rate of such natural invasions. The remoteness and small size of Easter Island are clearly important factors in this regard (Macarthur and Wilson 1963). Nonetheless, herons were prehistoric residents on the island (Steadman 1995) and still appear as vagrants, and may be capable of making a return. The successful establishment by natural colonists will likely be hindered by the ubiquity of human-modified habitat and the strong hold that exotic species currently have over the island (Case 1996).

Conservation of Easter Island Avifauna

Is Easter Island still in an extinction crisis? As previously mentioned, it has been suggested that the human-caused biodiversity crisis of the tropical Pacific Islands as a whole has nearly run its course (Steadman 1995). For Easter Island specifically, one might argue that the extinction crisis is over because there is so little left to lose. The entire endemic terrestrial avifauna is extinct and approximately half the seabird fauna were driven to extirpation during prehistoric times (Steadman 1995). Our results suggest that two species (Phoenix Petrel and Masked Booby) may have colonized the islets in recent years. However, the remaining seabird populations on Easter Island and surrounding islets are still at risk of local extinction because the remaining breeding populations have highly restricted breeding sites. Conservation efforts would increase the stability of the seabird populations on the islets and potentially attract seabirds to nest on the main island as they once did. Such success could be achieved by creating reserves on the islets, as well as similar reserves at relatively remote locations on Easter Island itself. The success of such a project would hinge on the ability to keep areas free from domestic animals, rats, and humans. The task is not a trivial one, but necessary if we are to preserve the natural and human history of Easter Island.

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TABLE 1. The recent, historic and prehistoric occurrence of 49 bird taxa known from Easter Island. The presence of taxa within a time period is designated by X; it is in bold if breeding was observed or inferred. We did not attempt to assign breeding status to prehistoric records, as has been done in past studies (Steadman 1995). Recent observations are based on our observations in 2001 and 2003, as well as anecdotal reports of birds since 2000. The currently widespread terrestrial species are shown in bold.

Common Name	Scientific Name	Recent	Historic	Pre-historic
Terrestrial				
Tinamiformes				
Chilean Tinamou	*Nothoprocta perdicaria perdicaria*	**X**[n,f]	**X**[1]	
Ciconiiformes				
Cattle Egret	*Bubulcus ibis*	X[a]		
Pacific Reef Heron	*Egretta sacra*		X[2]	
endemic heron	Ardeidae sp. nov.			X[5]
Gruiformes				
endemic crake	*Porzana* sp. nov.			X[5]
endemic rail	Rallidae sp. nov.			X[5]
Charadriiformes				
Sharp-tailed Sandpiper	*Calidris acuminata*	X[n]		
Sanderling	*Calidris alba*	X[a]		
Wandering Tattler	*Heteroscelus incanus*	X[a]		
Bristle-thighed Curlew	*Numenius tahitiensis*		X[3]	
Falconiformes				

Chimango Caracara	*Milvago chimango*	**X**[n,f]	**X**[1]	
Galliformes				
Domestic Chicken	*Gallus gallus*	X[n]	X[1]	X[6]
Columbiformes				
Rock Pigeon	*Columba livia*	**X**[n,f]	X[2]	
Psittaciformes				
endemic parrot	Psittacidae sp. nov. 1			X[5]
endemic parrot	Psittacidae sp. nov. 2			X[5]
Strigiformes				
endemic barn owl	Tytonidae sp. nov.			X[5]
Passeriformes				
Common Diuca-Finch	*Diuca diuca*	**X**[n,f]	**X**[1]	
House Sparrow	*Passer domesticus*	**X**[n,f]	**X**[1]	
Long-tailed Meadowlark	*Sturnella loyca*		X[1]	
<u>Seabirds</u>				
Procellariiformes				
Cape Petrel	*Daption capensis*		X[1]	
Shy Albatross	*Thalassarche cauta*		**X**[4]	X[5,6]
Southern Fulmar	*Fulmarus glacialoides*			X[5]
Southern Giant Petrel	*Macronectes giganteus*		X[1,6]	
White-throated Storm-Petrel	*Nesofregetta fuliginosa*			X[56]
Fairy Prion	*Pachyptila turtur*			X[6]
Broad-billed Prion	*Pachyptila vittata*			X[5]
Petrel species	*Procellaria sp.*			X[5]
endemic petrel	Procellariidae sp. nov.			X[5]

Phoenix Petrel	*Pterodroma alba*	**X**[f]		
Herald Petrel	*Pterodroma arminjoniana heraldica*	**X**[f]	**X**[1,6]	
Henderson Petrel	*Pterodroma atrata*	X[f]		
Juan Fernandez Petrel	*Pterodroma externa*			X[5]
White-headed Petrel	*Pterodroma lessonii*			X[5,6]
Kermadec Petrel	*Pterodroma neglecta*	**X**[f]	**X**[1,6]	
Murphy's Petrel	*Pterodroma ultima*			X[5]
Pink-footed Shearwater	*Puffinus. creatopus*			X[5]
Sooty Shearwater	*Puffinus griseus*			X[5]
Christmas Shearwater	*Puffinus nativitatis*	**X**[f]	**X**[1]	X[5]
Pelecaniformes				
Great Frigatebird	*Fregata minor*	X[n,f]	X[1]	X[5]
White-tailed Tropicbird	*Phaethon lepturus*		X[1]	X[5]
Red-tailed Tropicbird	*Phaethon rubricauda*	**X**[n,f]	**X**[1]	X[5]
Masked Booby	*Sula dactylatra*	**X**[n,f]	X[1]	X[5]
Charadriiformes				
Brown Noddy	*Anous stolidus pileatus*	**X**[n,f]	**X**[1]	X[5,6]
White Tern	*Gygis alba candida*		X[1,6]	X[5]
Little White Tern	*Gygis microrhyncha*			X[5]
Gray Noddy	*Procelsterna cerulean albivitta*	X[f]	X[1]	X[5]
Sooty Tern	*Onychoprion fuscatus luctuosus*		**X**[1]	X[5]
Grey-backed Tern	*Onychoprion lunatus*		X[1,6]	
Arctic Tern	*Sterna paradisaea*			X[5]

[n] observed in November, 2001; [f] observed in March, 2003; [a] anecdotal evidence (see text); [1] (Johnson et al. 1970); [2] (Schlatter 1987); [3] (Vilina et al. 1992); [4] (Milberg and Tyrberg 1993); [5] (Steadman 1995); [6] (Carr 1980),

TABLE 2. Summary of the Principle Component Analysis. Cover by herbaceous plants, shrubs and boulders are reduced to principal component (PC) axes. Eigenvalues and variable loadings on each axis are given. The first two PC axes explained 50% and 36% of the total habitat variation

	Principal Component	
	1	**2**
Eigenvalue	1.50	1.09
Herbaceous	0.63	0.22
Shrub	-0.52	0.25
Boulder	-0.08	-0.91

Figure legends, Jaramillo et al.

FIGURE 1. Mean abundance (± SE) of the exotic terrestrial species. Letters indicate species that were statistically different in abundance according to a Wilcoxon's Signed-Rank Test (P=0.05). The difference between Common Diuca-Finch and Chimango Caracara was weakly significant (P=0.059). Rock Pigeon was not significantly more abundant than the Chilean Tinamou (as opposed to Chimango Caracara) because of its high variability in abundance among replicate surveys. CDFI=Common Diuca-Finch, HOSP=House Sparrow, ROPI=Rock Pigeon, CHCA=Chimango Caracara, CHTI=Chilean Tinamou.

FIGURE 2. The relative abundance of the five exotic bird species as determined in the relevé and one-hectare surveys.

FIGURE 3. Sharp-tailed Sandpiper (*Calidris acuminata*), November 2001. Judged to be similar in size and structure to a Pectoral Sandpiper (*Calidris melanotos*) in the field, but showed a contrasting rufous cap, buffy breast, and rufous edging on tertials. The fresh appearance in the field, and color patterns suggest it is a juvenile. Photo by MJ.

FIGURE 4. Henderson Petrel (*Pterodroma atrata*), 4 March 2003. This *Pterodroma* was similar in structure to adjacent Herald Petrels, but seemed slimmer winged, longer-tailed and rounder bodied. It was entirely dark brown, except for a whitish patch on the patagium, and some pale on the chin. The primary shafts were entirely dark, and the underwings showed a slightly paler silvery look when compared to the more matte coverts. The legs were pink with black feet.

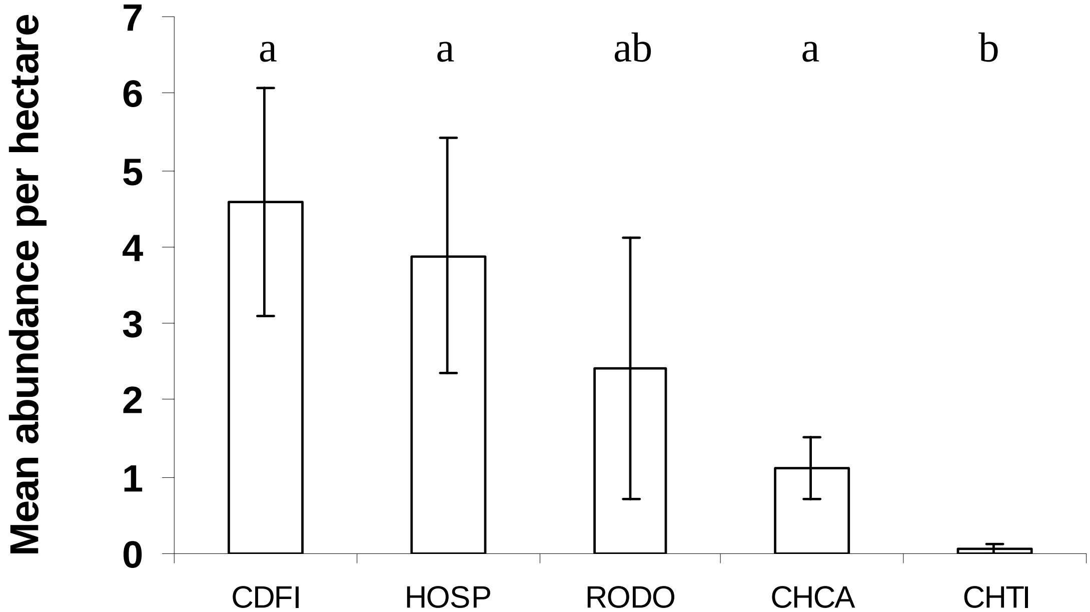
Mean abundance per hectare
7
6
5
4
3
2
1
0
a
a
ab
a
b
CDFI
HOSP
RODO
CHCA
CHTI

Figure 1

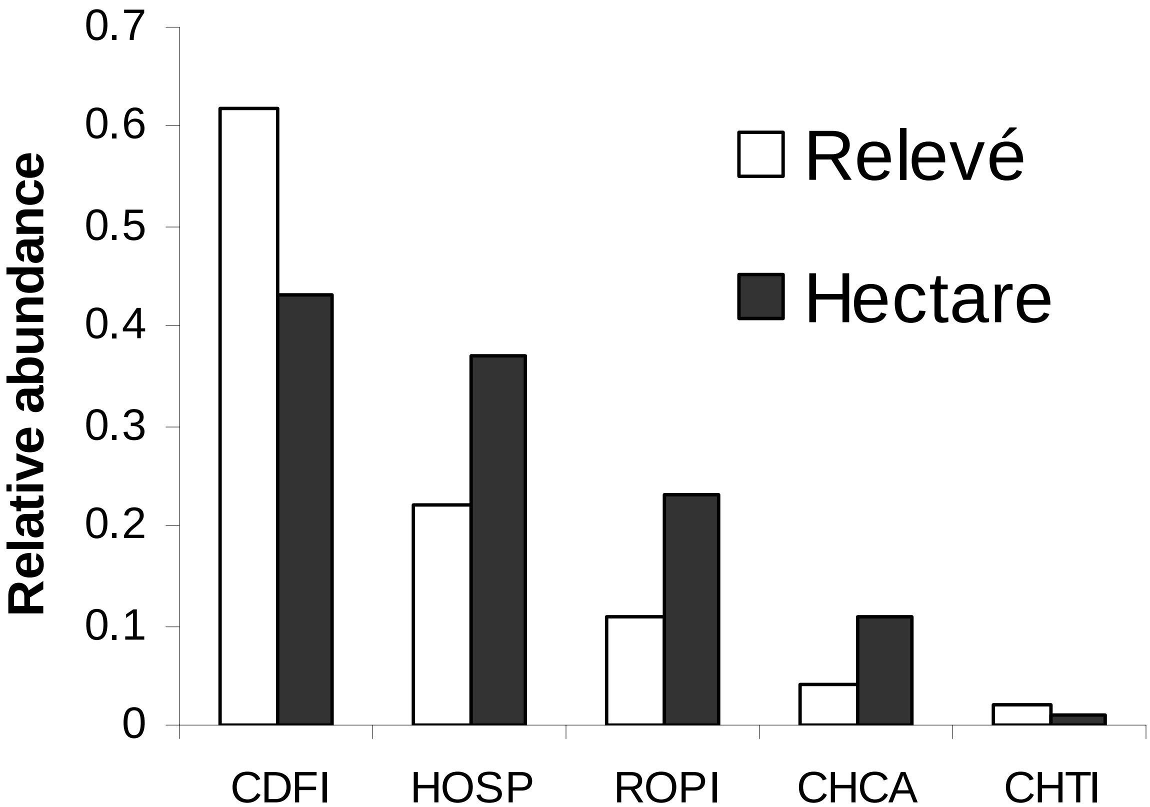
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Relative abundance
Relevé
Hectare
CDFI
HOSP
ROPI
CHCA
CHTI

Figure 2

Figure 3

Figure 4