

**BIRD PERCHES INCREASE SEED DISPERSAL IN ABANDONED PASTURES
AT COLOMBIAN ANDEAN FORESTS**

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**UNIVERSIDAD INDUSTRIAL DE SANTANDER
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Trabajo de grado presentado para optar al título de Biólogo

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RESUMEN

TÍTULO: LAS PERCHAS ARTIFICIALES AUMENTAN LA DISPERSIÓN DE SEMILLAS EN PASTIZALES ABANDONADOS DE BOSQUES ANDINOS COLOMBIANOS*

AUTOR: DIEGO ARMANDO RINCÓN GUARÍN**

PALABRAS CLAVES: Perchas para aves, Colombia, pastizales, semillas, dispersión de semillas.

DESCRIPTION:

La transformación y la pérdida de los bosques Andinos en Colombia se deben a la colonización antropogénica de tierras que son destinadas para la agricultura, el pastoreo de ganado y la explotación de madera. Por consiguiente, estas tierras son abandonadas y muestran una lenta recuperación. En este estudio se pusieron perchas artificiales para aves en dos pastizales con diferente vegetación circundante en un bosque Andino de la Cordillera Oriental de Colombia para atraer aves frugívoras y determinar si ellas contribuían a la dispersión de semillas y si la vegetación circundante afectaba el proceso de dispersión de semillas. Las perchas facilitaron la entrada de más semillas al pastizal abierto comparado con el pastizal rodeado por bosque secundario. Las aves dispersaron semillas durante los doce meses de muestreo en el pastizal abierto, pero en el pastizal cerrado la dispersión de semillas se llevó a cabo durante los tres primeros meses de muestreo. Durante las épocas secas hubo más dispersión de semillas. La riqueza de las especies de semillas incrementó de acuerdo con las épocas lluviosas. Nueve especies de aves típicas de áreas abiertas fueron observadas visitando las perchas solamente en el pastizal abierto, de las cuales *Zonotrichia capensis* fué el visitante más común y no hubo diferencias entre el tiempo de visita para cada ave registrada. La visita mensual de las aves a las perchas mostró diferencias significativas y el número de visitas estuvo relacionado con el número de semillas dispersadas y con el tiempo de duración de las visitas, pero no con la riqueza de especies de semillas. Estos resultados sugieren que en esta parte de la región Andina, la dispersión de semillas a través de las perchas artificiales depende de la vegetación circundante, además la dispersión de semillas aumentó en el pastizal abierto donde se pusieron las perchas. Aunque la sucesión del bosque es un proceso de muchas etapas, este método de rehabilitación de sitios degradados debería ser suplementado con otras estrategias que aseguren la recuperación del bosque.

* Trabajo de Grado

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ABSTRACT

TITLE: BIRD PERCHES INCREASE SEED DISPERSAL IN ABANDONED PASTURES AT COLOMBIAN ANDEAN FORESTS *

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KEY WORDS: Bird perches, Colombia, pastures, seeds, seed dispersal

DESCRIPTION

Andean forests in Colombia have been transformed and lost due to anthropogenic colonization of lands dedicated to agriculture, cattle raising and wood exploitation. In consequence, these lands are abandoned and show slow recovery. In this study we placed artificial bird perches in two pastures with different amounts of surrounding Andean forest vegetation at Cordillera Oriental of Colombia to attract avian frugivores and determine if they contribute to seed arrival and if surrounding vegetation affects seed dispersal. Perches contributed most to seed arrival at open pasture than to pasture surrounded by secondary growth forest. Birds dispersed seeds during the twelve month study in open pasture, but at closed pasture only during the three first months sampled. Most seed dispersion occurred during the dry seasons. Seed richness increased accordingly with the rainy seasons. Nine bird species typical of open areas were observed visiting perches only at open site, in which *Zonotrichia capensis* was the most common visitor but there were no differences between visitation times for each bird species recorded. Monthly bird visitation to perches showed significant differences and number of visits was related with number of seeds dispersed and visitation time, but not with seed richness. These results suggest that in this Andean region, seed dispersal by means of artificial perches depends on surrounding vegetation and open sites with perch additions increases seed dispersal. Although forest succession is a many phased process, this method of rehabilitation of degraded sites should be supplemented with other restoration strategies to enhance forest recovery.

* Work of Degree

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INTRODUCTION

In Colombia since more than half a century ago mountain forests have suffered great transformation from human pressure, originating open areas represented by pastures and as a matrix in which forest patches of different size are left imbedded, due mainly to the extent of lands dedicated to agricultural activities, to cattle raising and commercial forest plantations (Repizzo 1993; Cavalier & Etter 1995). These lands are commonly abandoned due to decrease of its productivity and its condition of degraded areas makes them more difficult to recovery (Uhl et al. 1988; Holl et al. 2000).

Seed dispersal is an important event in restoration ecology of neotropical forests and seed arrival is just the first step in a many phased process leading to this recovery (Aide et al. 1995; Toh et al. 1998; Duncan & Chapman 1999; Posada et al. 2000; Zimmerman et al. 2000). Many plant species that inhabit these forests show a decrease in propagule availability, which constitutes the major limiting factor for there restoration (Howe & Smallwood 1982; Holl 1998), as well as the loss of soil nutrients, competition with forbs, distance between forest and pastures, dry seasons, seed-and-seedling predation and the mechanisms of seed dispersal (Aide & Cavelier 1994; Nepstad et al. 1996; da Silva et al. 1996; Holl 1998, 1999; Duncan & Chapman 1999; Restrepo et al. 1999; Galindo-González et al. 2000; Ingle 2003, Shiels & Walker 2003). However the input of pioneer tree species by means of avian dispersers is high and its establishment is elevated by there high colonization characteristics (Dalling 2002). These successional category plant species create secure places for the germination and survival of other species that are not able by themselves to establish in open pastures (McClanahan &

Wolfe 1993; Shiels & Walker 2003). Moreover, pastureland recovery is slower if soil degradation is high and proposed efforts and strategies for its restoration are applicable on a long time scale (Aide & Cavelier 1994; Holl 1998).

Isolated trees in pasturelands, their majority pioneers, make shorter the distance among fragments and encourage dispersers to arrive allowing seed dispersion and establishment of other species which make part of advanced successional states and as nuclei of regeneration (Nepstad et al. 1996; Galindo-González et al. 2000; Holl 2002). A potential way to facilitate forest restoration of abandoned pastures has been by using artificial structures that serve as perches for birds, increasing the probability of seed dispersal as result of bird deposition and enhancing seed germination and seedling establishment of species from inside forest (McClanahan & Wolfe 1993; Aide & Cavelier 1994; Fonseca 2001; Shiels & Walker 2003; Velasco 2004). Bird perches have been built to increase seed rain in pastures at temperate latitudes (McDonnell & Stiles 1983), flooded plains (McClanahan & Wolfe 1993), pastures in tropical wet forests in lowlands (Aide & Cavelier 1994; Holl 1998, Shiels & Walker 2003), and Subparamo (Fonseca 2001; Velasco 2004).

The main goal of this research is to determine if artificial perches for birds contribute to seed arrival in abandoned pastures of Andean Cloud forests to facilitate forest recovery, to determine if the surrounding vegetation affects seed dispersal and finally, to examine the relationship among bird dispersers, seed rain and use of perches by dispersers along one year.

1. METHODS

1.1 Study Site

Research was conducted at Reserva Biológica Cachalú (RBC) (Lat 6°05'N, Long 73°07'W) owned and administrated by Fundación Natura-Colombia, located inside the widest part of the Cordillera Oriental of Colombia at the municipalities of Encino and Charalá, Department of Santander between 1800 and 2600 m elevation. The reserve embraces 1302 ha, mainly of Subandean and Andean forest (sensu Cuatrecasas 1958) and encompasses the *Quercus humboldtii* (Fagaceae) greatest forest remnant on the eastern of the Colombian Andes, constituting the main forested zone with oak forest in good conservation state (Cadena et al. 2002; Galindo-T. et al. 2003).

Average monthly temperature at RBC is relatively constant (18.24 °C) (Sorzano-L. 1998) and the area receives approximately 3827 mm of annual rainfall (this study, Estación Pluviométrica Encino, 1800 m elevation; IDEAM 2004). A bimodal rainfall regime is found for the area, showing decreased rainfall (< 300 mm per month) from July to August 2003, January to February 2004 and June 2004 (dry seasons) and more than 300 mm per month from September through December 2003 and March through May 2004 (wet seasons).

The reserve presents a landscape mosaic of mature forest, second growth forest, abandoned pastures and adjacent active pastures with grazing cows. Some forest in the reserve was cleared approximately 50 years ago for extensive cattle grazing, slash and burn for agricultural lands and wood exploitation (Romero 1998). Of the total area of

RBC, 76% represents mature forest along hillsides and mountain ridges with continuous canopy and typical Highandean forest species such as *Clusia* spp. (Clusiaceae) and *Weinmannia* spp. (Cunoniaceae). Secondary growth forest occupies 20% of the reserve which is in an advanced successional state and the 4% remaining is of abandoned pastures. The most common grass species in the abandoned pastures are *Arthrostylidium* spp., *Andropogon bicornis* and *Melinis minutiflora* (Poaceae) and the fern *Pteridium aquilinum* (Dennstaedtiaceae).

Two pastures with different surrounding vegetation and stages of succession were chosen (Fig. 1). The first one named La Casa (LC; 70 ha) is an open pastureland and acts as matrix for isolated trees and shrubs and small vegetation patches composed mainly by *Vismia ferruginea* (Clusiaceae), *Brachyotum* spp., *Tibouchina lepidota* (Melastomataceae), *Cordia* spp. (Boraginaceae), *Rubus* spp. (Rosaceae), *Cecropia* sp. (Cecropiaceae), *Solanum* spp. (Solanaceae). Some areas may still be used occasionally for cattle grazing. The second pastureland, known as Galilea (GA; 3 ha), presents a low number of isolated shrub species mainly of Melastomataceae and Ericaceae families, is surrounded by secondary growth forest and no grazing has been done since 1999. The most common species of the surrounding vegetation include *Q. humboldtii*, *Piper* spp. (Piperaceae), *Psychotria* spp. (Rubiaceae), *Croton killipianus* (Euphorbiaceae), *Miconia* spp. (Melastomataceae) and *Clethra* spp. (Clethraceae).

1.2 Seed Collection

On each pasture chosen twenty-one rectangular plots (1.5 x 1.5 m) were randomly placed with a perch, eighteen plots for data collection and three served as control plots.

Each perch was separated 3 m from one another. A perch consisted of a wood post 2 m tall and 10 x 5 cm wide with a crossbar 1 m long and 10 x 5 cm attached at the top. Perch position from forest edge was not accounted. Grass cover was minimal surround the perches and was regularly cleared by reserve staff. Perches were held in place by burying the post 30 cm and all perches were approximately 1.7 m high. Beneath each perch a seed trap consisting of a fine square nylon cloth (1m²; 0.5 mm mesh) was placed elevated 40 cm from ground to avoid seed removal by vertebrates and invertebrates, from which bird depositions were collected. No perch had baiting trials during the study.

Seed traps were visited five days every month during 15 July 2003 to 31 July 2004. All seeds collected from bird feces under each perch in each pasture were separated from dry leaves and other fecal material, identified to morphospecies and counted (Holl 1998). Each morphospecies was saved, some seeds deposited in FAA solution, compared with herbarium specimens from the study area for identification, and deposited in a reference collection. Seeds belonging to grasses were excluded from analyses because those were more probably dispersed by gravity or wind and comprised 3% of total seed catch.

1.3 Bird Observations

Bird activity in each study site was evaluated through direct observations from 10 July 2003 to 29 June 2004. Monthly observation periods were distributed between both sites to register bird community variation (Holl 1998). To record bird visits in all perches, observations were made from several points between 06:00 and 10:00 hours. During

observations each perching bird species, weather condition and total visit time on perch was recorded, as well as birds on isolated trees and crossing the sampled area. However, this study focused more in the amount of time each species spent on perches than in the number of individuals of each species recorded (Shiels & Walker 2003). Nomenclature of families and bird species follows Hilty and Brown (1986) and Stotz et al. (1996).

1.4 Data Analysis

A chi-square test was used to compare if average seeds collected was different between seed traps below perches and control plots. To test differences in the abundance of bird dispersed seeds between pastures a Mann-Whitney U test was performed. Kruskal-Wallis nonparametric ANOVA tests were used to determine if the total abundance of seeds dispersed varied among months in each pasture. To determine differences in perch time duration per bird species and per month Kruskal-Wallis nonparametric ANOVA tests were used. Relations among bird visits, visitation time, and bird dispersed seeds and richness was tested with lineal regressions. Species diversity of seeds dispersed by birds in the two pastures was calculated with the Shannon diversity index (H'). To compare differences in H' between sites a t test for diversity indices was computed (Zar 1996). Morisita-Horn index (C_{mH}) was used to compare the similarity of ornithochorous plant species dispersed in the pasturelands ($C_{mH} = 1.0$ means complete similarity) (Magurran 1988). All statistical tests were evaluated at $p < 0.05$ level of significance and means are presented with ± 1 SE.

2. RESULTS

In total, 48,513 seeds (0.6 to 6.2 mm long) were collected during the 12 month study from bird feces, caught by the seed traps under perches. The ornithochorous plant community was conformed by 16 species and 12 families. Three species accounted for 80.83% of total seeds dispersed: *Rubus urticifolius* (42.56%), *Viburnum cornifolium* (19.2%) and *Cordia cylindrostachya* (19.07%); unknown species represented 0.88% of total seeds dispersed (Table 1). Although the avian dispersers of each plant species could not be determined, 51% of the fecal samples were monospecific, containing seeds of *R. urticifolius* (D. Rincon-Guarín, 2004 personal observation).

Average seeds dispersed per plot were significantly different between perches and control plots ($X^2 = 1284.93$; $df = 1$; $p < 0.001$), open pasture (LC) tended to have more bird dispersed seeds under perches and control plots than pasture GA surrounded by forest (Table 2). Additionally, seed abundance in open pasture LC had a highly significant difference ($T = 26$; $p < 0.001$) compared with GA pasture (Fig. 2). Abundance of bird dispersed seeds varied during the 12 month study, and differed significantly among months for the two pastures (Fig. 3). In LC pasture more seeds were dispersed in July, August and September than in other months ($X^2 = 96.66$; $df = 11$; $p < 0.001$). Number of seeds collected in pasture GA was highest in September, followed for July 2003 and lowest in August 2003 ($X^2 = 29.08$; $df = 11$; $p = 0.002$), from October 2003 through June 2004 no seeds were found in the seed traps for this pasture. Richness of seed species dispersed by birds increased in the wet seasons. For LC pasture the highest richness was in November with 17 species and lowest in March with 3 species; for GA four species were found in September (Fig. 4).

During the 288 hours of observation for the two pastures, a total of 21 non migratory bird species were commonly observed (Table 3), of which nine species used perches in LC and not one was observed perching at GA. All species observed on perches include fruit, seeds and insects as part of their diet, and occur in open areas and edge forest, moreover were frequently observed feeding fruits. Since bird observations were limited to both pastures in the reserve, recorded birds probably represent only a subset of the avian frugivores in RBC. Bird visitation rate was 1.6 visits per hour. Perch visiting time varied among species, but did not differ significantly ($X^2 = 14.05$; $df = 8$; $p = 0.08$). The species with lowest visit duration were *Tangara cyanicollis* (Blue-necked Tanager) and *Turdus ignobilis* (Black-billed Thrush) and the most common bird visitor was *Zonotrichia capensis* (Rufous-collared Sparrow). Bird visitation rates was 3.73 ± 0.65 minutes per visit and varied significantly per month observation ($X^2 = 22.19$; $df = 11$; $p = 0.002$) with more birds and for more time observed perching in August 2003 and lowest in June 2004 (Fig. 5). There was a positive relationship between number of bird visits to LC perches and visit duration time ($r^2 = 0.94$; $p < 0.001$; Fig. 6a) and also with number of seeds dispersed ($r^2 = 0.62$; $p = 0.002$; Fig. 6b). In contrast, the number of bird visits to perches in open pastures was independent of the richness of seeds dispersed (Fig. 6c). Diversity between the overall seeds dispersed by birds in the LC ($H' = 0.741$) and GA ($H' = 0.533$) differed significantly (t for diversity index = 9.31; $df = 248$; $p < 0.001$). Five species of seeds dispersed were common to both pasturelands, sharing more than half of the species ($C_{mH} = 0.58$).

3. DISCUSSION

Comparisons between seed numbers collected from perch and control plots show differences among the two treatments, in which birds that inhabit open pastures in RBC defecate more on perches than controls plots. Shiels and Walker (2003) also registered most bird dispersed seeds under perches than control plots. The rate of seed deposition at each site (LC 9.6 seeds $\text{m}^{-2} \text{day}^{-1}$, and GA 0.03 seeds $\text{m}^{-2} \text{day}^{-1}$) agrees with those of Velasco (2004), which recorded a rate of 3.2 seeds $\text{m}^{-2} \text{day}^{-1}$ and 1.76 seeds $\text{m}^{-2} \text{day}^{-1}$ at perches placed at open pasture and gap forest respectively in a Subparamo at Cordillera Oriental of Colombia. Thus, it seems that using artificial bird perches increases the deposition and seed rain in open pastures but not in forests gaps or closed pastures.

Birds used more perches placed in open pastures than in pasture surrounded by forest in RBC, therefore increasing seed deposition and seed rain at this open site. Aproximately 99.7% of total seeds dispersed by birds was deposited in the open site, indicating that perches did facilitate seed input in this study. The four seed species collected in LC control plots were also found in perch plots, and were commonly found at early successional forests in RBC. Differences found among seed rain between pastures may be due to distance to surrounding vegetation, because the small pasture (GA site) received very low seed input compared to the open site, perhaps because tall grass and near forest may provide sufficient perching, feeding resources and nesting sites (Holl 1998; Duncan & Chapman 1999). In addition, many shrub species attract bird dispersers and increase seed rain from forests to perturbed sites (Nepstad et al. 1996; McDonnell & Stiles 1983; da Silva et al. 1996; Ingle 2003); but in the closed pasture (GA) at RBC with few and scattered trees and shrubs many of which do not produce abundant small-

fleshy fruits it seems they were not attractive enough for avian dispersers. Likewise, Shiels and Walker (2003) working with perch additions, also found most seeds dispersed by birds in grass dominant ground cover than on bare soil and climbing ferns at Puerto Rican landslides. Data suggests that seed rain in closed sites may be more related with movement and behavior of birds on the already available natural perches, than on newly placed structures.

Differences in bird visitation rate and bird movements may also cause variations on the ornithochoral process (Levey 1987), in which the relationships among number of bird visits to perches versus number of seeds dispersed by birds and seed species richness, indicates dependence with seed abundance but not with seed richness. It is difficult to give generalizations among relationships, since fruit type, seeds per fruit, and crop size were not measured in this study (Howe 1977; Moermond & Denslow 1985; Wheelwright 1985; Levey 1987). Mean rate visitation by birds at perches in open site LC was 1.6 visits/hour and mean visit time was 3.73 minutes/month, similar in average time with the Puerto Rican study, but showing more time for visit duration than that study (1.5 visits/hour and 1.10 minutes; Shiels & Walker 2003). Nevertheless, in a study at grasslands in southern Costa Rica (Holl 1998), visitation rate and visit length recorded was 0.12-0.41 visits/hour and 3.2 minutes respectively. Although, the distance from perches to forest edge may explain differences in variation between studies (Shiels & Walker 2003), bird perches at RBC were placed at a distance to edge forest less than 100 m for GA and greater than 300 m at LC. Holl (1998) and Shiels and Walker's (2003) studies show that visitation rates and visit duration are not related. Although the use of baiting trial as bananas, plantains or other large-fleshy fruits on artificial perches

in restoration sites did not affect bird visitation rates on perches (Aide & Cavelier 1994; Holl 1998), this method could have been effective to attract frugivorous birds to perches at GA pasture, where no birds were observed on perches.

Based on the monthly variation of seed rain at the two restoration sites, more bird seeds dispersed inputs were found from July through September, corresponding to the first dry season and the beginning of the first wet season. Temporal seed rain variation can be due possibly to differences in seasonal fruiting abundance and hence removal fruit rates (Levey 1987) as well as proportion of fruits and seeds consumed by dispersers may also be influenced by either the quantity or quality of fruits produced during a given season (Howe & Vande Kerckhove 1981); in this case, the dry seasons. Furthermore, most Andean forest plant species have small sized seeds with maximum fruit abundance in the dry seasons (i.e., Ericaceae and Melastomataceae) (Snow 1981; Pavajeau 1993; Velasco 2004). Bird dispersers observed on perches were considered omnivorous and feeding resources different from fruits and seeds, such as insects, may be less abundant during dry seasons, which favor omnivorous bird species to consume mostly fruits in these seasons (Herrera 1982). Fruit seasonality in RBC may encourage bird dispersers to increase more its numbers than other flying vertebrate frugivorous such as bats during the dry seasons at open pastures. However, da Silva et al. (1996) recorded low bird movements and fruit abundance in pastures at tropical forest in Amazonia in the dry seasons.

Bird visits to LC perches as well as seed dispersal increased in August (dry season), these appears to be closely related with foraging behavior for fleshy fruits in which

isolated shrubs and trees likely fructify asynchronously during this season and each plant species may present fruit only during a short period throughout the year (Kattan 1992; Galindo-González et al. 2000). Seeds of *R. urticifolius* were the most common species dispersed in both restoration sites; this invasive herb of early successional stages with continuous fruiting periods was present on all monthly bird depositions. Consequently, in disturbed areas and secondary growth Andean forests, the Blackberry (*Rubus* spp.) is very common, as well as dispersal of its seeds, but this herb contributes mostly to avian dispersers as foraging resources rather than as a keystone plant species in restoration processes (Fonseca 2001, Velasco 2004). Although the disperser of each plant species could not be determined, birds observed visiting perches in open pasture at RBC as the Blue Gray Tanager and some species of Thrushes are considered important seed dispersers in neotropical perturbed lands according to its foraging strategy (Aide & Cavelier 1994; da Silva et al. 1996; Holl 1998; Fonseca 2001; Velasco 2004); but species specific studies on their roles as dispersers on restoration are limited or lacking for the neotropics.

Birds dispersed in high proportion small-seeded pioneer trees and shrub plant species (early successional stages), which frequently also have small fruit size, high crop size and are easily eaten and defecated, being consumed by a wide array of dispersers (Howe 1977; Wheelwright 1985; Levey 1987); characteristics that also play an important role for seed dispersal of neotropical plants. Furthermore, small bodied frugivorous birds transport mostly small sized seeds and are the most significant avian dispersers (Herrera 1982; Moermond & Denslow 1985). Vertebrate seed dispersers in tropical forests include birds and bats (Uhl 1987; Thomas et al. 1988; Duncan & Chapman 1999;

Medellín & Gaona 1999; Galindo-González et al. 2000; Ingle 2003; Shiels & Walker 2003), nevertheless, early successional plant species that inhabit at mountain neotropical forests, commonly establish in open areas near to edge forest (i.e., *Solanum*, *Myrsine*, *Piper*, *Cecropia* and *Rubus*) and are bird-dispersed (Aide & Cavelier 1994; Holl 1998; McClanahan & Wolfe 1993; Zimmerman et al. 2000), although, some pioneer species of genera such as *Piper* and *Solanum* are most likely dispersed by frugivorous bats (da Silva et al. 1996; Galindo-González et al. 2000).

Diversity of bird seeds dispersed in the two pastures was not completely similar probably due to plant heterogeneity and asynchronous in fruiting at open sites (Velasco 2004). During periods of scarcity of feeding resources regenerating habitats provide fruits and nectar for birds and other animals (Loiselle & Blake 1994). Moreover, perches placed in perturbed open lands has shown to be an effective method to increase bird visitation and seed dispersal, encouraging the recovery of these sites. Although this study did not evaluate seedling establishment, bird perches may accelerate forest regeneration on pastures in RBC, because, most of the seeds were dispersed under perch plots than control plots. Therefore, artificial perches give a better chance for restoration, but at the long term (McClanahan & Wolfe 1993; Holl et al. 2000). Since vertical structure of vegetation in adjacent areas to recovery and abandoned time of sites to recovery are factors that can affect seed dispersal in Highandean forests at Colombia (Velasco 2004), and perches placed in pastures surrounded by secondary growth forest were less attractive to birds than open pastures with isolated trees, probably because of low vegetation heterogeneity composition, perches could be placed to reach canopy

height of surrounding forests to attract large-bodied frugivores from forest interior (Holl 1998; Shiels & Walker 2003).

4. CONCLUSION

Perches contributed to seed arrival, but the number of seeds dispersed was significantly higher in perches placed at open pastures compared to pastures surrounded by secondary growth forest. Surrounding vegetation and distance from it likely affect seed dispersal, as our results indicate at two pastures in Colombian Andean forest. Moreover, seed dispersal and bird visitation to perches increased during the dry seasons, two early successional species from forest interior, *Cordia cylindrostachya* and *Viburnum cornifolium*, were mainly dispersed. The recruitment and sowing of native tree species (i.e., *Quercus humboldtii*, *Weinmannia* spp. and *Cecropia* spp.) and species with high crop size and fleshy fruits at RBC may help increase the ornithochoral process, encouraging changes in microclimate conditions and soil structure, and helping to attract and create habitat for bird dispersers (Toh et al. 1998; Holl et al. 2000; Durán & Kattan 2004). Furthermore, birds are important agents in seed dispersal and recovery of anthropogenic pastures of the Andean forest at RBC. However, to restore pastures in the short term, seedling establishment needs to be evaluated and several restoration methods combined, such as implementing bird perches at a larger scale and the seeds and seedlings being transported from grasslands to places which may give better chances of establishment and for taking care of the less abundant but important species for late and old forest succession. Seed predation and herbivory were not evaluated in the two restoration sites, but these potential barriers can impede seed germination and seedling establishment and could partially explain the low germination rate and survivorship in some Andean degraded lands.

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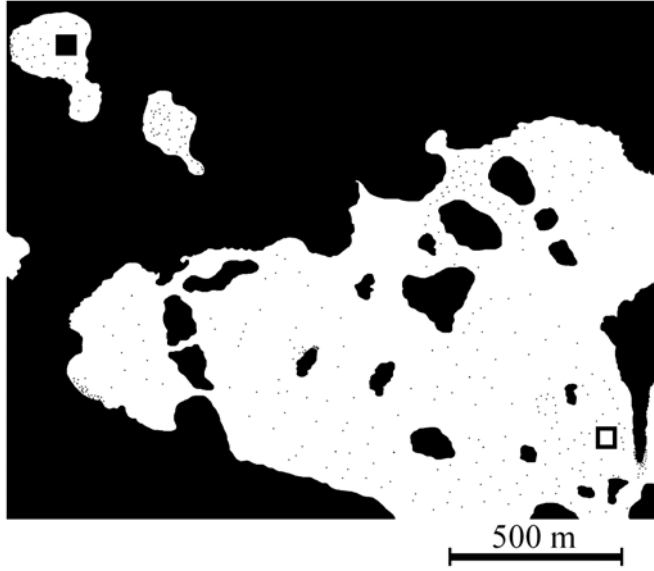


Figure 1.

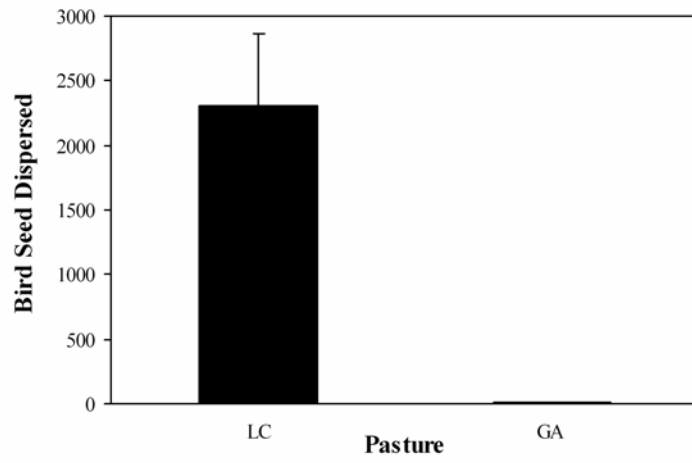


Figure 2.

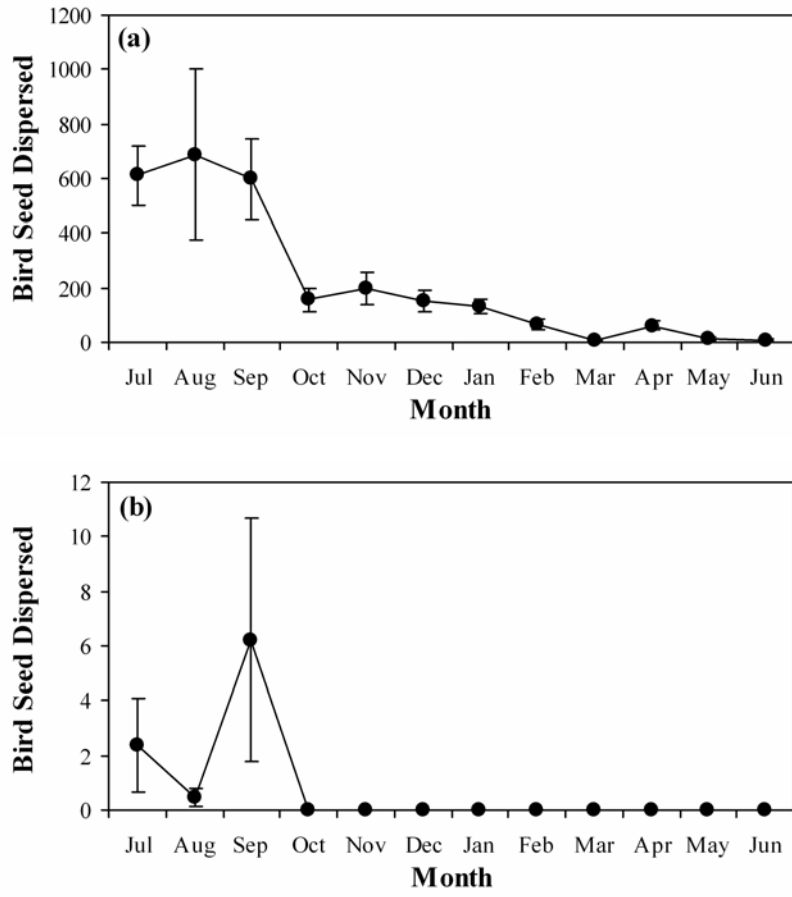


Figure 3.

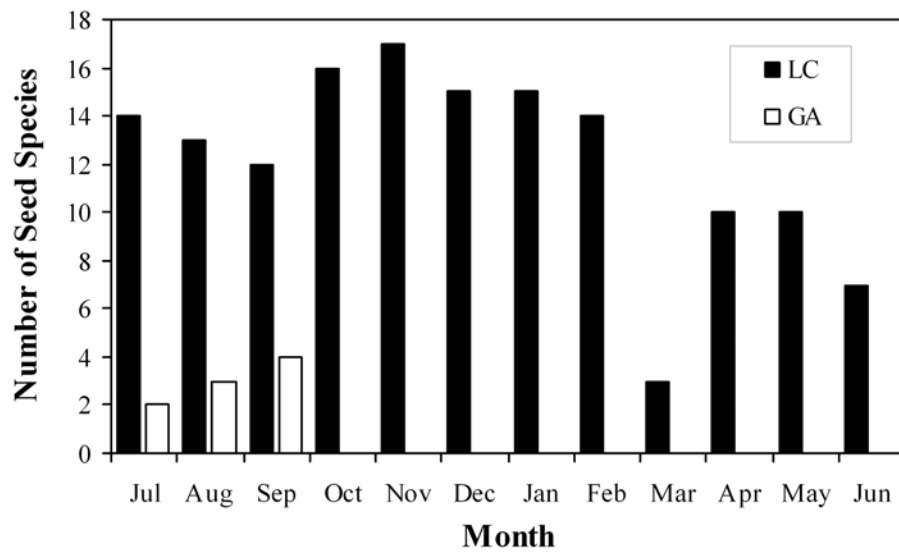


Figure 4.

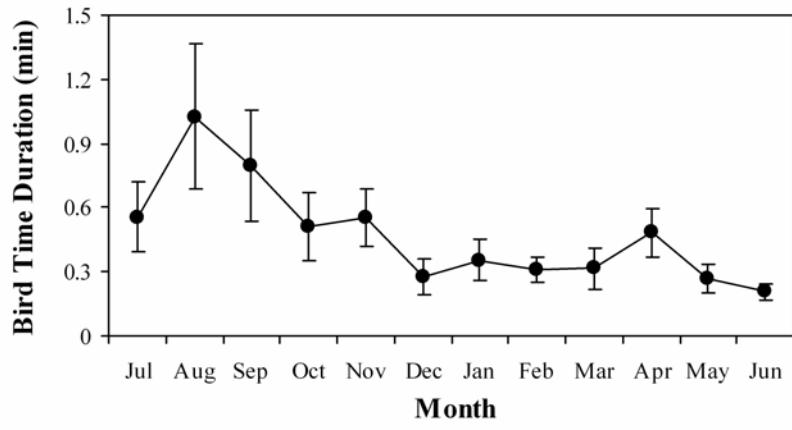


Figure 5.

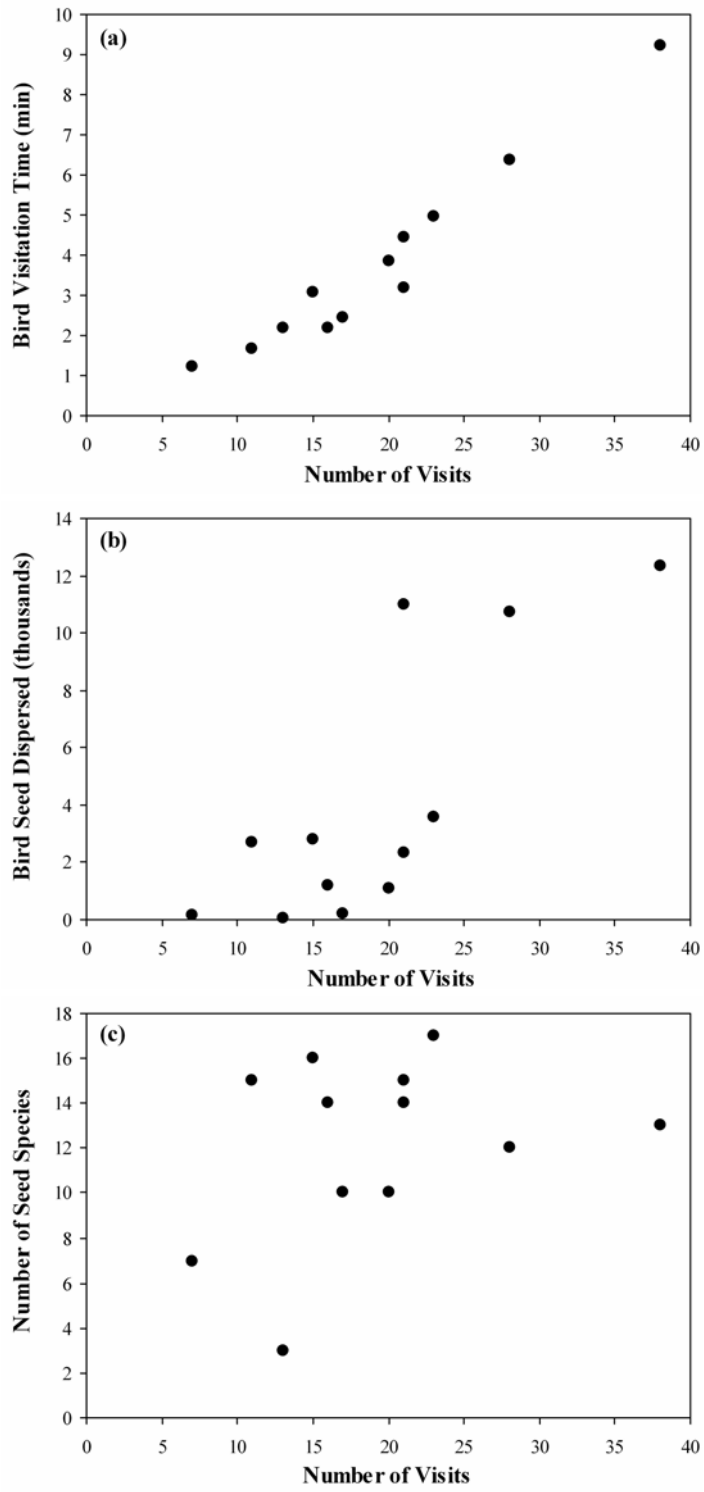


Figure 6.

Table 1.

<i>Species</i>	<i>Growth form</i>	<i>Successional category</i>	<i>Seed size (mm)*</i>	<i>Seeds/m²</i>	
				<i>LC</i>	<i>GA</i>
BORAGINACEAE					
<i>Cordia cylindrostachya</i>	Tree	Pioneer	3.1	219.12	1.19
CAPRIFOLIACEAE					
<i>Viburnum cornifolium</i>	Tree	Pioneer	6.2	221.1	0.71
ERICACEAE					
<i>Vaccinium</i> sp.	Shrub	Pioneer	0.6	7.21	0
MELASTOMATACEAE					
<i>Miconia</i> sp.	Shrub	Pioneer	0.6	17.84	0
MENISPERMACEAE					
<i>Cyssampelos pareira</i>	Vine	Late	3.5	1.1	0
MYRSINACEAE					
<i>Myrsine coriacea</i>	Tree	Pioneer	3.2	55.17	0.14
MYRTACEAE					
<i>Psidium</i> sp.	Tree	Late	3	5.95	0
PHYTOLACCACEAE					
<i>Phytolacca rivinoides</i>	Herb	Ruderal	2.5	6.2	0
POLYGONACEAE					
<i>Muehlenbeckia</i> sp.	Herb	Pioneer	2.2	34.43	0
ROSACEAE					
<i>Rubus urticifolius</i>	Shrub	Pioneer	2.1	489.88	1.76
RUBIACEAE					
<i>Coccocypselum hirsutum</i>	Herb	Ruderal	1.1	56.95	0.07
<i>Relbunium hypocarpium</i>	Herb	Ruderal	2	2.64	0
SOLANACEAE					
<i>Solanum nigrum</i>	Shrub	Pioneer	1.5	23.26	0
<i>Solanum</i> sp. 1	Herb	Pioneer	3	0.05	0
<i>Solanum</i> sp. 2	Herb	Pioneer	4	0.05	0
<i>Solanum</i> sp. 3	Herb	Pioneer	3.6	1.21	0
Unknown species			0.6 - 2	9.04	0

Table 2.

<i>Pasture</i>	<i>Bird Dispersed Seeds</i>	
	<i>Perch</i>	<i>Control</i>
LC	2,679.36 ± 609.43	20.16 ± 20.16
GA	9.05 ± 5.38	0

Table 3.

<i>Species</i>	<i>Common Name</i>	<i>Diet</i> ^a	<i>Habitat</i> ^b	<i>Perch Visits</i>
CUCULIDAE				
<i>Crotophaga ani</i>	Smooth-billed Ani	F-I	P-E	34
TYRANNIDAE				
<i>Tyrannus melancholicus</i>	Tropical Kingbird	F-I	P-E	24
COTINGIDAE				
<i>Pipreola riefferii</i>	Green and black Fruiteater	F	F	0
MIMIDAE				
<i>Mimus gilvus</i>	Tropical Mockingbird	F-I	P-E	36
TURDIDAE				
<i>Turdus fuscater</i>	Great Thrush	F-I	P-E	29
<i>T. ignobilis</i>	Black-billed Thrush	F-I	P-E	18
<i>Platycichla flavipes</i>	Yellow-legged thrush	F	P-E	0
EMBERIZIDAE				
<i>Atlapetes albobrenatus</i>	Moustached Brush-finch	F-I	F	0
<i>Zonotrichia capensis</i>	Rufous-collared Sparrow	F-I	P-E	51
<i>Sporophila minuta</i>	Ruddy-breasted Seedeater	S	P-E	0
FRINGILLIDAE				
<i>Carduelis psaltria</i>	Lesser Golgfinch	S	P-E	0
<i>C. xanthogastra</i>	Yellow-bellied Siskin	S	P-E	0
THRAUPIDAE				
<i>Thraupis episcopus</i>	Blue Gray Tanager	F-I	P	18
<i>Chlorospingus canigularis</i>	Ashy-throated Bush Tanager	F	F-E	0
<i>Tangara cyanicollis</i>	Blue-necked Tanager	F-I	P-E	9
<i>T. vitriolina</i>	Scrub Tanager	F-I	P-E	11
<i>Diglossopsis caerulea</i>	Bluish Folwer-piercer	F-I-N	P-E	0
<i>D. cyanea</i>	Masked Flower-piercer	F-I-N	P-E	0
<i>Diglossa albilatera</i>	White-sided Flower-piercer	F-I-N	P-E	0
PARULIDAE				
<i>Coereba flaveola</i>	Bananaquit	F-I-N	P-E-F	0
ICTERIDAE				
<i>Molothrus bonariensis</i>	Shiny Cowbird	F-I-S	P-E	0