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ABUNDANCE AND DISTRIBUTION OF PARROTS ALONG THE ELEVATIONAL GRADIENT OF CALILEGUA NATIONAL PARK, ARGENTINA

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Resumen. – Abundancia y distribución de loros a lo largo del gradiente altitudinal del Parque Nacional Calilegua, Argentina. – En Febrero de 2001, registramos seis especies de loros y detectamos diferencias en sus patrones de distribución y abundancias a lo largo de un gradiente altitudinal en las selvas de montaña del Parque Nacional Calilegua en el noroeste de Argentina. El área de estudio fue dividida en cuatro tipos de bosque (de menor a mayor altitud: pedemonte, transición a selva montana, selva montana y transición a bosque nublado). La transición a bosque nublado tuvo el menor número de especies. El Maracaná cuello dorado (*Propyrrhura auricollis*), el Loro maitaca (*Pionus maximiliani*) y el Chiripepe cabeza parda (*Pyrrhura molinae*), ocuparon tres tipos de bosque hacia el extemo más bajo del gradiente altitudinal. El Calancate ala roja (*Aratinga leucophthalma*) ocupó el pedemonte y la transición a selva montana, mientras el Calancate cara roja (*A. mitrata*) ocupó la selva montana y la transición a bosque nublado, mostrando un reemplazo de especies del género *Aratinga* en diferentes tipos de bosque. El Loro alisero (*Amazona tucumana*) se registró sólo en la transición a bosque nublado. Cinco especies fueron significativamente más abundantes en algún tipo de bosque en particular: Calancate ala roja en el pedemonte, Calancate cara roja en la transición a bosque nublado, Loro maitaca en la transición a selva montana, Chiripepe cabeza parda en el pedemonte, y Loro alisero en la transición a bosque nublado. Sin embargo, el Maracaná cuello dorado no mostró diferencias significativas en sus abundancias entre los tres tipos de bosque donde fue detectado. La mayoría de las observaciones del Calancate ala roja y Loro alisero correspondieron a parejas, mientras las del Calancate cara roja, Maracaná cuello dorado, Loro maitaca y Chiripepe cabeza parda fueron en grupos ≥ 4 individuos. Este estudio resalta la importancia de conservar el gradiente altitudinal completo.

Abstract. – In February 2001, we recorded six parrot species and detected differences in their distribution patterns and abundances along an elevational gradient in the montane forests of the Calilegua National Park in northwestern Argentina. The study area was divided into four forest types (from low to high altitude: piedmont, transition to montane, montane, and transition to cloud). The transition to cloud forest had the lowest number of species. Yellow-collared Macaws (*Propyrrhura auricollis*), Scaly-headed Parrots (*Pionus maximiliani*), and Green-cheeked Parakeets (*Pyrrhura molinae*) occurred in three forest types at the lower end of the elevational gradient. White-eyed Parakeets (*Aratinga leucophthalma*) occupied piedmont and transition to montane, whereas Mitred Parakeets (*A. mitrata*) occupied montane and transition to cloud forest, showing a replacement of species of the genus *Aratinga* in different forest types. Tucuman Parrots (*Amazona tucumana*) were found only in transition to cloud forest. Five species were significantly more abundant in a particular forest type: White-eyed Parakeet in piedmont, Mitred Parakeet in transition to cloud, Scaly-headed Parrot in transition to montane, Green-cheeked Parakeet in piedmont, and

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Tucuman Parrot in transition to cloud. However, Yellow-collared Macaws did not show significant abundance difference among the three forest types where it was detected. Most observations of White-eyed Parakeets and Tucuman Parrots were in pairs, whereas Mitred Parakeets, Yellow-collared Macaws, Scaly-headed Parrots, and Green-cheeked Parakeets were in groups ≥ 4 individuals. This study highlights the importance of conserving the complete elevational gradient. *Accepted 1 October 2004*.

Key words: Parrots, elevational gradient, montane forests, conservation, habitat association, flock size, Northwestern Argentina.

INTRODUCTION

Parrots comprise one of the most endangered groups of birds of the world; 30% of the some 140 species of Neotropical parrots are at risk of extinction, and the 70% remaining species are rapidly declining (Beissinger & Snyder 1992). The main causes of this situation are habitat loss, pet trade, and a combination of both factors. These parrot species require conservation actions that offset the current impacts of habitat conversion and trade (Collar & Juniper 1992). Even though these Neotropical parrot species are highly threatened and are important in the pet trade since Colonial times (Snyder *et al.* 1987), their ecology is still poorly known and basic biological information is lacking (Forshaw 1989). The acquisition of this knowledge is a prerequisite for determining threats, monitoring population trends, and evaluating conservation and management actions to be taken (Masello & Quillfeldt 2002).

The numbers of parrots exported from Argentina was in the order of 900,000 in a 6-year period (Thomsen & Mulliken 1992). Approximately 90,000 individuals were exported from the montane forests of northwestern Argentina in the 90s (data from Dirección Nacional de Flora y Fauna Silvestre). Eight parrot species occur in these forests (Narosky & Yzurieta 1987): Military Macaw (*Ara militaris*), Yellow-collared Macaw (*Propyrrhura auricollis*), Mitred Parakeet (*Aratinga mitrata*), White-eyed Parakeet (*A. leucophthalmus*), Green-cheeked Parakeet (*Pyrrhura molinae*), Scaly-headed Parrot (*Pionus maximi-liani*), Blue-fronted Parrot (*Amazona aestiva*) and Tucuman Parrot (*A. tucumana*). The latter species is endemic and considered as vulnerable (Juniper & Parr 1998).

Montane forests of northwestern Argentina are disappearing at an alarming rate: 1.1% annually, a value much higher than for many other tropical forests (FAO 1993). There are protected areas including montane forests in northwestern Argentina, but they do not include a complete representation of the elevational gradient. So, although parrot species do occur in these protected areas, it is not known if such reserves are large enough to hold viable populations (Soulé 1987) or can meet the requirements of parrot species (Collar & Juniper 1992).

Communities inhabiting montane regions show distribution patterns, diversity, and species turnover that are more variable within shorter distances than in plain areas, which increases their ecological value (Huston 2002). Additionally, many species undergo altitudinal movements to meet their life requirements, and the integrity of the gradient as a whole is essential. Thus, it is important to understand the species distributional patterns along the elevational gradients of montane forests. Previous efforts have already been made to understand the variations along montane forests using different taxa, e.g., birds (Terborgh 1977, Blake & Rougés 1997, Blake & Loiselle 2000), bats (Graham 1983), frogs (Vaira 2002), but there are no studies dealing with the parrot community.

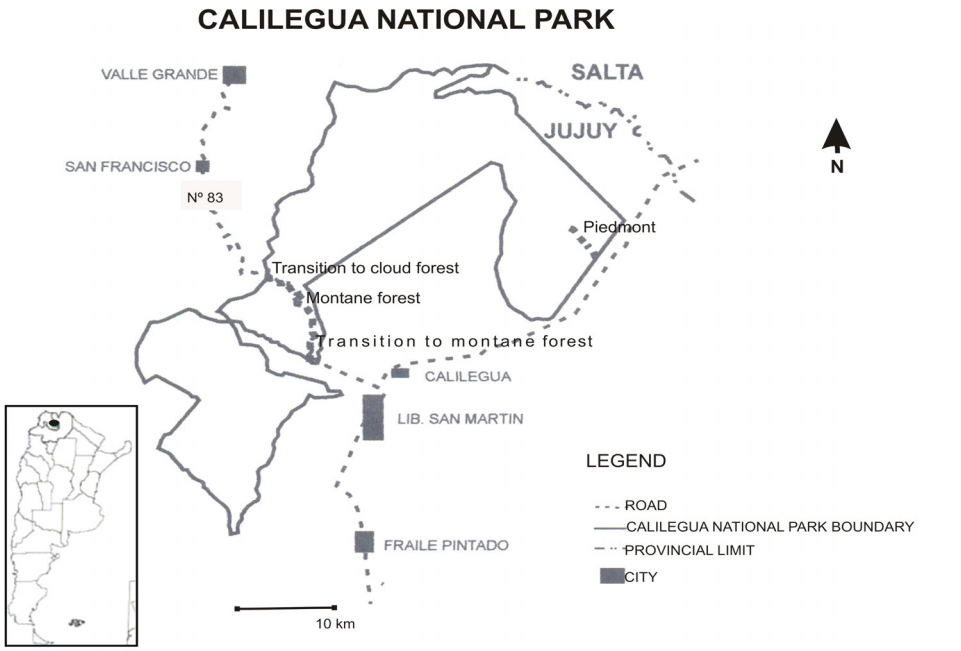

FIG. 1. Study area and location of the four forest types surveyed in the Calilegua National Park, Argentina, February 2001. Black dot in smaller map indicates the location of Calilegua National Park in Argentina.

Parrots have been found to have a positive association with certain forest types, while they avoid others. For example, in Peru *Ara* spp. prefer upland habitats, but *Amazona* spp. prefer transitional forests and avoid high elevation habitats (Gilardi & Munn 1998). In similar studies of parrot habitat associations, it has been shown that the abundance of Puerto Rican Parrots (*Amazona vittata*) varies among forest types, and they avoid dwarf forests (Snyder *et al.* 1987).

Parrots exhibit various levels of gregariousness, likely to increase the efficiency of foraging depending on the density and distribution of resources (Chapman *et al.* 1989, Juniper & Parr 1998). Some authors have considered that flocking functions mainly as a mechanism to reduce predation risks (Lack 1968, Ward & Zahavi 1973).

The objectives of our study were to gather information, during the breeding season, on distribution, abundance, flock size, and daily morning and afternoon patterns of activity among parrot species along an elevational gradient of northwestern montane forests.

STUDY AREA

We conducted this study in the Calilegua National Park (23°35'S 64°50'W), in southeastern Jujuy province, Argentina (Fig. 1), which protects 76,000 ha of montane forests. The climate is considered as wet subtropical seasonal; 80% of the total rains being distributed from November to April (austral summer) (Ramadori *et al.* 1996).

The northeastern portion of the national park (Fig. 1) is characterized by the presence

of piedmont forests. The region has unimproved roads to oil storage tanks and wells maintained by an oil company. This is a highly disturbed area with many exotic trees (i.e., *Melia* sp., *Eucalyptus* sp., *Ricinus* sp.). Piedmont forests occur from 400 to 500 m, where the main trees are *Callycophyllum multiflorum*, *Phyllostylon rhamnoides*, *Anadenanthera macrocarpa*, *Parapiptadenia excelsa*, *Cedrella angustifolia*, and *Astronium urundeuva*, in addition to *Tecoma stans*, *Tessaria integrifolia*, *Cascaronia astragalina.* (Brown *et al.* 2001). Rainfall averages 800–1000 mm/year. Mean monthly temperatures average 18ºC (Ramadori *et al.* 1996). About 70% of premontane trees lose their leaves in winter (Brown & Grau 1993).

Calilegua National Park is crossed by provincial road Nº 83 (Fig. 1), which divides the protected area and crosses the elevational gradient from 500 to 1700 m. The elevational gradient along road Nº 83 can be divided into three zones according to the vegetation communities. Transition to montane forests occurs from 650 to 850 m, where trees are 20–30 m high, with straight trunks. The main tree species are those of piedmont forest intermingled with that of montane forest. Montane forests are distributed from 850 to 1300 m. They are very humid and are characterized by high abundance of epiphytes and vines. The main tree species being *Cinnanumin porphyria*, *Blepharocalix salicifolius*, *Nectandra pichurim*, and *Inga* spp. (Brown *et al.* 2001). Rainfall averages 1000–1400 mm/year. Mean monthly temperatures vary from 15 to 18°C (Ramadori *et al.* 1996). Transition to cloud forests occur from 1300 to 1700 m, where tree species are those typically found in montane forests, intermixed with *Ilex argentina, Cedrella lilloi, Juglans australis, Podocarpus parlatorei*, and *Alnus acuminata*, found in cloud forests (Brown *et al.* 2001). Rainfall averages 800–1200 mm/year. Mean monthly temperatures vary from 10 to 15°C (Ramadori *et al.* 1996).

METHODS

We divided the study area into four elevational zones according to the main vegetation communities described above; three along a 23-km section on road Nº 83 (transition to montane, montane, and transition to cloud forest), and one along the 5-km road on the northeastern portion of the national park (piedmont forest). The study was conducted in February 2001, during late breeding season. We assumed that the study area was representative of the elevational gradient in the park. We counted the parrots at six 100-m radius point counts in each forest type. Points were separated by 400 m, and points between different forest types were separated at least by 1 km. Each point was visited five times during February (a total of 30 point counts for each forest type). Observations at points had a total duration of 15 min. We conducted 15 point counts from dawn (07:00) until approximately 11:00 (hereafter, morning surveys) and 15 from 17:00 until dusk (20:00) (hereafter, afternoon surveys) because Pizo & Simao (1997) and Gilardi & Munn (1998) found that parrots in the breeding season had their major activities during these time intervals. Parrots were counted visually and vocally (Pizo & Simao 1997). We minimized the probability of double counts by excluding flocks that appeared in the same direction as a flock already recorded and lost from sight (Chapman *et al.* 1989).

We compared morning and afternoon abundance of each parrot species using Wilcoxon test (*Z*) (Zar 1999). We also compared the abundance of each parrot species among elevational zones using Kruskal-Wallis test (*H*), followed by Tukey's comparisons among means tests (Zar 1999). Values are given as mean ± SE; we used standard error since it is a better estimate of the mean (Quinn & Keough 2002), especially when there are large variations between samples. Percentage of

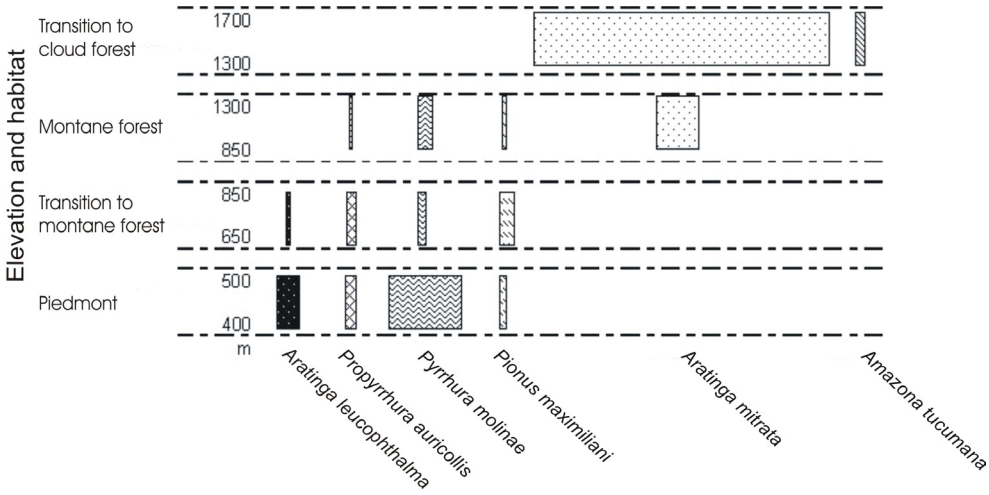

FIG. 2. Distribution of six parrot species along four forest types in Calilegua National Park, Argentina, February 2001. The width of the bars reflects the proportional abundance of each parrot species.

each parrot species flock size (1, 2, 3, and ≥ 4 individuals) was calculated.

RESULTS

We recorded six parrot species during point counts. We did not find significant differences between morning and afternoon abundances of any species (Mitred Parakeet: $Z = 0.133$, $P = 0.921$; Tucuman Parrot: $Z = 0.13$, $P = 1.00$; Scaly-headed Parrot: $Z = 0.09$, $P = 0.99$; Green-cheeked Parakeet: $Z = 0.08$, $P = 1.00$; Yellow-collared Macaw: $Z = 0.11$, $P = 0.91$; White-eyed Parakeet: $Z = 0.11$, $P = 0.99$). As a consequence, we grouped the results from both periods for further analysis, which increased the sample size. We recorded significantly more individuals, but significantly fewer species during point counts in the transition to cloud forest than at lower elevation sites (Fig. 2, Table 1). Scaly-headed Parrot, Green-cheeked Parakeet, and Yellow-collared Macaw were the species with the broadest distribution along the gradient, whereas Tucuman Parrot was restricted to one elevation zone (Fig. 2). Each species' abundance showed a significant difference between at least two elevational zones (Table 1). Most species where recorded in flocks of more than 4 individuals, except Alder Parrot and White-eyed Parakeet, which were seen mainly in pairs (Table 2).

DISCUSSION

In Calilegua National Park we found a clear association between certain parrot species and forest types along the elevational gradient of the montane forests, in agreement with studies on other parrots species (Snyder *et al.* 1987, Gilardi & Munn 1998). We detected a spatial stratification in the distribution of the six parrot species recorded in Calilegua National Park, determined by changes in their abundances. The highest forest type (transition to cloud forest) contained the least number of parrot species (2), which is in agreement with various studies of bird communities in different areas of the Neotropics (Rahbek 1997, Goerck 1999, Blake & Loiselle 2000).

Elevational distributions of many forest

TABLE 1. Mean ± SE and sample size (in parenthesis) of individuals of six parrot species during 30 15-min point counts at four forest types in the Calilegua National Park, Argentina, February 2001. *H* = Kruskal-Wallis test statistic.

Species	Forest types				*H*
	Piedmont	Transition to montane	Montane	Transition to cloud forest	
White-eyed Parakeet (*Aratinga leucophthalma*)	2.9 ± 1.1a (83)	0.3 ± 0.2b (10)			33.7
Scaly-headed Parrot (*Pionus maximiliani*)	0.9 ± 0.6b (27)	1.8 ± 0.4a (53)	0.6 ± 0.4b (17)		32.7
Mitred Parakeet (*Aratinga mitrata*)			5.2 ± 2.7b (155)	35.1 ±7.8a (1052)	58.3
Green-cheeked Parakeet (*Pyrrhura molinae*)	8.4 ± 1.7a (261)	0.9 ± 0.3c (27)	1.7 ± 0.6b (57)		49.8
Yellow-collared Macaws (*Propyrrhura auricollis*)	1.2 ± 0.4b (37)	1.2 ± 0.5b (34)	0.4 ± 0.2ab (12)		17.0
Tucuman Parrot (*Amazona tucumana*)				1.2 ± 0.4a (36)	32.4

[a,b,c]Forests types with the same letter are not significantly different at $P = 0.05$ using Tukey multiple comparison of means.

TABLE 2. Percentage (%) of flock size observed for six parrot species at Calilegua National Park, Argentina, February 2001.

Species	Number of individuals in flocks				Largest number of individuals in flocks
	1	2	3	≥ 4	
White-eyed Parakeet (*Aratinga leucophthalma*) [93][a]	3	48	3	46	16
Scaly-headed Parrot (*Pionus maximiliani*) [97]	19	29	9	43	9
Mitred Parakeet (*Aratinga mitrata*) [1207]	2	1	-	97	51
Green-cheeked Parakeet (*Pyrrhura molinae*) [83]	6	6	3	85	20
Yellow-collared Macaws (*Propyrrhura auricollis*) [83]	21	34	-	45	8
Tucuman Parrot (*Amazona tucumana*) [36]	11	67	-	22	8

[a]Number in brackets is total number of individuals counted of the species

birds are extremely narrow, especially in the eastern Andes. Their restricted distributions make them more susceptible to habitat alterations (Stotz *et al.* 1996). This might be the case for Tucuman Parrots which make a narrow use of the elevational zones, occurring only in the transition to cloud forest. This was the least abundant species, a result that could be due to the fact that we did not census cloud forest (ranging from 1700–2300 m), its optimal habitat during the breeding season. Although Juniper & Parr (1998) state that Tucuman Parrot can be found from 1800 to 2000 m during the breeding season, we found it as low as 1500 m.

The species with the greatest ecological plasticity, occurring in three of the elevational zones of this study, were the Scaly-headed Parrot, Green-cheeked Parakeet, and Yellow-collared Macaw. The Green-cheeked Parakeet was recorded from 400 to 1300 m, in disagreement with Juniper & Parr (1998) who mentioned this species up to tree line of the cloud forest (around 2500 m). We found White-eyed Parakeets from 400 to 850 m, which is clearly different from the findings in Bolivia where this species can occur up to 2500 m (Juniper & Parr 1998), although our results agree with those of Stotz *et al.* (1996), who mentioned the species as occurring below 1000 m.

White-eyed and Mitred parakeets occupy opposite elevational zones in the gradient, showing a clear replacement of species of the same genus in different forests types. The replacement of closely related species has also been noted in other parts of the Andean slopes (Terborgh 1971), with little sympatric occurrence among members of the same genus (Juniper & Parr 1998). For example, the same pattern has been described for Peach-fronted (*Aratinga aurea*) and Cactus parakeets (*A. cactorum*) where their ranges overlap, but the former inhabits the grassier areas of the cerrado and caatinga woodlands of interior Brazil, whereas the latter is mainly found in the woodier portions of the caatinga (Juniper & Parr 1998).

The fact that abundances were roughly the same during morning and afternoon counts for the six parrot species suggests that both surveys can be grouped to increase sample size. This is important because parrot abundances are highly variable, and larger samples are required for statistical analysis. Even though we did not survey in the early afternoon (between 12:00 and 16:00), we noticed a lower activity of parrots in that period, a fact which can be explained by temperatures (Wescott & Cockburn 1998), since activities

that require elevated metabolic rates are best done when temperatures are relatively mild; early morning hours provide a relatively cool and well-lit opportunity to forage (Snyder *et al.* 1987, Pizo & Simao 1997, Gilardi & Munn 1998).

We found great variation among the grouping strategy of the six parrot species, and even within species of the same genus. The large variation in the number of detected individuals might be due to their social behavior or grouping patterns. For example, most flocks of the Mitred Parakeet, a very social species, were composed of more than four individuals, whereas most White-eyed Parakeets were pairs. Tucuman Parrots were observed mainly as pairs, which is a typical behavior of *Amazona* species during the breeding season (Snyder *et al.* 1987, Martuscelli 1995). Our findings seem to disagree, at least in part, with the observations of Gilardi & Munn (1998) who stated that parrots that inhabit forests are less social since these flocks are smaller than those in other habitat types. We also detected large flocks of Tucuman Parrot in the non-breeding season (unpubl. data).

We found the Mitred Parakeets in different forest types, and in large flocks. Indeed, they were nesting (we detected an active nest with three eggs, unpubl. data) on the transition to montane forest, whereas they descended in the early mornings to montane forest for foraging (we recorded the species feeding on fruits of *Blepharocalix salicifolius*, unpubl. data).

Of the seven species that inhabit the Calilegua National Park, we were able to record only six. We did not observe the Blue-fronted Parrot. This species is found primarily in the piedmont forest, which is poorly represented in Calilegua National Park (1.6%; Ramadori *et al.* 1996).

Because our study focused only on the breeding season, the possibility of changes in the distributional patterns of parrots in Calilegua National Park cannot be ruled out for other seasons. For example, it is well known that Tucuman Parrots gather in large flocks, and descend in altitude during the non-breeding season (Wetmore 1926, Mosa *et al.* 1992, Rivera & Politi 2004). Further studies must be conducted to determine the distribution of parrot species out of the breeding season.

Montane forests have served in the past as a refuge for bird species when the climate was changing, acting as a center of evolution and endemism for birds (Fjeldså & Mayer 1996). However, for the montane forests to function as such, the distributional movements of their species must be assured, which can only be attained by maintaining connectivity through their entire elevational gradient (Noss 2001). Several parrot species appear to be already suffering from the lack of continuous altitudinal habitats for seasonal foraging and breeding (Snyder *et al.* 2000). Since montane forest parrot species have altitudinal movements (Wetmore 1926, Mosa *et al.* 1992, Rivera & Politi 2004), it is likely that the loss and degradation of any forest type (Brown *et al.* 2001) of the altitudinal gradient will have an effect on them.

To develop successful conservation strategies for these parrot species, it is necessary to study their ecology and distributional patterns. Accurate assessments of their status and habitat requirements are needed for all habitats where they occur. In addition, forest types that are not properly protected in the Calilegua National Park must be identified and given appropriate protection. The seasonal distribution, large range, and dependance on old-growth forests make parrots susceptible to the high rate of transformation of montane forests. Our study suggests that parrots are highly dependent on different forest types and a strategy that protects the entire altitudinal gradient should be adopted

to assure the long-term conservation of montane forest parrot species.

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