

First density estimate of the Rufous-fronted Parakeet (*Bolborhynchus ferrugineifrons*: Psittacidae) in the southern sector of Las Hermosas National Natural Park, Colombia

Primera estimación de densidad del Periquito frentirrufo (*Bolborhynchus ferrugineifrons*: Psittacidae) en el sector sur del Parque Nacional Natural Las Hermosas, Colombia

Néstor Roncancio-Duque ^{1,2}

¹ Parque Nacional Natural Las Hermosas Gloria Valencia de Castaño - WWF. Tolima, Colombia

² Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá, Colombia

>< nroncancio@humboldt.org.co

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Abstract

Given the scarce population information available for the Rufous-fronted Parakeet (*Bolborhynchus ferrugineifrons*), much of which is based on studies conducted more than two decades ago in one locality, I present the first estimate of population density for this species in the southern sector of National Natural Park Las Hermosas - Gloria Valencia de Castaño. Using line-transect distance sampling, I obtained 13 independent detections along seven transects (total survey effort = 300.7 km). Observed data fitted with a uniform key function with cosine adjustments. The estimated density was 4.05 individuals per km² (95% CI 1.68–9.80). Detection probability was 0.42 (95% CI 0.24–0.74) and the effective strip width was 42.17 m (95% CI 24.14–73.68). Expected cluster size from regression was 7.90 individuals (95% CI 4.74–13.17). These results update our knowledge of the species' status and provide a quantitative baseline for conservation of this endemic and threatened Andean parakeet.

Key words: Central Andes, distance sampling, paramo, population density, protected area

Resumen

Dada la escasa información poblacional disponible para el Periquito frentirrufo (*Bolborhynchus ferrugineifrons*), basada en gran medida en estudios de hace más de dos décadas en una sola localidad, se presenta la primera estimación de densidad poblacional para esta especie en el sector sur del Parque Nacional Natural Las Hermosas - Gloria Valencia de Castaño. Mediante muestreo a distancia con transectos lineales, se obtuvieron 13 detecciones independientes a lo largo de siete transectos (esfuerzo total de muestreo = 300,7 km). Los datos observados se ajustaron a un modelo uniforme con ajustes de coseno. La densidad estimada fue de 4,05 individuos por km² (IC 95%: 1,68 - 9,80). La probabilidad de detección fue de 0,42 (IC 95%: 0,24 - 0,74) y el ancho efectivo del transecto fue de 42,17 m (IC 95%: 24,14 - 73,68). El tamaño de bandada esperado a partir de la regresión fue de 7,90 individuos (IC 95%: 4,74 - 13,17). Estos resultados actualizan nuestro conocimiento sobre el estado de la especie y proporcionan una base cuantitativa para la conservación de esta cotorra andina endémica y amenazada.

Palabras clave: Andes centrales, área protegida, densidad poblacional, muestreo a distancia, páramo



The Rufous-fronted Parakeet (*Bolborhynchus ferrugineifrons*) is a threatened, range-restricted species endemic to the Andes. Its distribution is highly localized within the high-Andean forests, subparamos, and paramos of the Central Andes of Colombia, with populations documented mainly in the massifs of Los Nevados, Las Hermosas, and Puracé (Chaparro-Herrera *et al.* 2024). Due to its highly restricted range and specialized habitat requirements, the species is

categorized as Vulnerable (BirdLife International 2021, Ministerio de Ambiente y Desarrollo Sostenible *et al.* 2024) and is considered a high conservation priority.

Despite this, robust and updated quantitative estimates of abundance are lacking. Previous density estimates rely heavily on localized surveys conducted more than two decades ago in Los Nevados National Natural Park (Verhelst *et al.* 2002, Espinosa *et al.* 2016

based on data from 2001). These results remain the main references for its population status. Establishing updated density baselines within protected areas, such as Parque Nacional Natural Las Hermosas - Gloria Valencia de Castaño (GVC), a keystone area for the conservation of high-mountain Psittacidae (Roncancio-Duque *et al.* 2022), is essential for assessing local population status and guiding conservation strategies. Therefore, the objective of this study was to estimate the population density of *B. ferrugineifrons* in the southern sector of Las Hermosas National Natural Park - GVC. To achieve this, I applied line-transect distance sampling, a method that offers the advantage of correcting for imperfect detection to provide more reliable and robust density estimates (Buckland *et al.* 2015). From October 2020 to April 2021, I conducted line-transect distance sampling along seven transects, with a total survey distance of 300.7 km. Surveys were conducted between 06:27 and 17:00 hours. Perpendicular distances from the transect line to detected clusters were measured using a laser rangefinder for distances up to 40 m. For distances beyond 40 m, distances were estimated visually by a single observer (the author), who has over 20 years of experience in distance estimation in the field. During these surveys, I recorded 13 independent detections of *B. ferrugineifrons* clusters (Fig. 1).

Line-transect distance sampling allows for the estimation of population densities by correcting for imperfect detection as individuals move further away from the observer. Detection probability (p), effective strip width (ESW), cluster size, and animal density were estimated in Distance 7.5 software (Thomas *et al.* 2010). Cluster size bias was corrected by regressing log (cluster size) against detection distance, while no distance truncation was applied to the observed data. Right truncation above 60 meters was explored based on the continuity of the intervals in the frequency histogram; however, model precision (evaluated via the Coefficient of Variation) did not improve. Given the small sample size ($n = 13$), applying a truncation rule would result in a greater loss of useful biological information compared to the analytical gain.

Six candidate detection models were evaluated. (1) Half-normal with Cosine, (2) Half-normal with Hermite

polynomial, (3) Uniform with Cosine, (4) Uniform with Simple polynomial, (5) Hazard-rate with Cosine, and (6) Hazard-rate with Simple polynomial (Buckland 2015). The decision rule for selecting the best-fitting model was based on Akaike's Information Criterion (AIC). The six evaluated models did not show significant differences among them ($\Delta AIC \leq 2$), except for the Uniform key with a simple polynomial adjustment, which had a ΔAIC of 2.05. Ultimately, model selection supported the uniform key function with cosine adjustments. For this selected model, adequate goodness-of-fit was confirmed using the Kolmogorov-Smirnov ($p = 0.49$) and Cramer-von Mises ($p > 0.40$) tests.

The estimated density was 4.05 individuals per km^2 (95% CI 1.68–9.80). Variance in the final density estimate was primarily due to encounter rate (38.7%), followed by detection probability (33.4%) and cluster size (27.8%). While this study provides a critical first quantitative baseline for Las Hermosas National Natural Park - GVC, the low number of detections ($n = 13$) resulted in wide confidence intervals and a high coefficient of variation ($\approx 45\%$). This highlights the need for caution in interpreting these estimates and their reliability for the entire region. The negative slope of the regression of cluster size on detection distance suggests that larger flocks are preferentially detected at closer ranges, reinforcing the importance of applying cluster-size corrections.

This estimated density is notably lower than the global estimate of 23.5 individuals/ km^2 (95% CI 10.6–51.9) reported for Los Nevados National Natural Park (Espinosa *et al.* 2016). However, this comparison must be interpreted cautiously. The discrepancies may stem from both ecological and methodological factors. Because my surveys were restricted to specific sectors, they may not represent the optimal habitat conditions—such as specific high-Andean forest patches or dense subparamos—that might have been more heavily sampled in Los Nevados. Furthermore, true differences in local carrying capacities could explain the lower density observed in Las Hermosas – GVC.

Although the original sampling design aimed to cover

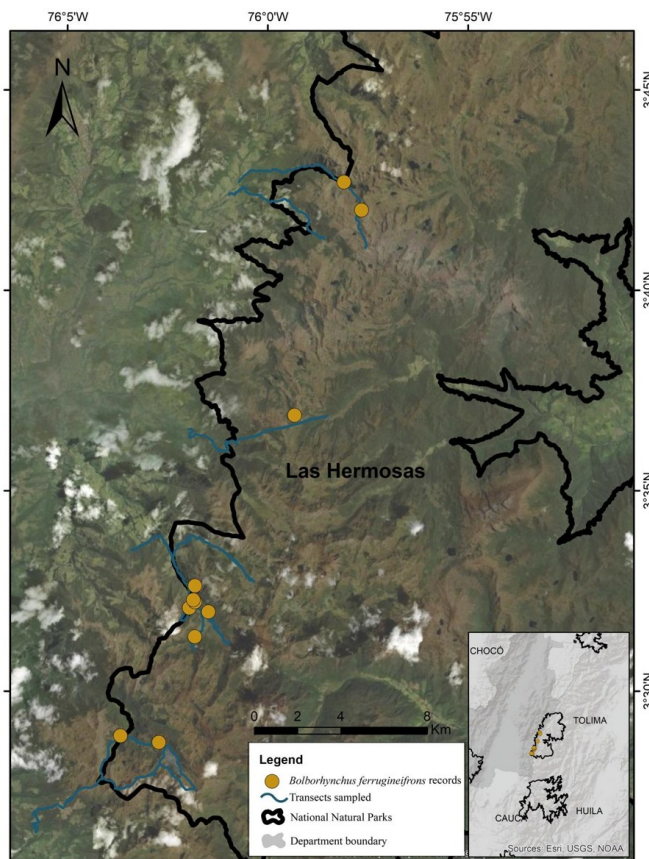


Figure 1. Location of surveyed transects and detections of *Bolborhynchus ferrugineifrons* in the southern sector of Parque Nacional Natural Las Hermosas – Gloria Valencia de Castaño, Colombia.

the full altitudinal range of the species' habitat within the park, primarily in the paramo ecosystem (which covers approximately 79,000 ha), ongoing security situations prevented access to several areas. As a result, sampling was restricted to the south-central and western sectors, which may limit the representativeness of density estimates for the entire protected area.

Despite these spatial and sample size limitations, this study provides the first density estimate for *B. ferrugineifrons* in Las Hermosas National Natural Park - GVC, and the second to use distance sampling methodologies for the species (Espinosa *et al.* 2016). Given that much of the available population data for this endemic, range-restricted, and vulnerable species relies on studies conducted more than two decades ago, these results fill a critical knowledge gap.

Expanding surveys to include additional sectors, altitudinal gradients, and temporal replicates will improve precision and enable the assessment of habitat- or elevation-related effects on density. Such efforts are essential to inform effective conservation planning for this threatened Andean parakeet.

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