The Mantled Howler Monkey (*Alouatta palliata*) Population at La Selva Research Station, Costa Rica: Comparing Censuses in 1992 and 2022

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Introduction

Quantifying primate populations is critical for primate conservation because it allows us to detect changes in population size, compare habitats, and assess the effectiveness of conservation interventions. Howler monkeys (*Alouatta* spp.) are the most well-studied platyrrhine genus, whose low-energy, folivore-frugivore diet leads to a daily activity budget of mostly resting and foraging within small home ranges (Cortes-Ortíz et al., 2021). Quantifying howler monkey density based on collecting call data is straightforward and effective, because they produce loud calls, which can be heard more than 2 km away, to spatially distance themselves from other groups and these calls are made simultaneously across all groups in a forest at sunrise (Stoner, 1994).

Mantled howler monkeys (*Alouatta palliata*) range from southern Mexico to western Ecuador. Their range includes La Selva Research Station in northeastern Costa Rica, which has been a protected forest reserve since the late 1960s. The most recent forest-wide census of mantled howler monkeys at La Selva was conducted in 1992 and used acoustic triangulation of early morning loud calls to census howler monkeys at 23 forest locations, reporting the presence of 15 groups and a population density of 7–15 individuals/km^2 (Stoner, 1994). A human yellow fever epidemic throughout Central America in the 1950s greatly reduced nonhuman primate populations at La Selva

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through the 1970s (Stoner, 1994). Since 1992, forest cover has changed across Costa Rica due to forestry laws established in the late 1990s and specifically at La Selva through acquisition and reforestation of adjacent properties that connects it to Braulio Carrillo national park (Johnson et al., 2023). Population growth also may have occurred due to howler monkeys taking refuge at La Selva from neighboring forest fragments that have been cut down over the past 30 years.

Given that three decades have elapsed and howler monkeys are now rated as Vulnerable on the IUCN Red List (Cortes-Ortíz et al., 2021), an updated howler monkey census at La Selva is needed. We predicted that the population of mantled howler monkeys had increased since 1992 as a result of the enhanced connectivity of the protected forest and population recovery from the effects of the yellow fever epidemic.

Methods

We conducted a follow-up of the 1992 forest-wide howler monkey census at La Selva Research Station (10°25′19″N, 84°00′54″W) on May 29, 2022. Researchers collected data from 4–7 AM across 24 sites in the 1,600-ha, protected forest, using the same timeframe and acoustic triangulation methodology as Stoner (1994). Of the site locations, 23 were as close as possible to the 1992 census given current forest conditions, and we added one site near the field station. Forty-five volunteers collected data mostly in pairs and recorded the time they heard a call, the direction (angle in degrees) of the origin of the call, and a distance category following Stoner's methodology based on the volume of the call: close (0–100 m), near (100–1,000 m), and far (1000 + m).

We visualized and analyzed the data in the same way as Stoner (1994) and by using ArcGIS Pro 3.1. We placed call locations at consistent distances for each of the distance categories: close = 50 m, near = 500 m, and far = 1,000 m. We then conducted a point cluster analysis with a cluster distance of 200 m. We considered a cluster characterized by at least two calls heard by different volunteer pairs as a group. The Sarapiquí and Puerto Viejo rivers border the western, northern, and eastern boundaries of the forest, meaning that groups heard close to these borders were likely to be within the La Selva boundary as there are mainly residences and cultivation across the river but no forest. In contrast, the southern boundary is adjacent to Braulio Carrillo National Park, meaning that groups heard beyond this boundary could be inside the national park. Detected groups located on the La Selva border or within 250 m were included when reporting the number of howler monkey groups at La Selva.

Ethical Note

This research met the legal requirements of Costa Rica and was approved by the Sistema Nacional de Áreas de Conservación (permit #SINAC-ACC-PIre-045–2022). Our research protocol was approved by Indiana University's
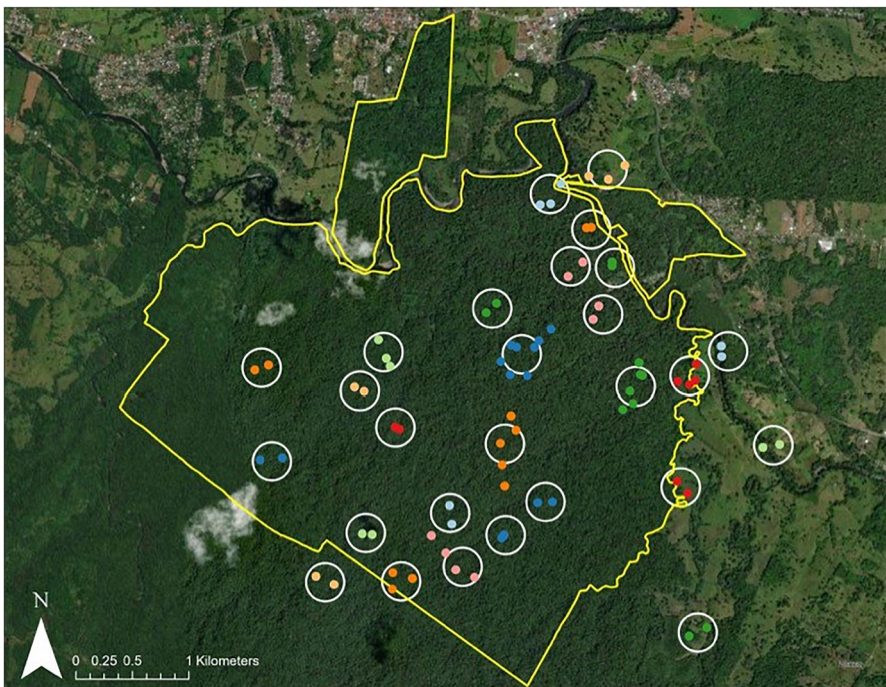
Institutional Animal Care and Use Committee (IACUC permit #22–027-2). All data collection was noninvasive, and this research adhered to the IPS Code of Best Practices for Field Primatology.

Data Availability The datasets generated and analyzed in this study are available from the corresponding author upon request.

Conflict of Interest The authors declare that they have no conflict of interest.

Results

Volunteer pairs perceived 27 different clusters of calls, suggesting the presence of 27 howler groups in or near the forest at La Selva Research Station (Fig. 1). Of these groups, six were located on or within 250 m of the La Selva boundary and two were located over 250 m outside the La Selva boundary in neighboring properties, suggesting that 25 groups inhabit the forest at La Selva Research Station, with a population density of 23.4 individuals/km^2.

Fig. 1 Visualization of a point cluster analysis using direction and distance data from an acoustic triangulation census of mantled howler monkeys at La Selva Research Station, Costa Rica, on May 29, 2022

Discussion

The main finding of the 30-year follow-up census is that there are now more howler monkey groups (25) at La Selva Research Station than the 15 detected in 1992 (Stoner, 1994), indicating a 1.7× increase in the number of groups and a 1.6–3.3× increase in density. These findings suggest that the howler population in La Selva has rebounded following the 1950s yellow fever epidemic. This population growth also may be due in part to howler monkeys migrating into La Selva from neighboring forest fragments as they have been cleared over the past few decades. This increasing trend opposes the general state of mantled howler monkeys, that are currently declining as a species (Cortes-Ortíz et al., 2021). The population may continue to rise as connectivity to neighboring fragments increases over time (Johnson et al., 2023). Howler monkey density is influenced by the structural integrity and heterogeneity of tropical forests (Milton, 1982), and our findings highlight how populations can be sustained and bolstered by long-term protection and increasing connectivity. Ensuring similar protection and connectivity efforts elsewhere in the mantled howler monkeys' geographic range will help to stem species-wide population decline. Our study is an example of how regularly quantifying primate populations using noninvasive methods and advocating for forest protection is crucial as most primates currently inhabit increasingly fragmented landscapes (Estrada et al., 2017).

Declarations

Inclusion and Diversity The author list includes contributors from the location where the research was conducted, who participated in study conception, study design, data collection, analysis, and/or interpretation of the findings. One or more of the authors of this paper self-identifies as a member of the LGBTQ+community.

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