



Tropical pine plantations as **corridors** between forest fragments for *Alouatta palliata* in Las Choapas, Veracruz, Mexico

Plantaciones de pino tropical como corredores entre fragmentos de bosque para *Alouatta palliata* en Las Choapas, Veracruz, México

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ABSTRACT

Howler monkeys are known for their ability to adapt to various habitat types, including modified environments. Despite howlers' adaptability, habitat disturbances can negatively affect their local populations. In this context, agroecosystems may play a key role in improving connectivity between forest fragments, facilitating wildlife movement. Las Choapas, Veracruz, Mexico, is a municipality where forested areas have been heavily modified by deforestation and still harbor a population of mantled howler monkeys (*Alouatta palliata*). In this report, we document one direct observation and anecdotal accounts of *A. palliata* using the canopy of tropical pine (*Pinus caribaea* and *Pinus elliottii*) plantations for travel between forest fragments and as potential resting sites. These findings provide a new account of the role agroforestry plantations can play in improving landscape connectivity within disturbed forest matrices.

KEYWORDS: agroecosystems, connectivity, fragmentation, land-use change, local knowledge, neotropical primates.

RESUMEN

Los monos aulladores son conocidos por su capacidad de adaptarse a diversos tipos de hábitat, incluidos ambientes modificados. A pesar de esto, la fragmentación y modificación del hábitat puede afectar negativamente a sus poblaciones. En este contexto, los agroecosistemas pueden desempeñar un papel clave en la mejora de la conectividad entre fragmentos de bosque, facilitando el desplazamiento de la fauna silvestre. Las Choapas, Veracruz, México, es un municipio cuya cobertura vegetal se ha visto gravemente modificada por el cambio de uso de suelo, y a pesar de esto, aún alberga una población de monos aulladores de manto (*Alouatta palliata*). En este reporte, documentamos una observación directa y relatos anecdóticos sobre el uso del dosel de plantaciones tropicales de pino (*Pinus caribaea* y *Pinus elliottii*) por parte de monos aulladores de *A. palliata*, tanto como corredores para desplazarse entre fragmentos de bosque como posibles sitios de descanso. Estos hallazgos constituyen un nuevo registro sobre el papel que pueden desempeñar las plantaciones agroforestales en la mejora de la conectividad del paisaje dentro de matrices forestales perturbadas.

PALABRAS CLAVE: agroecosistemas, conectividad, fragmentación, cambio de uso de suelo, conocimiento local, primates neotropicales.

INTRODUCTION

Mexico represents the northernmost distribution of non-human primates (hereafter referred to as primates) on the American continent (Dirzo & Miranda, 1991). Three species of Atelids—*Alouatta palliata*, *A. pigra*, and *Ateles geoffroyi*—inhabit the tropical forests of the states of Campeche, Tabasco, Oaxaca, Quintana Roo, Yucatan, and Veracruz. These primates are listed as endangered at both the national (NOM-059; Secretaría de Medio Ambiente y Recursos Naturales [Semarnat], 2010) and international levels (International Union for the Conservation of Nature [IUCN], 2025), with habitat loss due to anthropogenic activities being the primary threat to their survival (Estrada & Coates-Estrada, 1984; Cristóbal-Azkarate & Dunn, 2013; Von Thaden et al., 2020; Estrada et al., 2017; Chapman et al., 2022).

In recent decades, tropical Mexico has experienced rapid land-use and land-cover change, with the state of Veracruz among the most affected by deforestation, with more than 80% of its state area altered (Alan-Ellis & Martínez-Bello, 2010; Bonilla-Moheno et al., 2013). Among these changes, the forestry industry has favored the introduction of exotic species for their exploitation potential, including *Acrocarpus fraxinifolius*, *Gmelina arborea*, *Tectona grandis*, *Eucalyptus urophylla*, *Hevea brasiliensis*, *Pinus elliotii*, and *Pinus caribaea*, driving the conversion of agricultural lands into forest plantations (Rivera Ríos et al., 2008; Torres Ávila et al., 2020; Agroforestal & Grupo AIEn, 2022). These changes in vegetation cover have various effects on behavior, distribution, and habitat use in wildlife. While the replacement of forests with large commercial tree plantations poses a threat to the richness and composition of mammal and bird assemblages (Barlow et al., 2007; Jezzi et al., 2018), smallholdings and agroforestry systems can contribute to landscape heterogeneity in areas with remnants of native and second growth forests, potentially mitigating the effects of fragmentation for some species (Estrada, 2007; Estrada et al., 2012; Niether et al., 2020; Escobar-Ibañez et al., 2023).

Under these circumstances, strategies such as land-sharing and improved landscape connectivity, particularly in agroecosystems, are crucial for wildlife and primate conservation (Estrada et al., 2012; Estrada et al., 2017). For primates, these systems may provide food resources, temporary shelter, and safe passage through degraded or fragmented areas (Estrada et al., 2012; Arroyo-Rodríguez & Galán-Acedo, 2018). Understanding how these landscapes affect their mobility and navigation is essential for designing effective conservation strategies.

Howler monkeys (*Alouatta* spp.) exhibit ecological and behavioral plasticity and can adapt to various habitats, including deciduous forests, riparian forests, gallery forests, and high evergreen forests (Bicca-Marques, 2003; Arroyo-Rodríguez & Dias, 2010). They are primarily found in the middle and upper strata of the forest, where they engage in daily activities, such as resting, locomotion, and feeding (Carrera-Sánchez, 1994; Muñoz et al., 2001). Their resilience to fragmentation allows them to survive in small forest patches, even disturbed ones, thanks to their flexible folivorous-frugivorous diet and ability to subsist mainly on leaves during periods of fruit scarcity, occasionally consuming exotic and secondary plant species (Crocket & Eisenberg, 1987; Bicca-Marques & Calegario-Marques, 1994; Bicca-Marques, 2003; Cristóbal-Azkarate & Arroyo-Rodríguez, 2007; Arroyo-Rodríguez & Dias, 2010; Bonilla-Sánchez et al., 2012). Additionally, aspects of howler monkey ecology, such as home range and behavior, are relatively genus-specific, with their activities primarily consisting of resting, feeding, and traveling (Bicca-Marques, 2003; Van Belle et al., 2013; Cristóbal-Azkarate & Arroyo-Rodríguez, 2007; Agostini et al., 2010).

Despite their ecological plasticity, howlers are vulnerable to threats from fragmentation, such as predation, disease, reduced gene flow due to isolation, conflicts with human populations and exotic fauna, and the development of adaptive behaviors such as terrestrial locomotion, all of which challenge their long-term survival (Bicca-Marques, 2003; Cristóbal-Azkarate & Arroyo-Rodríguez, 2007;



Oklander et al., 2010; Solórzano García & Rodríguez Luna, 2010; Estrada et al., 2017; McKinney, 2019; Serio-Silva et al., 2019; Schreier et al., 2020). For mantled howler monkeys, such landscape breaks reduce long-term population viability and heighten the risk of local extirpation.

OBJECTIVES

The objective of this study is to report on how mantled howler monkey (*Alouatta palliata*) groups utilize the canopy of tropical pine plantations as corridors to travel between forest fragments in a highly modified landscape of southern Veracruz, Mexico. This aims to lay the ground for further research on the ecological value of forest plantations and agroecosystems in fragmented landscapes, and their importance for the movements and conservation of endangered species.

MATERIALS AND METHODS

Between October and December 2022, we monitored the home range and social behavior of two groups of mantled howler monkeys (*Alouatta palliata*) in a forest patch within a forest plantation in the Municipality of Las Choapas, Veracruz, Mexico (Fig. 1; Álvarez-López, 2023). The site, Finca Los Pericos (1445.1 ha; 17.8207, -94.1186, WGS84;

34 m a.s.l.), consists primarily of tropical pine (*Pinus caribaea* and *Pinus elliottii*) distributed across 135 polygons averaging 4.9 ha \pm 5.0 ha, sourced mainly from Australia, Argentina, and Guatemala, with fewer from Cuba and the United States. The plantations were established about nine years ago. Embedded within this matrix are 25 patches and isolated trees of tropical sub-deciduous and evergreen forest, covering an area of 68 ha, at different stages of ecological succession. The climate is warm and humid with a mean temperature of 25 °C and annual precipitation ranging from 2400 mm to 3100 mm (Rzedowski, 2006; Instituto Nacional de Estadística y Geografía [Inegi], 2010; Agroforestal & Grupo AIEn, 2022). All subjects were habituated to human presence and easily recognized by physical characteristics. We observed each group for two weeks per month in eight-hour periods (06 h 00 to 14 h 00; 480 h total) and recorded data on foraging, locomotion, and resting behavior using scan sampling (Altmann, 1974), with observations every 15 minutes, with five minutes for scanning and 10 minutes for interval (Prates & Bicca-Marques, 2008; Ferreguetti et al., 2020). Additional anecdotal accounts were gathered through informal interviews with plantation staff, in accordance with ethical recommendations (Albuquerque et al., 2014).

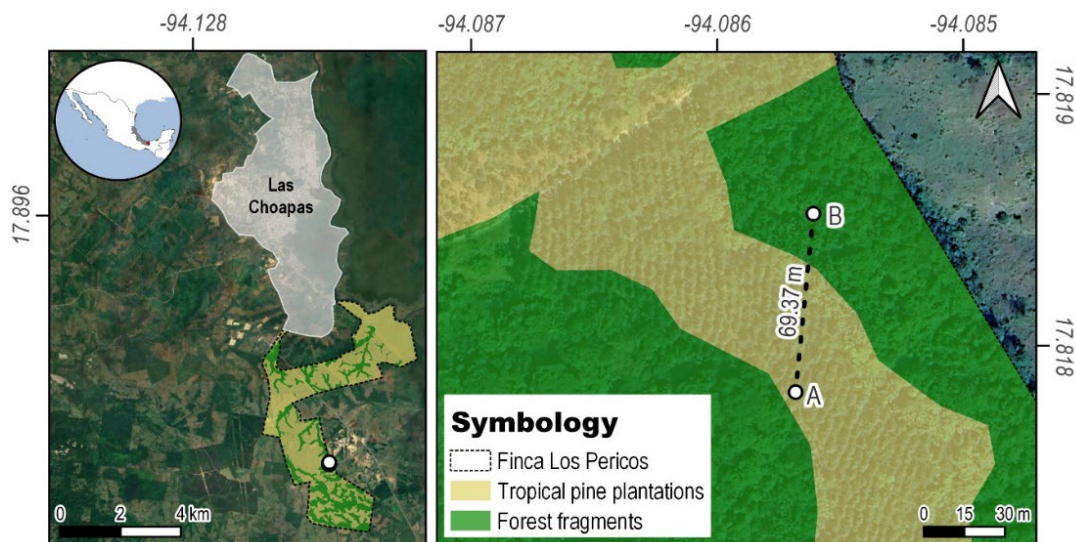


FIGURE 1. Location of Finca Los Pericos in relation to the urban area of Las Choapas, Veracruz, and the area within the Finca where movement between fragments was observed (from point A to point B).

Image taken from Google Earth 2024.

RESULTS AND DISCUSSION

Over the course of two weeks between November and December 2022, we observed on three separate days that a group of 14 mantled howler monkeys had moved between forest patches outside our monitoring hours. These patches were separated by a matrix of tropical pine on the southeast side of Finca Los Pericos.

Following these observations, on December 12, 2022, at 09 h 29, we documented the same group of monkeys resting on the edge of Finca Los Pericos (17. 818424, -94. 085645, 17. 818424, -94. 085645, WGS84; 34 m a.s.l.), a transition area of disturbed tropical forest with *Vochysia guatemalensis*, *Enterolobium cyclocarpum*, *Spondias mombin* and *Tabebuia guayacan* trees. After 29 minutes of rest, an elder male led the group's movement toward a nearby young pine tree (DBH 20.1 cm). It quickly traversed the branches (Fig. 2b), followed by two adult males a minute later, and subsequently by the rest of the group (one male, five females, four juveniles, and one infant of undetermined sex). The group covered approximately 69.7 meters (as measured in a straight line; Fig. 1) without vocalizing.

Several photographs and a brief video (showcasing the two adult males following the leading individual) were captured (Fig. 2b, c; <https://vimeo.com/916037753>). This movement matched our previous observations of the howlers switching forest patches.

Informal interviews with plantation staff revealed five additional accounts of mantled howler monkeys occasionally using the pine canopy to cross the plantation. Observations were made during the early morning hours (5 h 00 - 6 h 00). They occurred during periods of low fruit production, when the groups moved to reach fig trees (*Ficus cotinifolia*) isolated within the pine matrix. Staff also reported observing the monkeys resting in the pine trees and possibly feeding, though no such feeding was observed during the study period. Interviewees were unsure if the monkeys consumed any parts of the pine trees (e.g., bark, cones, or needles). Workers also mentioned having seen these behaviors at another plantation belonging to the same owners, Finca Santa Elena, 14 km north of Los Pericos (942.7 ha; 17.9682, -94.1675, WGS84; 59 m a.s.l.), which shares a similar vegetation matrix.

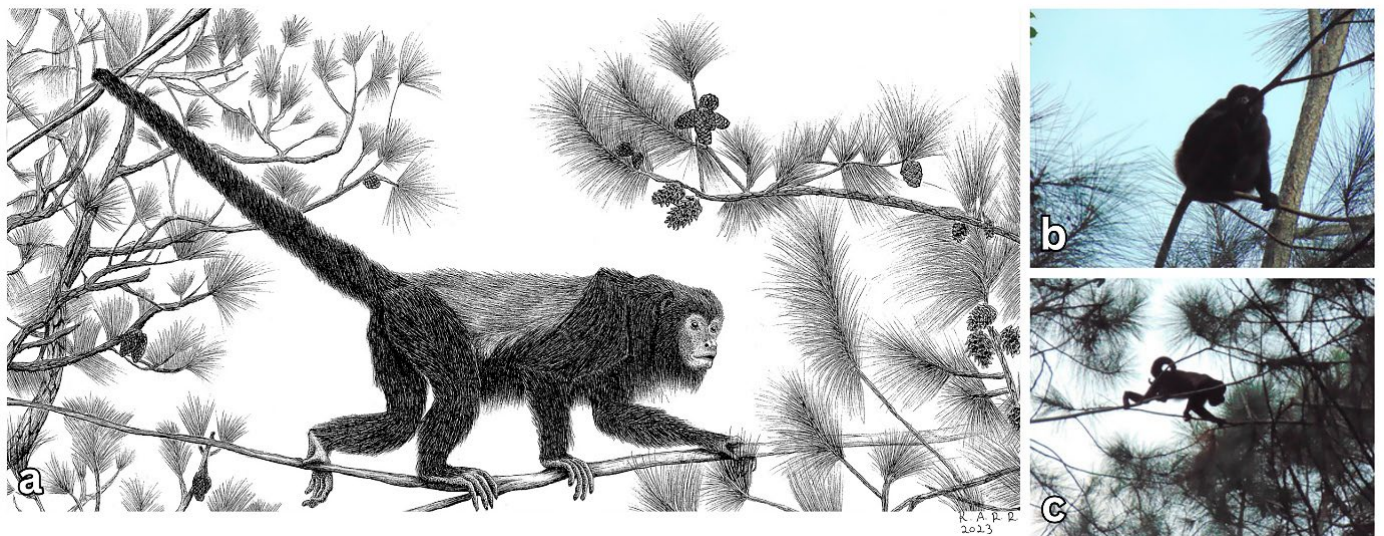


FIGURE 2. Use of tropical pine plantation as corridors by *Alouatta palliata*.

a) Illustration showcasing a male mantled howler moving from an individual tree of *Pinus elliottii* to an individual *P. caribaea*. Illustration by Roberto Antonio Ruiz Ramirez; b) Male mantled howler resting prior to leading the travel event; c) Male mantled howler using the canopy of tropical pines to follow the rest of the group.



The activity patterns we recorded for the group during our study showed that the howlers spent 67.5% of their time resting, 7.3% feeding and 25.2% traveling (Álvarez-López, 2023). These observations align with previous reports of mantled howler activity patterns (Estrada et al., 1999), as the movement we documented occurred briefly in the morning, and likely again in the afternoon, given that on three occasions we found the group in different patches of forest from one day to the next.

These movements likely reflect the extensive habitat loss and forest fragmentation in the region, where small forest patches are embedded within a heterogeneous matrix of agroforestry systems, early-successional secondary forests, and farmland (Díaz-Rivera et al., 2010; Torres Ávila et al., 2020). Agroforestry areas can partly mitigate the effects of fragmentation by providing canopy continuity, but reliance on these managed habitats may also expose howlers to additional threats, including closer contact with humans and disturbances associated with plantation activities (Estrada, 2007; Estrada et al., 2012; Escobar-Ibañez et al., 2023).

Few studies have documented the use of tropical pine plantations by Neotropical primates. Notable examples include *Callithrix aurita* moving through the *Pinus elliottii* canopy in Itatiaia National Park, Brazil (Aximoff et al., 2016) and *Sapajus cay* consistently consuming *P. elliottii* seeds as part of their diet in the Upper Paraná Atlantic Forest (Smith et al., 2022). There are also reports of *S. nigritus* damaging tropical pine plantations (*P. caribaea* and *P. elliottii* among other seven pine species) in Southern Brazil (Koehler & Firkowski, 1996; Liebsch & Mikich, 2016; Liebsch et al., 2018). For howler monkeys, movement through the canopy and use of pine trees as resting sites have been reported for *Alouatta seniculus* (Gómez-Posada, 2006; Londoño & Gómez-Posada, 2010), with no damage reported to plantations. Conversely, *S. nigritus* and Old World monkeys like *Cercopithecus mitis* and *Papio ursinus* have been known to cause significant economic damage to pine plantations (Di Bitetti, 2019).

CONCLUSIONS

This report provides evidence of the use of agroforestry plantations as locomotion corridors for *Alouatta palliata*, a rarely documented behavior. While based on a single direct observation, supplemented by anecdotal accounts, our findings highlight the potential role of agroforestry systems in maintaining landscape connectivity for primates in tropical regions undergoing fragmentation. Our results also raise questions and present opportunities for outreach and conservation education activities. For one, continued monitoring could evaluate activity patterns and travel frequency of mantled howlers through the pine canopy—both in Finca Los Pericos and eventually in Santa Elena—to better understand the species' response to habitat disturbance. Further research could examine whether pines serve as a food source and assess possible stress in mantled howler groups related to human presence and plantation activities. Finally, conservation and environmental education initiatives with plantation staff and neighboring communities could promote coexistence and help design wildlife corridors to prevent human-wildlife conflict.

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