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Front Cover: Bearded capuchin monkey (*Sapajus libidinosus*) eating a scorpion (*Jaguajir agamemnon*) she captured a few moments before. Serra da Capivara National Park, south Piauí, Brazil. May 2024. This photo by Tiago Falótico was the winner of the 1st prize in the photo contest at the XX Congresso Brasileiro de Primatologia in Santa Teresa, Espírito Santo, Brazil. This issue of *Neotropical Primates* was kindly sponsored by the Margot Marsh Biodiversity Foundation, VA, and Los Angeles Zoo, CA.

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EFECTO DE LA FRAGMENTACIÓN Y COMPOSICIÓN DEL PAISAJE SOBRE LA PRESENCIA DE *ATELES FUSCICEPS RUFIVENTRIS* EN COLOMBIA

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Resumen

La fragmentación del hábitat, asociada con la pérdida de biodiversidad y la disminución de poblaciones de especies silvestres, impacta negativamente los recursos ecológicos esenciales para los primates, como el alimento y reproducción. La fragmentación y los cambios en la composición del paisaje afectan la conectividad estructural del entorno y representan una amenaza significativa para el mono araña de cabeza negra (*Ateles fusciceps rufiventris),* uno de los primates más amenazados por su sensibilidad a la deforestación y la presión por cacería. Su estado de conservación no está actualizado y las respuestas a las perturbaciones en el paisaje aún son desconocidas. Este estudio busca evaluar cómo la fragmentación y composición del paisaje influyen sobre la presencia de *A. f. rufiventris* en Colombia. En este contexto, se realizó un análisis en 23 localidades con hábitat potencial para *A. f. rufiventris* en Colombia, para evaluar cómo diferentes características de composición del paisaje, como el tipo y cantidad de hábitat, así como la conectividad entre fragmentos, influyen en su presencia y comportamiento. Para ello, se recopilaron datos sobre la presencia de la subespecie y se caracterizó la composición del paisaje mediante análisis de métricas de fragmentación. La presencia de *A. f. rufiventris* se confirmó en el 52% (n=12) de las localidades evaluadas. Los resultados revelaron que las zonas con mayor área de bosques maduros y menor perturbación humana tienen una mayor probabilidad de presencia de *A. f. rufiventris*. Además, la proximidad a los asentamientos humanos afecta la presencia de *A. f. rufiventris* de manera negativa. Aunque la fragmentación del hábitat no mostró una relación significativa con la presencia de *A. f. rufiventris*, resulta fundamental mitigar sus efectos mediante la protección y restauración de los bosques existentes, así como la implementación de biocorredores que favorezcan la conectividad ecológica y un aumento de la proporción de bosques en el paisaje. Asimismo, es prioritario desarrollar programas orientados a mejorar la estructura y la composición del paisaje ante la expansión de las actividades humanas.

Palabras clave: Conectividad, conservación, ecología del paisaje, impacto humano

Abstract

Habitat fragmentation, associated with biodiversity loss and declining populations of wild species, negatively impacts essential ecological resources for primates, such as food and reproduction. Fragmentation and changes in landscape composition affect the structural connectivity of the landscape and represent a significant threat to the Colombian black headed spider monkey (*Ateles fusciceps rufiventris)*, one of the most threatened primates due to its susceptibility to deforestation and hunting. Its conservation status is not yet updated and its responses to landscape disturbance are still unknown. This study assesses how landscape fragmentation and composition influence the presence of *A. f. rufiventris* in Colombia. We carried out analyses on 23 localities with potential habitat for *A. f. rufiventris* in Colombia. This was done to evaluate how different landscape composition characteristics, such as the type and amount of habitat and connectivity between fragments, influence the presence and behavior of the subspecies. To this end, data on the presence of the species were collected and the composition of the landscape was characterized using fragmentation metrics analysis. The presence of *A. f. rufiventris* was confirmed at 52% (n=12) of the assessed localities. Our results revealed that larger areas of mature forest and less human disturbance have a higher probability of *A. f. rufiventris* presence. In addition, proximity to human settlements negatively affects the presence of *A. f. rufiventris*. Although habitat fragmentation did not show a significant relationship with the presence of *A. f. rufiventris*, it is essential to mitigate its effects through the protection and restoration of existing forests, as well as the implementation of biocorridors that favor ecological connectivity and an increase in the proportion of forests in the landscape. It is also a priority to develop programs aimed at improving the structure and composition of the landscape in the face of expanding human activities.

Key words: Connectivity, conservation, landscape ecology, human impact

Introducción

La fragmentación del paisaje, entendida como un proceso en que el hábitat se divide en parches más pequeños y aislados (Fahrig, 2003), junto con los cambios en la composición del paisaje, impacta de manera significativa la distribución y viabilidad de las poblaciones silvestres de primates (Harcourt y Doherty, 2005; Arroyo-Rodríguez y Mandujano, 2009; Benchimol y Peres, 2013). Para caracterizar la fragmentación se utilizan diferentes métricas y herramientas de análisis espacial que permiten evaluar tanto la estructura del paisaje (área y densidad de los parches), como la conectividad (distancia entre parches), la cual puede limitar la capacidad de dispersión de las especies. Por otro lado, la composición del paisaje hace referencia a los tipos de hábitats que componen un área geográfica específica, su proporción y distribución. Esto incluye la identificación de diferentes usos del suelo (e.g., bosques, agroecosistemas, áreas urbanas), así como la calidad y diversidad de estos hábitats, y las relaciones espaciales entre ellos.

La pérdida y fragmentación de hábitat y la reducción de conectividad entre parches aumenta la vulnerabilidad de las poblaciones de primates a perturbaciones y eventos determinísticos y estocásticos, ya que dificulta el desplazamiento e interacciones de los individuos, alterando sus dinámicas poblacionales y su estructura y variabilidad genética (Cowlishaw y Dunbar, 2000; Marsh, 2003; Arroyo-Rodríguez y Dias, 2009). La deforestación ha afectado el 46% de los bosques tropicales del planeta (Haddad et al., 2015), obligando a muchas poblaciones de primates a vivir en parches aislados dentro de áreas transformadas, lo que aumenta su vulnerabilidad y puede provocar reestructuración poblacional y pérdida de diversidad genética (Marsh et al., 2013; Estrada et al., 2017). La respuesta de cada especie de primate a las cambiantes condiciones de sus hábitats depende de su historia natural, dieta, dispersión y ámbito hogareño (Galán-Acedo et al., 2024). Por ejemplo, muchas especies de primates tienden a evitar áreas con alta actividad humana y fragmentación severa (Bersacola et al., 2021). Las poblaciones de monos araña (*Ateles* spp.) pueden ser especialmente sensibles a las alteraciones de su hábitat. Su tamaño corporal grande implica una alta demanda energética, lo que requiere una abundante disponibilidad de alimento y grandes áreas de espacio vital (Fedigan et al., 1988; Rylands y Keuroghlian, 1988; Galán-Acedo et al., 2024). Además, presentan una baja fecundidad, lo que limita su capacidad de recuperación frente a las perturbaciones (Campbell y Gibson, 2008). A estas presiones se suman la caza y la captura para el comercio ilegal como mascotas y para el consumo humano, lo que agrava aún más su situación (Ramos-Fernández y Wallace, 2008).

Las especies del género *Ateles* presentan requisitos específicos de hábitat, como una estructura adecuada y una alta diversidad en la composición de la vegetación. Además, tienen grandes ámbitos hogareños, recorren largas distancias diarias (Ramos-Fernández y Wallace, 2008; Wallace, 2008; Link et al., 2010; Asensio et al., 2012) y cuentan con un sistema social de fisión-fusión, en el cual los individuos se dividen y agrupan temporalmente para acceder a los recursos (Symington, 1990; Aureli et al., 2008). En fragmentos pequeños con recursos limitados la competencia por estos recursos puede generar estrés fisiológico y reducir la viabilidad de la población (Rimbach et al., 2013; Marsh et al., 2016). Además, su dieta que está compuesta por más del 70% de frutos (Di Fiore et al., 2008) los hace especialmente vulnerables a la reducción de la calidad del bosque y a la modificación de la estructura de la vegetación, factores que disminuyen la abundancia de árboles grandes productores de frutos (Hill y Curran, 2003; Arroyo-Rodríguez y Mandujano, 2006; Dunn et al., 2009).

En Colombia, la fragmentación del paisaje es un fenómeno ampliamente extendido debido a la expansión de la frontera agrícola, la urbanización y la tala de bosques para la extracción de recursos naturales. La región del Chocó biogeográfico, hogar de *Ateles fusciceps rufiventris*, ha experimentado una rápida pérdida de hábitat en las últimas décadas, intensificando las amenazas para su conservación (Hernández-Jaramillo et al., 2024). A pesar de su importancia ecológica y vulnerabilidad frente a la pérdida de hábitat y la fragmentación, aún existe un vacío significativo en el conocimiento sobre cómo las características específicas de la fragmentación y la composición del paisaje afectan la presencia de *A. f. rufiventris* en la región. En el país no existen datos sobre el ámbito hogareño de *A. f. rufiventris*, pero en Ecuador se ha estimado que utilizan fragmentos entre las 35 a 124 ha (Cervera y Griffith, 2016).

Este estudio tuvo como objetivo evaluar cómo la fragmentación y composición del paisaje influyen en la presencia de *Ateles fusciceps rufiventris* en Colombia. La principal plantea que su presencia será más probable en áreas con menor fragmentación y en aquellas donde los hábitats forestales sean más grandes y menos perturbados por actividades humanas. Dado que *A. f. rufiventris* depende de los bosques, se espera que su presencia se relacione positivamente con la cantidad de bosque disponible, mientras que la distancia entre los parches se relacionará negativamente con su presencia. Este análisis no solo contribuye al conocimiento de la ecología de *A. f. rufiventris*, sino que también ofrece recomendaciones cruciales para las políticas de conservación, como la creación de corredores biológicos, la restauración de hábitats fragmentados y la implementación de medidas de manejo sostenible en áreas clave para la conservación de los primates en Colombia.

Métodos

Selección de áreas de estudio
Nuestra área enfoque cubre las laderas occidentales de la Cordillera Occidental de los Andes, y las tierras bajas occidentales hasta la costa pacífica en Colombia. La mayor parte de esta zona se encuentra en la región biogeográfica del Chocó Colombiano e incluye la región de Urabá, un tramo de costa caribeña en el noroeste de Colombia, y el valle central del río Magdalena con sus afluentes Cauca-Nechí y San Jorge (Bonilla, 2021). La precipitación anual oscila entre 800 mm y 12.000 mm, con temperaturas diurnas entre 12,6 °C y 35,0 °C, y humedad relativa promedio de 80% (Rangel-Churio y Arellano, 2004).

Recolección de Datos
Seleccionamos 23 localidades en las que verificamos la presencia o ausencia de la subespecie *Ateles fusciceps rufiventris*. Muestreamos los sitios entre noviembre de 2018 y septiembre de 2022 (Figura 1), visitando áreas dentro de la EOO, definida como el área geográfica máxima de distribución de *A. f. rufiventris* (IUCN 2019). Durante los muestreos se utilizó detección directa, indirecta y entrevistas con personas locales, recorriendo senderos existentes en zonas boscosas y abriendo nuevos con el menor impacto posible (i.e., sin exceso de ruido, camino angosto, alteración mínima de la vegetación circundante) para acceder a zonas menos alteradas. Detección directa se refiere a registro visual de *A. f. rufiventris* y detección indirecta incluyó vocalización, heces y confirmación confiable de entrevistados claves. Los recorridos en el bosque, siempre en compañía de al menos un residente local, se realizaron en cada sitio hasta encontrar a *A. f. rufiventris* o por un máximo de tres días. Si después de tres días no se encontraba, ni era reconocido por los entrevistados, se consideró ausente en el sitio. Se entrevistó a habitantes locales con el apoyo de fotografías y dibujos para identificar especies de primates presentes. Escogimos informantes locales con base en dos tipos de muestreo (Newing et al., 2011): 1) *Muestreo a conveniencia*: seleccionamos entrevistados adultos que mostraron disposición y disponibilidad para participar, identificando personas clave con una relación directa con el bosque, como por ejemplo, cazadores o aserradores; 2) *Muestreo por bola de nieve*: utilizamos información en cadena y recomendaciones de los entrevistados para identificar personas clave en la comunidad hasta que dejaron de aparecer nuevos candidatos (Patton, 2002; Tójar, 2006).

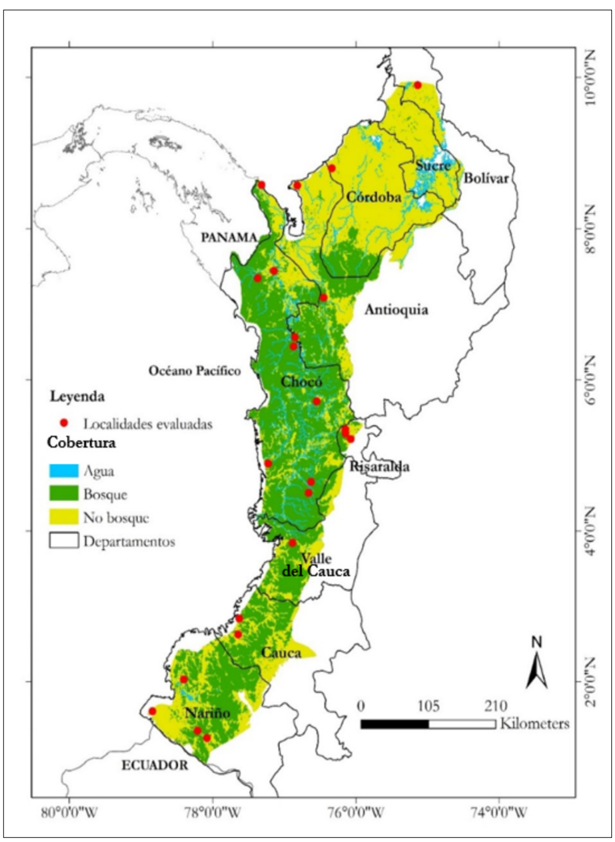

Figura 1. Ubicación geográfica de las 23 localidades evaluadas a lo largo de la distribución potencial de *Ateles fusciceps rufiventris* en Colombia. "No bosque" incluye bosque fragmentado, agro-ecosistema, y vegetación secundaria.

Análisis espacial
Utilizando ArcGIS 10.5 (ESRI 2020), clasificamos el uso del suelo y la cobertura vegetal con datos de sensores remotos, utilizando la leyenda Corine Land Cover adaptada para Colombia; el mapa fue creado a partir de imágenes satelitales con resolución espacial de 30 metros (IDEAM, 2017). Generamos un mapa raster con cinco clases de cobertura: bosque, bosque fragmentado (parches de bosque alterados por actividades humanas que están rodeados por otros usos del suelo), agroecosistema (cultivos, ganadería, estructuras humanas), vegetación secundaria (áreas previamente intervenidas con regeneración natural por abandono) y agua (Figura S1). Calculamos el porcentaje de cobertura boscosa (la capa de bosque) en cada ventana de análisis.

Para analizar la composición del paisaje y la distribución de *A. f. rufiventris,* definimos un centroide para cada localidad muestreada. Cada centroide representó tanto los sitios con registros confirmados de presencia de *A. f. rufiventris* como aquellos en los que se realizaron búsquedas sin verificación de su presencia. En torno a cada centroide delimitamos una ventana de análisis del paisaje de 2.800 ha (correspondiente a un radio de 3 km) (Gorresen y Willig, 2004; Klingbeil y Willig 2009; Peck et al., 2011). Esta delimitación se realizó con base en reportes para especies del género, que recorren en promedio distancias diarias de 3 km (Suarez, 2006) y tienen un ámbito hogareño que incluyen hasta 900 ha (Klein y Klein, 1977; Campbell, 2000; Dew, 2005; Suarez, 2006; Wallace, 2006; Asensio et al., 2017).

Fragmentación

En las 23 localidades incluidas en este estudio, analizamos la densidad de parches, el aislamiento de los parches y el índice de parche mayor para determinar el efecto de la fragmentación (Correa-Ayram et al., 2014; Tabla 1). En este estudio, se definió como parche de hábitat las áreas clasificadas como bosque y bosque fragmentado. Realizamos los cálculos de las métricas de paisaje con Fragstats 4.2 usando la regla de vecindad de ocho vecinos, que considera adyacentes todas las celdas contiguas, permitiendo definir la conectividad espacial entre píxeles de la misma cobertura en un entorno de 3×3 (McGarigal et al., 2002). Determinamos la distancia lineal desde el bosque hasta el asentamiento humano más cercano (D_AHU) (Tabla 1) generando tabla de cercanía entre capas de puntos. Para ello, utilizamos una capa raster con la localización de los parches de bosque y otra con la ubicación de los asentamientos humanos, y se aplicó la herramienta Near de ArcGIS. De manera similar, para calcular la distancia entre cada parche de bosque y la ciudad más cercana, empleamos una capa con la ubicación georreferenciada de centros urbanos clasificados como ciudades. La herramienta Near estimó la distancia mínima en línea recta desde el borde de cada parche de bosque y el centroide urbano más próximo.

Composición del paisaje

Para evaluar el efecto de la composición del paisaje calculamos el índice de diversidad y el índice de equidad de Shannon, así se determinó el porcentaje de bosque en relación con otros tipos de uso del suelo para entender la proporción de las coberturas en el paisaje (Mateucci y Silva, 2005; Galán-Acedo et al., 2018) (Tabla 1).

Análisis de datos

Verificamos la normalidad de los datos con una prueba de Shapiro-Wilk. Una de las variables no tuvo distribución normal (Tabla S1) por lo que para comprobar si las variables estaban correlacionadas se aplicó el análisis de correlación de Spearman (Tabla S2). Utilizamos modelos lineales generalizados binomiales para analizar la relación entre la presencia de *Ateles fusciceps rufiventris* (variable dependiente) y las variables de fragmentación y composición del paisaje (variables independientes). Todos los análisis estadísticos se realizaron en R (R Core Team, 2024).

Resultados

Se visitaron 23 localidades distribuidas en los departamentos de Bolívar (n=1), Córdoba (n=1), Antioquia (n=2), Chocó (n=9), Risaralda (n=3), Valle del Cauca (n=1), Cauca (n=2) y Nariño (n=4) (Figura 1), con altitudes que oscilaron entre 0 y 1.850 m.s.n.m. Se confirmó la presencia de *Ateles fusciceps rufiventris* en 12 (52%) de estas localidades (Figura 2, Tabla 2).

Fragmentación del Paisaje

El 50% de los sitios con presencia de monos araña tuvieron valores de densidad de parches menores a 0,12, frente al 19% de los sitios sin presencia. Es decir, la mayoría de los sitios con presencia de *A. f. rufiventris* estuvieron asociados a un paisaje menos fragmentado.

Los valores menores a 25 en el grado de desconexión se asociaron al 50% de los sitios con presencia y al 10% de los sitios sin presencia. El 67% de los sitios con presencia

Tabla 1. Definición de métricas usadas para este estudio (McGarigal y Marks, 1994; Saura y Martínez-Millán, 2001; McGarigal et al., 2002).

Tipo de métrica	Definición	Efecto
Densidad de parches (PD)	Número de parches por unidad de área	Fragmentación
Aislamiento de parches (CONNECT)	Grado de desconexión física entre los parches, representado por la distancia entre parches. Valor 0 cuando solo hay un fragmento o ninguno de los fragmentos está conectado; Valor 100 cuando todos los fragmentos están conectados	Fragmentación
Índice de parche mayor (LPI)	Porcentaje que ocupa el fragmento más grande en el total de tipos de cobertura	Fragmentación
Índice de diversidad de Shannon (SHDI)	Medida de la diversidad de los ecosistemas naturales y presentes en un área de interés y de su abundancia relativa. Valores cercanos a 0 indican baja diversidad y valores cercano a 1,6 alta diversidad o un paisaje más heterogéneo.	Composición
Índice de equidad de Shannon (SHEI)	Medida de la equidad con que los diferentes ecosistemas presentes en el área de interés ocupan dicha extensión. Valores cercanos a 0 indican baja equidad (i.e., una clase de usos del suelo domina el paisaje) y valores cercanos a 1 alta equidad (i.e., todas las clases de uso del suelo tienen la misma proporción)	Composición
Bosque (Bq)	Porcentaje de cobertura de bosque	Composición
Distancia a asentamiento humano más cercano (D_AHU)	Distancia al borde del asentamiento humano más cercano	Composición

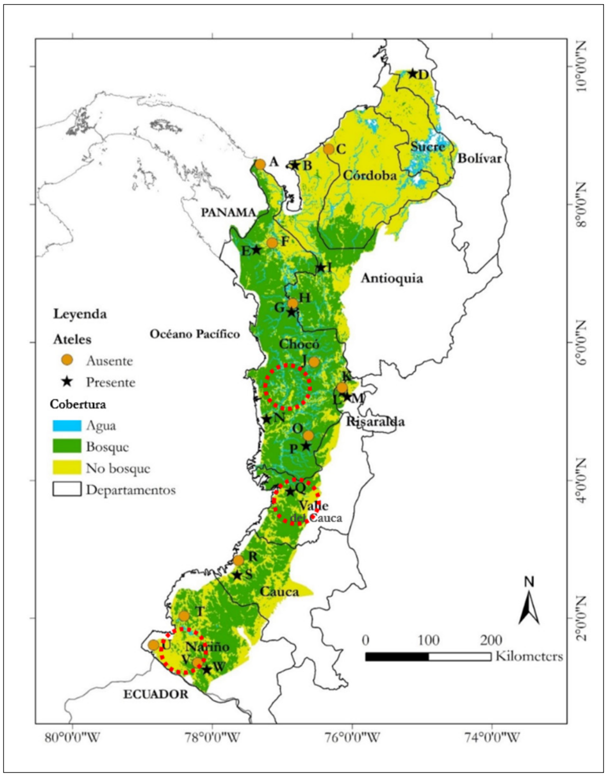

Figura 2. Detalle de las localidades evaluadas. A. Aguacate. B. Marimonda. C. Los Córdobas. D. San Juan. E. Barranco. F. Salaquí. G. Tebadá. H. Conto. I. Pavarandó. J. Tutunendo. K. Bachichí. L. Amurrupá. M. Tatamá. N. Dotenedó. O. Sipí. P. Sipí alto. Q. Venado. R. Santa Rosa. S. Cheté. T. Iscuandé. U. El Jagua. V. El diviso. W. Ñambí. Más detalles en Anexo 1. Círculos de línea punteada roja son puntos críticos de deforestación (Etter et al., 2006; Fagua et al., 2019). "No bosque" incluye bosque fragmentado, agroecosistema, y vegetación secundaria.

tuvieron valores mayores a 50 en el índice de parche mayor, comparado con el 46% de los sitios sin presencia (Tabla 2, Figura 3). No se observaron diferencias significativas para las métricas de fragmentación (Figura 3).

Composición del Paisaje
Se encontró que las localidades con mayor porcentaje de bosque tuvieron una mayor probabilidad de presencia de *Ateles fusciceps rufiventris*. Los sitios con presencia de monos araña mostraron mayores porcentajes de bosque. En 10 de los 12 parches con presencia de *A. f. rufiventris*, el porcentaje de bosque superó el 60%, excepto en Antioquia y Bolívar, departamentos con mayor pérdida de hábitat para *A. f. rufiventris* (Tabla 2). Se observaron diferencias significativas en el porcentaje de bosque entre los sitios con y sin monos ($z=2,016$, $df=21$, $p=0,0438$), lo que sugiere que mayores valores de porcentaje de bosque se asocian con una mayor probabilidad de presencia de *A. f. rufiventris* (Figura 4).

Discusión

Impacto de la Composición del Paisaje sobre la Presencia de A. f. rufiventris
Nuestros resultados destacan que la composición del paisaje influye sobre la distribución de *Ateles fusciceps rufiventris*. Las localidades con mayor porcentaje de cobertura forestal presentan una mayor probabilidad de presencia de *A. f. rufiventris*, ya que los bosques son sus hábitats preferidos y por lo tanto son susceptibles a su pérdida (Galán-Acedo et al., 2019b; Daskalova et al., 2020). Esto resalta la importancia de conservar la integridad del hábitat y garantizar la disponibilidad de recursos. De acuerdo con Ordoñez-Gómez et al. (2014), la disponibilidad de hábitat tiene un impacto más relevante sobre las especies del género *Ateles* que la fragmentación del paisaje, como lo encontramos en este estudio. Cuando la disponibilidad de hábitat es alta, mejora la conectividad y aumenta tanto la oferta de alimento como el tamaño del hogar (Fahrig, 2003; Wallace, 2008; Chaves et al., 2012). Hay un potencial declive y colapso poblacional en paisajes con menos del 30-40% de cobertura de bosque (Galán-Acedo et al., 2019a; Rybicki y Hanski, 2013; Saldívar-Burrola et al., 2022).

Ordóñez-Gómez et al. (2014) encontraron que las especies del género *Ateles,* debido a su tamaño, necesitan paisajes con una alta cobertura de bosque (i.e., >60%; Ordóñez et al., 2014), ya que están estrechamente vinculadas a la disponibilidad de recursos alimenticios (Chaves et al., 2012; Galán-Acedo et al., 2019; Arroyo-Rodríguez et al., 2021). En este sentido, la probabilidad de presencia de *A. f. rufiventris* disminuye en parches de bosque más pequeños y en áreas transformadas por actividades humanas, como la ganadería y la agricultura. Esto está alineado con los datos sobre ámbito de hogar de especies del género *Ateles*, que varía entre 35 a más de 900 ha entre paisajes fragmentados y con baja intervención humana (Campbell, 2000; Pozo, 2001; Cervera y Griffith, 2016).

La relación negativa significativa entre la presencia de *Ateles fusciceps rufiventris* y la proximidad a asentamientos humanos resalta la necesidad de conservar áreas remotas y sin intervención (Moscoso, 2010; Ramos Fernandez y Wallace, 2008). La cacería y la baja tasa de reproducción (Di Fiore y Campbell, 2007; Shimooka et al., 2008) pueden ser factores clave para la extinción local de *A. f. rufiventris*, como se observó en la localidad de El Diviso (punto V en Figura 2) y como se ha documentado por otros autores (Aquino et al., 2012; Altrichter y Carbonell, 2013; Peres et al., 2016; Pérez-Peña et al., 2018).

El uso del suelo ha cambiado drásticamente a lo largo de la distribución de *Ateles fusciceps rufiventris*, en las últimas décadas, con una reducción del 10% en áreas forestales

Tabla 2. Métricas evaluadas por cada localidad. Abreviaturas: Densidad de parches (PD), aislamiento de parches (CONNECT), índice de parche mayor (LPI), índice de diversidad (SHDI), índice de equitatividad (SHEI), distancia del bosque al asentamiento humano más cercano (D_AHU), y distancia del bosque a la ciudad más cercana (D_MUC).

Sitio	Depto	Altitud m.s.n.m	*A. f. rufiventris*	Comunidad	PD	CONNECT	LPI	SHDI	SHEI	% Bosque	D_AHU (km)	D_MUC (km)
Sipí alto	Chocó	150	Presente	Afro	0,2	50	93,8	0,27	0,57	98,5	10	10
Tebadá	Chocó	27	Presente	Afro	0,04	0	96,4	0,15	0,66	98,3	6	10
Barranco	Chocó	109	Presente	Indígena	0,04	15	79,2	0,69	0,43	97,2	4	29
Santa Rosa	Cauca	60	Ausente	Indígena	0,24	29,17	24,2	1	0,8	95,2	3	10
Tatamá	Risaralda	1851	Presente	Mestiza	0,11	28,57	67,5	0,93	0,69	85,5	5	5
Cheté	Cauca	87	Presente	Afro	0,08	62,5	36,9	0,97	0,69	78,5	5	13
El diviso	Nariño	700	Ausente	Indígena	0,16	22,92	36,8	0,98	0,7	77,6	3	25
Dotenedó	Chocó	28	Presente	Afro	0,13	31,82	38,5	1,13	0,72	73,5	5	15
Venado	Valle	91	Presente	Afro	0,08	17,27	68,2	0,82	0,49	73	3	7,5
Pavarandó	Antioquia	255	Presente	Indígena	0,12	21,87	61,7	0,78	0,63	70,5	6	15
Ñambí	Nariño	1544	Presente	Mestiza	0,16	44	62,4	1,08	0,6	6,9	4	15
Aguacate	Chocó	38	Ausente	Afro	0,12	22,81	37,2	1,23	0,74	62,7	2	13
Amurrupá	Risaralda	1063	Presente	Afro	0,2	25	58,9	1,1	0,81	61	3	17
Bachichí	Risaralda	650	Ausente	Afro	0,12	26,67	27,9	1,26	0,9	50	0,6	19
Iscuandé	Nariño	3	Ausente	Afro	0,27	57,14	26,7	1,05	0,74	49,2	1,5	3
Sipí	Chocó	59	Ausente	Afro	0,31	28,57	51,1	0,7	0,75	45,6	0,55	0,5
Tutunendo	Chocó	105	Ausente	Afro	0,12	39,29	65	0,68	0,61	25,3	3	13
Salaquí	Chocó	0	Ausente	Afro	0,04	10,71	63,9	0,72	0,69	24,64	2	3
El Jagua	Nariño	119	Ausente	Afro	0,16	33,33	76,3	0,61	0,51	23	3,5	19
Marimonda	Antioquia	21	Presente	Mestiza	0,04	9,09	37,6	1,08	0,89	22	4	17
Conto	Chocó	31	Ausente	Afro	0,29	27,27	35,3	1,01	0,86	17,6	1,5	5
San Juan	Bolivar	482	Presente	Mestiza	0,28	17,88	24,1	1,26	0,82	12	4	9,5
Los córdobas	Córdoba	167	Ausente	Mestiza	0,08	50	70,9	0,5	0,76	1,7	2	11

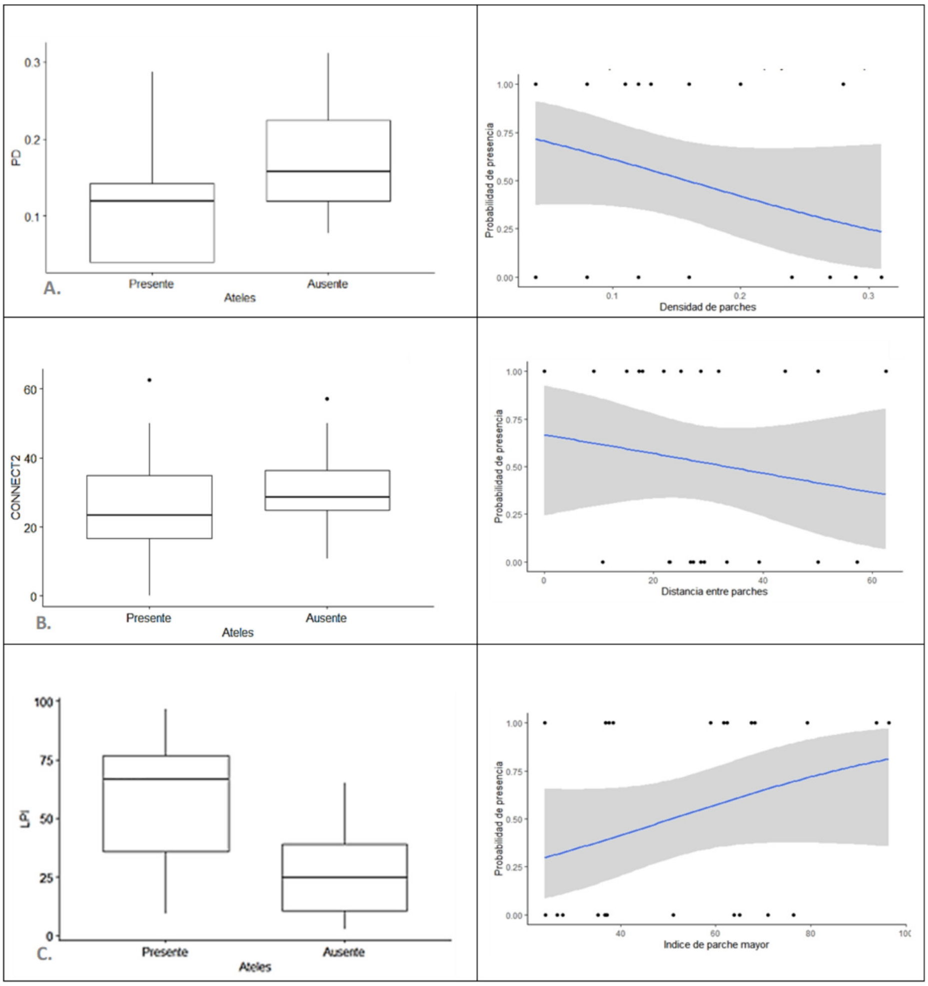

Figura 3. Resultados del análisis de ocurrencia de *Ateles fusciceps rufiventris*. Izquierda: diagrama de cajas que muestra (A) la densidad de parches (PD), (B) la distancia entre parches (CONNECT2) y (C) el índice de parche mayor (LPI) en relación con la ocurrencia de esta subespecie. Derecha: Modelo lineal generalizado binomial de la relación entre la probabilidad de ocurrencia de *A. f. rufiventris* y la densidad de parches (A), la distancia entre parches (B) y el índice de parche mayor (C).

casi intactas debido a la colonización y recolonización humana (Negret et al., 2017; Clerici et al., 2019; Correa-Ayram et al., 2020). Los índices de huella humana en el Pacífico colombiano, una región muy biodiversa (Myers et al., 2000; Gómez et al., 2014), son muy altas. Se han identificado tres puntos críticos de deforestación en el Chocó biogeográfico: Quibdó-Tribugá, Farallones-Micay y Patía-Mira (Etter et al., 2006; Fagua et al., 2019: Figura 2). Esta región, fundamental como corredor biológico (Correa-Ayram et al., 2020) y *hotspot* de biodiversidad, está amenazada por la transformación de su cobertura forestal (Myers et al., 2000). La destrucción del hábitat reduce la población de primates en el neotrópico, afectando interacciones, procesos demográficos y tamaños poblacionales debido a la falta de dispersión (Ravetta y Ferrari, 2009; Arroyo-Rodríguez y Dias, 2010; Link et al., 2010; Marsh y Chapman, 2013). La sustitución de vegetación nativa por cultivos y pastos representa una amenaza significativa a corto y mediano plazo para las especies.

La persistencia de *Ateles fusciceps rufiventris* en la mayoría de grandes parches de bosque está favorecida por una menor presión de cacería y de enfermedades en estos lugares poco intervenidos (Peres, 2001; Arroyo-Rodríguez y Dias, 2010). La subespecie presenta mayor probabilidad de presencia en bosques conservados y remotos, alejados de asentamientos y caminos (Terborgh, 1986). En zonas con intensa cacería, como al menos en cinco localidades (Barranco (E), Pavarandó (I), Dotenedó (N), Santa Rosa (R) y Iscuandé (T): Figura 2), puede producirse una extinción local y una reducción en el tamaño poblacional efectivo (Marsh et al., 1987; Peres, 1990; Sorensen y Fedigan, 2000; Aquino et al., 2013). Este estudio subraya la necesidad urgente de conservar hábitats remotos y poco perturbados, reducir la fragmentación del paisaje y promover la conectividad ecológica entre los parches forestales. También resalta la importancia y necesidad de restaurar hábitats forestales continuos y considerar la estructura del paisaje en las estrategias de conservación (Galán-Acedo et al., 2019b), especialmente

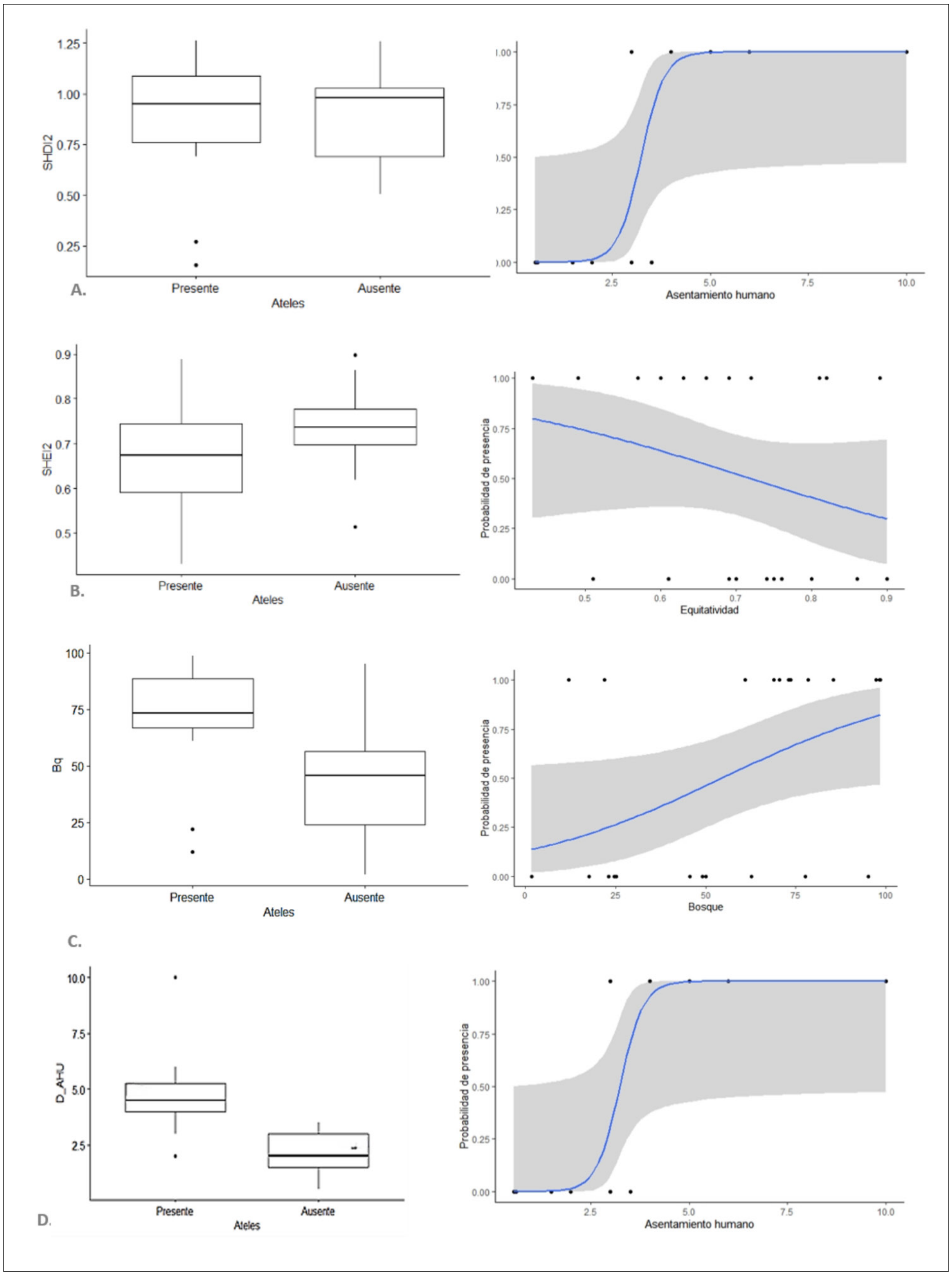

Figura 4. Resultados del análisis de ocurrencia de *Ateles fusciceps rufiventris*. Izquierda: diagrama de cajas que muestra (A) Índice de diversidad de Shannon (SHDI), (B) Índice de equidad de Shannon (SHEI), (C) Porcentaje de cobertura de bosque (Bq) y (D) Distancia del bosque al asentamiento humano más cercano (D_AHU) en relación con la ocurrencia de *A. f. rufiventris*. Derecha: Modelo lineal generalizado binomial para Índice de diversidad de Shannon (A), Índice de equidad de Shannon (B), Porcentaje de cobertura de bosque (C) y Distancia del bosque al asentamiento humano más cercano (D), con diferencias significativas y la ocurrencia de *A. f. rufiventris.*

en áreas afectadas por la expansión agrícola, minera, urbanización y otras actividades humanas. La protección de estas áreas es fundamental para mitigar el impacto del cambio en el uso del suelo sobre *A. f. rufiventris* y garantizar su supervivencia a largo plazo en el Chocó biogeográfico.

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THE USE OF INFRARED THERMOGRAPHY TO DIAGNOSE EFFECTS OF ELECTRIC SHOCK ON THE BROWN HOWLER MONKEY (*ALOUATTA GUARIBA*)

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Abstract

The brown howler monkey (*Alouatta guariba*) is a platyrrhine primate classified as Vulnerable (VU) due to threats such as habitat loss, fragmentation, hunting and diseases. This species often persists in urbanized environments. Three free-living brown howler monkeys were treated in the veterinary hospital of Sorocaba Zoo, São Paulo state, Brazil after being subject to electrocution from electrical wires. Each individual presented different degrees of severity of electric shock. Here we describe the utility of infrared thermography to evaluate lesions and blood perfusion of tissues in monkeys affected by electric shock. Infrared thermography is a non-invasive and non-radioactive detection method that captures images of a specific body region at a distance. It has the advantage that users can avoid handling or restraint of an animal and, in some cases, it provides early detection of physiological problems. It has been widely used as a tool for examination of free-living wild animals as well as those kept under human care. In this report, infrared thermography was decisive for improving decision-making in the prognosis of the howler monkeys that initially survived electric shock.

Key-words: Electrocution, image, platyrrhine primates, temperature, zoological park

Resumo

O bugio-ruivo (*Alouatta guariba*) é um primata platirrino classificada como Vulnerável (VU) devido à ameaças como a perda e fragmentação de habitat, caça e doenças. Essa espécie frequentemente vive em ambientes urbanizados. Três indivíduos de bugio-ruivo de vida livre foram atendidos no hospital veterinário do Zoológico de Sorocaba, São Paulo, Brasil, após sofrerem eletrocussão por fios elétricos. Cada indivíduo apresentou diferentes graus de severidade do choque elétrico. Neste estudo, descrevemos a utilidade da termografia infravermelha para a avaliação de lesões e da perfusão sanguínea dos tecidos em primatas acometidos por choque elétrico. A termografia infravermelha é um método de detecção não invasivo e não radioativo, capaz de capturar imagens de uma região corporal específica à distância. Apresenta a vantagem de dispensar a contenção ou o manejo direto do animal e, em alguns casos, possibilita a detecção precoce de alterações fisiológicas. Essa técnica tem sido amplamente utilizada como ferramenta de exame em animais silvestres de vida livre, bem como naqueles mantidos sob cuidados humanos. Neste relato, a termografia infravermelha foi decisiva na tomada de decisão prognóstica em bugios que sobreviveram inicialmente à eletrocussão.

Palavras-chave: Eletrocussão, imagem, primatas platirrinos, temperatura, zoológico

Introduction

The brown howler monkey (*Alouatta guariba*) is a platyrrhine primate endemic to the Atlantic Forest, and in Brazil it has a wide distribution, from Espírito Santo to Rio Grande do Sul (Fortes, 2008). It is classified as Vulnerable (VU) on the Official National List of Endangered Fauna Species of the Brazilian Institute of the Environment and Renewable Resources (IBAMA) and the International Union for Conservation of Nature (IUCN) due to threats such as habitat loss, fragmentation, hunting and disease (Jerusalinsky et al., 2021; Brasil, 2022). After major outbreaks of yellow fever that occurred in Brazil during 2007–2009 and 2016–2018, this species had a great population decline; it has been classified as one of the world's 25 most endangered primates (Mittermeier et al., 2022).

Platyrrhine primates have morphological and functional adaptations to arboreal life. Some of these characteristics include great skill with the hands and feet, greater rotational movement in the arms, and in some species, a prehensile tail (Verona and Pissinatti, 2014). Forest fragmentation affects biodiversity as it modifies the distribution patterns of forest space and reduces areas of continuous forest to smaller isolated fragments (Maués and Oliveira, 2010). Arboreal species are more vulnerable to the effects of fragmentation in places where there is no canopy connectivity, as in many species and populations arboreal animals avoid descending to the ground and moving through an open area. Arboreal species that do tolerate descending to the ground to move through open areas are susceptible to being run over by cars or killed by terrestrial predators (Weston, 2003; Monticelli and Morais, 2015).

Electrocution is an additional risk that primate species are exposed to when living in forest fragments in proximity to urban areas. Electric shocks are caused by exposed wiring and transmission lines on poles (Petrucci et al., 2009; Souza et al., 2018). Anthropized areas and forest edges where the vegetation comes into contact with electrical wiring are the main sites of electrocution. When primate groups are moving along the boundaries between vegetation and urban environments, they often make use of the electrical wires to travel (Monticelli and Morais, 2015).

Electric shock occurs when an electric current passes through the body, causing a rapid stimulus (Fundacentro, 2005). When the electric current contacts the body it may cause several types of tissue damage and organic imbalances. The vast majority of animals die after electric shock. Survivors, may present sequelae such as burns, neurological deficiencies, and circulatory issues (Botelho, 2017).

Infrared thermography (IRT) is a noninvasive and nonradioactive detection method that captures images of a specific body region at a distance. It is able to analyze physiological and pathological conditions related to skin temperature control (Hilsberg-Merz, 2008). IRT detects the infrared light that the body emits and shows changes in body temperature related to blood flow alterations (Corte and Hernandez, 2016). It has the advantage that caretakers can avoid handling or restraining an animal and, in some cases, it can detect physiological problems relatively early (Mikail, 2010). It has been widely used as a diagnostic healthcare tool for both free-living wild animals and those kept under human care (Costa et al., 2020; Mota-Rojas, 2022).

The aim of this study was to evaluate how well infrared thermography could help in the diagnosis of physiological problems, management of treatment, and prognosis in three cases of free-living howler monkeys that had undergone electrocution in an urban environment and were treated at the Sorocaba Zoo.

Materials and methods

Study site
The Sorocaba Zoo, in São Paulo state, Brazil, is located in a secondary forest area of 128,339 m² (Figure 1A). This area is inhabited by brown howler monkeys (Prefeitura de Sorocaba, 2023). The howlers are often in direct contact with urban life and sometimes electricity cables (Figure 1B).

Electrocution
We evaluated three cases of electric shock in free-living *Alouatta guariba* referred to the veterinary hospital of Sorocaba Zoo. Each individual presented a different degree of severity, assessed based on their state of consciousness, and the extent and depth of the lesions. After prompt care

Figure 1. A) Satellite image of Sorocaba Zoo area, São Paulo state, Brazil. **B)** Free-living brown howler monkey walking along a non-energized electric cable in an urban area adjacent to the forested Sorocaba Zoo.

and clinic stabilization, the animals were photographed using an infrared thermography device as an aid in determining treatment and prognosis.

For infrared thermographic image capture, we used a Forward-Looking InfraRed (FLIR)® device, model T420, with thermal sensitivity of 0.04ºC and fourth generation detector with 76,800 pixels (320 x 480 pixels). We used the "rainbow" color pattern, with multicolored images, in which the shades of blue indicate that the temperature is low, while colors in warmer tones, ranging from white to red, indicate higher temperatures. The average temperature for each color varies according to the range of temperatures detected in each image.

Results

Case studies of treatment after electrocution

Case 1: Adult male with moderate electric shock severity

A 5.7 kg adult male *Alouatta guariba* was referred to Sorocaba Zoo presenting lack of coordination, absence of reflexes and poor response to stimuli. During physical examination, we observed mild burns in the fur and abrasions on the limbs and on the face, the latter suggestive of head trauma. The initial treatment performed included oxygen therapy, Meloxicam (0.2mg/kg, intramuscularly, once daily), Mannitol 20% (2g/kg, intravenously, once daily), Tramadol (2mg/kg, intramuscularly, twice daily), and NaCl 0.9% (60m, subcutaneously, once daily), during three days.

After the animal was stabilized, IRT was used to evaluate the temperature of different affected body regions. The right hand presented an average of 37.5°C (max 40.8 and min 29.9°C) while the left hand had an average temperature of 36.3°C (max 39.8 and min 32.6°C). The right foot had an average temperature of 37.9°C (max 40.1 and min 36.3°C) and the average left foot temperature was 37.5°C (max 40.0 and min 35.1°C) (Figure 2A).

On the fourth day, the clinical signs improved. The animal was alert and responsive, his reflexes and coordination had also improved, and he was able to drink and eat by himself.

IRT now showed the right hand with an average temperature of 36°C (max 39.3 and min 28.2°C), the left hand with 36.7°C (max 40.5 and min 27.2°C), the right foot 37.5°C (max 39.3 and min 34.5°C) and the left foot 37.4°C (max 39.4 and min 34.2°C) (Figure 2B).

After the three-day treatment, the animal presented normal behaviors for the species. He fed and drank normally and did not present any new lesions on the body. He was discharged from the veterinary hospital and monitored for another five days until he was released back into his natural environment.

Case 2: Adult male with extreme electric shock severity

A 6.4 kg adult male presented an absence of reflexes and no response to stimuli. During physical examination, burns were observed all over the animal's fur. There were abrasions on the limbs and face, blood inside the oral cavity with a wound on the tongue. The exam suggested that traumatic brain injury had occurred.

First aid included airway clearance and oxygen therapy. Meloxicam 0.2mg/kg IM, Mannitol 20% 2g/kg IV, Tramadol 2mg/kg IM and NaCl 0.9% 60ml SC were given. After animal stabilization, IRT indicated a maximum body temperature of 42.0°C in the abdominal region and low temperatures in the extremities. The right hand had an average temperature of 29.9°C (max 33.9 and min 27.2°C), the left hand 25.2°C (max 32.3 and min 21.0°C),

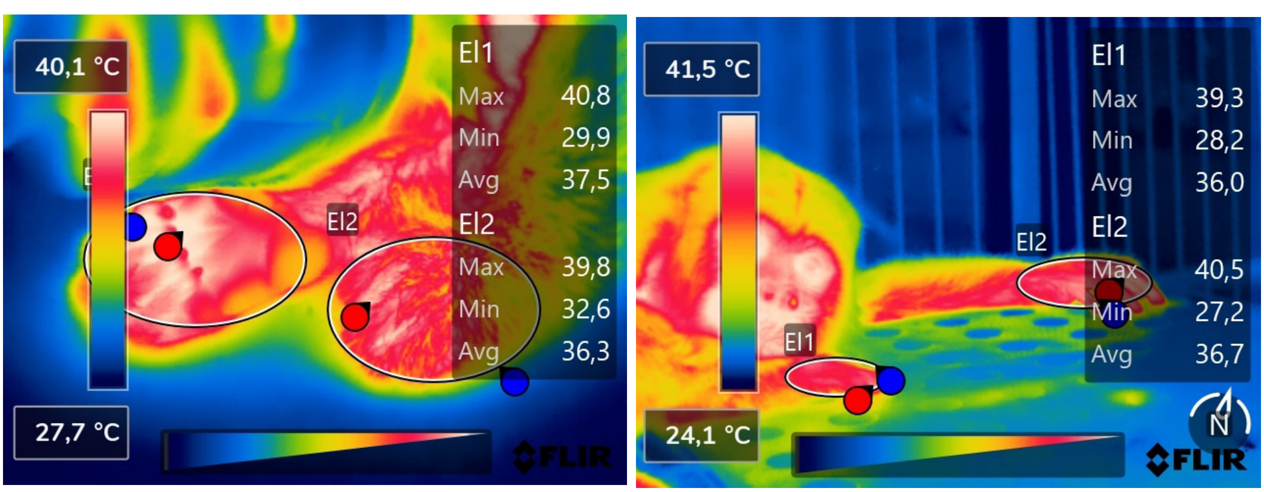

Figure 2. A) IRT of both hands of adult male *Alouatta guariba* (Case 1) on the day of admission. **B)** IRT at the next day, showing the same average temperature for the hands as on the admission day.

the right foot 30.0°C (max 31.9 and min 27.1°C) and the left foot, 29.0°C (max 31.2 and min 25.7°C) (Figure 3A).

The animal's clinical condition progressed very poorly the next day. He was apathetic and did not ingest food or water. Generalized edema and several new skin lesions appeared throughout the body. IRT showed maximum body temperature of 41.0°C and even lower temperatures in the extremities. The right hand had an average temperature of 23.8°C (max 25.5 and min 21.3°C), the right foot 31.6°C (max 33.8 and min 27.4°C) and left foot 25.3°C (max 27.0 and min 23.5°C) (Figure 3B). As the animal was in acute pain and IRT images showed limb ischemia, the prognosis was poor and to prioritize the animal's welfare, he was euthanised.

Case 3: Another adult male with extreme electric shock severity

An adult male weighing 6.1 kg was in a stupor, non-responsive to environmental stimuli and, at the same time, vocalized excessively and showed dyspnea (shortness of breath). He was promptly anesthetized for accurate evaluation and analgesia. The physical examination revealed lesions on the face, hind limbs and tail, and that the fur was burnt over his entire body. IRT showed maximum body temperature of 40.6°C and lower temperatures in the extremities. The right hand had an average temperature of 34.6°C (max 39.8°C on the arm and min 28.1°C on the fingers) and the left hand 33.8°C (max 39.6°C on the arm and min 21.3°on the fingers) (Figure 4).

The IRT revealed a large temperature difference between the limbs and the body, reaching up to 19.3°C difference between the hand and fingers; this pointed to ischemia, possibly resulting in necrosis. Due to the clinical presentation of acute pain associated with the images showing limb ischemia, the prognosis was poor and the animal was euthanized.

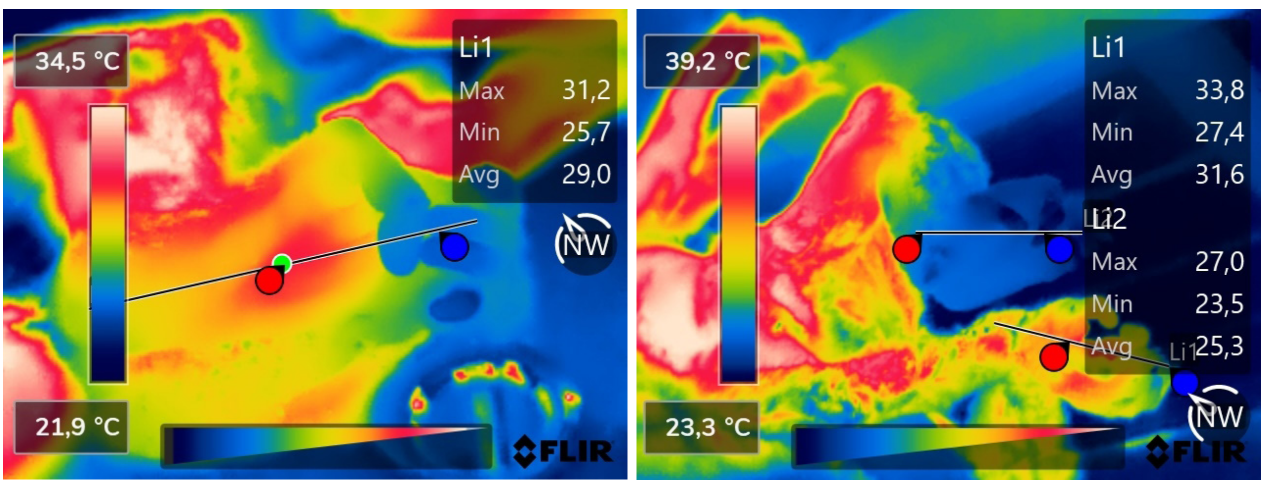

Figure 3. A) Left foot of adult male *Alouatta guariba* (Case 2) presenting an average temperature of 29.0°C on the admission day. B) Left foot showing an average temperature of 25.3° the following day.

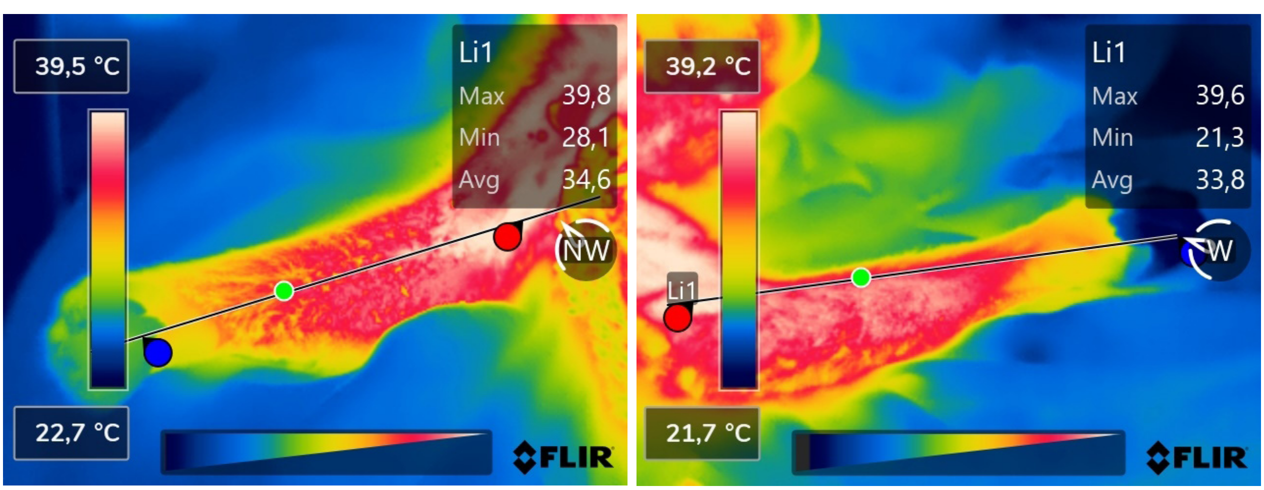

Figure 4. Right hand (A) and left hand (B) of adult male *Alouatta guariba* (Case 3). The IRT shows less heat radiation on the fingers than on the arms.

Discussion

Electric shock is reported in the literature for at least 31 species of primates (Cunneyworth and Slade, 2021). Electrocution in howler monkeys in areas close to urban developments has been reported in Porto Alegre, RS, Brazil (Lokschin et al., 2007). Media and conservation organizations describe additional species that have been injured or killed by the electrical infrastructure, though they remain undescribed in the scientific literature (Cunneyworth and Slade, 2021).

The injury severity caused by electrical energy depends on factors such as: voltage, intensity and frequency of the electric current, duration of contact, path taken by the electric current in the body and the structure and resistance of the tissues (Lee, 1997; Botelho, 2017). Injuries may vary from no visible marks to first to fourth degree burns or even completely carbonized tissues. These lesions may develop at any time after the accident, even after several weeks. This occurs due to the strong electricity conductivity of blood, so current tends to flow along the blood vessels, causing damage to endothelial cells and myocytes, resulting in thrombosis and ischemia (Schulze et al., 2016).

In addition, the flow disturbs physiologic electric processes of the body, including brain and heart activity, leading to respiratory and cardiac complications, organ damage and systemic infections (Schulze et al., 2016). Most of the power lines in Brazil are aerial and when the howlers suffer an electric shock, their fall results in secondary trauma (Kumar and Kumar, 2015). In this study, head trauma was observed in all the three of the treated animals. The reduced tissue temperature caused by thrombosis and ischemia can be visualized by IRT. As such, the use of this equipment in these cases not only allowed the detection of visually inapparent lesions but was also decisive in determining the prognosis and choosing the course of treatment in severe cases (Melero et al., 2013).

In Case 1, the average body and limb temperature oscillated little, showing normal temperatures both at admission and the following day. No lesions appeared in the following days. The animal fully recovered and was released back into his natural habitat. In cases 2 and 3, the howlers showed no apparent skin injury on the body or limbs on the day of admission. However, infrared thermography showed low temperatures on the limb's extremities reaching up to 17.2°C degrees difference in Case 2 and 19.9°C in Case 3, suggesting necrosis of those areas. In both cases, thermography was decisive for making the prognosis and choosing the option of euthanasia.

Previous reports state that for birds that have suffered electrocution, thermography can assist in predicting tissue damage and in guiding rehabilitation efforts (Melero et al., 2013). In thermography, the injured tissues appeared cooler than their corresponding healthy ones, and the thermal pattern was altered (Melero et al., 2013). Thermal symmetry and thermal distribution are more important parameters than absolute temperature, as also observed in the primates in this study.

Conclusion

Electric shock caused by electrical wiring can be very damaging to howler monkeys and other primates, causing serious injuries and potential death. The use of infrared thermography in this study proved to be useful in the identification of lesions caused by electrocution. It allowed veterinarians to access non-visible lesions, as well to determine their degree of severity, helping to direct the treatment and clinical prognosis of the animals.

Conflict of interest

The authors have no conflict of interests related to this manuscript.

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EFFECTS OF HISTORICAL LOGGING ON SQUIRREL MONKEY (*SAIMIRI MACRODON*) POPULATION DENSITY AND PRIMATE SPECIES RICHNESS IN THE PERUVIAN AMAZON

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Abstract

Primates in the Amazon are threatened by the expansion of human activities, including logging. Here, we investigate how primate communities are affected by different forest use and disturbance histories in two adjacent indigenous territories. We assess how logging in the recent past has changed primate community composition. One of the territories was protected from selective commercial logging activities, whilst the other had decades of selective logging before starting the process of becoming an indigenous territory in 2012. The past logging has left forest gaps and secondary forests, and was accompanied by small agricultural plots. Using line transect surveys and distance sampling analysis, we compared primate species richness between the two territories, and the density of the ecologically dominant squirrel monkey species, *Saimiri macrodon*. Villa Belén, the territory with more recent and more intense logging supported a higher population density of squirrel monkeys (192 indiv./km^2) than Jaldar (107 indiv./km^2), the territory with a less intense and more distant logging history. We found no difference in squirrel monkey group size between the forests of Villa Belén and Jaldar. Primate species richness declined as logging pressure and anthropogenic disturbance increased with an estimated richness of seven species in Villa Belén, compared to 11 species in Jaldar. Our findings suggest that squirrel monkeys can persist in tropical forests with high levels of historical logging pressure and at greater densities than in less disturbed areas with higher overall primate species richness.

Keywords: Anthropogenic disturbance, distance sampling, indigenous lands, population density, primate communities

Resumen

Los primates de la Amazonía se encuentran amenazados por la expansión de las actividades humanas, incluida la tala forestal. En este estudio, investigamos cómo las comunidades de primates se ven afectadas por diferentes historiales de uso y perturbación del bosque en dos territorios indígenas adyacentes. Evaluamos cómo la tala ocurrida en el pasado reciente ha modificado la composición de las comunidades de primates. Uno de los territorios estuvo protegido de actividades de tala comercial selectiva, mientras que el otro experimentó décadas de extracción selectiva de madera antes de iniciar su proceso de constitución como territorio indígena en el año 2012. La tala histórica generó claros en el bosque y áreas de bosque secundario, además de estar asociada con pequeñas parcelas agrícolas. Mediante muestreos por transectos lineales y análisis basados en muestreo por distancia, comparamos la riqueza de especies de primates entre ambos territorios, así como la densidad poblacional de la especie de mono ardilla ecológicamente dominante, *Saimiri macrodon*. Villa Belén, el territorio con una historia de tala más reciente e intensa, presentó una mayor densidad poblacional de monos ardilla (192 individuos/km^2) que Jaldar (107 individuos/km^2), territorio con un historial de tala menos intenso y más antiguo. No encontramos diferencias en el tamaño de los grupos de monos ardilla entre los bosques de Villa Belén y Jaldar. La riqueza de especies de primates disminuyó conforme aumentaron la intensidad de la tala y la perturbación antropogénica, registrándose una riqueza estimada de siete especies en Villa Belén, frente a las 11 presentes en Jaldar. Nuestros resultados sugieren que los monos ardilla pueden persistir en bosques tropicales sometidos a una elevada presión histórica de tala y alcanzar densidades mayores que en áreas menos perturbadas, donde existe una mayor riqueza general de especies de primates.

Palabras clave: Comunidades de primates, densidad poblacional, muestreo de distancias, perturbación antropogénica, territorios indígenas

Introduction

Non-human primates around the world are threatened by human activities such as overexploitation, habitat destruction and fragmentation, and a changing climate (Young et al., 2016). Indigenous territories, areas governed, managed, and used by indigenous peoples, have been shown to be a land use system that contributes to conserving biodiversity, including primates (Blackman et al., 2017). However, not all indigenous territories are managed by the people in the same way, and differences in land and resource use have different impacts on primates. The responses of primate populations to these differences must be studied if we are to understand their impacts and provide data for evidence-based conservation strategies (Paim et al., 2019).

The traditional approach to biodiversity conservation is the designation and management of protected areas, to provide sanctuaries for primates and other wildlife and relief from the pressure of human activities (Anaya and Espírito-Santo, 2018). However, there is strong debate as to their effectiveness and morality, and Laurance et al. (2012) suggest that only half of protected areas in tropical forests worldwide perform well in conserving biodiversity. In the Peruvian Amazon, strictly protected areas are less effective at conserving biodiversity and preventing deforestation than mixed-use protected areas, as the former results in conflict with the traditional lands of indigenous territories (Bodmer et al., 2008; Miranda et al., 2016).

Primates in the Amazon are threatened by the expansion of human activities such as logging (da Silva et al., 2022) and agricultural expansion (Pereira et al., 2020). These activities result in the clearance of primary rainforest and loss of space for wildlife to inhabit, adversely affecting ecosystem functioning and services (Balvanera et al., 2006). Approximately 20% of the Amazon rainforest is currently exploited for timber, typically by selective harvest (Piponiot et al., 2019). In the Peruvian Amazon most of the timber extraction is low level selective logging removing targeted trees for timber (Putz et al., 2008). Inevitably, such removal causes effects on biodiversity (Bicknell et al., 2014). These effects must be studied if we are to better understand the impact logging has on different species, especially as timber concessions are now a major land-use strategy in tropical forests.

Logging can also induce ecological alterations beyond physical disturbance. For instance, selective tree removal alters floristic composition by favouring fast-growing pioneering and secondary tree species, altering canopy openness, understorey density, and spatial distribution of fruiting and flowering trees (Bousfield et al., 2023), leading to a greater availability of early-successional food plants. Such modifications affect resource availability for primates, with varying impacts on species depending on dietary guild (i.e. folivory vs. frugivory). Consequently, logged forests may favor small, generalist species capable of exploiting patchy and diverse resources, while reducing habitat suitability for larger, specialized, or canopy-dependent primates (Almeida-Rocha et al., 2017). These ecological shifts can therefore drive measurable demographic responses such as changes in primate population density, group size, and movement patterns, and alter community-level species richness as adaptable species expand while sensitive taxa decline.

Here, we investigate how primates are affected by different forest use in two adjacent indigenous territories to understand how logging in the recent past has impacted the primate community composition. Primarily, our investigation is centered on the population dynamics of an ecologically dominant species, the squirrel monkey (*Saimiri macrodon*), including population density, group size, and encounter rate. Furthermore, we assess the difference in estimated primate species richness between the two territories. One of the territories was protected from commercial selective logging activities, whilst the other had decades of selective logging before starting the process of becoming an Indigenous Territory in 2012. The past logging has left forest gaps and secondary forests, and was accompanied by small agricultural plots and hunting.

Saimiri is a genus of small platyrrhine primate native to the forests of South and Central America (Ruiz-García et al., 2015). They are diet generalists, consuming fruit and flowers, as well as arthropods and small vertebrates taken from arboreal foliage (Boinski, 1999). Squirrel monkeys are most often observed in large groups of 25–75 individuals (Boinski, 1999). Smaller all-male alliance groups may also be observed migrating between larger breeding groups, whereas females are philopatric (Mitchell, 1994). This social organisation may be driven by high predation, despite the resulting cost of higher within-group competition for feeding resources (Mitchell et al., 1991).

Methodology

Study area and focal species

Data were collected in the Lower Yarapa *várzea* forests between the Pacaya-Samiria National Reserve and the Tamshiyacu-Tahuayo Community Reserve, located in the Marañon-Ucayali subsidence area of the Ucamara depression, Peru. The focal species of squirrel monkey in this study area was *Saimiri macrodon* (see Link et al., 2021). These forests make up part of the largest area of *várzea* flooded forests in the Western Amazon, extending over an area of 120,000 km^2 in the Department of Loreto, Peru. The study was based at the FundAmazonia research station situated on the Yarapa channel (Figure 1).

Amazonian *várzea* forests are floodplains that are seasonally inundated by the flooding of white-water rivers, resulting in distinct seasons of high-water and low-water (Parolin et al., 2004). The high-water season at the study site typically lasts from December-June, coinciding with periods of heavy rainfall, with the low-water season running from July-November (Bodmer et al., 2014). Large quantities of nutrient-rich sediments drain from Andean landscapes and are deposited in the *várzea* forests, resulting in fertile soils (Irion 1978; Räsänen et al., 1987).

The study site included two indigenous territories, Villa Belén and Jaldar, and their territories are divided by the Ango Canal (Figure 1). The Jaldar territory is a 'Comunidad Nativa' that the community has managed since the late 20th century. The area of Villa Belén has recently begun the designation of their territory, and only over the past decade have they begun to manage it.

We ascertained the extent of logging in each territory since the 1950s using semi-structured interviews to gain insights from local people. Interviews were led by FundAmazonia staff, and information was provided by Villa Belén and Jaldar authorities.

Villa Belén
Villa Belén is at the mouth of the Lower Yarapa channel. From 1999–2013, the forests were logged yearly. Over this period, ~700 tree trunks were removed from the territory of approximately 4,000 ha, with commercial tractors being used to remove timber on two occasions.

The trees most often taken from this area were the 'capinuri' (*Monteverdia laevis*) and 'capirona' (*Calycophyllum spruceanum*), making up around half of all the trunks that were removed. As of 2013, commercial timber concessions have not been allowed into Villa Belén, and timber has only been removed for the needs of local people.

Jaldar
Jaldar territory borders Villa Belén to the south and is in the middle section of the Lower Yarapa channel. The territory of Jaldar did not allow commercial timber extraction. Timber was removed selectively prior to Jaldar becoming an indigenous territory at a low rate between the 1950s and 1999. Since then, the people of Jaldar have not allowed any commercial logging in their territory and only use timber for local village infrastructure. The forests of Jaldar show less evidence of anthropogenic disturbance, according to the authorities of each territory.

Study design and data collection
We conducted line-transect surveys to observe primates in the two territories, according to the distance sampling methodologies set out by Buckland et al. (2001). Seven transects were used, four in Villa Belén and three in Jaldar (see Table 1), and were walked on rotation between July and September 2022. All trails were either disused hunting paths once used by the local communities or placed in targeted areas specifically for wildlife research. The mean transect length was 1.78 km, and each started on the bank of the Yarapa, entering the forest perpendicular to the Yarapa channel (see Figure 1).

The survey team consisted of 2–4 people observing the primates, including one local field assistant and 1-3 biologists. Occasionally, there were other people at a distance from the observers who would help measure

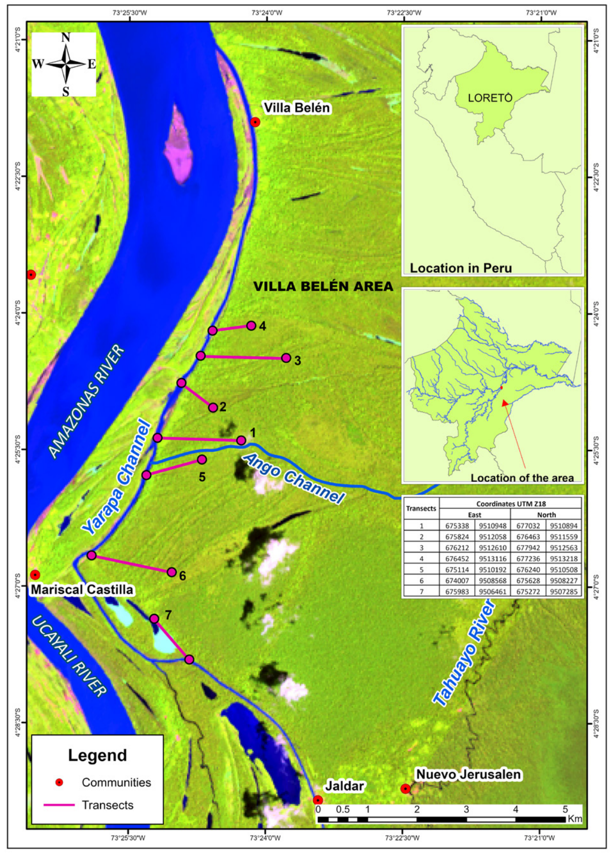

Figure 1. Location of study area and transects within Villa Belén and Jaldar territories, Loreto, Peru.

distances and record GPS and habitat data. We walked at approximately 1 km/h, between 07:00 and 12:00 and 14:00 and 17:00 to avoid the hottest period of the day when primate activity is reduced (Campos and Fedigan, 2009). Transects were not walked during heavy rain or poor visibility. In detection of primates, we recorded the time, species, distance walked along the transect, and the geographical coordinates of the location using a handheld GPS. One lead observer counted the number of individuals within the group, and this number was recorded as the group size. Perpendicular distance was measured from the trail to the location where the first individual was detected. We measured distances up to 20 m with a tape measure, and distances greater than 20 m were estimated. After each sighting, no new records for the same species were made within 150 m to ensure independence of observations (Leca et al., 2013). At the end of each transect route, we waited 15 minutes before undertaking the reverse journey, terminating at the same point as the start. We collected data on both the outward leg and the return leg of the transect.

Data analysis

Population density calculation
We used Distance software version 7.5 (Thomas et al., 2010) to estimate population densities for *Saimiri*

macrodon and calculate the effective strip width (w). The data for Villa Belén and Jaldar were pooled to calculate a value for w across the entire study area due to an insufficient number of observations in Jaldar for separate analysis. Examination of histograms generated in Distance revealed heterogeneity in the detection distances; therefore, the data were aggregated into five groups at 10 m intervals. Primate observations with a perpendicular distance of greater than 50 m were omitted to avoid the influence of outliers.

Table 1. Summary of location and length (in km) of each transect.

Transect number	Territory	Length (one way)
1	Villa Belén	2.2
2	Villa Belén	1
3	Villa Belén	2.2
4	Villa Belén	1.3
5	Jaldar	1.3
6	Jaldar	2.5
7	Jaldar	2

We then fitted models with every combination of key function (i.e., uniform; half normal; hazard rate) and series expansion (i.e., cosine; simple polynomial; hermite polynomial) to our data. We took multiple steps to compare and verify which of these models were the most appropriate for our dataset. Firstly, we screened out ill-fitting models using the chi-square goodness-of-fit test values, coefficient of variation, and visual inspections of the histograms and Q-Q plots generated by each model. The remaining models were compared using Akaike's Information Criterion (AIC) and the Delta AIC to determine the best-fitting model for our data, with the value of w being derived from the best-fitting model.

We obtained population density (D) using the formula:

where n is the total number of individuals observed on each transect, and L is the length of the transect. The value of w is multiplied by 2 in the equation to account for the strip width, both left and right of the transect. Due to the insufficient number of observations per transect, results were pooled to calculate a single value of population density in each territory.

$$D = \frac{n}{2wL}$$

Statistical analysis
Squirrel monkey group size values were normally distributed after a log10 transformation (Kolmogorov-Smirnov p=0.09 and p=0.13 respectively), and we used a 2-tailed independent t-test to compare the mean squirrel monkey group sizes observed in Villa Belén and Jaldar. All statistical analyses were performed in IBM SPSS Statistics 27. Means were presented ±SD.

Species accumulation and richness estimates
We plotted the total cumulative number of primate species observed against the survey effort in terms of the number of transects walked using Microsoft Excel to produce a species accumulation curve for each territory. We then added a logarithmic trend line for each territory to the scatter graph and simulated an extension of our survey effort to 60 transects walked per territory. We used the asymptote of the resulting trend curves as an estimation of total primate species richness in the territories (Ugland et al., 2003).

Results

Saimiri macrodon
We observed 1,291 squirrel monkeys over 54 transect repeats, with a total survey effort of 178.6 km. These totals comprised 853 individuals observed in Villa Belén over a total length of 93.2 km, and 438 individuals observed in Jaldar over 85.4 km.

Population density
According to the AIC and Delta AIC values for each model fitted using Distance software, the best-fitting model was derived from a combination of half-normal key function and cosine series expansion. The distribution of perpendicular distances (Figure 2) showed that most *Saimiri macrodon* detections occurred close to the transect line, with the number of records declining steadily up to the 50-m truncation distance. The fitted half-normal detection function with cosine adjustment provided a good visual fit to the data, indicating that detectability decreased smoothly with increasing distance. The absence of irregular peaks or gaps in the histogram suggests that distance measurements were consistent and that the dataset met the assumptions of distance sampling analysis.

Across the entire Lower Yarapa region, we estimated 151 squirrel monkeys per km^2 (Table 2). The territory with the higher population density was Villa Belén with 192 individuals per km^2, compared to 107 individuals per km^2 in Jaldar (Figure 3).

Group size and encounter rate
Across the Lower Yarapa forests, we observed 66 groups of squirrel monkeys, ranging in size from 1–70 individuals (mean±SD: 19.56±15.13). In the Jaldar territory, we observed 21 groups at an encounter rate of 0.25 groups/km. The group encounter rate was almost twice as high in Villa Belén, where we observed 45 groups, at 0.48 groups/km. There was no difference in group size between the two territories (t_{64}=0.53, p=0.6). In fact, the mean group sizes were remarkably similar between Villa Belén (18.96±14.57) and Jaldar (20.86±16.56; see Table 3).

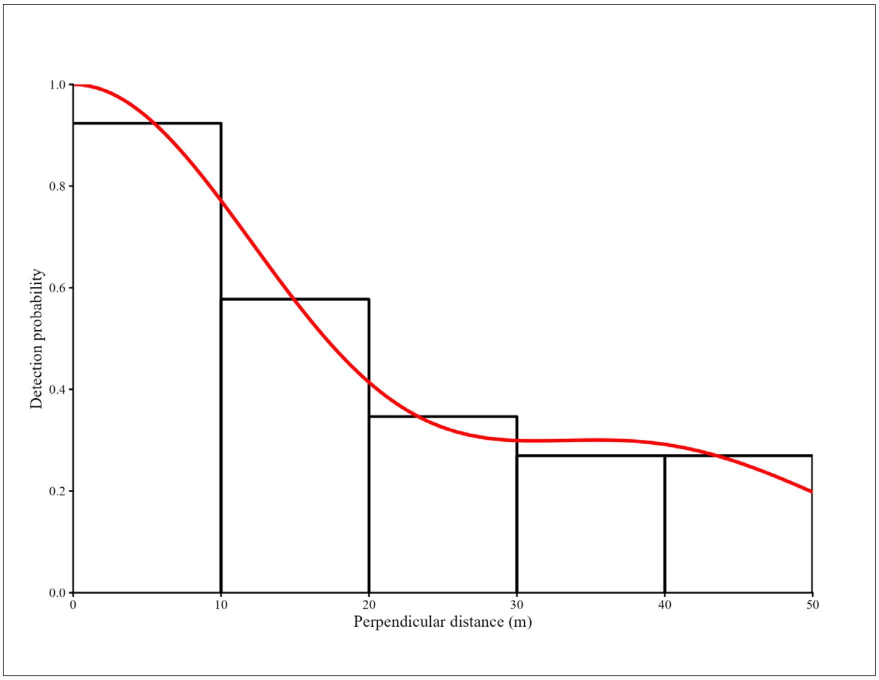

Figure 2. Histogram of *Saimiri macrodon* detections by perpendicular distance (black bars) with the fitted half-normal detection function (red line). Observations beyond 50 m were truncated prior to model fitting.

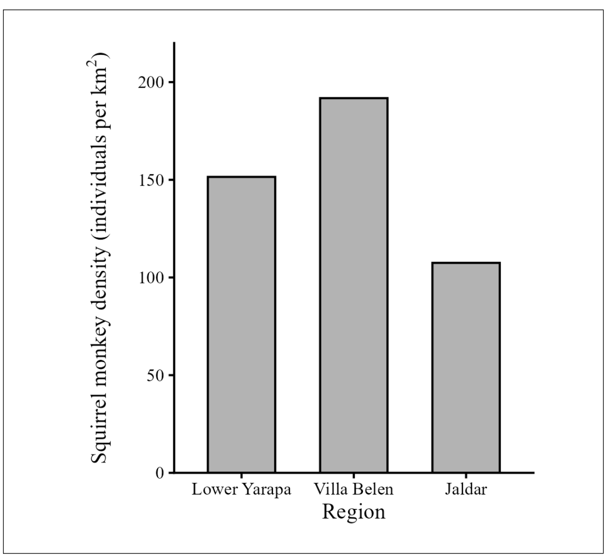

Figure 3. Density of squirrel monkeys (individuals per km^2) for the entire Lower Yarapa forests, as well as Villa Belén and Jaldar territories specifically.

The transect with the highest mean group size was transect #6 in the Jaldar territory, with a mean group size of 24.64±18.82 individuals. Transect #6 was also the transect where the largest group was observed, with 70 individuals.

Primate species richness

Across the 178.6 km walked in the Lower Yarapa forests, we observed eight species of primates including the squirrel monkey, large-headed capuchin (*Sapajus macrocephalus*), white-faced capuchin (*Cebus unicolor*), pygmy marmoset (*Cebuella niveiventris*), moustached tamarin (*Tamarinus mystax*), saddleback tamarin (*Leontocebus nigrifrons*), coppery titi monkey (*Plecturocebus cupreus*), and red howler monkey (*Alouatta seniculus*).

Across the 93.2 km that we walked in Villa Belén territory, we observed six of the eight species (*Saimiri macrodon, Sapajus macrocephalus, Cebus unicolor, Cebuella niveiventris, Tamarinus mystax* and *Plecturocebus cupreus*), over the course of 28 transect repeats divided across the four transect routes (see Table 2 for survey effort per transect). Using the logarithmic trendline on a species accumulation curve, we extrapolate an estimated species richness in Villa Belén territory of seven primates (Figure 4). In neighbouring Jaldar, we observed all eight of the species, across a total of 85.4 km and 25 transect repeats divided along the three transect routes. Using the logarithmic trendline on a species accumulation curve, we extrapolate an estimated species richness in Jaldar territory of 11 primates (Figure 4).

Discussion

We produced squirrel monkey population density estimates across two indigenous territories with differing historic resource uses, including logging. Villa Belén, the territory with a more recent and more intense logging intensity (yearly commercial logging between 1999-2013), had a higher population density of squirrel monkeys (192 individuals per km^2) than Jaldar (107 individuals per

Table 2. Summary of squirrel monkey population density calculated per territory, and survey effort per transect.

Territory	Transect number	Individuals observed	Total survey effort (km)	Effective strip width (m)*	Population density (ind/km^2)
Villa Belén	1-4	853	93.2	23.86	191.79
	1	221	30.8		
	2	195	16		
	3	149	30.8		
	4	288	15.6		
Jaldar	5-7	438	85.4	23.86	107.48
	5	54	23		
	6	345	41.6		
	7	39	20.8		
Lower Yarapa Total	**1–7**	**1,291**	**178.6**	**23.86**	**151.48**

*Effective strip width calculated within Distance software 7.5 (Thomas et al. 2010).

Table 3. Summary of squirrel monkey group size per transect.

Territory	Transect	Mean group size (individuals)
Villa Belén	1–4	18.96
	1	18.42
	2	16.25
	3	21.29
	4	20.57
Jaldar	5-7	20.86
	5	18
	6	24.64
	7	9.75
Lower Yarapa total	**1–7**	**19.56**

km^2), the territory with a less intense and more distant logging history (low-level local use only since the 1950s).

Our results suggest that areas of forest with a higher historical logging pressure support a higher population density of squirrel monkeys than the less disturbed surrounding forests. There are various ecological aspects of logged forests that could lead to a higher density of a primate species in a habitat conventionally described as degraded. Firstly, *Saimiri* species are generalist feeders (Boinski 1999) and are more able to adapt to a shift in food type availability from anthropogenic pressures than specialist feeders. For example, Oliveira-Silva et al. (2018) demonstrated that *S. sciureus* continued to thrive and contribute to the natural recovery of a highly anthropogenically disturbed Atlantic Forest in Brazil,

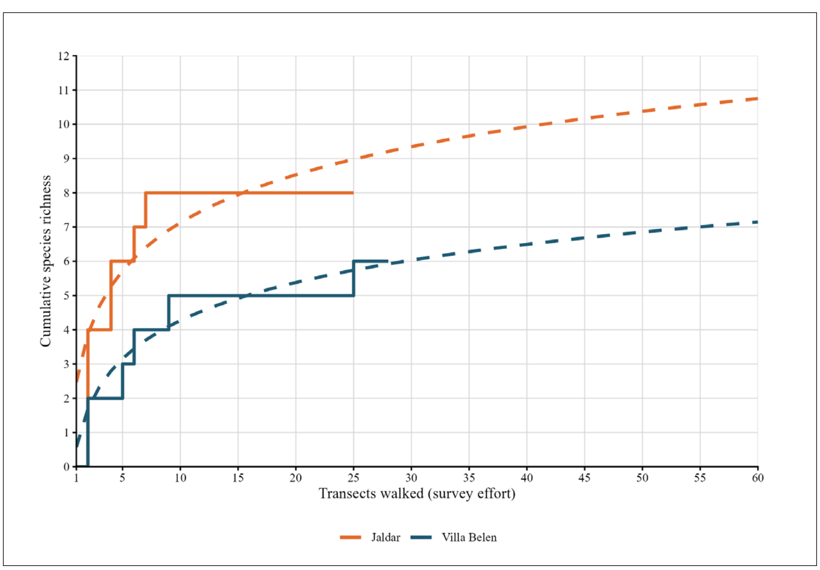

Figure 4. Extrapolated species accumulation curve showing estimated primate species richness in Villa Belén (blue line) and Jaldar (orange line) after 60 transects in each region.

despite the fact that the population was illegally released outside of its natural range. The forest gaps left by commercial timber concessions will likely not prevent squirrel monkeys from feeding, as they can support a greater variety and higher abundance of invertebrates (Watkins et al., 2017; Hill et al., 2001), and squirrel monkeys were regularly observed foraging for and consuming insects, myriapods, and arachnids during this study.

Another aspect of logged forests, which may explain the higher density of squirrel monkeys, is the development of a complex 3-D understory structure. Figueira et al. (2008) demonstrated that forest gaps created by selective logging promoted regrowth of small (10–35 cm DBH) and medium (35–55 cm DBH) sized trees, creating a complex understory with a higher density of trees than areas with a dense canopy cover limiting light availability to the forest floor. This dynamic and complex forest structure is beneficial to squirrel monkeys due to the reduced pressure of avian predation. Squirrel monkeys in Peru face predation from large birds such as harpy eagles (*Harpia harpyja*), and observations by Boinski et al. (2003) suggest that squirrel monkeys in habitats with a more complex understory are victims of fewer successful avian attacks than those in areas with an intact canopy. Studies of harpy eagle foraging ecology also support this theory, as adult harpy eagles require a clear flight path towards their prey, and struggle to locate and retrieve arboreal prey from dense foliage (Touchton et al., 2002).

The higher density of squirrel monkeys in Villa Belén may be related to a decrease in interspecific competition for resources. In tropical ecosystems, primate species richness declines as logging pressure and anthropogenic disturbance increase (Almeida-Rocha et al., 2017), a conclusion corroborated by our observations of an estimated richness of seven species in Villa Belén, compared to 11 species in Jaldar. Villa Belén may support fewer primate species due to more recent and intense degradation of the forest, creating vacant niches in the ecosystem. Squirrel monkeys can fill vacant niches due to their generalist diet and opportunistic adaptability to disturbed landscapes (Estrada et al., 2012). Members of the Villa Belén and Jaldar communities are subsistence hunters as permitted by wildlife management plans, primarily focussing on species with higher reproduction rates, such as collared peccary (*Pecari tajacu*) and lowland paca (*Cuniculus paca*). Hunting of primates is prohibited (Mahabale et al., 2025). Due to this prohibition, very few of primates are hunted in the Lower Yarapa forests each year, and this does not have any appreciable impact on the primate community composition or population densities in each territory (Mahabale et al., 2025).

We found no difference in squirrel monkey group size between the forests of Villa Belén and Jaldar. In fact, with mean group sizes of 18.96 and 20.86, respectively, the socio-ecological aspects of squirrel monkey distribution are similar in Villa Belén and Jaldar. Group size in social primates is generally determined by predation, food availability, and competition (Janson and Goldsmith, 1995). Large group sizes are beneficial for squirrel monkeys because they enable them to retain access to productive fruit trees, as competing primate species are not able to successfully expel them in the same way they would with a small group (Terborgh and Janson 1986). This may have contributed to the observation of the largest group size also occurring on the transect with the highest number of primate species observed.

The results of our study provide an insight into the ecological benefits of the self-governance and land management of indigenous territories. The contrast between the neighbouring territories in terms of primate species richness allows us insight into the potential ecological benefits of land management strategies – in this case, the prevention of any further commercial timber extraction being allowed. Of the two indigenous territories analysed here, Jaldar was the first to place a strict ban on timber extraction in 1999. Therefore, the forests of Jaldar were able to recover at a natural rate for 23 years until the point of data collection, and support a greater diversity of primates. In contrast, Villa Belén was only free from commercial logging for 9 years, to the point of data collection after banning commercial operations in 2013, meaning it had only 39.1% of the time to recover when compared to Jaldar. This difference demonstrates that, over time, indigenous territories may have beneficial consequences for biodiversity.

Pantropical reviews have revealed that formally protected areas may not be the only tool to create effective protection for biodiversity and the function of tropical rainforests. Indigenous territories perform well to protect areas in terms of conserving rainforest structural integrity, and support 71% of all primate species across the globe, while receiving a fraction of formal biodiversity conservation funding (Sze et al., 2022, 2024). These benefits demonstrate, in this case, an enormous contribution made by indigenous people towards the conservation of primates, and the recent management of the Lower Yarapa forests by the people of Villa Belén and Jaldar preventing commercial timber workers or loggers from destroying primate habitat, is an example of this contribution. These trends highlight the importance of developing community-based conservation strategies alongside indigenous people as major stakeholders, to create landscapes within which both human and non-human primates can prosper.

Overall, our findings suggest that squirrel monkeys can persist at high densities in tropical forests with greater levels of historical logging pressure. However, this increase in population density may come at the expense of other primates, and squirrel monkeys may simply be filling the vacant niche available to them via the habitat becoming unsuitable for other species.

Acknowledgments

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Short Articles

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NOTAS SOBRE LA ESTRUCTURA DE UN GRUPO DE *ALOUATTA SENICULUS SENICULUS* (PRIMATES: ATELIDAE), EN LIMONCOCHA, ECUADOR

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Resumen

Las estructuras poblacionales de primates de la Amazonía ecuatoriana son poco conocidas. Las presentes observaciones se realizaron en la localidad de Limoncocha, provincia de Sucumbíos, en Ecuador. Se avistó un grupo de monos aulladores rojos (*Alouatta seniculus*), conformado por nueve individuos: tres machos adultos, dos hembras adultas, dos hembras en gestación y dos juveniles, uno de ellos macho. El grupo se observó desplazándose entre las ramas de los árboles hasta detenerse en busca de alimento y para ubicarse para pernoctar. En el lugar usado como dormidero los individuos adultos se alimentaron de hojas, mientras los juveniles jugaron hasta las 17h30 cuando se ubicaron para pasar la noche. A las 7h30 de la mañana siguiente el grupo se había desplazado a otro lugar. La información sobre la composición del grupo de *A. seniculus* en la Amazonía de Ecuador es escasa, por lo que la presente observación contribuye a nuestro conocimiento al respecto.

Palabras clave: Aullador rojo, clases de sexo-edad, composición del grupo, dinámicas sociales, dormidero, interacciones ecológicas

Abstract

Population structure in primate groups in the Ecuadorian Amazon is little studied. The present observations occurred in Limoncocha, Sucumbíos province, Ecuador. We observed a group of red howlers (*Alouatta seniculus*), composed of nine individuals: three adult males, two adult females, two pregnant females and two juveniles, one of them male. The group was observed moving among the branches of the trees until they stopped in search of food and settled down to spend the night. In the place used as a sleeping site, adults fed on leaves while the juveniles played until 17h30 when they settled down for the night. By 7h30 the next morning the group had moved on to another location. Information on the group composition for *A. seniculus* in Amazonian Ecuador is scarce, so this observation contributes to our knowledge of it.

Key words: ecological interactions, group composition, red howler monkeys, sex-age classes, sleeping sites, social dynamics

Yuyaykunata uchillachishka

Kay killkay ñawpamanda Antisuyu Kaysa maya killkashka tiyanshu ansallami riksirishka. Kay rikuy rurarishkami Limonkucha llaktay, Sucumbios marka Ecuador mamallakta. Rikurikami puka kushillu tuta (*Alouatta seniculus*), karan yurapi kuyurisha mikunata maskanunashka, sambayasha chikanwasiy puñunun. Tiyashkami iskun wiwakuna, kimsa ruku kari, ishki iksayuk ruku warmikuna astawan ishki malta warmikuna shuk kari mikunara maskashami rikurika yura pallkakunay tupankakama chillayrami puñunkawa taripawka. Kay kuchuy puñunay ruku kushillukuna pankarami mikurianushka, maltakuna pukllanunmi 17:30 washay maskanun pay puñunapallkara. Tutamanda 7:30 shuk kuchumami rinushka. Kay rikuykuna yanapanmi yachaykunara Kay wiwa Kawsayra Ecuador mamallakta, alli yuyayrami Kun akllashka.

Killkay: karan runakuna, karan wata, karikuna, maltakuna, Puka kushillu, puñu kuchuy, Sacha Kawsay, wankuri, warmikuna

Introducción

Alouatta seniculus es una especie con una historia taxonómica compleja. Actualmente se reconocen tres subespecies a partir de caracteres anatómicos y genéticos (Hill, 1962; Stanyon et al., 1995; Wilson y Reeder, 2005; Rylands et al., 2013; Cortés-Ortiz et al., 2015; Ruiz-García et al., 2016; Doyle et al., 2020). Es euritérmica, se distribuye entre 0 a 3200 msnm en Venezuela, Colombia, Ecuador, Perú, y Brasil (Defler, 2010; Rylands et al., 2013; Cortés-Ortiz et al., 2015; Link et al., 2021). Sus poblaciones ocupan distintos hábitats, con mayor frecuencia hacia las orillas de lagos y ríos que al interior del bosque, cruza ríos anchos nadando y sobreviven en zonas con poca vegetación (Defler, 2010). Presenta mayor densidad en hábitats poco intervenidos y está ausente en hábitats muy intervenidos (Martin-Solano et al., 2018). Su actividad es diurna, su dieta es principalmente folívora, aunque también incluye frutos, algunos insectos y lodo con sales minerales (Estrada y Garber, 2009; Defler, 2010; Martin-Solano et al., 2018; Smith, 2023).

En Ecuador ocurre la subespecie *Alouatta seniculus seniculus* (Linnaeus, 1766) (ver Rylands et al., 2013; Cortés-Ortiz et al., 2015), pero existe poca información sobre su estructura poblacional (Blake et al., 2010; Martin-Solano et al., 2018). Por tal motivo, en esta nota describimos una observación puntual sobre la estructura y comportamiento de un grupo de *A. s. seniculus* en la Amazonía norte de Ecuador.

El 26 de agosto de 2018, entre las 14:18h y las 18:00h se avistó un grupo de *Alouatta seniculus* en la localidad de Limoncocha, cantón Shushufindi, provincia de Sucumbíos (0°24'34''S, 76°37'16''W, 247 msnm). La localidad corresponde al ecosistema de herbazal inundado lacustre-ripario de la llanura aluvial de la Amazonía (MAE, 2013). Para describir la estructura del grupo categorizamos a los individuos en infantes (menores de un año), juveniles (entre uno a tres años) y adultos (mayor a tres años) (Pullido, 1997), y según el sexo en macho, hembra y hembra en gestación.

El grupo conformado por nueve individuos (Tabla 1) fue observado desplazándose sobre árboles de entre 15 y 30m de alto hasta detenerse y posarse en un árbol de *Ficus* sp., que posteriormente sería usado como dormidero.

Uno de los machos se ubicó en la parte más alta mientras el resto del grupo buscaba donde forrajear, jugar y ubicarse para pasar la noche (Figura 1A). Una vez ubicados se alimentaron de hojas disponibles a su alrededor, doblándolas ligeramente para consumirlas, aunque en algunos casos solo eran consumidas parcialmente (Figura 1B). Dos juveniles (un macho y otro sin determinar) jugueteaban de un lado a otro entre las ramas (Figura 1C), mientras interactuaban en ocasiones con sus madres. Paralelamente, un macho adulto se sostenía de una rama con su cola y se alimentaba de hojas, mientras tanto otro macho adulto se posaba observándolo y comía pocas hojas e inflorescencias secas (Figura 1D-E); por momentos cortos interactuaban entre ellos. Los individuos del grupo continuaron moviéndose y forrajeando hasta las 17:00h cuando todos los individuos comenzaron a buscar y ubicarse en lugares donde pasar la noche (17:30h) (Figura 1F). Los individuos pasaron toda la noche en el sitio, y a las 7:30h de la mañana siguiente ya se habían movilizado a otro lugar del bosque.

El tamaño de grupo de nueve individuos se encuentra dentro del promedio de individuos reportado para la especie (Tabla 1). Por ejemplo, la información compilada por Dias y Rangel-Negrín (2015) es de entre cinco y 10 individuos, con un promedio de 7.2 individuos. En Colombia, donde también ocurre esta subespecie, Defler (2010) reportó tamaños de grupo de hasta 16 individuos o más, con promedio de 6 a 9 individuos, mientras que Estrada y Garber (2009) reportaron un tamaño de 7.8 individuos (n= 8) con una composición de 1.8 machos adultos y 2.4 hembras adultas con proporción de machos/hembras 1:1.4. La observación realizada en Limoncocha presenta una proporción sexual de 1:1. En la tabla comparativa entre Pullido (1997) y Morales-Jiménez (2002) (Tabla 1) se observa que, aunque los estudios no cuentan con las mismas categorías de edad, presentan porcentajes similares en cuanto a la estructura del grupo. Además, presenta categorías de edad que consideramos que pueden ser empleadas en futuros estudios.

La estructura del grupo en Limoncocha es similar a la descrita por Braza et al. (1981), quien registra 40% de hembras adultas, 26% de machos adultos, 16% de juveniles y 18% de infantes. Por su parte, Ochoa et al. (2011) reportan, para 22 grupos, una composición media por sexos y por edad de 30.1% en machos adultos, 34.6% hembras adultas, 6.8% machos juveniles, 8.3% hembras juveniles y 16.5% infantes.

Durante el avistamiento, las actividades que realizaban los individuos eran de alimentación, descanso y juego en el caso de los juveniles (Figura 1). En general, la mayor parte de las actividades realizadas por la especie son alimentarse, descansar y dormir sobre ramas de árboles grandes y medianos, incluso guaduas (Defler, 2010), y suelen interactuar con otras especies de primates viviendo en simpatría y sintopía (Estrada y Garber, 2009). Por

Tabla 1. Estructura poblacional de siete grupos de *Alouatta seniculus seniculus*. Cada columna corresponde a un grupo diferente.

	Este estudio	Pullido (1997)	Morales-Jiménez (2002)				
Tamaño del grupo	9	15	9	6	7	3	5
Machos adultos	3 (33.3%)	2 (13.3%)	3 (33.3%)	2 (33.3%)	2 (28.6%)	2 (66.6%)	1 (20%)
Hembras adultas	2 (22.2%)	4 (26.6%)	4 (44.4%)	2 (33.3%)	3 (42.8%)	1 (33.3%)	2 (40%)
Hembras en gestación	2 (22.2%)	-	-		-	-	-
Juveniles sin determinar	1 (11.1%)	-		-	-	-	-
Juveniles machos	1 (11.1%)	3 (20%)	1 (11.1%)	-	1 (14.3%)	-	1 (20%)
Juveniles hembras	-	2 (13.3%)	-	1 (16.6%)	1 (14.3%)	-	1 (20%)
Infantes sin determinar	-	-	1 (11.1%)	1 (16.6%)	-	-	-
Infantes machos	-	3 (20%)	-	-	-	-	-
Infantes hembras	-	1 (6.6%)	-	-	-	-	-

otro lado, en ambos juveniles del grupo se observó la dependencia relativa materna, como señala Ochoa et al., (2011).

El conocimiento sobre la estructura de este grupo representa un aporte importante para establecer medidas de protección de la especie, dejando un antecedente para nuevos estudios que permitan comparar su estructura poblacional en distintas localidades de su distribución.

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Figura 1. Grupo de *Alouatta seniculus*. A: Ubicación del grupo en el sitio donde pasaría la noche. B: Una hembra en gestación descansando sobre sobre la rama y alimentándose de hojas. C: Dos juveniles jugueteando. D: Dos machos adultos, uno colgado de la cola y forrajeando, y el otro observando. E: Un macho adulto colgado de la cola forrajeando. F: Una hembra y un juvenil abrazados, y un macho adulto situados en su dormidero (Fotos: Salomón Ramírez).

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SOCIAL INTEGRATION OF A LONE WILD HOWLER MONKEY (*ALOUATTA PALLIATA*) INTO A CAPTIVE-RAISED TROOP IN COSTA RICA

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Magdalena S. Svensson

Abstract

In Sarapiquí, Costa Rica, Toucan Rescue Ranch has started a rehabilitation program for orphaned golden-mantled howler monkeys (*Alouatta palliata*). These individuals are brought to the rescue center by the National Systems of Conservation Areas (SINAC), the government organization in charge of managing conservation areas in Costa Rica. The orphaned howler monkeys are received primarily due to electrocutions and are cared for by a team of trained biologists and veterinarians. Since the beginning of the program in 2021, seven individuals have been reintroduced at a release site. Post-release monitoring has been conducted in order to track their adaptation and survival in the wild. During routine observations, a lone wild male began to spend time near the reintroduced individuals. A series of interactions took place over the course of several weeks, culminating into the acceptance of the wild male by one of the reintroduced groups. This integration illustrates the potential for captive-raised individuals to form social bonds with wild counterparts, while highlighting the importance of monitoring behaviors during reintroduction efforts. By documenting these interactions, conservationists can gain valuable insights into how captive-raised individuals are adapting to wild habitats. Future research is critical in order to explore whether these connections can facilitate learning and ease the transition to a natural environment, ultimately contributing to more successful reintroduction outcomes.

Keywords: *Alouatta*, post-release monitoring, primate conservation, rehabilitation, reintroduction

Resumen

En Sarapiquí, Costa Rica, Toucan Rescue Ranch ha iniciado un programa de rehabilitación para monos aulladores (*Alouatta palliata*) huérfanos. Estos individuos son llevados al centro de rescate por el Sistema Nacional de Áreas de Conservación (SINAC), organismo gubernamental encargado de gestionar las áreas de conservación en Costa Rica. Los monos aulladores huérfanos son recibidos por diversos motivos y son atendidos por un equipo de biólogos y veterinarios capacitados. Desde el inicio del programa en 2021, se han reintroducido siete individuos en un sitio de liberación. Se ha realizado un seguimiento posterior a la liberación para rastrear su adaptación y supervivencia en la naturaleza. Durante las observaciones de rutina, un macho salvaje solitario comenzó a pasar tiempo cerca de los individuos reintroducidos. A lo largo de varias semanas pasó una serie de interacciones que culminaron con la aceptación del macho salvaje por parte de una de las tropas reintroducidas. Esta integración ilustra el potencial de los individuos criados en cautiverio para formar relaciones sociales con sus homólogos salvajes, al mismo tiempo que resalta la importancia de monitorear los comportamientos durante los esfuerzos de reintroducción. Al documentar estas interacciones, los conservacionistas pueden obtener información valiosa sobre cómo los individuos criados en cautiverio se están adaptando a los hábitats salvajes. La investigación futura es fundamental para explorar si estas conexiones pueden facilitar el aprendizaje y facilitar la transición a un hábitat natural, contribuyendo en última instancia a resultados de reintroducción más exitosos.

Palabras clave: *Alouatta*, conservación de primates, monitoreo posterior a la liberación, rehabilitación, reintroducción

Introduction

Documentation of the outcomes of primate rehabilitation efforts is limited in the existing literature (Guy et al., 2013). For example, Guy et al. (2015) found low survival rates in vervet monkey releases and poor adherence to IUCN guidelines, highlighting challenges in rehabilitation efforts. Similarly, Cheyne (2009) emphasizes the importance of long-term monitoring and standardized procedures to improve the chances of success. Despite these insights, many projects lack adequate post-release monitoring, leaving gaps in understanding rehabilitation effectiveness (Speiran et al., 2023). Many rehabilitation projects do not monitor post-release outcomes or do it for insufficient amounts of time, leading to significant gaps in our understanding of the effectiveness of these initiatives (Speiran et al., 2023). Researchers often debate the definition of success in these rehabilitation efforts, leading to difficulties when comparing reintroduction programs (Speiran et al., 2023). Short-term success for wildlife is typically measured by the self-sufficiency of individuals post-release (Griffith et al., 1989), while long-term indicators commonly include successful reproduction of viable offspring, integration with wild conspecifics, and survival without human intervention (Beck, 2018).

While several studies have documented the release of primates in areas with existing conspecifics (Vogel et al., 2002; de Palomino, 2013), there is often a lack of information regarding the interactions between released individuals and their wild counterparts. Howler monkeys (*Alouatta* spp.) have been the focus of various translocation studies (Ostro et al., 1999; Richard-Hansen, 2000; Shedden-Gonzalez, 2010; Tricone, 2017). However, there is a lack of focused investigations addressing the integration process of rehabilitated individuals with wild conspecifics. In a study by Brockett (2000), two wild-born, captive-raised black howlers in Belize (*Alouatta pigra*) were released and later observed alongside three other individuals; however, no specific observations were made regarding their group formation.

In our study, we report on the immigration of a wild-born male golden-mantled howler monkey (*Alouatta palliata*) into a troop of three captive-raised individuals as a benchmark of success for our reintroduction program in Sarapiquí, Costa Rica.

Methods

In 2021, prompted by a rise in electrocution incidents in the area, Toucan Rescue Ranch began its efforts to rescue howler monkeys at a release site in Sarapiquí, Costa Rica (Fig. 1). Most of the individuals were orphaned due to their mothers succumbing to electrocution injuries. Two howler monkeys were released in 2023, and five more in 2024. One of the five from the second troop (Troop 2) joined the first two individuals, and this is the troop we focus on in our study (Troop 1).

We collected *ad libitum* behavioral data on Troop 1 from October 10, 2023, to May 31, 2024, allowing us to capture spontaneous behaviors and interactions that occurred with the wild male. The troop consisted of three sub-adult males, each estimated to be around 2 years old at the time of release. We identified the monkeys based on their genitals, distinct pigmentations, and the facial characteristics we became familiar with during their rehabilitation. One lone wild male, frequently seen in the trees bordering the Release Site since 2021, was referred to by researchers as Pata Rosada, named for the unique pink markings on the pads of his back feet.

Figure 1. Map showing Toucan Rescue Ranch and the release site of Troop 1 and 2. Map created in ArcMap 10.8.2.

Results

The initial interaction between the lone wild male and the rehabilitated individuals was recorded on April 26th, 2024. All individuals from Troop 1 were resting in a beach almond tree, and the lone wild male (Pata Rosada) appeared in a nearby tree and attempted to approach them. Two of the males and Pata Rosada maintained consistent eye contact while intermittently vocalizing for several minutes. The vocalizations included howling and a mixture of soft grunting noises. During this period, the youngest male emitted sounds resembling the cries of infant howlers. Subsequently, the lone male engaged in a tongue-flicking behavior directed towards them, prompting all four monkeys to move in a parallel manner, neither advancing or retreating from one another. After a few minutes, the three individuals from Troop 1 began moving towards Pata Rosada, resulting in his retreat through the canopy.

On April 29th, Pata Rosada was observed with a female from Troop 2. At the same time one of the juvenile males from Troop 1 was observed running nearby along the ground. Upon scanning the trees above him, we observed Pata Rosada less than one meter away from the female. After several seconds of observation, he proceeded to tongue-flick in her direction. The captive-raised female permitted him to approach, prompting soft grunting sounds, which escalated into a frantic embrace between the two. At that moment, one of the other juveniles from Troop 1 ran to their companion on the ground. Upon noticing both males fleeing, the female quickly retreated from the lone male and followed Troop 1 males. Pata Rosada pursued the trio for approximately ten minutes, both in the trees and on the ground before losing track of them.

On April 30th, Pata Rosada displayed rapid tongue movements toward one of the reintroduced Troop 1 males, eventually approaching him. This interaction culminated in an embrace similar to that previously observed with the female, followed by anogenital sniffing.

On May 1st, Troop 1 was observed foraging and resting, with the three males a few meters apart from each other and continuously vocalizing. Pata Rosada maintained a distance of 5 to 10 meters behind them, positioning himself below the canopy. When any of the three vocalized loudly, he would increase the distance accordingly. About an hour into the observation, an undetermined negative interaction took place when Pata Rosada was in close proximity to one individual; however, we were unable to identify which one due to the dense foliage. This interaction was marked by loud scuffle sounds, prompting the three males to flee the location swiftly. Pata Rosada followed at a greater distance than before, not matching their speed. Ten minutes later, having lost sight of them completely, he began to vocalize softly, producing a sound that combined elements of a soft howl and the infantile vocalizations previously exhibited by the youngest male on April 26th.

The next sighting occurred on May 8th, when Troop 1 and the lone wild male were observed resting and foraging within five meters of one another. They stayed together for the entirety of the four-hour observation period. During the remainder of the data collection period, which concluded on May 31st, it was more common than not to observe the individuals functioning as a cohesive group, foraging and moving together.

Discussion

Our observations provide valuable insights into the specific behaviors that facilitate social bonds, particularly between rehabilitated individuals and wild conspecifics. Natal dispersal is a common occurrence among juvenile golden-mantled howler monkeys (*Alouatta palliata*), with reports indicating that nearly 80% of males leave their natal troops and may remain solitary for up to four years before joining another group (Glander, 1992). As seen in our study, male golden-mantled howler monkeys typically integrate into established groups by trailing their chosen troop and gradually reducing the distance between them (Glander, 1992). Upon meeting, howlers engage in a behavior known as the "greeting ceremony," characterized by a tight embrace that lasts several seconds (Glander, 1980). This interaction often includes soft grumbling vocalizations and sniffing of armpits and/or genitalia (Wang and Milton, 2003). Howler monkeys over two years old are known to only engage in ceremonies with males under two, avoiding interactions with peers of their own age or older (Glander, 1980).

Our observations are consistent with previous research on all except two counts: 1) The "tongue flicking" display is predominantly associated with sexual behavior in *Alouatta palliata* (Jones, 1985), making it notable that the lone male utilized this behavior to gain acceptance within the all-male group, 2) The "greeting ceremony" in our study also occurred between the lone male and a female howler. This is notable because previous studies state that participants of this behavior were always of the same sex (Glander, 1980).

During their solitary phase, males often focus on growing larger and stronger in preparation for confronting the alpha male of a troop, which is essential for gaining acceptance (Glander, 1992). Solitary males may opt to collaborate with other individuals rather than join an established group (Glander, 1992). Collective actions such as predator vigilance and alarm calling can also provide better protection from potential threats (Garber and Kowalewski, 2011). This could be an explanation for why the lone howler in our study chose to integrate with the other three individuals, seeking a strategic alliance rather than facing the challenges of solitary life. Research on lone male howlers indicates that these individuals tend to utilize smaller trees with lower-quality food resources for feeding and resting, likely as a competition avoidance strategy (Bolt, 2021). Belonging to a small group may signal to other groups that the individual is part of a cohesive unit, which could deter confrontations and increase the likelihood of the small group accessing better resources together. Consequently, lone male howler monkeys can boost their overall fitness by forming alliances with other males, leveraging social bonds to improve access to resources and reduce competition. A study on *Alouatta pigra* found that two males formed coalitions and successfully took over another group by evicting resident males, suggesting a potential strategy for taking over another troop (Van Belle, 2012). It would be interesting to investigate whether this tactic becomes a future survival strategy for the four males in our study.

Interactions between wild-born and captive-raised individuals of other primates have been reported, but there are few published reports on the details of these integrations. The successful integration of captive-raised individuals with wild counterparts is regarded as a key indicator of success for rehabilitation programs (Beck, 2018). Post-release monitoring of spider monkeys (*Ateles* spp.) revealed that some groups benefited from interactions with established groups, particularly during foraging activities (Pottie, 2021). It is very possible that recently released primates may benefit from these social learning opportunities and integration with wild individuals may reduce the stress of navigating a new environment.

To our knowledge, this is the first comprehensive report on rehabilitated howler monkeys successfully integrating with wild conspecifics. This marks a significant milestone in reintroduction efforts for these primates, not only contributing to our understanding of the social dynamics and behaviors involved but also underscoring the potential for captive-raised individuals to enhance their fitness through strategic alliances. Further research is essential to monitor the long-term outcomes of this integration, assess its effects on the behavior of both the solitary male and the captive-raised juveniles, and explore the broader implications for rehabilitation programs aimed at promoting successful reintegration into wild populations.

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FIRST RECORD OF TWINS IN WILD BLACK AND GOLD HOWLER MONKEYS (*ALOUATTA CARAYA*)

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Abstract

Twinning is a rare occurrence in non-callitrichid wild primates. Here we report an observation of twins in wild black and gold howler monkeys (*Alouatta caraya*). In May 2023, an adult female howler monkey was observed carrying twin infants that had been born the night before. The female was observed for 5 hours on the first day after birth. Both infants were observed to change positions on their mother frequently during their first day of life. Through long-term monitoring of the group, we can also report that the twins both survived their first year of life, longer than found in previous records of twins in other *Alouatta* species.

Keywords: Atelidae, Latin America, multiple-birth, Paraguay, reproduction

Resumen

Los nacimientos múltiples son eventos poco comunes en primates silvestres que no sean callitrichideos. Aquí informamos el primer registro en monos aulladores negros y dorados (*Alouatta caraya*) silvestres. En mayo del 2023 observamos a una hembra adulta de mono aullador trasladando dos crías que habían nacido la noche anterior. La hembra fue observada durante 5 horas el primer día después del nacimiento. Durante el primer día de vida, ambas crías cambiaron de posición con frecuencia sobre la madre. Atraves de monitoreamiento de largo plazo del grupo, podemos reportar que los gemelos sobrevivieron su primer año de vida, más que en registros anteriores de gemelos/mellizos de monos aulladores.

Palabras clave: América Latina, Atelidae, nacimiento múltiple, Paraguay, reproducción

Ñemombyky:

Ka'i kuera oikova ka'aguyrehe sa'i ojehecha heñoiva mokoi ojuehegua oñondive. Ape romombe'u ojehechaha ka'i karaja ra'y heñoiha mokoi ojohegua oñondive ka'aguype. Jasypo 2023 jave rohecha petei ka'i karaja kuña kakuava oraharamo ijapere umi ememby kuera heñoi va'ekue pe pyharepe. Heñoî rire pe arape romaña kuri pe kuñavare po aravo pokukue. Pe arape voi mokoiveva umi ka'i

ra'y rohecha ova ha ova py'ĩnde ysy aperehe. Upeguive añepyru ahai ko articulo. Umi ka'i ra'y kuera oikovepa pe ary pokukue. Hetave ara oikove hikuai ñambojojaramo umi ymave ejehecha vaykuegui.

Ñe'ẽ tenondegua: Latino Amerikape; Ñemoña; Paraguai; Teñoi ojuehegua; Teñoi Heta

Introduction

Single infant births are the norm for most species in the order Primates, with multiple infant births (such as twins or triplets) being rare outside the Callitrichidae (Chapman et al., 1990; Beltrán and Stevenson, 2012). Some species that typically give birth to a single offspring have been observed to have twin births, including macaques (*Macaca thibetana*, Xia et al., 2012), langurs (*Presbytis entellus*, Winkler et al., 1989), gracile capuchins (*Cebus imitator*, Manson, 1999), spider monkeys (*Ateles belzebuth belzebuth*, Link et al., 2006), and several species of howler monkeys (*Alouatta palliata*: Chapman and Chapman, 1986; *Alouatta seniculus*: Richard-Hansen et al., 2000; Beltrán and Stevenson, 2012, *Alouatta ululata*: Freire-Filho et al., 2025). In general, howler monkeys have a single-infant birth pattern, with a gestation period of around six months, and an interbirth interval of around 16 months (Rumiz, 1990; Kowalewski and Zunino, 2004; Pavé et al., 2010a; Kowalewski et al., 2015). In the genus *Alouatta,* the wild twin births that have been reported had low survival rates of infants apart from the recent case of *A. ululata* who were observed for a year until they became independent (Freire-Filho et al., 2025). In one case of twins, both of the *A. seniculus* infants disappeared soon after the first sighting and were assumed dead (Richard-Hansen et al., 2000). In a second twin birth in *A. seniculus*, one infant was still-born (asphyxiation by umbilical cord) and the other was live-born but died shortly after in an assumed infanticidal attack (Beltrán and Stevenson, 2012). In *A. palliata*, despite illness in the mother being observed 35 days after birth, the twin infants were observed to survive over the first year of life (Chapman and Chapman, 1986).

The black and gold howler monkey (*Alouatta caraya*) is found in northern Argentina, central and southwestern Brazil, Paraguay, eastern Bolivia and Uruguay (Bicca-Marques et al., 2021). Here we report the first known observation of twins in a wild group of *A. caraya*. The observation was made in the Estancia Santa Ana (-26.836120, -58.024260), a 700-ha privately owned cattle

Figure 1. *Alouatta caraya* twins, on their first day of life (May 24th 2023), observed in lateral contact with the mother as she feeds on palm fruits in the Ñeembucú Wetland Complex, Paraguay. Photograph credit: R. Taylor.

ranch located 27 km east of the city of Pilar, Ñeembucú department, Paraguay. The Ñeembucú Wetland Complex is a naturally mosaic habitat of grasslands, islands of humid Chaco gallery forest, grasslands and swamps. The gallery forest at Estancia Santa Ana naturally exists in small, fragmented patches that have not been altered by anthropogenic activity, despite the land being used for cattle ranching. Approximately 15 to 20 groups of *A. caraya* can be found on the property residing in such habitat patches (Kane and Smith, 2020; Fundación Para La Tierra, unpubl. data).

The newborn twins were observed during a research study on infant care behavior carried out from 14th May to 9th December 2023, as part of the long-term Fundación Para La Tierra Urban Howler Project (https://www.paralatierra.org/neembucuwetlands). During this time, 19 infants were recorded across six local *A. caraya* groups; all other cases were single births except the one described here. At the time of the first observation of the twins, the study group (a fully habituated group of eight) was composed of an adult male, three adult females, a sub-adult female, two juvenile males and a juvenile female. At 07:32 on 24th May 2023, an adult female was observed carrying two newborns. The group had been followed from dawn until dusk the previous day and no infants were present. The female carrying the twins was the only female in the group that had shown signs of late pregnancy, a strong indication that the twins were born to her on the night of the 23rd May 2023. The possibility that one infant was adopted from another female in the group is highly unlikely, as neither of the other two females had infants at that time (one of these other group females gave birth to an infant three months later, at the end of July 2023). Here we present information about the first day's observation of the newborn twins and their mother, and verify the twins' survival to at least one year old; a later publication will provide more details of the development of the twins over the first year of life.

During the first observation period of the twins (7:33–12:30 of 24th May 2023), both infants moved on the mother in ventral, lateral and dorsal positioning, but were predominantly in ventro-ventral contact with her, particularly during resting periods, whilst the mother carried them on her side during a travelling and a feeding bout (Fig. 1). During a group displacement, when the whole group travelled continuously for 7 minutes, the infants changed their positions continuously. The two infants did not appear to coordinate their movements on the mother or interact with each other on their first day of life. The mother was seen to actively interact with the infants, adjusting their contact position on two occasions; once to adjust their position on her ventral side prior to a group displacement, and once when a juvenile group member approached her.

For the majority of this first day of observation, the mother stayed distant (approximately 5 m) from other group members, being inactive but alert for extended intervals. During group movement, the mother did travel in close proximity behind an adult female. The adult male of the group was also observed to remain within 5 m of the mother for the majority of the first hour of observation, performing an affiliative reunion display with the mother on one occasion (Dias et al., 2008). On two other occasions the mother rejected agonistically the interaction of a juvenile male and an adult female, after which she then groomed a juvenile female with the newborns in ventro-ventral contact.

The infants, both later confirmed as female, were similar in size and appeared to develop physically at similar rates, in terms of independent locomotion, interaction with the environment, and interaction with other group

Figure 2. *Alouatta caraya* twins at about 5 ½ months old with their mother (12th October 2023). A) the mother foraging whilst hanging by her tail and carrying both infants; B) both infants being carried on the mother's back while she feeds. Photograph Credits: R. Taylor.

members (Fig. 2). Both survived their first year, however one disappeared (and is assumed to have died) in July 2024, just as the mother had a new infant. The surviving twin appears to be doing well (as of July 2025) (Fig. 3) and is monitored twice a week as part of the Fundación Para La Tierra Howler Monkey Research Programme.

In Paraguay, wild primates are impacted by extreme deforestation and land use change (Smith, 2021; Smith et al., 2021a). While the twins' howler monkey group inhabits a natural environment that until recently has only experienced low-intensity cattle ranching, industrial agricultural rice production is beginning to encroach into the Ñeembucú department (R. Smith pers. obs. Sept. 2023). This may lead to habitat loss and fragmentation, pesticide use and increasing domestic animal encounters in the forest. Evidence for the potential impact of these threats in the Ñeembucú Wetland Complex has already been observed through high numbers of congenital malformations (cleft lip and/or palate in the Estancia Santa Ana howler population) (Smith et al., 2021b), road kills (Fundación Para La Tierra, unpubl. data) and parasite infections (Kane and Smith, 2020; Fundación Para La Tierra, unpubl. data). With all of these risks added to the already documented low survival of *Alouatta* twins in the wild (Richard-Hansen et al., 2000; Beltrán and Stevenson, 2012) it is not yet known whether the surviving twin will make it to adulthood. However both survived until over a year old and were able to become more independent of their mother.

As no observable change in behaviour has been noted in *Alouatta* mothers with twins compared to singletons, it has been hypothesized that howler monkey females display maternal care behaviors suitable for caring for twins (Chapman and Chapman, 1986; Pavé et al., 2010b). Our observations that the newborns' primary positioning on their mother was ventral contact is in line with other studies of newborns in *Alouatta*. For singletons ventral positioning of newborn infants is standard, with exclusively ventral contact with the mother for at least the first day of life, and the subsequent transition to dorsal positioning is an important stage in infant development (Dias, 2005; Camargo and Ferrari, 2007). However, as records of twin births in *Alouatta* are so uncommon there are limited comparative data available. The surviving twin of Estancia Santa Ana, Ñeembucú will continue to be monitored long-term to document its development.

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Figure 3. Surviving twin in January 2025. Photograph Credit: W. Kobrinsky.

Ambiente y Desarrollo Sostenible of Paraguay (MADeS) and complied with all local laws. The study was non-invasive and followed the American Society of Primatology Code of Best Practices for Field Primatology (2014).

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News

PSGB FIELD SKILLS WORKSHOP

The Primatological Society of Great Britain offers a 3-day Field Skills Workshop aimed to develop theory and practice in field skills. This provides access, learning, and opportunities to develop and practice field skills, aimed at those who may have economic, time, or other constraints that might prevent them from being able to gain these skills in other ways. For more information visit https://www.psgb.org/pages/psgb-field-skills-workshop.

Recent Publications

BOOKS

Primate Socioecology: Shifting Perspectives, by L. A. Isbell. Johns Hopkins University Press, Kindle edition, 2024. ISBN: 978-1421448916. This book addresses scientific debates about primate social organizations. It discusses why some primates live alone while others live in pairs or groups. This new approach diverges from the traditional focus on predation pressure as the main determinant of primate social organization to reveal deeper ecological causes of primate behaviour. *Contents*: 1) Highlights in the history of primate socioecology; 2) Dispersal and philopatry; 3) The variable home range sharing model and its classification system for primate social organizations; 4) Movement strategies help identify constraints on home range expansion and their importance for female social organizations; 5) Beginning to test the variable home range sharing model; 6) Problems with predation as a selective force on primate social organizations; 7) Resolving the nocturnal/diurnal and solitary/group forager divides; 8) Male contributions to female social organizations; 9) Answers to some questions about the model.

How Primates Eat: A Synthesis of Nutritional Ecology across a Mammal Order, by J. E. Lambert, M. A. H. Bryer, J. M. Rothman, T. H. Clutton-Brock (eds.). University of Chicago Press, Kindle edition. 2024. ISBN: 978-0226829746. Exploring everything from nutrients to food acquisition and research methods, this book provides a comprehensive synthesis of the study of diet and feeding in nonhuman primates. State-of-the-art information presented at physiological, behavioural, ecological, and evolutionary scales will serve as a road map for graduate students, researchers, and practitioners as they work toward a holistic understanding of life as a primate and the urgent conservation consequences of diet and food availability in a changing world. *Contents*: 1) Finding, building and using a diet; 2) Nutrients, nutrition and food processing; 3) Food acquisition and nutritional social environments; 4) Methods, practice and application.

Neotropical Primates by A. B. Rylands, R. A. Mittermeier, J. W. Lynch, et al. Lynx Nature Books, 142pp. 2024. ISBN: 978-8416728503. Esta guía describe e ilustra las especies y subespecies de primates de América del Sur, América Central y México. Con un formato fácil de usar y muy práctico para el campo, la guía abarca todas las especies y subespecies de primates que se encuentran de manera natural en los Neotrópicos, así como tres especies africanas que han sido introducidas y que ahora son asilvestradas en algunas islas del Caribe.

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ABSTRACTS

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Meetings

IPS 30TH CONGRESS

The 30th congress of the International Primatological Society will be held from the 20th to 25th of July 2025, in Madagascar. This prestigious event is a cornerstone in the field of primatology, bringing together leading scientists, conservationists, educators, and policymakers from around the globe to discuss and advance primate research and conservation efforts. For more information visit https://ipsmadagascar.org/

14TH MEETING OF THE ASP AND THE 22ND MEETING OF THE MPIG

The 47th meeting of the American Society of Primatologists and the 22nd meeting of the Midwest Primate Interest Group will be held in Chicago on September 17th–20th 2025. For more information go to https://asp.org/asp-meetings/asp-chicago-meeting-2025/.

Notes to Contributors

Scope

The journal aims to provide a basis for conservation information relating to platyrrhine monkeys. We welcome texts on any aspect of primate conservation, including articles, thesis abstracts, news items, recent events, recent publications, primatological society information and suchlike.

Contributions

Manuscripts may be in English, Spanish or Portuguese, should be prepared with MS Word, and must use page and line numbering. The full name and address for each author should be included. Please avoid abbreviations and acronyms without the name in full. Authors whose first language is not the language of the manuscript submission should have their manuscripts carefully reviewed by a native speaker. To submit a manuscript on-line, please register at https://primate.socgen.ucla.edu/index.php/multivitaminic/user/register or you can send your contribution to: Jessica Ward Lynch, University of California, Los Angeles, email: jwlynx@g.ucla.edu. Manuscripts that do not conform to the formal requirements (formatting, style of references, etc.) will be returned to authors without review. They can be resubmitted, provided all formal requirements are met.

Articles. Each issue of *Neotropical Primates* will include up to three full articles, limited to the following topics: Taxonomy, Systematics, Genetics (when relevant for systematics and conservation), Biogeography, Ecology and Conservation. Text for full articles should be typewritten, double-spaced with no less than 12 cpi font (preferably Times New Roman) and 3-cm margins throughout, and should not exceed 25 pages in length (including references). Please include an abstract in the same language as the rest of the text (English, Spanish or Portuguese) and (optional) one in Portuguese or Spanish (if the text is written in English) or English (if the text is written in Spanish or Portuguese). An abstract in the local Indigenous language relevant to the study may also be included. Tables and illustrations should be limited to six, except in cases where they are fundamental for the text (as in species descriptions, for example). Full articles will be sent out for peer-review. For articles that include protein or nucleic acid sequences, authors must deposit data in a publicly available database such as GenBank/EMBL/DNA Data Bank of Japan, Brookhaven, or Swiss-Prot, and provide an accession number for inclusion in the published paper.

Short articles. These manuscripts are usually reviewed by the editors only. A broader range of topics is encouraged, including such as behavioral research, in the interests of informing on general research activities that contribute to our understanding of platyrrhines. We encourage reports on projects and conservation and research programs (who, what, where, when, why, etc.) and most particularly information on geographical distributions, locality records, and protected areas and the primates that occur in them. Text should be typewritten, double-spaced with no less than 12 cpi (preferably Times New Roman) font and 3-cm margins throughout, and should not exceed 12 pages in length (including references).

Figures and maps. Articles may include small color photographs, high-quality figures, and high-quality maps. (Resolution: 300 dpi. Column widths: one-column = 8-cm wide; two-columns = 17- cm wide). Please keep these to a minimum. We stress the importance of providing maps that are publishable. When reporting geographic coordinates please utilize one of the following formats consistently throughout the manuscript: DMS (degrees, minutes, seconds) standard 4°36'19.1"N, 74°3'20.7"W or DD (Decimal Degrees) 4.605306, -74.055750.

Tables. Tables should be double-spaced, using font size 10, and prepared with MS Word. Each table should have a brief title.

News items. Please send information on projects, field sites, courses, theses or dissertations recently defended, recent publications, awards, events, activities of Primate Societies, etc. to Brenda Solórzano brenda_solorzano@yahoo.com.mx.

References. Examples of house style may be found throughout this journal. In-text citations should be first ordered chronologically and then in alphabetical order. For example, "…(Fritz, 1970; Albert, 1980, 2004; Oates, 1981; Roberts, 2000; Smith, 2000; Albert et al., 2001)…"

In the list of references, the title of the article, name of the journal, and editorial should be written in the same language as they were published. All conjunctions and prepositions (i.e., "and", "In") should be written in the same language as rest of the manuscript (i.e., "y" or "e", "En" or "Em"). This also applies for other text in references (such as "PhD thesis", "accessed" – see below). Please refer to these examples when listing references:

Journal article
Stallings, J. D. and Mittermeier, R. A. 1983. The black-tailed marmoset (*Callithrix argentata melanura*) recorded from Paraguay. *Am. J. Primatol.* 4: 159–163.

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For references in Portuguese and Spanish:

"and" changes to "e" and "y" for articles in Portuguese and Spanish respectively. "In" changes to "Em" and "En" for articles in Portuguese and Spanish respectively.

"Doctoral thesis" changes to "Tese de Doutoramento" and "Tesis de Doctorado" for articles in Portuguese and Spanish respectively.

"MSc Thesis" changes to "Dissertação de Mestrado" and "Tesis de Maestría" for articles in Portuguese and Spanish respectively.

"Unpublished report" changes to "Relatório Técnico" and "Reporte no publicado" for articles in Portuguese and Spanish respectively.

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Contents

Articles

Efecto de la fragmentación y composición del paisaje sobre la presencia de *Ateles fusciceps rufiventris* en Colombia
Alma Hernández-Jaramillo, Juan Carlos Serio-Silva, Sam Shanee 1

The use of infrared thermography to diagnose effects of electric shock on the brown howler monkey (*Alouatta guariba*)
Maraya Lincoln Silva, Mayara Grego Caiaffa, Rodrigo Hidalgo Friciello Teixeira, Cássia Regina Ramos Gonzaga, Flora Nogueira Matos, André Luiz Mota da Costa 13

Effects of historical logging on squirrel monkey (*Saimiri macrodon*) population density and primate species richness in the Peruvian Amazon
John Rowland, Richard Bodmer, Miguel Antunez, Dave Seaman 19

Short Articles

Notas sobre la estructura de un grupo de *Alouatta seniculus seniculus* (Primates: Atelidae), en Limoncocha, Ecuador
Salomón M. Ramírez-Jaramillo, Alejandro Mesías, Lizbeth C. Andi-Grefa 28

Social integration of a lone wild howler monkey (*Alouatta palliata*) into a captive-raised troop in Costa Rica
Tesa Mendoza, Clara Martinez-Soares, Magdalena S. Svensson 32

First record of twins in wild black and gold howler monkeys (*Alouatta caraya*)
Rachel V. Taylor, Mikel Redin Hurtado, Matthew T. Owen, Rebecca L. Smith 36

News 41
Recent Publications 41
Meetings 45