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ASSESSMENT OF BLACK AND GOLD HOWLER MONKEY (*ALOUATTA CARAYA*, HUMBOLDT, 1812) POPULATIONS IN TWO NEW STUDY SITES IN NORTHEASTERN ARGENTINA

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Abstract

Alouatta caraya has the southernmost distribution of the howler monkeys. While information about most populations remains limited, the forests this species inhabits are being altered continuously. We present data about populations of *A. caraya* from two new study sites in northeastern Argentina: the "Laguna Oca" Biosphere Reserve (RLO) (26°14'S, 58°10'W), and the "Las Lomas" Private Reserve (RLL) (27°23'S, 58°22'W). We conducted censuses along roads within forest patches in both areas to find groups of *A. caraya*, counting all visible individuals, and classifying them by sex and age. We found only mixed sex groups in both areas, with a density of 1.12 individuals/ha in RLO and 2.05 individuals/ha in RLL. At other study sites in Argentina, *A. caraya* population densities vary from 0.11 to 3.25 individuals/ha, where forest continuity may be important in determining densities. Maintaining long-term study sites of *A. caraya* across different habitats will allow comparative analyses to explore the underlying mechanisms of behavioral, ecological, and demographic variability.

Keywords: Atelidae, population density, study sites, Chaco Region

Resumen

Alouatta caraya es la especie del género con distribución más austral. Información sobre la mayoría de sus poblaciones sigue siendo limitada, mientras los bosques que habitan están bajo continua modificación. Presentamos datos sobre poblaciones de *A. caraya* en dos nuevos sitios de estudio del nordeste de Argentina: la Reserva Biosfera "Laguna Oca" (RLO) (26°14'S, 58°10'O), y la Reserva Privada "Las Lomas" (RLL) (27°23'S, 58°22'O). Realizamos censos a lo largo de caminos dentro de parches de bosque en ambas áreas para encontrar grupos de *A. caraya*, contar los individuos visibles y clasificarlos por sexo y edad. En ambas áreas encontramos grupos mixtos con densidad de 1,12 individuos/ha en RLO y 2,05 individuos/ha en RLL. En otros sitios de estudio en Argentina, las densidades poblacionales de *A. caraya* varían de 0,11 a 3,25 individuos/ha, donde la continuidad del bosque parece ser un factor importante. Mantener sitios de estudio a largo plazo en diferentes hábitats nos permitirá comparar datos para explorar mecanismos subyacentes de la variabilidad conductual, ecológica y demográfica de *A. caraya*.

Palabras claves: *Mono aullador*, densidad, sitios de estudio, Región Chaqueña

Introduction

The genus *Alouatta* inhabits the broadest range of habitats of any Neotropical primate species (Crockett and Eisenberg, 1987; Di Fiore et al., 2011; Cortés-Ortiz et al., 2015). Fourteen species are currently recognized by the IUCN (2022); the distribution of the genus extends from southern Veracruz State in Mexico, through Central and South America to northern Argentina and Uruguay (Cortés-Ortiz et al., 2015). The black and gold howler monkey (*Alouatta caraya*) is the southernmost species (Brown and Zunino, 1994; Jardim et al., 2019). This species is a diurnal, arboreal, folivore-frugivore and is characterized by sexual dimorphism (males are larger than females) and dichromatism (adult males are black and females are golden, all infants are gold and males turn black during sexual maturation) (Kowalewski et al., 2019).

Alouatta caraya occupies diverse habitats in Argentina, including continuous forests, gallery forests, and flooded forests of the Chaco region (Brown and Zunino, 1994; Zunino et al., 2001). Populations of *A. caraya* are decreasing because of habitat loss, alteration, and fragmentation due to deforestation and urbanization (Kowalewski and Zunino, 1999; Zunino et al., 2007). These anthropogenic habitat alterations may increase the risk of emerging infectious diseases in wild-domestic interface areas (Kowalewski et al., 2011). Currently, *A. caraya* is listed as Near Threatened on the IUCN Red List of Threatened Species

(Bicca-Marques et al., 2021); as Vulnerable nationally in Argentina and Endangered in the provinces of Misiones and Corrientes where the species has suffered recurrent yellow fever outbreaks (Holzmann et al., 2010, Oklander et al., 2019). Information about most *A. caraya* populations remains limited. In Argentina, two populations of *A. caraya* close to the junction of the Paraguay and Paraná rivers have been the subject of long-term study, with monitoring ongoing for over 30 years in flooded and fragmented forests (Kowalewski et al., 2019). It is crucial to establish additional long-term study sites of populations of the same species to understand the adaptability of the genus *Alouatta*, developing a framework from which to understand behavioral variability, and demographic and life history patterns (Kappeler and Watts, 2012; Kowalewski et al., 2015).

Here we present data on populations of *Alouatta caraya* from two new study sites. One is a peri-urban reserve located to the west of the Paraguay River and the other is a private reserve below the Paraná River. Our aim was to identify group demography of *A. caraya* at the sites prior to the possible establishment of long-term field studies, including habituation of study groups.

Methods

The two study sites are the "Laguna Oca" Biosphere Reserve (RLO), in Formosa city, Argentina (26°14'S, 58°10'W), on the Paraguay River, 125 km above its confluence with the Paraná River, and the "Las Lomas" Private Reserve (RLL) in San Cosme, Corrientes province, Argentina (27°23'S, 58°22'W).

The RLO is on the outskirts of Formosa city (pop. 234,354) and functions as a recreation site with more than 20,000 visitors (local residents and tourists) per year (Figure 1). The 50 km^2 alluvial plain is made up of river bends, oxbow lakes, and inland deltas, which creates a mosaic ecosystem of wetlands surrounded by gallery forests and seasonally floodable savannas dominated by Copernicia alba palms and herbaceous species (Manzur, 2017).

The RLL is a 6.82 km^2 landscape of undulating sandy hills, and convex slopes where forests alternate with different types of grasslands and savanna (Carnevali, 1994).

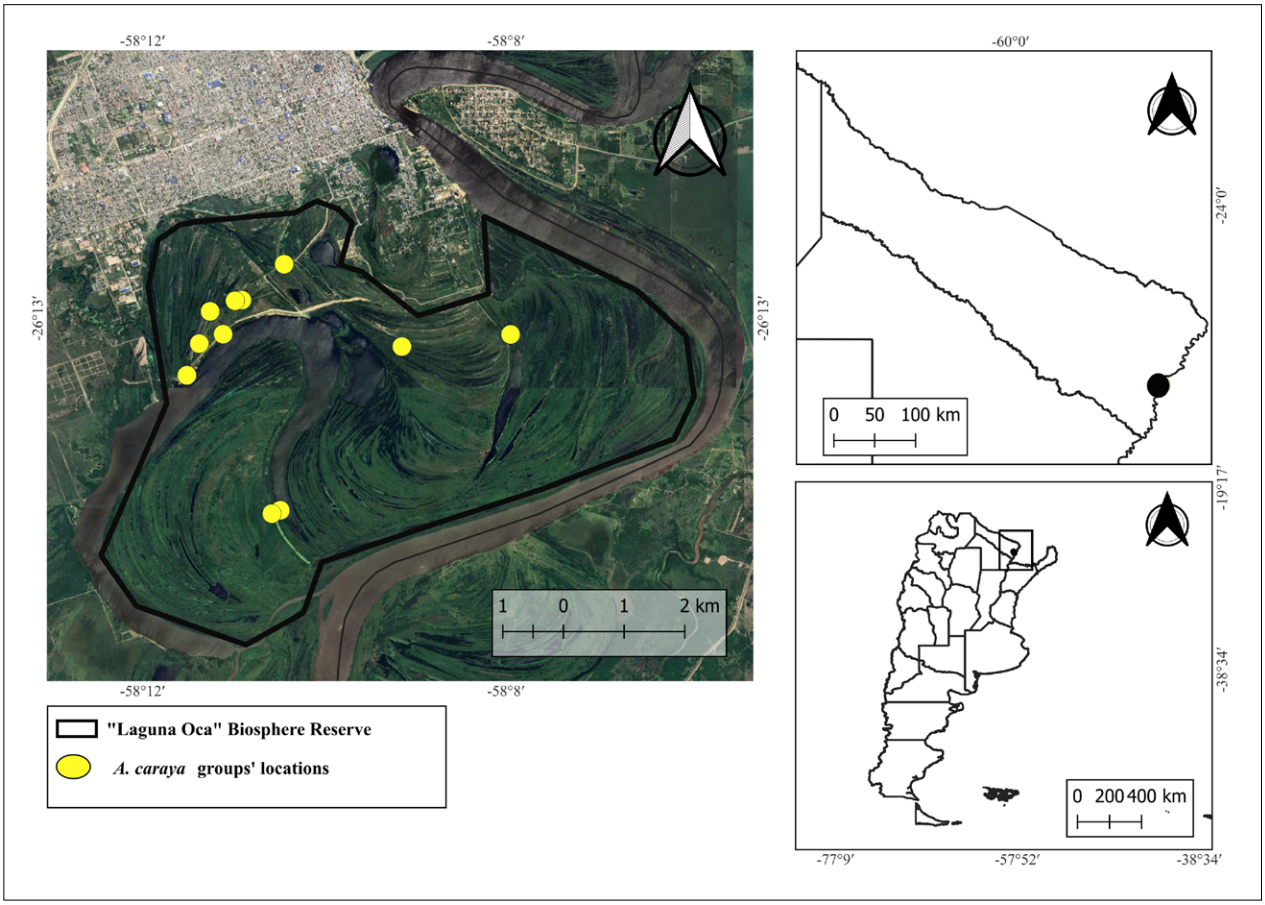

Figure 1. *Alouatta caraya* groups' locations in the "Laguna Oca" Biosphere Reserve (RLO), Formosa, Argentina. The lower inset map shows Formosa Province within Argentina, and the upper inset map shows Laguna Oca within Formosa.

Forest modification here is minimal, and mainly due to selective logging and livestock farming. In 2008, the RLL served as a study site for *Alouatta caraya*, where Bruno et al. (2012) and Milozzi et al. (2012) habituated groups to study behavior and parasite prevalence for one year.

We conducted censuses for 10 days between September 2021 and December 2021 in RLO and for 15 days between February 2022 and March 2022 in RLL. Censuses were made along roads within patches of forest in both areas. We surveyed each fragment with two teams of two field assistants walking at 1.5 km/h, with 150-200 m between each team to cover a wider area of each fragment. In this way, we could distinguish if animals detected simultaneously were part of the same, or different, groups. We were limited to surveying accessible forest patches. Certain areas in RLO and RLL were impossible to access due to the lack of roads or to being inaccessible islands.

We found *Alouatta caraya* by following their vocalizations, or spotting resting individuals, moving branches, or from fresh fecal material. Each time we found a group, we recorded their geographical location, counted all visible individuals and classified them into sex and age categories as suggested by Rumiz (1990) and Kowalewski (2007). Observers remained with the groups for one hour to conduct a total group count. We found differences in group counts between each survey, probably as some members were separated from the main group or out of sight in the canopy. Therefore, we considered the largest count of each visit for analysis.

Results

In RLO, we identified 82 individuals in 11 different groups. The groups ranged in size from three to 12 individuals (mean 7.5, SD ± 4.5), and a density of 1.12 individuals/ha. The study population consisted of mixed sex groups with one or more adult males in each group. Approximately 41.5% of individuals were adults, followed by sub-adults (33%), juveniles (17%), and then infants (8.5%) (Table 1). All groups within the reserve were found in patches of forest separated by roads and grasslands. The groups closer to public recreational areas of the reserve were already habituated to human presence and easily counted each time we found them. However, groups that were more distant were not habituated and tended to flee or howl at observers. A large part of the area could not be surveyed, due to the presence of water bodies. In the future, we hope to access these forests via boat.

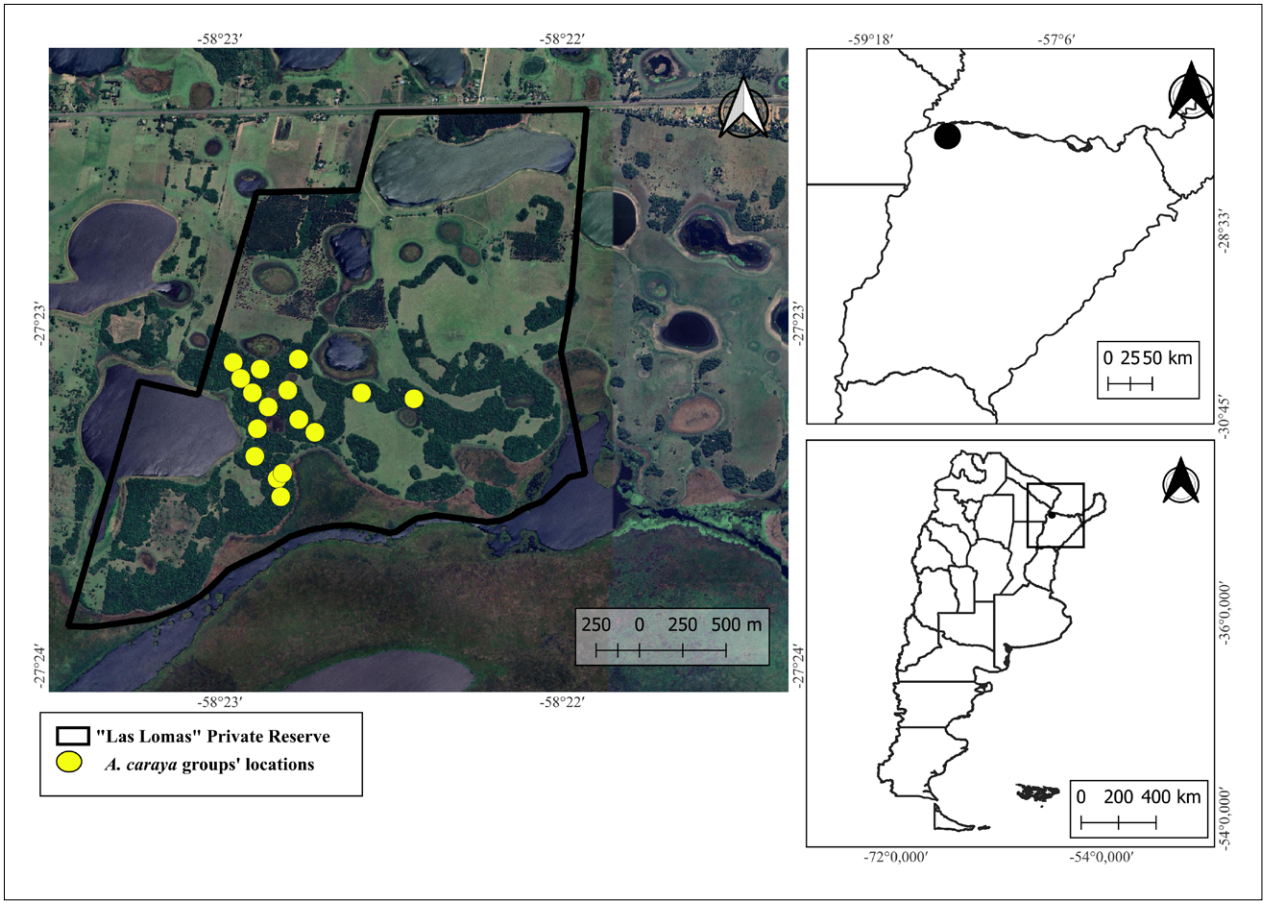

Figure 2. *Alouatta caraya* groups' location in the "Las Lomas" Private Reserve (RLL), Corrientes, Argentina. The lower inset map shows Corrientes Province within Argentina, and the upper inset map shows Las Lomas within Corrientes.

Table 1. Group size and composition of *Alouatta caraya* in "Laguna Oca" Biosphere Reserve (RLO), Formosa, Argentina.

Groups	AM	AF	SAM	SAF	JM	JF	I	Total
I	3	2	2	1	1	1	2	12
II	2	1	2	1	1	1	-	8
III	1	2	2	1	-	1	1	8
IV	1	2	3	-	1	1	-	8
V	3	2	1	1	1	1	1	10
VI	2	1	2	2	1	1	1	10
VII	2	1	1	1	-	-	-	5
VIII	1	1	1	1	-	2	1	7
IX	2	1	1	1	1	-	1	7
X	1	1	-	2	-	-	-	4
XI	2	-	1	-	-	-	-	3
Total	20	14	16	11	6	8	7	82

AM: Adult male; AF: Adult female; SAM: Sub-adult male; SAF: Sub-adult female; JM: Juvenile male; JF: Juvenile female; I: infant.

In RLL, we encountered 99 individuals from 15 different groups. Group size ranged from three to 15 individuals (mean 6.6, SD ± 3.01), and a density of 2.05 individuals/ha. All groups consisted of mixed sexes with one or two adult males in each group. Most individuals were adults (54.6%) followed by sub-adults (24.2%), juveniles (17.2%), and infants (4%) (Table 2). The groups were found in interior forest where taller and bushier trees were predominant. The monkeys were not habituated to human presence, tended to howl at observers and remained alert without doing other activities.

Discussion

To our knowledge, this is the first time that groups of *Alouatta caraya* have been recorded and studied in the "Laguna Oca" Biosphere Reserve. Groups of *A. caraya* have previously been studied in Formosa, Argentina in the gallery forests of the Guaycolec Ranch (25°54'S, 58°13'W) (Arditi and Placci, 1990; Dvoskin et al., 2004; Juarez et al., 2005) where mean group size was reported as 8.5 and a density of 0.11 individuals/ha. Previous studies also mentioned increasing population sizes after recovery from an apparent botfly epidemic in the early 1980s, with populations having a relatively large number of juveniles, infants, and reproducing adult females in studies in the 1990's (Dvoskin et al., 2004, Juarez et al., 2005). The Guaycolec Ranch and RLO both consist of fragmented patches of forest, but with differing levels of anthropogenic disturbance. The RLO has a higher level of human alteration due to its proximity to the city, while the forests of Guaycolec Ranch are considered "naturally fragmented" and remain less altered. *A. caraya* density was higher in RLO than the last study in Guaycolec Ranch. Populations in Guaycolec are possibly still recovering from the botfly epidemic, or perhaps the presence of another species of primate (*Aotus azarae*) at this site may result in a lower *Alouatta caraya* density.

Alouatta caraya density at Isla Brasilera (an island with continuous flooded forest in the Middle Parana River, 27°18'S, 58°38'W) is 3.25 individuals/ha (Kowalewski et al. 2019). Another long-term study site, Estación Biológica Corrientes (EBCo) (a mainland fragmented forest, 27°30'S, 58°41'W) has a density of 1.04 individuals/ha (Kowalewski and Zunino, 2004; Zunino et al., 2007; Kowalewski et al., 2019). EBCo and RLL have similar forest structure and composition, however EBCo has suffered intense deforestation and habitat modification through the years, and was recently further damaged by massive fires in late 2020, where half of the *A. caraya* groups died (Heidt, 2020; Smichowski et al., 2021). In 2020-2022, fires affected a large part of Corrientes province, including areas with populations of *A. caraya* where numerous individuals died in the fires or escaping from fires (Heidt, 2020). Therefore, establishing a long-term study site in this area, and describing the current group structure after the fires is necessary.

RLL is of potential importance as a long-term study site from which to compare the effects of habitat degradation and modification on *Alouatta caraya* populations. RLL has a higher density of *A. caraya* than RLO and EBCo but lower than the flooded forest in Isla Brasilera (Kowalewski et al., 2019). Isla Brasilera has continuous forest, which allows overlapping group home ranges and a tendency to frequent intergroup encounters, which allows exchange of information between groups, such as availability of dispersal partners, and reproductive status of females (Kowalewski et al., 2019). On the mainland, home range overlap is more unusual due to the distance between fragments reducing the chances of more than one group occupying the same patch (Kowalewski et al., 2019).

Forest continuity may be an important factor in determining *Alouatta caraya* densities across study sites

Table 2. Group size and composition of *Alouatta caraya* in "Las Lomas" Private Reserve (RLL), San Cosme, Corrientes, Argentina.

Groups	AM	AF	SAM	SAF	JM	JF	I	Total
I	2	2	1	-	-	-	1	6
II	2	3	2	-	2	-	1	10
III	1	1	2	-	-	-	1	5
IV	2	2	1	-	1	-	-	6
V	1	4	4	2	2	2	-	15
VI	2	3	1	-	-	1	-	7
VII	2	2	1	-	-	-	-	5
VIII	1	2	1	1	2	1	-	8
IX	2	1	-	1	-	1	-	5
X	2	2	2	-	1	-	-	7
XI	2	1	1	-	1	3	-	8
XII	1	1	-	1	-	-	-	3
XIII	1	1	-	1	-	-	-	3
XIV	2	3	2	-	-	-	1	8
XV	1	2	-	-	-	-	-	3
Total	24	30	18	6	9	8	4	99

AM: Adult male; AF: Adult female; SAM: Sub-adult male; SAF: Sub-adult female; JM: Juvenile male; JF: Juvenile female; I: infant.

(Figure 3, Table 3). Isla Brasilera has a higher density of *A. caraya* and completely continuous forest, followed by RLL where little anthropogenic fragmentation has occurred, while RLO and EBCo have similar densities and are the sites with the highest levels of fragmentation and human impact. Guaycolec Ranch has the lowest *A. caraya* density, but with no human alteration. There are several proposed hypotheses to explain why densities differ between sites, such as food availability (Kowalewski and Zunino, 2004), group dynamics, and history (Kowalewski et al., 2019) or the presence of sympatric primate species. Maintaining long-term study sites of *A. caraya* across different habitats will allow comparative data analysis to explore the underlying mechanisms of behavioral, ecological, and demographic variability (Kowalewski et al., 2015).

Both proposed study sites have existing infrastructure that will be useful for researchers. The RLO, as a public reserve, has a camping area, as well as a building where researchers can store equipment. The owner of RLL has offered a house that could function as a field station for future researchers. Both areas are close to towns (5-10 km) with easy access along paved routes. It is necessary to further investigate the status of *Alouatta caraya* in both areas to promote them as long-term study sites to examine how different environmental variables effect the conservation of the black and gold howler monkey in Argentina.

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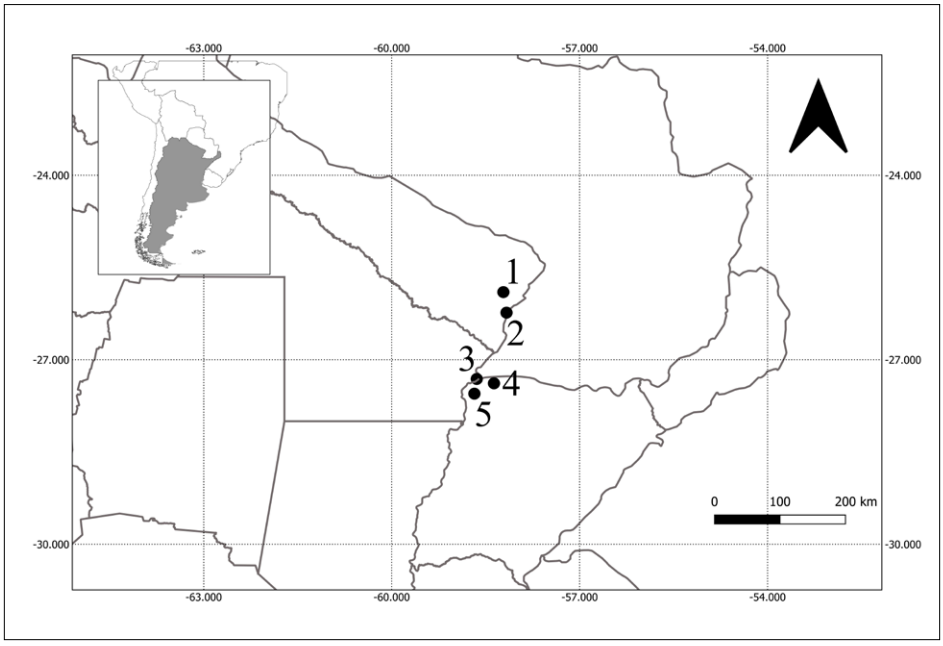

Figure 3. Location of study sites for *Alouatta caraya* in northeastern Argentina. 1) Guaycolec Ranch, Formosa, 2) "Laguna Oca" Biosphere Reserve, Formosa, 3) Isla Brasilera, Chaco, 4) "Las Lomas" Private Reserve, Corrientes, 5) Estación Biológica Corrientes, Corrientes.

Table 3. Ecological and population characteristics of study sites and *A. caraya* in northeastern Argentina.

	Laguna Oca	Las Lomas	EBCo	Isla Brasilera	Guaycolec Ranch
Lat. Long.	26°14'S, 58°10'W	27°23'S, 58°22'W	27°30'S, 58°41'W	27°18'S, 58°38'W	25°54'S, 58°13'W
Region	Humid Chaco	Humid Chaco	Humid Chaco	Humid Chaco	Humid Chaco
Forest Continuity (*)	GF FA	GF C-F	GF FA	FF C	GF C-F
Years studied	2021	2012, 2022	1982-current	1997-current	1981, 2001
Density	1.12 individuals/ha	2.05 individuals/ha	1.04 individuals/ha	3.25 individuals/ha	0.11 individuals/ha
Mean Group Size	7.5	6.6	10.9	9.4	8.5
Source	This study	This study	1, 2	2	3-5

* **GF:** Gallery Forest, FF: Flooded Forest, C: Continuous, C-F: Continuous with isolated fragments, FA: Fragmented by anthropogenic activities.
References: 1) Zunino et al. 2007, 2) Kowalewski et al. 2019, 3) Arditi and Placci 1990, 4) Dvoskin et al. 2004, 5) Juárez et al. 2005.

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Conflict of interest statement: The authors declare none.

Research ethics: The study complied with the current laws and permission of Argentina.

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