

Discovery of New Populations of Southern Muriquis (*Brachyteles arachnoides*) in Paraná, Brazil, and Implications for the Species' Conservation

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Abstract: The muriquis, *Brachyteles*, are the largest of the Neotropical primates. The southern muriqui, *Brachyteles arachnoides* is endemic to the Brazilian Atlantic Forest, occurring in the states of Rio de Janeiro, São Paulo and Paraná. It is categorized as Critically Endangered on the IUCN Red List of Threatened Species. In 2019, only four populations were known to occur in Paraná, in the municipalities of Castro, Doutor Ulysses, Sengés and Adrianópolis. Between 2019 and 2021, we searched for further locations in the state where they might still occur. Having identified sites where people indicated that muriquis were present, we searched for them using direct (sightings and calls) and indirect methods (carcasses, fecal samples and odor). We were able to find six new populations in three municipalities, Castro (Morro do Capim and Ribeira), Cerro Azul (Água Morna, Pinhalzinho and Pinhal Grande) and Campo Largo (Erva). All were in forest patches on private properties. Our findings extend the known southern limit of their geographic distribution, provide new information on their ecology, and reinforce the need to create legally protected areas to ensure the conservation of this species at the southern limit of its range.

Keywords: Neotropical biodiversity, primate conservation, threatened species, Brazilian Atlantic Forest

Introduction

The southern muriqui, *Brachyteles arachnoides* (É. Geoffroy Saint-Hilaire, 1806), and its northern congener, *Brachyteles hypoxanthus* (Wied, 1820), are the largest non-human primates of the Americas (Nishimura *et al.* 1988), endemic to the Atlantic Forest, and Critically Endangered (CR) (Talebi *et al.* 2019; Melo *et al.* 2021).

Southern muriqui populations are distributed from the north of Rio de Janeiro state, eastern São Paulo state, and the northeast of Paraná state (Aguirre, 1971; Strier *et al.* 2017). In São Paulo, its range extends west into the municipality of Anhembi (Talebi and Soares 2005; Cunha *et al.* 2009; Ingberman *et al.* 2016). Most of the populations in Rio de Janeiro and São Paulo are in forest remnants at an advanced stage of natural succession and under some degree of protection (Coles 2009; Breves *et al.* 2013; Boubli *et al.* 2010; Talebi and Lee 2010; Coles *et al.* 2012). This is not the case for the populations in Paraná.

Krieg (1939 *apud* Hill, 1962) was the first to record the presence of muriquis in the state of Paraná, mentioning the northern region of the Rio Ribeira de Iguape basin as part of the species' range. Aguirre was the first to give precise

localities (Aguirre 1971). He mentioned the species' occurrence in the municipalities of Sertaneja and Marilena, both near the banks of the Rio Paranapanema, but with no indication of group size or sex/age composition. These two populations have been extirpated.

In the 1990s, Martuscelli *et al.* (1994; see also Rylands *et al.* 1997, 1998) indicated that they occurred in the municipalities of Guaraqueçaba and Jaguariaíva. The first actual confirmation of the species' occurrence in Paraná was made by Koehler *et al.* (2002), who found them in the municipality of Castro, on the left bank of the Rio Ribeira de Iguape. Based on information from local residents, Koehler *et al.* (2005) later pointed to the possibility of their occurrence in the municipality of Doutor Ulysses, near the rios Teixeira and Turvo.

In 2016, the second documentation of the species' occurrence in Paraná, Ingberman *et al.* (2016; S2 Table) listed the Fazenda Olho D'Água in the municipality of Doutor Ulysses (B. Ingberman and N. Kaminski, pers. obs.) along with three localities in the municipality, of Castro – Abapã, Fazenda João Paulo II, and Fazenda Santana. Fialek *et al.* (2020) reported the existence of two new locations with muriqui

populations: one in the municipality of Sengés, in the Private Natural Heritage Reserve (RPPN) Vale do Corisco, in the Alto Rio Paranapanema valley, and the other in the Fazenda Taquarussu, in the Vale do Ribeira, near the 27,000-ha Lauráceas State Park, in the municipality of Adrianópolis.

In this study, we present records of six new locations in the state, its geographic distribution to the south, as well as data on the composition of these new groups. Finally, we discuss some aspects for the conservation of the species in Paraná.

Methods

We recorded the occurrence of *Brachyteles arachnoides* during fieldwork of the Monos Conservation Project in Paraná, which includes demographic monitoring of known populations and the search for new populations of the species in the state. The records presented here were obtained between the 2019 and 2021 in the Rio Ribeira de Iguape basin, Paraná. This region has a temperate climate with mild and humid weather throughout the year (Köppen classification: Cfb: Alvares *et al.* 2013). The original vegetation is an ecotone of two types of Atlantic Forest: dense rainforest and *Araucaria* rainforest, the distribution of which depends on altitude (Castella and Brites, 2004), which in the study area, ranges from 100 m to 1100 m above sea level.

We first carried out semi-structured interviews with local residents to identify potential sites for the species occurrence in the region. We considered that a site had potential when the local residents described correct morphological and behavioral aspects of the mureiqui, correctly distinguishing this species from the other primates known to occur in the area. Following this, we set up field surveys to search for their presence. Verification was by direct methods, sightings and calls – staccatos mainly produced in short-range vocal exchanges and neighs, typical of long-range exchanges (Mendes and Ades, 2004) – and indirect methods – carcasses, fecal samples and odor (Jerusalinsky *et al.* 2011). Drone overflights and call playback sessions were used to increase the probability of detecting them.

Once a group was found, individuals were counted, respecting the criteria “only individuals moving in the same direction” in order to avoid double-counting and overestimating the group size. Age and sex composition of these individuals were also recorded, following Strier *et al.* (2006).

Results

We found previously unrecorded populations of the species in six localities: two in the municipality of Castro – Morro do Capim and Ribeira; three in the municipality of Cerro Azul – Água Morna, Pinhal Grande and Pinhalzinho; and one in the municipality of Campo Largo – Erva (Fig. 1).

Local residents strongly suggested the occurrence of at least one group of mureiquis at Morro do Capim, Castro (49°41'25.10"W, 24°50'23.42"S) (Fig. 1: locality 8).

During fieldwork, at around 16:00 on 30 April 2019, we heard vocalizations and noticed the smell of urine and feces. Although we failed to see the group, the evidence was sufficient to confirm the presence of the mureiquis at this site.

During a field survey at Ribeira, Castro (49°41'45.84"W, 25°0'31.42"S) on 30 September 2019, we found feces in two different places, and heard them calling at one of them (Fig. 1: locality 9). Again, although we were unable to see them, the evidence was sufficient to confirm the presence of the mureiquis at this site.

On 14 July 2020, at 12:45, a group was sighted in the locality of Água Morna, Cerro Azul (49°31'54.13"W, 24°45'25.65"S) (Fig. 1: locality 5). We counted the group members twice on the first day and counted six individuals: one female with an infant, three adult males and a juvenile of undefined sex. The next day we caught up with them on three occasions and were able to count nine: one female with an infant, six adult males, and two young ones, one of which was a male (Fig. 2).

The fourth record took place in Pinhalzinho, Cerro Azul (49°31'28.79"W, 24°49'21.46"S), where a group of mureiquis was found at 10:50 on 14 January 2021, after reports from local residents (Fig. 1: locality 7). The group was located by their calling, and we were able to count nine individuals. We determined the sex and age of three of them: two adult males and an adult female. The forest fragment was bordered by a *Eucalyptus* plantation. We saw the mureiquis entering the plantation, the first documented sighting of the species in a *Eucalyptus* plantation (Fig. 3).

On 4 August 2021, at 17:15, a group was recorded in the locality of Pinhal Grande, Cerro Azul (49°31'2.47"W, 24°48'12.25"S) (Fig. 1: locality 6). Six adult individuals were counted moving through a native forest fragment (Fig. 4). An aerial drone allowed us to count six males. According to local residents, this forest is inhabited by a group of about 20 mureiquis.

The sixth record was obtained on 6 December 2021, at 10:35, at the locality of Erva in Campo Largo (49°41'00.3"W, 25°07'25.8"S) (Fig. 1: locality 10). At the time, only a single female was seen (Fig. 5) but local residents told us that the group had at least nine individuals. This record is significant in that it is the first documentation of the species' presence on the right bank of the Rio Ribeira de Iguape.

Discussion

It was believed that the southern boundary of the range of the southern mureiqui in Paraná was the left (north) bank of the Rio Ribeira de Iguape (Ingberman *et al.* 2016). Our finding of mureiquis at Erva, in the municipality of Campo Largo, extends its range south, to the right bank and raises the possibility that they may occupy other forests along the right bank and even further south towards the Curitiba metropolitan region and in the vicinity of the Devonian Escarpment that faces east in the south-east of Paraná.

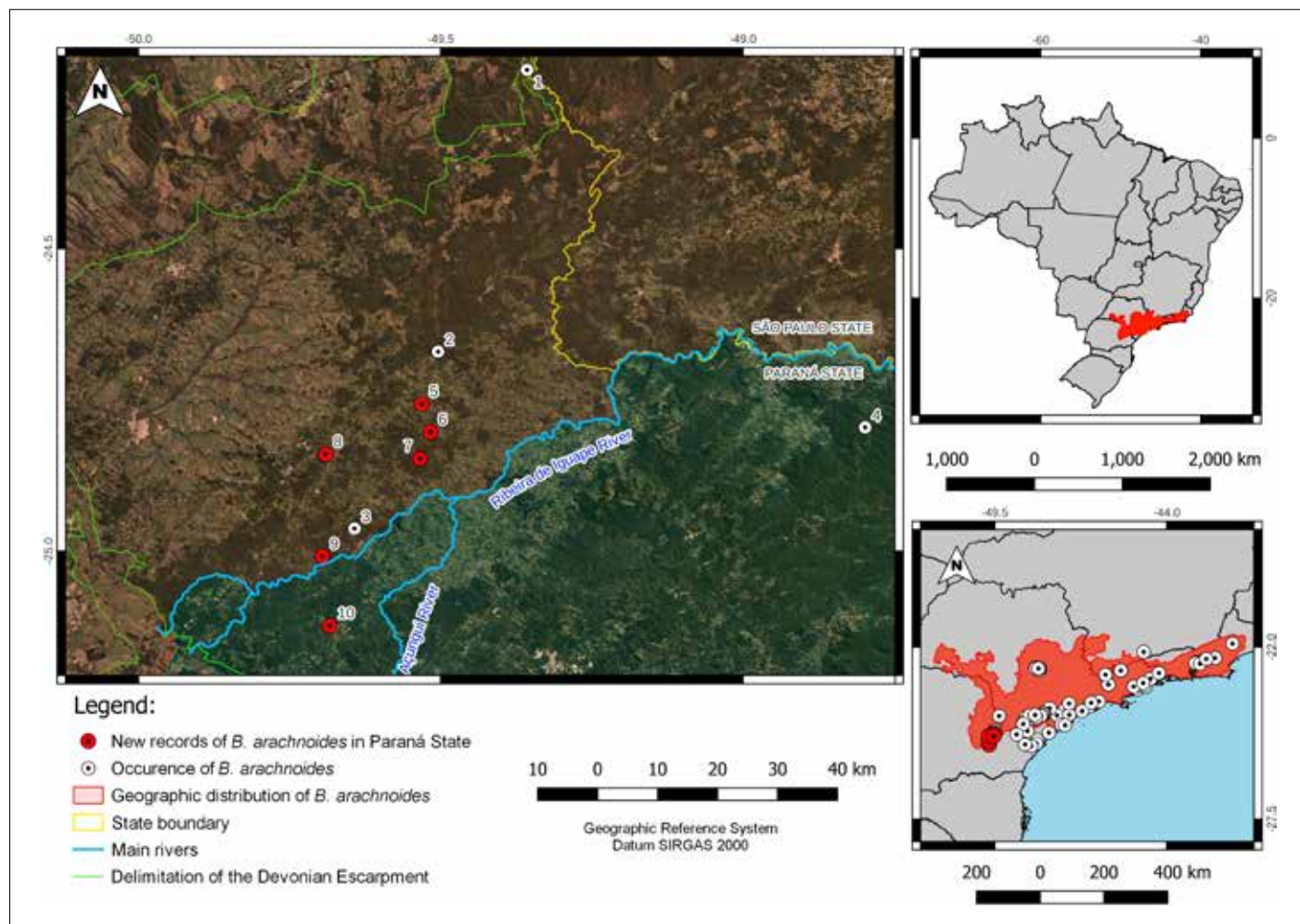


Figure 1. Geographic distribution of *Brachyteles arachnoides*, adapted from Ingberman *et al.* (2016). The entire range is shown in red in the two maps on the right. The larger map details the occurrence of the species in the state of Paraná. Red circles – localities of the new southern muriqui records. White circles – historical and current occurrence records (Brazil, CPB/ICMBIO, 2020).

These new localities are forest patches in the northeast region of Paraná. These native forest remnants are composed of secondary vegetation in various stages of ecological succession and are ≤ 1000 ha, interspersed with extensive areas of forestry, mining, grazing and subsistence agriculture (Koehler *et al.* 2005; Hack *et al.* 2017).

This landscape situation reflects the deforestation in the state that has been occurring since the beginning of the 20th century, where this region was the first to be explored, along with the northern region, for the timber industry and coffee plantations, respectively (Gubert Filho 2010). According to Maack (1968), deforestation in the Rio Ribeira de Iguape basin ceased around the 1930s, when secondary forest dominated the landscape. This scenario of forest fragmentation is also found in many localities where *Brachyteles* populations occur elsewhere in South-east Brazil (Mendes *et al.* 2005; Melo and Dias 2005; Talebi and Soares 2005; Strier 2007) and has led to the continuous isolation of small populations that has an insidious effect on their viability (Strier 1993/1994).



Figure 2. An adult male southern muriqui in a forest fragment in the locality of Água Morna, municipality of Cerro Azul, Paraná (49°31'46.06"W, 24°45'28.62"S).



Figure 3. An adult male southern murrelet in a *Eucalyptus* plantation in the locality of Pinhalzinho, municipality of Cerro Azul, Paraná (49°31'28.79"W, 24°49'21.46"S).



Figure 4. An adult male southern murrelet in the locality of Pinhal Grande, municipality of Cerro Azul, Paraná (49°31'12.47"W, 24°48'12.25"S).



Figure 5. A subadult female southern muriqui recorded in the locality of Erva, in the municipality of Campo Largo, Paraná (49°41'00.3"W, 25°07'25.8"S).

The southern muriqui prefers tall forest (Talebi and Soares, 2005), and the situation in Paraná highlights its behavioral plasticity in tolerating different degrees of disturbance, as is the case for a number of populations of its congener, the northern *Brachyteles hypoxanthus* in the states of Minas Gerais, Espírito Santo and Bahia (Strier 2007, 2021; Strier and Mendes 2012).

This fragmentation is of particular concern for the group found in Água Morna, Cerro Azul. The landscape matrix is dominated by pasture, agriculture and pine plantations, and the largest patch of native forest there is approximately 10 ha and the total forest habitat available at this site, is approximately 50 ha. These forest patches are separated by distances of at least 50 m. From our observations and reports from local residents, the muriquis are also threatened

by forest fires, illegal capture for sale, and hunting. Under this scenario the persistence of this group (nine individuals) is unlikely if no conservation measures are taken.

Compared to the more widespread geographic distribution in the states of Rio de Janeiro and São Paulo, the survival of these tiny, fragmented populations in Paraná is precarious and critical. Based on the results presented here for the populations of Cerro Azul (Água Morna, Pinhalzinho and Pinhal Grande) and the counting of the individuals existing in the documented populations located in Doutor Ulysses (Ingberman *et al.* 2016), Castro (Hack *et al.* 2017) and Sengés (Fialek *et al.* 2020), we currently know that about 62 individuals live in the state of Paraná. According to Strier *et al.* (2017), population estimates for the species in the state of Rio de Janeiro total less than 400

free-living individuals and less than 950 mature individuals in São Paulo. Unlike the populations of the states of Rio de Janeiro and São Paulo, where most inhabit legally protected areas, most of the recorded southern miquis groups in the state of Paraná occupy private lands. With the exception of the recent population in the Vale do Corisco private reserve (RPPN) (Fialek *et al.* 2020), none are in strictly protected areas.

Our results extend the findings of previous studies, and emphasize that measures to protect the southern miquis populations by public and private institutions are urgent. The discovery of miquis at Erva call for further surveys to search for other populations to the south, and projects involving citizen science (Nery *et al.* 2021) and local residents to monitor the miquis populations are a crucial next step. A better understanding of the status of these populations can provide the basis for local society and government agents to improve public policies aimed at restoring forest areas to improve landscape connectivity and seek opportunities to reconcile species protection with current and planned land use in the area. Management options should be examined to improve the conservation prospects of the southern miquis in the state of Paraná.

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