Update of the Project **Understanding Capuchin Bark Stripping Behaviour: from Conflict to Primate-Friendly Forestry (ID 42099-2)**

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This project aims to understand the ecology of black capuchin monkeys (*Sapajus nigritus*) in pine plantations of northeastern Argentina. This case study serves as an example to better understand how primates adapt to land-use conversion. At least 67 primate species use tree plantations for key activities such as foraging and resting (Galán-Acedo et al. 2019). Moreover, 13 of them, including black capuchins, engage in bark-stripping of planted trees to consume inner tissues (phloem and cambium). While adaptive, this behaviour causes economic losses for timber producers, leading to human-primate conflict (Di Bitetti 2019).

Pine plantations are simplified and suboptimal habitats for many mammals (Iezzi et al. 2019). The combination of habitat constraints and conflicts with producers further threatens primate populations. However, the ecology of primates living in plantation landscapes remains poorly understood, likely leading to ineffective primate-friendly forestry practices (Di Bitetti 2019). In response to bark-stripping, some producers have resorted to unethical and often illegal methods, such as killing monkeys (Di Bitetti 2019).

This project follows a three-step approach: 1) Understanding movements and trophic ecology of capuchins living in pine plantations; 2) Testing a primate-friendly strategy to mitigate bark-stripping and promote coexistence between primates and producers; and 3) Disseminating and refining information together with producers, adapting to their scale of production. To achieve these goals, we have been conducting monthly monitoring of seasonal variations in bark-stripping intensity over three years across 2,000 pine trees. We have also analyzed its relationship to profitability, which, according to the Optimal Foraging Theory (Stephens & Krebs 1986), is the ratio between energy intake from a resource and the handling time required to obtain it. For this, we measured variations in phloem thickness and nutrient content (energy intake) and the force

required to peel off the bark (a proxy for handling time). Nutrient analysis is still ongoing, but all samples have been collected.

We have also studied the movement and space use of six black capuchin groups in plantations and compared their patterns with long-term data from a nearby protected area, Iguazú National Park (Janson et al. 2012). In 2022 and 2023, we conducted two trials to test the effectiveness of the diversionary feeding technique as a primate-friendly solution to bark-stripping (Kubasiewicz et al. 2016). These trials included four black capuchin groups in 2022 and two groups in 2023. We are also organizing participatory workshops to discuss the feasibility and challenges of implementing diversionary feeding. The results will be compiled into tailored manuals, explaining: The ecological and behavioral drivers of bark-stripping, The ecological importance of black capuchins and other primates and sustainable management practices to mitigate bark-stripping

Methods and Preliminary results

Causes behind bark-stripping

Our bark-stripping surveys indicate that this behaviour is highly seasonal and strongly associated with specific pine stand ages, which facilitates more efficient management planning. Bark-stripping was concentrated between late winter (July) and early spring (October) (Figure 1). Although nutrient content analyses are still pending, we estimated phloem thickness using a Trephor hammer and measured the force required to peel off bark using a dynamometer (see photo 3 and 4 below). These measurements were taken in the upper half of trees, where capuchins predominantly engage in bark-stripping, and were conducted across a two-year cycle. The results indicate that phloem thickness increases from June to September, while the force required to peel off bark decreases from July to September (Figure 2). These findings support the hypothesis proposed by Di Bitetti (2019), which suggests that bark-stripping is linked to an increase in pine phloem profitability. This partially aligns with a hypothesis previously proposed for the same primate species in Brazil (Mikich & Liebsch 2014a), which classified pine phloem as a fallback food, consumed when other food resources are scarce. However, mitigation techniques based on this explanation, such as food supplementation trials, have been unsuccessful (Mikich & Liebsch 2014b), suggesting that the underlying causes of bark-stripping may be more complex than initially thought.

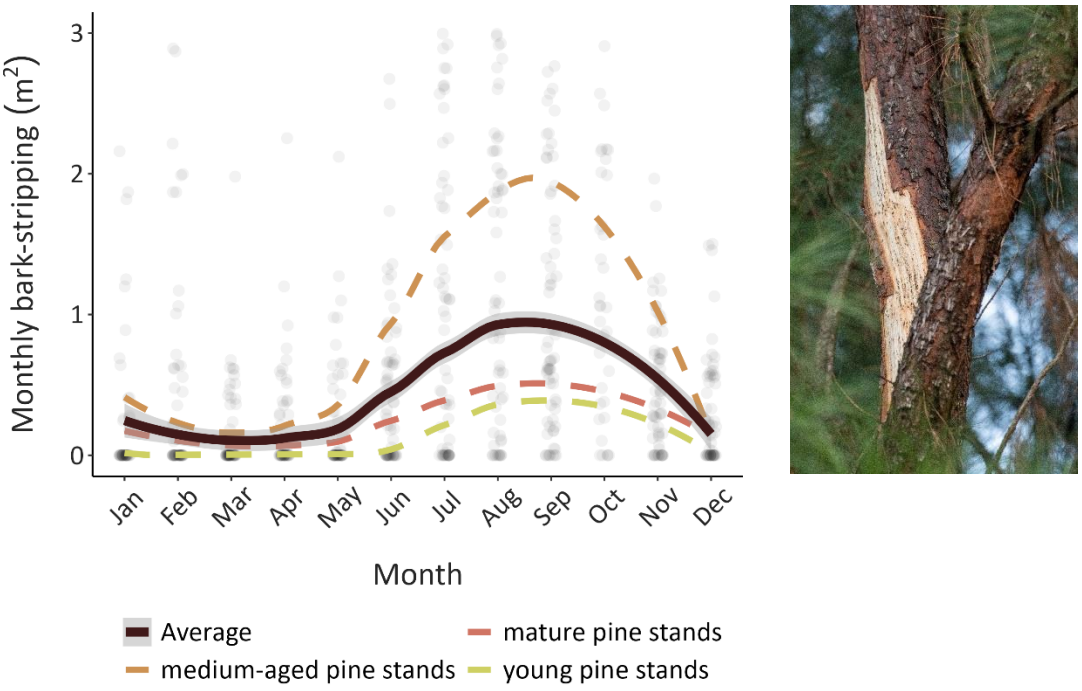


Figure 1. Monthly bark-stripped area by black capuchin monkeys (*Sapajus nigritus*) in pine plantations (*Pinus taeda*) of northeastern Argentina. Monitoring was conducted from 2021 to 2023 on 2,000 pine trees, categorized into three age classes: young stands (0–4 years), medium-aged (5–8 years), and old stands (9–13 years). Photo: Hernando Rivera (left).

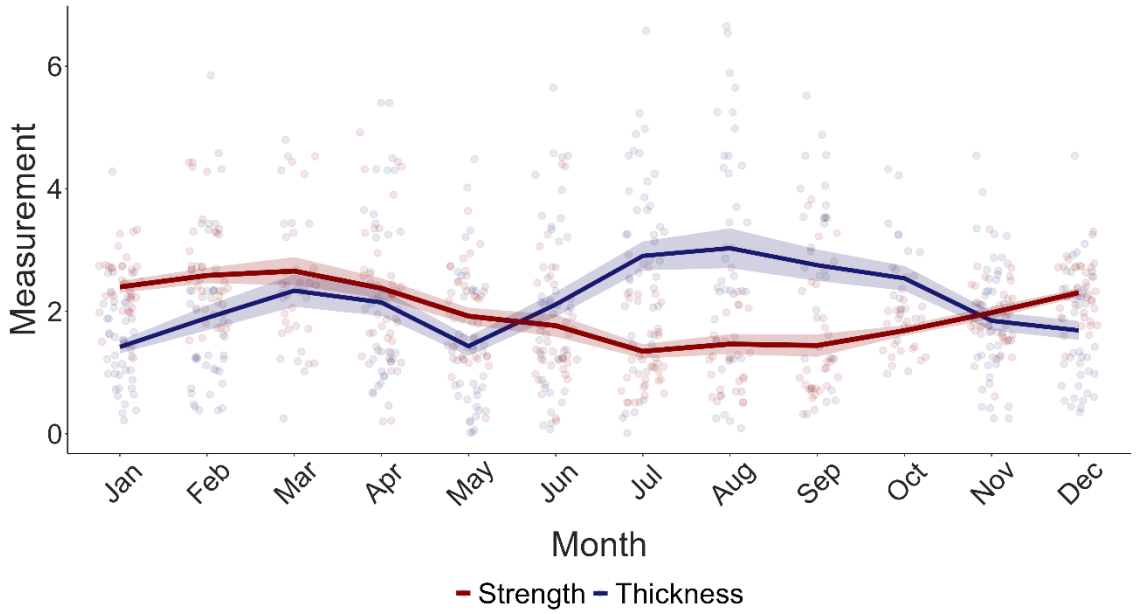


Figure 2. Monthly monitoring of pine phloem thickness (*Pinus taeda*, mm) and force required to peel off bark (N) in pine plantations of northeastern Argentina from 2021 to 2023.

Movement and space use of capuchins

We studied the movement and space use patterns of 11 black capuchin groups, including six groups in pine plantations (2022–2024) and five in Iguazú National Park (INP) (2008–2024). Data collection combined GPS-VHF collars, VHF collars, and direct group follows. During 2022 and 2023, we captured 17 black capuchins using Tomahawk traps (81 × 25 × 30 cm) placed on platforms baited with bananas. Of these, 14 individuals from six plantation groups were captured (12 fitted with GPS-VHF collars and two with VHF collars), along with three individuals from three INP groups (two fitted with GPS-VHF collars and one with a VHF collar). Trapping was conducted before 14:00 h to ensure that captured individuals fully recovered and rejoined their groups before dusk. Anesthesia was administered intramuscularly using a combination of medetomidine (0.04–0.08 mg/kg) and ketamine (10–15 mg/kg) by trained wildlife veterinarians (Pomerantz and Blanks, 2012), and effects were reversed with yohimbine (0.1–0.3 mg/kg). Only adult and subadult individuals (>1.6 kg) were captured to ensure that collars, comprising GPS-VHF units (Telonics Inc. TGW-4100-4) or VHF-only units (ATS model), weighed less than 3% of body weight. All handling procedures were designed to minimize stress and adhered to ethical guidelines (American Society of Primatologists, 2025). Research permits were obtained from the Ministry of Ecology of Misiones Province, Argentina, and all activities complied with local and international wildlife research regulations.

Using 21,103 location points collected from 11 capuchin groups, 11,348 from plantations and 9,755 from INP, we completed 606 full days of tracking across 10 groups, with eight evenly spaced locations per day from dawn to dusk. This included 334 days (2,670 locations) for plantation groups and 272 days (2,175 locations) for Iguazu National Park (INP) groups. From these data, we calculated daily travel distances and influencing factors, segmented movement using two-state Hidden Markov Models (McClintock et al., 2020), and estimated home ranges and core areas using autocorrelated kernel density estimators (Calabrese et al., 2016), based on 95% and 50% isopleths, respectively.

Our findings show that capuchins in plantations traveled significantly longer daily distances (2,590 ± 668 m) than those in INP (2,122 ± 739 m), but their sleeping sites were more concentrated, with 94% located in native forest

fragments, which make up only 22% of the landscape (Figure 2). Movement patterns varied between plantation stands and forest fragments: in plantations, capuchins exhibited traveling-like movement (quicker and more persistent), while in forest fragments, movement was slower and more convoluted, likely reflecting feeding, social and resting behaviours. Consistent with our bark-stripping surveys, stationary-like movement (likely linked to feeding) increased in medium-aged pine stands during peak bark-stripping months. Home ranges in plantations (~390 ha) were nearly three times larger than those in INP (~130 ha), though core area sizes did not differ significantly (~71 ha vs. 49 ha). In plantations, 79% of core activity areas were located within forest fragments, highlighting their key role in capuchin survival. These results provide insights for habitat management, emphasizing both the lower carrying capacity of plantations compared to less-disturbed native forests and the importance of conserving forest fragments for capuchin subsistence.

Diversionary feeding trails

During 2022 and 2023, we installed feeding platforms baited with locally grown bananas to assess their effectiveness in mitigating bark-stripping. In August and October, we placed 25 platforms in groups of five within the home ranges of two capuchin groups, while the remaining two groups served as controls (without platforms). Midway through the experimental period, the roles of the groups were switched to account for behavioural variability. In 2023, we focused on studying only two groups. Throughout the trials, we tracked the monkeys' movements, estimated home ranges and core areas to analyzed changes in space use in response to the diversionary feeding experiment.

Our results indicate a notable shift in space use following the installation of feeding platforms. For example, during the 2023 trial, when platforms were present, the core areas of the experimental groups overlapped with medium-aged pine stands (the most frequently bark-stripped age category, see Figure 1) by only 0–19%. However, when those same groups served as controls (without platforms), their core area overlap with medium-aged pine stands increased to 24–51% (Figure 3). These findings suggest that diversionary feeding can significantly alter capuchins' space use, potentially reducing bark-stripping pressure on pine stands.

Dissemination of results with producers

We have actively engaged with stakeholders and forestry professionals to communicate our findings. Our results were presented to managers from

Arauco Argentina S.A., who have shown interest in our project and have supported logistics to facilitate continued research. Additionally, we have presented our work at four national conferences on ecology and conservation in Argentina and in a symposium at the International Primatological Society, titled "Measuring Sustainability Targets in Primatology." We also participated in the Technical Forestry Journals of Misiones Province, further promoting knowledge exchange with local forestry experts.

Moreover, we shared our findings in a webinar hosted by the Food and Agriculture Organization (FAO) of the United Nations, which is currently developing a guidance document on mammal-forestry coexistence. Our project will contribute valuable insights to this initiative. Additionally, I have presented this research and preliminary results in three postgraduate courses within the Specialization in Conservation Biology, offered by the Faculty of Forestry Sciences (National University of Misiones, Argentina). These courses provide an ideal space to train future professionals who will work directly with human-wildlife conflicts such as bark-stripping.

Looking ahead, in March 2025, we will submit our first research article to a conservation journal (tentatively Biological Conservation), focusing on capuchin movement ecology in plantation landscapes and how bark-stripping influences their daily trajectories and space use.

In all these cases, Rufford was mentioned as key supporter of our work.

Next Steps

Over the next six months, we plan to submit two additional research articles to forestry management and conservation journals. The second article will explore the trophic ecological drivers behind bark-stripping, while the third will build on these findings to analyze the effectiveness of diversionary feeding as a mitigation strategy.

We will also conduct three workshops in collaboration with timber companies in Misiones Province, including Arauco Argentina S.A., LIPSIA, and PINDO. Additionally, we will engage independent producers, whom our colleague Paula Tujague is currently interviewing to understand how their perceptions of capuchins and bark-stripping vary based on economic losses and production scale. Following these workshops, we will develop informative manuals to further disseminate our findings among forestry professionals and local producers.

Our international collaborations with researchers in South Africa (Ilaria Germishuizen) and southern Brazil (Sandra Mikich) will help expand the scope of these informative materials, as similar human-primate conflicts occur in these regions. By integrating findings from different landscapes, we aim to develop management practices for mitigating primate-induced damage in plantation forests.

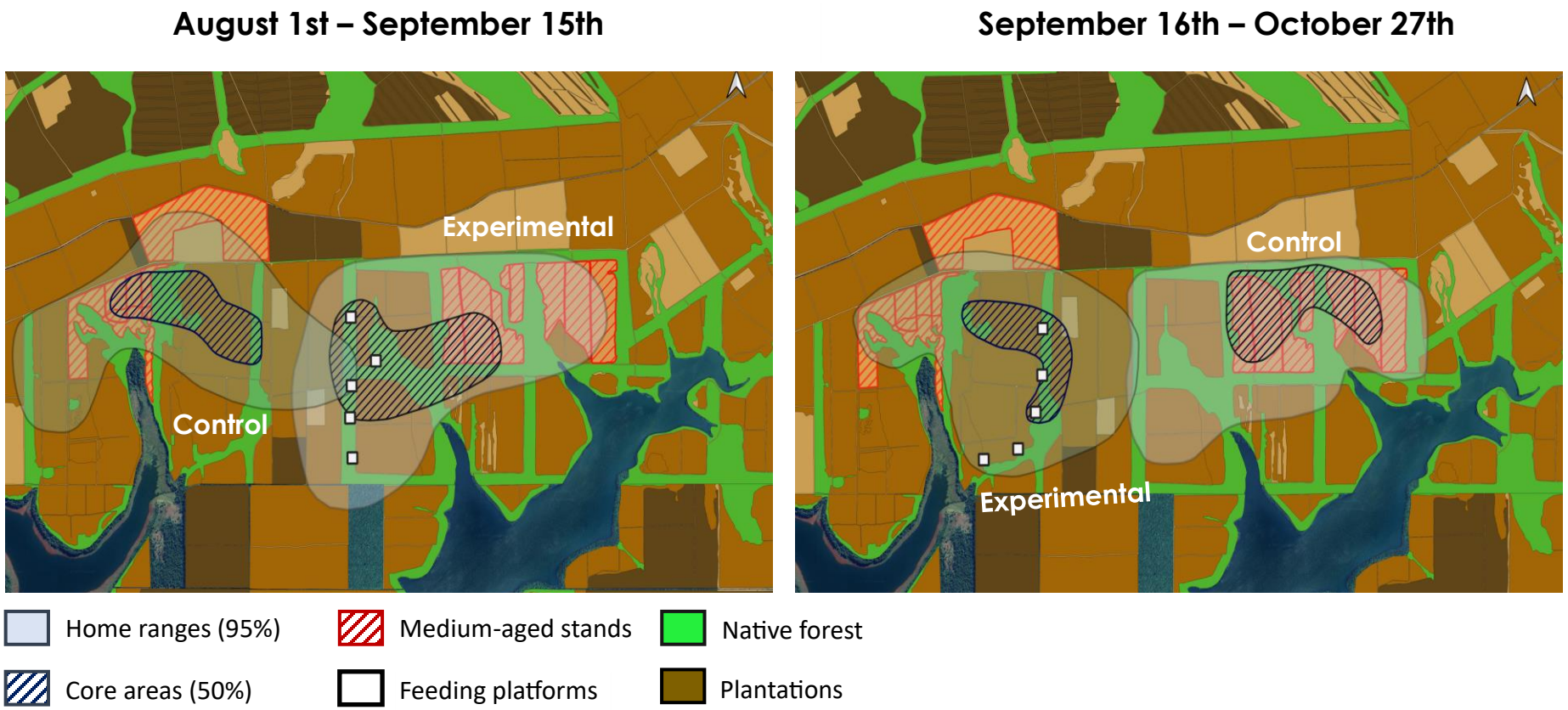
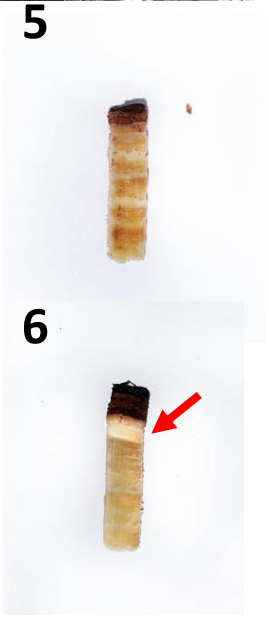


Figure 3. Home ranges and core areas of black capuchin monkey groups (Sapajus nigritus) during diversionary feeding experiments in pine plantations of northeastern Argentina (2023). Feeding platforms baited with bananas were deployed to modify capuchin space use patterns and reduce bark-stripping.

Fieldwork Photos



Fieldwork photos: (1) Valentín measuring the force required to peel off bark, (2) working at height to conduct samplings at the same level where capuchins engage in bark-stripping, (3) dynamometer adapted to remove bark strips and measure both mean and maximum force, (4) Trephor hammer used to measure phloem thickness, (5) wood core sample extracted with a Trephor in May (phloem layer undetectable), and (6) wood core sample extracted with a Trephor in August (thicker phloem layer present).

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