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Colegio de Ciencias Biológicas y Ambientales

Monitoring populations of the southern pygmy marmoset *Cebuella niveiventris* in the Tiputini Biodiversity Station

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Dedicatoria

Este trabajo está dedicado a mi madre quien me ha apoyado durante todo este proceso de manera incondicional y quien ha hecho de mi sueño el suyo. A mi padre por quien elegí esta carrera y quien sé que me acompaña siempre y guía mis pasos.

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RESUMEN

Las poblaciones de primates ecuatorianos están amenazadas por la deforestación y fragmentación de hábitat, la cacería furtiva y las enfermedades zoonóticas. Una de estas especies es *Cebuella niveiventris* listada como vulnerable en Libro Rojo de Mamíferos del Ecuador, por lo cual el objetivo de este estudio fue estimar la densidad ecológica de la población de *C. niveiventris* en la Estación de Biodiversidad Tiputini (EBT) y evaluar si esta ha cambiado en los últimos 10 años. Para ello se realizaron censos poblacionales en los meses de mayo a agosto, 2022 en 12 transectos ubicados en bosques de galería en los alrededores de EBT en los que se realizaron censos con un esfuerzo de muestreo similar en 2012. La densidad ecológica en cada año de muestreo se calculó al dividir el número de leoncillos registrado en ese año para la suma total de las longitudes de los transectos. La densidad ecológica en el año 2012 fue de 0.9 leoncillos/km de bosque de galería, mientras que en el año 2022 fue de 0.14 leoncillos/km de bosque de galería. Esta disminución evidencia un declive poblacional particularmente preocupante al ocurrir en un área protegida no afectada por deforestación y con mínimo impacto humano. Es necesario continuar con el monitoreo de las poblaciones de esta especie en Ecuador y realizar estudios complementarios para entender los factores que estarían causando este declive.

Palabras clave: *Cebuella niveiventris*, Tiputini, primates ecuatorianos, Amazonía ecuatoriana, densidad ecológica, declive poblacional.

ABSTRACT

Ecuadorian primate populations are threatened by deforestation and habitat fragmentation, poaching and zoonotic diseases. One of these species is Cebuella niveiventris, listed as vulnerable in the Red Book of Mammals of Ecuador, so the objective of this study was to estimate the ecological density of the population of C. niveiventris in the Tiputini Biodiversity Station (EBT) and evaluate if it has changed in the last 10 years. For this purpose, population censuses were conducted in the months of May to August, 2022 in 12 transects located in gallery forests in the surroundings of EBT where censuses were conducted with a similar sampling effort in 2012. Ecological density in each sampling year was calculated by dividing the number of tawny owls recorded in that year by the sum total of transect lengths. The ecological density in 2012 was 0.9 lions/km of gallery forest, while in 2022 it was 0.14 lions/km of gallery forest. This decrease is evidence of a particularly worrisome population decline in a protected area not affected by deforestation and with minimal human impact. It is necessary to continue monitoring the populations of this species in Ecuador and to carry out complementary studies to understand the factors that could be causing this decline.

Key words: *Cebuella niveiventris*, Tiputini, Ecuadorian primates, Ecuadorian Amazon, ecological density, population decline.

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INTRODUCTION

The 22 Ecuadorian primate species face numerous conservation challenges, including habitat loss stemming from deforestation for extractive and agricultural activities, illegal life traffic, hunting, and zoonotic diseases (de la Torre, 2010). In the Red List of Mammals of Ecuador, published in 2021, 19 species are in some category of threat (critically endangered, endangered, vulnerable), that is, approximately 86% of the species, with deforestation and hunting being their main threats (Tirira, 2021). Ecuadorian primates play pivotal ecological roles as predators, prey, dispersers, and pollinators, so their loss would be detrimental to the integrity and functions of forest ecosystems (de la Torre & Morelos-Juárez, 2022; Tirira et al., 2018). In the face of the threats these species encounter, conducting population monitoring becomes a fundamental tool for understanding the status and dynamics of populations. Periodic population surveys allow us to document changes in population size, sex ratio, and age structure. This information is crucial for developing conservation plans in response to population declines (Chen et al., 2022).

One of the threatened Ecuadorian primates is the Southern pygmy marmoset *Cebuella niveiventris*. This species is distinguished by its high specialization in diet, habitat and reproductive behavior (de la Torre et al., 2009; de la Torre et al., 2018). Pygmy marmosets feed mainly on exudates of few plant species (e.g., *Parkia* sp., *Sloanea* sp., *Inga* spp., *Spondias mombin*), complementing their diet with animal prey, mainly insects. They inhabit gallery forests near water sources such as rivers, in lowland areas (180 to 650 meters above sea level) south of the Napo river (Tirira et al., 2018). They are monogamous and can have offspring twice a year. They live in family groups formed by a reproductive couple and their offspring of different ages. There is reproductive suppression of the female daughters by the dominant female (the mother), as care for the offspring is shared among all group members (Tirira et al., 2018). This hyper-specialization renders them highly susceptible to natural and anthropogenic environmental changes.

In this context, population monitoring of this species is a priority. As part of our long-term research on the ecology and behavior of the two species of pygmy marmosets in Ecuador, we carried out periodic surveys of the population of Southern pygmy marmosets in the gallery forests of the Tiputini Biodiversity Station (TBS). Although TBS forests are not affected by logging and human activity is minimal, in 2017 the three pygmy marmoset groups that we were studying disappeared in a short time frame. Since these disappearances seemed to align with reported declines in bird populations in the same area (Blake & Loiselle, 2015), we aimed to assess if a similar decline was occurring in the population of Southern pygmy marmosets by comparing the results of surveys we carried out in 2012 and 2022.

METHODOLOGY

Study area

TBS is a biological station of Universidad San Francisco de Quito dedicated to research and conservation. It has 744 hectares of primary lowland rainforest on the banks of the Tiputini River, in the Yasuní Biosphere Reserve. These forests experience minimal human impact and are not affected by deforestation, as they are under the supervision of the station (de la Torre et al., 2018).

Survey method

In 2012 and 2022, from May through August, we surveyed 36.98 km of gallery forests in 12 transects along the Tiputini river and small forest creeks (Research permits: 0010-2012-FAU-

MAE-DPO-PNY; MAATE-ARSFC-2022-2365) In each survey year, teams of 2-3 field researchers carried out daily surveys in these transects early in the morning (06h00 to 11h00, local time) or in the afternoon (14h00 to 18h00) for a total of 18 survey days. We recorded the track of each transect with a GPS (Garmin, Etrex10). Five transects were located along the Tiputini river and were surveyed in a boat, floating or paddling. The length of these transects varied between 0.47 km and 5.73 km. The other seven transects, located along small creeks inside the forest, were shorter and were surveyed by foot (Table 1, Figure 1). Three surveys were carried out in each of the river transects and two surveys in each of the forest transects.

Table 1. Type and length of survey transects

Transect #	**Type**	**Length (km)**
1	Tiputini River	5.73
2	Tiputini River	4.63
3	Land	3.05
4	Land	1.67
5	Tiputini River	5.77
6	Tiputini River	4.67
7	Tiputini River	5.43
8	Land	1.53
9	Land	1.30
10	Land	0.47
11	Aguas Negras River	1.40
12	Land	1.33

For river transects, the speed of the boat was 1.5 km/h approx., whereas in land transects, the walking speed was 1 km/h. During each survey, we listened carefully for pygmy marmoset calls and search with binoculars (Eagle Shrike 10x42) for marmosets and fresh gauged holes in each of the individuals of the plant species known to be used by pygmy marmosets as exudate sources (de la Torre et al. 2018), located in a 20 m band at both sides of each transect. In river transects, every time we found an exudate tree, we halted the canoe and walked to the tree looking for any signal of pygmy marmosets. After completing the inspection, we returned to the canoe to continue the survey (de la Torre et al., 2009). When we found a group of pygmy marmosets, we approached the animals slowly and quietly, and observed them for about 1 – 2 hours to record the group size and composition. The minimum distance between the observers and the marmosets was 3 m.

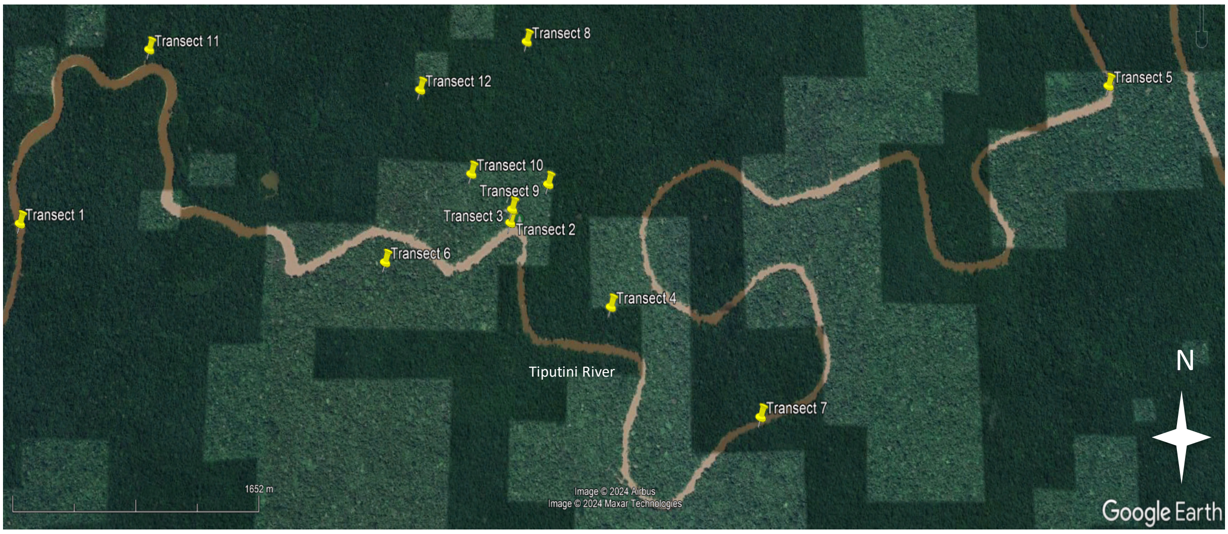

Figure 1. Location of the survey transects (marks show the coordinates of the beginning of each transect)

Determining the group composition required identifying the sex and developmental stage of the individuals. Sex determination was only possible in adults by observing the genitals, with binoculars. We identified adults, subadults, juveniles, and infants based on morphological criteria. Infants are small, with proportionally larger heads than their bodies, fluffy fur of a different color than other stages (yellowish with black spots on the body, with dark gray heads), and are often carried by another group member. After infancy, their fur changes to resemble that of adults (gray-gold on the head and back, with mottled gray, brown, and gold on the limbs, torso, and tail). Juveniles are larger than infants and have a lower head-to-body ratio. Subadults are similar in size and body proportion to adults, but they lack the white whisker-like marks on the sides of the mouth and in the middle of the nose, which are prominent in adults (Tirira et al., 2018).

Data analysis

We estimated the ecological density by dividing the total number of pygmy marmosets recorded in each survey year by the total transect length (36.98 km). We qualitatively compared the ecological density of 2012 with the ecological density of 2022; no statistical analysis was performed.

RESULTS

In the 2012 surveys, seven groups of pygmy marmosets were recorded. Group size ranged between 3 and 9 individuals (mean: 5.3 ± 2) (Table 2, Figure 2). In the 2022 surveys, only one group of pygmy marmosets was recorded. This group had 5 individuals (Table 3, Figure 2). In the 2022 surveys we found no trees with fresh exudate holes outside the home range of the recorded group; some trees had old, dry holes suggesting that they were used by pygmy marmosets in the past.

Table 2. Group size and composition of *C. niveiventris* groups in the gallery forests of the Tiputini Biodiversity Station in 2012.

Group	Group size (# ind)	Adult males	Adult females	Subadults	Juveniles	Infants
1	3	1	1			1
2	7	1	1	2	1	2
3	5	1	1	1	2	
4	4	1	1	1		1
5	5	1	1	1		2
6	4	1	1		2	
7	9	1	1	3	2	2

Table 3. Group size and composition of *C. niveiventris* in the gallery forests of the Tiputini Biodiversity Station in 2022

Group	Group size (# ind)	Adult males	Adult females	Subadults	Juveniles	Infants
1	5	1	1	1		2

The ecological density in 2012 was estimated in 0.9 individuals/ km of gallery forest, as we recorded a total of 37 pygmy marmosets in seven groups (Table 2). In 2022, the ecological density was 0.14 individuals/km of gallery forest, as we recorded only five individuals of one group (Table 3).

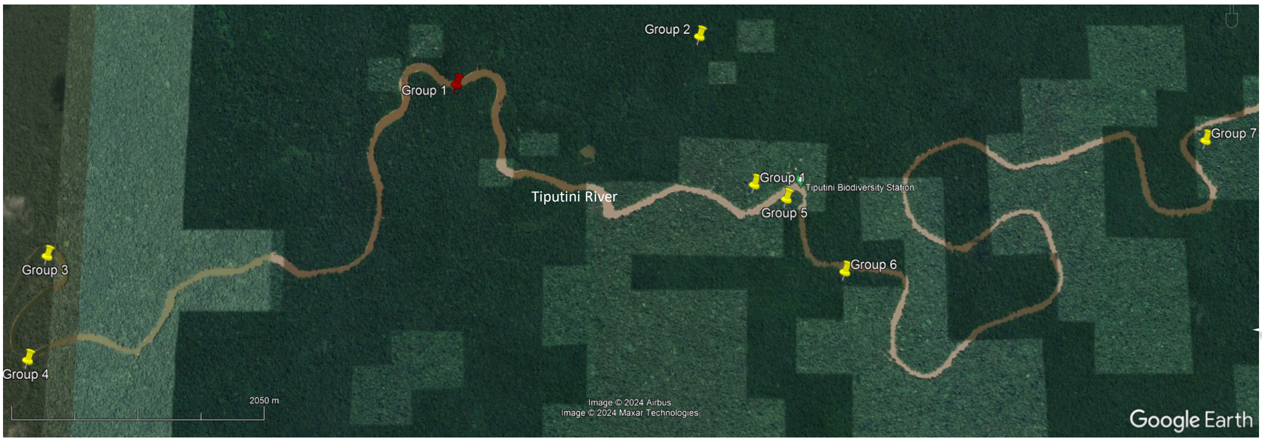

Figure 2. Location of the pygmy marmoset groups recorded in the 2012 (yellow) and 2022 (red) surveys

DISCUSSION

Our results suggest that there has been a severe decline of the population of southern pygmy marmosets in the TBS forests in a period of 10 years. We acknowledge that we could have had a detection bias in our surveys due to the difficulty of observing pygmy marmosets given their small size and cryptic behavior. However, since at least one member of the survey teams in both years had more than 10 years of experience tracking pygmy marmosets, we believe that this bias was low and similar between years. Furthermore, the fact that similar declines in relatively well-preserved forests have been reported in primate populations in India (Hameed et al., 2023) and in bird populations in TBS (Blake & Loiselle, 2015) and Guánica Commonwealth Forest, Puerto Rico (Faaborg et al., 2013) suggest us that our results are reliable and point to the need of understanding the factors that are causing this decline.

One of the possible causes could be associated with climate change. Evidence on how climate change affects primates is scarce, however, it is known that habitat change derived from climate change could affect food availability, or the abundance of pathogens, predators or competitors, increasing stress and reducing reproductive rates (Estrada et al., 2017). The increase in average temperatures and average precipitation generates changes in the composition, structure and dynamics of forests (Deb et al., 2018). Indeed, increases in tree mortality, and changes the distribution of species and aboveground biomass have been reported in tropical forests (Raghunathan et al., 2015). Considering the high specialization of pygmy marmosets in habitat and diet, it is possible that they are greatly affected by these environmental changes. Also, with this increase in temperatures, the habitat of many insects (vectors) increases as conditions change, becoming favorable for them and contributing to accelerate their life cycles, so they can reproduce at a faster rate (Williams et al., 2021). With increased rainfall, diseases such as dengue spread more easily because there are adequate conditions for these vectors to reproduce, what threatens diversity As climate change is a source of habitat modification, some individuals have low ranges of tolerance to these changes and, therefore, are not in a position to compete as would an introduced species; which usually has a wide tolerance and, therefore, manages to displace other individuals(Finch et al., 2021). Thus, climate change increases these factors. Being highly specialized, lions are vulnerable to these climatic changes, because if they lose the few plant species that produce the ooze, most of their diet is lost, making them more prone to an epidemic, increasing their competition and thus their stress level, which is counterproductive to the well-being and survival of the species.

Another possible cause could be local epidemics caused by viruses or bacteria. There are reports on the propensity of pygmy marmosets to suffer from respiratory diseases, yellow fever, malaria and herpes. Infections in pygmy marmosets could be caused by paramyxovirus, *Bordetella* sp., *Streptococcus* sp., adenovirus (AdV), among other pathogens, and can be lethal (Gál et al., 2013). A 32% decline in a four-year period was reported in a population of golden tlion tamarins (*Leontopithecus rosalia*), a related Callitrichid species, likely due to yellow fever (Dietz et al., 2019).Currently, we have no evidence to test this epidemics hypothesis of the population decline in TBS, but it is clear that epidemiology studies of pygmy marmoset populations are urgently needed.

It is also necessary to continue conducting periodical surveys in the area, as well as in other areas of distribution of the species to understand the dynamics of populations. This information is key to generate future conservation plans to prevent the loss of populations (Bessone et al., 2023). In addition, genetic studies should be carried out to evaluate the genetic diversity of the populations, since inbreeding and loss of gene flow are known to increase the risk factors for low reproductive success (Srivathsan et al., 2016). Finally, efforts should be put on assessing the magnitude of illegal pet trade that is known to affect pygmy marmosets in Ecuador the occurrence and effect of life traffic on the species (Tirira et al., 2018).

CONCLUSION

We present evidence of a severe decline of the pygmy marmoset population in the gallery forests of TBS in a 10-year period. The fact that forests in TBS are protected from logging and have low human impact point to the existence of other environmental factors affecting the population dynamics of this species. Our results point to the importance of long-term monitoring of this and other pygmy marmoset populations and of assessing the potential effects of climate change and local epidemics on this primate that should be periodically monitored for us to be able to take action against this decline.

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