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Mammals in atlantic forest remnants of Barbacena, Minas Gerais

Mamíferos em remanescentes florestais de mata atlântica, Barbacena, Minas Gerais

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Abstract
Habitat loss and fragmentation are the main causes of biodiversity decline, since changes in environmental and ecological conditions directly affect species richness, abundance, and distribution. This study aimed to identify medium- and large-sized mammals occurring in three Atlantic Forest remnants located in the Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG). The species were recorded in track plots and through active search for direct and indirect signs. 16 species distributed in six orders and 14 families were identified, including some vulnerable and threatened species such as *Lycalopex vetulus* (meadow fox), *Lontra longicaudis* (otter), and *Callicebus nigrifrons* (black-fronted titi monkey). *Canis familiaris* (domestic dog) and *Didelphis* sp. (opossum) were the species most frequently observed in the track plots. The largest fragment had the greatest species richness, with 15 species, or 93.75% of the total. The number of species shared among the three sampled areas was 31.2%. The similarities identified between the fragments indicate the need for higher connectivity among them, through the creation of ecological corridors to allow the movement and, consequently, gene flux among the populations, favoring the maintenance of important ecosystem services in the region. Although small, the study area plays a major role in mammal conservation in the region, preserving species from the Cerrado and the Atlantic Forest domains. To reduce potential impacts on the local fauna, management and conservation efforts should be put forward.
Keywords: Fragmentation; biodiversity; mammalian fauna

Resumo
A perda e fragmentação de habitats são as principais causas do declínio da biodiversidade, uma vez que as alterações das condições ambientais e ecológicas afetam diretamente a riqueza, a abundância e a distribuição das espécies. O presente trabalho teve como objetivo identificar mamíferos de médio e grande porte em três fragmentos

remanescentes de Mata Atlântica, situados no *Campus* Barbacena do Instituto Federal do Sudeste de Minas Gerais (IFSudesteMG). As espécies foram registradas por meio de parcelas de areia e busca ativa de vestígios diretos e indiretos. Foram identificadas 16 espécies distribuídas em seis ordens e 14 famílias, dentre elas, algumas vulneráveis e ameaçadas como *Lycalopex vetulus* (raposa do campo), *Lontra longicaudis* (lontra) e *Callicebus nigrifrons* (sauá). *Canis familiaris* (cão doméstico) e *Didelphis* sp. (gambá) foram mais frequentes nas parcelas de areia. O maior fragmento apresentou maior riqueza, com 15 espécies, 93,75% do total registrado no *Campus.* O número de espécies compartilhadas nas três áreas amostradas foi 31,2%. Os índices de similaridade registrados entre os fragmentos indicam que há necessidade de maior conectividade entre as áreas através da criação de corredores ecológicos, permitindo assim o deslocamento das espécies e, consequentemente, o maior fluxo gênico, favorecendo a manutenção de importantes serviços ecossistêmicos para a região. Apesar de pequena, a área de estudo desempenha importante papel na conservação dos mamíferos da região, preservando espécies de Cerrado e Mata Atlântica. Com o intuito de reduzir os impactos na fauna local, torna-se necessário a implantação de ações de manejo e conservação.
Palavras-chave: Fragmentação; biodiversidade; mastofauna

Introduction

Brazil has 759 mammal species, 298 of which occur in the Atlantic Forest domain, 90 being endemic[1, 2]. Due to reductions in its original area and its great biodiversity, the Atlantic Forest has been declared a biodiversity hotspot, a global priority for conservation for harboring endemic and highly threatened species[3].

The Atlantic Forest is the second largest biome in Minas Gerais state. Originally covering 49% of the state's total land area, in 2018 only 10.2% of this original cover remained (2,829,026 ha)[4]. Although fragmented, the Atlantic Forest in Minas Gerais still contains a highly diverse fauna, sheltering more than 50% of the threatened mammal species present in the biome[5]. Mammals play an important ecological role in the maintenance of forest ecosystems and Minas Gerais harbors nearly 70% of all Atlantic Forest mammal species. Approximately 1/3 of these species are exclusively found in this biome[6].

Fragmentation is the breakup of once continuous natural ecosystems into smaller parts, a process that alters the local environmental conditions in comparison with the surroundings[7]. Although sometimes a natural process, fragmentation is strengthened by anthropogenic interventions[8]. In forest fragments, degradation results from a complex interaction between multiple factors that promote area reduction followed by greater exposure to edge effects and isolation. These factors affect forest dynamics and may lead to biodiversity loss in these fragments, increasing their ecological vulnerability[7].

The ecological changes that take place in a given fragment are proportional to fragment size. Thus, small fragments tend to have lower species richness and lower species

density than large fragments[9]. Other than that, small fragments usually have lower habitat diversity than large fragments, which may also lead to species loss[10]. Studies conducted in Atlantic Forest remnants have shown that changes in large-sized mammal communities are directly related to area size and resource availability[11, 12].

Habitat loss and fragmentation are the main causes of biodiversity decline, since changes in environmental and ecological conditions directly affect species richness, abundance, and distribution[13]. Moreover, fragmented ecosystems are also affected by the decrease in long-distance animal migration, which may lead to isolation, reductions in population sizes, decreases in genetic diversity, and, especially in smaller remnants, population decline and extinction[14].

Despite the degraded state of Atlantic Forest remnants, the biological potential of many of them still lacks a basic understanding, highlighting the importance of conducting inventories[15]. The low density and home range of different mammal species, coupled with their nocturnal and crepuscular habits, hamper the conduction of inventories and require different, complementary methodologies[16]. Mammals often leave indirect signs of their presence, such as footprints, scat, burrows, claw marks on trees, and carcasses[17]. This type of evidence may allow sound identification of the animal that produced it and reveal important information about its ecology. Among these signs, footprints tend to be found more often and are deemed reliable for interpretation[16].

Knowing the composition of the mammalian fauna in forest fragments helps to advance species conservation strategies[18] and may aid the development of measures towards reducing potential impacts on biodiversity and ecosystem services offered by these fragments[19]. Thus, here we aimed to identify medium and large-sized mammals occurring in three forest fragments located in the municipality of Barbacena, Minas Gerais state, to provide a basis for potential conservation strategies in the area.

Material and methods

The study was conducted between June 2019 and January 2020, in monthly field trips to the Federal Institute of Southeast Minas Gerais (IFSudesteMG) – Barbacena *campus* (latitude: 21° 13’ 33” S, longitude: 43° 46’ 25” W, altitude: 1164 meters above sea level). The *campus* is located in the municipality of Barbacena, Minas Gerais state, in the mesoregion of the *Campo das Vertentes*, which belongs to the Mantiqueira region. According to Koppen’s classification, the climate in Barbacena is Cwb – temperate with warm and rainy summers, between four and five dry months, an average annual temperature of 18ºC, and average annual precipitation of 1,436 mm[20].

The sampling was performed in three fragments of Montane Semideciduous Seasonal Forest. This vegetation type is characterized by two kinds of climatic seasonality: tropical, with intense summer rainfall followed by strong periods of drought; and subtropical, without a dry period but enduring physiological droughts provoked by intense winter cold, with average temperatures below 15°C[21]. The sampled fragments present different sizes: the smallest has approximately 15 ha (named fragment one, or F01), the intermediate has 26 ha (fragment two, or F02) and the largest has 167 ha (fragment

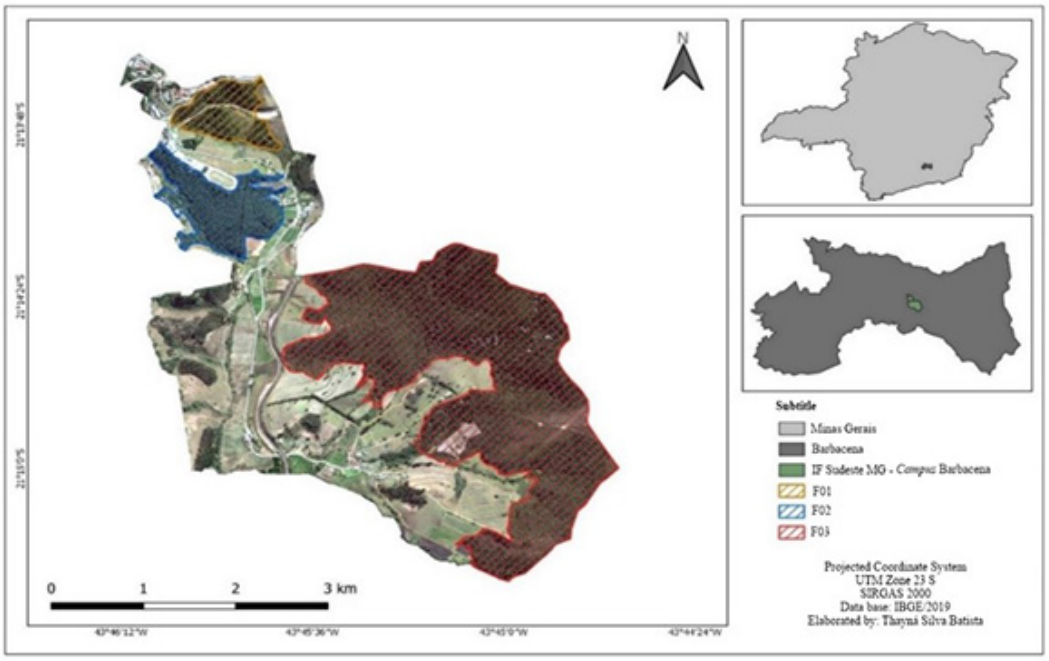

Figure 1. Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG), Minas Gerais state, along with the location of the three sampled fragments. F01: Fragment one; F01: Fragment two; F03: Fragment three.

Since the Barbacena *campus* has both urban and native vegetation areas, the studied fragments are inserted in different matrices with different levels of anthropization. The urban areas include chemistry (NQ), informatics (NI), agriculture (NA), and animal husbandry nuclei (NZ). In native vegetation areas, Montane Semideciduous Seasonal Forests predominate, the typical phytophysiognomy of the region.

The fragment F01 is located near the NQ and NI nuclei, in close proximity with urban areas of the northern part of the *campus* and areas cleared for agricultural exploration in the southern part of the *campus*. Throughout several decades, this fragment has undergone intense anthropogenic activities that significantly reduced its area. On the other hand, F02, which is located near the NA nucleus, is mainly delimited by agricultural and cattle raising activities, bordering an urban area to the west. Previously a pasture, this fragment is currently undergoing natural regeneration after nearly 40 years of abandonment. The fragment F03 is located near the NZ nucleus. Its east portion is limited by an ecotone between forest and *candeal* (open vegetation dominated by *Eremanthus* sp.), whereas its west portion borders other fragments, pastures, and Eucalyptus and Araucaria plantations. This fragment is predominantly composed of Montane Semideciduous Seasonal Forests and, occasionally, of Alluvial Semideciduous Seasonal Forest.

For field data collection, we used four previously established transects (F1, F2, F3.1, F3.2), which were defined through the maps produced by a Global Position System (GPS) device, model GPSmap 60CSx (Figure 2).

Figure 2. Location of the sample transects in fragments F01, F02, and F03 in the Federal Institute of Southeast Minas Gerais (IFSudesteMG), Barbacena *campus*, Minas Gerais state. Source: Adapted from Google Earth, 2020.

To survey medium and large-sized mammals, we used two complementary methodologies: track plots and active search for direct and indirect signs of mammal presence. In each field trip, we set up 21 track plots of 0.50 x 0.50 m, distributed 100 m apart from each other, and using nonwoven fabric to minimize sand loss during the study. 5 track plots were established in F01, 5 in F02, and 11 in F03. We placed baits in the center of each track plot (banana and oats) to increase the chances of obtaining records[22].

We inspected the plots on four consecutive mornings during each field trip. In each inspection morning, we sieved and leveled the sand surface before placing the baits in their center. In the drier months, the sand was moistened with the aid of a spray bottle. We recorded the presence or absence of footprints in each plot and omitted from the analysis the sand marks that did not allow identification, given that they prevented us from recognizing footprint patterns and identifying the species.

Complementarily, we actively searched for direct and indirect signs of mammal presence. Direct signs included sighting and vocalization, occasionally perceived while walking the transects for track plot inspection. Indirect signs included scat, carcasses, claw marks on trees, and footprints outside the track plots. This type of evidence allowed us to identify the animals without the need for their presence in real time[23].

For species identification, scientific classification, and popular nomenclature, we consulted the book *Mamíferos do Brasil* (Mammals of Brasil)[15]. To identify the threatened animal species, we consulted *Lista de Espécies Ameaçadas de Extinção da Fauna do Estado de Minas Gerais* (List of Threatened Species of the Minas Gerais State Fauna)[24], *Livro*

Vermelho da Fauna Brasileira Ameaçada de Extinção (Red Book of Threatened Brazilian Fauna)[25] and the IUCN Red List of Threatened Species[26]. Following identification, we separated the mammals by order, genus and species.

We built species rarefaction curves using the richness values obtained through 100 randomizations using the rarefaction method. To assess the significance of differences in species richness between the study fragments, we used a confidence interval of 95%. We performed this procedure with the software EstimateS Version 9.1.0.[27], using each field trip as a sample unit and including all records obtained in the track plots and the direct and indirect signs recorded in the active search.

To compare the sampled areas in terms of species similarity, we performed a multivariate cluster analysis using the unweighted pair group method with arithmetic mean (UPGMA). We used the Jaccard's index (Cj) as a coefficient of similarity, which varies between 0 and 1 (the closer to 1, the higher the similarity between the areas)[28]. To visualize the associations in the species composition of the fragments, we built a dendrogram using the software Paleontological Statistics (Past 4.02).

We obtained the relative frequency of each mammal species recorded in the track plots by calculating the proportion of its records relative to the total number of records obtained during data collection.

Results and discussion

The plots were inspected 672 times throughout the study (160 times in F01, 150 in F02, and 352 in F03). Footprints were observed in 32% of inspections. 16 species were recorded in the three fragments: nine in F01, distributed among five orders and nine families; nine in F02, distributed among five orders and eight families; and 15 in F03, distributed among six orders and 14 families. The most common orders were Rodentia and Carnivora, each comprising 31.25% of the records. The least common orders were Cingulata and Lagomorpha, each with 6.25% of the records (Table 1).

Some species were only recorded through active search, namely: *C. nigrifrons*, *Callithrix penicillata*, *Coendou* sp., *L. vetulus*, *L. longicaudis*, and *Gracilinanus microtarsus.* We also encountered *Dasypus novemcinctus* carcasses (Table 1).

Table 1. List of species recorded in the fragments F01, F02, and F03 in the Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG) using track plots (pa) and active search for footprints outside the plots (pf), sighting (vi), vocalization (vo), scat (fe), claw marks on trees (ma), and carcasses (ca). The last columns show extinction risk categories according to state, national and international classifications

Taxon	Popular name	Method	Fragment	Conservation status		
				MG	Brazil	International
CARNIVORA						
Canidae						
Canis familiaris	Domestic dog (*cão doméstico*)	pa, vi	F01,F02,F03	-	-	-
Lycalopex vetulus	Meadow fox (*raposa do campo*)	vi	F02	-	VU	NT
Procyonidae						
Nasua nasua	Coati (*quati*)	pa, vi	F01,F02,F03	-	LC	LC
Mephitidae						
Conepatus semistriatus	Skunk (*cangambá*)	pa	F03	-	LC	LC
Mustelidae						
Lontra longicaudis	Otter (*lontra*)	vi, fe	F03	VU	NT	NT
DIDELPHIMORPHIA						
Didelphidae						
Didelphis sp.	Opossum (*gamba*)	pa	F01,F02,F03	-	-	-
Gracilinanus microtarsus	Gracile opossum (*cuica Graciosa*)	vi	F03	-	LC	LC
LAGOMORPHA						
Leporidae						
Sylvilagus brasiliensis	Brazilian cottontail (*tapiti*)	pa	F02,F03	-	LC	EN
PRIMATES						
Callitrichidae						
Callithrix penicillata	Black-tufted marmoset (*mico estrela*)	vi, vo	F01,F02,F03	-	LC	LC
Pitheciidae						
Callicebus nigrifrons	Black-fronted titi monkey (*sauá*)	vo	F03	-	LC	NT
RODENTIA						
Caviidae						
Cavia sp.	Brazilian guinea pig (*preá*)	pa	F01,F03	-	-	-
Cricetidae						
Nectomys squamipes	Water rat (*rato d'água*)	pa	F02,F03	-	LC	LC
Cuniculidae						
Cuniculus paca	Lowland paca (*paca*)	pa, pf	F01,F03	-	LC	LC
Dasyproctidae						
Dasyprocta sp.	Agouti (*cutia*)	pa	F01,F02,F03	-	-	-
Erethizontidae						
Coendou sp.	Brazilian porcupine (*ouriço-cacheiro*)	ma	F01,F02,F03	-	-	-
CINGULATA						
Dasypodidae						
Dasypus novemcinctus	Nine-banded armadillo (*tatu galinha*)	pa, ca	F01,F03	-	LC	LC

Extinction risk categories according to the *Lista de Espécies Ameaçadas de Extinção da Fauna do Estado de Minas Gerais* (List of Threatened Species of the Minas Gerais State Fauna)[24], *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (Red Book of Threatened Brazilian Fauna)[25] and the IUCN Red List of Threatened Species[26]: Least concern (LC), Near threatened (NT), Vulnerable (VU) and Endangered (EN).

Although the sampling methods employed are recommended to detect medium- and large-sized mammals, no large animals were recorded. We did identify, however, and included in the analysis some small mammal species, including *Didelphis* sp., *G. microtarsus, S. brasiliensis, C. penicillata, Cavia* sp., and *N. squamipes*. For a broader and more reliable sampling of small mammals, future studies should be performed in the same location using methods dedicated to capturing these animals (such as Sherman and Tomahawk traps)[29].

The number of species that we found may be the result of using baits as attractants, as they increase the chances of obtaining records[22]. Although banana and oats have been considered efficient baits, the employment of a single type of attractant may result in selective sampling and influence the records of certain species[30].
The estimated mammal richness in the *campus* was 16 species (CI ± 0,95). The rarefaction curve tended towards stability after the seventh field trip, indicating that the methodology applied enabled sufficient sampling to capture the mammal community of the study area (Figure 3).

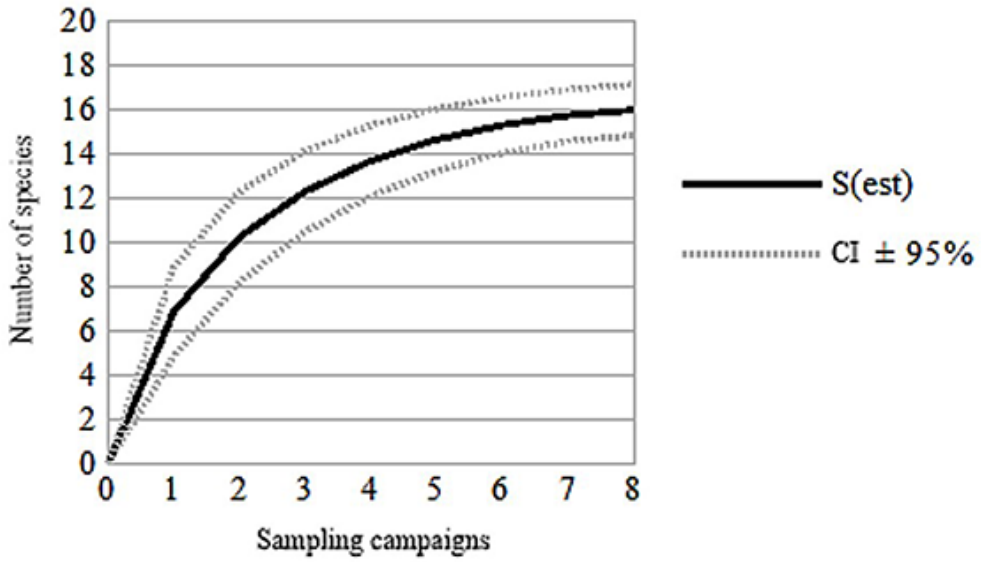

Figure 3. Rarefaction curve of the mammal species recorded in the Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG), Minas Gerais state, through track plots and active search for direct and indirect signs. S(est) estimated species richness (95% confidence interval).

The similarity analysis revealed similar species composition between fragments F01 and F03 (j= 0.6). F02 displayed lower similarity values with F01 (j= 0.41667) and with F03 (j= 0.4375) (Figure 4).

The low similarity between F02 and the other sampled areas is due to the lower number of species shared between this fragment and the others: F02 shares five species with F01

and seven species with F03, whereas F01 and F03 share nine species among themselves. The finding of *L. vetulus* (popularly known as *raposa do campo* or meadow fox) solely in this fragment may have also contributed to its lower similarity with the other areas.

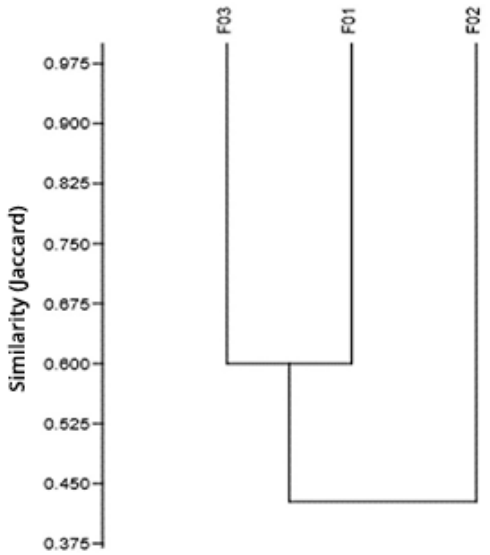

Figure 4. Cluster analysis of the mammal species recorded in three fragments in the Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG), Minas Gerais state.

The distribution of *L. vetulus* is associated with the Cerrado biome, although it may also be found in other open and transition areas[31, 32]. For instance, this species had been recorded by Cáceres et al.[33] in Atlantic Forest areas in the Mato Grosso do Sul state. According to Lemos et al.[34], *L. vetulus* is considered one of the least studied canids in Brazil and, with a poorly defined geographic distribution, the species requires more investigation. *L. vetulus* is classified as vulnerable in Brazil[25] and near threatened in the international classification[26].

The presence of *L. vetulus* may be associated with Cerrado enclaves in the Barbacena region[25]. Its records may also be related to its preference for open habitats instead of the semideciduous forest habitats also available[36]. This would explain the fact that this species was only found in F02, given that this fragment was previously composed of cattle pastures and is now under natural regeneration.

Another factor that may favor the occurrence of this species in F02, a fragment bordered by the nucleus of agriculture of the *campus*, is its spatial proximity with pastures and agricultural areas. Due to its mostly termite-based diet, *Lycalopex* finds high food availability in these open areas[37]. The accumulation of cattle manure also attracts insects that are largely consumed by the meadow fox, such as beetles[38]. According to Juarez[39], *L. vetulus* is predominantly found in pasture areas. This species has also been recorded in agricultural and silvicultural areas, more specifically in new Eucalyptus plantations[40].

The percentage of species shared among the three sampled areas was 31.2%. The species recorded in all sampled sites were: *C. familiaris*, *Dasyprocta* sp., *Didelphis* sp., *C. penicillate,* and *N. nasua*. Other than being recorded in all three fragments, they also appeared at a higher frequency in the track plots (Figure 5).

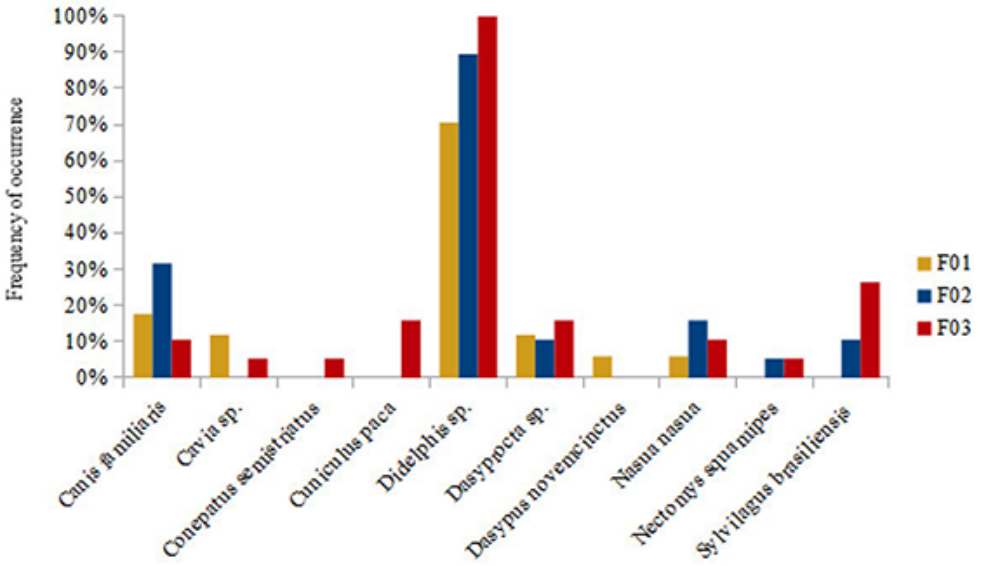

Figure 5. Frequency of mammal occurrence recorded in track plots established in three fragments in the Barbacena *campus* of the Federal Institute of Southeast Minas Gerais (IFSudesteMG), Minas Gerais state.

Other than being an important seed disperser that promotes natural regeneration in forest fragments, *Didelphis* sp. is also prey for other animals[41]. The fact that we found this species in all sampled areas may be explained by its generalist and adaptable behavior, which allows it to occupy even urban environments[42].

The high frequency of *C. familiaris* recorded in our study may be related to the human population density near the study areas. A large portion of these animals ends up roaming freely in both human and wild environments[43]. Domestic dogs negatively impact the natural environment and offer risks to the wild fauna through competition, predation, and disease transmission[44]. The introduction of this exotic predator may extensively reduce native prey populations and potentially lead to their local extinction[45].

Another species recorded in the three fragments was *C. penicillate*, an invasive alien primate reported in several Atlantic Forest areas in southeast Brazil[46, 47]. Its occurrence may be explained by its highly diverse diet, absence of predators, and high environmental plasticity, which allow it to occupy even fragmented habitats outside its natural distribution range[48]. Due to intense fragmentation, the native *Callithrix aurita* (*sagui-da-serra-escuro* or buffy-tufted marmoset) has mostly disappeared from the *Zona da Mata* region of Minas Gerais. Considered one of the 25 most endangered primate species on the planet, *C. aurita* has been replaced by *C. penicillata* throughout the region[49], due to resource competition and problems such as hybridization and disease transmission.

The highest species richness was recorded in F03, with 15 species or 93.75% of the total number recorded on *campus*. *C. semistriatus*, *L. longicaudis*, *C. nigrifrons*, and *G. microtarsus* were only recorded in this fragment (Table 1). *L. longicaudis* is classified as vulnerable at the state level classification[24], and as near threatened at national and international levels[25, 26]. *C. nigrifons* is classified as near threatened in the international list[26].

The occurrence of *C. nigrifons* in F03 may be influenced by several interacting factors. According to Trevelin et al. [51], the species in this genus are relatively tolerant to fragmentation and habitat disturbances. Their persistence in fragmented environments may be associated with the abundance of food resources and a flexible diet. Moreover, according to Melo, Quadros, Jerusalinsky[52], the species' diet, small group sizes, and small home range may contribute to their occurrence in small fragments.

The occurrence of *L. longicaudis* solely in F02 likely owes to the existence of lakes in this fragment, since this is a semi-aquatic species usually found in streams, rivers, and lakes[53]. Studies on *L. longicaudis* have confirmed that its diet in Brazil is predominantly made up of fishes and crustaceans but, depending on resource availability, they can also feed on insects, birds, mollusks, amphibians, and small mammals[54].

The highest species richness observed in F03 compared to the other fragments may be associated with its size and higher plant diversity, since F03 contains different phytophysiognomies: Montane Semideciduous Seasonal Forest, Alluvial Semideciduous Seasonal Forest, and an ecotonal zone between forest and *candeal* (open vegetation dominated by *Eremanthus* sp.). Besides, with multiple springs and lakes, F03 had the highest water availability among the three fragments. These factors provide a broader range of habitats that allow the maintenance of a higher number of species[12, 55]. Also, F01 and F02 smaller sizes and degraded surroundings due to anthropogenic influences could explain the lower species richness in these areas.

Here, we found lower species richness than other studies in the Atlantic Forest domain. For example, using track plots and through direct and indirect signs, Duprat, Andriolo[56] recorded 20 species in an area of 200 ha in the municipality of Rio Novo - MG. Prado, Rocha, Giudice[57] recorded 21 species in an area of approximately 384 ha at the *Mata do Paraíso* Research, Training, and Environmental Education Station (EPTEA - *Estação de Pesquisa, Treinamento e Educação Ambiental*) in Viçosa, MG, through the adoption of different methodologies: active search, Tomahawk traps, and camera traps. They also consulted the João Moojen Zoology Museum (MZ-UFV) collection to produce the species inventory.

However, comparably to our study and employing track plots, camera traps, and active search, Eduardo, Passamani[58] found a similar number of species (S=15) in an area of 300 ha. In a smaller area of Montane Seasonal Semideciduous Forest, same phytophysiognomy as investigated here, Passamani, Dias[59] recorded 20 species (distributed among nine orders and 14 families), eight of which were also found in our study. We highlight that the variations in species richness between the different studies possibly owe to differences in sampling effort, methodology, sampled area size, and occupation history, due to different anthropogenic pressures.

The mammal species richness found in the Barbacena *campus* represents approximately 84% of the species recorded in the *Campo das Vertentes* mesoregion, which comprises Lavras, São João Del Rei, and Barbacena microregions, with six species common to our study [60]. The high representativity of the mammal community found in the Barbacena *campus* fragments highlights their importance for the maintenance of these species in the region, especially those that appear in threatened species lists.

Conclusion

During the study period, we recorded 16 mammal species. Fragment three (F03), which was the largest fragment of the Barbacena *campus*, had the highest species richness (93.75% of the total number of species) and contained species considered vulnerable and near threatened in state, national, and international extinction risk classifications. The high occurrence frequency of *C. familiaris* and *Didelphis* sp. in all fragments studied, both generalist species adaptable to different types of environments, highlights the disturbed state of the fragments.

Knowing the species contained in a given fragment is essential to inform conservation decision-making. Therefore, since our study pioneered this type of investigation on the mammalian fauna of the Barbacena *campus*, complementary studies using other sampling methodologies are needed to identify a higher number of species and expand the knowledge on the local mammalian fauna.

Thus, although small, the forest remnants in the Barbacena *campus* play an important role in conservation by contributing to the maintenance of habitat patches that work as wildlife refugia and increase the viability of the region's mammal populations. Our findings evidence the need for management actions, since the species are locally threatened by the presence of domestic and exotic animals and by impactful anthropogenic activities. The indices of similarity recorded between the fragments indicate the need for higher connectivity among the areas, through the creation of ecological corridors to increase the movement and, consequently, gene flux among the populations, which would favor the maintenance of important ecosystem services in the region.

Acknowledgments

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Conflict of interest

The authors declare no conflict of interest.

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