

Non-volant small mammals recorded from *Tyto furcata* pellets in a human-modified landscape of Zona da Mata, Minas Gerais, Brazil, with an updated regional checklist

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Owl pellets provide a valuable, non-invasive tool for documenting small mammal assemblages, particularly in areas lacking systematic faunal surveys. We used pellets of the American Barn Owl (*Tyto furcata*), collected during three sampling events (2022–2024), to document the non-volant small mammal fauna of a human-modified rural landscape in São Pedro dos Ferros, Zona da Mata, Minas Gerais, Brazil, the first faunal record for this municipality. We identified 14 species, including two exotic rodents (*Rattus* sp. and *Mus musculus*), with a predominance of generalist taxa such as *Calomys* cf. *cerqueirai*, *C. tener*, *Oligoryzomys nigripes*, and *Necomys lasiurus*. Forest-dependent species, including *Trinomys setosus* and *Gracilinanus microtarsus*, were rare, suggesting that the owl, although typical of open habitats, also forages along forest edges. Species richness recorded here was lower than in nearby protected areas of the Zona da Mata, consistent with the site's extensive historical deforestation and current landscape composition, although differences in sampling method also likely contribute to this pattern. Combining these records with published surveys and museum data, we compiled an updated checklist of 59 non-volant small mammal species for the Zona da Mata mesoregion, including several endemic, rare, and threatened taxa. Our results reinforce the value of owl pellets as a complementary tool for small mammal inventories in poorly known, human-modified landscapes of the Atlantic Forest.

Keywords: Atlantic Forest, checklist, owl pellets, rodents, *Trinomys setosus*.

Las egagrópilas de lechuza constituyen una herramienta valiosa y no invasiva para documentar ensambles de pequeños mamíferos, especialmente en áreas que carecen de estudios faunísticos sistemáticos. Utilizamos egagrópilas de la lechuza de campanario (*Tyto furcata*), recolectadas durante tres eventos de muestreo (2022–2024), para documentar la fauna de pequeños mamíferos no voladores de un paisaje rural antropizado en São Pedro dos Ferros, Zona da Mata, Minas Gerais, Brasil, el primer registro faunístico para este municipio. Se identificaron 14 especies, incluidas dos exóticas (*Rattus* sp. y *Mus musculus*), con predominio de taxones generalistas como *Calomys* cf. *cerqueirai*, *C. tener*, *Oligoryzomys nigripes* y *Necomys lasiurus*. Las especies dependientes de bosque, incluyendo *Trinomys setosus* y *Gracilinanus microtarsus*, fueron raras, lo que sugiere que esta lechuza, aunque típica de ambientes abiertos, también forrajea en los bordes de los fragmentos forestales. La riqueza de especies registrada aquí fue menor que la de áreas protegidas cercanas a la Zona da Mata, lo que es consistente con la intensa deforestación histórica y el paisaje actual del sitio, aunque las diferencias metodológicas de muestreo probablemente también contribuyen a este patrón. Combinando estos registros con estudios publicados y datos de colecciones, compilamos un listado actualizado de 59 especies de pequeños mamíferos no voladores de la mesorregión de la Zona da Mata, incluyendo varios taxones endémicos, raros y amenazados. Nuestros resultados refuerzan el valor de las egagrópilas de lechuza como herramienta complementaria para inventarios de pequeños mamíferos en paisajes antropizados y poco conocidos de la Mata Atlántica.

Palabras clave: egagrópilas, inventario faunístico, Mata Atlántica, roedores, *Trinomys setosus*.

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The Atlantic Forest, a well-known biodiversity hotspot (Myers *et al.* 2000; Mittermeier *et al.* 2004), has undergone various historical processes of vegetation loss over the past 520 years, including pau-brasil extraction, sugarcane cultivation, gold, diamond, and iron mining, and urbanization (Dean 2004). Currently, it is estimated that only 22.9% of its original cover remains in Brazil (Vancine *et al.* 2024). In the state of Minas Gerais, the situation is no different: Atlantic Forest cover has been reduced from 46% to 9.64% of its original extent in the state (Fundação SOS Mata Atlântica/INPE 2017).

Like other Atlantic Forest areas, the Zona da Mata mesoregion of Minas Gerais (ZM hereafter) in Brazil also experienced intense historical land-use change and vegetation loss, especially with the establishment of coffee plantations in its mountainous areas during the early 19th century (Paula 2006; Vittoretto *et al.* 2025). This mesoregion comprises 142 municipalities and is currently dominated by small, isolated forest fragments, mostly smaller than 0.5 km² (Fundação SOS Mata Atlântica/INPE 2017), surrounded by coffee and sugarcane crops, cattle ranching, and poultry

farming, among other land uses (Faria *et al.* 2022).

Despite being highly fragmented and degraded, the Atlantic Forest still harbors remarkable mammalian diversity, with more than 320 species, many of which are endemic (Paglia *et al.* 2012; Graipel *et al.* 2017). Among small non-volant mammals (rodents and marsupials weighing less than 1 kg), approximately 120 species occur in this biome, 59 of them endemic to the Atlantic Forest (Graipel *et al.* 2017). In addition to their high diversity, many small mammal species are restricted to well-preserved habitats, such as primary forests, making them valuable bioindicators (Bonvicino *et al.* 2002).

In Minas Gerais, most studies on small non-volant mammals have been conducted in protected areas such as state and national parks and private reserves (RPPNs) (e.g., Stallings *et al.* 1990; Paglia *et al.* 2005; Melo *et al.* 2009; Moreira *et al.* 2009; Bruna *et al.* 2010; Lessa and Paula 2014; Talamoni *et al.* 2014; Braga *et al.* 2016; Keesen *et al.* 2016). In the ZM region, where few protected areas exist, studies remain scarce and are concentrated in just a few localities: Serra do Brigadeiro State Park, in Araponga (Moreira *et al.* 2009); the private reserves RPPN Santuário Ecológico Mata dos Jacus and RPPN Refúgio dos Sauás, in Alto Jequitibá (Faria *et al.* 2020); RPPN Mata do Banco and RPPN Dr. Marcos Vidigal Vasconcellos, in Tombos (Faria *et al.* 2018); Caparaó National Park, in Alto Caparaó (Bonvicino *et al.* 1997; Hershkovitz 1998); and Mata do Paraíso, in Viçosa (Paglia *et al.* 1995; Lessa *et al.* 2014). The Rio Doce State Park, bordering the ZM, also represents an important protected area where small mammal communities have been studied (Stallings *et al.* 1990; Keesen *et al.* 2016).

All these previous non-volant small mammal surveys in the ZM relied on conventional trapping methods (e.g., Sherman and Tomahawk live traps, pitfall traps); none has used owl pellets to document the small mammal fauna of this mesoregion. Owl pellets are a well-established, non-invasive tool for documenting small mammal assemblages, since raptors such as the American barn owl (*Tyto furcata*) forage across multiple habitats around their roosts and accumulate skeletal remains that can be identified to species level (Andrews 1990; Taylor 1994). Pellet-based inventories can detect species rarely captured by conventional trapping, including small, fossorial, or otherwise elusive taxa, and have proven to be a reliable, rapid, and complementary approach for characterizing small mammal faunas (Bonvicino and Bezerra 2003; Terry 2010a, 2010b; Heisler *et al.* 2016; Mancini *et al.* 2018; Cadena-Ortiz *et al.* 2023).

At the same time, pellet-derived records carry well-documented biases, including the owl's preference for prey weighing 10–40 g, its selectivity toward open-habitat prey, and its foraging radius of up to 3 km around the roost, all of which shape the recovered assemblage independently of true local abundance (Marti 1987; Andrews 1990; Bonvicino and Bezerra 2003; Terry 2010b; Heisler *et al.* 2016). Despite these limitations, pellet analysis is particularly valuable in

regions such as the ZM, where systematic field surveys of small mammals in agricultural and pasture-dominated landscapes are scarce and logistically demanding, offering a rapid, low-cost means of documenting local faunal composition and revealing species that might otherwise go undetected.

Even with the extensive transformation of its original vegetation, the small terrestrial mammal fauna of the ZM in Minas Gerais remains poorly known, as do the long-term effects of landscape modification on these assemblages. Studies conducted in disturbed areas are essential for assessing biodiversity patterns, detecting local extinctions, identifying remaining refugia, and supporting conservation strategies in these production-dominated mosaics, which represent the predominant land-use matrix of the ZM and, increasingly, of the Atlantic Forest as a whole. Within this context, we used *Tyto furcata* pellets to document the non-volant small mammal assemblage of a highly impacted area of the ZM region, sampled over three independent events between 2022 and 2024. We also compare our findings with data from nearby, better-preserved sites and provide an updated checklist of non-volant small mammal species occurring in this mesoregion of Minas Gerais.

Materials and methods

Study area. The study was conducted on a rural property (UTM 23K 752424, 7771667) located in the municipality of São Pedro dos Ferros, in the northern portion of the ZM region, Minas Gerais, Brazil (Figure 1A). The municipality covers an area of 40,274 hectares, but currently only 1,127 hectares of Atlantic Forest remain, less than 3% of its original forest cover (Fundação SOS Mata Atlântica/INPE 2017) (Figure 1B). The remaining territory is largely composed of pasturelands and urbanized areas. The study site consists mainly of pastures and anthropogenic structures, interspersed with small permanent preservation areas (APPs) undergoing natural regeneration and crossed by small streams, but lacking any substantial forest fragments.

The municipality is located within the Doce and Piranga river basins (Fundação SOS Mata Atlântica/INPE 2017). In the absence of specific studies characterizing the local vegetation, we adopted the classification used for Rio Doce State Park, a protected area with forest remnants contiguous with the municipality's northern boundary along the Rio Doce River. The vegetation in this region is classified as Submontane Semideciduous Seasonal Forest (Veloso *et al.* 1991). Elevation ranges from 246 to 990 meters, with an average of approximately 425 meters. According to the Köppen climate classification, the region has an AW-type climate (humid tropical savanna, megathermic), characterized by a dry winter and a rainy summer (Alvares *et al.* 2013). The mean annual precipitation is about 1,300 mm, and the mean annual temperature is around 23°C (Lopes *et al.* 2002).

Data collection. Small non-volant mammals were sampled from owl pellets collected inside a barn on the

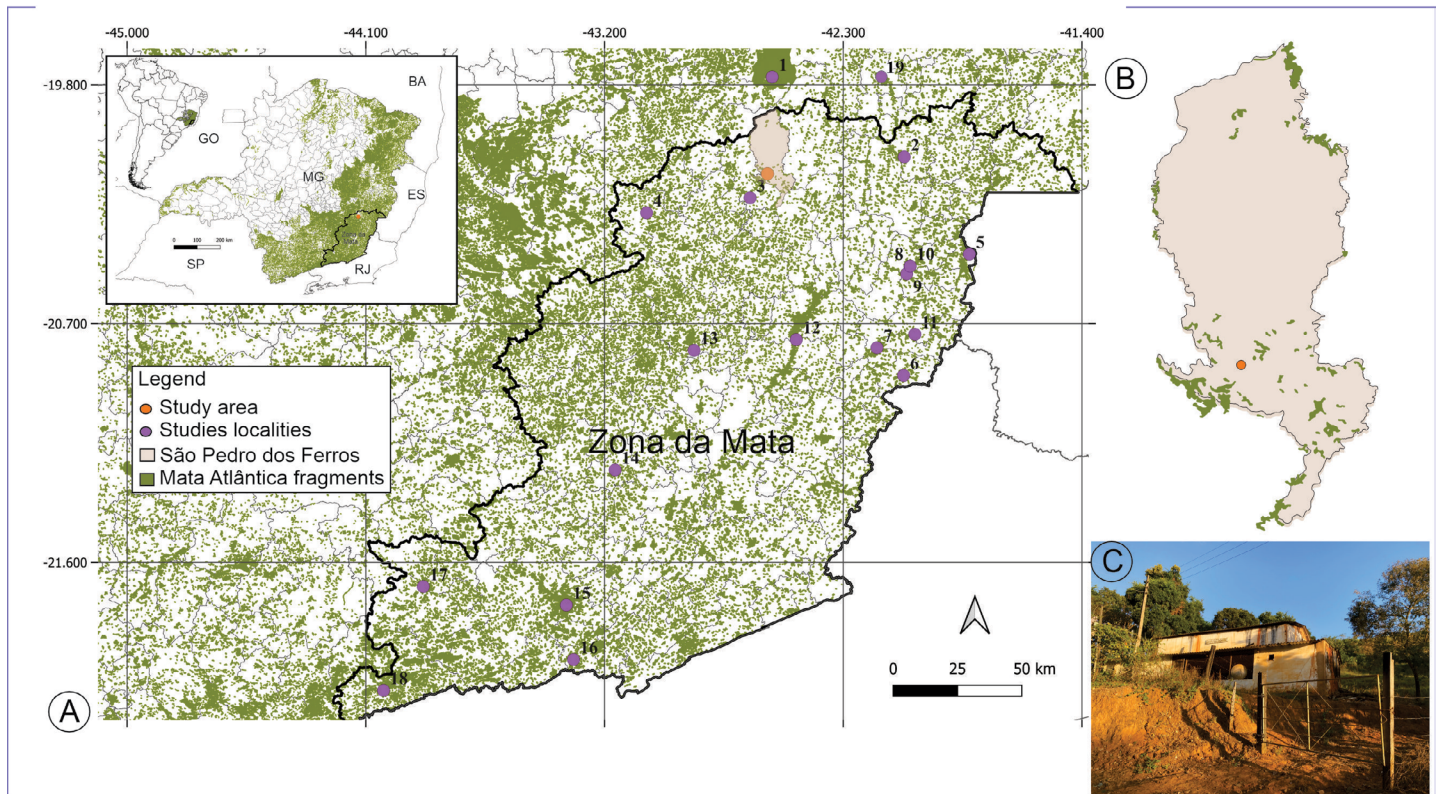


Figure 1. Study locality. A – Map of Minas Gerais highlighting the ZM mesoregion and the remaining Atlantic Forest fragments, showing the study locality (orange dot) and other localities with records of terrestrial small mammals (purple dots). B – Municipality of São Pedro dos Ferros and the location where owl pellets were collected. C – Specific site where the owl pellets were collected. Purple dots: 1 = Rio Doce State Park, municipalities of Marliéria, Dionísio, and Timóteo (Keesen et al. 2016); 2 = Mata do Sossego Private Natural Heritage Reserve (RPPN), municipality of Simonésia (CCT-UFMG); 3 = municipality of Rio Casca (CCT-UFMG; Lara and Patton 2000); 4 = municipality of Barra Longa (CCT-UFMG); 5 = Caparaó National Park, municipality of Alto Caparaó (Bonvicino et al. 1997; Hershkovitz 1998; Gonçalves et al. 2007; Pavan and Leite 2011; Silva et al. 2012; Pavan 2015; Abreu et al. 2021; Ribeiro et al. 2025); 6 = Dr. Marcos Vidigal Vasconcellos RPPN, municipality of Tombos (Faria et al. 2018); 7 = Pedra Dourada Environmental Protection Area (APA), municipality of Pedra Dourada (Faria et al. 2018); 8 = Grumirim I RPPN, municipality of Alto Jequitibá (Faria et al. 2018); 9 = Grumirim II RPPN, municipality of Caparaó (Faria et al. 2018); 10 = Mata dos Jacus Ecological Sanctuary RPPN, municipality of Alto Jequitibá (Faria et al. 2020); 11 = municipality of Carangola (Faria et al. 2019b); 12 = Serra do Brigadeiro State Park, municipalities of Araponga and Fervedouro (Moreira et al. 2009; CCT-UFMG); 13 = Mata do Paraíso, municipality of Viçosa (Lessa et al. 2014; Brandão et al. 2026); 14 = municipality of Rio Pomba (CCT-UFMG); 15 = municipality of Juiz de Fora (Queirolo and Granzinoli 2009); 16 = municipality of Simão Pereira (Geise et al. 1996); 17 = Ibitipoca State Park, municipality of Lima Duarte (CCT-UFMG); 18 = municipality of Santa Rita de Jacutinga (CCT-UFMG); 19 = municipality of Caratinga (Pardiñas et al. 2015).

rural property (Figure 1C), where an American Barn Owl (*Tyto furcata*) was frequently observed roosting. Pellets and pellet fragments were found scattered across the barn floor in variable states of preservation, from intact to highly fragmented, representing an accumulation of unknown duration. Because most of the material, particularly from the May 2022 event, was already disaggregated into isolated bone fragments, discrete pellets could not be reliably counted, and sample size is therefore reported as the number of specimens (NISP) and the minimum number of individuals (MNI) recovered per event (Table 1), rather than as the number of pellets. Material was collected during three independent sampling events, conducted on 3 May 2022, 20 December 2023, and 25 December 2024, each consisting of a single search of the barn floor lasting approximately 20, 15, and 20 minutes, respectively. The 2024 sample consisted mostly of whole pellets, dozens of them, though they were not counted. On each occasion, all pellet material visible on the barn floor was collected by hand, placed in plastic bags, and labeled.

The pellets were manually sorted using fine-tipped forceps, and cranial bones were separated for identification (cranium, maxilla, mandible, and molars). Intact pellets were manually disaggregated with a small amount of warm

water and fine-tipped forceps. The material recovered from these pellets was air-dried and then combined with the other collected samples.

Data analysis. Rodents were identified based on complete or fragmentary skulls, maxillae, mandibles, and molars by examining cranial structures and tooth morphology under a stereomicroscope. For identification to the lowest possible taxonomic level, reference collections and specialized literature were consulted; however, some fragments could not be reliably assigned to the species level. Species nomenclature follows Abreu et al. (2025), and rodent dental terminology follows Reig (1977). Seventeen measurements (adapted from Myers and Carleton 1981 and Musser et al. 1998) were taken from genera with sympatric species in the mesoregion (*Akodon*, *Oligoryzomys*, and *Calomys*), whenever possible, with a digital caliper with 0.02 mm precision: width of the zygomatic plate (WPZ), length of the incisive foramina (IF), length of the upper molar row (LSM), lengths of the upper molars M1, M2, and M3 (LM1, LM2, LM3), widths of the upper molars M1, M2, and M3 (WM1, WM2, WM3), mandible length (HM), length of the lower molar row (lsm), lengths of the lower molars m1, m2, and m3 (lm1, lm2, lm3), and widths of the lower molars m1, m2, and m3 (wm1, wm2, wm3). Molar measurements were

Table 1. Non-volant small mammal species identified from *Tyto furcata* pellets collected in São Pedro dos Ferros, Minas Gerais, Brazil, during the May 2022, December (Dec) 2023, and December (Dec) 2024 sampling events, and the respective number of identified specimens (NISP) and minimum number of individuals (MNI).

Taxon	May/2022		Dec/2023		Dec/2024		Total	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI (%)
Didelphimorphia								
Didelphidae								
<i>Gracilinanus microtarsus</i>	11	5	6	2	21	9	38	16 (7.1%)
Lagomorpha								
Leporidae								
<i>Sylvilagus minensis</i>	4	1	-	-	-	-	4	1 (0.5%)
Rodentia								
Cricetidae								
<i>Akodon cf. cursor</i>	35	11	-	-	1	1	36	12 (5.3%)
<i>Akodon</i> sp.	2	2	-	-	-	-	2	2 (0.9%)
<i>Calomys cf. cerqueirai</i>	36	14	31	12	134	45	201	71 (31.8%)
<i>Calomys tener</i>	3	2	4	2	55	19	62	23 (10.3%)
<i>Calomys</i> sp.	2	1	-	-	15	8	17	9 (4.0%)
<i>Cerradomys subflavus</i>	9	3	-	-	-	-	9	3 (1.3%)
<i>Necomys lasiurus</i>	35	13	13	5	20	8	68	26 (11.6%)
<i>Necomys squamipes</i>	7	2	-	-	4	2	11	4 (1.7%)
<i>Oligoryzomys nigripes</i>	26	10	8	3	47	18	81	31 (13.9%)
<i>Oligoryzomys</i> sp.	-	-	-	-	5	3	5	3 (1.3%)
Sigmodontinae	22	15	-	-	6	2	27	17 (7.6%)
Muridae								
<i>Mus musculus</i>	-	-	6	2	3	1	9	3 (1.3%)
<i>Rattus</i> sp.	-	-	-	-	1	1	1	1 (0.5%)
Echimyidae								
<i>Trinomys setosus</i>	3	1	-	-	-	-	3	1 (0.5%)
Total specimens	195	80	68	26	312	117	575	223 (100%)
Total richness	11		6		10		14	

taken along the coronal plane. All measurements and their respective descriptions are presented in Supplementary SD1. All collected material was deposited in lots (LO) in the Mammalogy Collection of the Taxonomic Collections Center at the Federal University of Minas Gerais (CCT-UFMG), and voucher numbers are provided in Appendix 1.

For each taxon, the number of identified specimens (NISP) was calculated as the sum of all fragments (mandibles, maxillae, skulls), and the minimum number of individuals (MNI) was determined based on the most frequently occurring element (mandibles, maxillae, skulls) on the right or left side (Grayson 1973). The relative occurrence of small mammals was estimated by dividing the number of specimens collected for each species by the total number of specimens. Species richness was calculated as the total number of species obtained per sample, and abundance was determined using the MNI for each species. MNI was used here as a measure of sample size rather than sampling effort, since it is itself an outcome of the identification process rather than an independent metric of the collection effort invested. Individual pellet analyses

were not conducted, as most material, especially from the 2022 sample, was already completely fragmented into isolated bone elements, precluding a pellet-based estimate of effort.

Sampling completeness for each event was assessed using individual-based (Type 1) rarefaction and extrapolation curves, based on the MNI of each taxon, via the iNEXT package (Hsieh *et al.* 2024). These curves allow richness to be compared among samples of different sizes by standardizing for the number of individuals recorded, and convergence of the interpolation curve toward an asymptote was interpreted as evidence that most species detectable through this method had been sampled in a given event.

The trophic niche breadth of the species was quantified using Levin's standardized index (BA) (Hurlbert 1978), an approach that estimates diet breadth based on the evenness of resource distribution. This index assumes that a species utilizing various food items in similar proportions occupies a broader niche than one concentrated on a few specific resources. The resulting BA values range from 0 to 1,

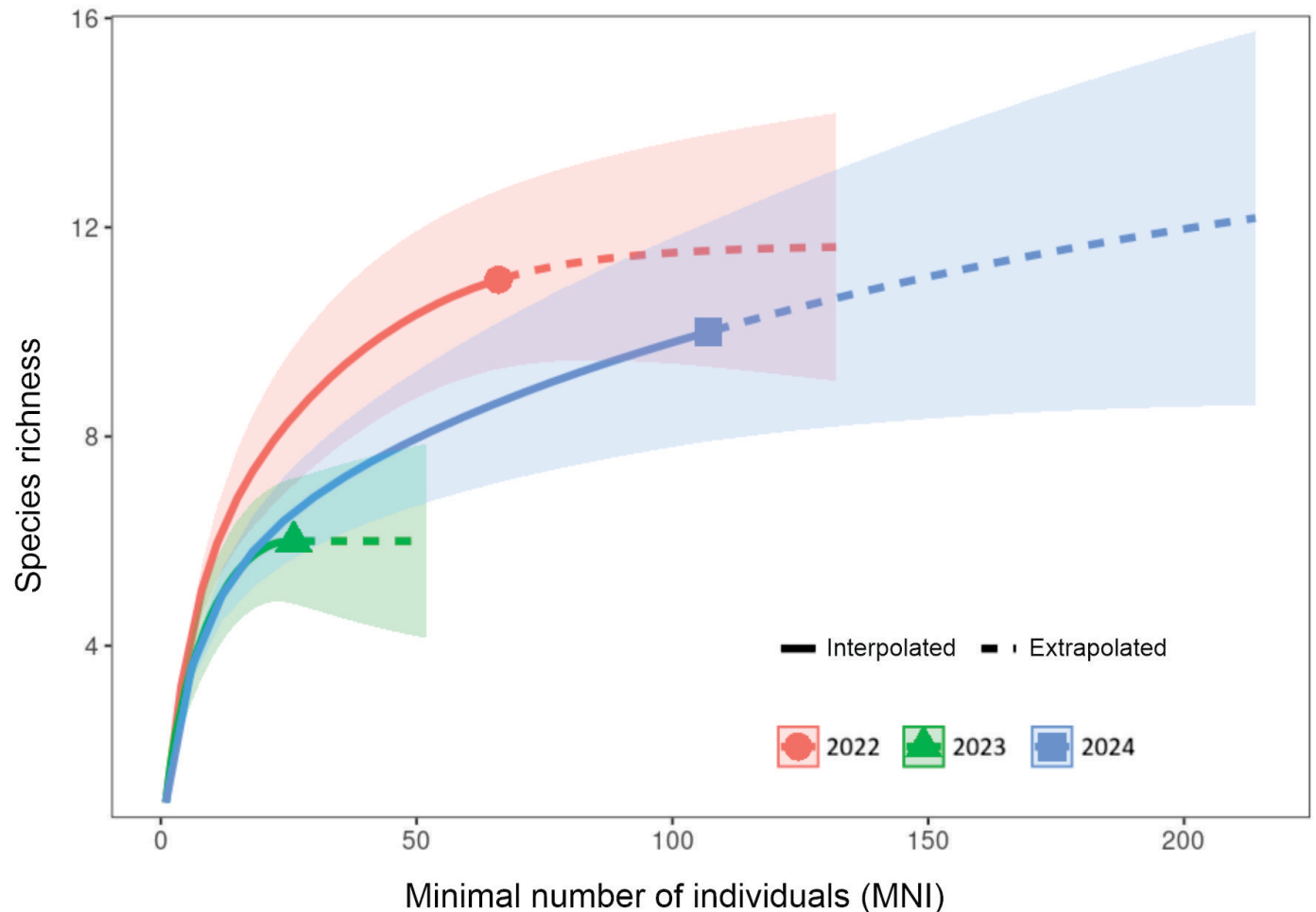


Figure 2. Species accumulation curve for mammal species identified in *Tyto furcata* pellets from São Pedro dos Ferros, Minas Gerais, Brazil, as a function of the minimum number of individuals (MNI) recorded for each sampling year. Sampling events: red circles = May 2022; green triangles = December 2023; blue squares = December 2024. Solid lines represent interpolated (rarefied) richness, dashed lines represent extrapolated richness beyond the observed sample size, and shaded areas represent 95% confidence intervals.

where values near 0 indicate a specialized diet (dominance of a few prey types) and values approaching 1 reflect a generalist strategy characterized by a more uniform consumption of available resources. Because this index reflects the evenness of the recovered prey composition, variation in BA among sampling events may result not only from changes in the owl's foraging behavior, but also from differences in prey availability, prey selectivity, sample size, or the (unknown) period of pellet accumulation represented by each sample; these alternative explanations are considered in the Discussion.

To compile the list of non-volant small mammals of the ZM, we consulted faunal surveys from different localities within the mesoregion: Rio Doce State Park, municipalities of Marliéria, Dionísio, and Timóteo (Keesen et al. 2016); Caparaó National Park, municipality of Alto Caparaó (Bonvicino et al. 1997; Hershkovitz 1998; Gonçalves et al. 2007; Pavan and Leite 2011; Silva et al. 2012; Pavan 2015; Abreu et al. 2021; Ribeiro et al. 2025); Dr. Marcos Vidigal Vasconcellos Private Natural Heritage Reserve (RPPN), municipality of Tombos (Faria et al. 2018); Pedra Dourada Environmental Protection Area (APA), municipality of Pedra Dourada (Faria et al. 2018); Grumarim I (RPPN), municipality of Alto Jequitibá (Faria et al. 2018); Grumarim II (RPPN),

municipality of Caparaó (Faria et al. 2018); Mata dos Jacus Ecological Sanctuary (RPPN), municipality of Alto Jequitibá (Faria et al. 2020); municipality of Carangola (Faria et al. 2019b); Serra do Brigadeiro State Park, municipalities of Araponga and Fervedouro (Moreira et al. 2009); Mata do Paraíso, municipality of Viçosa (Lessa et al. 2014; Brandão et al. 2026); municipality of Juiz de Fora (Queirolo and Granzinolli 2009); and municipality of Simão Pereira (Geise et al. 1996).

Complementarily, a search was conducted in the mammalogy collection of CCT-UFMG. A query was made for the 142 municipalities of the ZM region, and specimens from 14 municipalities were found (Barra Longa, Estrela Dalva, Fervedouro, Lima Duarte, Matipó, Ponte Nova, Recreio, Rio Casca, Rio Pomba, Rio Preto, Santa Rita de Jacutinga, Simonésia, Viçosa, Visconde do Rio Branco). We chose to list only the most representative localities, with at least five species deposited in the collection: Mata do Sossego RPPN, Simonésia; Rio Casca; Barra Longa; Serra do Brigadeiro State Park, Fervedouro; Rio Pomba; Ibitipoca State Park, Lima Duarte; Santa Rita de Jacutinga. It is important to note that these specimens were not directly examined, and their identification was based solely on the specimen tags; however, their taxonomy has been

Table 2. Richness and trophic niche breadth for small mammals identified from *Tyto furcata* pellets collected in São Pedro dos Ferros, Minas Gerais, Brazil, during the May 2022, December (Dec) 2023, and December (Dec) 2024 sampling events, and the respective species richness (S), Levin’s Index (B), and Standardized Levin’s Index (B_s).

Period	Richness (S)	Levin’s Index (B)	Standardized Levin’s Index (B _s)	Interpretation
May/2022	11	6.46	0.55	Intermediate/Broad niche
Dec/2023	6	3.56	0.51	Intermediate niche
Dec/2024	10	3.99	0.33	Narrow niche (Specialization)

updated according to current classifications (Abreu *et al.* 2025). We also incorporated literature data based on specimens deposited in collections, focusing on species not reported in previous studies, particularly within *Akodon* (Pardiñas *et al.* 2015) and *Trinomys* (Lara and Patton 2000). All municipalities mentioned above are shown in Figure 1.

Results

A total of 575 specimens (NISP) and 223 individuals (MNI) were recorded, representing 14 species of small non-volant mammals across the three sampling events, including two exotic rodent species (Table 1). Species richness for Rodentia, Didelphimorphia, and Lagomorpha was 12, 1, and 1 species, respectively, distributed among four families (Table 1). *Calomys* cf. *cerqueirai*, *Oligoryzomys nigripes*, and *Necomys lasiurus* were the most frequent species, accounting for 31.8%, 13.9%, and 11.6% of the samples, respectively. Together, these three species represented 57.4% of all records. Species with the lowest frequency were *Trinomys setosus*, *Rattus* sp., and *Sylvilagus minensis*, each recorded only once.

Comparison among samples. Small mammal species composition and abundance exhibited distinct variations across the sampling events conducted over the three years. In the first sampling, in May 2022 (NISP = 195), the highest richness was recorded with 11 species, among which *Akodon* cf. *cursor*, *Necomys lasiurus*, and *Calomys* cf. *cerqueirai* were the most abundant. Notably, species such as *Cerradomys subflavus*, *Sylvilagus minensis*, and *Trinomys setosus* were exclusive to this period. Conversely, the December 2023 sampling yielded a reduced sample size (NISP = 68) and the lowest recorded richness, with only six species, where *N. lasiurus* and *C. cf. cerqueirai* accounted for 64.7% of the specimens. The December 2024 period was characterized by the highest absolute abundance (NISP = 312), with 10 identified species and a marked dominance of *C. cf. cerqueirai*, *Oligoryzomys nigripes*, and *C. tener*. In this final sample, the presence of the exotic rodent *Rattus* sp. was also recorded. Throughout the study, only four species remained common to all three samples: *N. lasiurus*, *C. cf. cerqueirai*, *C. tener*, and *Gracilinanus microtarsus* (Table 1).

Individual-based rarefaction and extrapolation curves indicated high sampling completeness for the 2022 and 2024 events (Figure 2), both of which approached, but had not yet fully reached, an asymptote, suggesting that most species detectable through pellet analysis under the recorded sample size had been recovered in these two events. The low slope of the extrapolation curves for these events indicates that a substantial increase in sample size

would likely add few additional species to the pellet-derived inventory. The 2023 curve, based on a smaller sample (NISP = 68), did not reach a clear asymptote, indicating lower sampling completeness for that event.

Although December 2024 had the highest number of individuals (MNI = 117) and slightly lower observed richness than May 2022 (MNI = 65, S = 11), the 95% confidence intervals of the rarefaction/extrapolation curves for these two events overlap broadly (Figure 2), indicating that the numerical difference in richness between them is not statistically supported. The gentler slope of the 2024 curve likely reflects the strong numerical dominance of *C. cf. cerqueirai* in that sample, which increases the number of individuals needed to detect additional, rarer species. The curve for December 2023 (MNI = 26) reached a lower asymptote than the other two events; however, its confidence interval also overlaps with that of December 2024 across the range of shared sample sizes (Figure 2).

Levin’s standardized niche breadth (BA) varied among sampling events (Table 2), from 0.55 in May 2022 (the broadest, most even prey composition, including the two rarest items recorded, *S. minensis* and *T. setosus*) to 0.33 in December 2024 (the narrowest), when *C. cf. cerqueirai* alone accounted for nearly 40% of records; December 2023 showed an intermediate value (BA = 0.51). These differences are interpreted in the Discussion, along with alternative explanations besides changes in foraging behavior (see Methods).

Discussion

Taxonomic considerations. Species of *Calomys* are known for their morphological similarity and difficulty of diagnosis, with karyotypic and molecular data serving as more reliable tools for their identification (Bonvicino *et al.* 2010). These species are commonly divided into two main groups based on body size: the “small” group (e.g., *C. tener* and *C. laucha*) and the “large” group (e.g., *C. expulsus*, *C. cerqueirai*, *C. mattevi*, *C. tocantinsi*). In addition to morphological similarity, many species of this genus are sympatric (Bonvicino *et al.* 2010). These factors together further complicate species-level identification.

Previous studies in the ZM report the occurrence of *Calomys tener* (e.g., Moreira *et al.* 2009; Lessa *et al.* 2014; Faria *et al.* 2018), one of the smallest species of the genus, which was also present in the samples analyzed here (Figures 3A, B; Figures 4B, G). However, the samples also contained crania from *Calomys* of the “large” group, similar in size to *C. expulsus* and *C. cerqueirai*. In addition to their larger size, these crania exhibited a well-developed alisphenoid strut, a

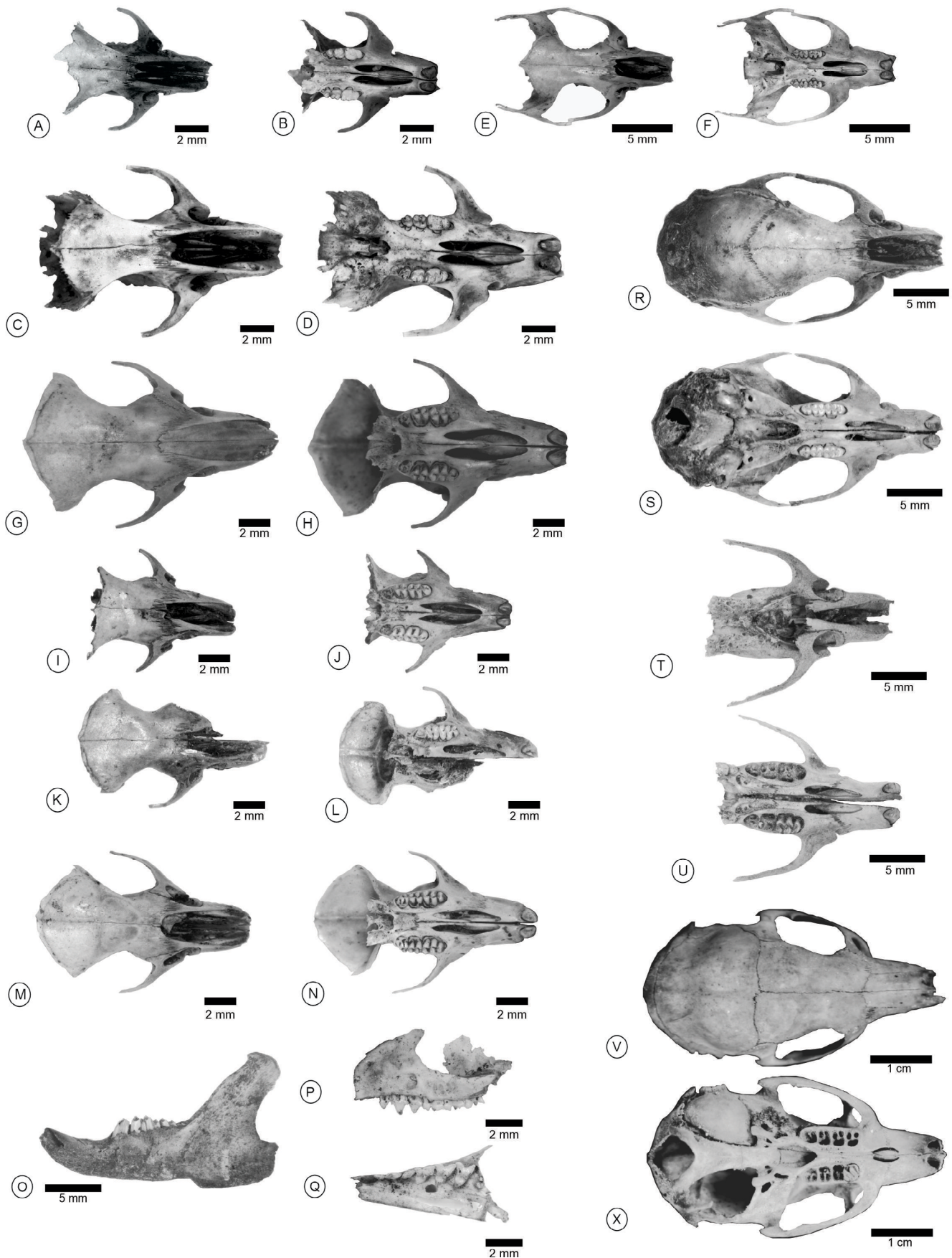


Figure 3. Cranial and dental remains of non-volant small mammals recorded in this study, shown in dorsal and ventral views except where indicated. A, B – *Calomys tener* (UFMG LO20); C, D – *Calomys* cf. *cerqueirai* (UFMG LO21); E, F – *Oligoryzomys nigripes* (UFMG LO23). G, H – *Akodon* cf. *cursor*; I, J – *Akodon* sp. (UFMG LO10); K, L – *Akodon* sp. (UFMG LO32); M, N – *Necomys lasiurus* (UFMG LO02). V, X – *Trinomys setosus* (UFMG LO11); O – lateral view of *Sylvilagus minensis* dentary (UFMG LO12); P (lateral), Q (ventral) – *Gracilinanus microtarsus* (UFMG LO30). R, S – *Cerradomys subflavus* (UFMG LO06); T, U – *Nectomys squamipes* (UFMG LO24).

Table 3: Non-flying small mammals reported for the Zona da Mata region, Minas Gerais, Brazil, including locality (numbered 1–17, detailed in the legend below the table), endemism (MA = Atlantic Forest), and conservation status according to the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio 2026) and the International Union for Conservation of Nature (IUCN 2026) assessments (DD = Data Deficient; NL = not listed; NT = Near Threatened; VU = Vulnerable; EN = Endangered).

Taxon	Locality	Endemism	ICMBio/ IUCN
Order			
Didelphimorphia			
Family Didelphidae			
<i>Caluromys philander</i>	5, 8		
<i>Didelphis aurita</i>	3, 4, 5, 6, 11		
<i>Gracilinanus agilis</i>	1, 3, 11		
<i>Gracilinanus microtarsus</i>	3, 4, 5, 6, 8, 17	MA	
<i>Marmosa paraguayana</i>	5		
<i>Marmosops incanus</i>	1, 2, 4, 5, 12		
<i>Marmosops paulensis</i>	1, 4, 6, 7, 9	MA	
<i>Metachirus myosuros</i>	5, 7		
<i>Monodelphis americana</i>	1, 3, 4, 5, 6, 8		
<i>Monodelphis domestica</i>	4		
<i>Monodelphis pinocchio</i>	6	MA	NT/NL
<i>Monodelphis scalops</i>	1, 2, 3, 4	MA	
<i>Monodelphis dimidiata</i>	4	MA	
<i>Philander quica</i>	1, 2, 3, 4, 6, 9, 10, 12	MA	
<i>Monodelphis</i> sp.	4		
Order Lagomorpha			
Family Leporidae			
<i>Sylvilagus minensis</i>	3, 5, 17		
Order Rodentia			
Family Caviidae			
<i>Cavia aperea</i>	3, 6		
<i>Cavia</i> sp.	5		
Family Cricetidae			
Subfamily Sigmodontinae			
Tribe Akodontini			
<i>Abrawayaomys ruschii</i>	2, 3, 4, 5	MA	
<i>Akodon cursor</i>	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 17		
<i>Akodon montensis</i>	16		
<i>Castoria angustidens</i>	1, 4, 6, 9	MA	
<i>Akodon lindberghi</i>	3, 12, 13, 14		/DD
<i>Akodon</i> sp.	17		
<i>Akodon mystax</i>	6	MA	NT/DD
<i>Blarinomys breviceps</i>	2, 3, 4	MA	
<i>Bibimys labiosus</i>	3	MA	
<i>Brucepattersonius griserufescens</i>	6	MA	NT/DD
<i>Necomys lasiurus</i>	1, 3, 4, 17		
<i>Oxymycterus dasytrichus</i>	1, 2, 3, 4, 5, 6	MA	
<i>Oxymycterus rufus</i>	3	MA	DD/
<i>Oxymycterus caparae</i>	6	MA	VU/
<i>Oxymycterus</i> sp.	4, 9		
<i>Thaptomys nigrita</i>	1, 2, 3, 4, 6	MA	

Tribe Delomyini			
<i>Delomys sublineatus</i>	1, 2, 4, 6, 9	MA	
<i>Delomys altimontanus</i>	6	MA	NT/NL
Tribe Oryzomyini			
<i>Cerradomys subflavus</i>	1, 3, 4, 5, 7, 11, 17		
<i>Drymoreomys</i> sp.	4	MA	/NT
<i>Euryoryzomys russatus</i>	4, 6	MA	
<i>Holochilus brasiliensis</i>	3		
<i>Hylaeamys seuanezi</i>	5	MA	
<i>Oecomys catherinae</i>	5, 8		
<i>Oligoryzomys flavescens</i>	1, 2, 3, 6		
<i>Oligoryzomys nigripes</i>	1, 2, 3, 4, 5, 6, 7, 8, 9, 17		
<i>Oligoryzomys</i> sp.	9, 10, 12, 17		
<i>Nectomys squamipes</i>	1, 3, 4, 5, 6, 7, 8, 17		
<i>Pseudoryzomys simplex</i>	15		
<i>Sooretamys angouya</i>	1, 2, 4, 6	MA	
Tribe Phyllotini			
<i>Calomys cf. cerqueirai</i>	17		
<i>Calomys tener</i>	1, 3, 4, 5, 8, 17		
<i>Calomys</i> sp.	6, 8		
Tribe Rhagomyini			
<i>Rhagomys rufescens</i>	3, 4	MA	
Tribe Thomasomyini			
<i>Rhipidomys mastacalis</i>	4, 5		
<i>Rhipidomys tribei</i>	1, 2, 3	MA	/DD
<i>Rhipidomys macrurus</i>	4		
<i>Rhipidomys</i> sp.	12		
Tribe Wiedomyini			
<i>Juliomys ossitenuis</i>	1, 2, 4, 6	MA	
<i>Juliomys pictipes</i>	3, 8	MA	
Family Muridae			
<i>Mus musculus</i>	4, 17		
<i>Rattus rattus</i>	4, 5, 17		
Family Echimyidae			
Subfamily Eumysopinae			
<i>Trinomys graciosus</i>	1, 4, 6, 9	MA	
<i>Trinomys setosus</i>	7, 17	MA	
<i>Euryzygomatomys spinosus</i>	3, 5, 6, 9		
<i>Phyllomys lundii</i>	4	MA	NT/EN
<i>Phyllomys pattoni</i>	3	MA	
Family Sciuridae			
<i>Guerlinguetus brasiliensis</i>	5, 6, 8		
Total richness	59		

Legend: 1 = Serra do Brigadeiro State Park (Moreira *et al.* 2009; CCT-UFMG); 2 = Santuário Ecológico Mata dos Jacus RPPN (Faria *et al.* 2020); 3 = Mata do Paraíso (Lessa *et al.* 2014; Brandão *et al.* 2026); 4 = Dr. Marcos Vidigal Vasconcellos RPPN, APA Pedra Dourada, Grumirim I and II RPPN (Faria *et al.* 2018); 5 = Rio Doce State Park (Keesen *et al.* 2016); 6 = Caparaó National Park (Bonvicino *et al.* 1997; Hershkovitz 1998; Gonçalves *et al.* 2007; Pavan and Leite 2011; Silva *et al.* 2012; Pavan 2015; Abreu *et al.* 2021; Ribeiro *et al.* 2025); 7 = Rio Casca (CCT-UFMG; Lara and Patton 2000); 8 = Rio Pomba (CCT-UFMG); 9 = Simonésia (CCT-UFMG); 10 = Santa Rita de Jacutinga (CCT-UFMG); 11 = Barra Longa (CCT-UFMG); 12 = Ibitipoca State Park, Lima Duarte (CCT-UFMG; Brandão *et al.* 2026); 13 = Juiz de Fora (Queirolo and Granzinoli 2009); 14 = Simão Pereira (Geise *et al.* 1996); 15 =

structure not observed in *C. tener* (Salazar-Bravo 2015). These specimens were identified as *Calomys* cf. *cerqueirai* (Figures 3C, D; Figures 4A, F), a species occurring in the southern and southeastern portions of Minas Gerais, along the right bank of the Doce River, with additional records from the Atlantic Forest in Rio de Janeiro and Espírito Santo (e.g., Bonvicino et al. 2010; Colombi and Fagundes 2015; Gonçalves-Oliveira et al. 2016; Assis et al. 2020). Specimens that could not be reliably distinguished between *C. tener* and *Calomys* cf. *cerqueirai*, either due to fragmentation, missing molars, or overlapping measurements, were identified as *Calomys* sp. and were not included in species richness counts. Molecular or karyotypic analyses are required to confirm the species identification proposed here.

Most specimens of *Oligoryzomys* were identified as *O. nigripes* based on their morphological and morphometric traits (Figures 3E, F; Figure 4H). However, four mandibles exhibited reduction or absence of the mesolophid on m1 and/or m2 (Figure 4I), a character not observed in *O. nigripes* or *O. flavescens*, both of which can occur in the ZM (see Moreira et al. 2009; Faria et al. 2020). This reduction of the mesolophid has been reported in *O. mato Grossoe* (previously assigned to *O. fornesi*) (Paresque 2010; Boroni et al. 2015), a species with a wide distribution in the Caatinga, Cerrado, and ecotonal areas, including Minas Gerais. However, Weksler et al. (2017), in their amended diagnosis of *O. mato Grossoe*, describe mesolophids on the molars as present. One small-sized mandible (UFMG L022), although retaining the mesolophid, displayed an ectolophid, a character absent in the other specimens. These specimens were identified as *Oligoryzomys* sp., and additional samples are needed to determine whether these traits represent variation within *O. nigripes* or a different taxon.

Among the *Akodon* specimens recovered from the pellets, two crania stood out for their morphological differences and were identified as *Akodon* sp. (Figure 3). The skull LO10, although from a younger individual with little dental wear, was substantially smaller than other *A. cursor* specimens in the sample (Figures 3G, H). The incisive foramen is narrower than in other specimens and extends to the level of the protocone of the first molar (M1). The mesopterygoid fossa reaches M3 as in other *Akodon* specimens, but in LO10 it is slightly narrower and shaped like an "m" (Figures 3I, J). The first molar exhibits an anteromedial flexus, a small anteromedial fossette, and minor mesolophids. Morphometric comparisons suggest that this specimen is closest to *A. lindberghi*, though slightly larger for its age class, with consistent morphological differences. When compared with young *A. lindberghi* specimens, the latter show more parallel parietals, a less expanded interorbital region, a more tapered anterior nasal, and a narrower zygomatic plate. The incisive foramen in LO10 is shorter (IF = 5.25mm) and does not reach the hypocone, unlike in *A. lindberghi* (IF = 5.40–5.85mm). The incisive foramen also has a narrower distal portion than in *A. lindberghi*. Both specimens share the "m-shaped" mesopterygoid fossa, but

the molars of *A. lindberghi* are much smaller and narrower/longer. Additional comparisons with *A. lindberghi* from Simão Pereira and Rio Pomba, both in the ZM, support the identification of this specimen as *Akodon* sp., pending further sampling.

The specimen LO32 showed an intermediate size between LO32 and other *Akodon* individuals, with moderately worn molars (Figures 3K, L). Its molars are relatively broader (M1 = 1.37 mm) than those of other *Akodon* specimens in the sample (M1 = 1.14–1.30 mm) (Figure 4C). The antero-medial fossette and anteroloph remain visible despite dental wear. The anteromedial flexus is labially displaced, and the labial conule is slightly smaller than the lingual. The incisive foramen is long and reaches the hypoflexus of M1. The mesopterygoid fossa reaches the edge of M3, although its precise shape could not be determined due to breakage. The parietal bones are slightly convergent anteriorly, unlike the hourglass shape of other *Akodon* specimens, and the zygomatic plate edge is rounded.

Despite these differences relative to LO10, the specimen was also identified as *Akodon* sp., with further comparisons required for confirmation. The remaining *Akodon* specimens were identified as *Akodon* cf. *cursor* based on morphological characteristics, morphometric measurements, and geographic distribution. Although *Akodon montensis* has not been previously reported from the ZM region, we found a record of this species at the RPPN Feliciano Miguel Abdala (Pardiñas et al. 2015), in the municipality of Caratinga, located on the northern border of this mesoregion but formerly included in the Leste mesoregion. This taxon is likely to also occur in the ZM region.

A well-preserved skull of *Trinomys* with associated mandibles was recovered from the pellets (Figures 3V, X). Specimens were identified as *Trinomys setosus* based on cranial features, including a post-orbital process of the zygoma formed primarily by the jugal, an oval incisive foramen with a complete septum formed by the vomer, and inflated, rounded bullae (Dalapicolla and Leite 2015; Pessôa et al. 2015). *Trinomys graciosus* also occurs in the ZM (Moreira et al. 2009; Faria et al. 2018) but differs in cranial morphology, such as a post-orbital process formed by the squamosal and uninflated bullae (Dalapicolla and Leite 2015). Other recorded species, such as *N. lasiurus*, *C. subflavus*, and *S. minensis*, are illustrated in Figure 3 and 4.

Sampling. In this study, we recorded 14 non-volant small mammal species in the rural area of São Pedro dos Ferros, contributing to filling gaps in the knowledge of mammal fauna in the region, representing the first study in this municipality. Compared to other studies in the ZM of Minas Gerais (see Table 3), species richness was low, representing only 23.7% of the known regional diversity ($S = 59$). This was expected due to the municipality's historical land use and current landscape. The area developed through timber extraction, coffee and sugarcane cultivation, and dairy and beef cattle ranching, leading to extensive deforestation and leaving only 2.80% of the original vegetation cover

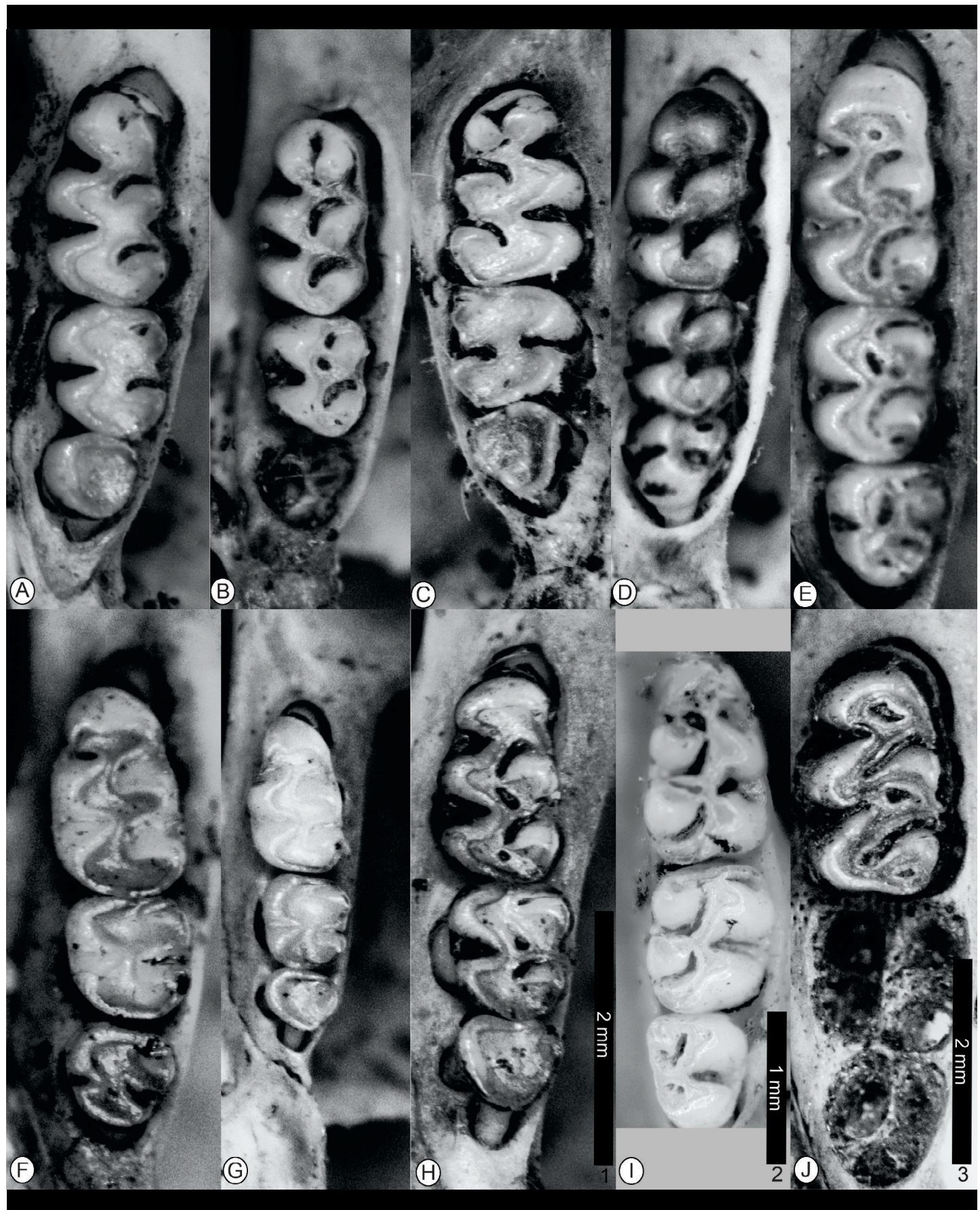


Figure 4. Occlusal views of upper and lower molars (lower molars shown only in image I) of Cricetidae rodents. A – *Akodon* cf. *cursor* (UFMG LO09); B – *Akodon* sp. (UFMG LO10); C – *Akodon* sp. (UFMG LO32); D – *Necomys lasiurus* (UFMG LO02); E – *Cerradomys subflavus* (UFMG LO06); F – *Calomys* cf. *cerqueirai* (UFMG LO21); G – *Calomys tener* (UFMG LO20); H – *Oligoryzomys nigripes* (UFMG LO23); I – *Oligoryzomys* sp. (UFMG LO22); J – *Nectomys squamipes* (UFMG LO24). Scale bar 1 applies to images A–H; scale bar 2 to image I; and scale bar 3 to image J.

(Fundação SOS Mata Atlântica/INPE 2017).

Other surveys of non-volant small mammals in the ZM recorded between five and 34 species, including rare and Atlantic Forest endemic species such as *Blarinomys breviceps*, *Rhagomys rufescens*, *Castoria angustidens*, and *Juliomys ossitenius* (Table 3). These studies were conducted in forest fragments within protected areas, such as the Rio Doce State Park (Keesen et al. 2016), Caparaó National Park (Bonvicino et al. 1997; Hershkovitz 1998), and Serra do Brigadeiro State Park (Moreira et al. 2009), with sampling periods extending over more than one year. The latter two parks are also located at higher altitudes, with peaks above 2000 m and the presence of Campos de Altitude vegetation. These areas harbor habitat-specific species such as *Akodon mystax*, *Delomys altimontanus*, *Oxymycterus caporae*, and *Monodelphis pinocchio*.

In addition to sampling duration, altitudinal variation, and local vegetation, another important factor affecting differences in fauna composition is the sampling method. All previous surveys compiled in Table 3 employed conventional trapping techniques (Sherman traps, Tomahawk traps, and/or pitfalls), whereas the present study is based on skeletal remains recovered from *T. furcata* pellets. Because pellets and traps sample small mammal assemblages through fundamentally different processes, one reflecting predator diet and detection ability, the other reflecting trap encounter rates for particular taxa, richness and abundance values obtained by the two methods are not directly comparable, and differences between our results and other ZM surveys should be interpreted with this caveat rather than as a straightforward measure of relative diversity. For instance, pitfall traps are known to substantially increase recorded richness by capturing fossorial and semi-fossorial species that owls rarely take (Umetsu and Pardini 2007), while owl pellets can detect species that evade conventional traps altogether (see below).

Given that American Barn Owls forage within a radius of up to 3 km of their roost (Andrews 1990; Taylor 1994), and that this radius around the study site encompasses mostly pastures and small forest fragments, except for one fragment approximately 7 km in length, where the Dr. João Carlos Bello Lisboa Municipal Natural Park was recently created (Prefeitura Municipal de Rio Casca 2025), together with streams and a larger river (Rio Casca) lacking substantial riparian forest (Figure 1). This habitat composition is consistent with the species recorded, with generalist, open-habitat taxa predominating and only two forest-dependent species detected, likely associated with the larger forest fragment within the owl's foraging range.

In this study, *Calomys* cf. *cerqueirai*, *C. tener*, *O. nigripes*, and *N. lasiurus* predominated, being species that occur in both open and forested areas (Pardiñas et al. 2017). *Calomys* and *Necomys* species are frequently preyed upon by American Barn Owls and are often among their most common prey in different studies (e.g., Motta-Junior

and Talamoni 1996; Bonvicino and Bezerra 2003; Stumpp et al. 2016; Boroni et al. 2018; Mancini et al. 2018; Cherem et al. 2022). Open-habitat specialist species are typically more abundant in agricultural landscapes (Benedek and Sîrbu 2018), reinforcing the predominance of these taxa in the samples. However, species that preferentially inhabit forested environments, such as *Trinomys setosus* and *Gracilinanus microtarsus*, were also recorded (Pardiñas et al. 2017; Faria et al. 2019b). The presence of these species suggests that the owls also hunted along forest edges, as they are not usually captured in pastures using conventional trapping methods.

All recorded species are common and widely distributed in the Atlantic Forest, with *T. setosus* being endemic to the biome (Graipel et al. 2017). Endemic species are more sensitive to the negative effects of habitat fragmentation and degradation (Ewers and Didham 2006), and may face local extinction, which was expected given the historical and current quality of the habitat. Although not reported in previous studies in the ZM (Table 3), *T. setosus* has been captured in Rio Casca (Lara and Patton 2000), a neighboring municipality. The species has a wide distribution in the Atlantic Forest of Minas Gerais, Espírito Santo, and southern Bahia (Pessôa et al. 2015). This record highlights the importance and practicality of owl pellets for small mammal inventories, as this method often detects species not captured by conventional traps. For example, the only record of the rodent *Pseudoryzomys simplex* in the ZM of Minas Gerais was also obtained from owl pellets (Faria et al. 2019a), further supporting the value of this approach.

Variation among samples. Species richness was similar in the samples collected in 2022 and 2024 (11 and 10 species, respectively), whereas the 2023 sample yielded fewer species (six) and specimens (NISP = 68). This lower sample size coincided with a shorter collection time in that event (~15 minutes, versus ~20 minutes in 2022 and 2024; see Methods), and likely reflects, at least in part, reduced search effort rather than a reduction in local richness. Accordingly, the lower asymptote reached by the December 2023 rarefaction/extrapolation curve relative to the other two events (Figure 2) should be interpreted with caution rather than as strong evidence of lower true richness in that year, given that the comparison is limited by the smaller sample size and shorter collection time noted above, which curtail the range over which the 2023 curve can be reliably extrapolated. These differences also illustrate how the composition of prey recovered from *T. furcata* pellets can vary according to prey availability and vulnerability at the time of sampling (Bellocq 1998; Bonvicino and Bezerra 2003; Teta et al. 2012).

The May 2022 sample showed the highest standardized niche breadth (BA=0.55), with a more even prey composition that included larger and rarer items such as *S. minensis* and *T. setosus*. One possible explanation is that lower density of the dominant prey during this period led American Barn Owls to include a broader range of less frequent or harder-

to-capture taxa, consistent with opportunistic foraging behavior reported for this species elsewhere (Bellocq 1998; Scheibler and Christoff 2007). However, this interpretation cannot be confirmed with the present data, since no direct behavioral observations of the owl were made.

In contrast, the December 2024 sample showed the lowest niche breadth ($BA = 0.33$), with the diet heavily dominated by *C. cf. cerqueirai*, which alone accounted for nearly 40% of records. Such strong numerical dominance of a single prey species in owl pellets has been associated elsewhere with local superabundance of that prey (Love et al. 2000; Tores et al. 2005) and with simplification of small mammal assemblages in open, pasture-dominated matrices (Gentili et al. 2014; Benedek and Sîrbu 2018). While consistent with these patterns, our data cannot distinguish this explanation from alternative, non-exclusive possibilities, such as differences in sampling effort or in the period of pellet accumulation between events. We therefore interpret the temporal variation in niche breadth as a working hypothesis about the local small mammal assemblage, rather than as direct evidence of shifts in owl foraging behavior or in prey population trends.

Sigmodontine rodents exhibit population dynamics closely linked to reproduction and resource availability (Fonseca and Kierulff 1989; Bonecker et al. 2009; Rocha et al. 2017), and species such as *A. cursor*, *O. nigripes*, and *N. lasiurus* are known to show marked interannual fluctuations elsewhere (Bonecker et al. 2009; Rocha et al. 2017). Because our sampling consisted of three discrete annual events rather than continuous monitoring, we cannot determine whether the observed differences among years, such as the higher representation of *Akodon cf. cursor* in the May 2022 sample, reflect true population fluctuations, seasonal effects, or simply variation in the pellet accumulation and collection process (see Limitations section). Distinguishing among these possibilities would require sustained, standardized monitoring, which we identify as a priority for future work in this area.

Impacted areas. The richness and abundance of non-volant small mammals observed in the area differ somewhat from those of other regions in the ZM (Table 3). In a forest fragment in Viçosa, *A. cursor*, *O. nigripes*, and *Didelphis aurita* were the most abundant species (Lessa et al. 2014). In Serra do Brigadeiro, *A. cursor*, *Castoria angustidens*, and *Thaptomys nigrita* were the most frequently captured species (Moreira et al. 2009). In the municipalities of Tombos and Pedra Dourada, *A. cursor*, *C. angustidens*, and *O. nigripes* were the most common rodents, while *D. aurita* and *Marmosops incanus* were the most common marsupials (Faria et al. 2018). Some differences were expected due to the use of different sampling methodologies. For instance, *D. aurita*, with an average body mass of 924 g (Faria et al. 2019b), is not commonly preyed upon by *T. furcata* because of its size. American Barn Owls usually prey on individuals weighing between 10 and 40 g (Bonvicino and Bezerra 2003; Scheibler and Christoff 2007; Bueno and Motta-Junior

2008), so its absence in the sample was expected, although predation on *D. aurita* has been previously observed in the study area (Boroni, N., pers. obs.). In contrast, *O. nigripes* and *A. cursor*, which are not strictly forest-dependent, were recorded but were not dominant species.

It is common for owl pellets collected in urban or rural areas to contain a high proportion of exotic species (*Rattus* spp. and *Mus musculus*), which can represent between 20% and 90% of the sample (e.g., Scheibler and Christoff 2007; Lemos et al. 2015; Köhler et al. 2019; Stutz et al. 2020; Almeida et al. 2022). In contrast, exotic species were scarce in our samples (1.8%; NISP = 10, MNI = 4), despite the rural, livestock-dominated setting, possibly because the owl's foraging range did not strongly overlap with buildings and grain-storage structures, where synanthropic rodents tend to concentrate. These exotic species have also been recorded in preserved forest habitats in the ZM (Keesen et al. 2016; Faria et al. 2018).

Although *T. furcata* hunts primarily in open areas and consumes mostly generalist prey, its diet is known to reflect the composition of the local small mammal community (Terry 2010a, 2010b; Heisler et al. 2016). Accordingly, the predominance of *Calomys* spp., *Necromys lasiurus*, and *O. nigripes*, all considered generalist species (Bonvicino et al. 2002), together with the presence of only two strictly forest-dependent species (*T. setosus* and *G. microtarsus*) in our sample, may reflect not only methodological biases but also the actual composition of the local assemblage.

Habitat loss and fragmentation influence species persistence in landscapes modified by human activities (Crandall et al. 2000; Smith et al. 2001), and species with generalist ecological requirements tend to be favored in fragmented habitats, whereas forest specialists may be entirely excluded from such altered environments (Donald and Evans 2006; Passamani and Fernandez 2011). Studies using conventional trapping methods have also frequently recorded *Calomys* and *Necromys* in open, anthropized environments such as pastures (Becker et al. 2007; Bezerra et al. 2009; Fialho et al. 2019; Assis et al. 2020). For example, Assis et al. (2020) recorded low small mammal richness in a pasture in southern Minas Gerais, dominated by *C. cerqueirai*, *N. lasiurus*, and *O. nigripes*.

Records of *C. cerqueirai* remain scarce in the state, likely due to taxonomic uncertainty, but the species has been frequently captured in degraded areas such as pastures and secondary forests (Colombi and Fagundes 2015; Gonçalves-Oliveira et al. 2016; Assis et al. 2020). Some studies indicate that *Calomys* spp. and *N. lasiurus* benefit from intense habitat modification, with their populations increasing in degraded environments (Love et al. 2000; Pardiñas et al. 2000; Boroni et al. 2018; Fialho et al. 2019; Assis et al. 2020). Common forest species recorded in other surveys (*M. incanus*, *Rhipidomys tribei*, *C. angustidens*, *Thaptomys nigrita*) were not found in our samples. Studies using owl pellets in the Atlantic Forest report low abundances of forest specialists, although

a higher species richness within this group is generally recorded, such as *Bibimys labiosus*, *T. nigrita*, *Sooretamys angouya*, *Brucepattersonius* sp., and *Juliomys* sp. (e.g., [Scheibler and Christoff 2007](#); [Stutz et al. 2020](#); [Silveira et al. 2021](#); [Almeida et al. 2022](#); [Pontes et al. 2023](#)).

Besides the selectivity of the sampling method, another important factor for this result is habitat quality. Small mammals are good environmental indicators, responding quickly to changes in their habitat ([Bonvicino et al. 2002](#); [Pardini et al. 2005](#)). Strict forest species depend on sufficient quality and quantity of forest fragments ([Umetsu and Pardini 2007](#); [Passamani and Fernandez 2011](#)) and may disappear from fragmented landscapes ([Donald and Evans 2006](#); [Passamani and Fernandez 2011](#)). Anthropogenic changes in the study area over the past centuries ([Paula 2006](#)), which reduced forest fragments to less than 3% of the original cover, likely led to reduced local diversity. Consequently, strictly forest species such as *Juliomys* spp., *M. incanus*, *C. angustidens*, *R. tribei*, among others recorded in the ZM of Minas Gerais (see Table 3), were not detected in our pellet samples, which does not necessarily imply their local absence, given the method's inherent selectivity toward open-habitat prey (see Limitations).

Non-volant small mammals of the Zona da Mata. ZM is formed by a topographical complex of mountains in the Atlantic Forest, the “mares de morros,” with altitudinal variations ranging from 70 to 2,891 m (Pico da Bandeira), which directly shape the biome's landscapes ([Valverde 1958](#); [Ab'Saber 1970](#)). Today, its forests are reduced to small patches on steep slopes, serving as refugia in southeastern Brazil for many small mammal species. We compiled a list of 59 non-volant small mammal species from the ZM region of Minas Gerais, based on the analyzed studies and collection data from 17 localities (Table 3) (See Supplementary SD2 for a list of species by localities). This list includes 14 species of Didelphimorphia, one of Lagomorpha, and 44 of Rodentia, the latter comprising two exotic species (*Rattus* sp. and *M. musculus*), distributed among seven families.

Cricetid rodents were the most diverse group, with 35 species, reflecting the high richness of this family in Brazil, which currently includes 159 recognized taxa ([Abreu et al. 2025](#)). Species identified only to the genus level (e.g., *Monodelphis* sp., *Oligoryzomys* sp., and *Oxymycterus* sp.) were not included in species richness estimates, except for *Drymoreomys* sp. Although *Drymoreomys albimaculatus* is currently the only recognized species within the genus, we retained the taxonomic designation used in the original publication from which the record was obtained ([Faria et al. 2018](#)).

Among marsupials, the species *Philander quica*, *M. incanus*, and *G. microtarsus* were the most commonly recorded, appearing in nine, eight, and six studies, respectively. Among rodents, the most frequently listed were *A. cursor*, *O. nigripes*, and *Nectomys squamipes*, recorded in 14, 10, and 8 surveyed localities, respectively. These species are typically abundant in Atlantic Forest

assemblages and are known for their ecological plasticity, occurring in both primary and secondary forest habitats. Their recurrent presence across studies likely reflects their broad ecological tolerance and ability to persist in fragmented landscapes, which are characteristic of the ZM region.

In contrast, approximately 32% (N = 19) of the species recorded for the ZM were listed in only one study or locality, such as *Marmosa paraguayana*, *Monodelphis dimidiata*, *B. labiosus*, and *Hylaeamys seuanezi*. These species may represent locally rare taxa, edge-of-range populations, or species with specific habitat requirements that make them less likely to be detected in standard surveys. Among the recorded species, 27 are endemic to the Atlantic Forest ([Graipel et al. 2017](#)). Several taxa are considered rare (e.g., *Monodelphis pinocchio*, *Drymoreomys* sp., *Abrawayaomys ruschii*), reflecting their restricted distributions or low detectability in surveys. *Oxymycterus caparoae* and *Phyllomys lundii* are currently classified as threatened according to national ([ICMBio 2026](#)) and global ([IUCN 2026](#)) conservation assessments, respectively.

In addition, eight species are of scientific interest and are listed as Data Deficient or Near Threatened in different conservation lists: *M. pinocchio*, *Akodon mystax*, *A. lindberghi*, *Brucepattersonius griserufescens*, *Oxymycterus rufus*, *D. albimaculatus* (listed here as *Drymoreomys* sp.), *R. tribei*, and *Delomys altimontanus* ([ICMBio 2026](#); [IUCN 2026](#)). The presence of endemic, rare, and threatened species underscores the conservation importance of the remaining forest fragments in the ZM, which act as refugia within a heavily modified landscape.

Some studies in the ZM were conducted over ten years ago and have been updated according to the most recent taxonomic revisions, following the Brazilian Mammal Checklist ([Abreu et al. 2025](#)). In Serra do Brigadeiro, *R. mastacalis* was updated to *R. tribei* ([Costa et al. 2011](#)), and *Akodon serrensis* to *Castoria angustidens* ([Pardiñas et al. 2016](#)). In the Rio Doce State Park survey ([Keesen et al. 2016](#)), *Metachirus nudicaudatus* was updated to *M. myosorus* ([Voss 2022](#); [Abreu et al. 2025](#)). From [Faria et al. \(2018\)](#) survey, *Monodelphis sorex* was updated to *M. dimidiata* ([Pavan and Voss 2016](#)). *Holochilus sciureus* was cited in [Lessa et al. \(2014\)](#), however, based on more recent genus-level studies, the species occurs in Cerrado areas ([Prado et al. 2021a](#); [2021b](#)), and we updated the nomenclature to *H. brasiliensis*, a species occurring in the Atlantic Forest ([Prado et al. 2021b](#)). *Philander frenatus* was updated to *P. quica* ([Voss et al. 2018](#)).

The data from the CCT-UFMG collection illuminate important records for different municipalities and conservation units in the ZM region, which have not been published in scientific articles (Table 3). For example, in the RPPN Mata do Sossego, in the municipality of Simonésia, ten taxa are listed, including *Marmosops paulensis*, *Delomys sublineatus*, *Euryzomatomys spinosus*, and *T. graciosus*, species that are not commonly captured. In Ibitipoca State Park, in Lima Duarte, five typical Atlantic Forest

species have been collected (*M. incanus*, *P. quica*, *A. cursor*, *Oligoryzomys* sp., *Rhipidomys* sp.). More recently, a new record of *A. lindberghi* in the park has increased its species richness (Brandão et al. 2026). In Rio Pomba, 13 species are listed, although two are identified only to the generic level (*Calomys* sp. and *Akodon* sp.). These specimens were collected for studies on the Vaccinia virus in natural populations of small mammals (Miranda et al. 2017; Campos 2016). In her dissertation, Campos (2016) discussed *Akodon* sp. as *Akodon* cf. *mystax*, but Brandão and Gonçalves (in Press) reexamined the individuals and identified them as *A. lindberghi*, a species with an increasing number of records in the Atlantic Forest (Queirolo and Granzinolli 2009; Machado et al. 2016; Brandão et al. 2026). A revision of these CCT specimens is essential to confirm taxonomic identification and improve knowledge of local richness, as they may represent taxa not yet catalogued for the region or even undescribed species.

Akodon montensis, *M. paraguayana*, *B. griserufescens*, and *H. seuanezi*, although lacking records in municipalities officially included within the ZM, likely occur in the study area due to confirmed records from nearby localities, such as Caratinga (Pardiñas et al. 2015) and Rio Doce State Park (Keesen et al. 2016). It is important to note that “ZM” refers to a geopolitical designation, which does not necessarily reflect the natural distribution of species. Therefore, this study also incorporated data from relevant surveys conducted in municipalities bordering the mesoregion, such as Caratinga and Marliéria, which share similar Atlantic Forest phytophysionomies with the study area.

Among the compiled surveys, Faria et al. (2018) reported the highest richness with 34 taxa, including some rare species such as *P. lundii*, *M. paulensis*, and *Drymoreomys* sp., which have restricted distributions. This study included four different localities between Caparaó National Park and Serra do Brigadeiro State Park, which likely increased species richness. At Mata do Paraíso, in Viçosa, 28 taxa were recorded, with 18 Cricetid rodents (Lessa et al. 2014; Brandão et al. 2026). This high richness at a single site reflects long-term monitoring, with over 20 years of collection (Paglia et al. 1995; Lessa et al. 2014). Notable species recorded include *Rhagomys rufescens*, *B. labiosus*, *O. rufus*, and *Phyllomys pattoni* (Lessa et al. 2014).

For Caparaó National Park, a compilation of studies resulted in 26 recorded species (Bonvicino et al. 1997; Hershkovitz 1998; Gonçalves et al. 2007; Pavan and Leite 2011; Pavan 2015; Abreu et al. 2021). However, this number is likely underestimated, as common genera such as *Rhipidomys* were not listed. *Calomys callosus* (MN32168) was recorded by Bonvicino et al. (1997), but nowadays the *callosus* group in Brazil is considered to be restricted to the Cerrado of Mato Grosso do Sul (Salazar-Bravo 2015), and no subsequent taxonomic revision of the genus has mentioned this record. Later, Bonvicino et al. (2002) listed *C. expulsus* (MN43033) for Caparaó, and based on this reference, Silva et al. (2012) listed *C. tener* for the park. This appears to reflect

an error by Silva et al. (2012) during the taxonomic update, which they stated was based on Bonvicino et al. (2008). It is possible that this misunderstanding arose from the distribution maps presented in that work. We attempted to examine these specimens, but they were not found in the collection of the National Museum, Rio de Janeiro (MN). Nevertheless, we suggest that the specimen identified as *C. callosus* may actually correspond to *C. expulsus* or *C. cerqueirai*, both large-bodied species of *Calomys*. In our checklist, we maintain the identification as *Calomys* sp., since the specimens from this locality require further taxonomic revision.

For *Monodelphis*, taxonomic inconsistencies for Caparaó were also recorded. Bonvicino et al. (1997; 2002) cited the occurrence of *M. touan* (MN32166), a species currently known to have an Amazonian distribution. Silva et al. (2012), based on this record, cited the occurrence of *M. sorex* for the park, a taxon now synonymized with *M. dimidiata* and without confirmed records for Caparaó National Park. Later, Pavan (2015) described a new species of *Monodelphis* from the Atlantic Forest, *M. pinocchio*, which occurs in the park. The specimens used for the taxonomic description are deposited in the MZUSP (Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil). We suggest that the specimens listed by Bonvicino et al. (1997; 2002) may actually correspond to *M. pinocchio*, although further comparisons are necessary to confirm this hypothesis.

For *Marmosops*, Bonvicino et al. (1997; 2002) recorded the occurrence of *M. incanus* (MN31927). Later, Gardner and Creighton (2008), in their review of the genus, listed *M. paulensis* for the park, but without providing details. More recently, Ribeiro et al. (2025) studied the phylogenetic relationships of the genus and its association with altitude environments, and analyzed specimens of *M. paulensis* collected in the park (MN31916; MN31923; MN31919; MN31918). Therefore, we report here only the occurrence of *M. paulensis* for Caparaó.

Another example suggesting potential undescribed species comes from Blair (1989) (also cited by Hershkovitz 1998), which mentions the occurrence of *Blarinomys breviceps*, *Wilfredomys oenax* (based on owl pellets), and the capture of an unknown species with “short ears almost hidden in the dense, dark rufous-chestnut fur and a tail somewhat longer than the head and body” (Blair 1989). But without voucher specimens, we cannot confirm the occurrence of these taxa. Interestingly, Blair (1989) collected owl pellets over several months in 1979 and 1980 and listed at least 15 species in the park: *Marmosa murina*, *M. cinerea*, *Marmosa* spp., *Sylvilagus brasiliensis*, *Cavia aperea*, *Akodon arviculoides*, *A. cursor*, *A. serrensis*, *Oryzomys capito*, *O. flavescens*, *Oryzomys* spp., *Thomasomys dorsalis*, *Thomasomys* sp., *T. oenax*, *Oxymycterus hispidus*, and an indeterminate Cricetidae. Local diversity may be even higher, since some taxa were not identified. In these pellets, *O. capito* was the most abundant species, with 190 specimens (Blair 1989). However, *O. capito* was later

recognized as a species complex and divided into at least ten species (Weksler et al. 2006). Currently, *Sooretamys angouya* and *Euryoryzomys russatus*, both formerly assigned to the *O. capito* complex, are known to occur in the park.

Serra do Caparaó harbors unique high-altitude vegetation ("campos de altitude"), which allows the occurrence of locally endemic species, some of which have their type localities within the area (e.g., *O. caparaoe*, *D. altimontanus*, *A. mystax*, and *B. griserufescens*), as well as Atlantic Forest species with restricted distributions (e.g., *C. angustidens*, *M. pinocchio*, *J. ossitenius*, and *M. paulensis*). These records highlight Serra do Caparaó as a key area of endemism within the Atlantic Forest for poorly known or potentially undescribed small mammal species. The park lies within a strict area of endemism of only ~11,548 km², yet only about 4.5% of that area is under formal protection (Dalapicolla et al. 2021). This underscores the urgency for continued taxonomic and faunal surveys, as well as for expanding conservation efforts in this biologically critical and under-protected region.

Limitations and future perspectives. Estimating small mammal abundance and richness is subject to method-specific biases regardless of the sampling approach used, and owl pellet analysis is no exception. Compared with conventional trapping, however, pellet-based sampling offers a relatively rapid and low-cost means of characterizing small mammal composition over large areas, since it relies on material that owls themselves collect across their foraging range rather than on trap encounter rates at fixed points (Heisler et al. 2016). The composition recovered in pellet-based inventories nonetheless depends strongly on the predator's own foraging strategy, which can range from broadly opportunistic to comparatively selective; American Barn Owls are generally considered opportunistic foragers that track locally available prey, which supports the use of their pellets as a reasonable proxy for the composition of the small mammal assemblage within their foraging range, while also cautioning against treating pellet-derived proportions as a direct, unbiased measure of true prey abundance (Bellocq 1998; Heisler et al. 2016).

These methodological features directly constrain how our own results should be interpreted. Because pellets and pellet fragments found in the barn represented an accumulation of unknown and potentially variable duration, and because collection events differed in duration (15–20 minutes; see Methods), differences in richness, abundance, and trophic niche breadth among the three sampling events cannot be unambiguously attributed to changes in the local small mammal assemblage; they may equally reflect differences in the amount of material accumulated between visits, in search effort, or in the time window represented by each sample. This temporally averaged nature of pellet accumulations, while advantageous for capturing rare or transient species over time, can also dampen the visibility of short-term or spatially localized population fluctuations that a trapping-based design might otherwise detect

(Heisler et al. 2016). For instance, the interannual variation we observed in standardized niche breadth illustrates the method's sensitivity to shifts in prey composition, although confirming whether this reflects true dietary or population change, rather than sampling-related factors, will require the kind of sustained monitoring discussed below.

Additionally, owl pellet-derived records are inherently shaped by the predator's prey-size preference (typically 10–40 g) and its foraging radius (up to ~3 km around the roost), neither of which we measured directly in this study; consequently, our data document the small mammal taxa detectable by *T. furcata* under these conditions, rather than providing an unbiased, quantitative measure of local small mammal richness, abundance, or population dynamics. We did not conduct complementary field sampling (e.g., live-trapping) of small mammals at the study site, which would have allowed direct comparison between pellet-derived records and locally trapped assemblages; we recommend this as a priority for future studies in the area.

Despite these limitations, owl pellet analysis remains a valuable tool for documenting small mammal occurrence in poorly surveyed, human-modified landscapes such as the ZM, particularly where systematic field sampling is logistically constrained. Barn owls also tend to show strong fidelity to their roosting and nesting sites, often occupying the same shelter for years (Andrews 1990; Taylor 1994), which makes pellet collection at a single, well-established site an especially practical basis for sustained, standardized, multi-year monitoring. Such long-term monitoring would allow future studies to distinguish genuine temporal changes in small mammal richness and abundance, potentially driven by ongoing habitat loss and fragmentation in the region, from the sampling-related noise inherent to single, short-duration collection events like those conducted here.

Conclusions

This study provides the first faunal record of non-volant small mammals for the municipality of São Pedro dos Ferros, documenting 14 species from *T. furcata* pellets collected in a highly modified rural landscape of the Zona da Mata. The lower richness recorded here compared with nearby, better-preserved sites is consistent with this area's extensive historical deforestation and current pasture-dominated landscape, although differences in sampling method between studies also likely contribute to this pattern.

Combined with published surveys and museum records, our data allowed us to compile an updated checklist of 59 non-volant small mammal species for the Zona da Mata mesoregion, including several endemic, rare, and threatened taxa, underscoring the high conservation value of the region's remaining forest fragments, particularly the high-altitude areas that serve as refugia and remain priority sites for taxonomic and faunal surveys. Our results reinforce owl pellets as a valuable, low-cost complementary tool for documenting small mammal assemblages in poorly

surveyed, human-modified landscapes of the Atlantic Forest. Future studies combining pellet analysis with field trapping and sustained multi-year sampling will be important for evaluating population trends and the broader impacts of land-use change on the region's small mammal fauna.

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Declaration of Artificial Intelligence use

AI tools (ChatGPT) were used for preliminary translation and grammar checking. The authors are fully responsible for the original content of the manuscript.

Author contributions

Natália L. Boroni collected and identified the material, analyzed the data, and prepared the manuscript. Rodolfo Stumpp performed the statistical analyses and reviewed the manuscript. Larissa Lacerda Moraes reviewed the manuscript. Fernando A. Perini catalogued and deposited the specimens in the scientific collection and reviewed the manuscript. All authors contributed to the interpretation of the results, accepted responsibility for the content of the manuscript, and approved its submission.

Supplementary data

SD1. Minimum and maximum values of 17 cranial and dental measurements (in mm) recorded for *Akodon*, *Calomys*, and *Oligoryzomys* specimens recovered from *Tyto furcata* pellets, used to support species-level identification within these genera. Data are available at Zenodo, <https://doi.org/10.5281/zenodo.23535077>

SD2. Presence/absence list of the 59 non-volant small mammal species compiled for the Zona da Mata region of Minas Gerais, by locality (numbered 1–17, as in Table 3). Data are available at Zenodo, <https://doi.org/10.5281/zenodo.23535077>

SD3. Voucher specimens examined in this study. Data are available at Zenodo, <https://doi.org/10.5281/zenodo.23535077>

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