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ORIGINAL PAPER

Bamboo shapes the fine-scale richness, abundance, and habitat use of small mammals in a forest fragment

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Abstract
A classic question in community ecology is how species coexist within a community. Studies have sought to understand how species occurrence vary according to habitat structure, space, food, predators, and competitors. Small mammals are widely used as a model system in community ecology, since they represent the most diverse group of mammals in the neotropical forests. Hence, we investigated whether microhabitat features, food resource (fruits), and presence of medium and large mammals can explain fine-spatial scale richness, abundances, and habitat use of small mammals in a forest in Brazil. Three species represented 83% of all captured individuals (*Didelphis albiventris, Oligoryzomys nigripes, Akodon montensis*). Species richness, abundance, and habitat use of small mammals were affected positively by the distance of bamboo (*Chusquea* sp.) thickets. The occurrence of predators (carnivores and omnivores) and potential competitors (large herbivores), however, did not affect richness, abundance, and habitat use of small mammals at small spatial scales. Our findings suggest that the bamboo patches can influence spatial distribution and shape small mammal communities in tropical forests.

Keywords Atlantic rainforest · Brazil · *Chusquea* · Grid method · Caetetus Ecological Station · Community ecology

Introduction

A classic question in community ecology is how species manage to coexist (Hutchinson and MacArthur 1959; Macarthur and Levins 1964). Neotropical forest mammals (small, mid, and large) that occur in the same space and time must have different characteristics in at least one dimension of the niche (Chesson and Kuang 2008; Galetti et al. 2016; Hutchinson 1957; Pinotti et al. 2011). Species can partition space and time according to (1) habitat structure: forest cover, bamboo, leaf litter, and fallen logs on forest (e.g., Delciellos et al. (2018); Lima et al. (2010); Melo et al. (2011); Naxara et al. (2009); Pinotti et al. (2011)); (2) vertical stratification: some species, for example, can use the canopy whereas others forage in the understory (Melo et al. 2013; Melo et al. 2011; Vieira and Monteiro Filho 2003); (3) food: a certain species can feed more on fruits, leaves, grasses, roots, other species more on insects, or seeds with different sizes (Ben-Moshe et al. 2001; Galetti et al. 2015a; Galetti et al. 2016; Leite et al. 1996), (4) predators: limiting the population size by predation, affecting reproduction, population growth, and behavior (Magioli and Ferraz 2021; Melo et al. 2013; Moura et al. 2009), and (5) competitors: by limiting space, resource availability, and displacement, affecting abundance, composition, and behavior (Akkawi et al. 2020; Pedó et al. 2010). Despite the number of recent studies, the factors that allow coexistence of mammals in Neotropical communities are still poorly understood (DeMattia et al. 2004; HilleRisLambers et al. 2012; Santos et al. 2019).

Neotropical small non-flying mammals (rodents and marsupials) are the most diverse group of mammals inhabiting Neotropical forests, with approximately 289 species

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described for Brazil (Paglia et al. 2012), with 124 species in the Atlantic Forest, 94 species of rodents, and 30 species of marsupials (Bovendorp et al. 2017b). Rodents, according to classic dietary studies, can be classified as omnivorous, granivorous, frugivorous, insectivorous, and herbivorous (Carvalho et al. 1999; Galetti et al. 2016; Pinotti et al. 2011; Vieira et al. 2003; Vieira et al. 2006; Vieira et al. 2011), with the majority being seed predators (Galetti et al. 2015a; Galetti et al. 2015b). Marsupials have a diet consisting of fruits, small invertebrates, nectar, and flowers (Vieira and De Moraes 2003). Small mammals are of great importance for the functioning of ecosystem processes, as they can act as pollinating agents (Amorim et al. 2020; Vieira and de Carvalho-Okano 1996), seed dispersers, and seed predators (Iob and Vieira 2008). In addition, they contribute to the maintenance of trophic connections, being a source of food for carnivorous mammals (Facure and Giaretta 1996), birds (Cabral et al. 2006), and snakes (Henderson et al. 1987). Some species can also be considered biological indicators, as they are sensitive to changes in habitat (Banks-Leite et al. 2014).

Given the rapid response to changes in the environment, these animals constitute an ideal model group to assess the effect of resource availability, spatial distribution, and ecological interactions on species coexistence and composition (Naxara et al. 2009; Pinotti et al. 2011; Püttker et al. 2019; Püttker et al. 2008). Studies focusing in microhabitat preference show that the amount of canopy cover, density of vegetation, presence of ferns, presence of fallen logs, leaf litter structure, and rocky outcrops used by different species of small mammals can influence reproduction and coexistence between species (Bovendorp 2013; Lima et al. 2010; Melo et al. 2013; Püttker et al. 2013). Small mammal species with morphological and behavioral similarity, for example, may show spatial segregation to avoid direct competition for resources (Dalmagro and Vieira 2005; Naxara et al. 2009; Pinotti et al. 2011). In this way, species tend to present spatial segregation in the environment using different microhabitats and resources (e.g., fallen logs, litter, arboreal strata, availability of insects, and fruits) (Bergallo and Magnusson 2004; Bergallo and Magnusson 1999; Dueser and Hallett 1980; Melo et al. 2013); however, if resources are grouped or scarce in the environment, species can aggregate around resources (Pinotti et al. 2011). The spatial structure of the forest surface (i.e., spatial variation in quality and quantity of litter) creates distinct microhabitats that can allow the coexistence of multiple species and influence the richness, diversity, and abundance of small mammal communities (Melo et al. 2013; Naxara et al. 2009; Pinotti et al. 2011).

However, changes in population dynamics and composition of the small mammal community may occur with local or functional extinction of large- and medium-sized mammals that act as potential competitors (e.g., *Tayassu pecari*) and predators (e.g., *Puma concolor*) (Akkawi et al. 2020; Bovendorp et al. 2018; Fonseca and Robinson 1990; Galetti et al. 2017; Galetti et al. 2015b). Indeed, small mammals tend to be overabundant in defaunated forest fragments and/or predator-free patches with very low density or extinct large- and medium-sized mammals (see Dirzo et al. 2007; Galetti et al. 2017; Lopez and Terborgh 2007; Terborgh et al. 2001). This may be more significant for generalist species (Bovendorp et al. 2018; Galetti et al. 2021), since the increase in the abundance of generalist species can relate to changes in the structure of the small mammal community through interspecific competition (Galetti et al. 2015b; Püttker et al. 2019).

Here we focus on four dimensions that may affect coexistence: microhabitat feature, resource availability, and occurrence of predators and potential competitors. We evaluate how these factors affect richness, abundance, and habitat use of small mammals at a fine-spatial scale in the largest remnant of semideciduous Atlantic Forest (Caetetus Ecological Station) in Brazil. We hypothesize that richness, abundance, and habitat use of small mammals are affected positively by microhabitat feature and resources (Bergallo and Magnusson 1999; Fonseca and Robinson 1990; Lima et al. 2010; Melo et al. 2013) and negatively by the occurrence of predators and potential competitors (Bovendorp et al. 2018; Fonseca and Robinson 1990; Galetti et al. 2015b).

Methods

Study area

The study was conducted at the Caetetus Ecological Station, Gália, São Paulo, Brazil (hereafter ESEC, 22° 24′ 11″ S, 49° 42′ 08″ W), a 2178-ha remnant of semideciduous forest of Atlantic Forest (Fig. 1). ESEC holds a complete community of large- and medium-sized forest mammals like the endangered black-lion tamarin *Leontopithecus chrysopygus* (Tabanez et al. 2005), white-lipped peccary *Tayassu pecari*, collared peccary *Pecari tajacu*, agouti *Dasyprocta azarae*, tapir *Tapirus terrestris*, paca *Cuniculus paca*, red brocket deer *Mazama americana* (Akkawi et al. 2020), cougar *Puma concolor*, ocelot *Leopardus pardalis*, andoncilla *Leopardus tigrinus* (Tabanez et al. 2005). The ESEC presents a semideciduous seasonal vegetation (Veloso et al. 1991) and holds threatened plants species such as the peroba rosa *Aspidosperma polyneuron*, juçara *Euterpe edulis*, and jequitibá branco *Cariniana estrellensis* (Durigan et al. 2000). The Köppen climate classification is Cwa, mesothermic with dry winter, rains from October to March ranging from 120 to 200 mm with temperatures between 22 and 26°C, and periods of drought from April to September with rainfall

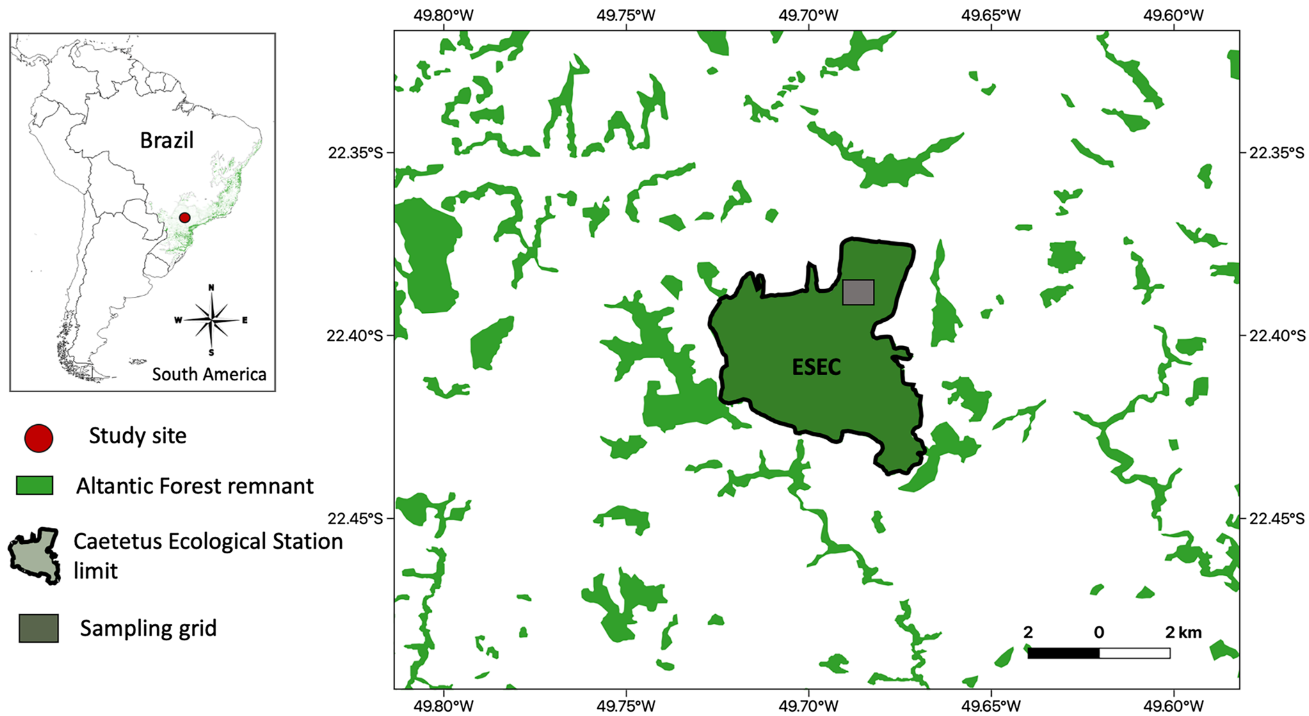

Fig. 1 Location of the study site, Caetetus Ecological Station (ESEC) exhibiting the sampling grid (22k -22.385743°, −49.688663°, 661 m) within the Atlantic Forest remnant in the central west of the state of São Paulo, Brazil

ranging from 35 to 75 mm and lower monthly and temperatures from 16 to 25°C.

Capture of small mammals

We sampled the small mammal community using the capture-mark-recapture method for 10 days every 2 months from June 2017 to April 2018 comprising six campaigns during this period. Small mammals were captured in a 3-ha trapping grid located in the north-east of ESEC. The grid consisted of 11 parallel 150-m lines, 15 m from each other, with trapping stations located every 15 m containing one Sherman trap (37.5×10.0×12.0 cm or 23.0×7.5×8.5 cm; H. B. Sherman Traps, Inc., Tallahassee, Florida) or Tomahawk (42.0 × 12 × 15 cm) placed on the ground. Additionally, pitfall traps (60-L buckets, 53.0 cm in depth, and 40.0 cm in diameter) connected by a 50-cm-high plastic fence were placed at each trap station in 5 of the 11 lines (Appendix Fig. 3). Three different types of traps were used to maximize both capture and recapture rates because pitfall traps result in higher capture rates and a higher proportion of young individuals (Barros et al. 2015; Bovendorp et al. 2017a; Umetsu et al. 2006). All traps were baited with a mixture of sardines, peanut butter, banana, and cornmeal. Captured animals were marked with a numbered ear tag (Small Animal Tags OLT; A. Hartenstein GmbH, Würzburg-Versbach, Germany), recording capture station, trap type, and species of each individual prior to releasing in the location of capture. Capture and recapture data at the station level were used to estimate richness, abundance, and habitat use of small mammals. The habitat use metric was calculated summing captures and recaptures. This metric is closely related to the habitat use once animals use the area for foraging, having positive (mating, food resources, shelter) and negative (fear from predators, possible competitors, etc.) interactions in the habitat (Fonseca and Robinson 1990; Melo et al. 2013; Oliveira et al. 2007; Puttker et al. 2006). Nonetheless, species differing in home range sizes, occupying and using different parts of the habitat. Ten individuals who accidentally died during the fieldwork were deposited at Escola Superior de Agricultura “Luiz de Queiroz” - ESALQ (University of São Paulo, Piracicaba - SP) under supervision of Dr. Alexandre R. Percequillo as testimony material, for taxidermy and species identification. All capture, handling, and tagging protocols followed the guidelines of the American Society of Mammalogists (Sikes et al. 2016).

Sampling of medium and large mammals

In the first moment, we placed 40 camera traps (Bushnell) at the end of each grid line during 30 consecutive days in December 2017 and January 2018. After removing the 40 camera traps, we installed 24 camera traps in 24 randomly selected grid intersections for 15 consecutive days in January and February 2018 (Appendix Fig. 3). From a total of 64 camera traps, 16 did not work in the first sampled period and 4 in the second sampled; therefore, were excluded from the analysis. The camera traps were set to record videos with 10 s to identify the medium and large mammals that used the grid area. Individuals of the same species that were recorded more than once within a 30-min period and that were not possible to identify based on natural marks (stripes, spots, moles, etc.) were considered a single record. For further analyses, we classified medium and large mammals into two categories: predators (carnivores) and potential competitors (herbivores) of small mammals. (Appendix Table 3). We estimated their abundances as the average number of predators and competitors individuals recorded in each sampling station per day. The small mammals (Rodentia and Didelphimorphia) captured in the videos were not considered.

Microhabitat features and resource availability

To characterize the microhabitat features in the grid, we delimited a 5-m radius plot around each trapping station and we measured (I) number of trees with a diameter at breast height (DBH) greater than 20 cm; (II) number of fruits and seeds on the ground; (III) number of fallen logs with a diameter greater than 20 cm; (V) litter height (cm); (VI) distance to water bodies, and (VII) distance to bamboo *Chusquea* sp. thickets. We measured fruits and seeds on the ground every field campaign. Due to the semideciduous nature of the vegetation in the ESEC, we measured the litter height every two campaigns.

The litter height was measured at 10 random points within the 5-m radius plots with a metallic skewer introduced perpendicularly to the ground until it reached the surface of the soil. The height of the litter in the metallic skewer was then measured with a ruler with millimeter precision. The average litter height per plot was calculated using the 10 measurements. We measured all points in the first campaign and then measured again only in the third campaign. Because the average litter height did not vary between the two campaigns, we replaced the litter missing values from the non-measured campaigns with the overall average for each plot.

Knowing that presence of water bodies can influence the occurrence of small mammals, we calculated the distance of each trap station in the grid to the nearest water body. Similarly, we calculated the distance to the nearest bamboo thickets.

Data analysis

Diversity and abundance of mammals

We recorded the richness (number of species), abundance (number of captures), and habitat use (all captures and recaptures by sampling station—see Appendix Fig. 4) for small mammals using the capture-mark-recapture methodology. Also we record all explanatory variables by sampling station (see Appendix Fig. 5). To evaluate if our sampling effort was sufficient to estimate small mammal diversity, we generated the collector curve using vegan package (Oksanen et al. 2016) in the software R (R Core Team 2019).

Factors that influence small mammal spatial patterns

Because large mammals were sampled in two fieldwork campaigns (December 2017–January 2018 and January–February 2018) and camera traps recorded only a fraction of the small mammal traps, we analyzed two sets of data: one including all six fieldwork campaigns and sampling points (full sample hereafter), but without the predator and competitor variables ($N = 121$ sampling points) and another including only the two campaigns and the sampling points at which predators and competitors were sampled (subset sample hereafter, $N = 35$ sampling points, December 2017 and January 2018), thus containing information on all explanatory variables (except for the number of fruits that almost did not vary across sampling points of the subset dataset). We centered and standardized all continuous variables using z-scores and then checked for collinearity ($r > |0.60|$) between variables to avoid biases in coefficient estimates. We found two collinear variables: distance to bamboo thickets and distance to water bodies ($r = -0.74$, Appendix Fig. 6) and we removed distance to water bodies because it had higher correlation with all other variables.

Using the full sample dataset, we tested which microhabitat feature covariates affected small mammals in ESEC using generalized linear mixed-effects models (GLMMs) using the package lme4 (Bates et al. 2014). We considered trap type and fieldwork campaigns as random effects in all models, coding them as (1|Campaing) and (1|Trap). We built three sets of models to test the effects of variables on small mammals. The response variables were richness (number of species), abundance (number of individuals captured), and habitat use (all captured and recaptured individuals), while microhabitat features were represented by distance to the nearest bamboo thicket (m), number of fruits, number of fallen logs, number of trees, and litter thickness (cm). Because we used three trap types to maximize the captures of small mammals (Barros et al. 2015; Bovendorp et al. 2017a) and we conducted six campaigns during the entire period of sampling (totalizing 10 months) we considered trap type and the fieldwork campaigns as random effects in the models.

Using the subset sample dataset, we tested which variables affected small mammals in ESEC. Unfortunately, due to the low number of observations, we were not able to fit models for richness of small rodents. Therefore, we built two sets of models (one for abundance and another for habitat use) to test the effects of variables on small mammals. We included the same microhabitat feature covariates used to analyze the full dataset, except for the number of fruits. There were too few observations with fruits to estimate the coefficients. We also included the recorded number of potential competitors and predators as additional covariates. Because the GLMMs fitted using this dataset were zero inflated and/or suffered from "singularity," we fitted the models using zero-inflated Poisson mixed models (ZIPMM) using R package glmmTMB (Brooks et al. 2017). We considered trap type and fieldwork campaigns as random effects in all models, coding them as (1|Campaing) and (1|Trap). ZIPMM are constituted of two components: the fixed effects that include all covariates of GLMMs and the zero-inflated fixed effects (ZI hereafter), which include the variables that account for the excess of zeroes in the data. Variables included in the ZI component were specified in the same way as variables of the fixed effects component.

Model selection

For model selection, we built sets of models containing all possible combinations of explanatory variables, compared models using second-order AIC (AICc) weights (w), and built the averaged model for each model set (Anderson 2008; Burnham and Anderson 2002). Because of the smaller sample size of the subset dataset and because of the additional ZI component of ZIPMM that doubles the number of covariates, we restricted the number of candidate models (N = 37) in the model set. This was performed by creating models with all combinations of two variables, one in the fixed effect component and another in the ZI component, plus the null model. We also assessed the statistical evidence of the variables (variable importance) by summing the AICc weights (w) of the model in which the explanatory variables were present (Burnham and Anderson 2002). Some combinations of variables did not converge for the ZIPMM model selection and the log likelihood of these models was not calculated. These models were excluded from the calculations of variable importance and the number of times each variable appeared across the candidate set was not fully balanced. The 85% confidence interval of each variable in the averaged models was used to check for uninformative parameters (Arnold 2010). For model building, comparison, and averaging, we used the R package "MuMIn" (Barton 2019). We assessed the quality (overdispersion, zero-inflation, and singular model fits) of global models using the R package "performance" (Lüdecke et al. 2020). All analyses were conducted in program R (R Core Team 2019).

Results

Diversity of small mammal species

Our total trapping effort was 7260 trap nights (represented by 3300 pitfall traps, 1320 small Sherman, 1320 large Sherman and 1320 Tomahawk trap nights). We obtained a low capture rate (0.99%) and captured 72 individuals from 11 species of small mammal (Appendix Table 4). The most captured species were *Didelphis albiventris* (n=31 individuals), *Oligoryzomys nigripes* (n=20), and *Akodon montensis* (n=9). The species richness, as well abundance and habitat use curves, indicates slow increment of species, individuals, and captures, respectively, with increasing sampling effort (Appendix Fig. 7). We did not record any species considered threatened with extinction by the IUCN red list (Appendix Table 4).

Occurrence of medium and large mammals

The total trapping effort was 1080 camera-trap-days and we had 283 records from 14 species of medium and large mammals (Appendix Table 3). In total, we had 49 records of predators (n=6 species) and 234 records of competitors (n=8 species). The species with higher number of records belonging to the competitors' group were *Dasypus novemcinctus* (n=93), *Tayassu pecari* (n=85), and *Sylvilagus brasiliensis* (n=28), and the most frequent predators were *Nasua nasua* (n=35), *Leopardus pardalis* (n=4), and *Leopardus wiedii* (n=3). Four species are considered threatened with risk of extinction based on the IUCN red list and these are *Tayassu pecari*, *Sylvilagus brasiliensis*, *Leopardus wiedii*, and *Tapirus terrestris* (Appendix Table 3).

Factors affecting small mammals

Exploring only the microhabitat features in the full sample dataset, from all 37 models in the model set, 11 were better than the null model for richness (Appendix Table 5), 16 for abundance (Appendix Table 6), and 19 for habitat use (Appendix Table 7). Distance to bamboo thickets was the most important variable, positively affecting all small mammal responses (Fig. 2; Appendix Fig. 8). The relative importance was 0.87 for richness, 0.97 for abundance, and 0.94 for habitat use (Table 1). Distance to bamboo thickets was the only informative variable (i.e. confidence intervals did not overlap with 0) for richness and abundance, and was informative together with number of fallen logs for habitat use, both positively related to the respective response variables.

None of the 37 models of the subset sample dataset was considered more plausible than the null model to

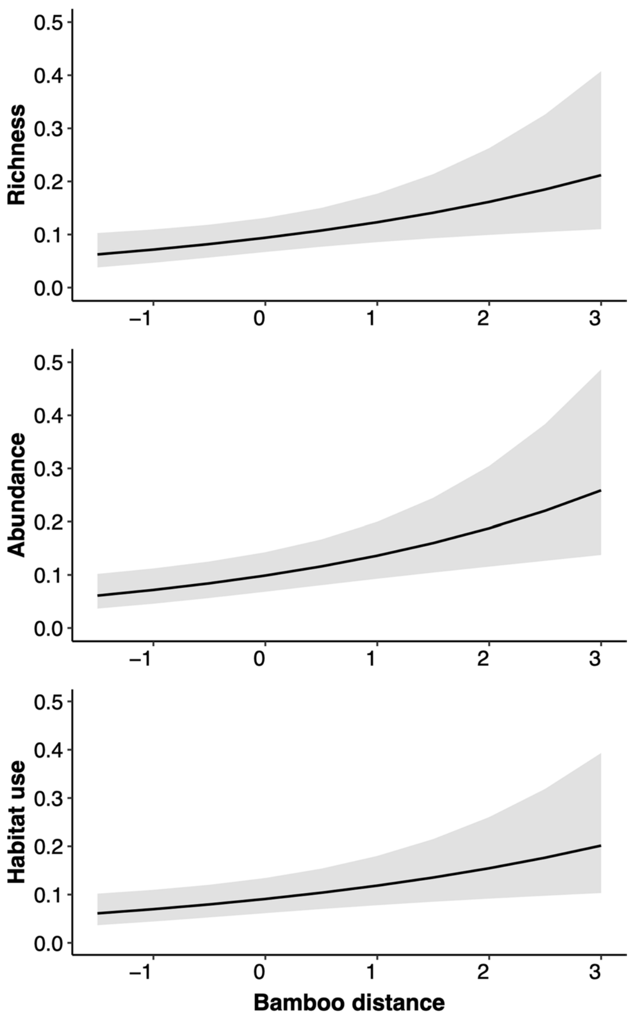

Fig. 2 Effects of bamboo distance (normalized) on the three response variables (richness, abundance, and habitat use) of small mammals

explain abundance (Appendix Table 8) or habitat use of small mammals (Appendix Table 9). For abundance, 18 models did not converge while one model did not converge for habitat use. These models were excluded from the candidate set. Predators and competitors had greater importance than most covariates in the abundance and habitat use models (Table 2); however, our analyses using the subset dataset did not have enough statistical power to outrun the null model.

Discussion

Our hypotheses were partially corroborated. Species richness, abundance, and habitat use of small mammals were affected only by a single microhabitat feature, more specifically by the distance to the nearest bamboo patch). In the other hand, litter and number of fallen logs were not significant in the models, contrasting with other studies that highlight the importance of theses microhabitat features for small mammals (Melo et al. 2013; Pinotti et al. 2012). Also, divergent to our expectation, the occurrence of potential competitors and predators did not significantly affect any small mammals' dimension.

Many species of small mammals captured in ESEC are common and have a wide distribution, like *D. aurita*, *O. nigripes*, *A. montensis*, *M. americana*, *N. lasiurus*, *C. subflavus*, and *C. tener* (Patton et al. 2015). It is important to note that we have no capture of arboreal rodent or marsupials like *Caluromys philander*, but we found one specimen of *C. philander* killed in a road nearby (C. André personal comm.). Probably the use of canopy platform traps in the grid could have captured arboreal species (Graipel et al. 2003), like *C. philander*. Nevertheless, the abundant species *D. albiventris* and *O. nigripes* are common in the ecotone of Atlantic Forest and Cerrado and these species occurred in more than 50% of the sites in the Atlantic Forest (Bovendorp et al. 2017b).

The small mammal assemblage in ESEC is dominated by very few species. It is suggested that large mammals can shape small mammals communities (Bovendorp et al. 2018), so that in defaunated sites, *Oligoryzomys* sp. and *Akodon* sp. are highly abundant compared to sites with peccaries (Galetti et al. 2017; Galetti et al. 2015b). Indeed, the abundance or diversity of large mammals helps maintaining the diversity of small mammals, decreasing the abundance of dominant species (Bovendorp et al. 2018; Galetti et al. 2017). However, our best models, when using the subset dataset, indicate that potential competitors and predators did not significantly affect the abundance or habitat use of small mammals even with high abundance of large mammals (Appendix Table 5). It is important to note that both predators and competitors ranked as the most important covariates among all variables in the model's subset, but the null model was top-ranked. Therefore, it is possible that the extremely low capture rate of small mammals during the camera traps survey or the very fine-spatial scale sampled in this study was not sufficient to detect the effect of larger mammals.

Bamboo emerged as the most important microhabitat feature in our best models, affecting richness, abundance, and habitat use by small mammals. The positive correlation was found between the distance of bamboo thickets and all three response variables. We did not expect such an influence from bamboo, especially because its shoots and seeds can be used as food resources by some small mammal species (Bovendorp et al. 2020; Silva 2005), but bamboos were not reproductive during our study. Also, small mammals usually use dense bush and more complex structures for foraging and hiding (Fonseca and Robinson 1990;

Table 1 Results table from the model-averaged coefficients showing estimates, lower and upper limits of confidence interval (CI LL and CI UL), test statistic (*z* value), *p* value (the probability to find the observed *z* value under null hypothesis), and relative importance of each variable affecting richness, abundance, and habitat use. Results based on the full sample dataset to model the effect of microhabitat features covariates (distance to bamboo, litter, fruits, trees, and fallen logs) on small mammal richness, abundance, and habitat use in a 3-ha grid in the Caetetus Ecological Station, Brazil

	Variable	Estimate	CI LL	CI UL	*z* value	*p* value	Importance
Richness	Intercept	−2.361	−2.604	−2.117	13.930	0	
	Bamboo distance	0.265	0.112	0.419	2.483	0.013	0.870
	Litter	−0.110	−0.295	0.075	0.852	0.394	0.345
	Fallen logs	0.076	−0.095	0.247	0.637	0.524	0.307
	Fruits	−0.390	−1.857	1.077	0.382	0.702	0.282
	Trees	−0.048	−0.235	0.138	0.372	0.710	0.281
Abundance	Intercept	−2.318	−2.592	−2.045	12.181	0	
	Bamboo distance	0.314	0.169	0.458	3.114	0.002	0.971
	Fallen logs	0.124	−0.036	0.284	1.110	0.267	0.398
	Litter	−0.104	−0.284	0.076	0.832	0.405	0.340
	Fruits	−0.451	−1.912	1.011	0.443	0.658	0.288
	Trees	−0.030	−0.209	0.148	0.244	0.807	0.273
Habitat use	Intercept	−2.405	−2.694	−2.116	11.962	0	
	Bamboo distance	0.279	0.135	0.423	2.788	0.005	0.941
	Litter	−0.154	−0.317	0.010	1.352	0.176	0.484
	Fallen logs	0.166	0.016	0.316	1.586	0.113	0.561
	Fruits	−0.080	−1.134	0.974	0.109	0.913	0.267
	Trees	−0.018	−0.172	0.137	0.165	0.869	0.270

Table 2 Results table from the model-averaged coefficients showing estimates, lower and upper limits of confidence interval (CI LL and CI UL), test statistic (*z* value), *p* value (the probability to find the observed *z* value under null hypothesis), the relative importance of each variable, and the number of models containing each variable affecting abundance and habitat use of small mammals. Results based on the subset sample dataset to model the effect of microhabitat features (distance to bamboo, litter, trees, and fallen logs) and medium and large mammal covariates (competitors and predators) on small mammal abundance and habitat use in a 3-ha grid in the Caetetus Ecological Station, Brazil. Variables beginning with "zi" indicate those used as zero-inflated fixed effects

	Variable	Estimate	CI LL	CI UL	*z* value	*p* value	Importance	N models
Abundance	Intercept	−1.338	−2.846	0.169	1.244	0.213		
	Competitors	1.101	−4.411	6.613	0.284	0.777	0.264	5
	Fallen logs	0.327	−0.723	1.378	0.444	0.657	0.170	3
	Predators	0.889	−0.370	2.147	0.988	0.323	0.154	2
	Litter	−0.504	−1.304	0.296	0.879	0.379	0.127	3
	Bamboo distance	0.183	−0.674	1.040	0.302	0.763	0.071	3
	Trees	0.050	−0.639	0.738	0.101	0.919	0.065	2
	zi Intercept	−33.164	−1,804,127	1,804,060	0.00003	1.000		
	zi Predators	29.042	−6,832,588	6,832,646	0.00001	1.000	0.283	4
	zi Fallen logs	54.693					0.207	2
	zi Competitors	40.406	−40,558	40,639	0.001	0.999	0.144	3
	zi Bamboo distance	114.469	−47.688	276.627	1.016	0.310	0.120	3
	zi Trees	−8.118	−129,135	129,119	0.0001	1.000	0.098	6
Habitat use	Intercept	−0.506	−1.643	0.631	0.622	0.534		
	Competitors	0.849	−0.173	1.871	1.173	0.241	0.241	6
	Fallen logs	0.711	−0.076	1.499	1.276	0.202	0.177	5
	Predators	−0.746	−3.931	2.439	0.330	0.741	0.127	6
	Litter	0.272	−0.790	1.334	0.363	0.716	0.122	6
	Bamboo distance	−0.457	−1.325	0.411	0.734	0.463	0.115	6
	Trees	−0.190	−0.788	0.407	0.447	0.655	0.107	6
	zi Intercept	−1.631	−91,122	91,119	0.00002	1.000		
	zi Predators	13.387	−364,246	364,272	0.0001	1.000	0.238	6
	zi Fallen logs	1.155	−0.214	2.525	1.181	0.238	0.231	6
	zi Competitors	1.101	−0.482	2.685	0.978	0.328	0.165	6
	zi Bamboo distance	3.387	−3.573	10.347	0.681	0.496	0.107	6
	zi Trees	0.629	−0.968	2.225	0.549	0.583	0.085	6

Lima et al. 2010; Melo et al. 2013). Bamboo thickets generate open areas inside the forest and this happens because the bamboo leaves cover the soil and prevent seedlings to grow, creating a less complex and open structure in the area (Campanello et al. 2007; Lima et al. 2012; Rother et al. 2016). It is important to mention that the distance to bamboos was negatively and significantly correlated with distance to water in our study, pointing out that may the capture of small mammals have been some influence of proximity of water bodies (Fonseca and Kierulff 1989; Honorato et al. 2015).

Litter and fallen logs were marginally important explanatory variables in the models. Because terrestrial species comprised most of our captures, these elements in the forest floor may be important to shape the small mammal community in ESEC (Grelle 2003; Pardini et al. 2005; Pinotti et al. 2015). Our results show that open areas inside the forest, such as the ones created by bamboo thickets, may influence more the small mammal behavior than other microhabitat features (liana, simple tree, forked tree, ferns) (Grelle 2003; Melo et al. 2013; Pardini et al. 2005). Indeed forest specialists tend to avoid open areas and sometimes those areas act as an barrier for displacement and population dispersion (Olifiers et al. 2005; Pardini et al. 2005).

Conversely, an unexpected result was that the presence of fruits was not a significant explanatory variable in the models. The ESEC presents a semideciduous seasonal vegetation (Veloso et al. 1991) and holds 76 plants species (Durigan et al. 2000), among them important palm trees, like *Euterpe edulis*, that are source of fruits for fauna (Akkawi et al. 2020). Our findings contrast with other studies that found influence of variables such as fruit, litter, and trees in small mammal communities (Bergallo and Magnusson 1999; Bovendorp 2013; Melo et al. 2013; Naxara et al. 2009; Pinotti et al. 2011). One plausible explanation for these results is that during the campaigns, the availability of fruits in the trees and on the ground was overall very low in the grid.

As a conclusion, we found that only bamboo is shaping community of small mammals in the fine scale in the ESEC. In this way, the lack of fruits during our campaigns and the strong influence of water (strongly negatively correlated with bamboo) might associate with the finding result. On the other hand, the low captured rate of small mammals in this study may was not capable to capture all nuances of the factors explored here. However, to solve this puzzle, we encourage future studies about small mammals in the ESEC once the low capture rate may be associated with other factors that we have not quantified and/or because there is no replication. In addition, we encourage to collect other variables that may influence the community of small mammal in the ESEC, such as the presence and abundance of fungi and/or invertebrates once mostly of small mammals are omnivorous and/or insectivorous.

Appendix

Table 3 Species of medium and large mammals recorded in camera traps in the Caetetus Ecological Station, Brazil. Diet and functional groups were based on Paglia et al. (2012) and conservation status by IUCN Red list (DD, data deficient; LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered; NE, note evaluated)

Common name	Species	Diet	Functional groups	Records	Conservation status
Nine-banded armadillo	*Dasypus novemcinctus*	Omnivore	Competitor	93	LC
White-lipped peccary	*Tayassu pecari*	Herbivore	Competitor	85	VU
Tapeti	*Sylvilagus brasiliensis*	Herbivore	Competitor	28	EN
Red brocket	*Mazama americana*	Herbivore	Competitor	17	DD
Agouti	*Dasyprocta azarae*	Herbivore	Competitor	7	DD
Tapir	*Tapirus terrestris*	Herbivore	Competitor	2	VU
Lowland paca	*Cuniculus paca*	Herbivore	Competitor	1	LC
Southern tamandua	*Tamandua tetradactyla*	Insectivore	Competitor	1	LC
Coati	*Nasua nasua*	Carnivore	Predator	35	LC
Ocelot	*Leopardus pardalis*	Carnivore	Predator	4	LC
Margay	*Leopardus wiedii*	Carnivore	Predator	3	NT
Cougar	*Puma concolor*	Carnivore	Predator	3	LC
Domestic dog	*Canis lupus familiaris*	Carnivore	Predator	2	NE
Tayra	*Eira barbara*	Carnivore	Predator	2	LC

Table 4 Captures of small mammals in a 3-ha grid in the Caetetus Ecological Station, Brazil, with the order, species name, number of individuals, number of captures (including recaptures) and weight average (in grams), the standard deviation of weight average (in grams), dietary (Fr/On, frugivorous/granivorous; In/On, insectivorous/omnivorous; Fr/Gr, frugivorous/granivorous), and conservation status by IUCN (LC, least concern)

Order	Species	Number of individuals	Number of captures	Weight average (g)	Standard deviation (g)	Dietary	Conservation status IUCN
Didelphimorphia	*Didelphis albiventris*	31	118	525.26	246.92	Fr/On	LC
Didelphimorphia	*Gracilinanus microtarsus*	1	1	31	-	In/On	LC
Didelphimorphia	*Marmosa paraguayana*	3	3	20.66	19.50	In/On	LC
Didelphimorphia	*Monodelphis americana*	2	2	14,5	0,70	In/On	LC
Rodentia	*Akodon montensis*	9	10	28.7	8.95	In/On	LC
Rodentia	*Calomys tener*	1	1	10	-	Fr/Gr	LC
Rodentia	*Cerradomys subflavus*	1	1	25.5	-	Fr/Gr	LC
Rodentia	*Delomys sublineatus*	2	2	35.5	13.43	Fr/Gr	LC
Rodentia	*Necromys lasiurus*	1	1	34	-	Fr/On	LC
Rodentia	*Nectomys squamipes*	1	1	NA	-	Fr/On	LC
Rodentia	*Oligoryzomys nigripes*	20	23	19	7.19	Fr/Gr	LC

1) NA represent the individual that escaped before weighing. 2) - represents no standard deviation due the unique individual captured

Table 5 Model selection table showing variable estimates or presence (+) of factor variables, degrees of freedom (df), log Likelihood (logLik), AICc values, delta AICc values (ΔAICc), and weight (w) of each model testing the effects of variables on the species richness of small mammals in the Caetetus Ecological Station, Brazil. Here we use the full sample dataset and only microhabitat features (bamboo, litter, fruits, trees, and fallen logs) were explored in the models

Intercept	Trees	Bamboo distance	Fruits	Litter	Fallen logs	df	logLik	AICc	Delta	Weight
−2.366		0.271				4	−237.264	482.583	0	0.208
−2.361		0.262		−0.104		5	−236.935	483.953	1.369	0.105
−2.378		0.267			0.070	5	−237.090	484.264	1.681	0.090
−2.356		0.271	+			5	−237.176	484.434	1.851	0.082
−2.363	−0.050	0.266				5	−237.188	484.459	1.875	0.081
−2.376		0.256		−0.112	0.080	6	−236.708	485.532	2.949	0.048
−2.352		0.261	+	−0.105		6	−236.838	485.792	3.209	0.042
−2.362	−0.052	0.257		−0.104		6	−236.850	485.817	3.233	0.041
−2.369		0.266	+		0.069	6	−237.007	486.130	3.547	0.035
−2.376	−0.039	0.263			0.064	6	−237.045	486.206	3.623	0.034
−2.355	−0.041	0.267	+			6	−237.125	486.367	3.783	0.031
−2.329						3	−240.325	486.683	4.100	0.027
−2.366		0.255	+	−0.114	0.079	7	−236.616	487.388	4.805	0.019
−2.373	−0.041	0.252		−0.113	0.075	7	−236.658	487.472	4.889	0.018
−2.354	−0.042	0.257	+	−0.105		7	−236.783	487.721	5.138	0.016
−2.324				−0.124		4	−239.833	487.722	5.138	0.016
−2.344					0.098	4	−239.993	488.042	5.458	0.014
−2.368	−0.030	0.263	+		0.065	7	−236.980	488.117	5.533	0.013
−2.328	−0.078					4	−240.131	488.318	5.734	0.012
−2.320			+			4	−240.232	488.520	5.937	0.011
−2.344				−0.137	0.112	5	−239.405	488.894	6.310	0.009
−2.327	−0.080			−0.125		5	−239.625	489.332	6.749	0.007
−2.364	−0.031	0.252	+	−0.114	0.075	8	−236.588	489.377	6.794	0.007
−2.315			+	−0.125		5	−239.728	489.539	6.956	0.006
−2.343	−0.065				0.089	5	−239.861	489.806	7.222	0.006
−2.336			+		0.097	5	−239.907	489.898	7.314	0.005
−2.321	−0.070		+			5	−240.079	490.242	7.659	0.005
−2.342	−0.067			−0.138	0.104	6	−239.267	490.650	8.067	0.004
−2.334			+	−0.138	0.111	6	−239.308	490.733	8.149	0.004
−2.320	−0.072		+	−0.125		6	−239.566	491.250	8.666	0.003
−2.336	−0.057		+		0.089	6	−239.808	491.733	9.149	0.002
−2.335	−0.058		+	−0.138	0.104	7	−239.206	492.569	9.985	0.001

Table 6 Model selection table showing variable estimates or presence (+) of factor variables, degrees of freedom (df), log Likelihood (logLik), AICc values, delta AICc values (ΔAICc), and weight (*w*) of each model testing the effects of variables on the species abundance of small mammals in the Caetetus Ecological Station, Brazil. Here we use the full sample dataset and only microhabitat features (bamboo, litter, fruits, trees, and fallen logs) were explored in the models

Intercept	Trees	Bamboo distance	Fruits	Litter	Fallen logs	df	logLik	AICc	Delta	Weight
−2.315		0.321				4	−255.405	518.865	0	0.202
−2.338		0.314			0.120	5	−254.832	519.747	0.882	0.130
−2.311		0.311		−0.096		5	−255.102	520.287	1.422	0.099
−2.305		0.320	+			5	−255.286	520.655	1.790	0.083
−2.312	−0.039	0.317				5	−255.353	520.790	1.925	0.077
−2.336		0.302		−0.112	0.130	6	−254.429	520.975	2.110	0.070
−2.328		0.314	+		0.119	6	−254.722	521.560	2.695	0.053
−2.336	−0.020	0.312			0.117	6	−254.819	521.755	2.890	0.048
−2.301		0.311	+	−0.097		6	−254.976	522.070	3.205	0.041
−2.309	−0.041	0.307		−0.097		6	−255.044	522.204	3.339	0.038
−2.304	−0.029	0.317	+			6	−255.258	522.633	3.768	0.031
−2.326		0.301	+	−0.113	0.129	7	−254.314	522.783	3.918	0.029
−2.334	−0.021	0.300		−0.112	0.128	7	−254.415	522.985	4.120	0.026
−2.328	−0.009	0.313	+		0.117	7	−254.719	523.594	4.729	0.019
−2.300	−0.031	0.307	+	−0.098		7	−254.945	524.046	5.181	0.015
−2.326	−0.010	0.300	+	−0.113	0.128	8	−254.310	524.821	5.956	0.010
−2.260						3	−260.204	526.441	7.576	0.005
−2.285					0.152	4	−259.315	526.685	7.820	0.004
−2.286				−0.146	0.167	5	−258.606	527.295	8.430	0.003
−2.257				−0.124		4	−259.675	527.405	8.540	0.003
−2.259	−0.075					4	−260.005	528.065	9.200	0.002
−2.250			+			4	−260.076	528.207	9.342	0.002
−2.276			+		0.150	5	−259.199	528.482	9.617	0.002
−2.285	−0.056				0.145	5	−259.211	528.504	9.639	0.002
−2.255	−0.078			−0.126		5	−259.460	529.004	10.139	0.001
−2.276			+	−0.147	0.166	6	−258.479	529.076	10.211	0.001
−2.285	−0.057			−0.146	0.161	6	−258.495	529.107	10.242	0.001
−2.247			+	−0.125		5	−259.535	529.153	10.288	0.001
−2.252	−0.066		+			5	−259.925	529.934	11.069	0.001
−2.277	−0.047		+		0.145	6	−259.128	530.373	11.508	0.001
−2.247	−0.068		+	−0.126		6	−259.375	530.866	12.001	0.001
−2.277	−0.047		+	−0.147	0.161	7	−258.406	530.968	12.103	0.0005

Table 7 Model selection table showing variable estimates or presence (+) of factor variables, degrees of freedom (df), log Likelihood (logLik), AICc values, delta AICc values (ΔAICc), and weight (*w*) of each model testing the effects of variables on the habitat use of small mammals in the Caetetus Ecological Station, Brazil. Here we use the full sample dataset and only microhabitat features (bamboo, litter, fruits, trees, and fallen logs) were explored in the models

Intercept	Trees	Bamboo distance	Fruits	Litter	Fallen logs	df	logLik	AICc	Delta	Weight
−2.398		0.265		−0.162	0.174	5	−408.146	826.375	0	0.143
−2.401		0.282			0.153	4	−409.200	826.455	0.080	0.138
−2.410		0.293				3	−410.305	826.643	0.268	0.125
−2.408		0.281		−0.135		4	−409.549	827.154	0.779	0.097
−2.395		0.265	+	−0.162	0.174	6	−408.138	828.394	2.019	0.052
−2.398	−0.009	0.264		−0.162	0.173	6	−408.142	828.401	2.026	0.052
−2.399		0.282	+		0.153	5	−409.195	828.474	2.099	0.050
−2.401	−0.007	0.282			0.152	5	−409.197	828.478	2.103	0.050
−2.411	−0.026	0.291				4	−410.275	828.606	2.231	0.047
−2.408		0.293	+			4	−410.297	828.650	2.275	0.046
−2.409	−0.029	0.278		−0.136		5	−409.512	829.107	2.732	0.037
−2.405		0.280	+	−0.136		5	−409.538	829.159	2.784	0.036
−2.396	−0.006	0.264	+	−0.162	0.173	7	−408.137	830.429	4.054	0.019
−2.400	−0.005	0.282	+		0.152	6	−409.194	830.505	4.130	0.018
−2.409	−0.024	0.291	+			5	−410.273	830.629	4.254	0.017
−2.407	−0.027	0.278	+	−0.136		6	−409.508	831.132	4.757	0.013
−2.431				−0.193	0.204	4	−411.590	831.236	4.861	0.013
−2.437					0.179	3	−413.086	832.205	5.830	0.008
−2.446				−0.163		3	−413.436	832.906	6.531	0.005
−2.451						2	−414.523	833.063	6.688	0.005
−2.431	−0.036			−0.194	0.200	5	−411.534	833.152	6.777	0.005
−2.428			+	−0.194	0.203	5	−411.580	833.243	6.868	0.005
−2.437	−0.035				0.174	4	−413.034	834.124	7.749	0.003
−2.435			+		0.178	4	−413.080	834.216	7.841	0.003
−2.446	−0.059			−0.164		4	−413.284	834.623	8.248	0.002
−2.451	−0.056					3	−414.387	834.808	8.433	0.002
−2.443			+	−0.163		4	−413.420	834.896	8.521	0.002
−2.448			+			3	−414.513	835.060	8.685	0.002
−2.430	−0.034		+	−0.194	0.200	6	−411.532	835.180	8.805	0.002
−2.437	−0.034		+		0.174	5	−413.034	836.150	9.775	0.001
−2.445	−0.057		+	−0.164		5	−413.282	836.648	10.273	0.001
−2.450	−0.055		+			4	−414.387	836.829	10.454	0.001

Table 8 Model selection table showing variable estimates or presence (+) of factor variables, degrees of freedom (df), log Likelihood (logLik), AICc values, delta AICc values (ΔAICc), and weight (*w*) of each model testing the effects of variables on the abundance of small mammals in the Caetetus Ecological Station, Brazil. Here we use the subset sample dataset and microhabitat features (bamboo, litter, trees, and fallen logs) and medium and large mammals (competitors and predators) were explored in the models. Variables beginning with "zi" indicate those used as zero-inflated fixed effects

Intercept	zi Intercept	Trees	zi Trees	Competitors	Bamboo distance	Predators	Litter	Fallen logs	zi Competitors	zi Bamboo distance	zi Predators	zi Fallen logs	df	logLik	AICc	Delta	Weight
−1.423	−0.990												4	−22.24	53.508	0	0.149
−1.274	−14.957					0.989					26.108		6	−19.68	53.645	0.137	0.139
−1.207	−30.620							0.577				55.471	6	−19.83	53.947	0.439	0.120
−1.467	−33.946			−0.230								53.627	6	−20.15	54.575	1.067	0.087
−0.352	0.652			4.217					12.511				6	−20.22	54.716	1.208	0.081
−1.800	−175.482						−0.668			130.227			6	−20.54	55.350	1.842	0.059
−1.667	−38.342						−0.337				35.756		6	−20.74	55.750	2.242	0.049
−1.650	−38.492	0.140									35.581		6	−20.74	55.756	2.249	0.048
−1.618	−25.967			−0.208							24.016		6	−20.78	55.833	2.325	0.047
−1.635	−246.763			−0.535						178.957			6	−21.12	56.514	3.006	0.033
−1.542	−7.157							−0.261	75.608				6	−21.14	56.562	3.055	0.032
−1.441	−7.046				−0.169				78.324				6	−21.22	56.721	3.213	0.030
−1.093	−0.986				0.661					1.837			6	−21.31	56.904	3.396	0.027
−1.540	−4.705		−9.585				−0.418						6	−21.69	57.650	4.142	0.019
−1.365	−3.592		−7.639					−0.275					6	−21.73	57.740	4.232	0.018
−0.944	−3.271	−0.217	−8.748										6	−21.82	57.918	4.410	0.016
−1.344	−3.487		−7.432	−0.311									6	−21.86	57.997	4.489	0.016
−1.281	−3.437		−7.624			−0.074							6	−21.95	58.170	4.662	0.014
−1.307	−3.384		−7.324		0.004								6	−21.96	58.204	4.696	0.014

Table 9 Model selection table showing variable estimates or presence (+) of factor variables, degrees of freedom (df), log Likelihood (logLik), AICc values, delta AICc values (ΔAICc), and weight (w) of each model testing the effects of variables on the habitat use of small mammals in the Caetetus Ecological Station, Brazil. Here we use the subset sample dataset and microhabitat features (bamboo, litter, trees, and fallen logs) and medium and large mammals (competitors and predators) were explored in the models. Variables beginning with "zi" indicate those used as zero-inflated fixed effects

Intercept	zi Intercept	Trees	zi Trees	Competitors	Predators	Litter	Fallen logs	zi Competitors	Bamboo distance	zi Bamboo distance	zi Predators	zi Litter	zi Fallen logs	df	logLik	AICc	Delta	Weight
−0.693	−7.784				1.163						15.040			6	−25.09	64.455	0	0.164
−0.491	0.378													4	−28.10	65.239	0.784	0.111
−0.285	0.099								1.009	1.611				6	−25.65	65.578	1.123	0.093
−0.094	0.616						0.834						1.754	6	−26.14	66.554	2.099	0.057
0.050	1.146								0.602				0.892	6	−26.43	67.144	2.690	0.043
−0.706	0.517			−1.271									1.082	6	−26.45	67.186	2.731	0.042
−0.652	0.491					−0.396							0.900	6	−26.67	67.625	3.171	0.034
−0.373	0.705				0.218								0.945	6	−26.85	67.971	3.516	0.028
−0.371	0.690	−0.125											0.954	6	−26.88	68.044	3.589	0.027
−0.793	0.524					−0.443		2.555						6	−27.15	68.583	4.128	0.021
−0.123	1.110			2.062				6.793						6	−27.16	68.590	4.136	0.021
−0.768	0.347			−1.821						0.563				6	−27.17	68.612	4.158	0.020
−1.269	−34.759	−0.017									34.416			6	−27.18	68.641	4.186	0.020
−0.107	−2.183	−0.570	−7.875											6	−27.18	68.647	4.192	0.020
−0.697	0.547						−0.267	3.060						6	−27.30	68.872	4.417	0.018
−0.722	0.279					−0.545				0.418				6	−27.30	68.885	4.431	0.018
−0.667	0.500			−0.941								0.628		6	−27.40	69.074	4.619	0.016
−0.450	0.800				0.190			2.631						6	−27.41	69.090	4.635	0.016
−0.856	0.061					−0.476					0.413			6	−27.44	69.155	4.700	0.016
−0.350	0.880	−0.115						2.382						6	−27.45	69.177	4.722	0.015
−0.402	0.807							2.117	0.108					6	−27.45	69.179	4.724	0.015
−0.794	0.172			−1.060							0.422			6	−27.49	69.254	4.800	0.015
−0.390	0.710				0.257							0.799		6	−27.55	69.372	4.917	0.014
−0.354	0.745								0.185			0.652		6	−27.55	69.387	4.932	0.014
−0.778	0.206		−0.060			−0.516								6	−27.58	69.432	4.977	0.014
−0.715	0.321					−0.434						0.195		6	−27.58	69.434	4.979	0.014
−0.604	0.452						−0.181					0.740		6	−27.58	69.442	4.987	0.014
−0.343	0.745	−0.145										0.757		6	−27.61	69.491	5.036	0.013
−0.719	0.340		−0.146	−1.240										6	−27.63	69.538	5.083	0.013
−0.842	−0.132						−0.214				0.561			6	−27.70	69.679	5.224	0.012
−0.565	0.327						−0.204			0.340				6	−27.75	69.773	5.318	0.011
−0.594	0.251								0.136		0.418			6	−27.77	69.812	5.358	0.011

Table 9 (continued)

Intercept	zi Intercept	Trees	zi Trees	Competitors	Predators	Litter	Fallen logs	zi Competitors	Bamboo distance	zi Bamboo distance	zi Predators	zi Litter	zi Fallen logs	df	logLik	AICc	Delta	Weight
−0.261	0.654	−0.134								0.373				6	−27.80	69.882	5.428	0.011
−0.383	0.525				0.071					0.360				6	−27.84	69.968	5.514	0.010
−0.654	0.220		−0.141				−0.237							6	−27.89	70.053	5.599	0.010
−0.452	0.450		−0.134		0.094									6	−28.03	70.340	5.886	0.009

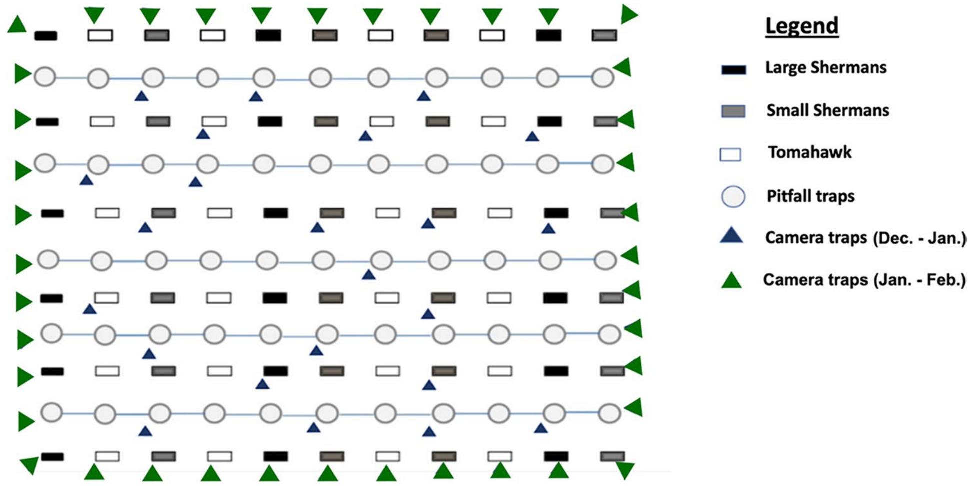

Fig. 3 Sample grid design for capturing small mammals and medium and large mammals in the Caetetus Ecological Station, Brazil. Large Sherman trap (23 × 7.5 × 8.5 cm) are represented by dark rectangle, small Sherman trap (23 × 7.5 × 8.5 cm) are represented by light gray rectangle, and Tomahawk (42.0 × 12 × 15 cm) are represented by open rectangle. The open circles connected by continuous line represent the pitfall traps connected by plastic fence. The cameras trap is represented by the dark blue triangle for the period to December 2017 to January 2018 and dark green from January to February 2018 in the grid

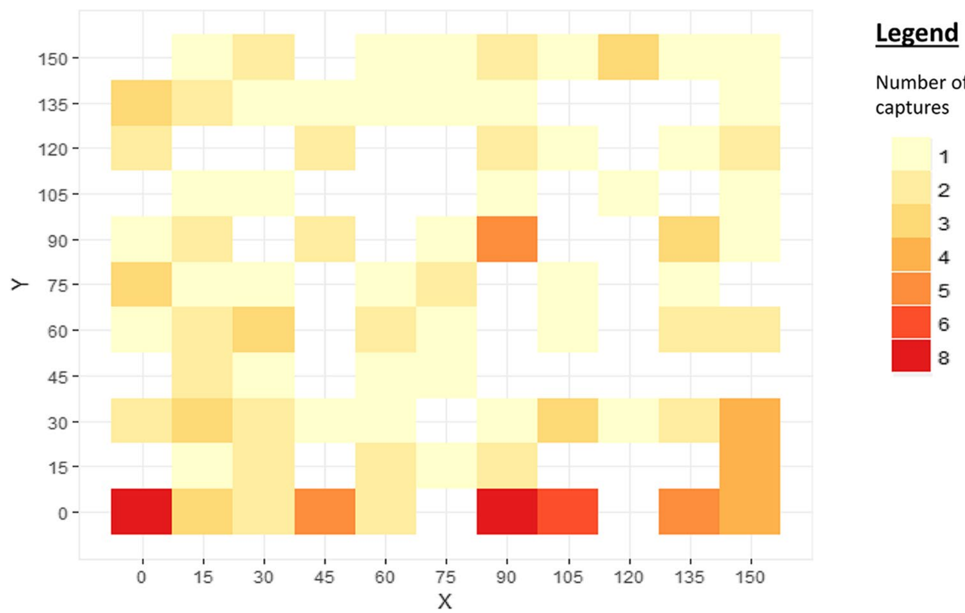

Fig. 4 Spatial accumulation of captures of small mammals in the grid sampling stations during all campaigns in the Caetetus Ecological Station, Brazil


Occurrence of predators
No. predators
0
2
4
6
8
Occurrence of potential competitors
No. competitors
0
5
10
15
20
25
Average litter
Avg. litter (cm)
0.8
1.2
1.6
2.0
2.4
Fallen logs
No. logs
0
1
2
3
4
5
Trees with DBH>20 cm
No. trees
0
1
2
Fruits and seeds
Presence fruits/seeds
0
1
Presence of water body
Water body
0
1
Presence of bamboo thickets
Bamboo
0
1
X
Y
0
15
30
45
60
75
90
105
120
135
150

◂**Fig. 5** Spatial accumulation of occurrence of predators, potential competitors, average litter, fallen logs, trees, fruits and seeds, and presence of water body and bamboo thickets in the grid sampling stations during all campaigns in the Caetetus Ecological Station, Brazil

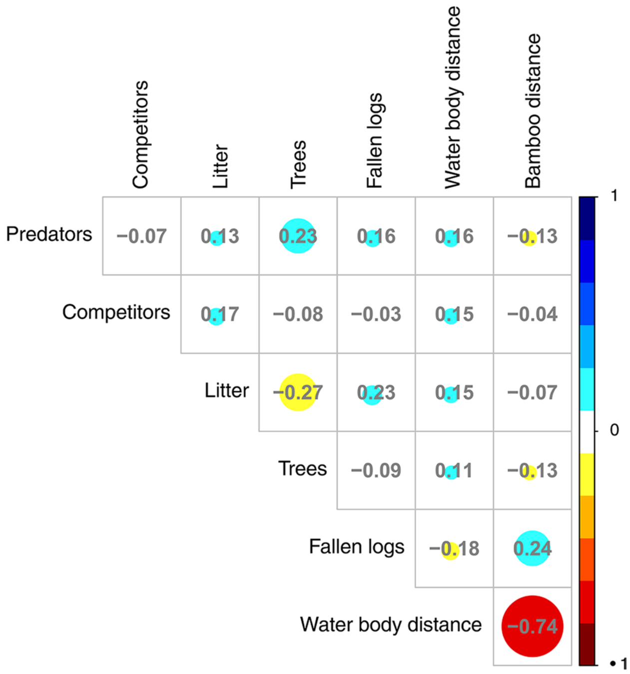

Fig. 6 Correlation tests between covariates (predators, potential competitors, litter, trees, fallen logs, distance to nearest water body, and distance to nearest bamboo thicket) using the complete dataset (all sampling points in the grid) in the Caetetus Ecological Station, Brazil

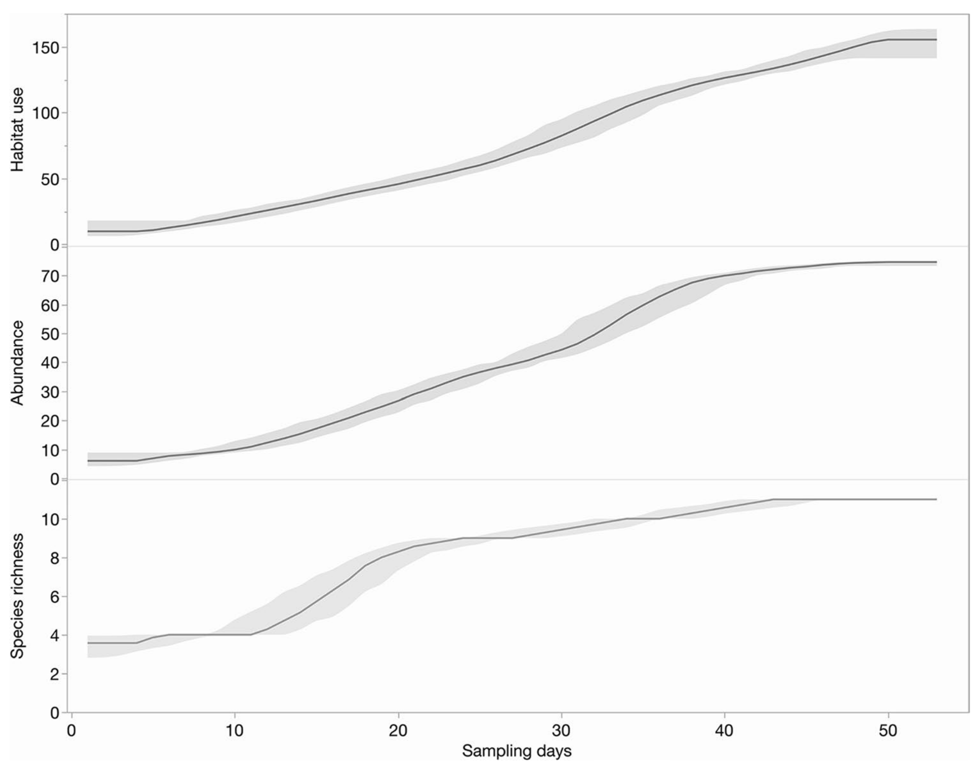

Fig. 7 Species richness, abundance, and habitat use accumulation curves in the Caetetus Ecological Station, Brazil

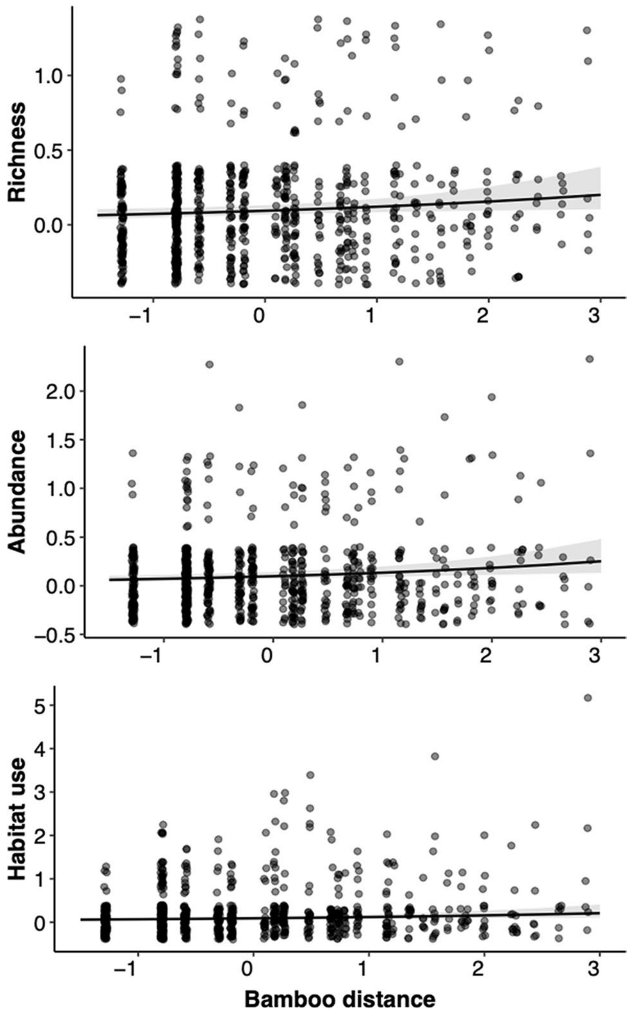

Fig. 8 Effects of bamboo distance (normalized) on the three response variables (richness, abundance, and habitat use) of small mammals

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Author contribution CLA, MCC, MG, and RSB contributed to the study conception and design. Data collection was performed by CLA and RSCA. Data analysis was performed by MCC and NMH. The first draft of the manuscript was written by CLA, NMH, and RSB, and MCC and MG commented and contributed on the manuscript and approved the final version.

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Declarations

Conflict of interest The authors declare no competing interests.

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