


How forest amount and bioclimatic factors shape small mammal communities in Atlantic Forest fragments?

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Abstract:

Understanding how the mammalian diversity responds to anthropogenic disturbances on local and landscape scales is an urgent task. The Atlantic Forest biome, with only 12% of its original area remaining, still harbors great diversity of small mammals (Rodentia and Didelphimorphia), a key group that responds quickly to disturbances. Here, using the largest dataset of Atlantic Forest small mammals, we evaluate how forest amount and bioclimatic variables affect the non-volant small mammal diversity. For this purpose, we use 214 small mammal assemblages across the Atlantic Forest domain. Our results show that forest amount, with a positive relation, was the most important predictor explaining the diversity of small mammals in Atlantic Forest remnants. We also found that the bioclimatic variables (temperature and precipitation) can positively and/or negatively affect small mammal biodiversity, depending on the region analyzed. This is the first study that has assessed diversity across the entire Atlantic Forest biome, showing the importance of large-scale assessment and of forest amount and bioclimatic variables in shaping the diversity of small mammals regardless of the biogeographic context.

Keywords: precipitation, temperature, diversity, fragmentation, marsupials, rodents.

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Short title

Forest amount and bioclimatic shapes small mammal assemblies

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19 Introduction

20 Community assembly at multiple spatial scales has been an essential topic in community ecology
21 (Fukami and Morin, 2003). Assessments of how species diversity is distributed has become
22 relevant due to provision of ecosystem services (Tschardt et al., 2012; Whittaker et al., 2001).
23 Changes in environmental variables and habitat amount can occur together with anthropogenic
24 disturbances at multiple spatial and temporal scales (Chase et al., 2019). These have been shown
25 to influence community composition (Dambros et al., 2015; Delciellos et al., 2016; Gaston,
26 2000; Melo et al., 2017). The native Atlantic Forest in Brazil is experiencing significant habitat
27 loss and deforestation due to human activities such as cultivation of crops, grazing of livestock
28 and general overexploitation of natural resources (FAO, 2018). As a result, habitat loss and
29 deforestation have been identified as the main drivers of the decline in biodiversity in Atlantic
30 Forest regions (Cassano et al., 2014; Galetti et al., 2021; Pardini et al., 2017; Rios et al., 2021).
31 The Brazilian Atlantic Forest covers 1.5 million km² along the country's coast to northeastern
32 Argentina and eastern Paraguay (Tabarelli et al., 2005). After hundreds of years of deforestation
33 due to anthropogenic disturbances (Joly et al., 2014; Lapola et al., 2014; Marcilio-Silva and
34 Marques, 2017), the Atlantic Forest has lost around 77% of its original vegetation cover
35 (Vancine et al., 2024). Today, remnants surrounded by several different anthropogenic matrices
36 can be found throughout the original Atlantic Forest biome (Lira et al., 2012). Even so, the
37 remaining Atlantic Forest fragments are noted for high biodiversity, including endemic species
38 (Mittermeier et al., 2011), and are considered global hotspots of biodiversity (Myers et al., 2000).
39 Within its rich biodiversity, these Atlantic Forest remnants harbor substantial diversity of
40 mammals, comprising more than 41% of all Brazilian species and most of the non-volant

41 41 mammals belong to the orders Rodentia and Didelphimorphia (Bovendorp et al., 2017; Paglia et
42 42 al., 2012).

43 43 Rodents and Didelphimorphs are composed of more than 200 species within Atlantic Forest
44 44 remnants (Bovendorp et al., 2017). They occupy several habitat strata (underground, ground and
45 45 arboreal) and have different habitat requirements (Abreu and De Oliveira, 2014; Estavillo et al.,
46 46 2013; Umetsu and Pardini, 2007). Compared to medium and large mammals, rodents and
47 47 marsupials are less vulnerable to extinction from anthropogenic disturbances due to their small
48 48 size and rapid reproductive rates (Gardner, 2008; Keesing, 2000; Pardini et al., 2010; Smith,
49 49 2001). However, many species are sensitive to fragmentation and loss of landscape connectivity
50 50 (Banks-Leite et al., 2014; Pardini et al., 2010), land use changes (Cassano et al., 2014; Ferreira et
51 51 al., 2020; Silva et al., 2019; Vieira et al., 2009), variation in food availability (Taitt, 1981; Taitt
52 52 and Krebs, 1981) and climate change (Loyola et al., 2012). Anthropogenic disturbances in
53 53 natural habitats lead to defaunation (Bovendorp et al., 2019; Cardillo et al., 2008; Fritz et al.,
54 54 2009; Galetti et al., 2015; Lira et al., 2012). Therefore, small mammals are ideal models for
55 55 investigating how diversity is shaped by bioclimatic variables and forest amount in the
56 56 biogeographic context.

57 57 The diversity of small mammals has been associated with the amount and composition of the
58 58 landscape elements (forest remnants and matrices) (Palmeirim et al., 2019; Pardini et al., 2010;
59 59 Vieira et al., 2018). Large forest remnant is associated with greater small mammal richness in
60 60 different biomes as well as for some assemblages in the Atlantic Forest (Palmeirim et al., 2019;
61 61 Pardini et al., 2010; Vieira et al., 2018). In addition, the matrix composition can positively or
62 62 negatively influence small mammals' richness and abundance, depending upon the species'
63 63 response to the matrix composition (Brady et al., 2011; Delciellos et al., 2016; Paise et al., 2020).

64 64 Studies have shown that factors such as temperature and precipitation can influence small
65 65 mammal assemblages locally (Bergallo and Magnusson, 1999; Dambros et al., 2015; Ferregueti
66 66 et al., 2021; Graipel et al., 2006). Thus, the spatial variation of climate can shape small mammal
67 67 assemblages by imputing dispersion limits (Dambros et al., 2015). Precipitation can also shape
68 68 small mammal assemblages due to the positive effects on primary productivity (i.e., food
69 69 availability) (Ferregueti et al., 2021).

70 70 Using the largest dataset of Atlantic Forest small mammals, we evaluate how bioclimatic
71 71 variables and forest amount affect non-volant small mammal diversity in Atlantic Forest
72 72 fragments. Furthermore, this is the first study aiming to ascertain how the effects of these factors
73 73 differ among the tree main Atlantic Forest regions (northeast, southeast and south) (see detailed
74 74 explanation in Material and Methods - Small mammal assemblages) because of geographic
75 75 barriers (rivers and mountains) and heterogeneous species pools (Costa et al., 2000; DaSilva et
76 76 al., 2015; Prance, 1982; Leite et al., 2016). The physical characteristics of remnants (size, forest
77 77 amount and landscape heterogeneity) are frequently mentioned as the primary drivers of species
78 78 diversity (da Fonseca 1989; Hortal et al., 2008; Banks-Leite et al., 2014; Magioli et al., 2021),
79 79 and based on studies in the Atlantic Forest (Pardini 2004; Pardini et al., 2005, 2010; de la Sancha
80 80 et al., 2020), we hypothesized that small mammal diversity would be more affected by forest
81 81 amount than by bioclimatic variables. Thus, we expect small mammal diversity to increase as the
82 82 forest amount expands due to the area effect, since a larger total forest amount will contain more
83 83 individuals and for a given abundance distribution, this will imply more species available to
84 84 colonize the forest area (Fahrig, 2013). Nonetheless, previous studies have demonstrated this
85 85 relationship locally for small mammals in the Cerrado, Amazon Forest and some areas in the
86 86 Atlantic Forest biome (Melo et al., 2017; Palmeirim et al., 2018; Pardini et al., 2005, 2010).

87 87 Also, we hypothesized that factors that affect the diversity of small mammals in the whole
88 88 Atlantic Forest will be different from ones that affect regional pools (de la Sancha et al., 2020),
89 89 since the remaining Atlantic Forest fragments (ranging from 3° S to 31° S in latitude) contain
90 90 diverse habitats and environmental conditions at, both on large and small scales, and this
91 91 heterogeneity can lead to factors influencing small mammal assemblages at different scales
92 92 (Fuentes-Montemayor et al., 2020).

93 93 **Materials and Methods**

94 94 **Small mammal assemblages**

95 95 We gathered information about small mammals (rodents and marsupials) available in the most
96 96 recent and complete studies (Bovendorp et al., 2017 and Figueiredo et al., 2017). We only
97 97 included studies providing appropriate geographic coordinates, richness, abundance, taxonomic
98 98 identification, sampling year and trapping effort (Fig. 1), and we removed any duplicated data.
99 99 We classified the dataset into three subgroups (northeast, southeast and south), creating a non-
100 100 homogeneous pool due to geographic barriers (mainly rivers, in particular to Rio Doce (Leite et
101 101 al., 2016)). These three main regions are widely accepted for systematic studies of small
102 102 mammals by taxonomists and also identify different areas of Atlantic Forest endemism,
103 103 highlighting the different and unique species composition across Atlantic Forest fragments
104 104 (Dalapicolla et al., 2021) and the factors that affect small mammals in these three main regions
105 105 (see Bovendorp et al., 2019).

106 106 **Forest amount**

107 107 For the landscape variables, we obtained land use information from MapBiomas (Souza et al.,
108 108 2020) (<https://mapbiomas.org/en>), which covers the period from 1985 to 2017 for Brazil. Given

109 109 that our small mammal assemblage data span several years of sampling (from 1986 to 2015) and
110 110 that land use has changed substantially over time, we tried to obtain the most accurate
111 111 information by extracting land use data for the average years of sampling. By matching the time
112 112 of both sampling and land use data we reduced potential bias due to the temporal trends in land
113 113 use change. Land use data for each year of sampling was extracted using QGIS 3.18 (QGIS
114 114 Development Team, 2020).

115 115 Our analysis focused on forest, pasture and agriculture land uses, which were the predominant
116 116 categories of our sampling sites. We combined pastures and cropped areas into one category
117 117 (farming) since they are both unnatural plantations with a production objective. We did not
118 118 consider other land cover types, such as urban infrastructure, rivers, lakes, mangroves, beaches,
119 119 dunes and mining areas, due to their low prevalence in our dataset. Using the geographic
120 120 coordinates and sampling year provided in each study, we quantified the proportion of forest and
121 121 farming amount around each sampling site within multiple spatial scales (100, 250, 500, 1000,
122 122 1500, 2000, 3000, 4000 and 5000 m radius). For example, a single sampled site can have a large
123 123 amount (e.g., 90%) of forest cover at a 100 m radius because it is located in the middle of a
124 124 fragment. However, this fragment can be isolated from other forest patches, so at 5000 m radius,
125 125 the forest cover can be only 10%. Then, we selected the appropriate spatial scale for the
126 126 subsequent analyses using the AIC value with the ‘multifit’ R package (Huais, 2018). For each
127 127 variable, the package fits multiple models, i.e., one model for each scale. With a set of candidate
128 128 models across all scales, the appropriate scale is selected according to the lowest AIC value
129 129 (Huais, 2018). In our analyses, the forest amount was expressed as percentages. Since the
130 130 amount of forest cover and farmed areas were strongly negatively correlated (-0.95), we only
131 131 maintained forest amount. We only included assemblages with complete land cover use

132 132 information for the largest radius (5km), which we determined using Diva-Gis version 7.5
133 133 (Hijmans et al., 2012).

134 134 **Bioclimatic variables**

135 135 Unfortunately, bioclimatic variables were not available for each sampling site due to the lack of
136 136 information in published studies. In most cases, climatic information for sampling sites simply
137 137 does not exist. To standardize the metric for all sampling sites, we used the bioclimatic variables
138 138 from the nearest pixel accessed from the WorldClim database (www.worldclim.org) as a proxy
139 139 for local (site) conditions. To ensure that the variables used in our analyses were not highly
140 140 correlated and were statistically independent, we performed a correlation test with the 19
141 141 bioclimatic variables using the ‘ENMwizard’ package (Heming et al., 2019). After that step, we
142 142 just used seven bioclimatic variables (mean diurnal range, isothermality, maximum temperature
143 143 of warmest month, annual precipitation, precipitation seasonality, precipitation of wettest
144 144 quarter, and precipitation of coldest quarter).

145 145 **Data analysis**

146 146 We calculated the Shannon index for each small mammal assemblage using the function
147 147 ‘diversity’ of the vegan package (Oksanen, 2017). In addition, we conducted Mantel correlation
148 148 analysis using the ‘mantel’ function of the vegan package (Oksanen, 2017) to certify that the
149 149 assemblages were not correlated spatially ($t=0.969$; $df=3445$; $p=0.33$) and/or temporally ($t=-$
150 150 0.338 ; $df=3445$; $p=0.73$). Note that the data assembled by us only allow a single diversity
151 151 estimate to be obtained for each study site.

152 152 We utilized the iNEXT package (Hsieh et al., 2016) to estimate the completeness of assemblages
153 153 through interpolation/extrapolation analysis. This approach was necessary due to variations in

154 154 sampling efforts and species pools in the available literature (Hsieh et al., 2016). For each
155 155 assemblage, we provided species richness as input to the package, which then extrapolated the
156 156 estimates to predict the total number of species and the percentage of the dataset represented.
157 157 This rarefaction/extrapolation curve-based analysis allowed us to estimate the expected number
158 158 of species as sampling effort increased and the proportion of the assemblage that was sampled.
159 159 The analysis involves systematically increasing the number of individuals or samples collected
160 160 from the community and calculating the cumulative number of observed species at each
161 161 sampling effort level. By analyzing the rarefaction/extrapolation curves, we were able to make
162 162 inferences about the species diversity and richness of the community. We estimated how many
163 163 additional species would likely be observed if more sampling effort was applied and assessed the
164 164 level of completeness of the actual sampling. Following these steps, were included 214
165 165 assemblages were included, with sample completeness of 80% or higher the analysis.

166 166 Because diversity indices combine species richness and evenness in a single number, frequently
167 167 they do not reflect differences in species richness, so biological or statistical interpretations can
168 168 be misleading (Gotelli and Colwell 2001). Therefore, we tested the correlation between species
169 169 richness and the Shannon index ($r(212)=0.837, t=22.3, p<0.005$) to make sure that our
170 170 interpretation of the Shannon diversity index was straightforward (Fig. 2).

171 171 To understand the relationship between the Shannon index and various predictor variables (forest
172 172 amount, mean diurnal temperature range, isothermality, max temperature of the warmest month,
173 173 annual precipitation, precipitation seasonality, precipitation of wettest quarter and precipitation
174 174 of coldest quarter), we built linear models (LMs) using the function ‘lm’, because the variance of
175 175 the residuals was constant. We generated a model selection table using the ‘dredge’ function and
176 176 limited the number of predictor variables to two per model. We ranked the models using second

177 177 order AICc weights and built an average model (Anderson, 2008; Burnham and Anderson, 2002)
178 178 using the ‘model.avg’ function, based on the weights of the models (≥ 0.001). To check for
179 179 uninformative parameters, we used the 85% confidence interval of each variable in the averaged
180 180 models (Arnold, 2010). For model building comparison and averaging, we used the R package
181 181 “MuMIn” (Barton 2019).

182 182 Due to the different species pools in the Atlantic Forest fragments, we split the dataset into three
183 183 subsets representing the regions (south, southeast and northeast - see above) and analyzed them
184 184 separately. We used the average model for the subsets as well, under the same terms, to verify if
185 185 the factors that affected the diversity of small mammals differed among all the Atlantic Forest
186 186 remnants in the three regions. The landscape variable (forest amount) was used in linear and
187 187 polynomial (quadratic) form (Edwards, 2002). The consideration of a quadratic effect can help
188 188 identify potential threshold effects in the relationship between forest cover and the amount of
189 189 forested area. Thresholds represent points at which the impact of forest cover on the variable
190 190 undergoes a qualitative change. This can be crucial to understand critical levels of habitat for
191 191 certain species of as small mammals (Pardini et al., 2010; Banks-Leite et al., 2014). The model
192 192 was fitted using the normal distribution. We also assessed the statistical evidence of the variables
193 193 (variable importance) by summing the AICc weights (W) of the model in which the explanatory
194 194 variables were present (Burnham and Anderson, 2002). All analyses were performed with the R
195 195 platform version 4.2.3 (R Core Team, 2023).

196 196 **Results**

197 197 The final dataset included 214 assemblages, with 45,195 individuals from 104 species, and the
198 198 average number of individuals per assemblage was 186 (2 to 5,188 individuals; SD=429). The
199 199 most abundant species in these assemblages were *Akodon montensis* (n=6401), *Oligoryzomys*

200 200 *nigripes* (n=4826), *Akodon cursor* (n=3650), *Didelphis aurita* (n=3582) and *Nectomys*
201 201 *squamipes* (n=2236).

202 202 The appropriate spatial scale of our data was 5km radius, and all variables in the model selection
203 203 analysis were performed within this size. The most informative variables were forest amount
204 204 (quadratic, $w=0.58$, estimate=0.00004, $p=0.001$ and linear, $w=0.41$, estimate=0.005, $p=0.003$)
205 205 and maximum temperature of warmest month ($w=0.42$, estimate=-0.004, $p=0.004$), with negative
206 206 effects on diversity of small mammals, and precipitation of coldest quarter ($w=0.27$, estimate=-
207 207 0.001, $p=0.007$) and precipitation of wettest quarter ($w=0.25$, estimate=0.001, $p=0.008$) having
208 208 negative and positive effects on diversity of small mammals, respectively (Tab. 1; Fig. 3). The
209 209 other variables had importance of less than 0.05.

210 210 In the northeast region, none of the variables had statistical significance. In the southeast region,
211 211 precipitation of wettest quarter ($w=0.42$, estimate=0.001, $p=0.012$), forest amount (linear,
212 212 $w=0.34$, estimate=0.005, $p=0.004$; quadratic, $w=0.40$, estimate=0.00004, $p=0.003$) and annual
213 213 precipitation ($w=0.09$, estimate=0.0005, $p=0.019$) had positive effects on the diversity of small
214 214 mammals (Tab. 2 and 3). On the other hand, maximum temperature of warmest month ($w=0.50$,
215 215 estimate=-0.006, $p=0.001$), mean diurnal temperature range ($w=0.19$, estimate=-0.009, $p=0.014$)
216 216 and isothermality ($w=0.4$, estimate=-0.025, $p=0.046$) had negative effects (Tab. 2 and 3).

217 217 In the south region, forest amount (linear, $w=0.46$, estimate=0.007, $p=0.022$; quadratic, $w=0.54$,
218 218 estimate=0.0007, $p=0.016$) and mean diurnal temperature range ($w=0.29$, estimate=0.008,
219 219 $p=0.046$) had a positive effect on the diversity of small mammals (Tab. 2 and 4).

220 220 Discussion

221 221 As hypothesized, our findings reveal that forest amount exerted a significant influence on the
222 222 small mammal diversity in the of Atlantic Forest fragments studied. Additionally, our analyses
223 223 demonstrate that bioclimatic variables (temperature and precipitation), have a discernible impact
224 224 on the biodiversity of small mammals in this region. This is the first study assessing diversity
225 225 across the entire Atlantic Forest biome, showing the importance of large-scale assessment and
226 226 forest amount and bioclimatic variables in shaping the diversity of small mammals, regardless of
227 227 the biogeographic context.

228 228 The diversity of small mammals increases in proportion to the amount of forest cover in the
229 229 landscape (5km radius), across all levels of analysis, including per region and in all the Atlantic
230 230 Forest remnants. This relationship has also been observed in previous studies of small mammals
231 231 in the Cerrado and Amazon Forest biomes (Melo et al., 2017; Palmeirim et al., 2019), where
232 232 amount of forest cover was associated with high species diversity (Pardini et al. 2010) based on
233 233 the variety of habitat types and levels of habitat complexity (Umetsu et al. 2007). It is important
234 234 to note that this positive correlation is not universal, and small mammal assemblages inhabiting
235 235 small fragments (Pardini et al., 2005, 2010) or an inhospitable matrices (Estavillo et al., 2013) may
236 236 be negatively impacted. But the significant relationships between the amount of forest cover and
237 237 species diversity of small mammals in Atlantic Forest patches have also been observed in various
238 238 studies in the last 20 years (Pardini et al. 2005, Püttker et al. 2011, Estavillo et al. 2013).

239 239 Our analyses indicate that bioclimatic variables, specifically temperature and precipitation, can
240 240 have a significant impact on small mammal diversity. Indeed, changes in temperature and
241 241 precipitation are expected to induce species range shifts and alter diversity and distribution
242 242 patterns in the Atlantic Forest, since the region is projected to become warmer and drier (Brown

243 243 et al., 2020, Almazroui et al., 2021). Based on this unique dataset, we observed a negative
244 244 correlation between the maximum temperature of the warmest month and precipitation in the
245 245 coldest quarter with small mammal diversity, while precipitation in the wettest quarter was found
246 246 to have a positive relationship with small mammal diversity. Some studies investigating the
247 247 relationship of temperature and precipitation with small mammal abundance and richness have
248 248 reported contrasting findings (Barros-Battesti et al., 2000; Ferreguetti et al., 2021). Bioclimatic
249 249 variables can indirectly influence small mammal diversity and abundance by increasing the
250 250 availability of food resources (Bergallo and Magnusson, 1999; Graipel et al., 2006; Passamani
251 251 and Ribeiro, 2009), leading to higher reproduction rates (Barros, 2013; Bonecker et al., 2009;
252 252 Graipel et al., 2006). Such indirect impacts can help explain the complex and varied relationships
253 253 between bioclimatic variables and small mammal biodiversity observed in different studies.

254 254 Upon analyzing the three regions of the Atlantic Forest, we observed that none of the variables
255 255 investigated in this study were statistically significant in the northeast region. The protected areas
256 256 in this region are considered to have the "worst state of conservation" compared to other regions
257 257 where Atlantic Forest fragments are present (SOS Mata Atlântica and INPE, 2023). The
258 258 northeast region also has the lowest number of forest fragments (Dalapicolla et al., 2021), which
259 259 are typically small (<50 ha) and isolated from one another (Ribeiro et al., 2009; Vancine et al.,
260 260 2024). Due to these landscape characteristics, it is likely that much of the original mammal
261 261 diversity in these areas has become extinct, since there are not enough large forest patches left to
262 262 support their populations (de la Sancha et al., 2020). Furthermore, our investigation of the
263 263 bioclimatic variables found no effect on small mammal diversity in the northeast Atlantic Forest
264 264 region. This lack of effect may be due to the low variance in precipitation and temperature in the
265 265 area (Carvalho et al., 2020).

266 266 For the southeastern region, we discovered that the maximum temperature of the warmest month
267 267 and precipitation of coldest quarter had a negative impact on small mammal diversity.

268 268 Conversely, precipitation of wettest quarter, and quadratic and linear forest amount were
269 269 positively correlated. The temperature and precipitation are closely related to the geographic and
270 270 latitude conditions of regions. In this region, the summer is generally characterized by high
271 271 temperatures and abundant rainfall, which enhances food availability, and consequently small
272 272 mammal abundance (Corrêa et al., 2017). Warmer temperatures and precipitation in the coldest
273 273 periods can affect the availability of suitable microhabitats, food resources and water sources for
274 274 small mammals, potentially leading to negative impacts on their population and diversity (de
275 275 Castro and Fernandez 2004). Despite historical disturbances caused by agriculture and urban
276 276 encroachment (Joly et al., 2014), the southeast region has the largest Atlantic Forest fragments
277 277 (Vancine et al., 2024), which can promote small mammal conservation and reinforce the
278 278 importance of forest amount in this group (Pardini et al., 2010).

279 279 In the south region, mean diurnal temperature and the quadratic and linear forest amount has a
280 280 positive relationship with small mammal diversity. The southern region has the lowest
281 281 temperatures in the Atlantic Forest biome, reflecting also the geographic and latitude conditions
282 282 of the region (Oliveira-Filho and Fontes 2000; Colombo and Joly 2010). Indeed, the mean
283 283 diurnal temperature can have positive impacts on small mammal populations and diversity, not
284 284 only on microhabitat, food and water resources (de Castro and Fernandez 2004), but also on
285 285 furthermore in the individuals' activities and foraging (Kenagy 1973; Milling et al., 2017).

286 286 Moreover, the southern region contains the second and third largest Atlantic Forest fragments
287 287 (Vancine et al., 2024), contributing to small mammal conservation in these areas. The positive
288 288 relationship between small mammal diversity and forest amount can be attributed to the legally

289 289 protected forest remnants in the region (protected areas), which have the capacity to support a
290 290 high richness of non-volant small mammal species within the southern Atlantic Forest. This
291 291 underscores the presence of areas characterized by high endemism among small mammal species
292 292 (Dalapicolla et al., 2021).

293 293 **Conclusions**

294 294 This is the first study assessing diversity in the entire Atlantic Forest biome (214 small mammal
295 295 assemblages), showing the importance of large-scale assessment. The results of this study also
296 296 reveal the importance of forest amount in the landscape for small mammal diversity in the
297 297 Atlantic Forest, regardless of the biogeographic region. Future research should focus on
298 298 investigating the variation in bioclimatic variables (temperature and precipitation), climate
299 299 change and the characteristics of the surrounding land cover, since these factors can also
300 300 contribute to small mammal diversity. By better understanding the factors that influence this
301 301 diversity, conservation efforts can be targeted more effectively to protect these important and
302 302 often overlooked members of the ecosystem (Asfora and Pontes, 2009; Dalmagro and Vieira,
303 303 2005; Lima et al., 2010; Püttker et al., 2008).

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311 311

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TABLES

Table 1 -- Variables, model averaged estimates (Estimate), standard errors (SE), z values (z) and p-value given by the Z-statistic (p) across the model-average linear mixed model (LM) and the importance of each variable (W) to testing the variation of the small mammal Shannon index with data from studies carried out in the Atlantic Forest. The importance value (W) was obtained by the sum of the weights of each variable in the global models. The spatial scale used was 5km radius.

	Estimate	SE	z	p	W
(Intercept)	1.671	0.750	2.227	0.026	
Max temperature of warmest month	-0.004	0.001	2.855	0.004*	0.42
Forest amount quadratic	0.00004	0.00001	3.265	0.001*	0.58
Precipitation of coldest quarter	-0.001	0.0002	2.695	0.007*	0.27
Forest amount	0.005	0.002	3.014	0.003*	0.41
Precipitation of wettest quarter	0.001	0.0002	2.673	0.008*	0.25
Isothermality	0.012	0.006	1.762	0.078	0.03
Mean diurnal temperature range	-0.001	0.003	0.193	0.847	0.01
Annual precipitation	-0.00001	0.0001	0.065	0.948	0.01

Significance code: *p<0.05

647 637 **Table 2** - Variables and importance of each variable (*W*) for each region. The importance value
 648 638 for small mammal diversity (Shannon index) was obtained by the sum of the weights of each
 649 639 variable in the global models. The spatial scale used was 5km radius.

Variables	<i>W</i> Northeast	<i>W</i> Southeast	<i>W</i> South
Annual precipitation	0.13	0.09	0.04
Isothermality	0.44	0.04	0.25
Max temperature of warmest month	0.11	0.50	0.10
Mean diurnal temperature range	0.14	0.19	0.29
Precipitation of coldest quarter	0.17	0.01	0.12
Precipitation of wettest quarter	0.22	0.42	0.08
Forestry amount	0.16	0.34	0.46
Forestry amount quadratic	0.16	0.40	0.54

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Table 3 - Variables, model averaged estimates (Estimate), standard errors (SE), z values (z) and the p-values given for the Z-statistic (p) across the model-average linear mixed model (LM) testing the variation of the Shannon index for small mammals with data from studies carried out in the Atlantic Forest (for the southeast dataset). The spatial scale used was 5km radius.

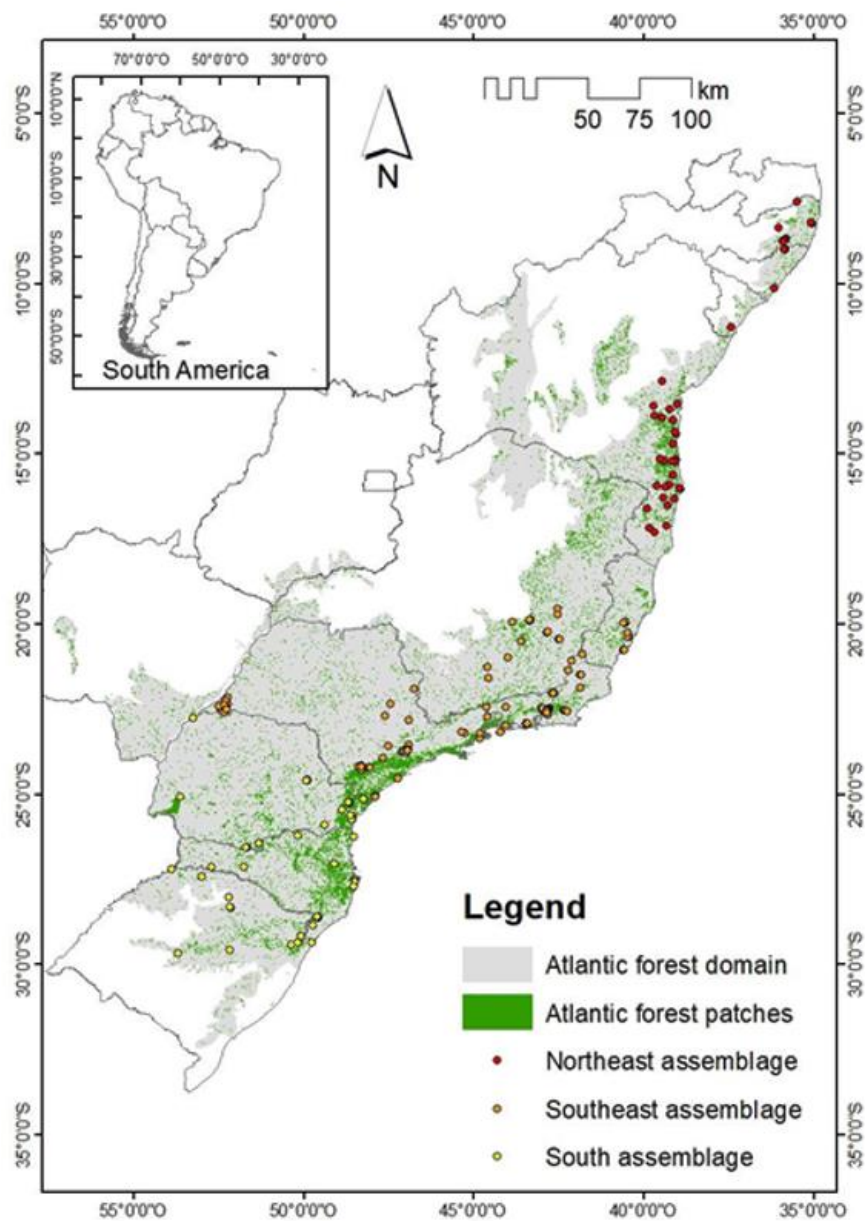
Variable	Estimate	SE	z	p
Intercept	2.076	1.373	1.511	0.131
Max temperature of warmest month	-0.006	0.002	3.176	0.001*
Forest amount quadratic	0.00004	0.00002	2.934	0.003*
Forest amount	0.005	0.002	2.849	0.004*
Precipitation of wettest quarter	0.001	0.0004	2.515	0.012*
Mean diurnal temperature range	-0.009	0.004	2.446	0.014*
Annual precipitation	0.0005	0.0002	2.355	0.019*
Isothermality	-0.025	0.013	1.993	0.046*
Precipitation of coldest quarter	0.0008	0.0013	0.639	0.523

Significance code: *p<0.05

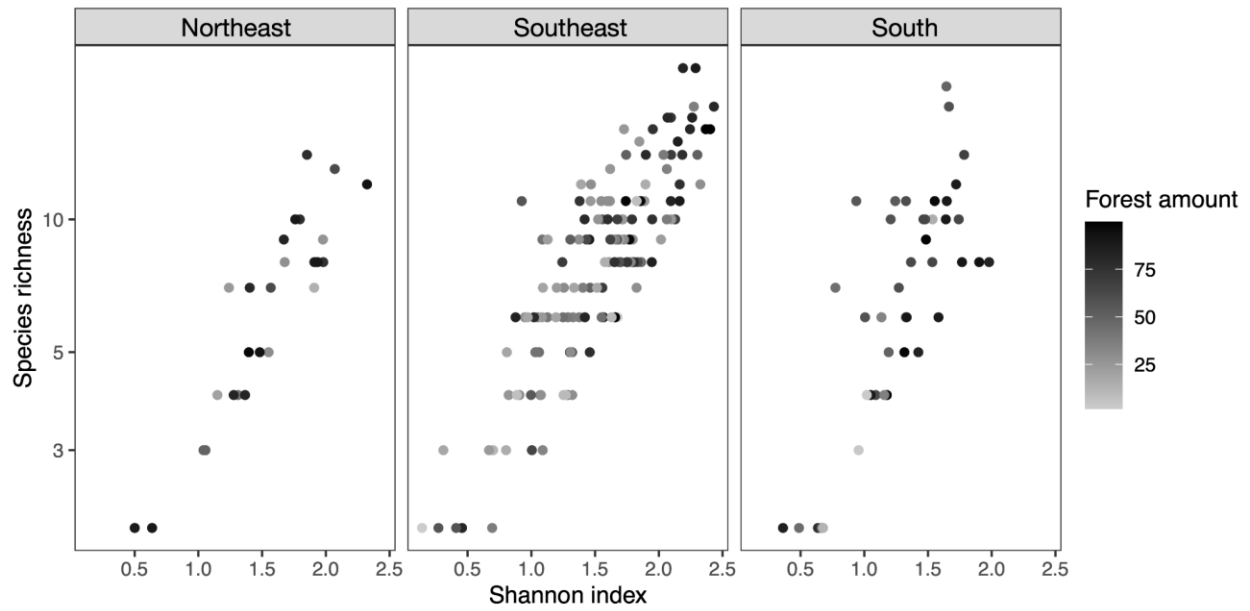
Table 4 - Variables, model averaged estimates (Estimate), standard errors (SE), z values (z) and the p-values given for the Z-statistic (p) across the model-average linear mixed model (LM) testing the variation of the Shannon index for small mammal with data from studies carried out in the Atlantic Forest (for the south dataset). The spatial scale used was 5km radius.

	Estimate	SE	z	p
(Intercept)	0.405	1.019	0.394	0.694
Forestry amount quadratic	0.0007	0.0003	2.407	0.016*
Forestry amount	0.007	0.003	2.288	0.022*
Mean diurnal temperature range	0.008	0.004	1.995	0.046*
Isothermality	0.028	0.016	1.737	0.082
Precipitation of coldest quarter	0.001	0.0007	1.434	0.152
Max temperature of warmest month	-0.004	0.003	1.275	0.202
Precipitation of wettest quarter	-0.0005	0.0005	0.957	0.338
Annual precipitation	0.0002	0.0003	0.073	0.942

Significance code: *p<0.05



692 652
693 653 **Figure 1** - Geographic distribution of the 214 small mammal assemblages in the Atlantic Forest
694 654 fragments in Brazil. Gray shows the historical Atlantic Forest distribution, green shows the
695 655 remaining patches.



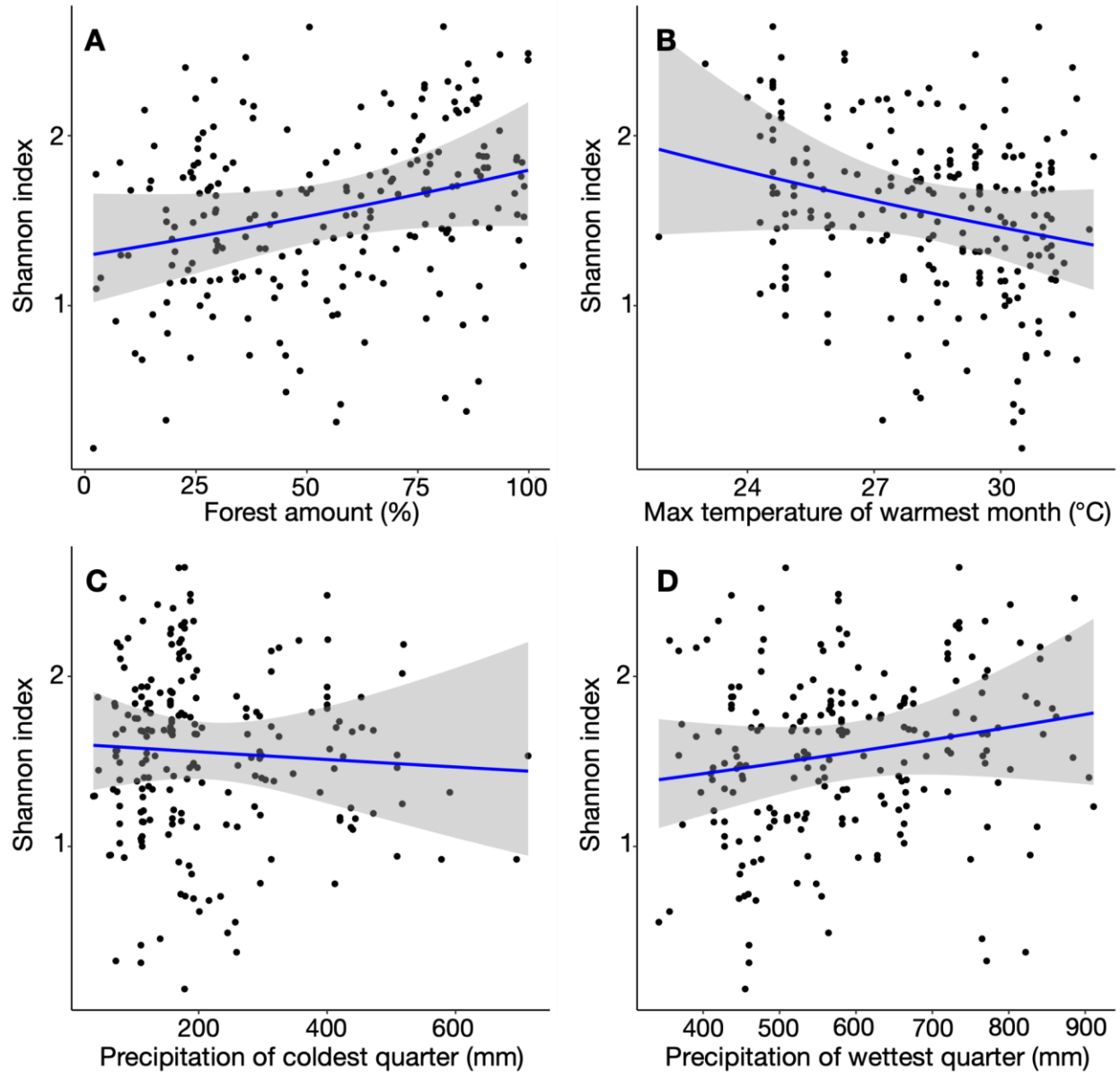
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Figure 2 - Relationship between the Shannon index estimates and the species richness of small mammals across sampled sites in northeast (NE), southeast (SE) and south (S) regions of the Atlantic Forest.



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701 661 **Figure 3** - Relationship between Shannon index (small mammal diversity) and (A) forest

702 662 amount, (B) max temperature of warmest month, (C) precipitation of coldest quarter and (D)

703 663 precipitation of wettest quarter. The spatial scale used was 5km radius.