1 **Assessing the Relation between the Spatiotemporal Microhabitat Heterogeneity**

2 **and the Dispersion Patterns of Two Syntopic Small Mammals in a Midlatitude**

3 **Temperate Forest**

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5 *De la Cruz-Arguello Ivan M.[a] (imda@xanum.uam.mx), Castro-Campillo Alondra[a] (acc@xanum.uam.mx),*

6 *Zavala-Hurtado Alejandro[a] (jazh@xanum.uam.mx), Salame-Méndez Arturo[b] (asam@xanum.uam.mx), and*

7 *Ramírez-Pulido José[a] (jrp@xanum.uam.mx).*

8

9 Authors affiliations:

10 [a] *Department of Biology (DB) and* [b] *Department of Reproduction Biology (DBR), Biological and Health*

11 *Sciences Division (DCBS), Metropolitan Autonomous University campus Izatapalapa (UAM-I). AP 55-*

12 *535- Av. San Rafael Atlixco 186, Vicentina, 09340 Iztapalapa, CDMX, México.*

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14 Running title: Ecological Dispersion of Syntopic Small Mammals

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Abstract

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28   One of the basics problems in ecology is to understand the factors that shape the spatial

29   patterns in the distribution of the species and the coexistence of close relatives species.

30   Among the most critical factors governing the distributions and the coexistence of

31   species are the spatiotemporal changes occurring in the microhabitat heterogeneity.

32   Here, we assessed the heterogeneity of microhabitats and how they affect the spatial

33   segregation of two species of small mammals (*i. e.*, *Peromyscus difficilis* and *P.*

34   *melanotis*), which coexist in a temperate, mixed forest. We evaluated the microhabitat

35   heterogeneity through multivariate statistics, using onto 23 habitat variables describing

36   horizontal-vertical habitat structure along pluvial seasons. To detect specific

37   microdistribution changes and habitat preferences by two species of small mammals, we

38   used second-order spatial statistics and general linear models. According to their

39   respective morphology and locomotive adaptations, the middle sized, midscansorial *P.*

40   *difficilis* was resident all year long and preferred microhabitats with a high log ground

41   cover, while the opportunistic, small sized, cursorial *P. melanotis* changed its

42   occupancy area, depending on the density of herbaceous and woody plants cover. Under

43   the more benign microhabitat conditions of the rainy season (denser plant coverage,

44   milder temperature), both species showed closer microdistribution patterns; while these

45   became repulsive at the less favorable conditions of the dry season (scarcer plant cover,

46   colder temperature). Thus, we could confirm that seasonal changes of microhabitat

47   heterogeneity promoted *Peromyscus* coexistence, through dispersion patterns reflecting

48   partition of microhabitat resources.

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50   Keywords: Microhabitat selection, Use of space, Small mammals, Dispersion, Resource

51   partition.

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Introduction

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55 Spatiotemporal habitat heterogeneity has a substantial impact on coexistence among

56 species since they become spatially segregated, according to niche preferences such as

57 resource requirements (Valladares *et al*. 2015). Model simulations reveal the potentially

58 important role of spatial heterogeneity and its complex and delicate interplay with

59 dispersal in mediating long-term outcomes of species coexistence (Schreiber and

60 Killingback 2013; Valladares *et al*. 2015). For example, an increase in the number of

61 habitat types, resources, and structural complexity should increase the available niche

62 space and thus allow more species to coexist (Currie 1991). Equally crucial for the

63 maintenance of coexistence is the heterogeneity in time, with an influence on natural

64 communities also variable depending upon the temporal scales (Valladares *et al*. 2015).

65 Temporal fluctuations on habitat structure can stabilize coexistence via storage effect

66 (Chesson 2000), when inter-annual variation in climate or resource availability favors

67 alternatively one group of species over the others (Zavaleta *et al*. 2003). For instance,

68 *Peromyscus* mice have been shown to respond to spatiotemporal habitat heterogeneity

69 regarding species coexistence (M'Closkey and Fieldwick 1975; M'Closkey and Lajoie

70 1975), spatial segregation (Monamy and Fox 1999), and competition (Morris 1984;

71 Seagle 1985).

72 Heterogeneous habitats contain patches of varying size, distribution, resources,

73 environmental conditions, and species composition (Fahrig and Merriam 1994) that

74 vary spatiotemporally, depending on observation scale and habitat type under study

75 (Wiens 2000). It is highly likely that small size species such as small mammals perceive

76 spatial habitat heterogeneity at a fine scale (microhabitat). Therefore, both movement

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77 and foraging by these kinds of mammals are affected by habitat heterogeneity (Bowne

78 *et al*. 1999), having different responses among species or demographic groups within

79 them (Dooley and Bowers 1996). Here we focus on whether small mammals are

80 capable of perceiving and to respond to spatiotemporal microhabitat heterogeneity.

81 Small mammals use resources selectively, based on their requirements for

82 growth, survival, and reproduction (Johnson and Gaines 1980). Several studies have

83 quantified variation in resource use in heterogeneous environments either among

84 congeneric and co-family mice species within a community (Kaufman and Kaufman

85 1989 and references therein). Indeed, syntopic related species are especially valuable for

86 studies of spatial and resource partitioning, since they are most likely to be current or

87 past competitors (Kalcounis-Rüppell and Millar 2002). Since habitat use varies

88 spatiotemporally (Haim and Rozenfeld 1993) due to distribution and availability of

89 resources, we expect that such variation also affects the use of resources and

90 relationships among non-closely related species. In this study, the primary objective is

91 to analyze how heterogeneity of microhabitats is structured and change through pluvial

92 seasons in a temperate, mixed forest, and how such changes affect the coexistence of

93 two syntopic species of *Peromyscus* (*i.e., P. difficilis* and *P. melanotis*). Therefore, 1)

94 We assess the presence of the spatiotemporal heterogeneity at a fine scale

95 (microhabitat) according to vertical and horizontal structure indicators. 2) We evaluate

96 the ecological dispersion patterns of two species of *Peromyscus* and is tested if the use

97 of space of the two small mammals is affected by the spatiotemporal changes in

98 microhabitat heterogeneity. 3) We determine what kind of spatial relationships occur

99 between both species, depending on seasonal changes in microhabitats heterogeneity (*i.

100 e.*, attraction or positive: sharing of same microhabitats and resources; repulsion or

101 negative: not sharing). Finally, we assessed which specific structural elements of each

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102   one of the microhabitats better explain the capture frequency of the two *Peromyscus*

103   species between seasons.

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105   **Material and methods**

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107   *Ethics statement*

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109   Animal capture and handling followed guidelines of the American Society of

110   Mammalogists (Sikes *et al*. 2011). If animals died, corpses were prepared as voucher

111   specimens to house them at the Mammal Collection of the Universidad Autónoma

112   Metropolitana-Iztapalapa (UAMI, Ramírez-Pulido *et al*. 1989). Collecting permit,

113   SEMARNAT-08-049-B, was issued by DGVS, SGPA-09712/13, SEMARNAT, to

114   Alondra Castro-Campillo (ACC).

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116   *Study area*

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118   The study area was located in a temperate forest of conifers and broad-leaved trees at

119   Parque Nacional Desierto de Los Leones (PNDL, CONANP 2006), Mexico City, within

120   the Transmexican Neovolcanic Range. Temperature averages 12.6 ± 6 °C from April to

121   July, while it descends to 8.1 ± 2 °C from December to February. Rainfalls occur from

122   late spring throughout summer (May to August), with average precipitation of 235 ± 30

123   mm, though this period can go until mid-fall (October). From winter to early spring

124   (December to March), precipitation average becomes 12 ± 4 mm, introducing a dry and

125   cold climate (PNDL, CONANP 2006). Dominating vegetation by strata includes

126   canopy, *Abies religiosa, Pinus hartwegii, P. leiophylla, P. montezumae, Prunus*

127   *serotina, Garrya laurifolia, Salix paradoxa, and Buddleia cordata; understory shrubs,*

128   *Baccharis conferta* and *Senecio spp*., and herbs, *Acaena elongata, Sigesbeckia*

129   *jorullensis,* and *Alchemilla procumbens*; ground level, a rich variety of mosses and

130   fungi.

131

132   *Mice sampling*

133

134   We captured mice along ten months (October 2013- August 2014), including the dry

135   and wet seasons within a 2,475 m² surface plot (Fig. 1) at 2289 m. The plot was gridded

136   (12 vertical lines, A-L; 10 horizontal lines, 1-10) marking intersections each 5 m with

137   buried wood stakes (150x2.5x2.5 cm) to construct a coordinate system for independent

138   sampling stations, where we set 120 Sherman live traps (Tallahassee, FL 32303, USA),

139   baited with oat flakes and vanilla scent (Fig. 1). Traps were set for two continues nights

140   (2400 trap-nights), shortly before dusk, left open overnight, and checked at next day

141   dawn. To avoid bias in the abundance and use of space of both *Peromyscus* during each

142   sampling session, we used a temporal mark (gentian violet applied in the abdomen of

143   the mice) to identify the captures and recaptures. If we saw signals that the gentian

144   violet was disappearing in the abdomen of the mice, we applied it again. This temporal

145   mark enabled us to count the net frequency of the individuals in each microhabitat. We

146   carried out an initial analysis with the recaptures, and we found the same patterns that

147   we obtained with the first frequency (without recaptures). Thus, for the analyses, we

148   used only the first capture data for each of the 120 sampling stations during all trapping

149   sessions. All the traps were cleaned, and bedding was changed at each trap check event.

150   Also, all the traps were set randomly in each sampling station to avoid bias in frequency

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151   quantification due to recurrence behavior or shyness of the mice to the trapping.

152   Coordinates of all trapped mice were recorded and the species and sex determined

153   through visual inspection.

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155   *Microhabitat features*

156

157   To assess spatiotemporal heterogeneity of microhabitat within the entire plot, we

158   delimited an influence zone (sub-plot, Fig. 1; close-up, Fig. 1), drawing a rectangle of

159   2.5 m^2 around each sampling station. 23 variables were sampled (Table 1) once in each

160   influence zone in both seasons. The sampling of the entire plot took ten days, we

161   sampled one transect per day, starting at 9 am in the second week of the most

162   represented month of rains (July) and in February for the dry season (PNDL, CONANP

163   2006). These variables have been proved to be components of the vertical and

164   horizontal structure of the microhabitat. Also as factors affecting the distribution of

165   small mammals at fine scales (Morris 1984, 1987; Stapp 1997; Jorgensen 2004,

166   Coppeto *et al*. 2006; Villanueva-Hernández *et al*. 2017). Environmental variables

167   include vegetation coverage at different heights (VC10-100 cm), number of herbaceous

168   forms (FH11-15), and number of woody forms (VF21-25) at five different heights: 10,

169   25, 35, 50, and 100 cm, respectively. Rock coverage (RC), logs coverage which include

170   stumps and fallen trunks (CLO); coverage of organic matter (OM); coverage of bare soil

171   (BS); vegetation species richness (VR); total herbaceous plants (TH); total woody plants

172   (TW) and the number of burrows (BW) also were sampled (Table 1). Overall, these

173   variables provide information about possible refuges for the small mammals against

174   predators, some elements of microhabitat also imply spaces for resting, breeding, for

175   food resources and safe roads to move from one place to another, avoiding predation

176   risk (Jorgensen 2004). Detailed information about ecological meanings for each variable

177   appears in Table 1.

178   We adapted Canfield's (1941) method of Line Intercept (LI) to measure all

179   variables in each pluvial station, for it allows sampling within-plot variation and

180   quantifies changes, both in plant species cover and height over time, by using transects

181   located within a plot. We drew eight graduated transects (cm) from the respective

182   influence zone of each station to cover the 2.5 m^2 sub-plots (Fig. 1); four 2.5 m transects

183   were cardinally oriented (N, S, E, W), while the other four 3.30 m ones were diagonally

184   oriented (NE, NW, SE, SW). Only plants intercepted by diagonal transects were

185   counted for vegetation species richness, number of life forms at different heights

186   (herbaceous and woody plants), and total herbaceous and woody plants; while all

187   transects were used to measure plant coverage at different heights, as well as coverage

188   of fixed elements (*i. e.*, rocks, logs, bare soil, dead organic matter). We calculated

189   coverage percentage of each variable within the sub-plots with the formula $\sum(Xi)\frac{100}{2400}$,

190   where *Xi* is centimeters occupied by every plant in each transect, and 2400 equals total

191   longitude (sum of the eight transects). We counted the number of woody and

192   herbaceous plant life forms at different heights and burrows within each influence zone

193   of every sampling station. We took each hole in the ground ca. 8-12 cm of diameter as a

194   potential burrow for both *Peromyscus* (Álvarez-Castañeda 2005; Fernandez *et al*. 2010).

195

196   *Statistical data analysis*

197

198   We standardized all variables and run statistical tests at *p* ≤ 0.05. We did not found

199   multicollinearity among the 23 variables which was assessed by examining the Variance

200   Inflation Factor (*i. e.,* all values were in a threshold <6) (Zar 1999). To identify and

201   categorized microhabitat heterogeneity within the grid, we performed two independent

202   Hierarchical Cluster Analysis (HCA) in JMP® (ver. 9, SAS Institute Inc., Cary, NC,

203   1989-2007) for each season. These analyses enabled us to cluster the sample stations

204   with similar characteristics according to the sampled variables for both seasons. We

205   used Ward´s method (1963) where the distance between two clusters is the ANOVA'

206   sum of squares between them, added up over all variables. Visual inspection of the

207   dendrogram and no drastic changes in the variance scree plot gave us three general

208   groups of stations for both seasons, which we interpreted as distinct microhabitat types

209   (M1-3). We further statistically validated such microhabitats carrying out independent

210   Discriminant Analyses for both seasons (DA, Addinsoft SARL's XLSTAT 2013; F =

211   9.99 dry; F = 9.64, rains; Wilk's Lambda = 0.0001 in both) (Fig. A.1). These analyses

212   allow us to know what type of microhabitat corresponded to each sampling station.

213   Thus, we constructed two different maps, assigning to each sampling station a color

214   mark that represented the three different microhabitats for both seasons (M1: red, M2:

215   green, M3: blue) (Fig. 2, Fig. A.1). To create typologies that describe at a fine scale the

216   behavior of each one of the 23 variables within three microhabitats for both seasons, we

217   built a plot whereas "Y" axis comprises of the 23 standardized variables and in the "X"

218   axis corresponds to the three microhabitats constructed with the same 23 variables (Fig.

219   A.1).

220   Due to not all 23 variables did not reveal a normal distribution, we applied two

221   different tests to analyze the distribution changes on each microhabitat variable between

222   the rainy and dry seasons. First, distribution normality was checked for every variable

223   with Kolmogorov-Smirnov tests (Zar 1999). Thus, we used Student's t-parametric tests

224   for variables normally distributed and non-parametric Wilcoxon test for non-normal

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225 variables (Table 2). To know whether the number of stations structuring each type of

226 microhabitat changed between seasons (seasonal microhabitat heterogeneity), we used a

227 contingency table and x^2 test. All these analyses were performed with XLSTAT 13

228 (Addinsoft SARL). To examine the association between changes in spatial

229 heterogeneity of microhabitats and dispersion patterns of *Peromyscus*, along with the

230 entire grid, we conducted a Contingency Tables Analysis. Then, for visualizing

231 associations between the *Peromyscus* and microhabitats, we performed a

232 Correspondence Analysis with the constructed Contingency Tables for both seasons,

233 including the abundance of each species in the three microhabitats (Table A.2).

234

235 *Spatial analysis*

236

237 To map variations in point density captures of small mammals, and to find density

238 gradients across the plot area, we used the Kernel function (PAST, ver. 3.14, Hammer *et*

239 *al*. 2001). To test the ecological dispersion patterns of both species within the plot (*i.e.*,

240 clustering or overdispersion) for both seasons, we used a "Nearest Neighbor Analysis"

241 (Clark and Evans, 1954) using the PAST software (ver. 3.14, Hammer *et al*. 2001). We

242 applied the Wrap-around edge effect adjustment which is only appropriate for

243 rectangular domains as our plot sampling (Hammer *et al*. 2001). In general, the

244 "Nearest Neighbor Analysis" compares the mean distance of each main individual from

245 its nearest neighbor of the same species with the mean distance expected for a set of

246 points randomly dispersed at the same density (Vázquez and Álvarez-Castañeda 2011).

247 The ratio of the observed mean distance to the expected distance (R) indicates how the

248 observed distribution deviates from random. Clustered points give $R<1$, Poisson

249 patterns give $R\sim1$, while overdispersed points give $R>1$.

10

250   To assess whether both species were associated or disassociated, we compared

251   dispersion patterns between the two mice, using Ripley's K bivariate function (Ripley

252   1977), since the method considers all distances among individuals located under a

253   Cartesian scheme (X, Y) in a quadrat plot (Ripley 1976, Dale 1999, Zavala-Hurtado *et*

254   *al*. 2000). We used PASSaGE (*ver. 2*, Rosenberg and Anderson 2011) to carry out

255   Ripley's bivariate K analysis. We used the option to test the associations conditional on

256   current locations hypothesis in PASSaGE. In this test, the point locations remain fixed,

257   and only the types are randomized (the two *Peromyscus*). The number of each type

258   remains fixed, but the association of each type with a specific, fixed location is

259   randomized. In this case, one is not testing whether the points are themselves random or

260   clustered, but rather whether the association of type A with type B (*P. difficilis vs. P.*

261   *melanotis*) is what one would expect given the locations of the points as fixed

262   (Rosenberg and Anderson 2011). We assigned coordinates to each sampling stations

263   considering 5 m distance between them. Therefore, because each sampling station had a

264   Cartesian coordinate system, we used as data input each station were we capture mice.

265   Thereby, our null hypothesis involved independence between our two species *P.*

266   *difficilis* and *P. melanotis* (Ripley 1976, Diggle 1983, Dale 1999), since we were

267   interested in whether points of a specific type (*P. difficilis*) were associated, or

268   disassociated, with points of the other specific type (*P. melanotis*). In other words,

269   Ripley's $K_{12}(d)$ allowed us to assess spatial attraction or repulsion between the two

270   species, among the stations of the plot. To evaluate the statistical significance of $K_{12}(d)$,

271   we estimated 95% confidence envelops (95% CI), using a Monte Carlo procedure,

272   based on 1000 stochastic relocation simulations of the sampling stations in the plot

273   (Upton and Fingleton 1985; Bailey and Gatrell 1995; Zavala-Hurtado *et al*. 2000).

274   When L(*d*) was positive and took values over the upper limit of the confidence region,

11

275   we inferred dissociation or repulsion between the *Peromyscus* at the corresponding (*d*)

276   scale; whereas a significant negative deviation indicated us a pattern of association or

277   attraction between the two mice (Dale 1999). If L(*d*) remains within the limits of the

278   95% CI for a given value of *d*, the null hypothesis of independence between the two

279   contrasts cannot be rejected (Dale 1999). The height of the L(*d*) function (peak height)

280   indicates the intensity of the association or repulsion. Control for edge effect was

281   carried out for analysis by rescaling the counts based overlap with the study boundary

282   setting the options area/volume which has been recommended for quadrats plots

283   (Rosenberg and Anderson 2011).

284

285   *Prediction of microhabitat elements affecting the use of space by each species*

286

287   The next *s*tep was to assess which specific environmental variables best explained the

288   frequency of both species within the plot at each season. For this, we performed

289   Generalized Linear Models (GLMs), using JMP® (ver. 9, SAS Institute Inc., 1989-

290   2007, Cary, NC,). First, we conducted a Principal Component Analysis (PCA) on the

291   means of the 23 variables to obtain functions summarizing the most significant variance

292   at each season. Because in both seasons the three first functions summarized a good

293   portion of the variance (38.61 for the dry season and 45.92 for rains), we used these

294   functions to construct the GLMs. Therefore, we assessed different models using the PCs

295   as effect variables to explain the frequency of the individuals of both species for both

296   seasons. Then, to visualize the fit of the model, the predicted values from the GLMs

297   were plotting against the Principal Components of the best model chosen. For each

298   species, the response variable in the models was the capture frequency at each trapping

299   station of the grid, and we assumed a Poisson distribution with a log link function.

300

301   **Results**

302 *Frequency of captures*

303

304 The total number of individuals captured from both species during the dry season was

305 111, while for the rainy season was 168. For *P. difficilis* the total number of frequency

306 capture in the dry season was 64. For *P. melanotis* during the dry season, we captured 47

307 individuals. On the other hand, during the rainy season, the frequency of capture of *P.*

308 *difficilis* was 87. While the total captures for *P. melanotis* were 81 (Table A.2).

309

310 *The Behavior of 23 variables of microhabitat between seasons*

311

312 When considering the mean value over all stations, 16 out of the 23 environmental

313 variables showed a significant difference between the two seasons (Table 2, Fig. 3, Fig.

314 A.1). The main changes were observed for variables related to herbaceous vegetation,

315 according to plant coverage at different heights, and vegetation species richness (VR).

316 As expected in overall, woody life forms were more stable between seasons (Table 2,

317 Fig. 3, Fig. A.1). Components of microhabitat showing no statistical change between

318 seasons were frequency of herbaceous plants at 10 cm (FH11), the frequency of both 35

319 cm (FW23) and 50 cm (FW24) woody plants, as well as coverage of logs (CLO), rocks

320 (RC), and bare soil (BS). Therefore, space configuration given by these structural

321 features remained stable in both seasons (Fig. 3).

322

323

324

325   *Microhabitat heterogeneity*

326

327   The dendrogram from cluster analysis revealed three different classes of microhabitats

328   (M1, M2, and M3) within the sampling plot in each season (Fig. A.1). M1 included

329   more sampling stations during the dry season, while M2 covered the majority of

330   sampling stations during the rainy season (Fig. 2, Fig. A.1, Table A.1). Indeed, Fisher's

331   exact test of Contingency Tables Analysis revealed significant changes in the number of

332   sampling stations ($p = 0.004$) from dry to rains. The main changes occurred between

333   M1 ($x^2 = 2.123$, $p < 0.05$) and M2 ($x^2 = 3.348$, $p < 0.05$), especially in the latter, since it

334   augmented 24 sampling stations from the dry season to the rainy season (Fig. 2, Table

335   A.1). Conversely, the number of sampling stations remained quite stable in M3 ($x^2 =$

336   0.011) throughout the study (Fig. 2, Fig. A.1, Table A.1).

337   Discriminant analyses validated heterogeneity of the three microhabitats (Fig. 2)

338   within and between pluvial seasons. the percentage of variance associated to each

339   discriminant function was clearer during the rainy season (dry season: F1 = 58.67 %, F2

340   = 42.32 %; rainy season: F1 = 72.581 %, F2 = 27.419 %) (Fig. 2, Fig. A.1).

341   Discriminant functions explained variation due to woody plants in the understory in the

342   dry season, while herbaceous vegetation together with decayed matter and logs became

343   more relevant at rains (Table A.3). Wilk's Lambda showed that at least the mean of one

344   microhabitat differed statistically from the others either in the dry and rainy season ($p =$

345   0.0001; $p = 0.0001$, respectively) (Fig. A.1). These results corroborated spatial and

346   temporal heterogeneity drawn from cluster analysis of individual station features in the

347   grid plot. During the dry season, 93.33 % of individual sampling stations remained

348   correctly classified, and 94.17 % of them during the rainy season (Fig. 2).

349

350 *Description of microhabitats within the plot*

351

352 *Microhabitat 1*. M1 (Fig. 2, Fig. A.1) was characterized by low amounts, or absence, of

353 vegetation cover at different heights (VC) and by a low frequency of herbaceous and

354 woody plants (FH and FW, respectively). In contrast, organic matter on the ground

355 (OM) was the most frequent component. This microhabitat was also distinctive for

356 having extensive coverage of logs (CLO) on the ground and for being the microhabitat

357 with the significant presence of burrows (BW).

358 *Microhabitat 2*. M2 (Fig. 2, Fig. A.1) was the largest area covered by herbaceous life

359 forms at different heights; vegetation species richness (VR) and the total number of

360 herbaceous plants (TH) also remained very high. Woody life forms at 25 cm (FW22)

361 were present but at low frequencies, while FW24 and FW25 remained at higher

362 frequencies. Coverage on the ground of small logs or dead wood (CLO), of rocks (RC),

363 and organic matter (OM) were shallow during the study. Bare soil surface (BS)

364 increased to higher amounts during the dry season, while it decreased during the rainy

365 season. There were no burrows (BW) in this microhabitat.

366 *Microhabitat 3*. In M3 (Fig. 2, Fig. A.1), VC25, VC35, VC50, and VC100 showed high

367 values, while vegetation species richness (VR) averaged the highest compared to other

368 microhabitats. The total number of woody plants (TW) and frequency of woody plants

369 at different heights (FW21-25) remained very high, while the total number of

370 herbaceous plants (TH) was low. Vegetation coverage at 10 cm (VC10), rocks (RC),

371 logs (CLO), and bare soil surface (BS) were low during the dry season; however, VC10

372 increased in the rainy season. Conversely, OM was present in the dry season but

373 decreased in the rainy season. The number of burrows (BW) remained quite scarce.

374

375 *Association between the microhabitats and species*

376

377 Kernel Graphs (Fig. 4) indicated that the two species used space distinctive since they

378 were differentially scattered along the plot. *Peromyscus difficilis* was more abundant

379 during the dry season, occupying a large portion of the plot. Instead, *P. melanotis*

380 increased its distribution during the rains when it seemed to displace *P. difficilis* into

381 other sampling stations (Fig. 4). Distribution rearrangements between seasons implied

382 that one species occupied some stations more frequently than the other, and vice versa

383 (Fig. 4). Indeed, the two x^2 tests yielded statistical abundance differences in each species

384 at both microhabitats and seasons (Table A.2: dry season; R^2 (U) = 0.09, $n = 111$, df = 2,

385 Likelihood Ratio $x^2 = 15.07$, $p = 0.00005$; rainy season; R^2 (U) = 0.02, $n = 168$, df = 2,

386 Likelihood Ratio $x^2 = 6.40$, $p = 0.0406$).

387 During the dry season (Fig. 5 and Table A.2), *Peromyscus difficilis* was highly

388 related to M2 (80 % captured mice) and also related to M1 (64 % captured mice);

389 conversely, *P. melanotis* was captured more frequently in M3 (66 % captured mice).

390 Spatial use of microhabitats changed for both species in the rains (Fig. 5 and Table

391 A.2), showing a microhabitat partition again, though less visible: in the Correspondence

392 Analysis, 61 % of mice caught in M1 were *P. difficilis*. This species was also related to

393 M3, while 60% of mice caught of *P. melanotis* were captured in M2.

394

395 *Spatial Patterns*

396

397 The Nearest Neighbor Analysis revealed that in both seasons both species showed a

398 significant clustered pattern within the plot (Table 3). In the dry season, the mean

399 distance between individuals of *P. difficilis* displayed to be more clustered than the

16

400   individuals of *P. melanotis*. However, the mean distance between individuals of *P.*

401   *difficilis* increases in the rainy season, while individuals of *P. melanotis* showed a

402   reduction in their area occupied (Table 3).

403   On the other hand, during the dry season, Ripley's bivariate K showed a

404   statistically significant pattern of repulsion for both *Peromyscus* in almost all analyzed

405   distances of the entire plot, excused at 2 m where it shows an attraction pattern (Fig.

406   6a). Such repulsion pattern turned over in almost all distances during the rainy season

407   (Fig. 6b), since the two species became more associated, sharing microhabitats in

408   almost all capture stations. However, during the rainy season, significant statistical

409   peaks of repulsion reappeared between the species at distances of five, ten, and 14 m

410   (Fig. 6b). Analyses also revealed the intensity of these patterns; *e.g.*, the likelihood for

411   finding individuals of *P. difficilis* and *P. melanotis* together at the same capture station

412   was very low during the dry season (Fig. 6a), while this probability increased in the

413   rainy season (Fig. 6b).

414

415   *Structural components of microhabitats affecting the distribution of small mammals*

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417   Criteria for the selecting models that most explained the frequency of mice for each

418   species at each season in the sampling stations included: model significance of $p <$

419   0.05; lowest Akaike Information Criterion (AIC), *i. e.*, a measure of goodness-of-fit

420   penalized by the number of variables (Posada and Buckley 2004); Pearson goodness-of-

421   fit ($p < 0.05$) and its deviation (Deviance; $p < 0.05$); as well as the biological and

422   ecological meaning of results. Therefore, during the dry season, PC1 and PC3 predicted

423   the frequency of *P. difficilis* according to the best Generalized Linear Model for this

424   season (AICc 212.55) (Table 5, Fig. 5c). Environmental variables with higher scores in

17

425   the PC1 ($p = 0.0186$) were the total number of herbaceous plants (TH), vegetation

426   species richness (VR), and vegetation cover at 10 cm (VC10). In PC3 ($p = 0.0001$),

427   characterizing variables were the number of logs on the ground (CLO), as well as the

428   presence of burrows (BW) (Table 4, 5, Fig. 5c). These five variables were also the main

429   elements characterizing M2 (PC1) and M1 (PC3), the two habitats where the frequency

430   of capture of *P. difficils* was the higher. As for *P. melanotis* (Fig. 5c), the frequency of

431   capture of *P. melanotis* was positively related to PC2 (AICc = 204.47, $p = 0.0001$).

432   Here, among the four variables with higher scores, were the total number of woody

433   vegetation (TW) and frequency of woody life forms characterizing 10 cm height

434   (FW21), the two main elements at M3 for the dry season (Table 4, 5, Fig. 5c).

435   During the rainy season, a similar pattern of microhabitat partition occurred

436   between the two species. The best GLM model for *P. difficilis* in this season (Table 4, 5,

437   Fig. 5c) was mainly associated with the total number of woody plants (TW),

438   herbaceous forms at 50 cm (FH14), woody forms at 10 and 100 cm (FW21, FW25,

439   respectively) and with the number of logs on the ground (CLO), in PC2; and with the

440   number of logs on the ground (CLO), and organic matter (OM) in PC3 (AICc = 286.76,

441     $p = 0.0001$) (Table 4, 5). The latterly involved variables with a high presence at M1

442   (PC3) and M3 (PC2) during the wet season, where *P. difficilis* was more frequently

443   captured. On the other hand, *P. melanotis* (Fig. 5c) was only associated with PC1 (AICc

444   = 241.01, $p = 0.0343$). The primary variables characterizing this component were the

445   number of total herbaceous plants (TH), vegetation species richness (VR), and the plant

446   cover at almost all analyzed heights (VC10-100 cm) (Table 4).

447

448

449

450   **Discussion**

451

452   Our results of Contingency Tables Analysis, Correspondence Analysis, and GLMs

453   models showed that the two syntopic species of *Peromyscus* switched and split

454   resources in space, as environmental conditions changed. Also, our findings on

455   microhabitat relations of rodents in a patch of a mid-latitude temperate forest, concur

456   with the habitat heterogeneity coexistence hypothesis (Cramer and Willig 2002;

457   Valladares *et al*. 2015). We found that both *Peromyscus* were sensitive to slight changes

458   in microhabitat structure and that the three microhabitats provided different resources

459   for each one. Our results also suggest that coexistence between these syntopic

460   *Peromyscus* is facilitated by temporal differences in space structure, and probably also

461   by changes on the availability of both food and shelter that go with it (Pianka 1973;

462   Schoener 1974). For instance, *P. difficilis* was more related to M1 and M2 by the dry

463   season, while *P. melanotis* was highly related to M3. Conversely, *P. difficilis* was more

464   related to M1 and frequently captured to M3 by the rainy season, while *P. melanotis*

465   was highly related to M2. Partition in space use has already been documented for

466   coexisting species of *Peromyscus* within a community; *i.e.,* extensive studies of niche

467   partitioning by *Peromyscus leucopus* and *P. maniculatus* (Kaufman and Kaufman

468   1989). Moreover, several studies have demonstrated variation in spatial resource use by

469   congeneric species (Barry *et al*. 1990; Dooley and Dueser 1996; Kalcounis-Rüppell and

470   Millar 2002).

471   In our study, *P. difficilis* remained related to M1 in both seasons, especially to

472   the former during the wet season. The number of fallen logs was very high at M1. Such

473   microhabitat represents small patches of food for small mammals, offering invertebrates

474   (Bellows *et al*. 2001), refuges and shelters (Bowman *et al*. 2001). In this microhabitat,

475   individuals of *P. difficilis* can also use the long and big fallen logs as pathways for quick

476   and straight locomotion inside the forest (Bellows *et al*. 2001; Dewalt *et al*. 2003).

477   Indeed, fallen logs promote structural complexity of forests and may enhance positive

478   interaction among species of small mammals (Bowman and Facelli 2013). GLM's

479   analyses showed that PC1 and PC3 explained the abundance of *P. difficilis* during the

480   dry season and by PC2 and PC3 in the rainy season. In the dry season, variables

481   contributing most to PCA ordination in PC1 and PC3 were the total number of

482   herbaceous vegetation (TH), vegetation species richness (VR), vegetation coverage at

483   10 cm (VC10), herbaceous forms at 10 cm (FH11) and the number of logs on the

484   ground (CLO), as well as burrows (BW). While in the dry season, PC2 and PC3

485   represented woody vegetation (TW), the number of logs on the ground, herbaceous

486   forms at 50 cm (FH14), woody forms at 25 and 100 cm (FW21 and FW25, respectively)

487   and organic matter (OM). Bellows *et al*. (2001) found a similar result in a high latitude

488   temperate forest (Virginia, USA), where distribution of a small mammal, generalist

489   species was associated with the diameter of fallen logs, the frequency of shrubs, and

490   degree of canopy closure. Association between rodents and fallen logs was also

491   documented for *Nectomys squamipes* that builds up its nests inside decomposed, fallen

492   logs (Briani *et al*. 2004); this has also been recorded for other rodent species in several

493   biomes with different vegetation types (*e. g*., *Rattus rattus*, *Nesomys audeberti* in

494   Lehtonen *et al*. 2001; *Oligoryzomys nigripes* in Dalmagro and Vieira 2005). In contrast,

495   *P. melanotis* showed a close relation with only one PC over each pluvial season. During

496   the dry season, the frequency of this species was only related to PC2, which represented

497   the total number of woody vegetation (TW) and FW21. Then by the rainy season, the

498   species became only related to PC1, which accounted for understory dominated by

499   herbaceous life forms (TH). Relationships between frequency of rodents and habitats

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500 with increased understory density have been interpreted as a protection against aerial

501 predators (Dalmagro and Vieira 2005) or as a preference for more complex habitats that

502 enable for vertical stratifications and, thus for extended coexistence inside fragments

503 (Grelle 2003; Johnson 2007).

504 Intrinsic factors as sex and mating system must also be related to the coexistence

505 of both *Peromyscus*. For instance, the Nearest Neighbor Analysis revealed that in both

506 seasons both species showed a significant clustered pattern within the plot. However,

507 the mean distance between individuals of *P. difficilis* displayed to be more clustered

508 than the individuals of *P. melanotis*, especially during the dry season. Indeed, the mean

509 distance between individuals of *P. difficilis* increases in the rainy season, while

510 individuals of *P. melanotis* showed a reduction in their area occupied. These patterns

511 are related with the breeding season of both species. Our data (not published) revealed

512 that during the dry and rainy seasons were captured individuals of *P. difficilis* with signs

513 of reproductive activity, especially during the dry season (males: inguinal vs. scrotal

514 testicles, females: alopecia, the presence of milk, the appearance of the vagina,

515 gestation). While for *P. melanotis* the primary breeding season occurs during the rains.

516 Individuals need different resources requirements to fulfill the breeding season and this

517 impact on its dispersion and coexistence. We believe that *P. melanotis* may be moving

518 to other areas with more beneficial conditions (*i. e.* more availability of resources).

519 Thus, the coexistence between both *Peromyscus* may occur because the geographic

520 segregation of *P. melanotis* to search for better environmental conditions to survive.

521 Indeed, in this study, we define to *P. melanotis* as an opportunistic species throughout

522 the study area because the capture frequencies of the individuals only increased (as we

523 pointed out early) when the environmental conditions became more beneficial for the

524 survival of these. That is, throughout the time of capture except for the rainy season, its

21

525   frequency of capture remained at low levels compared to those of *P. difficilis* (resident

526   species), increasing drastically in the rainy season when there is greater accessibility for

527   the use of resources and competition between the two species decreases. Therefore, *P.*

528   *melanotis* may be coming back to the area during the rainy season to carry out the

529   breeding season. However, Chupp (2002) showed an opportunistic habitat use by small-

530   sized *Peromyscus leucopus*, which he related to predation risk. Further studies about the

531   geographic segregation and the influence of predation on the opportunistic behavior of

532   *P. melanotis* are needed. Also, the increase in the number of captures of both species

533   from the dry to the rains could be leaded for the breeding season and resources

534   availability. One possible consequence of such intrinsic and extrinsic operating factors

535   is that *P. difficilis* remained more abundant and always present at the microhabitats with

536   more stable elements in the study area (our unpublished data), while *P. melanotis* only

537   increased its abundance during the rainy season, when environmental conditions

538   became more benign, and plant cover became denser. Since rains promote an increase

539   of primary productivity, allowing more resource availability (mainly food) and

540   enhancing microhabitat carrying capacity, such habitat changes facilitate coexistence

541   between both *Peromyscus*, and with other small land mammals in the area (Castro-

542   Campillo *et al*. 2008, 2012). Ripley's bivariate K supported and shed light into such

543   outcome since the species showed repulsion between them in almost all analyzed

544   distances during the dry season; *i.e.*, due to resources availability are more scarce during

545   this season, is not so common that a mixed pair of mice used the same microhabitat.

546   Moreover, as in this season is the primary breeding season of *P. difficilis* is probably

547   that territoriality behavior can occur. Conversely, the intensity of such repulsion

548   decreased substantially during the rainy season; indeed, at some analyzed distances, the

549   two deer mice showed an association pattern. Holding our results that the increase of

550   resources available during the rainy season can allow that the species can share the

551   habitat. Thus, our results indicate that in these two syntopic *Peromyscus*, both

552   microhabitat use and spatial organization are seasonally variable (Brown and Zeng

553   1989; Cramer and Willig 2002). It is important to point out that during both seasons

554   Ripley's bivariate K indicated an interesting attraction pattern between 2 and 3 m. This

555   patterns could be due to sampling design. Ergo we set only one Sherman trap in each

556   sampling station for two days, therefore if one individual of *P. difficilis* was captured in

557   the first day and then one individual of *P. melanotis* was captured in the same station

558   where we captured the *P. difficilis*, the analysis counts this pattern as an association

559   because they were trapped in the same station at a very short distance.

560   Also, the partition of space by this syntopic deer mice must be facilitated by

561   their respective locomotive habits as semiarboreal (*P. difficilis*) and cursorial (*P.*

562   *melanotis*). The long tail of *P. difficilis* must enable it to rush and climb along shrubs or

563   trees (Álvarez-Castañeda 2005), thus easing its preference for habitats where it can

564   escape from predators. In fact, adult color coat changed in *P. difficilis* between pluvial

565   seasons, becoming more similar to ground litter; *e. g.*, in this resident deer mouse, color

566   phenotype plasticity must be a cryptic response elicited against predators. On the other

567   hand, a smaller sized body, together with a shorter tail and narrower soles (Fernandez *et*

568   *al.* 2010), should enable the cursorial *P. melanotis* to occupy such zones as M2 and M3,

569   where predators cannot easily spot it through a dense vegetation cover, so it can scape

570   very quickly. Indeed, high shrubs cover provide both protection from predators and

571   food sources, since seeds may be concentrated under shrub canopies (Thompson 1982;

572   Mohammadi 2010). In fact, rodents usually avoid foraging in unsheltered microhabitats

573   and forest edges where they are more likely to be spotted by avian (Kotler *et al.* 1991)

574   and other vertebrate predators (Morris and Davidson 2000; Mohammadi 2010).

575   Finally, we want to highlight and recommend our sampling of environmental

576   features and quantitative analyses, especially for Ripley's bivariate K, as neither one has

577   been extensively used in studies focusing on the spatial dynamics of dispersion in small

578   rodents, despite its important advantages. The methodological approach used here,

579   together with the gathered evidence became relevant for providing us with necessary

580   information about the ability of this two *Peromyscus* to split resources in a mid-latitude

581   temperate forest at the edge of a megalopolis, which continuous growth produces

582   fragmentation and patching of natural microhabitats. Therefore, our local scope was

583   explicitly designed at this initial point, to focus on small-sized rodents with low vagility.

584   Besides, we successfully aimed to reconstruct vegetation structure, to provide us with

585   clues as to how to eventually manage such perturbed ecosystems for conservation

586   purposes. We also think that our methodology can be helpful in other scenarios for

587   understanding small rodents, such as ethological dynamics, activity patterns, and

588   reproductive systems at either or both intra or interpopulation levels.

589

590   **Acknowledgments**

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790 **Figure legends**

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792   **Fig. 1.** Sampling plot design. a) Total plot area was 2475 m²; each intersection (n = 120)

793   was an independent sampling station for capturing mice. An influence area of 2.5 m²

794   around each station was constructed for sampling 24 microhabitat environmental

795   variables. b) Close up to the influence area showing the eight transects used for drawing

796   environmental variables; note subdivisions into three subtransects.

797   **Fig. 2.** Map of the distribution of the microhabitats (M1 = red, M2 = green, M3 = blue)

798   in the study quadrant for dry (A) and rainfall (B). The bar graph below shows the change

799   in the number of sampling stations between dry and rainy seasons. ** $p = 0.001$

800   **Fig. 3.** Box-plots are showing the seasonal heterogeneity of the 23 variables sampled in

801   the study plot between dry and rainy seasons. Overall, vegetation variables show an

802   increase in the rainy season, while the organic matter (OM) decrease. Structural elements

803   as logs on the ground do not shot differentiation between seasons. Some variables were

804   not present in high quantities along the study plot. Therefore we were unable to build the

805   box-plot. The red cross represents the mean of each variable.

806   **Fig. 4.** Spatial analysis with Kernel density points showing capture frequencies for *P.*

807   *difficilis* at dry (a) and rainy (b) seasons, and for *P. melanotis* at dry (c) dry and rainy (d).

808   Dots depict actual capture points, while hot spots color indicates higher density.

809   **Fig. 5.** Correspondence analysis from contingency tables of frequency capture data for

810   each deermouse (*P. difficilis* and *P. melanotis*) in each microhabitat (M1-3), during the

811   dry (a) and rainy (b) seasons, respectively. Axis c1 and c2 indicate the coordinates

812   resulted from the ordination of each variable from the analysis. Figure c shows the plots

813   for the GLMs models, the response variable for each graph are the predicted values of the

814   model to that principal component (the model effect). All of the PCs fitted in the model

815   show a positive relationship, indicating that the probability of capture frequency of the

816   individuals of two mice, increases with the presence of that variables. Therefore, the

817   figure also shows in the "X" axis in parenthesis the variables with the higher loading

818   scores in the ordination of this PCs.

819   **Fig. 6.** Ripley's bivariate K Analysis for interactions between the two *Peromyscus*. (a)

820   Repulsion pattern between both species in all analyzed distances during the dry season.

821   (b) Attraction from 6 - 12 m, and repulsion at 5, 10, and 14 m during the rainy season.

822   Black solid line represent the Ripleys K bivariate pattern; red dashed lines represent the

823   95% CI; blue solid line shows the null hypothesis.

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844   **Fig. 1**

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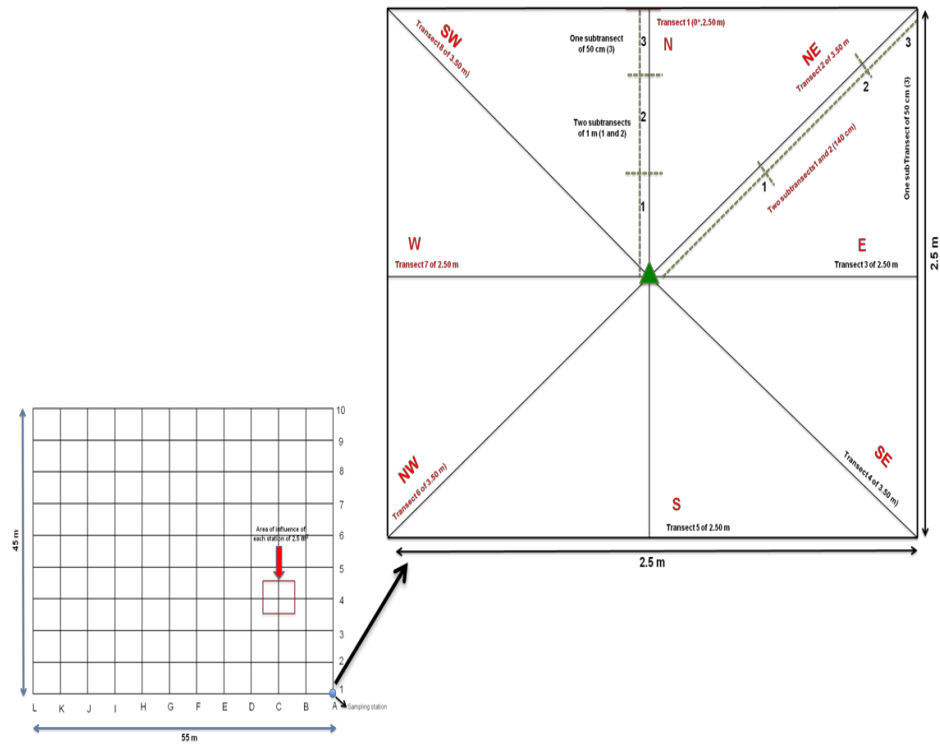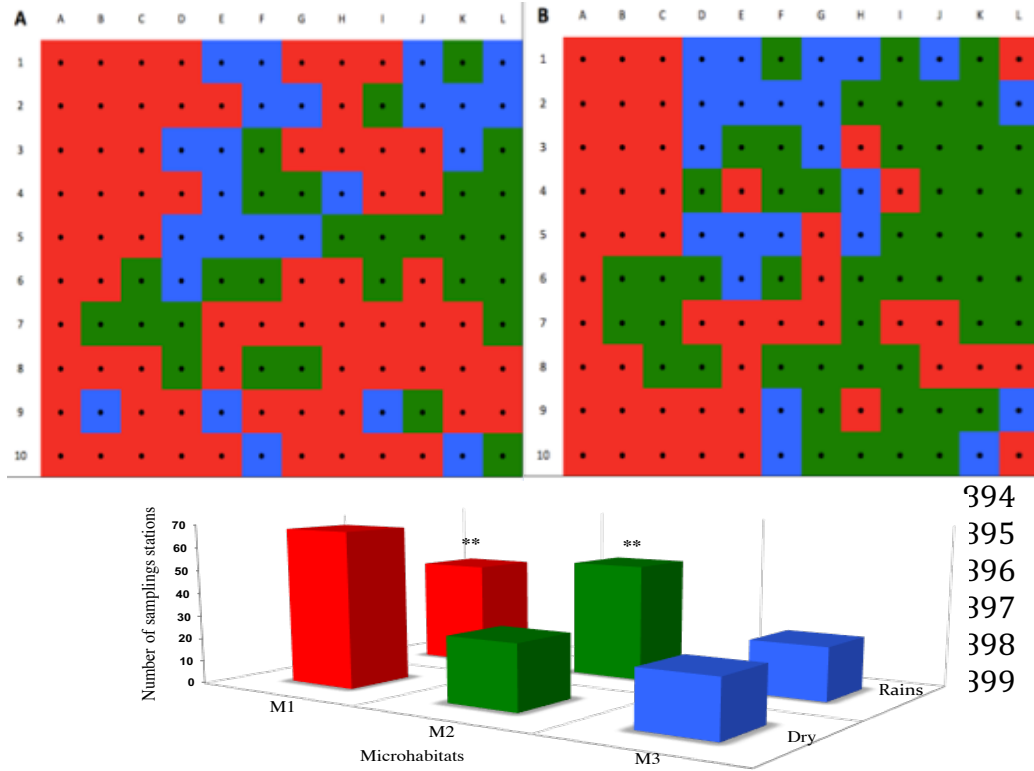859
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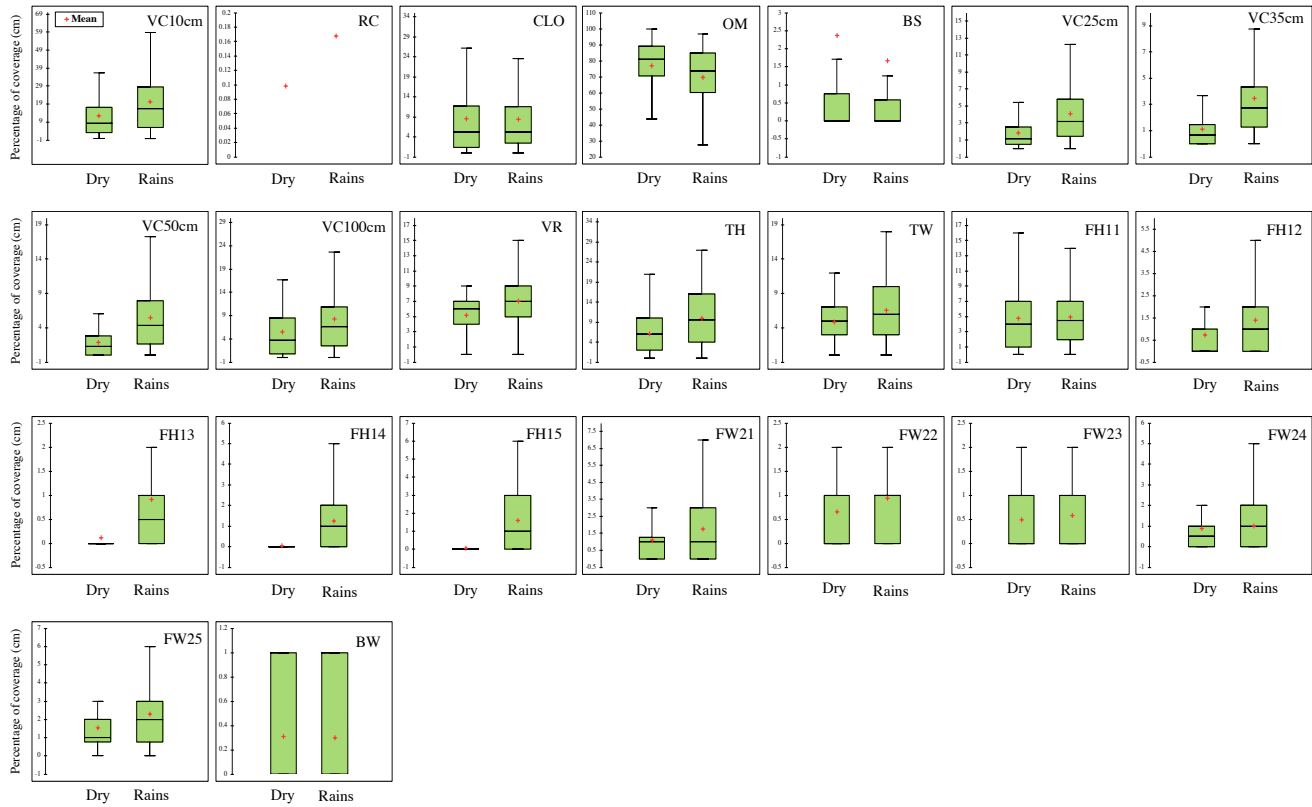863
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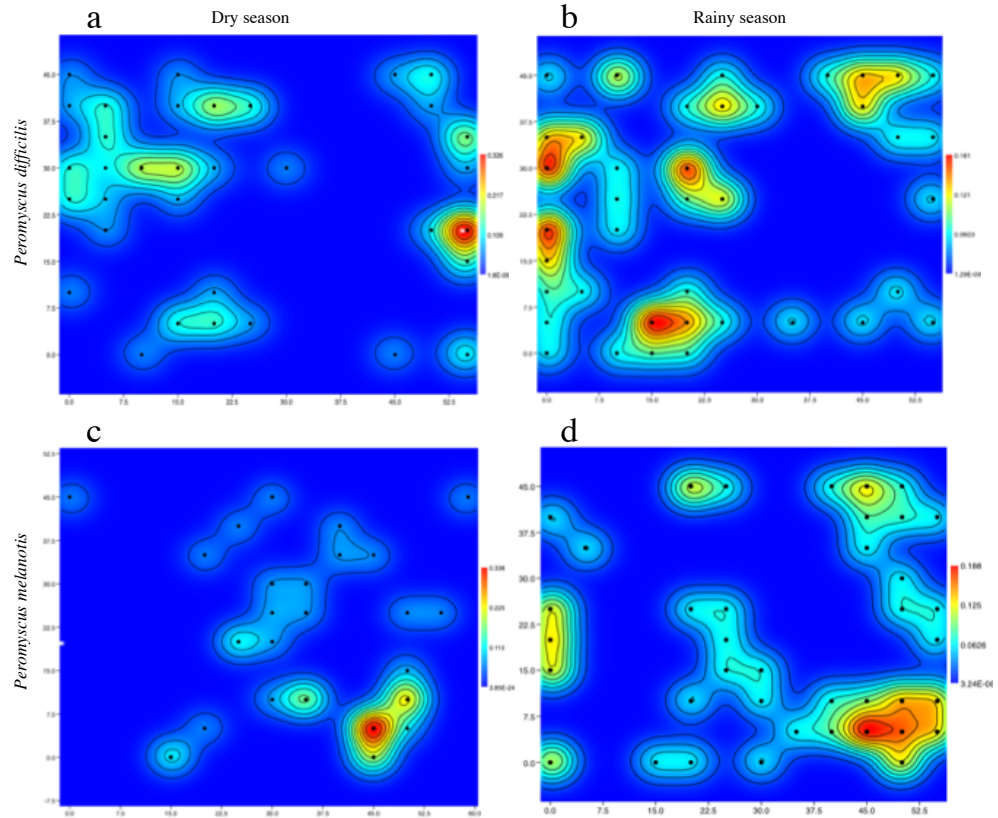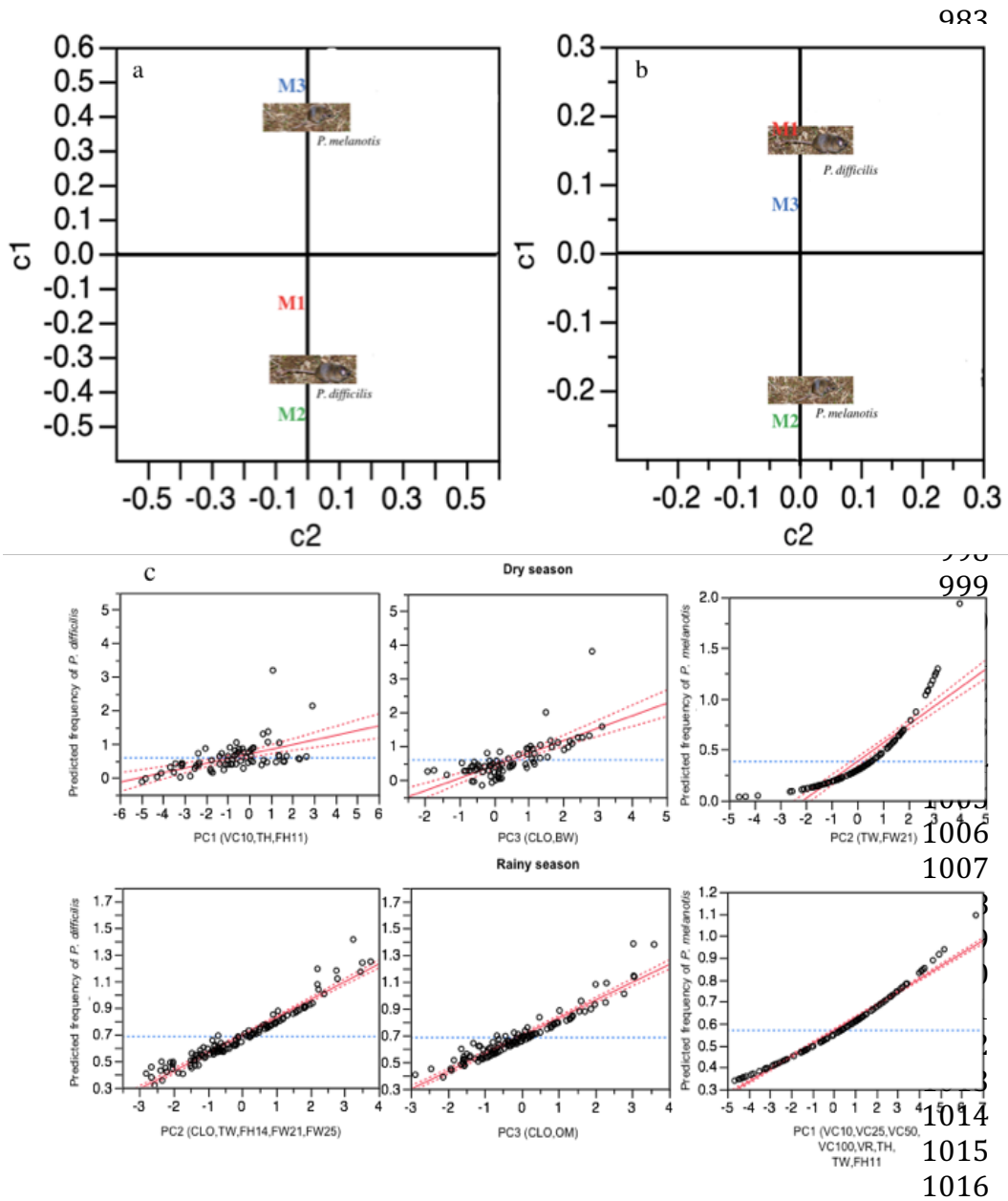
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1076 **Table 1.** Environmental variables used to measure the horizontal and vertical structure of microhabitat

1077 at each sampling station, showing its ecological interpretation (kind or resource type) for both species
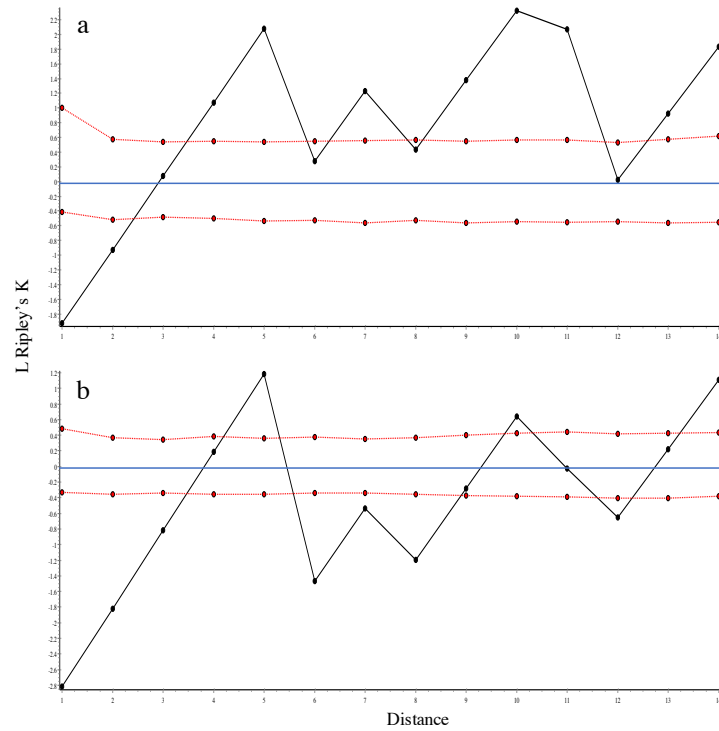
1078 of *Peromyscus*.

Variable code	Predation		Resources				
	Diminished risk	Refuges	Breeding Space	Food	Temporal food and refuges	Permanent	Resting places
Vegetation Cover (cm)							
VC10	X			X	X		X
VC25	X		X	X	X		X
VC35	X		X	X	X		X
VC50	X		X	X	X		X
VC100	X		X	X	X		X
Frequency of Herbaceous Plants (cm)*							
FH11	X		X	X	X		X
FH12	X		X	X	X		X
FH13	X		X	X	X		X
FH14	X		X	X	X		X
FH15	X		X	X	X		X
Frequency of Woody Plants (cm)*							
FW21	X	X	X	X	X	X	X
FW22	X	X	X	X	X	X	X
FW23	X	X	X	X	X	X	X
FW24	X	X	X	X	X	X	X
FW25	X	X	X	X	X	X	X
Species Vegetation Richness							
VR	X	X	X	X	X	X	X
Total of Herbaceous Plants							
TH	X		X	X	X		X
Total of Woody Plants							
TW	X	X	X	X	X	X	X
Rocks							
RC	X	X	X			X	X
Organic Matter (litter, twigs, small trunks)							
OM				X	X		
Bare Soil							
BS					X		
Coverage of Logs (stumps, fallen trunks)							
CLO	X	X	X			X	X
Numbers of Burrows							
BW	X	X	X			X	X

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1080 * = Frequencies of plant types (FH, FW) involve the same heights as in VC.

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Table 2. Normality (**NOR**) tests for 22 variables (**VAR**) of microhabitat, and comparisons[abc] (**COM**) for average values between the dry (**DRY**) and rainy (**RAINS**) seasons, respectively. Variable names in Table 1.

VAR	NOR		COM	VAR	NOR		COM	VAR	NOR		COM
	DRY	RAINS			DRY	RAINS			DRY	RAINS	
BS	0.0001	0.0001	*1.0*	VC100	0.002	0.003	0.0001	TW	*0.143*	*0.08*	0.0004
CLO	0.0001	0.0001	*0.972*	VR	0.006	*0.082*	0.0001	FW21	0.0001	0.0001	0.004
OM	0.010	0.034	0.0001	TH	0.0001	*0.072*	0.0001	FW22	0.0001	0.0001	0.026
RC	0.0001	0.0001	*0.432*	FH11	0.015	0.028	*0.658*	FW23	0.0001	0.0001	*0.875*
VC10	0.002	0.041	0.0001	FH12	0.0001	0.0001	0.001	FW24	0.0001	0.0001	*0.378*
VC25	0.009	0.003	0.0001	FH13	0.0001	0.0001	0.0001	FW25	0.0001	0.001	0.0001
VC35	0.0001	0.002	0.0001	FH14	0.0001	0.0001	0.0001	BW	0.0001	0.0001	1
VC50	0.0001	0.019	0.0001	FH15	0.0001	0.0001	0.0001				

Parametric: [a]Kolmogorov-Smirnov; [b]Student for two samples; non-parametric: [c]Wilcoxon). The p-values in italics do not reject normality ($p = 0.05$), or do not indicate significant differences between pluvial seasons.

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1107 **Table 3.** Nearest Neighbor Analysis for both species of *Peromyscus*, it shows the mean

1108 distance in which individuals from both *Peromyscus* are segregated. R-value indicates

1109 how the observed distribution deviates from random. Clustered points give *R*<1, Poisson

1110 patterns give *R*~1, while overdispersed points give *R*>1.

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	Dry season		Rain season	
	P. difficilis	*P. melanotis*	*P. difficilis*	*P. melanotis*
Points	57	39	58	52
Mean distance	1.40	2.39	1.67	2.09
R	0.42	0.77	0.55	0.64
P value	1.1263×10^{-16}	0.006	8.6577×10^{-11}	8.7708×10^{-7}
Point pattern	Clustering	Clustering	Clustering	Clustering

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1132 **Table 4.** Principal components used as effect model in the GLMs analysis for both

1133 seasons. Red colors represent the variables that have the major eigenfactors to the

1134 ordination of the components.

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Variables	Dry season			Rainy season		
	PC1	PC2	PC3	PC1	PC2	PC3
VC10	0.713	-0.388	-0.134	0.659	-0.179	-0.374
RC	-0.145	-0.055	-0.110	0.014	0.062	0.034
CLO	0.030	0.118	0.828	-0.153	0.411	-0.583
OM	-0.604	0.303	-0.487	-0.499	-0.122	0.775
BS	0.130	-0.187	0.112	-0.028	0.154	-0.328
VC25	0.415	0.280	0.034	0.658	-0.061	0.237
VC32	0.287	0.184	0.052	0.580	-0.003	-0.126
VC50	0.523	0.107	0.078	0.669	-0.173	-0.030
VC100	0.335	0.408	0.052	0.656	-0.053	0.107
VR	0.762	0.251	-0.269	0.776	0.380	0.058
TH	0.837	-0.430	-0.131	0.874	-0.319	-0.076
TW	0.520	0.684	-0.168	0.615	0.711	0.270
FH11	0.784	-0.394	-0.214	0.678	0.007	-0.228
FH12	0.573	-0.345	0.176	0.548	-0.278	0.256
FH13	0.247	0.073	0.113	0.463	-0.260	0.067
FH14	0.149	-0.186	-0.023	0.580	-0.530	-0.043
FH14	0.080	0.117	-0.236	0.481	-0.267	-0.019
FW21	0.127	0.510	-0.394	0.342	0.603	0.311
FW22	0.015	0.064	-0.105	0.266	0.212	0.416
FW23	0.199	0.256	-0.228	0.196	0.366	-0.241
FW24	0.424	0.359	0.195	0.337	0.165	0.159
FW25	0.515	0.366	0.380	0.494	0.469	0.026
BW	-0.105	0.249	0.557	-0.170	0.332	-0.218

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1157 **Table 5.** Generalized Linear Models constructed with the Principal Components and the

1158 frequency of P. *difficils* and *P. melanotis* for both seasons. The partition of resources by

1159 both species is observed at both seasons of the year. Different main components within

1160 each season explain the frequency of capture of each of the species. Also, the table is

1161 related to what type of microhabitat the new variables belong to (M1-M3). The goodness

1162 of fit tests are shown; Pearson and Deviance.

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Term	Estimate	Std Error	L-R x^2	P value	Pearson	Deviance
P. difficilis						
Dry season						
Intercept	-0.97	0.15	55.73	0.0001	$x^2 = 155.80$ ($p = 0.0096$)	$x^2 = 123.56$ ($p = 0.3210$)
PC1 = M2	0.11	0.05	5.53	0.0186	AICc = 212.55	
PC3 = M1	0.45	0.06	44.73	0.0001		
Rainy season						
Intercept	-0.40	0.11	14.37	0.0002	$x^2 = 168.56$ ($p = 0.0008$)	$x^2 = 156.43$ ($p = 0.0062$)
PC2 = M3	0.23	0.06	10.92	0.0009	AICc = 286.76	
PC3 = M1	0.26	0.07	10.95	0.0009		
P. melanotis						
Dry season						
Intercept	-1.21	0.18	74.28	0.0001	$x^2 = 237.65$ ($p = 0.0001$)	$x^2 = 138.70$ ($p = 0.0935$)
PC2 = M3	0.46	0.09	23.34	0.0001	AICc = 204.47	
Rainy season						
Intercept	0.60	0.12	28.15	0.0001	$x^2 = 132.71$ ($p = 0.13$)	$x^2 = 132.72$ ($p = 0.13$)
PC1 = M2	0.10	0.04	4.47	0.0343	AICc = 241.01	

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