

Nakamura, G. S., Gonçalves, L. O. and da Silva Duarte, L. 2019. Revisiting the dimensionality of biological diversity. – Ecography doi: 10.1111/ecog.04574

Appendix 1

Simulation procedure

We created an interactive simulation module using the shiny package of RStudio, to allow the reader to explore the basic patterns and simulation procedures used in our work. The module contains a user interface (Fig. A1 section A) that presents the parameters used to simulate (A) phylogenetic trees, (B) species traits and (C) communities. These parameters are also used to calculate three diversity metrics (richness, phylogenetic diversity [Faith, 1999] and functional diversity [Petchey and Gaston, 2000]; sections E, F and G, respectively). Each modification that is made to any parameter of the user interface triggers the simulation procedure and generates a new phylogeny, new species traits, community composition and diversity metrics, following the same methods for simulating communities as described in the section ‘Simulation methodology’ in the main text of this paper.

The default module begins by showing a pattern in which the community has a phylogeny containing 50 species (with a sliding bar called ‘Number of species in phylogeny’). The phylogenetic signal for species traits is high (set with a sliding bar called ‘Grafen parameter for phylogenetic signal’). Lower values of the Grafen parameter reduce phylogenetic signal, whereas higher values increase phylogenetic signal). The metacommunity was assembled by applying a phylogenetic habitat filter

(sensu Duarte, 2002). At one extreme only the most phylogenetically related species (top 10%) can occur (set at the upper value of the sliding bar called ‘Lower and upper values of habitat filtering’), while at the other extreme of the phylogenetic gradient any values of habitat filtering’), while at the other extreme of the phylogenetic gradient any species can occur (no phylogenetic restrictions, set at the lowest value of the sliding bar called ‘Lower and upper values of habitat filtering’). The phylogenetic filter create a gradient of phylogenetic and functional diversity (bar plots F and G). Richness can be set to be equal across all communities or a gradient can be applied by using the bottom widget (By selecting ‘Yes’ or ‘No’ in response to the question ‘Must richness be equal for all communities?’). Finally, the phylogenetic filter that is applied can be set to be either gradual (default) or not gradual (By selecting ‘Yes’ or ‘No’ in response to the question ‘Must the phylogenetic filter be gradual?’).

Supplementary material S1- Metacommunity simulation

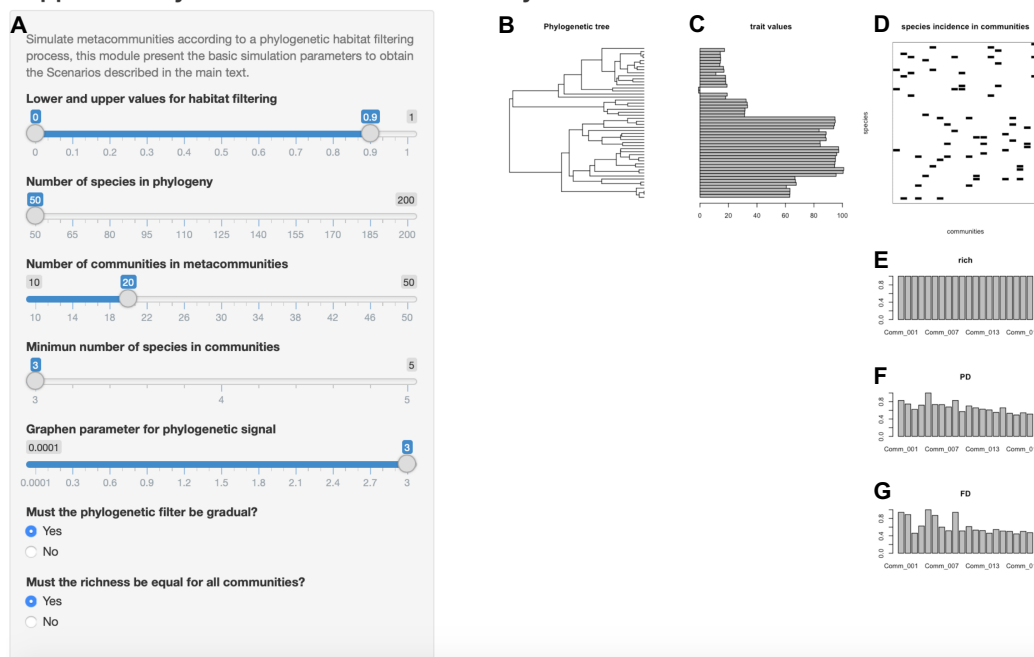


Figure A1. Layout of the interactive simulation module used to simulate metacommunities. The module comprises the basic parameters used for scenario simulation in the paper. A – buttons and sliding bars containing modifiable parameters that define the metacommunities; B – the

phylogeny used to simulate traits and metacommunities and to calculate the PD metric; C – bar chart representing the trait values for each species in the phylogeny; D – representation of species incidence in the communities that compose the metacommunity, where the columns represent communities, lines represent species and the filled space represents the presence of a species in a community; E, F and G – bar plots representing the values for, respectively, richness (rich), phylogenetic diversity (PD) and functional diversity (FD) of each community.

Each time that a widget control is modified the simulation processes starts again by creating a new phylogeny, thus reflecting the same procedure used to perform simulations in the section ‘Simulation methodology’ of the main text. Using all possible combinations of widget controls will not produce all the scenarios showed in the main text; however, the widgets comprise the basic controls necessary to obtain the scenarios used. The application can be accessed at:

https://gabrielnakamura.shinyapps.io/Supp_matShiny/.

References

- Duarte, L. D. S. 2011. Phylogenetic habitat filtering influences forest nucleation in grasslands. - *Oikos* 120: 208–215.
- Petchey, O. L. and Gaston, K. J. 2002. Functional diversity (FD), species richness and community composition. – *Ecol. Lett.* 5: 402-411.
- Faith, D. P. 1992. Conservation evaluation and phylogenetic diversity. - *Biol. Conserv.* 61: 1–10.

Appendix 2

Phylogenetic hypothesis and community data

Figure A1 shows the phylogenetic hypothesis used to calculate the phylogenetic diversity indices used to assemble matrix **M**. The phylogenetic tree was assembled by using the mammal phylogenies of Bininda-Emonds et al. (2007) and Fabre et al. (2012). More details about the phylogenetic hypothesis used here can be found in the Methods section of the main text.

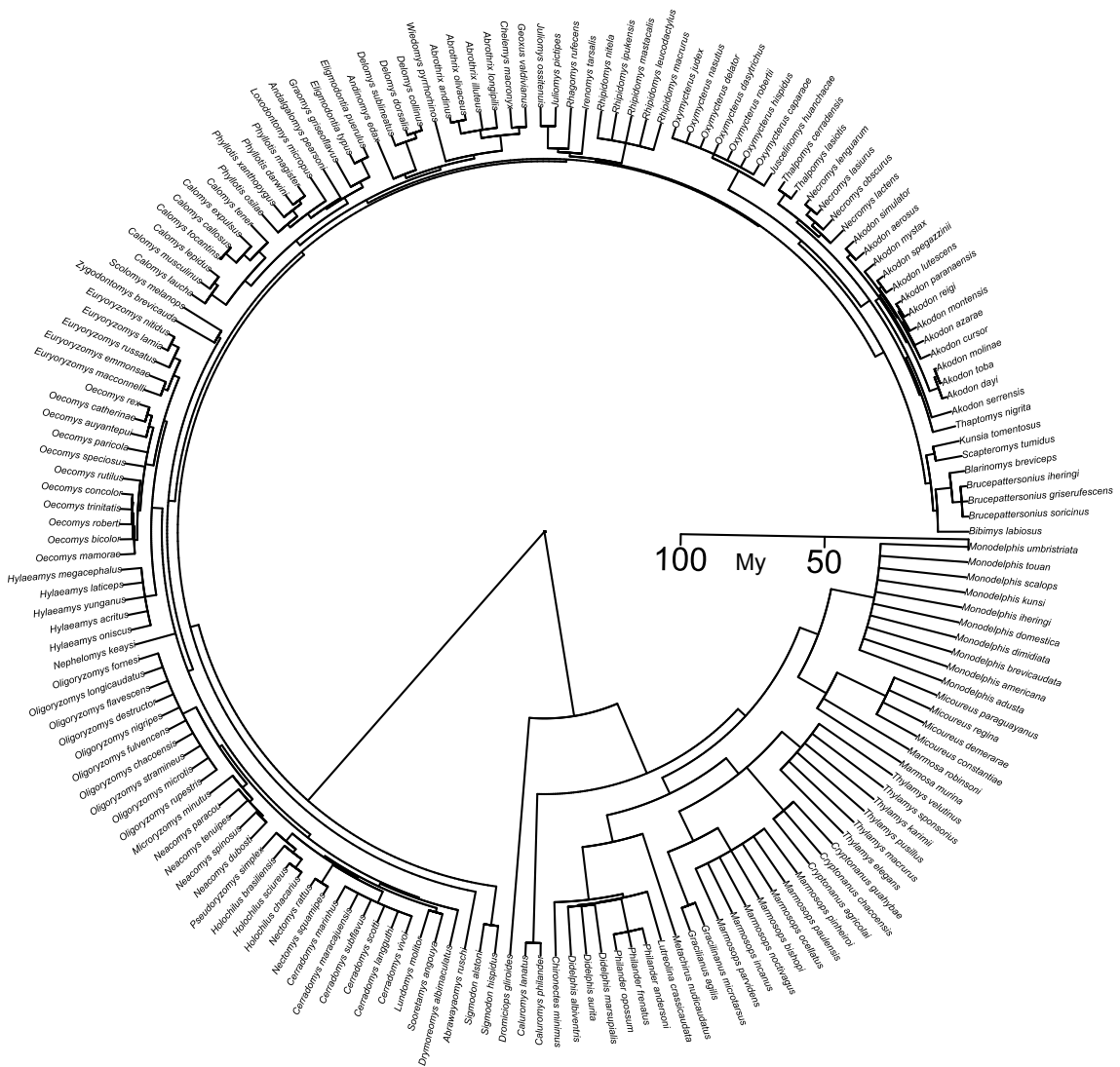


Figure A1. Phylogenetic hypothesis for small mammals (cricetids and marsupials) used to calculate phylogenetic metrics in this work.

Table A1. Reference, country, sampling effort (expressed as trap nights), latitude and longitude (decimal degrees) of the 103 small-mammal communities considered in this study.

| Reference | Country | Trap-night | Latitude | Longitude |
|--|----------------|-------------------|-----------------|------------------|
| Kelt (2000) | Chile | 2894 | -40.50 | -73.00 |
| Thibault et al. (2011) | Argentina | 3416 | -39.92 | -71.42 |
| Saavedra and Simonetti (2004) | Chile | 8747 | -35.98 | -72.68 |
| Thibault et al. (2011) | Argentina | 1600 | -34.59 | -68.14 |
| Corbálan and Ojeda (2004) | Argentina | 4410 | -34.03 | -67.97 |
| Thibault et al. (2011) | Chile | 5528 | -33.38 | -70.52 |
| Munoz-Pedrero et al. (2010) | Chile | 1476 | -33.12 | -71.4 |
| Sponchiado et al. (2012) | Brazil | 4320 | -32.53 | -52.53 |
| Thibault et al. (2011) | Argentina | 36060 | -32.50 | -60.00 |
| Lima et al. (2010) | Brazil | 2240 | -29.67 | -53.72 |
| Marques et al. (2011) and Pedó et al. (2010) | Brazil | 5754 | -29.47 | -50.22 |
| Marques et al. (2011) | Brazil | 11596 | -29.42 | -50.40 |
| Dalmagro and Vieira (2005) | Brazil | 5178 | -29.17 | -50.08 |
| Graipel et al. (2006) | Brazil | 12132 | -27.72 | -48.53 |
| Cherem et al. (2011) | Brazil | 50097 | -27.63 | -48.83 |
| Ferro and Barquez (2009) | Argentina | 3440 | -27.20 | -65.93 |
| Melo et al. (2011) | Brazil | 6932 | -27.17 | -53.92 |
| Cirignoli et al. (2011) | Argentina | 5310 | -27.1 | -54.97 |
| Ferro and Barquez (2009) | Argentina | 4181 | -26.67 | -65.63 |
| Quadros and Cáceres (2001) | Brazil | 1920 | -26.07 | -48.63 |
| Crespo (1982) | Argentina | >1000 | -25.52 | -54.13 |
| Quadros et al. (2000) | Brazil | 4380 | -25.48 | -53.12 |
| Bergallo et al. (1998) | Brazil | 5040 | -25.17 | -47.98 |
| Bergallo et al. (1998) | Brazil | 5040 | -24.53 | -47.25 |
| Vieira and Monteiro-Filho (2003) | Brazil | 3547 | -24.28 | -48.35 |
| Vieira and Monteiro-Filho (2003) | Brazil | 15227 | -24.23 | -48.06 |
| Pardini and Umetsu (2006) and Umestu and | Brazil | 9168 | -23.73 | -47.07 |

| | | | | |
|---|-----------|-------|--------|--------|
| Pardini (2007) | | | | |
| Barros-Battesti et al. (2000) | Brazil | 2888 | -23.55 | -46.93 |
| Pinheiro and Geise (2008) | Brazil | 1680 | -23.37 | -44.83 |
| Bittencourt and Rocha (2003) | Brazil | 7474 | -23.18 | -44.20 |
| Jaksic et al. (1999) | Argentina | 2736 | -22.97 | -68.22 |
| Bonvicino et al. (2002) | Brazil | 1830 | -22.72 | -46.92 |
| Viveiros de Castro and Fernandez (2004) | Brazil | 51122 | -22.54 | -42.28 |
| Pires et al. 2002 | Brazil | 1618 | -22.52 | -42.28 |
| Vieira et al. 2009 | Brazil | 1200 | -22.5 | -42.86 |
| Geise et al. 2004 | Brazil | 1500 | -22.45 | -44.58 |
| Yahnke (2006) | Paraguayi | 23296 | -22.33 | -60.33 |
| Gentile et al. 2000 | Brazil | 12250 | -22.03 | -42.68 |
| Lyra-Jorge et al. (2001) | Brazil | 3672 | -21.62 | -47.62 |
| Talamoni and Dias (1999) | Brazil | 2400 | -21.55 | -47.85 |
| Cáceres et al. (2008) | Brazil | 1426 | -21.15 | -51.87 |
| Rocha et al. (2011b) | Brazil | 10080 | -20.88 | -44.83 |
| Paglia et al. (1995) | Brazil | 5760 | -20.75 | -42.85 |
| Cáceres et al. (2007) | Brazil | 430 | -20.7 | -56.85 |
| Moreira et al. (2009) | Brazil | 3168 | -20.67 | -42.43 |
| Thibault et al. (2011) | Brazil | 7264 | -20.52 | -41.00 |
| Cáceres et al. (2011) | Brazil | 11865 | -20.5 | -55.3 |
| Bonvicino et al. (2002) | Brazil | 3231 | -20.47 | -41.8 |
| Cáceres et al. (2010) and Hannibal and Cáceres (2010) | Brazil | 2950 | -20.45 | -55.53 |
| Pinto et al. (2009) | Brazil | 2160 | -20.37 | -40.47 |
| Passamani and Ribeiro (2009) and Passamani and Fernandez (2011) | Brazil | 23285 | -19.95 | -40.52 |
| Oliveira et al. (2007) | Brazil | 7115 | -19.93 | -43.88 |
| Andreazzi et al. (2011) | Brazil | 21560 | -19.88 | -56.38 |
| Grelle (2003) and Stallings et al. (1991) | Brazil | 68220 | -19.63 | -42.55 |
| Godoi et al. (2010) | Brazil | 4032 | -19.2 | -57.57 |
| Cáceres et al. (2011b) | Brazil | 16992 | -19.2 | -57.55 |

| | | | | |
|---|---------|-------|--------|--------|
| Cáceres et al. (2011b) | Brazil | 4620 | -19.18 | -57.62 |
| Fonseca and Robinson (1990) | Brazil | 57120 | -19 | -42 |
| Rodrigues et al. (2002) | Brazil | 13562 | -18.25 | -52.88 |
| Cáceres et al. (2008) | Brazil | 1248 | -17.45 | -53.1 |
| Bonvicino et al. (1996) | Brazil | 1050 | -16.65 | -52.78 |
| Bonvicino et al. (1996) | Brazil | 2100 | -16.4 | -52.45 |
| Cáceres et al. (2008) | Brazil | 1350 | -16.37 | -51.95 |
| Aragona and Marinho-Filho (2009) | Brazil | 38635 | -16.23 | -56.37 |
| Thibault et al. (2011) | Brazil | 49810 | -16.07 | -47.92 |
| Santos and Henriques (2010) and Henriques et al. (2006) | Brazil | 2380 | -15.97 | -47.93 |
| Nitikman and Mares (1987) | Brazil | 12170 | -15.97 | -47.95 |
| Mares et al. (1986) | Brazil | 85101 | -15.93 | -47.88 |
| Santos and Henriques (2010) and Henriques et al. (2006) | Brazil | 3040 | -15.57 | -48.12 |
| Ribeiro e Marino-Filho (2005) | Brazil | 6600 | -15.53 | -47.6 |
| Santos-Filho et al. (2008) | Brazil | 17600 | -15.4 | -58.35 |
| Lacher Jr. and Alho (2001) | Brazil | 4821 | -15.33 | -55 |
| Pardini (2004) | Brazil | 7776 | -15.17 | -39.02 |
| Emmons (2009) | Bolivia | 13118 | -14.75 | -61.03 |
| Vargas and Simonetti (2004) | Bolivia | 4240 | -14.65 | -66.07 |
| Emmons (2009) | Bolivia | 6962 | -14.61 | -60.86 |
| Emmons (2009) | Bolivia | 7540 | -14.58 | -60.92 |
| Emmons (2009) | Bolivia | 4700 | -14.58 | -60.91 |
| Bonvicino et al. (2002) | Brazil | 2665 | -14.01 | -47.55 |
| Bonvicino et al. (2002) | Brazil | 1440 | -13.53 | -47.17 |
| Thibault et al. (2011) | Peru | 5600 | -13.14 | -69.61 |
| Thibault et al. (2011) | Peru | 1600 | -12.81 | -69.35 |
| Pereira and Geise et al. (2009) | Brazil | 10216 | -12.57 | -41.37 |
| Stevens and Husband (1998) | Brazil | 6144 | -11.18 | -37.42 |
| Bezerra et al. (2009) | Brazil | 5459 | -10.38 | -50 |
| Mena and Medellin (2010) | Peru | 5515 | -10.13 | -75.55 |

| | | | | |
|------------------------------|---------------|-------|-------|--------|
| Rocha et al. (2011) | Brazil | 32074 | -9.17 | -50.17 |
| Asfora and Pontes (2009) | Brazil | 1600 | -9 | -35.87 |
| Asfora and Pontes (2009) | Brazil | 1600 | -8.7 | -35.83 |
| Geise et al. (2011) | Brazil | 1391 | -8.53 | -37.25 |
| Asfora and Pontes (2009) | Brazil | 1600 | -8.25 | -35.08 |
| Thibault et al. (2011) | Brazil | 22800 | -7.77 | -51.96 |
| Thibault et al. (2011) | Peru | 5820 | -4.92 | -73.67 |
| Thibault et al. (2011) | Peru | 2888 | -4.50 | -73.42 |
| Hice and Schmidly (2002) | Peru | 2530 | -3.97 | -73.42 |
| Barnett and Cunha (1994) | Brazil | 3578 | -3.37 | -61.43 |
| Malcolm (1991) | Brazil | 25920 | -3.1 | -60.02 |
| Ribeiro Junior et al. (2011) | Brazil | 1206 | -1.95 | -51.60 |
| Thibault et al. (2011) | French Guiana | 4701 | 3.62 | -53.20 |
| Thibault et al. (2011) | Venezuela | 2225 | 7.40 | -62.82 |
| Thibault et al. (2011) | Venezuela | 38329 | 8.55 | -67.60 |
| Utrera et al. (2000) | Venezuela | 34455 | 9 | -69.75 |
| Thibault et al. (2011) | Venezuela | 1920 | 10.07 | -66.45 |

Appendix 3

Additional information on simulation and empirical results for dimensionality framework presented in the paper.

We present here some additional results to support interpretations of the main results of simulation and empirical investigation (with small-mammal communities) of the dimensionality framework. Figure A3 is a boxplot containing F-values derived from two linear OLS models that described differences in IV among the three diversity metrics (PD, FD and richness) calculated for simulated communities with (A) high and (B) low correlation among diversity metrics.

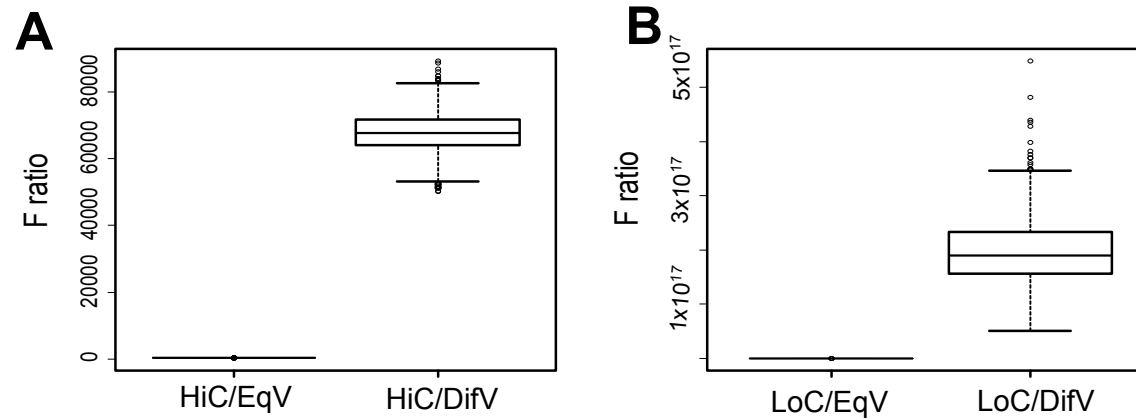


Figure A3. Boxplot with F-values for four simulated scenarios: HiC/EqV, HiC/DifV, LoC/EqV and LoC/DifV. Plot A shows F-values for a scenario with high correlation among metrics, while plot B shows F-values for scenarios with low correlation among metrics. The boxes represent the 25th, 50th and 75th quantiles.

We found that scenarios simulated with uneven variation among diversity metrics in biodiversity space had higher values for the F-ratio than scenarios with similar contribution, indicating great difference in IV among the three diversity metrics for both low and high correlation among metrics. It also becomes evident that differences among IV among the three diversity metrics were much higher for scenarios in which metrics were not correlated (boxplot B in Fig. A3) than the scenarios of high correlation (boxplot A in Fig. A3), indicating that the level of redundancy in metric importance can be much greater in scenarios with low complementarity (high correlation) than high complementarity (low correlation).

Figure A4 represents the null distribution and observed EE value calculated from matrix **M** containing all eight diversity metrics. The observed EE falls within the 95% confidence interval generated with a null model that changes species composition but keeps species richness of communities fixed.

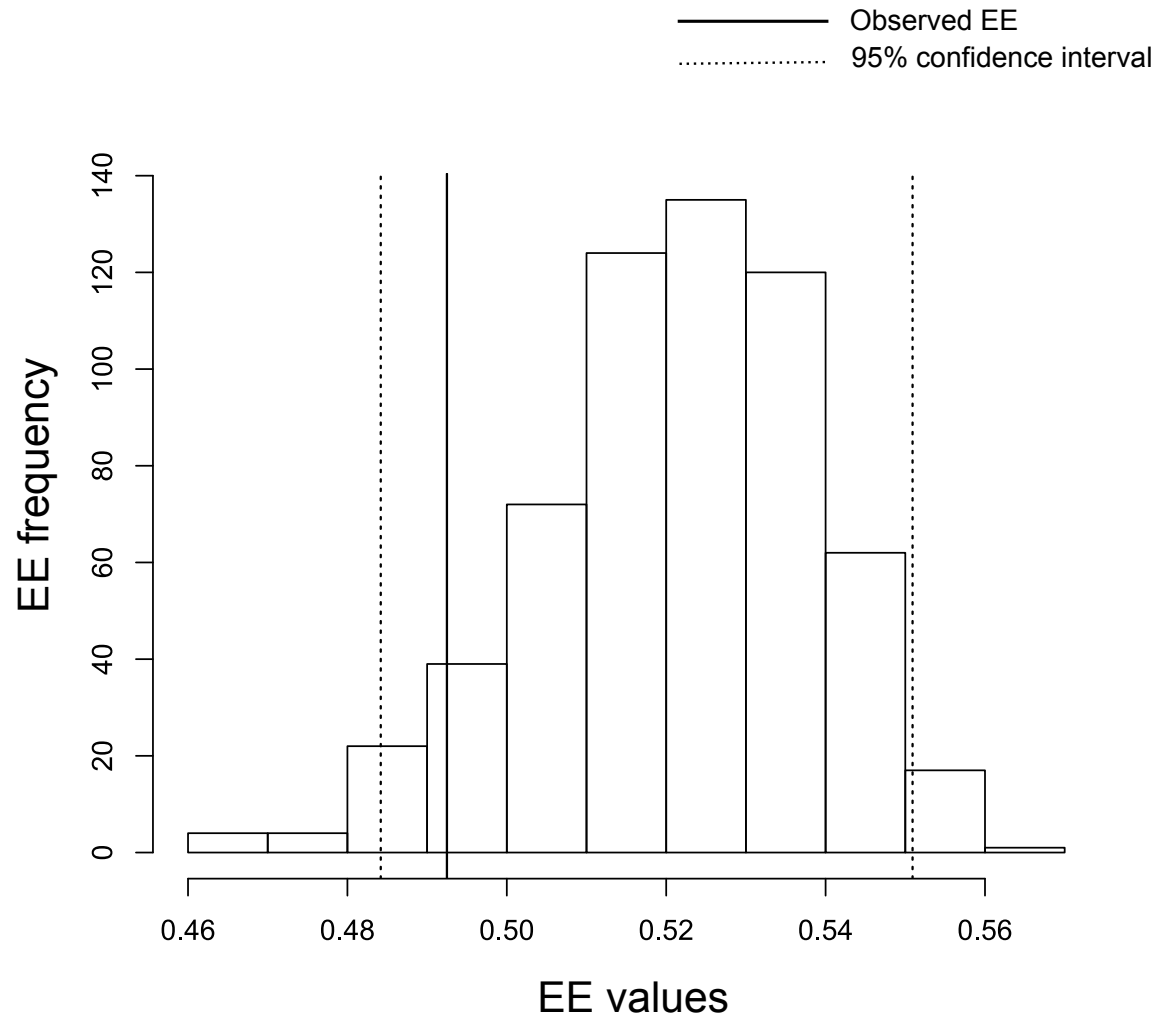


Figure A4. Null and observed values of EE for small mammal communities of cricetids and marsupials. The dotted lines represented the 95% confidence interval for a null model that changes community composition but keeps species richness fixed for each community. The continuous black line represent the observed EE calculated for matrix **M** with all eight diversity metrics.

We also performed Tukey tests using the two linear OLS models to compare IV values among the eight diversity metrics calculated for small mammal communities. Plot A shows pairwise comparisons among all diversity metrics, evidencing the greatest differences between PSV and functional indices. Plot B shows comparisons among the three components of diversity, which the eight indices represent, showing that the greatest difference in IV is between taxonomic and functional indices. This second Tukey test was performed by merging the metrics that represent a given component of diversity into the same category.

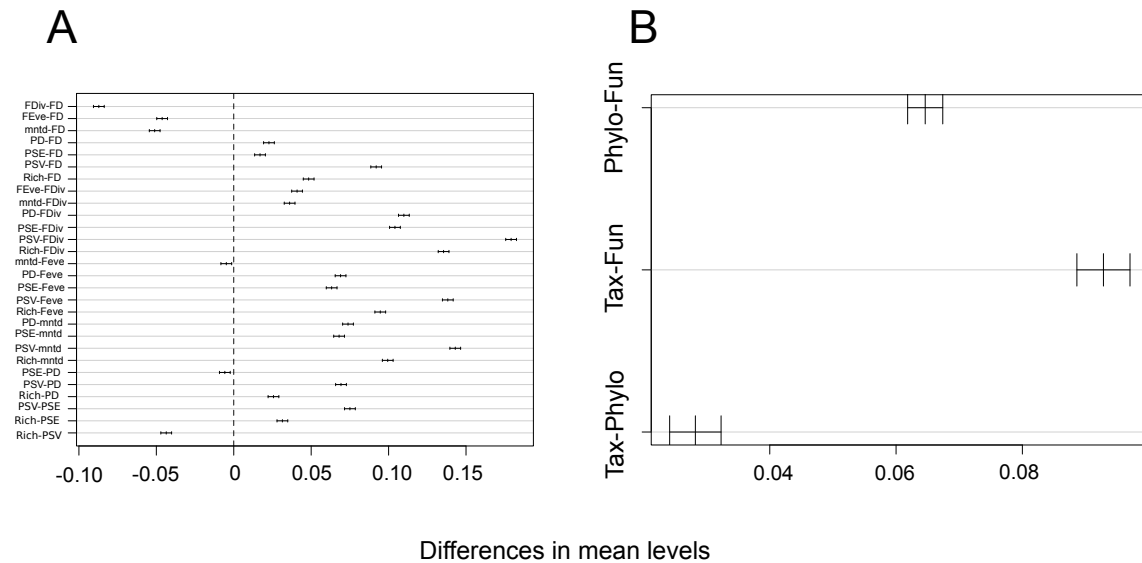


Figure A5. Plots showing mean differences for pairwise metric comparison (A) and pairwise comparison of functional, phylogenetic and taxonomic components of diversity (B). These two comparisons were obtained from a Tukey test of a linear OLS model.

