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Do spatial and temporal scales affect the efficiency of surrogates in ant monitoring on the hydroelectric power-plant area in Brazilian Amazon?

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ABSTRACT

In the last decade, we have experienced a huge loss of biodiversity on the planet. One of the possible ways to overcome this loss is to focus on places of human interest, monitoring the changes and the impacts on biodiversity. In general, impact assessments of hydroelectric power-plants on terrestrial invertebrates have been conducted after installation of the dam. Monitoring biodiversity is expensive, and shortcuts are often used to access this information. Therefore the use of the higher-taxon approach seems appropriate for this purpose. We investigated the effectiveness of ant genus-level at predicting ant species-level responses overtime in two grains of the spatial scale (site and plot) in the area of influence of a hydroelectric power-plant in the Amazon basin. We used a database from six sites, sampled over seven years in 14 ant collection events. The samplings were standardized, with five collection points along with 250 m plots. We tested whether the variation in the spatio-temporal scales affected the predictive power of genus-level for the metrics of richness and composition. We investigated if there is a difference in the predictive response of genera as surrogates for the species when using different spatial scales (site and plot) and also if the effectiveness of the prediction of genera changes over time. Also, we evaluated the effects of the species: genus ratio on the prediction of genera as a surrogate for species richness and composition.

We recorded a high positive correlation between the richness of genera and species. Also, detected high congruence among the composition of genera and species, and no species:genus ratio effect in the evaluated spatio-temporal scales. Thus, the robustness of genus data to predict the species-level does not change over time at both spatial scales under the influence area of a hydroelectric power-plant in the Amazon basin. It reinforces the use of the higher-taxon approach, which can be a useful and efficient tool in biodiversity studies or long-term monitoring.

1. Introduction

Biodiversity loss is accelerating rapidly in response to increasing human influence on the Earth's natural ecosystems (Laurance et al., 2012). One way to overcome this problem is by focusing on places of human interest and monitoring the changes and the impacts on biodiversity. The installation of hydroelectric power plants has been pointed out as one of the greatest sources of environmental impact around the world (Winemiller et al., 2016), including in the Amazon basin (Davidson et al., 2012; Fearnside, 2016). Most of the studies carried out in the hydroelectric plants located in the Amazon basin have taken place after the implementation of the dams, when assessing their impacts on the environment and biodiversity (Benchimol et al., 2015; Latrubesse et al., 2017; Sá-Oliveira et al., 2015). Studies on dam impacts have begun to be conducted before their implementation (Bobrowiec and Tavares, 2017; Fraga et al., 2014; Moser et al., 2014; Marques Peixoto et al., 2020), thus providing a better overview of the impact and a better assessment of its magnitude. However, as far as we know, this is the first study that evaluates terrestrial invertebrates in an area of hydroelectric influence before and after the total filling of the dam in the Amazon Basin.

Monitoring biodiversity is time-consuming and expensive (Whittaker et al., 2005; Gardner et al., 2008), especially in megadiverse environments such as the Amazon region (Magnusson et al., 2018; Magurran

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and Queiroz, 2010). These costs are usually inversely proportional to the size of the studied taxon (Lawton et al., 1998). One of the frequent shortcuts to obtain biodiversity information is the use of higher-taxon surrogacy (Andersen, 1995; Andersen et al., 2002; Gaston and Williams, 1993; Longino and Colwell, 1997; Oliver and Beattie, 1996, 1993; Souza et al., 2016). Surrogates could be a higher taxonomic unit (i.e. Genus or Family) in order to bridge a taxonomic gap for species identification in the same group. There is no consensus on which taxonomic level to use as a surrogate for the most of taxa (Jones, 2008; Neeson et al., 2013), but genus-level identification is often presented as a candidate surrogate for species-level identification in research on with aquatic and terrestrial invertebrates (Gallego et al., 2012; Gaspar et al., 2010; Pik et al., 1999). Also, the genus-level adequately retrieves species information over a wide environmental gradient, regardless of the sampling technique (Souza et al., 2018) or the impeding effect of species:genus ratio (de Oliveira et al., 2020), proving this to be a stable option throughout the taxonomic adjustments of the last decades (Souza et al. unpublished results). So among surveys using higher-taxon approach (Andersen, 1995; Groc et al., 2010), the genus seems to have the best cost-benefit (Souza et al., 2016).

Usual biodiversity metrics, such as species richness, assemblage composition, genetic variability, and productivity are all highly scale-dependent (Costa and Magnusson, 2010). Since fundamental ecological processes vary both spatially and temporally (Hawkins et al., 2003; Magurran et al., 2010). The effect of spatial scale on biodiversity measures and ecological processes is a central issue in ecological, biogeographic, and conservation studies (Ricklefs, 1987; Spiesman and Cumming, 2008). The effect of spatial scale has already been detected in research with ants in different biomes around the globe (Baccaro et al., 2012; Gotelli and Ellison, 2002). It is expected that the efficiency of the genus-level as a surrogate for species-level may be affected by the spatial scales. Higher-taxon approaches assume the congruence of species richness with other taxonomic levels (Favreau et al., 2006). However, these surrogates are tightly scale-dependent due to the variation in the spatial distribution patterns of natural communities and the spatial grains used in the sampling of species (Margules and Pressey, 2000). In some cases, genus as a higher-taxon approach is effective in reproducing ecological responses similar to those found with the use of species-level at different spatial scales (Ribas and Padial, 2015; Souza et al., 2016), but genus-level may not work very well in retrieving this information in other situations, especially at large scales (Andersen, 1995; Rosser and Eggleton, 2012). However, no study has tested the effect of the scale on the efficiency of the high taxon approach with standardized sampling methods, which favors the comparison of the results of different spatial scales (Andersen, 1999; Reyers et al., 2000; Souza et al., 2016).

Both natural assemblages and their intrinsic ecological processes (e.g. species richness, composition, turnover) change over time (McGeoch and Gaston, 2002, Preston, 1960). Monitoring the many aspects of ecosystem function to support science-based decision making is the principal goal of long-term research (Costa et al., 2015, 2020). Unfortunately, long-term studies are relatively scarce due to their maintenance costs and institutional financing (Magurran et al., 2010; Majer et al., 2007), resulting in limited knowledge about time-scale processes and their effects. For these reasons, the effect of the time scale in the study of higher-taxon approach is little explored, and its inclusion is crucial to understand how the surrogates' predictive efficiency works in the short and long term (Favreau et al. 2006). However, few of these studies have included the temporal component in their analysis (Magierowski and Johnson, 2006), and the effect of temporal scales on surrogate responses remains largely unknown. Although changes in the relative frequency or abundance of a set of taxa do not necessarily mean low effectiveness as surrogates for biodiversity, it is crucial to establish robustness in the performance of surrogates in the face of changes in assemblages structure over time. Consequently, useful surrogates for monitoring biodiversity are those associated with changes in biodiversity, whether due to spatial variability, succession, season, or disturbance (Colwell and Coddington, 1994; Delabie et al., 2021).

Ants are a mega-diverse group that is usually easily collected (Souza et al., 2012) and they work well in management, monitoring, and conservation research (Underwood and Fisher 2006). Spatial and temporal scales seem to affect measures of ant diversity. The rise in spatial grain tends to increase richness and heterogeneity, while evenness tends to decrease in a subtropical forest (Leponce et al., 2004). On the other hand, a long-term study detected that ant assemblages (richness and composition) tend to be resilient to temporal changes (Donoso, 2017). In this study, we used ground-dwelling ants to investigated the effects of spatial and temporal scales on the efficiency of the genus as a surrogate for species-level identification in the area of influence of a hydroelectric power-plant installed in the Brazilian Amazon. We record the differences in ant species composition between spatial and temporal scales and measure the degree of congruence of richness, and composition, between identification at the species level and at the genus level. We hypothesized that, regardless of the spatial or temporal scale used, the coarser level of taxonomic information (genus) could be used as an efficient surrogate for species-level identification, recovering the patterns on species richness, and composition in the studied area.

2. Methods

2.1. Study sites

The study was carried out in six sites (modules), associated with the Brazilian Biodiversity Research Program (PPBio) covering a gradient of 90 km and an area of approximately 1,800 km^2. The modules Ilha dos Búfalos, Ilha das Pedras, Jaci-Paraná, Teotônio, Morrinhos e Novo Módulo Jaci are situated within the influence area of Santo Antônio Hydroelectric Power-Plant in the margins of Madeira River in Rondônia State (Figure S.1). Construction of the hydroelectric plant began in 2008, and its main feature is the use of the flow of the Madeira River to generate energy with a reduced reservoir and a small waterfall. This plant's operating model, called the run-of-river (without stock water), allows its reservoir to occupy only 421.56 km^2. An area is slightly larger than that flooded during the flood periods of the Madeira River and of which 142 km^2 correspond to the natural river channel (Santo Antonio Energia, 2020). The Madeira River is situated in a 1.4 million km^2 basin, covering Brazil, Bolivia, and Peru (Ribeiro, 2006), being the biggest Amazonas' River affluent. Vegetation in the area varies, being mainly characterized by Open Ombrophilous Tropical Forest (Moser et al., 2014). The soil is predominantly red-yellow latosol, but gleyssol and argisols can also be found in the area (Cavalcante, 2012). The coordinates, vegetation types, elevation range, rainfall, and spatial sampling design of the study sites are summarized in Table 1.

2.2. Sampling design

We used published data from the first ten sampling events over four years (Fernandes and Souza, 2018a, 2018b), and we added more four sampling events carried out in 2017. Over seven years, 14 samplings of ground-dwelling ants were carried out. The first sampling took place in September 2011, the second in November of the same year. Both performed before filling the reservoir of the dam. The third sampling event took place in March 2012, during the reservoir filling and the fourth in June of the same year. The fifth sampling took place in January 2013. Still, in 2013, the sixth sampling was carried out in April, the seventh between June and July and the eighth in October. The ninth sampling took place in January 2014 and the tenth in November of the same year. There were no sampling events over the years 2015 and 2016. In 2017, the eleventh sampling took place between March and April, the twelfth in June, the thirteenth between September and October, and the fourteenth between November and December. Ants were sampled in permanent plots with five samples per plot. In total, we took 1,605 samples from 321 plots (Table 1). We used the RAPELD sampling design, which is

Table 1
Vegetation, rainfall, elevation range, number of samples and number of sampling events in the six sites on the Hydroelectric Power-Plant area in the Brazilian Amazon.

Sites	Coordinates	Vegetation type	Elevation range (m. a.s.l.)	Mean rainfall (mm)	Distance to the dam (km)	Sampling area (km^2)	Number of plots	Number of samples per plot	Total of samples	Sampling date	Number of sampling events
Teotônio	8°50′28.50″S 64°3′43.92″W	Open ombrophilous forest	69–112	2246	13.56	5	6	5	325	November/2011 to November 2017	13
Ilha dos Búfalos	9° 9′6.56″S 64°30′6.97″W	Open ombrophilous forest	82–115	2246	72.35	5	6	5	405	September/2011 to November 2017	14
Ilha das Pedras	9°10′36.22″S 64°36′38.83″W	Open ombrophilous forest	76–113	2246	84.56	5	6	5	325	September/2011 to December 2017	13
Jaci-Paraná	9°27′44.43″S 64°23′32.97″W	Open ombrophilous forest	103–134	2246	87.88	5	6	5	300	November/2011 to November 2014	10
Morrinhos	9°1′12.00″S 64°15′14.40″W	Open ombrophilous forest	67–82	2246	40.79	5	6	5	30	September/2011	1
Novo Módulo Jaci	9°23′56.93″S 64°22′41.68″W	Open ombrophilous forest	108–112	2246	80.62	5	6	5	220	January/2013 to June 2017	8

based on a system of trails and permanent plots where a diverse range of taxa can be sampled (Costa and Magnusson, 2010; Magnusson et al., 2013, 2005). The permanent plots had 250-m long and positioned to follow terrain contours to minimize the effects of topographical variation within plots. In each module, the first three plots had located 500 m from each other, and the last three plots had 1 km apart, following the same spatial design (see Figure S.1 and Fernandes and Souza, 2018a for details).

2.3. Ant sampling

Ground-dwelling ants collected in plots using litter samples were processed in Winkler extractors. Litter-dwelling ants were sampled from 1 m^2 quadrates of litter in sampling stations located at 50 m intervals along the centerline of each plot. Using a Winkler extractor with a 1 cm^2 mesh sieve, the ants were extracted from the sifted litter and placed in a mesh bag inside a cotton bag for 24 h. In behavioral response to litter drying, the ants migrate from the suspended sample and fall out a container partially filled with alcohol at the bottom of the bag (Agosti et al., 2000; Agosti et al., 2000a). The litter-sampling procedures were undertaken between 8:00 am to 17:00. All ants were first identified to genus using the taxonomic keys provide by Baccaro et al. (2015). Then, they were sorted to species and non-described species were sorted into morphospecies. We used available taxonomic keys or compared them with specimens in collections previously identified by experts. A identification code was given for each morphospecies based on morphological differences from related species. The morphotyping was the same for all collection sites. Vouchers are deposited in INPA's Entomological Collection.

2.4. Data analysis

All analyses were run in the R environment for statistical computing (R Core Team, 2020, version 4.0.2), using the vegan package 2.5–6 (Oksanen et al. 2019). All graphics were built using the ggplot2 3.3.2 (Wickham, 2016) and gridExtra 2.3 (Auguie, 2017) packages. We tested two spatial grains in this study, one coarse considering variation at the module level (n = 6), and a fine grain at plot level (n = 58), both situated within the influence area of Santo Antônio Hydroelectric Power-Plant. All the analyses described below were performed on both spatial grains. We provided the codes for all analyses in the supplementary material (Data S.1).

2.4.1. Higher-taxon and richness

We measured the correlation of ant species richness (the number of species found per site) against genus richness to estimate whether surrogate richness can predict species richness. The number of species and genera were measured by plots and correlations among the two taxonomic levels were calculated within each spatial scale over time. Differences in how much each genus richness predicted the species richness across both spatial grains (coarse and fine-scale) over time, as measured by correlations, were tested for by Welch Two Sample *t*-test, a modification of the *t*-test for samples with different sizes.

2.4.2. Higher-taxon and composition

We used relative-frequency data (i.e. number of Winkler extractors in a plot in which a species was sampled) to avoid giving more weight to species that have larger nests when constructing the taxa-composition matrix (Gotelli et al., 2011). We used the Mantel test with the Bray–Curtis distance measure to test the association between site-dissimilarity matrices calculated with species, and genus-level assemblage composition (Mantel, 1967). Mantel correlations were used to assess whether the genus-level would change the structure within the dissimilarity matrices (i.e. pairwise similarity). The statistical significance of the Mantel tests was estimated based on 999 permutations. Differences in how much each genus composition matrix predicted the species composition matrix across both spatial scales (coarse and fine grain), as measured by Mantel correlations, were tested for by Welch Two Sample *t*-test.

2.4.3. Species:genus ratio and the effect on higher-taxon responses

We used the species:genus ratio to evaluate if there is a loss of information when using genera as a surrogate of ant species due to differences in the number of species per genus. The value of the correlation coefficient (between genus and species-level) of each metric evaluated (richness, and composition) was correlated with the values of the species:genus ratio.

2.4.4. Efficiency in higher-taxon responses over time

We used a local polynomial regression (locally estimated dispersion plot smoothing - LOESS) to represent the association between the correlation coefficients between species and genera of the three metrics used (richness, and composition) with the decades analyzed. We set the LOESS parameter α to 0.99. This parameter α controls the proportion of points in the neighborhood in relation to the x-axis and is used to adjust to each y value using weighted least squares. The 95% confidence interval was calculated based on the Student's t-distribution for each adjusted y-value.

3. Results

After 14 sampling events, in seven years, we recorded 355 taxa, belonging to 69 genera (Table S.1). At the module spatial scale (coarse), the number of species ranged from 62 to 154 over all sampling periods. Before filling the reservoir, the sampling event with the greatest richness was the second with 131 taxa. After filling the reservoir, the eighth sampling event had the highest richness, with 154 taxa (Table S.2).

Genus richness adequately predicted species richness along time regardless of the spatial grain evaluated (Fine grain: $r = 0.86$; $p < 0.001$; Coarse-grain: $r = 0.75$; $p < 0.001$; Fig. 1).

In general, the richness correlation coefficients values had similar throughout the sampling events for fine ($r = -0.179$; $p = 0.182$) and coarse ($r = -0.347$; $p = 0.225$) spatial grains, however, the coarse grain has a greater variation in the data (Fig. 2A). There was no significant difference between the richness correlation coefficients and spatial grain over time (Welch *t*-test, $T = 0.1026$; $p = 0.919$).

The Mantel correlation coefficients were statistically significant in almost all comparisons between the genus- and the species-level composition matrix at the plot scale and significant in all comparisons at the module scale (Table S.2). The Mantel correlation coefficients were similar for both spatial grains over time (Fig. 2B). The Mantel correlation coefficients were not statistically different between sampling events in fine ($r = 0.010$; $p = 0.939$) and coarse ($r = 0.199$; $p = 0.496$) spatial grains. Also, there had no significant differences among the fine and coarse grain over sampling events (Welch *t*-test, $T = -0.5474$; $P = 0.587$).

No effect of the species: genus ratio was detected in any of the metrics tested (richness, and composition) in both spatial scales. The correlation analyses between species:genus ratios and correlation coefficients of richness (fine-scale: $r = -0.01$; $p = 0.928$; coarse-scale: $r = 0.12$; $p = 0.671$), and species composition (fine-scale: $r = -0.14$; $p = 0.296$; coarse-scale: $r = -0.01$; $p = 0.974$), were not significant in both spatial grains over time (Fig. 3A, B).

4. Discussion

Even with the wide debate in the literature on the identification and use of surrogates for species biodiversity, some issues are rarely addressed, such as the effect of spatial and temporal scales on the efficiency of surrogates. Using a database of ground-dwelling ant monitoring over time in an area under the influence of a hydroelectric power-plant, we demonstrate the effectiveness of the genus in predicting information on ant richness, and composition detected at the species level over seven years of biomonitoring and at two grains of spatial scale.

There are multiple approaches and different proposals for the use of higher-taxon as a shortcut to the diversity of species. Regardless of the coarse taxonomic level used, many studies suggest that the use of surrogates works effectively (Alves et al., 2016; Bhusal et al., 2014; Pik et al., 1999; Ricketts et al., 2002; Sætersdal et al., 2005; Su et al., 2004; Williams and Gaston, 1994), while many others have opposite results (Bilton et al., 2006; Gaspar et al., 2010; Lawler and White, 2008; Neeson et al., 2013). To possibly explain these contradictory results, there are at least two non-exclusive hypotheses. The first concerns the proportion of species within the genera, where surrogates that contain a high number of species would have their effectiveness reduced (Andersen, 1995; Driessen and Kirkpatrick, 2019; Lovell et al., 2007; Rosser, 2017). Although in ants there are some genera with many species (e.g. *Camponotus* and *Pheidole*), in our results there was no effect of the species: genus ratio on the tested diversity metrics. The second hypothesis is related to the lack of standardization of sampling (Lawler and White, 2008) in addition to the effect of spatio-temporal scales, which can also reduce the predictive power of surrogates (Rubinoff, 2001). Ant studies seem to have more robust results when using standardized sampling techniques (Andersen, 1999; Souza et al., 2016, 2018). We use standardized sampling throughout the ant monitoring. Also, our results were consistent over time in the two spatial grains tested.

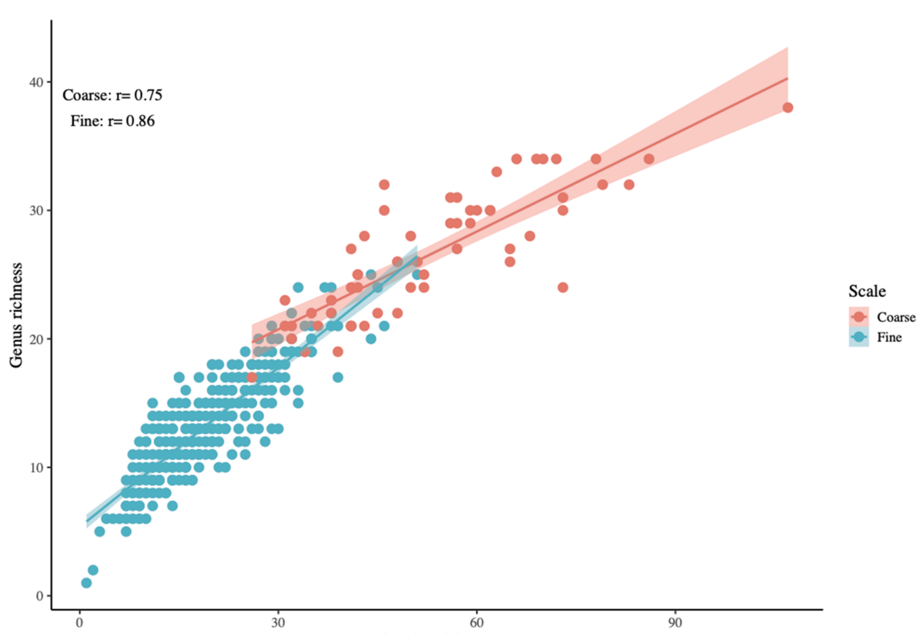

Fig. 1. Correlation between the numbers of genera and species of ground-dwelling ants for coarse and fine grains of the spatial scale used in six study sites located in the area of influence of the Santo Antônio hydroelectric power-plant in the Brazilian Amazon. The statistical significance of models was tested using 1000 permutations. Both correlations were significant at $P < 0.001$.

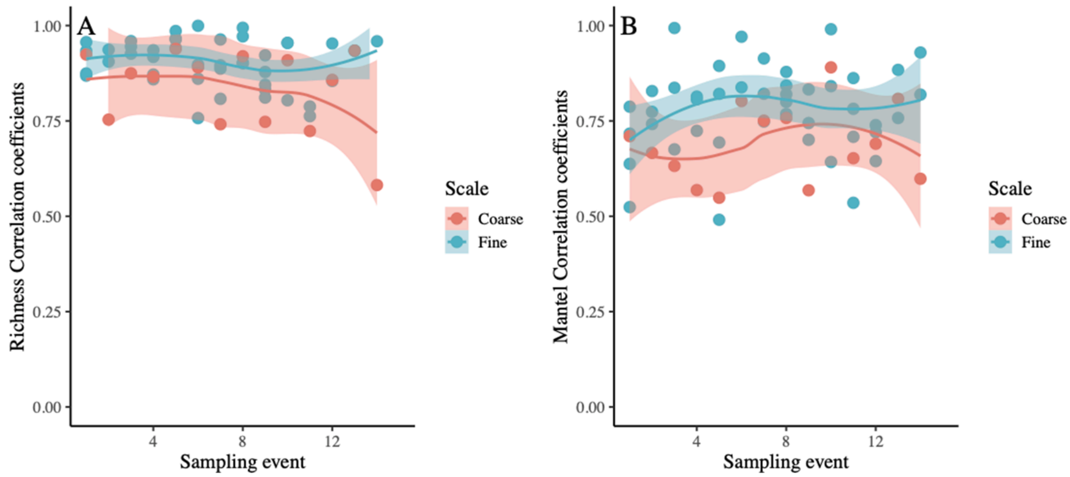

Fig. 2. Smooth curves fitted by LOESS and their respective 95% confidence interval (shaded area) for the correlation coefficients over time for both grains (coarse and fine) of the spatial scale used in six study sites located in the area of influence of the Santo Antônio hydroelectric power-plant in the Brazilian Amazon. A-Richness, and B-Composition (Mantel).

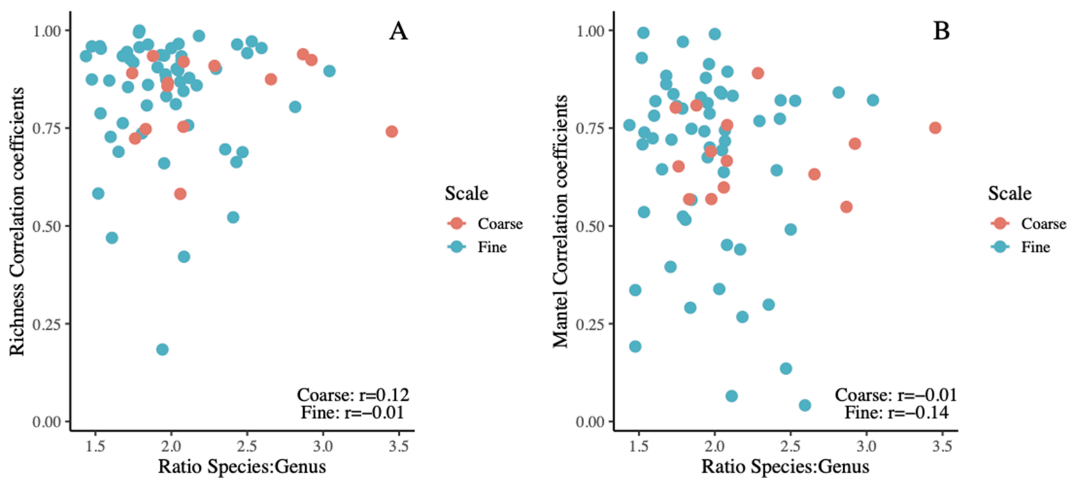

Fig. 3. Relationships between matrix correlation coefficients and the number of ant species per genus measured at coarse and fine grains of the scale used in six study sites located in the area of influence of the Santo Antônio hydroelectric power-plant in the Brazilian Amazon.by each database. A- Richness, and B- Composition (Mantel).

In an attempt to identify and apply biodiversity surrogates, researchers usually assume that the relationship between elected surrogate taxa and total biodiversity is constant over space and time (Colwell and Coddington 1994). The effect of the spatial scale on the use of surrogates has already been evaluated and in some studies with ants, there has been a suggestion that in some cases their efficiency is affected by the spatial scale (Andersen, 1995; Rosser and Eggleton, 2012). Comparing studies carried out in different environments and scales, with various methods and statistical analyses using a range of potential surrogates, makes the task of drawing efficacious conclusions arduous (Lawler and White, 2008). However, the use of standardized sampling methods (Andersen, 1999; Reyers et al., 2000) associated with studies in medium or large spatial scales (Balmford et al., 1996; Rosser and Eggleton, 2012) covering a broad environmental heterogeneity has obtained more credible results (Souza et al. 2016). We tested two grains of spatial scale, one coarse at the site level and the other finer at the plot level, and we did not detect any effect of the spatial scale on the effectiveness of the genus in predicting the responses detected at the species level. There was no difference in the correlation coefficients of the metrics of ant richness, and composition, between the spatial grains. There was also no difference in the effect of the number of species within the genus on both scales. We used a standardized collection, with a fixed sampling area (1 m^2), which possibly intensified the robustness of the results.

Unlike the spatial scale, the assumption that the correlations between surrogates and total biodiversity are stable over time has received little attention (Magierowski and Johnson, 2006). This is probably because long-term studies are scarce and expensive (Whittaker et al., 2005; Gardner et al., 2008). Regardless of the limitations, research must consider the time scale, because the factors that structure communities change over time. Even so, ants appear to have high resilience to structural change over time (Donoso, 2017). Over 14 sampling events spread over seven years of monitoring the ground-dwelling ant assemblages, the results of the genera as surrogates were robust for all the diversity metrics analyzed and tend to be stable over time. It is worth mentioning that this biomonitoring happened under a huge anthropic influence, in the area of influence of a hydroelectric power-plant. Long-term data sets probably contain outliers, such as for non-regular weather events, or atypical years that may influence the assemblages richness and composition, and can increase data variability. Ground-dwelling ants have a turnover rate considered high on a wide spatial (Vasconcelos et al., 2010) and temporal (Donoso, 2017) scales, which can add variation in the data. Thus, fluctuations in the surrogate predictions are expected but have not affected the overall quality of the results. Thus, the data at the genus-level were robust to the main concerns inherent to the spatio-temporal scales raised in the literature of the higher-taxon approach.

Although there are several surrogate options proposed to study ground-dwelling ants (e.g. Indicator Taxa; Andersen 1995, Mixed-level; Groc et al., 2010), genus seems to be the most cost-effective in the Amazon basin (Souza et al., 2016). Besides that, the genus-level was an efficient surrogate regardless of sampling technique, species:genus ratio (Souza et al., 2018) or taxonomic adjustments made in the last hundred years of modern ant taxonomy (Souza et al., unpublished results). Our results expand these findings in the Amazon region, demonstrating the efficiency in the use of the genus-level in predicting the responses of the species level over time, regardless of the spatial grain analyzed. Thus, genus-level identification has proven to be efficient and robust enough to overcome one of the major concerns (ie spatio-temporal effects) that have puzzled researchers about the effectiveness of surrogate responses. The effectiveness and robustness of these results are especially important in countries like Brazil, where science has been downplayed and discredited by politicians (Escobar, 2019; Thomé and Haddad, 2019) and research has been suffering severe and sequential cuts in its funding (Andrade, 2019; Angelo, 2016, 2017; Escobar, 2015), a situation that is not likely to change in the near future (Corlett et al., 2020).

5. Conclusion

The validity of using genera as surrogates for the level of species over time reinforces the applicability of the higher-taxon approach as a shortcut to low-cost biodiversity information (time and money). The predictions of the diversity of ant species using genera were consistent regardless of the spatial scale used (grain), probably due to the use of sound experimental design and standardized sampling methods. The use of surrogates enables the participation of people with less experience in identification and taxonomy (technicians or parataxonomists). However, it is necessary to emphasize that the operation of this approach is intrinsically linked to the essential work of the taxonomists, as appropriate definitions of the taxon limits directly influence the results with the higher-taxon approach. Thus, the use of genera as species surrogates seems to be a promising and cost-effective tool in monitoring biodiversity over time.

CRediT authorship contribution statement

Jorge Luiz Pereira Souza: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing - original draft, Writing - review & editing. **Itanna Oliveira Fernandes:** Data curation, Investigation, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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