Community structure of macroinvertebrates in freshwater rock pools of the Brazilian semiarid region

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ABSTRACT

Freshwater rock pools (FRPs) are temporary aquatic environments that provide refuge for biodiversity in regions with low precipitation. The macroinvertebrate communities of FRPs in the Brazilian semi-arid region constitute an important link between aquatic and terrestrial ecosystems, given their dependency on both to complete their life cycles. The knowledge about FRPs and their resident biota remains scarce, compromising effective conservation actions. In this study, we investigated the influence of dispersal mode and local environmental conditions on the structure of macroinvertebrate communities. We sampled 16 FRPs on a unique, continuous inselberg in the Brazilian semi-arid region during the wet and dry seasons of 2013. In each rock pool, we collected macroinvertebrates and measured local environmental variables related to water characteristics and pool morphology. We observe that seasonal variation influences the predominant dispersal mode of macroinvertebrate communities, while local environmental conditions shape their composition. Active dispersers were predominant in both wet and dry seasons. However, during the dry season, the abundance of passive dispersers increased sevenfold relative to that of active dispersers. Community composition was significantly influenced by dissolved oxygen, pH, water temperature, and electrical conductivity. These findings highlight the importance of FRPs as habitat refuges for aquatic biota from semiarid regions.

Keywords: Community ecology; Insecta; dispersal mode; temporary pools

INTRODUCTION

Freshwater rock pools (hereafter FRPs) are small temporary habitats (< 1 hectare area) resulting from the leveling process in rock outcrops and represent important habitats in the maintenance of biodiversity in scarce water regions (Washko and Bogan 2019a; Bonada et al. 2020). The hydrodynamics of FRPs are totally dependent on the regional pluviometric regime; the pools are filled with rainwater during the wet season, and the drying process occurs through evaporation in the dry season (Jocque et al. 2010; Washko and Bogan 2019a). These systems are highly heterogeneous, varying widely in morphology, hydroperiod, and limnological conditions, and they are typically characterized by oligotrophic waters and high solar and wind exposition (Jocque et al. 2010; Brendonck et al. 2016). As a result, FRPs communities rely heavily on dispersal and drought-resistance strategies to persist in such unstable and resource-limited environments (Williams 2006; Vanschoenwinkel et al. 2025).

Macroinvertebrates, especially insects and crustaceans, are the dominant group in temporary pools, although vertebrates such as reptiles, mammals, and amphibians could also explore these environments (Williams 2006; Pérez-Bilbao et al. 2015; Castro et al. 2018). In general, the FRPs biota are divided into species that exhibit effective dispersal mechanisms and those with drought resistance traits, such as diapause, to reside across intermittent inundations (Williams 2006; Brendonck et al. 2016). Active dispersers, such as Hemiptera, Coleoptera, Trichoptera, and Chironomidae, generally use FRPs as breeding sites, with flying adults depositing eggs during the wet season and larvae developing before the next dry season (Williams 1997, 2006). In contrast, the crustaceans are particularly represented by passive dispersers (transported by wind or other animals) that complete their life cycle in FRPs such as Branchiopoda, Ostracoda, and Copepoda (Williams 2006).

Dispersal capacity is extremely relevant to the distribution of FRPs residents, determining their colonization abilities and their interactions with local environmental conditions (Vanschoenwinkel et al. 2010; Castillo-Escrivà et al. 2017). The macroinvertebrate communities are strongly affected by FPRs local characteristics (Brendonck et al. 2014; Castillo-Escrivà et al. 2017). For instance, water temperature and electrical conductivity act as environmental triggers for passive dispersers to hatch after dormancy periods (Florencio et al. 2013). For active dispersers, local conditions dictate decisions for periods of high colonization efforts or migration to waterbodies with better conditions (Jocque et al. 2010; Carey et al. 2019). Therefore FRPs, like other temporary pools, are essential refuges not only for aquatic but also for semi-aquatic taxa during water scarcity (Washko and Bogan 2019b; Bonada et al. 2020). The management and conservation of these environments require basic knowledge of their biodiversity and factors that affect its dynamics (Bonada et al. 2020). However, the Brazilian studies of FRPs are still scarce (but see Castro et al. 2018; Barbosa et al. 2024).

As a preliminary step to contribute to FRPs conservation, we investigated the influence of dispersal mode (active *vs* passive dispersers) and local environmental conditions in structuring macroinvertebrate communities in 16 FRPs, distributed in a unique and continuous inselberg in the Brazilian semi-arid region during the wet and dry seasons of 2013. In aquatic ecosystems of the Brazilian semi-arid region, remarkable changes in hydrological and environmental conditions are associated with the seasonal periods (Medeiros 2008). Such variations are important drivers of community structure and composition (Medeiros 2008; Barbosa et al. 2024). Then, we expect to observe systematic changes in dispersal mode and composition of invertebrate communities across seasonal periods.

Active dispersers will be present exclusively during the wet season, while the dry season community will be mainly composed of passive dispersers equipped with drought resistance traits. These patterns are common in FRPs from other tropical regions (Jocque et al. 2010).

METHODS

Study area

We conducted this study at the paleontological site Lajinhas (03°25′18″ S and 39°41′39″ W), located in the upstream Mundaú River Basin, municipality of Itapipoca, Ceará state, northeast of Brazil (**Fig. 1**). The region experiences a tropical semi-arid climate, with consistently high temperatures throughout the year, averaging 28°C (Brasil et al. 2022). Mean annual rainfall remains below 700 mm, whereas evapotranspiration rates can exceed 2200 mm (Soares et al. 2024). Intense and irregular rainfall characterizes the area, with most precipitation occurring during the rainy season (December and June), especially during March and April (Brasil et al. 2022; Soares et al. 2024). Species from the Caatinga biome, including forest and shrubs from the families Cactacea, Fabacea, and Euphorbiacea, predominantly compose the vegetation in the area (Castro et al. 2018). We selected sampling sites in a continuous inselberg. Natural pools, which result from erosive processes in the crystalline rocks, dominate the landscape of this rock outcrop. These rock pools exhibit highly variable morphology, ranging from 3 to 20 meters in width, and up to 6 meters in depth (Ximenes 2009).

Sampling

We performed sampling during the wet season (June) and the dry season (September) in 2013. In the wet season, we sampled 16 FRPs, out of which only four persisted until September. Samples were composed of five randomly chosen subsamples from the macrophyte substrate in each rock pool, totaling 16 sampling units in the wet season and four in the dry season. The same collector sampled the macroinvertebrates with an aquatic sweep net with a 250 µm mesh size, 50 cm in diameter, and 15 cm net depth (Nessimian et al., 2008; Hamada et al., 2014). They swept the net for 1 m in a straight line within the macrophyte, using the same effort in each sample. We preserved the samples in 70% alcohol in the field. In the laboratory, we identified specimens to the lowest possible taxonomic level. We performed species identification using a Leica DFC 295 stereoscopic microscope and by consulting the taxonomic keys of Merrit and Cummings (1996) and Mugnai et al. (2010). After identification, we quantified the organisms and then classified them by their dispersal mode as active or passive dispersers (Liu et al., 2024, Li et al., 2016). We classified Insecta as active dispersers, and Ostracoda, Mollusca, and Annelida as passive dispersers.

Environmental and spatial variables

We measured five local environmental variables for each FRP. We calculated surface area (m²) from geographical coordinates of the pool perimeter using Quantum GIS software (v1.8). In addition, we record four limnological variables—pH, dissolved oxygen (mg/L), electrical conductivity (µS/cm), and temperature (ºC)—

using a YSI 7000 multiparameter probe. Finally, we determined the spatial distance between pools from field-collected geographical coordinates.

Data analysis

We analyzed proportions of active and passive dispersers using Chi-squared tests. These analyses were performed based on the abundance and composition data of macroinvertebrate communities from both wet and dry seasons. To analyze the local conditions across seasons, we run multicollinearity tests on the matrix of environmental variables using Spearman correlation. We retained all environmental variables for subsequent analysis, as only weak correlations ($r_S < 0.63$) were detected among them (Table S1). We then standardized these variables with a z-score transformation. We ordinated site distribution using non-metric multidimensional scaling (NMDS) based on a Euclidean distance dissimilarity matrix of the environmental variables for wet and dry seasons. We tested for similarity in environmental characteristics between both seasons using Permutational Multivariate Analysis of Variance (PERMANOVA) with Euclidean distance matrices and 1000 permutations. The associations between environmental variables and macroinvertebrate composition we analyzed using Redundancy Analysis (RDA). Due to the low number of sampling units from the dry season, we used data from 16 pools sampled in the wet season. Prior to RDA, the macroinvertebrate abundance data were Hellinger-transformed to reduce the influence of extreme values.

To assess spatial autocorrelation in the patterns of community abundance and richness, we calculated the global Moran's index (Moran's I) using a spatial neighborhood matrix constructed from inter-FRPs distances. Geographic coordinates were converted to a metric system (UTM 24S), and neighborhood structure was defined both by the four nearest neighbors ($k = 4$) and by distance thresholds (1 km for the full dataset and 200 m for the subset excluding the most isolated pools) (Table S2).

We performed all analyses in R (R Core Team 2025). The NMDS, PERMANOVA, and RDA analyses were conducted using functions of the vegan package: *metaMDS*, *adonis2*, and *rda*, respectively (Oksanen et al. 2025). Chi-square tests were performed with the *prop.test* function from the base stats package (R Core Team 2025). The spatial autocorrelation test was run with 999 randomizations using the *spdep* package (Bivand 2022).

RESULTS

The community structure of FRPs was composed of 58 morphospecies, including 52 active dispersers from the class Insecta and six passive dispersers from classes Gastropoda, Oligochaeta, and Ostracoda. These morphospecies represent 54 genera and 36 families (Table S3). The richest taxa were insects from the Dytiscidae, Aeshnidae, and Hydrophilidae families. We sampled a total of 8,013 individuals during the two seasons. During the wet season, active dispersals from the Hydrophilidae and Chironomidae families were the most abundant taxa, representing 27.54% of all individuals. In contrast, passive dispersals from the class Ostracoda represented 79.27% of the total community abundance during the dry season (Table S3).

In terms of community composition, we observed highly similar proportions of active and passive dispersal morphospecies across seasons ($X^2 < 0.01$, gl = 1, p = 1), with a greater contribution of active dispersal morphospecies in both seasons. During the wet season, the community was composed of 7.66 active morphospecies for each passive dispersal ($X^2 = 29.25$, gl = 1, $p < 0.01$). Similarly, in the dry season, the ratio was 7.00 active morphospecies for each passive dispersal ($X^2 = 16.53$, gl = 1, $p < 0.01$). In contrast, reverse proportions were revealed in the comparison of abundance data across seasons ($X^2 = 2926.7$, gl = 1, $p < 0.01$). We detected a greater contribution of active dispersals to the total community abundance in the wet season, 2.44 active dispersal individuals for each passive dispersal ($X^2 = 600.44$, gl = 1, $p < 0.01$) (**Fig. 2**). Nonetheless, in the dry season, passive dispersal individuals were the principal component of community abundance, with a ratio of 7.40 passive dispersal individuals for each active dispersal ($X^2 = 2664.1$, gl = 1, $p < 0.01$).

The local environmental characteristics of FRPs vary greatly across the sampling units, particularly in terms of surface area and water electrical conductivity (**Table 1**). This variability was independent of season (PERMANOVA, F = 1.98, p = 0.09), as evidenced by the overlap of sites sampled during wet and dry seasons in the multivariate space (**Fig. 3**).

We detected a relationship between local environmental characteristics and macroinvertebrates of FRPs during the wet season. The environmental variables explained 44% of the variation in the community composition ($R^2 = 0.44$, F = 1.60, p = 0.02), with dissolved oxygen, pH, temperature, and electrical conductivity emerging as particularly important drivers (**Fig. 4**). Overall, morphospecies exhibit low specialization in their relations with these variables. Additionally, we found no clear relationship between dispersal mode and the environmental variables. For instance, the passive dispersals of class Ostracoda (Ostr) and gastropods Physidae from the genus *Physa* (Phys) were associated with opposite directions of the dissolved oxygen gradient (Fig. 4B). Ostracods (Ostr) and mosquitoes Culicidae from genus *Orthopodomyia* (Culi.2), were associated with rock pools characterized by high oxygen levels, acidic pH, and elevated temperatures (Fig. 4B). In contrast, the gastropods Physidae from genus *Physa* (Phys) were associated with rock pools exhibiting low oxygen levels and high electrical conductivity. Similarly, gastropods Planorbidae from genus *Biomphalaria* (Plan.1), damselflies Coenagrionidae from *Chromagrion* (Coen.1), and dragonflies Libellulidae from *Erythrodiplax* (Libe.1) were also characteristic of low-oxygen water but showed a weak association with water electrical conductivity (Fig. 4B).

DISCUSSION

In this study, we aimed to investigate how dispersal mode (active vs. passive dispersers) and local environmental conditions shape macroinvertebrate communities in FRPs located on an inselberg in the Brazilian semi-arid region. Considering the strong hydrological seasonality of the region, we hypothesized that macroinvertebrate communities would exhibit systematic shifts between wet and dry seasons, with active dispersers predominating during the wet season and passive dispersers dominating during the dry season. Contrary to our expectations, communities were dominated by active dispersers in both seasons. However, seasonal differences emerged through abundance, with passive dispersers becoming seven times more abundant than active ones during the dry season. Local environmental conditions exhibited low seasonal variability, yet community composition during the wet season was influenced by dissolved oxygen, pH, temperature, and electrical conductivity. Even so, dispersal mode showed no clear association with environmental variables. Instead, specific taxa responded to these conditions: ostracods and Culicidae were positively associated with higher dissolved oxygen, pH, and temperature, whereas gastropods (Physidae and Planorbidae), damselflies, and dragonflies thrived in pools with low dissolved oxygen, with Physidae particularly linked to higher electrical conductivity.

The macroinvertebrate communities in the Brazilian FRPs were mainly composed of active dispersers (Insecta) during the wet season and dry season. This pattern differs from FRPs outside the Brazilian semi-arid region, in which insects are present exclusively during the wet season (Jocque et al. 2010). Here, during the dry season, although comprising only 11 % of total abundance, the insects represent 87% of total morphospecies. The consistently high diversity detected is characteristic of insect communities in the neotropical region (Balian et al. 2008). However, characteristic seasonal changes of FRPs communities were evident in the abundance patterns of active dispersers. Their predominance during the wet season was replaced by a small contribution to the total number of individuals in the dry season.

These seasonal changes in FRPs communities result from the balance between the stress of environmental and biotic factors (Jocque et al. 2010). During the wet season, when the habitat conditions are favorable, organism interactions such as predation and competition become the main drivers of community structure (Jocque et al. 2010; Vanschoenwinkel et al. 2010). Here, FRPs populations of passive dispersers are mainly composed of detritivorous and herbivorous groups, which are controlled by the action of predatory insects such as Coleoptera, Hemiptera, and Odonata (Covich 2010; Vanschoenwinkel et al. 2010; Brendonck et al. 2016). The high abundance of active dispersers in the rainy season represents the natural colonization of ephemeral habitats by insects during oviposition (Jocqué et al. 2007; Vanschoenwinkel et al. 2010). In addition, the contribution of adult winged insects associated with the deciduous seasonal vegetation maintains the predominance of active dispersers in this period (Ober and Hayes 2008; Vasconcellos et al. 2010; Arce et al. 2023).

In the dry season, we observed a succession in abundance of active dispersers by passive dispersers due to the reduction of terrestrial resources from terrestrial vegetation, and the drying of pools (Drummond et al. 2015; Washko and Bogan 2019b; Devánová et al. 2023). At this moment, the FRPs macroinvertebrate communities are dominated by specialists of adverse environments. The passive dispersers compensate for movement limitations with resistance mechanisms that allow them to remain in the FRPs up to the end of the dry season (Eitam et al. 2004; Sim et al. 2013). For instance, ostracod strategies include a detritivore diet, drought-resistant eggs, and the ability to live in high densities (Martens et al. 2008; Brendonck et al. 2016). Additionally, in general passive dispersers are tolerant to variations in water quality, including abrupt changes in temperature, potential redox, and pH (Külköylüoğlu and Yılmaz 2006; Glasby et al. 2021; Panda et al. 2022).

We also detected the importance of water characteristics in the FRPs macroinvertebrate composition, regardless of dispersal mode. The passive dispersers from Ostracoda and active dispersers from Culicidae were favored by higher levels of dissolved oxygen, acidic pH, and higher temperature. Both Ostracods and Culicids have broad tolerance to these water characteristics (Mezquita et al. 2005; Allen and Dodson 2011; Avramov et al. 2024). Particularly, high temperatures can favor larval development and high abundance of both groups (Maqbool et al. 2015; Moser et al. 2023; Martínez-Barciela et al. 2025). In addition, elevated temperatures support high photosynthetic activity, increasing the availability of feeding resources for ostracods (Maqbool et al. 2015; Külköylüoğlu et al. 2020).

Although tolerant to variations in water quality, unusual relations were detected here for Ostracods and Culicids. The association of ostracods with acid water was unexpected, since low pH values can reduce carapace calcification (Parameswari et al. 2020). However, the FRPs studied here are only slightly acidic, falling within a pH range tolerated by ostracods for normal calcification (4.6 to 13) (Parameswari et al. 2020). In respect to mosquitoes Culicidae, the association with high oxygenated water contradicts expectations since their larvae possess adaptations to live in low oxygen levels (Lee et al. 2017). Even though results like ours have been reported in other studies, demonstrating the generalist nature of Culicids (Mbuya et al. 2014; Medeiros-Sousa et al. 2020; Bastos et al. 2021). In addition, we observed a strong relation between gastropods Physidae and high water electrical conductivity, which is a consistent pattern for the mollusk group (Efitre et al. 2001; Garg et al. 2009; Mwabvu and Sasa 2009). This association is related to the need for cations, especially calcium, for shell formation in mollusks, whose shells contain calcium carbonate ($CaCO_3$) as an important structural component (Clark et al. 2020).

In contrast, dragonflies and damselflies exhibited a weak association with FRPs conductivity but were particularly important in pools with low dissolved oxygen. There is evidence that water conductivity can positively affect larval development in dragonflies; however, this relationship has not been investigated in damselflies (Aristizábal-Botero et al. 2023). Overall, dragonflies and damselflies occur in habitats with contrasting environmental conditions. Libellulids are characteristics of degraded environments. For instance, the genus *Erythrodiplax* is particularly tolerant to low dissolved oxygen waters (Fulan et al. 2011). Damselflies are associated with good water quality, generally found in environments with high dissolved oxygen (Monteiro Júnior et al. 2015; Silva et al. 2021; Olive et al. 2025). Nevertheless, environments classified as inappropriate for zygoptera to live combine low dissolved oxygen concentrations with abrupt temperature changes, as a result of deforestation (Couceiro et al. 2006; Ice et al. 2021; Rajesh and Rehana 2022). Conversely, in our study, even in pools with low dissolved oxygen levels, there are low variations in water temperature, suggesting that water quality was still adequate to support these species (Monteiro Júnior et al. 2015).

Despite being a single-year, single-formation assessment, our study provides novel insights into how dispersal mode and local environmental conditions jointly structure macroinvertebrate communities in Brazilian FRPs. Seasonal variation altered the relative contribution of dispersal strategies, increasing the abundance of passive dispersers during the dry season, whereas active dispersers remained taxonomically dominant throughout the year. Although community composition is influenced by variables such as dissolved oxygen, pH, and temperature, there is no clear relationship between these environmental conditions and dispersal mode. Future studies with broader spatial and temporal replication and a trait-based metacommunity approach are needed to disentangle the relative roles of environmental filtering, dispersal limitation, and drought resistance. As drought periods intensify under climate change, FRPs may undergo permanent ecological shifts, including altered physicochemical conditions, reduced water availability, and declines in macroinvertebrate diversity. Overall, our results highlight the importance of the natural dynamics of FRPs and reinforce that understanding these mechanisms is essential for the conservation of these habitats and their unique biota.

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DISCLOSURE OF INTEREST

The authors report there are no competing interests to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Figshare at https://doi.org/10.6084/m9.figshare.30906182.

ETHICS STATEMENT

Field expeditions were authorized by the Brazilian environmental agency Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), under the license number 28385-3.

AUTHOR CONTRIBUTION

F.A.C.G. contributed to conceptualization, investigation, methodology, data analysis, validation, and visualization. L.L.S. contributed to conceptualization, investigation, methodology, data analysis, validation, visualization, and manuscript writing. M.A.A.F. contributed to conceptualization, investigation, validation, visualization, and manuscript writing. M.G.S. contributed to data analysis, validation, visualization, and manuscript writing. F.E.R. contributed to investigation, validation, visualization, and manuscript writing. J.R.F.S. contributed to the investigation, validation, visualization, and supervision of the study. C.F.R. contributed to resources, conceptualization, investigation, methodology, data analysis, validation, visualization, manuscript writing, funding acquisition, project administration, and supervision of the study. All authors reviewed the manuscript.

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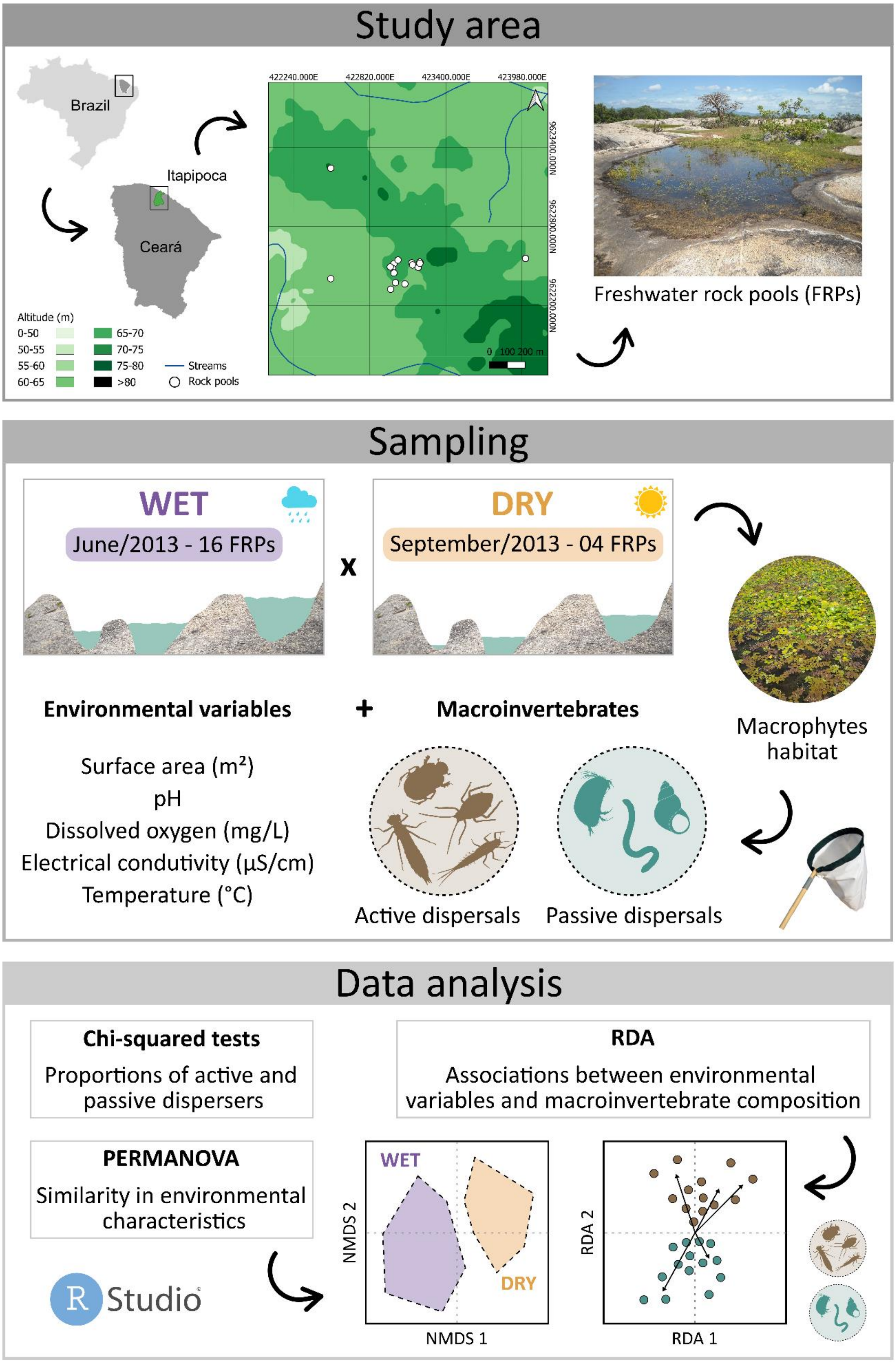
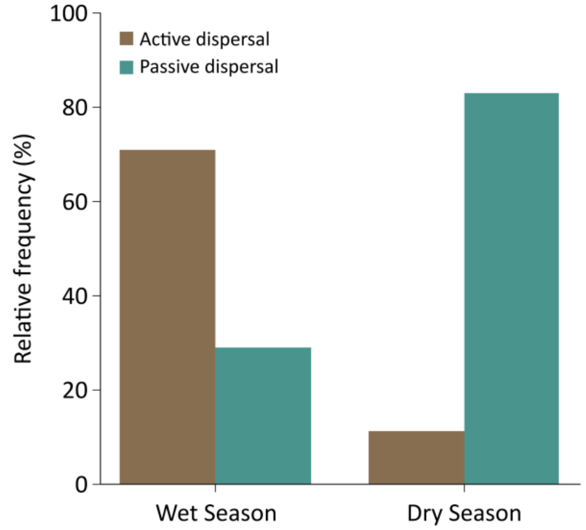
Tables

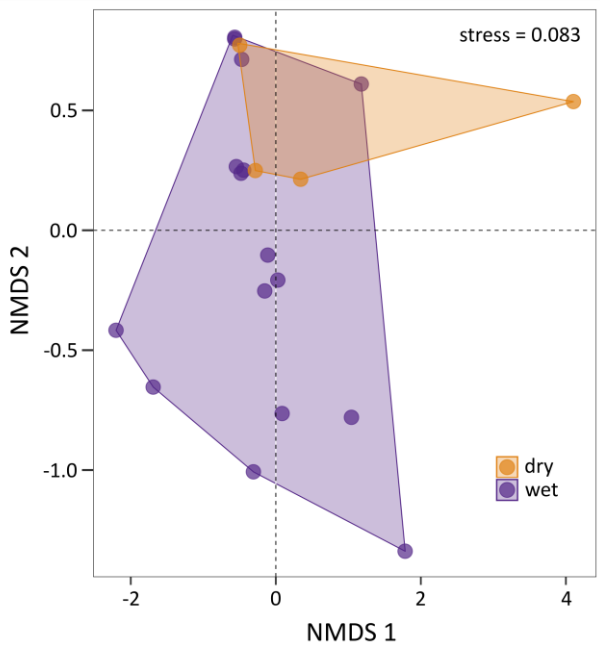
Table 1. Means and standard deviations of local environmental variables from 16 freshwater rock pools sampled in the Brazilian semi-arid region during the wet and dry seasons of 2013.

Variable	code	Season			
		wet		dry	
		mean	sd	mean	sd
Surface area (m²)	s_area	600.61	1082.65	257.15	303.35
Temperature (ºC)	temp	27.93	1.89	27.32	1.83
Dissolved oxygen (mg/L)	OD	2.72	1.81	2.20	1.17
Electrical conductivity (µS/cm)	cond	74.54	47.25	430.18	564.91
pH	ph	6.34	0.86	7.29	1.28

Figures


Study area
Brazil
Itapipoca
Ceará
Altitude (m)
0-50
50-55
55-60
60-65
65-70
70-75
75-80
>80
Streams
Rock pools
422240.000E
422820.000E
423400.000E
423980.000E
9623400.000N
9622800.000N
9622200.000N
0 100 200 m
Freshwater rock pools (FRPs)
Sampling
WET
June/2013 - 16 FRPs
x
DRY
September/2013 - 04 FRPs
Macrophytes habitat
Environmental variables
+
Macroinvertebrates
Surface area (m²)
pH
Dissolved oxygen (mg/L)
Electrical condutivity (µS/cm)
Temperature (°C)
Active dispersals
Passive dispersals
Data analysis
Chi-squared tests
Proportions of active and passive dispersers
RDA
Associations between environmental variables and macroinvertebrate composition
PERMANOVA
Similarity in environmental characteristics
RStudio
WET
DRY
NMDS 2
NMDS 1
RDA 2
RDA 1


Active dispersal
Passive dispersal
Relative frequency (%)
100
80
60
40
20
0
Wet Season
Dry Season


stress = 0.083
NMDS 2
0.5
0.0
-0.5
-1.0
-2
0
2
4
NMDS 1
dry
wet

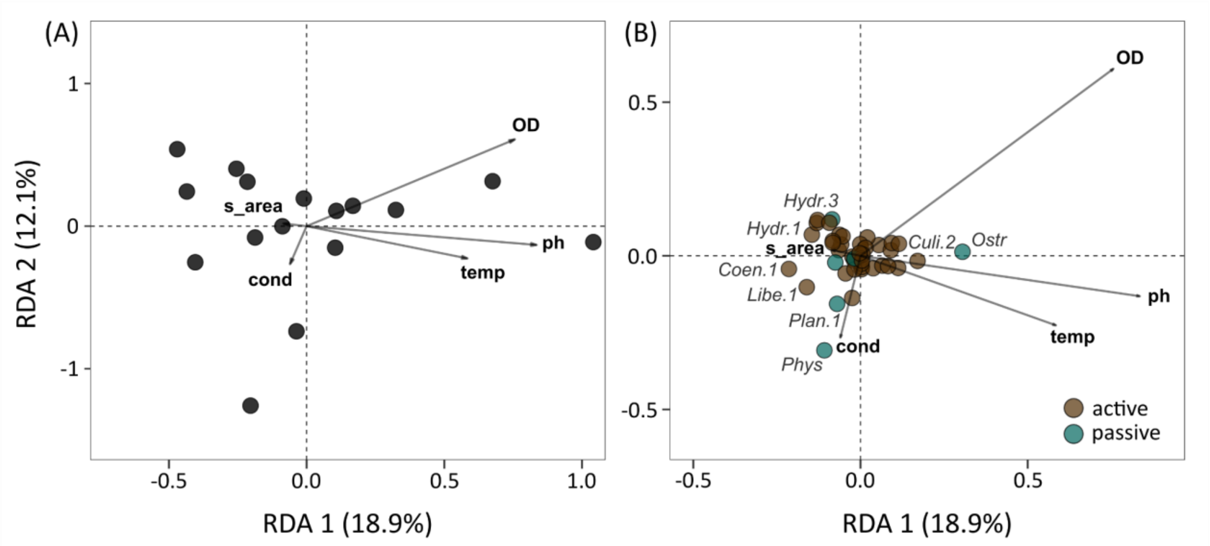

(A)
RDA 2 (12.1%)
RDA 1 (18.9%)
1
0
-1
-0.5
0.0
0.5
1.0
OD
s_area
ph
cond
temp
(B)
0.5
0.0
-0.5
-0.5
0.0
0.5
RDA 1 (18.9%)
OD
Hydr.3
Hydr.1
s_area
Coen.1
Libe.1
Plan.1
Phys
cond
Culi.2
Ostr
ph
temp
active
passive

Figure captions

Fig. 1 Methodological workflow for assessing the effects of dispersal mode and local environmental conditions on macroinvertebrate community structure in FRPs on a Brazilian semi-arid inselberg during wet and dry seasons.

Fig. 2 Abundance relative frequency (%) of Active and Passive dispersal in wet and dry season on the Lajinhas site, Sub-humid Northeastern, Brazil.

Fig. 3 NMDS ordination of local environmental variables from 16 freshwater rock pools sampled in the Brazilian semiarid region during wet and dry seasons of 2013.

Fig. 4 RDA associations of sites (**A**) and macroinvertebrate morphospecies with local environmental variables (**B**) from 16 freshwater rock pools sampled in the Brazilian semiarid region during the wet season of 2013. Morphospecies code: Coen.1 = *Chromagrion* spp., Culi.2 = *Orthopodomyia* spp., Hydr.1 = *Anacaena* spp., Hydr.3 = *Paracymus* spp., Libe.1 = *Erythrodiplax* spp., Ostr = Ostracoda, Phys = *Physa* spp., Plan.1 = *Biomphalaria* spp.

Supplemental material

Community structure of macroinvertebrates in freshwater rock pools of the Brazilian semiarid region

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Table S1 Spearman rank correlations among local environmental variables measured in 16 freshwater rock pools sampled in the Brazilian semi-arid region during the wet and dry seasons of 2013. Variable names are available in Table 1.

	s_area	**temp**	**OD**	**cond**	**ph**
s_area	1				
temp	-0.012	1			
OD	0.108	0.552	1		
cond	0.397	0.068	0.064	1	
ph	-0.137	0.089	0.171	0.534	1

Table S2 Results of permutation tests (999 permutations) for Moran's I assessing spatial autocorrelation in total abundance and species richness of macroinvertebrates morphospecies from 16 freshwater rock pools sampled in the Brazilian semi-arid region during the wet and dry seasons of 2013.

Dataset / Metric	**Moran's I**	**Observed rank**	**p-value**
Full dataset			
Total abundance	–0.08137	207	0.793
Richness	–0.060973	573	0.427

Subset (excluding p14, p15, p16)			
Total abundance	–0.018653	874	0.126
Richness	–0.10859	276	0.724

Table S3 Abundance and frequency of occurrence of macroinvertebrate morphospecies from 16 freshwater rock pools sampled in the Brazilian semi-arid region during the wet and dry seasons of 2013.

Taxon	**Species code**	**Season**				**Total**	
		wet		**dry**			
		n	**%**	**n**	**%**	**n**	**%**
Active dispersers							
Insecta							
Hydrophilidae							
Anacaena spp.	Hydr. 1	240	7.02%	9	0.20%	249	3.11%
Derallus spp.	Hydr. 2			5	0.11%	5	0.06%
Paracymus spp.	Hydr. 3	396	11.58%	22	0.48%	418	5.22%
Tropisternus spp.	Hydr. 4	24	0.70%	21	0.46%	45	0.56%
Chironomidae							
Chironomidae spp.	Chir	282	8.25%	85	1.85%	367	4.58%
Libellulidae							
Erythrodiplax spp.	Libe.1	222	6.49%	32	0.70%	254	3.17%
Libellula spp.	Libe.2			10	0.22%	10	0.12%
Coenagrionidae							
Chromagrion spp.	Coen. 1	210	6.14%	4	0.09%	214	2.67%
Hesperagrion spp.	Coen. 2	2	0.06%			2	0.02%
Pleidae							
Paraplea spp.	Plei	28	0.82%	171	3.72%	199	2.48%
Aeshnidae							
Aeshna spp.	Aesh. 1	120	3.51%			120	1.50%
Anax spp.	Aesh. 2	52	1.52%			52	0.65%
Coryphaeschna spp.	Aesh. 3	1	0.03%			1	0.01%
Gynacantha spp.	Aesh. 4	1	0.03%			1	0.01%
Curculionidae							
Listronotus spp.	Curc. 1	19	0.56%			19	0.24%
Steremnius spp.	Curc. 2	138	4.04%	1	0.02%	139	1.73%
Aphididae							
Aphididae spp.	Aphi	70	2.05%	61	1.33%	131	1.63%

Culicidae							
Deinocerites spp.	Culi.1	32	0.94%		0.00%	32	0.40%
Orthopodomyia spp.	Culi.2	59	1.73%	1	0.02%	60	0.75%
Macroveliidae							
Macrovelia spp.	Macr	82	2.40%	6	0.13%	88	1.10%
Dytiscidae							
Agabus spp.	Dyti.1	2	0.06%			2	0.02%
Cybister spp.	Dyti.2	31	0.91%	1	0.02%	32	0.40%
Dytiscus spp.	Dyti.3	26	0.76%	6	0.13%	32	0.40%
Hydrovatus spp.	Dyti.4		0.00%	1	0.02%	1	0.01%
Uvarus spp.	Dyti.5	17	0.50%	2	0.04%	19	0.24%
Tabanidae							
Chrysops spp.	Taba	78	2.28%	6	0.13%	84	1.05%
Mesoveliidae							
Mesovelia spp.	Meso	62	1.81%			62	0.77%
Baetidae							
Baetis spp.	Baet.1	35	1.02%	9	0.20%	44	0.55%
Cloeon spp.	Baet.2	12	0.35%			12	0.15%
Notonectidae							
Notonecta spp.	Noto	26	0.76%	23	0.50%	49	0.61%
Staphylinidae							
Bledius spp.	Stap.2	1	0.03%			1	0.01%
Stenus spp.	Stap.1	35	1.02%			35	0.44%
Lestidae							
Lestes spp.	Lest	31	0.91%			31	0.39%
Crambidae							
Crambus spp.	Cram. 1	21	0.61%	1	0.02%	22	0.27%
Paraponyx spp.	Cram. 2		0.00%	5	0.11%	5	0.06%
Naucoridae							
Limnocoris spp.	Nauc. 1	6	0.18%			6	0.07%
Pelocoris spp.	Nauc. 2	8	0.23%	11	0.24%	19	0.24%
Dryopidae							
Stygoparnus spp.	Dryo. 1			23	0.50%	23	0.29%
Veliidae							
Microvelia spp.	Veli	21	0.61%			21	0.26%
Elmidae							
Ancyronyx spp.	Elmi. 1	19	0.56%			19	0.24%
Phanocerus spp.	Elmi. 2	1	0.03%			1	0.01%
Noteridae							

Suphisellus spp.	Note			14	0.30%	14	0.17%
Stratiomyidae							
Odontomyia spp.	Stra	3	0.09%	10	0.22%	13	0.16%
Belostomatidae							
Abedus spp.	Belo	1	0.03%	6	0.13%	7	0.09%
Gomphidae							
Gomphus spp.	Gomp	3	0.09%			3	0.04%
Haliplidae							
Haliplus spp.	Hali	3	0.09%			3	0.04%
Ceratopogonidae							
Alluaudomyia spp.	Cera	1	0.03%	1	0.02%	2	0.02%
Muscidae							
Limnophora spp.	Musc	2	0.06%			2	0.02%
Perlodidae							
Isoperla spp.	Perl	1	0.03%			1	0.01%
Thaumaleidae							
Thaumalea spp.	Thau	1	0.03%			1	0.01%
Dryomyzidae							
Oedoparena spp.	Dryo. 2	1	0.03%			1	0.01%
Georissidae							
Georissus spp.	Geor	1	0.03%			1	0.01%
Passive dispersers							
Gastropoda							
Planorbidae							
Biomphalaria spp.	Plan.1	58	1.70%	384	8.36%	442	5.52%
Drepanotrema spp.	Plan.2	12	0.35%			12	0.15%
Physidae							
Physa spp.	Phys	121	3.54%	9	0.20%	130	1.62%
Ampullariidae							
Pomacea spp.	Ampu	32	0.94%			32	0.40%
Oligochaeta							
Oligochaeta	Olig	50	1.46%	12	0.26%	62	0.77%
Ostracoda							
Ostracoda	Ostr	720	21.05%	3641	79.27%	4361	54.42%
Total		**3420**	**100.00%**	**4593**	**100.00%**	**8013**	**100.00%**