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ARTICLE

Between cultivated and forested environments of the Atlantic Forest: environmental and morphological filters shaping arthropod communities in *Heliconia bihai* inflorescences

Entre ambientes cultivados e florestais da Mata Atlântica: filtros ambientais e morfológicos que estruturam comunidades de artrópodes em inflorescências de *Heliconia bihai*

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Abstract
The interplay between cultivated areas and forest fragments creates complex landscapes where ornamental plants such as *Heliconia bihai* (L.) L., 1763 act as microhabitats linking wild biodiversity to human-modified environments. Our goal was to evaluate how biodiversity, functional structure, and morphological traits influence the arthropod communities associated with *H. bihai* inflorescences in cultivated and forested environments of the Atlantic Forest. We analysed 344 inflorescences, yielding 14,665 arthropod individuals from 65 morphospecies across cultivated and forested sites. Forest fragments sustained richer and more abundant communities, while cultivated areas hosted mainly generalist taxa, revealing functional complementarity. Diptera dominated both habitats, whereas coleopterans and mites were more representative in forest stands, reflecting the importance of detrital input and structural complexity. Seasonality strongly modulated community composition, with aquatic and semi-aquatic taxa restricted to the rainy season. Community assembly was influenced by interacting microclimatic, seasonal, and morphological filters. These findings demonstrate that biodiversity conservation in cultivated landscapes depends on ecological connectivity between cultivated areas and adjacent forest fragments, which act as reservoirs of specialized taxa and sustain key ecological processes.
Keywords: Biodiversity conservation, Forest fragments, Functional complementarity, Landscape epidemiology, Ornamental plant, Phytotelmata.

Resumo
A interação entre áreas cultivadas e fragmentos florestais cria paisagens complexas, nas quais plantas ornamentais como *Heliconia bihai* (L.) L., 1763 atuam como micro-habitat que conectam a biodiversidade silvestre a ambientes antropizados. Nosso objetivo foi avaliar como a biodiversidade, a estrutura funcional e características morfológicas influenciam as assembleias de artrópodes em inflorescências de *H. bihai* em áreas cultivadas e naturais da Mata Atlântica. Foram analisadas 344 inflorescências, totalizando 14.665 indivíduos de artrópodes distribuídos em 65 morfoespécies em ambientes cultivados e florestais. Os fragmentos florestais sustentaram comunidades mais ricas e abundantes, enquanto áreas cultivadas abrigaram principalmente táxons generalistas, revelando complementaridade funcional. Diptera dominaram ambos os ambientes, enquanto coleópteros e ácaros foram mais representativos nos fragmentos florestais, refletindo a importância do aporte detrítico e da complexidade estrutural. A sazonalidade modulou fortemente a composição das comunidades, com táxons aquáticos e semiaquáticos restritos ao período chuvoso. A montagem das comunidades foi influenciada pela interação de filtros microclimáticos, sazonais e morfológicos. Esses achados demonstram que a conservação da biodiversidade em paisagens cultivadas depende da conectividade ecológica entre áreas cultivadas e fragmentos florestais adjacentes, que atuam como reservatórios de táxons especializados e sustentam processos ecológicos essenciais.
Palavras-chave: Complementaridade funcional, Conservação da biodiversidade, Epidemiologia da paisagem, Fitotelmata, Fragmentos florestais, Planta ornamental.

Introduction

Phytotelmata are aquatic microhabitats formed by the accumulation of water in plant structures such as bracts, leaves, or stems, sustaining complex communities of macro- and microinvertebrates (Williams, 2006). These habitats provide food resources and breeding sites for a wide range of organisms, acting as model systems to investigate key ecological processes, including community assembly, environmental filtering, and trophic dynamics (Lounibos and Frank, 2009). Ecologically, phytotelmata offer tractable systems for testing ecological filtering theory, in which species distributions emerge from sequential constraints imposed by environmental conditions, habitat structure, and temporal dynamics. In this broader context, biodiversity has increasingly been understood not only in terms of species richness but also considering the diversity of interactions and functional organization that underpin ecosystem processes and responses to environmental change (Lewinsohn et al., 2022).

Among Neotropical phytotelmata, *Heliconia* inflorescences stand out. Beyond their ecological role as sources of nectar and shelter, *Heliconia* are widely cultivated as ornamental plants, occurring in a variety of landscape contexts. This dual occurrence as a naturally occurring species in forest fragments and as a widely cultivated ornamental plant in anthropogenic environments makes *Heliconia bihai* (L.) L. a strategic model for evaluating how cultivation and conservation interact in sustaining biodiversity (Oliveira et al., 2010; Oliveira et al., 2018; Giongo et al., 2019; Hayford et al., 2021). From an applied perspective, understanding arthropod assemblages in *H. bihai* is also relevant for ornamental horticulture, since this species is extensively used in landscaping and commercial flower production. Identifying how cultivation practices and landscape context influence associated biodiversity provides insights for more sustainable ornamental management and conservation planning in anthropized environments. Recent comparative studies with other *Heliconia* species further demonstrate that forest context and plant traits play a key role in structuring dipteran and arthropod assemblages, reinforcing the suitability of *Heliconia* as a model system for evaluating environmental filtering across conserved and human-modified habitats (Méndez-Rojas et al., 2025).

Early studies had already indicated the importance of *Heliconia* phytotelmata as biodiversity reservoirs, highlighting the role of resource heterogeneity (Seifert, 1982; Naeem, 1990). Subsequent research

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reinforced this perspective, demonstrating how morphological and environmental heterogeneity in *H. bihai* influences arthropod community structure and functional diversity (Oliveira et al., 2010; Oliveira et al., 2018; Medeiros-Sousa et al., 2025; O'Reilly-Berkeley et al., 2025).

Studies have shown that community composition and diversity in phytotelmata are influenced by abiotic factors such as water volume, pH, and temperature, as well as by detrital input (Antonetti et al., 2021). Seasonal events, particularly rainfall variation, also exert strong effects, promoting rapid changes in the abundance and richness of invertebrates (Santos et al., 2023). Similarly, evidence from other phytotelmata-forming plant species indicates that morphological traits such as the number of bracts per inflorescence in bromeliads also modulate the associated diversity, thereby expanding our understanding of the biotic and abiotic filters that structure these communities (Medeiros-Sousa et al., 2025).

Despite these advances, few studies have systematically compared phytotelmata communities in cultivated and wild environments. Such comparisons are especially relevant in tropical regions, where the expansion of agriculture and ornamental cultivation reshapes tropical landscapes, but forest fragments persist as important biodiversity reservoirs (Méndez Rojas et al., 2024; Dendi et al., 2023). Evaluating how communities respond simultaneously to environmental, seasonal, and plant structural factors helps to elucidate not only patterns of diversity but also the functional connectivity between cultivated and natural landscapes. In studies focusing on Heliconia-associated arthropods, habitat type has been shown to influence abundance, diversity, and functional composition, often leading to a reorganization of trophic guilds and interaction patterns rather than simple species loss (Benítez-Malvido et al., 2016). However, the combined effects of environmental, seasonal, and morphological filters across cultivated and forested contexts remain poorly understood, especially for phytotelmata of ornamental species.

Considering that *H. bihai* is both a widely cultivated ornamental plant and a naturally occurring species adjacent to Atlantic Forest fragments, its inflorescences provide a unique model for investigating the interface between cultivation and conservation. The species exhibits deep and structurally complex bracts capable of retaining significant water volumes, which promote the establishment of diverse arthropod assemblages (Hayford et al., 2021). This morphological trait enhances habitat stability and contributes to differences in species richness across environments.

In this study, we tested the following hypotheses: (i) communities in forest fragments exhibit higher richness, abundance, and diversity than those in cultivated areas; (ii) cultivated environments sustain mainly generalist taxa, highlighting functional complementarity between habitats; and (iii) both microclimatic filters (temperature, pH, and water volume) and plant morphological traits (number and depth of bracts per inflorescence) influence community assembly, shaping patterns of abundance and richness.

Thus, this study aimed to evaluate arthropod biodiversity and community structure associated with *Heliconia bihai* inflorescences and to determine how environmental and morphological factors influence these assemblages in cultivated and forested environments of the Atlantic Forest.

Materials and methods

Study area

The study was conducted in Camaragibe, Pernambuco, northeastern Brazil (08°01′S, 34°59′W). Two habitats were sampled: (i) a *Heliconia* germplasm collection maintained under cultivation at an institutional experimental garden, and (ii) an adjacent fragment of Atlantic Forest considered "wild". The two areas are approximately 150–200 meters apart. Both areas share the same regional climate (Aw, Köppen classification), with a mean annual temperature of approximately 25 °C and total annual rainfall near 2,400 mm. According to data from the BDMEP–INMET meteorological station (Curado, Recife, Pernambuco), rainfall was concentrated between April and August 2012 (Fig. 1). The climatic conditions during the study period (August 2011–August 2012) are summarized in Figure 1, which shows monthly averages of temperature and precipitation for the metropolitan region of Recife that includes Camaragibe.

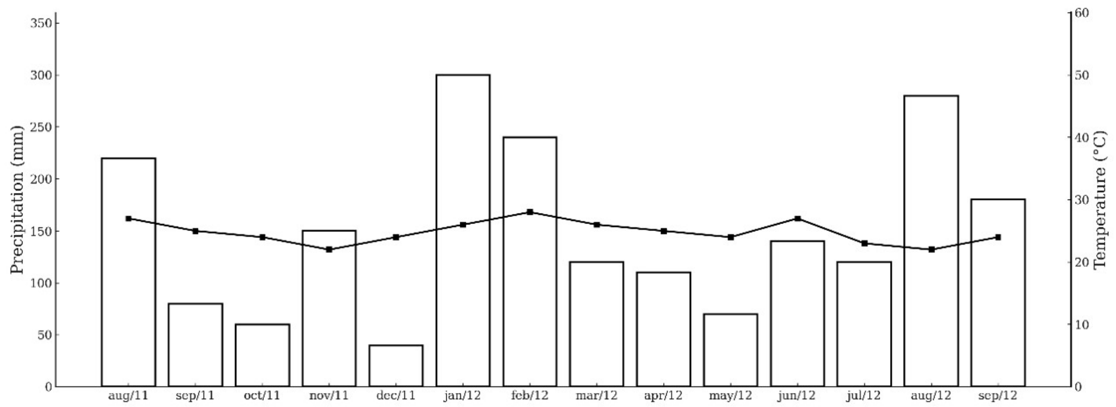

Fig. 1. Monthly rainfall and air temperature in the Metropolitan Region of Recife (including Camaragibe, PE) from August 2011 to August 2012. Data from BDMEP–INMET (Curado Station).

Sampling design

From August 2011 to August 2012, 344 inflorescences of *H. bihai* were sampled monthly (198 cultivated, 146 wild). Inflorescences were randomly selected from different flowering clumps to ensure sample independence. To avoid pseudoreplication, only one inflorescence per clump was sampled per month. This design ensured temporal replication across seasons and spatial replication across habitats.

For each sampled inflorescence, water retained in bracts was measured *in situ*: volume (mL) with a graduated cylinder, temperature (°C) with a digital thermometer, and pH with a portable pH meter.

Arthropod collection and identification

All water and associated detritus from bracts were extracted into white trays. Arthropods were collected with fine pipettes and entomological forceps, preserved in 70% ethanol, and transported to the laboratory. Specimens were identified to the lowest possible taxonomic level under a stereomicroscope. When species-level identification was not possible, operational morphospecies (e.g., *Psychodidae* sp. 1, *Brachycera* sp. 2) were recognized based on consistent external morphological characters. Diptera were identified following Brown et al. (2010), Coleoptera using regional taxonomic keys (Ślipiński et al., 2011), and mites (*Tropicoseius*) were identified by a taxonomic specialist through direct morphological examination. Identifications were cross-checked whenever possible, and voucher specimens were deposited in an institutional entomological reference collection.

Data analysis

Abundance, species richness, Shannon diversity (H′) and Pielou evenness (J′) were compared between habitats (cultivated vs. wild) using independent two-sample t-tests after confirming normality and homoscedasticity assumptions. When assumptions were not met, non-parametric Mann–Whitney U tests were applied, and differences were interpreted directly from U statistics. All analyses adopted a significance threshold of $p < 0.05$.

Community structure was evaluated using non-metric multidimensional scaling (nMDS) based on Bray–Curtis similarity. The quality of the ordination was assessed by the stress value, and compositional differences between habitats were tested with ANOSIM (999 permutations).

To identify the taxa contributing most to habitat separation, the SIMPER procedure was applied, considering species that accounted for up to 70% of cumulative dissimilarity.

The influence of environmental variables on community composition was first assessed by a Principal Component Analysis (PCA), with eigenvalues and correlations between environmental variables and principal axes calculated from the covariance matrix.

A Canonical Correspondence Analysis (CCA) was then performed to directly test the associations between species and environmental variables, with a Monte Carlo permutation test (999 permutations) used to evaluate the global significance of the models (Ter Braak and Šmilauer, 2002).

Finally, an ANCOVA was applied to test the effects of habitat (cultivated vs. wild), the number of bracts per inflorescence, and PCA axis 1 on arthropod abundance and richness. Results were expressed as F and p values, with a significance threshold of 5%.

Univariate analyses (t-tests, Mann–Whitney U tests, and ANCOVA) were performed using STATISTICA version 8.0 (StatSoft Inc., Tulsa, OK, USA). Principal Component Analysis (PCA), non-metric multidimensional scaling (nMDS), ANOSIM, and SIMPER analyses were conducted using PRIMER version 5.0 (PRIMER-E Ltd., Plymouth, UK). Canonical Correspondence Analysis (CCA) and the associated Monte Carlo permutation test (999 permutations) were performed using CANOCO version 4.5 (Ter Braak and Šmilauer, 2002). All statistical tests adopted a significance level of $\alpha = 0.05$.

Results and Discussion

Diversity and abundance

A total of 14,665 arthropods, distributed across 65 morphospecies, were collected from 344 inflorescences of *Heliconia bihai*. Wild areas sustained significantly more diverse and abundant communities than cultivated ones. Mean species richness per inflorescence was 7.9 ± 3.3 in wild habitats versus 4.96 ± 2.5 in cultivated habitats (t = 9.30; $p < 0.05$), while mean abundance was 63.6 ± 44.3 and 28.7 ± 25.3 individuals, respectively (t = 9.15; $p < 0.05$), (Fig. 2a e 2b). Shannon diversity (H′) averaged 1.4 ± 0.4 in wild areas and 1.0 ± 0.5 in cultivated areas (t = 5.94; $p < 0.05$), whereas evenness (J′) did not differ significantly (0.68 vs. 0.70; $p > 0.05$). These results indicate that forest fragments maintain more complex and diverse communities, in line with evidence from Neotropical phytotelmata.

Taxonomic composition and temporal variation

The arthropod community associated with *H. bihai* inflorescences was dominated by Diptera, particularly *Psychodidae* sp. 1 and *Piophilidae* sp. whereas coleopterans such as *Pelosoma lafertei* Mulsant, 1844 were more abundant in wild stands (Fig. 3). Other groups, including Formicidae and the mite *Tropicoseius venezuelensis* Fain & Hyland, 1980, also contributed to habitat differentiation (Fig .3). This pattern is consistent with the ecological plasticity of dipterans, which tolerate simplified habitats, whereas detritivorous beetles and mites depend on the structural heterogeneity and organic matter input typical of forest fragments (Progênio et al., 2023). Moreover, morphophysiological traits of *Heliconia* species themselves may influence environmental tolerance and indirectly affect the associated faunas (Souza et al., 2024).

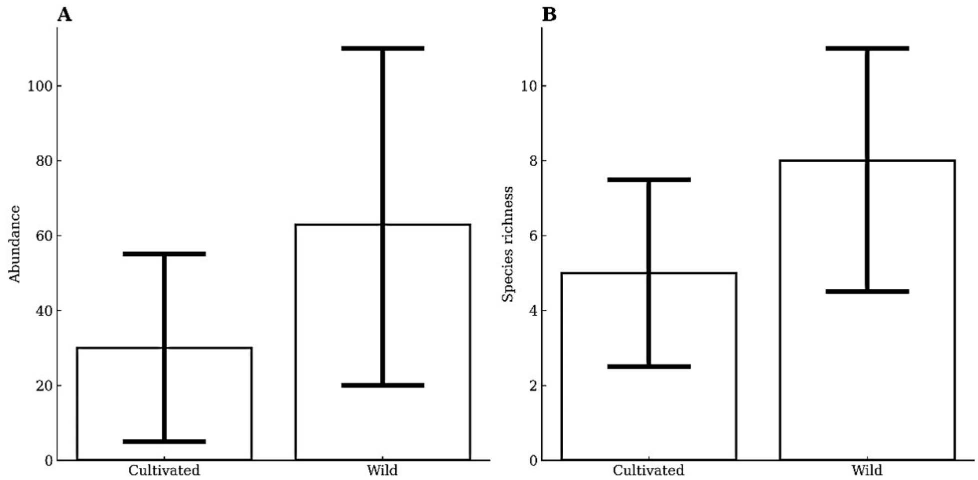

Fig. 2. Mean abundance (A) and species richness (B) of arthropods in *H. bihai* inflorescences from wild and cultivated areas. Differences between habitats were assessed using t-tests ($p < 0.05$).

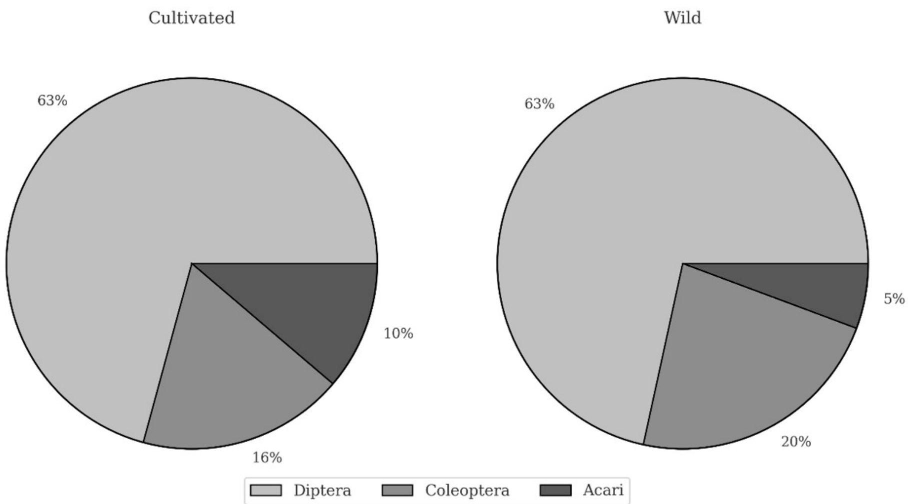

Fig. 3. Taxonomic composition (%) of arthropods in *H. bihai* inflorescences from cultivated and wild areas. Groups were pooled into major categories (Diptera, Coleoptera, and Acari).

Seasonality strongly influenced taxonomic composition (Fig. 4). Aquatic and semi-aquatic taxa (e.g., Culicidae, Elmidae, several Brachycera morphospecies) were recorded almost exclusively during the rainy season, being rare or absent in the dry season. These patterns emphasize that rainfall pulses play a decisive role in shaping phytotelmata assemblages, by modulating both richness and abundance across habitat.

These results confirm that water availability is the main seasonal factor modulating the structure of phytotelmata communities. The environmental heterogeneity of forest fragments, together with the greater input of detritus, sustains more complex and stable communities compared to cultivated areas. Similar patterns have been described in bromeliads, where rainfall pulses increase the input of organic matter and larval survival (Giongo et al., 2019; Santos et al., 2023).

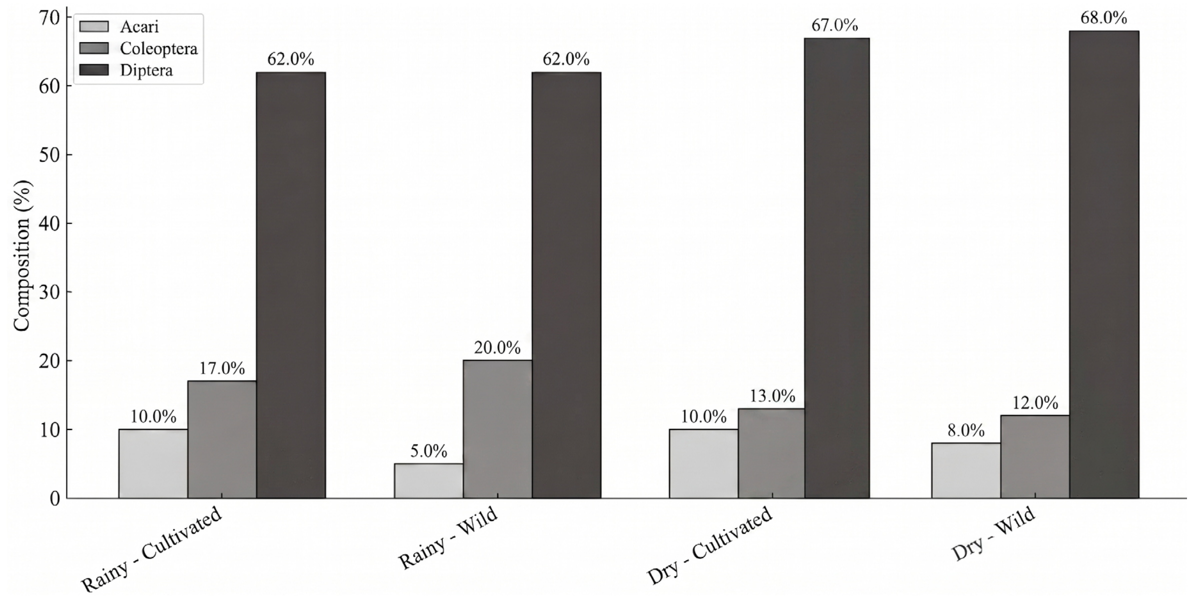

Fig. 4. Taxonomic composition (%) of arthropods in *H. bihai* inflorescences from cultivated and wild areas during the rainy and dry seasons. Groups were pooled into major categories (Diptera, Coleoptera, and Acari).

Community structure

The nMDS ordination revealed clear differences between habitats, although with some overlap among samples (Fig. 5). Arthropod communities associated with *Heliconia bihai* inflorescences in cultivated and wild stands exhibited distinct compositions, indicating the influence of habitat type on community structure. The ordination showed good fit (stress = 0.14), and differences between habitats were statistically supported by ANOSIM (R = 0.37; p = 0.001).

The SIMPER analysis revealed that differentiation between habitats was mainly explained by five taxa (Table 1). *Psychodidae* sp. 1, *Piophilidae* sp., and *Pelosoma lafertei* Mulsant, 1844, together accounted for more than 35% of total dissimilarity, while *Brachycera* sp. 2 and *Tropicoseius venezuelensis* Fain & Hyland, 1980 also contributed substantially. These results reinforce the importance of Diptera, Coleoptera, and Acari as key groups in habitat segregation.

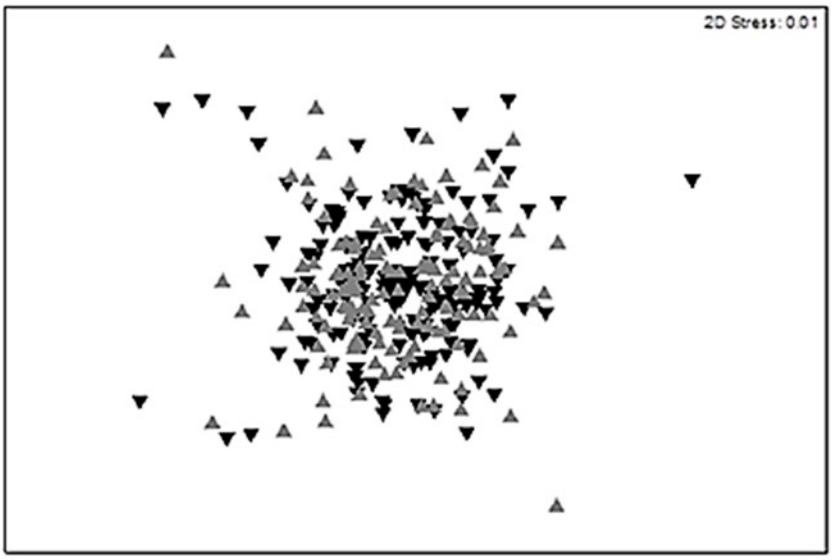

Fig. 5. Non-metric multidimensional scaling (nMDS) of arthropod community composition in *H. bihai* inflorescences from cultivated (gray triangles) and wild (black triangles) areas in Camaragibe, Brazil. The analysis was based on Bray–Curtis similarity, highlighting structural separation between habitats.

Table 1. Taxa contributing most (%) to dissimilarity between cultivated and wild habitats of *H. bihai*, according to SIMPER analysis. Only the top five contributors are shown.

Taxon	Contribution Cultivated (%)	Contribution Wild (%)
Psychodidae sp. 1	14.11	15.11
Pelosoma lafertei	11.10	13.96
Piophilidae sp.	11.08	9.48
Brachycera sp. 2	9.58	8.66
Tropicoseius venezuelensis	7.37	7.46

Although Diptera dominate in both habitats, the greater abundance of coleopterans and mites in wild areas adds structural complexity to communities, suggesting that forest fragments act as refuges for more specialized taxa. The prominent contribution of *Pelosoma lafertei* and other coleopterans in wild stands has been associated with a higher input of organic detritus, which serves as a key food resource and trophic base (Progênio et al., 2023).

These findings echo studies demonstrating the importance of detrital input and water volume in modulating richness and abundance of macroinvertebrates in phytotelmata (Antonetti et al., 2021). Such patterns highlight that structural heterogeneity and detritus availability in forest fragments favor functional guilds that are absent from cultivated environments.

This highlights habitat type as a key driver of community differentiation and emphasizes the role of forest fragments in sustaining specialized taxa. Furthermore, insects inhabiting phytotelmata may reduce host plant fecundity through florivory, linking community assembly to reproductive outcomes of the plant (Missagia and Alves, 2022).

Species–environment relationships

The PCA revealed that axis 1 explained 80.4% of variance and was strongly correlated with temperature (r = 0.79), followed by pH (r = 0.51) and water volume (r = 0.34). Axis 2 explained 17.5% of variance, whereas axis 3 contributed only 2.1% of the total variance. These results indicate that temperature was the main abiotic driver of arthropod communities in phytotelmata, with pH and water volume playing complementary roles (Fig. 6).

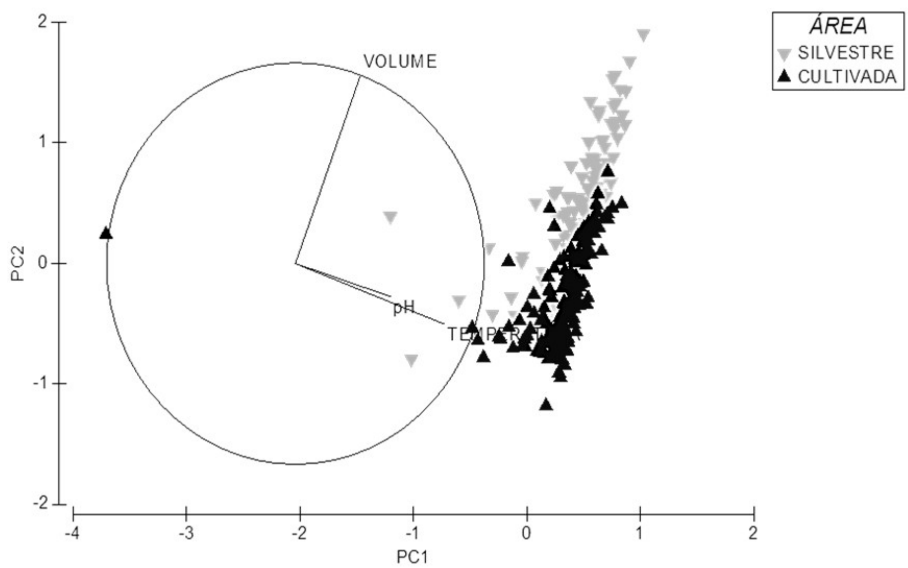

Fig.6. Principal Component Analysis (PCA) of environmental variables associated with *H. bihai* inflorescences in Camaragibe, Brazil. Axis 1 explained 80.4% of variance and was strongly correlated with temperature, followed by pH and water volume. Axis 2 explained 17.5% of variance.

The ANCOVA indicated that abundance was significantly influenced by habitat type (cultivated vs. wild; F = 18.2; $p < 0.05$) and by the number of bracts per inflorescence (F = 11.79; $p < 0.05$). In terms of species richness, significant effects were observed for the number of bracts (F = 3.28; $p < 0.05$) and for PCA Component 1 (F = 2.45; $p < 0.05$). These findings demonstrate that, beyond microclimatic conditions, plant morphological traits also play a key role in shaping the richness and abundance of associated communities.

The Canonical Correspondence Analysis (CCA) directly tested species–environment associations. The Monte Carlo test with 999 permutations confirmed significant relationships ($p < 0.05$) between abiotic variables and community composition.

In the cultivated area, the ordination diagram (Trace = 0.069; F-ratio = 3.045; $p = 0.005$) showed that *Psychodidae* sp. 1 and *P. lafertei* were positively associated with water volume, while temperature strongly influenced the distribution of Piophilidae sp. (Fig. 7a).

In the wild area, the ordination (Trace = 0.207; F-ratio = 2.093; $p = 0.022$) indicated that *P. lafertei* was again associated with volume, confirming its preference for habitats with greater water retention. *Psychodidae* sp. 1 was closely aligned with pH, suggesting a tendency toward more acidic environments, while *Piophilidae* sp. remained positively related to temperature (Fig. 7b).

The arthropod fauna associated with *H. bihai* inflorescences is influenced by environmental, seasonal, and structural factors. Wild areas showed higher abundance, richness, and diversity than cultivated ones, reinforcing the role of forest fragments as biodiversity reservoirs, a pattern also observed in other phytotelmata and Neotropical heliconias (Oliveira et al., 2018; Dendi et al., 2023; Giongo et al., 2019; Almeida et al., 2025).

Seasonality was also determinant: arthropod abundance increased during the rainy season, when aquatic and semiaquatic taxa, such as Culicidae and Elmidae, were recorded. These results confirm that water availability acts as a primary environmental filter in community assembly, consistent with studies showing that water and detritus input enhance larval survival and trophic complexity in bromeliads (Santos et al., 2023; Antonetti et al., 2021).

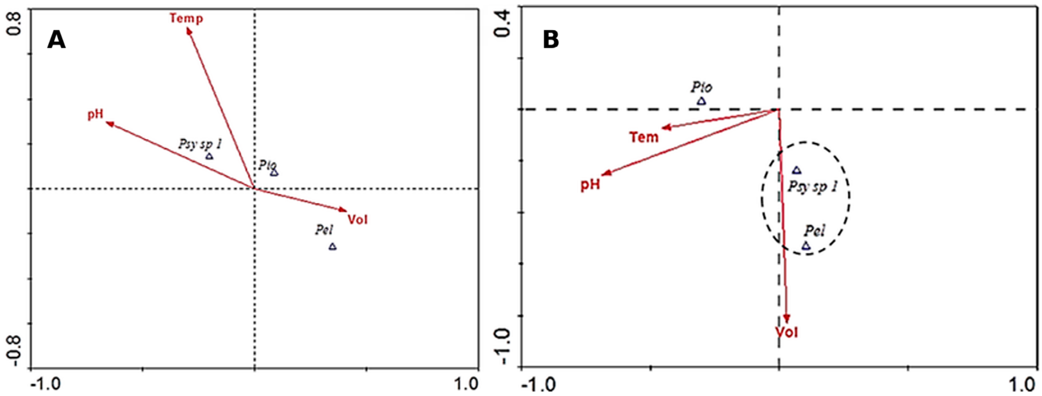

Fig. 7. Canonical Correspondence Analysis (CCA) of arthropod community composition in H. *bihai* inflorescences in Camaragibe, Brazil. (A) Cultivated area. (B) Wild area. Species are represented by triangles (*Pelosoma lafertei*, *Piophilidae* sp., *Psychodidae* sp. 1), and environmental variables by vectors (temperature, pH, water volume).

nMDS and SIMPER analyses revealed structural separation between habitats, with Diptera (e.g., *Psychodidae* sp. 1, *Piophilidae* sp.) dominant in both, but Coleoptera and Acari more abundant in wild environments. This highlights habitat type as a key driver of community differentiation and emphasizes the role of forest fragments in sustaining specialized taxa. Furthermore, insects inhabiting phytotelmata may reduce host plant fecundity through florivory, linking community assembly to reproductive outcomes of the plant (Missagia and Alves, 2022).

Environmental heterogeneity has also been shown to increase metacommunity stability in aquatic systems, reinforcing the role of structural diversity in sustaining community processes (He et al., 2023; Arancibia, 2024).

Integration of PCA and CCA further underscored the influence of environmental and plant structural variables on community assembly. Temperature emerged as the main predictor of community variation, with higher values (>28 °C) associated with decreased richness and abundance, particularly of Diptera and Coleoptera.

In contrast, near-neutral pH (6.5-7.0) and greater water volumes (>20 mL) within bracts were positively related to both richness and total abundance. Morphological traits, especially the number of bracts per inflorescence, also played a key role. Inflorescences with more than eight bracts, typically representing older and deeper structures, supported denser and more diverse arthropod assemblages.

These findings reinforce the combined role of abiotic and morphological filters in structuring *H. bihai* phytotelmata communities. These findings corroborate recent studies identifying water volume and structural complexity as consistent predictors of phytotelmata diversity (Medeiros-Sousa et al., 2025; Antonetti et al., 2021), reinforcing the view that community structure is shaped by multiple, interacting filters.

Although the field data were collected between 2011 and 2012, they represent a valuable historical record of arthropod communities associated with *H. bihai* phytotelmata in Atlantic Forest landscapes. Given the continuous transformation of tropical ecosystems driven by land-use change and habitat fragmentation, this dataset provides an important ecological baseline for future temporal comparisons and long-term assessments of biodiversity responses to environmental change.

From an applied perspective, *H. bihai* cultivated adjacent to forest fragments can sustain richer and more functionally diverse arthropod communities, with implications for both biodiversity conservation and ecological regulation of arthropods in ornamental environments. Beyond their aesthetic value, *H. bihai* inflorescences contribute to maintaining ecological interactions and highlight the importance of integrating horticultural practices into biodiversity management in the Atlantic Forest.

Conclusion

This study shows that arthropod communities inhabiting *Heliconia bihai* inflorescences are shaped by interacting environmental, seasonal, and morphological filters. Forest fragments consistently supported greater abundance, richness, and diversity than cultivated areas, highlighting their importance as reservoirs of specialized taxa.

Differences in community structure were strongly associated with microclimatic conditions, including temperature, pH, and water volume, as well as with inflorescence morphology, particularly the number and depth of bracts. These findings indicate that community assembly in phytotelmata arises from the combined action of abiotic and structural filters.

From an applied perspective, our results emphasize that cultivated stands of *H. bihai* located near forest fragments help maintain ecologically functional and diverse arthropod assemblages. This reinforces the need for landscape planning and horticultural practices that preserve ecological connectivity, contributing simultaneously to ornamental plant management and biodiversity conservation in the Atlantic Forest.

Taken together, these findings corroborate recent studies identifying water volume and structural complexity as consistent predictors of phytotelmata diversity, reinforcing the view that community structure is shaped by multiple interacting filters. In addition, the present study provides a valuable historical ecological baseline for future assessments of biodiversity changes in phytotelmata associated with ornamental plants under ongoing landscape transformation.

This ecological baseline will support future temporal comparisons and improve our understanding of how arthropod communities respond to environmental changes in tropical landscapes.

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Author Contribution

TRSO: Conceptualization, Methodology, Investigation, Taxonomic identification, Formal analysis, Data curation, Writing – Original Draft, Writing – Review & Editing. **VL:** Supervision, Methodology, Validation, Writing – Review & Editing. **DDC:** Supervision, Validation, Writing – Review & Editing. **CFM:** Supervision, Validation, Writing – Review & Editing.

Conflict of 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.

Data Availability Statement

All the research data is contained in the manuscript.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT (OpenAI) in order to assist with language editing, text organization and clarity of expression. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

References

ALMEIDA, N.M.; DIAS, R.F.; ALVES, D.C.V.; MACHADO, S.L.; SILVA, J.D.S.; MELLO, C.F.; ALENCAR, J. Mosquito fauna in phytotelmata across an Atlantic Forest remnant. **Frontiers in Ecology and Evolution**, v.13, 1525202, 2025. https://doi.org/10.3389/fevo.2025.1525202.

ANTONETTI, D.A.; MALFATTI, E.; UTZ, L.R.P. Influence of environmental and morphological parameters on the microfauna community present in phytotelmata of a bromeliad in a fragment of Atlantic Forest, southern Brazil. **Neotropical Biology and Conservation**, v.16, n.1, p.59–70, 2021. https://doi.org/10.3897/neotropical.16.e56186.

ARANCIBIA, P.A. The topology of spatial networks affects stability in experimental metacommunities. Proceedings of the Royal Society B: **Biological Sciences**, v.291, 20240567, 2024. https://doi.org/10.1098/rspb.2024.0567

BENÍTEZ-MALVIDO, J.; DÁTTILO, W.; MARTÍNEZ-FALCÓN, A. P.; DURÁN-BARRÓN, C.; VALENZUELA, J.; LÓPEZ, S.; LOMBERA, R. The multiple impacts of tropical forest fragmentation on arthropod biodiversity and on their patterns of interactions with host plants. **PLOS ONE**, v.11, n.1, e0146461, 2016. https://doi.org/10.1371/journal.pone.0146461.

BROWN, B.V.; BORKENT, A.; CUMMING, J.M.; WOOD, D.M.; WOODLEY, N.E.; ZUMBADO, M.A. (Eds.). **Manual of Central American Diptera.** Ottawa: NRC Research Press, 2010.

DENDI, D.; FÖRSTER, T.; CHABOO, C.S. Arthropod diversity in phytotelmata of *Calathea capitata* (Zingiberales; Marantaceae) host plants from Peru. **Revista Peruana de Biología,** v.30, n.2, p.1–12, 2023. https://doi.org/10.15381/rpb.v30i2.25654.

LOUNIBOS, L.P.; FRANK, J.H. Insects and allies associated with bromeliads: a review. **Terrestrial Arthropod Reviews,** v.2, p.163–256, 2009. https://doi.org/10.1163/187498308X414742.

GIONGO, A.; MEDINA-SILVA, R.; ASTARITA, L.V.; BORGES, L.G.A.; OLIVEIRA, R.R.; SIMÃO, T.L.L.; GANO, K.A.; DAVIS-RICHARDSON, A.G.; BROWN, C.T.; FAGEN, J.R.; ARZIVENCO, P.M.; NETO, C.P.; ABICHEQUER, A.D.; LINDHOLZ, C. G.; BAPTISTA-SILVA, A.; MONDIN, C.A.; UTZ, L.R.P.; TRIPLETT, E.W.; EIZIRIK, E. Seasonal physiological parameters and phytotelmata bacterial diversity of two bromeliad species in the Atlantic Forest of Southern Brazil. **Diversity,** v.11, n.111, 2019. https://doi.org/10.3390/d11070111.

HAYFORD, B.; FÖRSTER, T.; PATEL, V. N.; CHABOO, C. S. Aquatic flies (Diptera) in phytotelmata of Neotropical Zingiberales plants. **Journal of Natural History,** v.54, p.1–21, 2021. https://doi.org/10.1080/00222933.2020.1871522.

HE, S.; WANG, B.; CHEN, K.; SOININEN, J. Patterns in aquatic metacommunities are associated with environmental and trait heterogeneity. **Freshwater Biology,** v.68, n.1, p.91–102, 2023. https://doi.org/10.1111/fwb.14011.

LEWINSOHN, T.M.; ALMEIDA NETO, M.; ALMEIDA, A.M.; PRADO, P.I.; JORGE, L.R. From insect–plant interactions to ecological networks. **Biota Neotropica,** v.22, e20221399, 2022. https://doi.org/10.1590/1676-0611-BN-2022-1399.

MEDEIROS-SOUSA, A.R.; OLIVEIRA-CHRISTE, R.; CERETTI-JUNIOR, W.; BARRIO-NUEVO, K.M.; EVANGELISTA, E.; WILK-DA-SILVA, R.; MUCCI, L.F.; PAULA, M.B.; MARRELLI, M.T. Linking abiotic conditions to mosquito assemblage structure in bromeliads. **Scientific Reports,** v.15, 30308, 2025. https://doi.org/10.1038/s41598-025-15514-7.

MÉNDEZ-ROJAS, D.M.; HERNÁNDEZ-LÓPEZ, M.; MARTÍNEZ-FALCÓN, A.P.; RICARTE, A.; LOBATO-GARCÍA, J.M.; BENÍTEZ-MALVIDO, J. Forest type influence on *Heliconia*–dipteran interaction networks. **Insect Conservation and Diversity**, v. 18, p. 1–15, 2025. https://doi.org/10.1111/icad.70047.

MÉNDEZ-ROJAS, D.M.; MÁRQUEZ, J.; NAVARRETE-HEREDIA, J.L.; MARTÍNEZ-FALCÓN, A.P.; LOBATO-GARCÍA, J.M.; BENÍTEZ-MALVIDO, J. Rove beetle species diversity and the patterns of interactions with their host plants in primary and secondary tropical forests. **Journal of Insect Conservation,** v.28, p.1349–1362, 2024. https://doi.org/10.1007/s10841-024-00633-9.

MISSAGIA, C.C.C.; ALVES, M.A.S. Florivory by phytotelm-breeding insects decreases fecundity in *Heliconia* (Heliconiaceae). **Current Zoology,** v.68, n.1, p.195–203, 2022. https://doi.org/10.1093/cz/zoab015.

NAEEM, S. Resource heterogeneity and community structure in *Heliconia imbricata* phytotelmata. **Oecologia,** v.84, p.29–38, 1990. https://doi.org/10.1007/BF00665591.

OLIVEIRA, T.R.S.; MOURA, S.R.; CRUZ, D.D.; LOGES, V.; MARTINS, C.F. Interaction and distribution of beetles (Insecta: Coleoptera) associated with *Heliconia bihai* (Heliconiaceae) inflorescences. **Florida Entomologist,** v.101, p.160–165, 2018. https://doi.org/10.1653/024.101.0202.

OLIVEIRA, T.R.S.; SENA, D.C.A.; LOGES, V.; CAMARA, C.A.G.; REIS, A.C. Insetos (*Arthropoda*, *Insecta*) em inflorescências de *Heliconia bihai* (L.) L. (Heliconiaceae). **Horticultura Ornamental,** v.16, n.2, p.174–178, 2010. https://doi.org/10.14295/rbho.v16i2.560.

O'REILLY-BERKELEY, X.; CHAKRABORTY, A.; PATIÑO UYAGUARI, J.L.; MOSSMAN, H.L.; PREZIOSI, R.F.; ROWNTREE, J.K. Effect of genotype on herbivory and growth rate in *Heliconia* spp. **Acta Amazonica**, v.55, n.1, 2025. https://doi.org/10.1590/1809-4392202302421.

PROGÊNIO, M.; ANTIQUEIRA, P.A.P.; OLIVEIRA, F.R.; MEIRA, B.R.; LANSAC-TÔHA, F.M.; RODRIGUES, L.C.; ROMERO, G.Q.; NASH, L.M.; KRATINA, P.; VELHO, L.F.M. Effects of warming on the structure of aquatic communities in tropical bromeliad microecosystems. **Ecology and Evolution**, v.13, n.2, e9824, 2023. https://doi.org/10.1002/ece3.9824.

SANTOS, V.L.; SILVA, U.C.; SANTOS, E.H.; RESENDE, A.A.; DIAS, M.F.; CUADROS-ORELLANA, S.; MARQUES, A. R. Exploring the mycobiota of bromeliads phytotelmata in Brazilian Campos Rupestres. **Brazilian Journal of Microbiology**, v.54, n.3, p.1885–1897, 2023. https://doi.org/10.1007/s42770-023-00977-5.

SEIFERT, R.P. Neotropical *Heliconia* insect communities. **The Quarterly Review of Biology**, v.57, p.1–28, 1982.

ŚLIPIŃSKI, S.A.; LESCHEN, R.A.B.; LAWRENCE, J.F. Order Coleoptera Linnaeus, 1758. In: ZHANG, Z.-Q. (Ed.). Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. **Zootaxa,** v.3148, p.203–208, 2011. https://doi.org/10.11646/zootaxa.3148.1.39

SOUZA, G.C.S; RIBEIRO, J.E.S.; SOUZA, R.R.; SILVA, R.R.; SOUZA, A.R.; TORO-HERRERA, M.A.; FIGUEREDO, H.F.; FERREIRA, C.P.; BORGES, M.C.R.Z.; PAIVA NETO, V.B.; BECKMANN-CAVALCANTE, M.Z. Morphoanatomical and physiological mechanisms of solar irradiation tolerance in heliconia genotypes. **Scientia Horticulturae,** v.323, 112508, 2024. https://doi.org/10.1016/j.scienta.2024.113511.

TER BRAAK, C.J.F.; ŠMILAUER, P. **CANOCO** Reference manual and CanoDraw for Windows User's Guide (Version 4.5). Ithaca: Microcomputer Power, 2002.

WILLIAMS, D.D. **The Biology of Temporary Waters.** Oxford: Oxford University Press, 2006.