Hexapod diversity of Dominican monocotyledonous plants in the families Heliconiaceae and Zingiberaceae in relation to elevation

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ABSTRACT

Hexapod diversity is tightly linked to floral diversity in tropical regions, including the islands of the Caribbean. The aim of this study was to investigate the presence of any correlation between the diversity and evenness of the hexapod fauna inhabiting monocotyledonous plants in the families Heliconiaceae (i.e., heliconias) or Zingiberaceae (i.e., gingers) on the tropical island of Dominica. Arthropods were collected at different elevations on these two plan types throughout the island. Through the use of the Shannon-Weaver diversity index and analysis of r^2 trend line values no significant correlation was found between elevation and arthropod diversity. However, a higher number of taxonomic groups inhabiting heliconia plants was found compared to those in the ginger family.

Keywords: Shannon-Weaver Diversity, Evenness, Heliconiaceae, Zingiberaceae

INTRODUCTION

It is estimated that around sixty percent of Dominica is covered with natural forests categorized by nine vegetation types that form concentric rings around tall mountains. Some of these vegetation types include deciduous forest, dry scrub forest, elfin forests, as well as primary and secondary rain forests (Guye, 2009). The fauna of Dominica is just as diverse, especially regarding arthropods. For example, at least 14 species of leaf beetles have been reported across Dominica and 14 families of beetles have been noted throughout the forest canopy (Martin, et al. 2006; Vilaythong, 2001).

To date, there have been no studies concerning the hexapod fauna inhabiting the outside of flowering monocotyledonous plants on Dominica. Therefore, this study was focused on the determining the hexapod biodiversity found on the leaves and flowers of monocotyledonous plants in the families Zingiberaceae and Heliconiaceae. Throughout Dominica, heliconia plants (Heliconiaceae) are among the most common and noticeable large herbs (Lack and Whitefoord, 1997). Heliconias can be identified by their common deep-red or yellow elongated bracts, which are sometimes mixed with light green and often are pollinated by hummingbirds (Lack and Whitefoord, 1997). Another common type of monocotyledon plant on Dominica is the ginger family (Zingiberaceae), which is typically found at mid to high elevations in clearings or along paths. Gingers are important spice, ornamental, and medicinal plants (Lack and Whitefoord, 1997) throughout the Caribbean. More insight to the Hexapods present on monocotyledonous plants could provide a basis for further studies investigating the relationship between these plants and the fauna that inhabits them, especially with regards to an elevation gradient.

MATERIALS AND METHODS

Subsamples of hexapods were taken from flowering plants in the Heliconiaceae and Zingiberaceae families at different locations and elevations throughout the island of Dominica. To do this, a standard “beat-sheet” insect collection technique was utilized (Mississippi, 2015). Briefly, the beating method utilized consisted of physically agitating the stems and leaves of a flowering monocotyledonous plant five to seven times with the handle portion of a bug net (Bioquip) and catching the falling hexapods and debris on a beat-sheet blanket (Bioquip). The contents knocked onto the beat-sheet net were then gathered using an insect aspirator (Bioquip)

and aspiration took place for 30-45 seconds or until all visually noted hexapods were inhaled into a storing vial. All sample vials were placed in a freezer for 20 minutes to knock down any and all hexapods before transferring the contents into a container with 75% ethyl alcohol vials for storage and subsequent identification using microscopy and printed hexapod keys.

The locations of all sampling sites throughout Dominica included Syndicate National Park, the Roseau Botanical Gardens, Middleham Falls, the Kalinago Territory, Emerald Pool, the Archbold Tropical Research and Education Center (ATREC), and Boeri Lake. Hexapods were identified to the taxonomic level of family, or genus, based on the availability of proper keys and expertise.

The data were analyzed for diversity among the sites using Shannon's diversity index (*H*) as follows:

$$H = -\sum_{i=1}^{s} P_i \, lnP_i \qquad \text{(Equation 1)}$$

Where *s* is the total number of species in the community (i.e., species richness), and P_i is the proportion of *s* made up of the *i*th species. P_i is the proportion of *s* made up of the *i*th species, and E_H is the evenness. Evenness was calculated among the sites using the Evenness index (E_H) as follows:

$$E_H = H / \, ln \, S \qquad \text{(Equation 2)}$$

Where *H* is Shannon's diversity index, and *S* is the total number of species in the community (i.e., species richness). *H* reports both on the richness, *S*, and the probability that a

certain individual, *i*, belongs to a taxonomic group to give a numerical value for abundance. As *H* approaches 0 the chances that an individual belongs to only one taxonomic category increases and most of the abundance is concentrated around one taxonomic group as compared to many. As *H* moves away from 0 the inverse is true, and the chance that a certain individual belongs to any one of the present taxonomic groups increases. The value of *E* reports on how similar the abundance of different taxonomic groups is. When there are similar proportions of all species the value of *E* is close one, but when the abundance is very different, the value of *E* increases.

RESULTS

A total of 27 sites across Dominica were sampled from 8 to 23 June 2016. The samples ranged from 24.9 m.a.s.l. to 865.3 m.a.s.l. in elevation. The average elevation across the samples was 562.5 m.a.s.l. A total of 23 different hexapod families were found across the heliconia and ginger plants sampled. Tables 1 and 2 contain the numerical counts of specimens sampled from heliconia and ginger plants. The average number of taxonomic groups found across heliconia samples was 3.76, while that for ginger samples was 2.90.

Figure 1 reports the relative abundance of Hexapods from heliconia samples. A total of 16 different taxonomic groups were found across the heliconia samples. These plants were dominated by formicid ants in the genera *Wasmania* and *Dendromyrmex*. Figure 2 reports the relative abundance of Hexapods from ginger samples, in which *Wasmania* sp. were present across all samples. A total of 13 taxonomic groups were found across the ginger samples. The only taxonomic groups that were found on both heliconia and ginger samples were *Wasmania* sp., *Dendromyrmex* sp., *Pheidole* sp., Silvanidae, Isotomidae, Cercopidae, and Phylloxeridae.

Figure 4 reports the number of hexapod taxonomic groups founds with respect to elevation for both heliconia and ginger samples. The r^2 correlation coefficient value for the trend lines of insect diversity heliconia and ginger with respect to elevation were 0.03 and 0.10, respectively, thus not showing a strong association between hexapod diversity and elevation.

Figure 5 reports the evenness of Hexapods found in sites of heliconia and ginger in relation to elevation. The average evenness value for hexapods found in the heliconia sites was 0.65 and the r^2 value for the evenness trend line was 0.02. The average evenness value for hexapods found in the ginger sites was 0.68 and the r^2 value for the evenness trend line was 0.06.

DISCUSSION

Although no significant correlation between elevation and monocotyledonous plant insect diversity was shown by this study, we gained insight to prominent hexapods inhabiting the plants of the Heliconiaceae and Zingiberaceae families on the island of Dominica. Formicid ants in the genus *Wasmania* were found across the majority of samples taken from sites of differing elevations. When *Wasmania* or *Dendromyrmex* ants were found in tandem from the same site, they never appeared to be in equal proportions, as one genus always seemed to dominate the flora over the other. Heliconia generally had three to six differing taxa compared to that of the ginger samples, which generally had only one to three differing taxa.

Possible sources of error during sampling could include sampling bias, lack of numerous sample sites, human error, and unforeseen weather phenomena. Sampling bias could have occurred due to sampling heliconia or ginger that were easily accessible or on the side of the road and or trail. These samples could have different fauna as compared to the fauna inhabiting

heliconia or ginger found further in the brush. Ideally 30 samples per monocotyledon would allow for enough buffer room to account for type I and type II errors, and only 27 sites were sampled, 14 heliconia and 10 ginger. Increasing the sample size would improve the chances of producing more precise data and allow for more interpretation of the data obtained. Human error could have affected the data by failing to catch all the fauna on the beat-sheet that were agitated from the monocotyledons. Samples taken after the 19th of June were subject to abnormal amounts of rainfall due to a tropical storm, and the excess water could have affected the fauna clinging to the leaves of the monocotyledons.

Despite the lack of establishing a trend between elevation and Hexapod diversity in monocotiledoneous plants, information concerning the inhabitants of heliconias and gingers was obtained. These data could be used and built upon to better understand the diversity of fauna throughout Dominica. Perhaps further studies could incorporate more samples and take into account other variables such as average rainfall or wind speeds in different parts of the island.

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FIGURES AND TABLES

Table 1. Total number of individuals collected from each Hexapod taxonomic group at each of the 17 sites where heliconia plants were sampled.

Hexapod taxonomic group	Site Number																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Wasmania sp.	37	21	10	39	10	4	33	11	32	3	1	152	1		1	1	1
Dendromyrmex sp.			18	1		2	1			1	8		2	3			
Pheidole sp.	1						1										
Silvanidae	2	3			4		1			1				1			2
Staphylinidae		2		1		1	1	1									
Chrysomelidae				1	1				1								
Isotomidae		3	2	7						1			1		1	1	
Entomobryidae					3										2	2	
Sminturidae	2	1	11			1											
Pentatomidae							1										
Cercopidae			2														
Aphidae			1														
Psyllipsocidae		1	1														
Polyphagidae					1												
Thaumastocoridae								1	1								
Phylloxeridae	1																
Phasmatidae																	1
subtotal	43	31	45	49	19	8	38	13	34	6	9	152	4	4	4	4	4

Table 2. Total number of individuals collected from each Hexapod taxonomic group at each of the 17 sites where ginger plants were sampled.

Hexapod taxonomic group	Site Number									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wasmania sp.	3	2	4	6	1	167	14	10	1	2
Dendromyrmex sp.		1	3	1	3			1		
Pheidole sp.			3							
Silvanidae	4									
Isotomidae					1		4	6		
Cercopidae	1									
Phylloxeridae	2									
Blattellidae	1				4					
Miridae		1								
Peripsocidae			2							
Curculionidae					1					
Coccidae					1					
Pseudococcidae									1	
subtotal	11	4	12	7	11	167	18	17	2	2

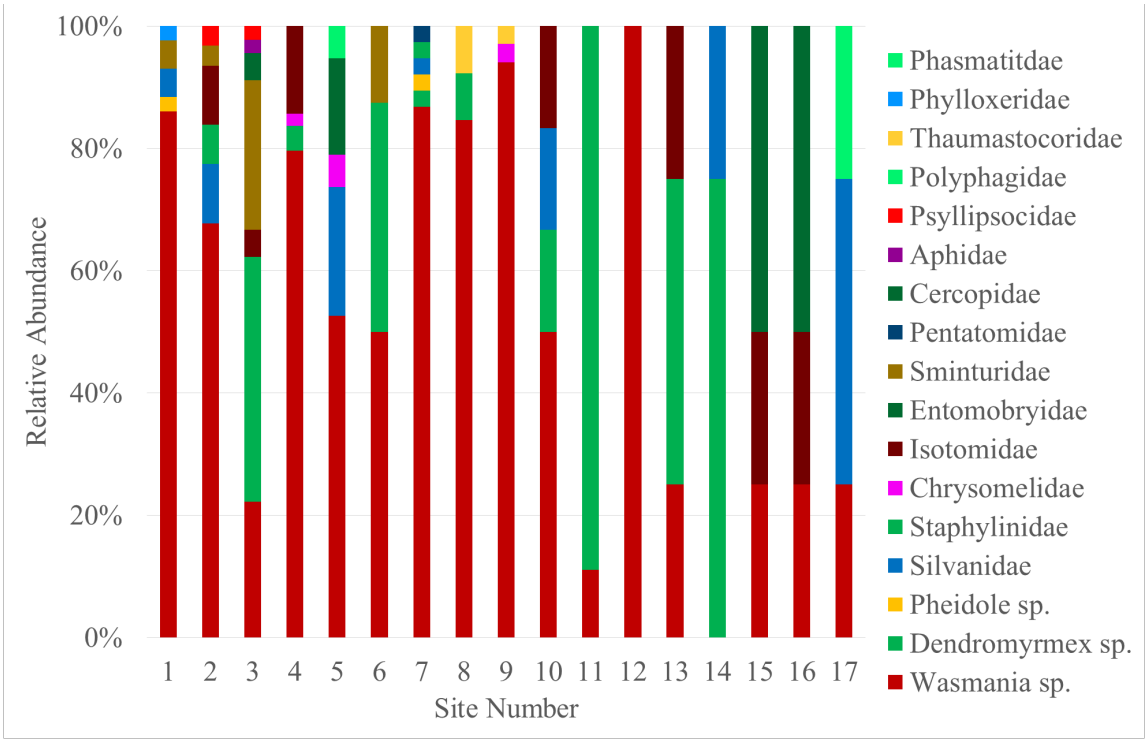

Figure 1. Relative abundance of hexapod taxonomic groups obtained from plants in the Heliconiaceae (H) family. A total of 17 sites were sampled across Dominica.

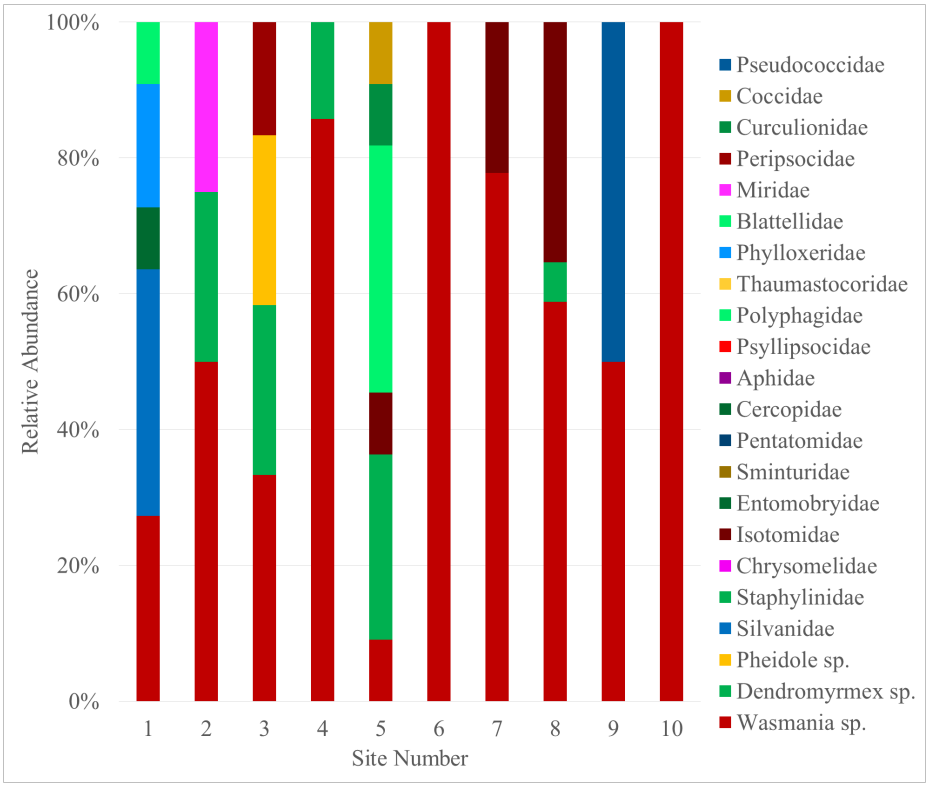

Figure 2. Relative abundance of hexapod taxonomic groups obtained from plants in the Zingiberaceae (Z) family. A total of 10 sites were sampled across Dominica.

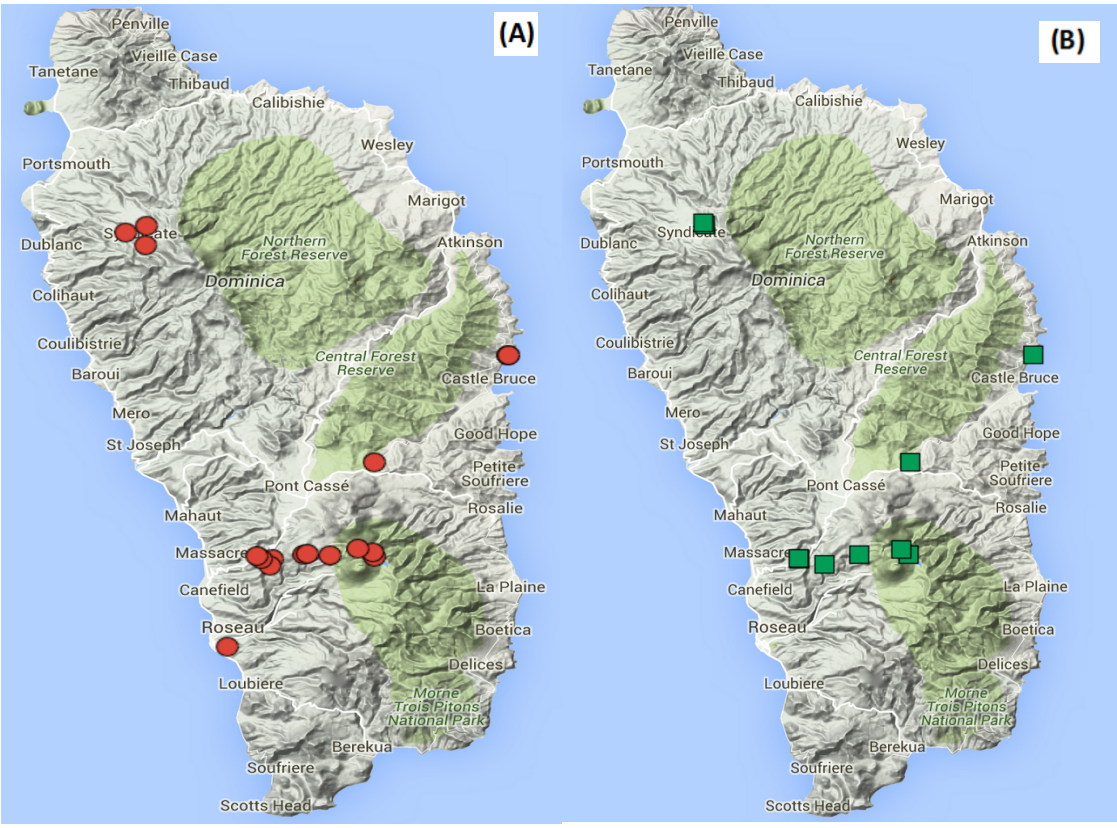

Figure 3. Physical map of Dominica showing the 17 locations (red circles) where hexapods were collected from plants in the Heliconiaceae family (panel A) and the 10 locations (green squares) where hexapods were collected from plants in the Zingiberaceae family (panel B).

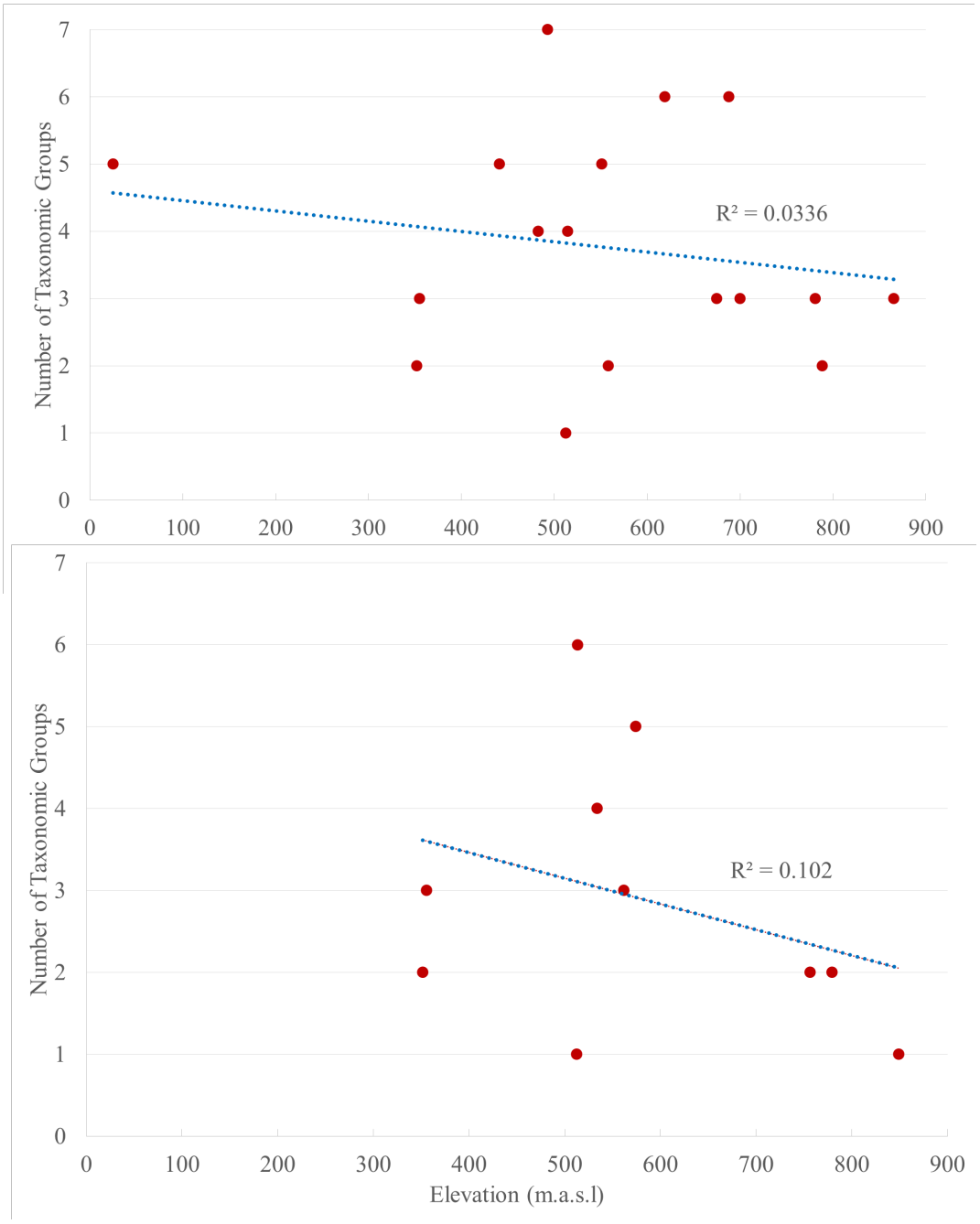

Figure 4. Number of hexapod taxonomic groups found on sampled plants in the families Heliconiaceae (A) and Zingiberaceae (B) based on elevation above sea level.

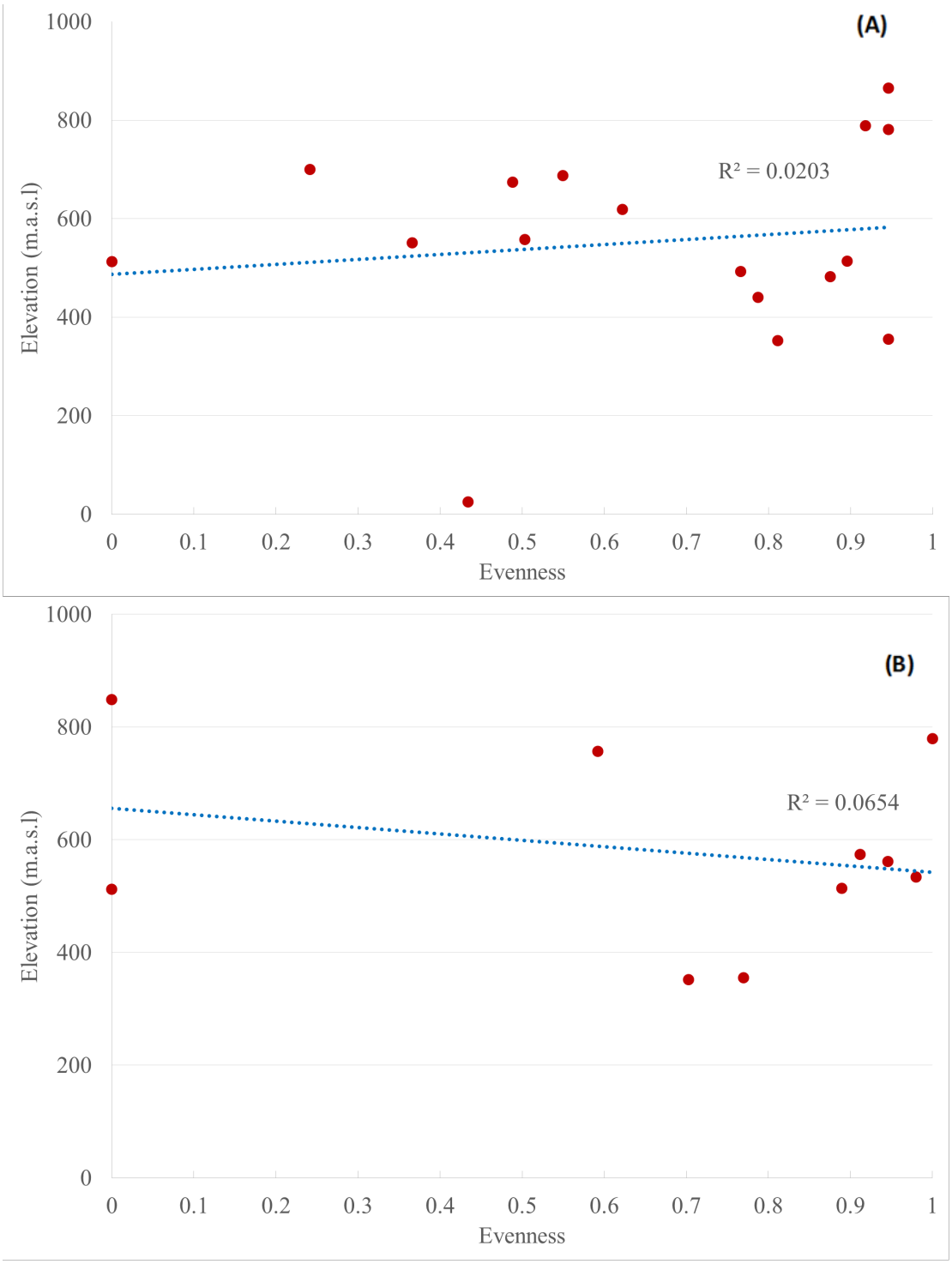

Figure 5. Evenness index found at different elevations above sea level for the taxonomic groups found on sampled plants in the families Heliconiaceae (A) and Zingiberaceae (B) based on elevation above sea level.

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