The influence of water volume and detritus on tank bromeliad communities

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Abstract: We investigated the impact of tank size and detritus content on the species richness and abundance of tank bromeliad invertebrate communities. We predicted that total invertebrate abundance and number of species would increase as bromeliad water volume and detrital mass increased. We sampled invertebrate communities in the tanks of ten epiphytic bromeliads, without respect to species, in the elfin forest near the continental divide, Monteverde, Costa Rica. Total invertebrate abundance was positively related to the amount of detritus, but species richness was not. Water volume and detrital mass were not correlated. Together water volume and detritus explained 75% of the variation in invertebrate abundance in tank bromeliads.

Key Words: Bromeliaceae, phytotelmata

Introduction

Tank bromeliads (Bromeliaceae), epiphytic terrestrial plants that collect water in basins formed by their interlocking leaves, are ideal systems in which to observe the influence of energy and nutrient inputs and habitat size on species richness and abundance. Bromeliad tanks host amphibians and aquatic invertebrates including insect larvae, worms, and zooplankton that derive their nutrients and energy from the detritus that falls into the tanks from the forest canopy (Forsyth and Miyata 1984). As the volume of water in the bromeliad bracts increases, there is more habitat available to aquatic invertebrates. Similarly, when a bromeliad collects more canopy detritus, there is a larger supply of energy and nutrients available to the community. Increasing water volume and nutrient availability may enable a tank to support more individuals (Begon et al. 1983).

An increase in bromeliad water volume may also increase the number of species present in a bromeliad. Studies of other phytotelmata, such as tree holes, have found that larger tanks of water had a corresponding increase in the number of invertebrate species (Jenkins 1992, Kitching 2001, and Yanoviak 2001). Studies in terrestrial communities and other aquatic communities have found similar results (Begon et al. 1983). However, the relationship between nutrient availability and species richness is less clear and the mechanisms are more controversial. Studies of phytotelmata have found that there is a positive relationship between the amount of detritus and invertebrate species richness (Kitching 2001, Yanoviak 2001). This suggests that an increase in resources within bromeliads may allow the tanks to support a greater variety of species. We predicted that both invertebrate abundance and species richness would increase when water volume and detrital mass increased.

Methods

We sampled ten epiphytic bromeliads, without respect to species, in the elfin forest near the continental divide in Monteverde, Costa Rica. We selected bromeliads that were 0.5-1.0 m at their maximum plant diameter and within 2 m of the ground. In the field, we removed particulate detritus from the tank with tweezers and by hand. We removed the tank water using a straw and turkey baster. Finally, we collected all macroinvertebrates visible on the inner surface of the bromeliad leaves, below the level of the water in the tank.

We weighed the detrital wet mass collected from each plant, then removed all visible animals from the particulate detritus. We measured the volume of water extracted from each tank and separated invertebrates into morphotypes using a dissecting microscope. In addition, we counted morphotype richness and total invertebrate abundance (number of individuals) found in the bromeliad water and detritus.

We used multiple linear regression (backward elimination) to determine whether bromeliad water volume and detritus were significant predictors of invertebrate morphotype richness. To assess the relative importance of each predictor to the final regression model, we used partial correlation coefficients.

Results

Tank bromeliad volume ranged from 31 -189 mL. Detrital mass ranged from 7.34 -197.9 g. In our invertebrate samples we found representatives from many taxonomic groups, including ostracods, copepods, chrionomids, dipterans, coleopterans, cladocerans, collembolans, and arachnids. The number of morphotypes per sample ranged from 5 to 19, and the abundance of individuals per sample ranged from 10 to 299 (Table 1). The tanks with the highest abundance of individuals were dominated by a few morphotypes.

The number of invertebrates species could not be explained by either the amount of nutrients or water volume (df = 9, P = 0.23). Detritus and bromeliad volume were not correlated (r = -1.15, P = 0.67). However, both detritus and bromeliad volume were significant predictors of total invertebrate abundance (Fig. 1; whole-model $r^2 = 0.75$, df = 9, P = 0.008). When considered separately, volume and detritus each significantly affected total abundance (P = 0.03 and P = 0.005, respectively). Detritus (partial correlation coefficient r = 0.87) contributed more to variance in invertebrate abundance than did bromeliad volume (r = 0.34).

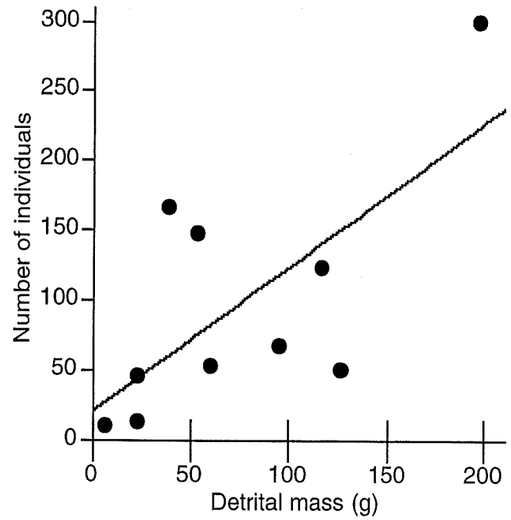

FIG. 1. Detrital mass of tank bromeliad samples (n = 10) collected in Monteverde, Costa Rica is a significant predictor of invertebrate abundance. Invertebrate abundance = -77.1 + (1.2 * detritus) + (0.90 * volume).

Table 1. Total number of morphotypes and total invertebrate abundance found in bromeliad tanks at Monteverde, Costa Rica.

Bromeliad Tank #	Total # of morphotypes	Total Abundance
1	11	53
2	18	67
3	19	166
4	5	10
5	8	13
6	13	299
7	16	49
8	19	123
9	18	148
10	12	46

Discussion

Our results indicated that invertebrate morphotype abundance in tank bromeliads increases with both detrital mass and water volume. However, detrital mass was the best predictor of invertebrate abundance. Thus, if the amount of detritus, and therefore nutrient levels, had not increased proportionally to increases in volume, larger bromeliads may not have supplied the resources needed to support greater invertebrate abundance.

Variation in invertebrate richness remains unexplained. Greater habitat heterogeneity can create more niches, increasing species richness. However, increases in volume, energy and nutrients do not necessarily increase heterogeneity. Furthermore, if invertebrate colonization of bromeliad tanks in the Monteverde elfin forest is rare, or the species pool of colonizers is small, morphotype richness would not necessarily increase with water volume and detrital mass.

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