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ABSTRACT

Protists are microscopic organisms which play a vital role in nutrient degradation in tank bromeliads (Carrias et al. 2001). Their communities provide good subjects of study for the effects of nutrient availability in an ecosystem. One hypothesis says that the number of individuals that an ecosystem harbors is determined by to total energy that enters. This study tested the prediction that there will be a relationship between nutrient availability and abundance of protists in tank bromeliads. Data were collected among 25 bromeliads located within the Monteverde Cloud forest, Cerro Plano, Costa Rica and the following parameters were estimated: the number of protists and nutrient resources (canopy density, water volume, tank diameter, and detritus dry weight). Regressions analyses showed there were only significance between detritus weight by water volume and number of detritivores by number of photosynthetic protists. This study shows that none of the resources tested were significant in determining protist abundance in bromeliad tank communities, however, further study is needed.

RESUMEN

Protists es los organismos microscópicos que desempeñan un papel vital en la degradación nutriente en los bromeliads del tanque (Carrias y otros. 2001). Sus comunidades proporcionan buenos temas del estudio para los efectos de la disponibilidad nutriente en un ecosistema. Una hipótesis dice que el número de los individuos que un ecosistema abriga está determinado cerca para sumar la energía que entra. Este estudio probó la predicción que habrá una relación entre la disponibilidad y la abundancia nutrientes de protists en bromeliads del tanque. Los datos fueron recogidos entre 25 bromeliads situados dentro del bosque de la nube de Monteverde, Cerro Plano, Costa Rica y los parámetros siguientes eran estimados: el número de protists y de recursos del alimento (densidad del pabellón, volumen del agua, diámetro del tanque, y peso seco del detritus). Los análisis de las regresiones demostrados allí eran solamente significación entre el peso del detritus al lado de volumen del agua y número de detritivores por el número de protists fotosintéticos. Este estudio demuestra que ningunos de los recursos probados eran significativos en la determinación de abundancia del protist en comunidades del tanque del bromeliad, sin embargo, el estudio adicional es necesario.

INTRODUCTION

Tank bromeliads are considered keystone species, especially in tropical forest (Carrias et al. 2001). Bromeliads are plants whose leaves are arranged spirally, forming a rosette that enables some species to store water that falls from the canopy as well as hold decaying materials; this tank provides the plant with both water and essential nutrients (Morales 2000). Fallen debris is caught by the bromeliad's rosette formation serves as one of the main sources of nutrients for the plant. These nutrients are absorbed by the roots and trichomes growing inside of the tank (Morales 2000). Thus, these tank bromeliads create their own phytotelm communities. Phytotelmata refers to small bodies of water within leaves, flowers, and tree holes. The phytotelm communities within these tanks represent almost all major groups of freshwater organisms (Carrias et al. 2001).

Though there are many macro and microorganisms represented in these communities, protists are one of most significant contributors. Protists are unicellular eukaryotes that obtain their energy and nutrients by heterotrophy, although some may contain chloroplasts for photosynthesis (Patterson 1998). They are essential in phytotelm communities because of the role they play in releasing nutrients to the plant by acting as pathways for dissolved organic matter, and by consuming bacteria (Spaulding 2005). Despite their small size, protists play a vital role in these tank bromeliad ecosystems, therefore, playing a vital role in tropical forest ecosystems.

The tanks of bromeliads are isolated communities, meaning that, protist inhabitants cannot move freely from one bromeliad to another. Therefore, these communities can be used as model systems to understand factors that influence the structure of natural communities, such as nutrients or weather patterns (Armbruster et al. 2002). Also, because of the tanks small size, the whole community from each plant can be collected and quantified with a degree of accuracy not possible in larger ecological systems (Richardson et al. 2000). Thus, bromeliads allow for accurate study of the cause and consequence of nutrient availability in ecosystems. Nutrient availability should have a huge impact on the number of individuals according to the "More Individuals Hypothesis". This states that a more nutrient-rich habitat has more individuals and species, because in productive habitats even scarce species are sufficiently abundant to resist extinction (Srivastava & Lawton1998). Therefore, bromeliads with more nutrients according to this hypothesis should have more individuals. This study will explore patterns between the numbers of individuals in protist communities and the amount of nutrients. It tests the "More Individuals Hypothesis" with the prediction that the number of protists will increase in a tank as the amount of nutrients increases.

MATERIALS AND METHODS

This study was conducted in closed canopy cloud forest in Cerro Plano, Costa Rica located behind the Monteverde Biological Station at an altitude of 1540-1750m. A total of 25 bromeliads were sampled for this study which included a variety of tank species and sizes. Only one bromeliad was sampled from each tree in order to keep the samples as independent as possible.

There were four parameters estimated: canopy density, tank diameter, volume of water in the tank, and detritus dry weight. Canopy density was quantified using a canopy densitometer. Tank diameter was measured (mm) using a caliper. The water within the tank was drained using a pipette, then gravity filtered, placed in a graduated cylinder, and the volume (mL) recorded. The collected water was homogenized by shaking the sample and two drops were viewed under a microscope at a magnitude of 400x. The number of protists was quantified using a five point system of analysis. With this system of analysis, five different fields of view of the microscope were viewed and the protists were counted in each individual field. Two groups of protists were identified: photosynthetic protists (possessing pigmentation) and detritivores (lacking pigmentation). The five fields of view were summed giving the total number of protists. The detritus that was filtered plus the detritus that was initially collected was dried and weighed.

With those measurements, a regression analysis was run to identify possible relationships between the aforementioned parameters and the numbers of individuals.

RESULTS

Of the nineteen regressions run, only volume of water by the detritus weight and the number of detritivores by the number of photosynthetic protist was significant (Table 1, Fig. 1&2). The number of detritivores by the detritus weight, the number of photosynthetic protist by the detritus weight, and the total protist abundance by the detritus weight were very close to significant (Fig. 3, 4, & 5). There was no significant regression between canopy density and photosynthetic protists (Table 1). One noticeable pattern during data collection were the fluctuations in the daily volume of water and the number of protists in tanks.

DISCUSSION

Overall, these results do not support the original hypothesis that there will be a relationship between the amount of nutrients and the number of protist individuals. Interestingly, detritus dry weight had no significant effect on the abundance of protists (Fig. 3, 4, & 5). These communities are supposed to be detritus based, so it is interesting that detritus did not have a greater effect on the number of protist. It is also intriguing that the other nutrients did not have a significant effect on protist abundance (Table 1). For instance, Rosenzweig (1995) considered habitat area to be the factor that most influences number of individuals and species richness, with larger areas supporting more individuals because of low extinction rates. My results, however, show no significance between number of protists and tank diameter (Table 1). It was also intriguing that there was no significance between canopy density and amount of photosynthetic protists (Table 1). This could be due to protists being such efficient converters of energy, with many species showing gross growth efficiencies of 50% or more. Therefore photosynthetic protists may only need small amounts of light (Covich &Thorp 1991).

There was a significant relationship between the number of photosynthetic protists and the number of detritivores (Fig. 2). Every bromeliad sampled had more detritivores than photosynthetic protists and no bromeliads were found soley with detritivores, there were either bromeliads with both types of protists or no protists. This may indicate a case of diffuse mutualism between the two groups of protists. There were also great fluctuations in the number of protists in each bromeliad. During the collection period, however, there were great fluctuations in the weather as well. There were periods of dry, hot days and periods of cool, rainy days. The protist communities seemed to be affected by these trends illustrating Fox's (2002) view that natural communities might not be closed dynamic systems at all, but rather open systems with structures reflecting the influence of the surrounding biogeographical region. Tank bromeliad protist communities may illustrate this statement if protist community successive composition is effected by the conditions, such as weather, of the surrounding cloud forest. Further research needs to be done to see exactly how phytotelm communities are affected by the surrounding biogeographical region.

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LITERATURE CITED

Armbruster, P., Cotgreave, P., Hutchinson, R.A. 2002. Factors influencing community structure in a South American tank bromeliad fauna. *Oikos*. 96 (2): 225-234.

Carrias, J, M.E. Cussac, and B. Corbara. 2001. A preliminary study of freshwater protozoa in tank bromeliads. *Journal of Tropical Ecology* 17: 611-617.

Covich, A.P. & Thorp, J.H. 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, Inc, pp. 60-61.

Fox, J.W., 2002. Testing a simple rule for dominance in resource competition. *American Naturalist* 159: 305-319.

Morales, J.F. 2000. Costa Rica Bromeliads. INBio, Costa Rica, pp. 10-15.

Patterson, D.J. 1998. Free-Living Freshwater Protozoa. John Wiley & Sons, New York, pp.181-193.

Richardson, B.A., Richardson, M.J., Scatena, F.N. & McDowell, W.H. 2000. Effects of nutrient availability and other elevational changes on bromeliad populations and their invertebrate communities in a humid tropical forest in Puerto Rico. *Journal of Tropical Ecology* 16: 348-356.

Rosenzweig, M.L. 1995. Species Diversity in Space and Time. *Cambridge University Press,* Cambridge.

Spaulding, J. 2005. Protist community diversity in relation to resources in bromeliads. CIEE Spring Tropical Biology and Conservation, pp 1-9. Unpublished.

Srivastava, D.S. & Lawton, J.H. 1998. Why more productive sites have more species: an experimental test of theory using tree-hole communities. *American Naturalist* 152: 510-529.

Table 1. Regression analyses for the relationships between water volume, tank diameter, detritus weight, canopy density, and protist abundance in Monteverde bromeliads. Sample size equals 25 bromeliads. Asterisks indicate significant relationships.

	R^2	P
% Photsythetic protist by Tank dm	0.02	0.54
by volume of water	0.06	0.23
by detritus dry weight	0.02	0.54
by canopy density	0.00	0.98
Detritivores by Tank dm	0.00	0.97
by volume of water	0.03	0.42
by detritus dry weight	0.13	0.08
by canopy density	0.00	0.94
Photosynthetic protist by Tank dm	0.00	0.78
by volume of water	0.02	0.48
by detritus dry weight	0.14	0.06
by canopy density	0.00	0.98
Total protist by Tank dm	0.00	0.95
by volume of water	0.03	0.44
by detritus dry weight	0.13	0.07
by canopy density	0.00	0.97
Canopy density by detritus dry weight	0.04	0.31
Detritus dry weight by volume of water	0.36	0.002*
# of detrivores by # of photosynthetic protist	0.98	0.0001*

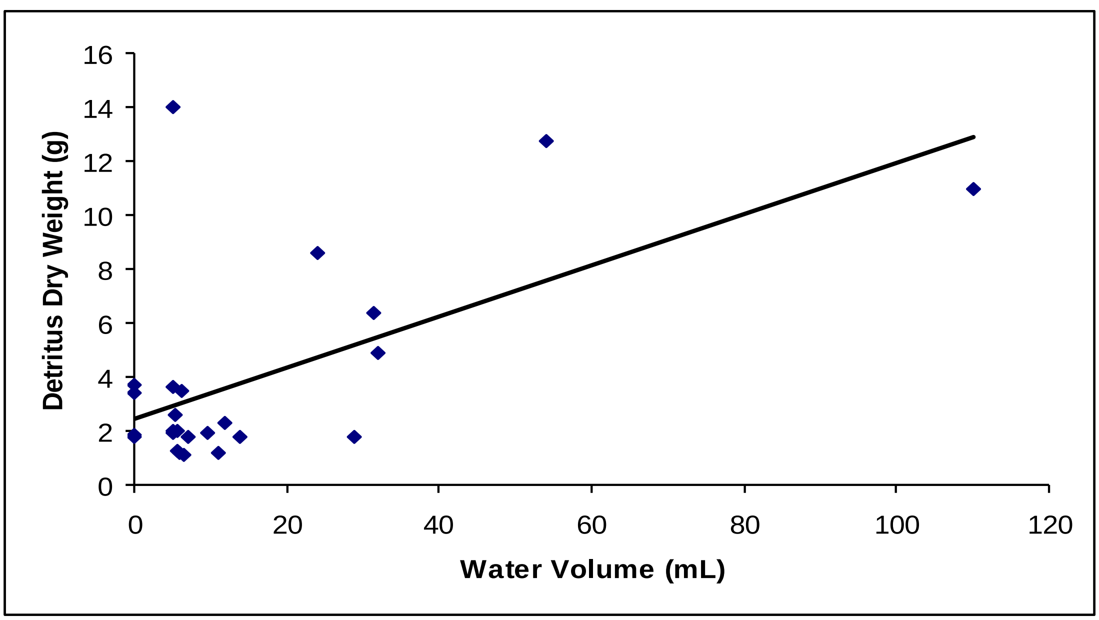

Figure 1. The simple regression for the detritus dry weight and water volume. The data were taken from cloud forest bromeliads. This regression was found to be significant ($R^2 = 0.36$, P value = 0.002, n =25).

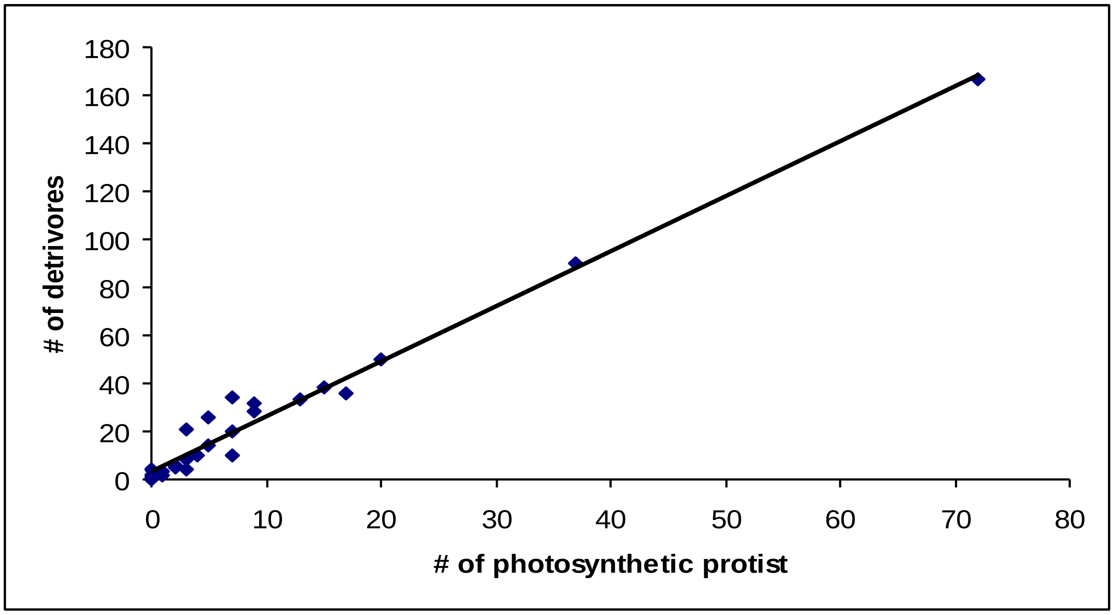

Figure 2. The simple regression for the number of detritivores and number of photosynthetic protist. The data were taken from cloud forest bromeliads. This regression was found to be significant ($R^2 = 0.98$, P = 0.0001, n = 25).

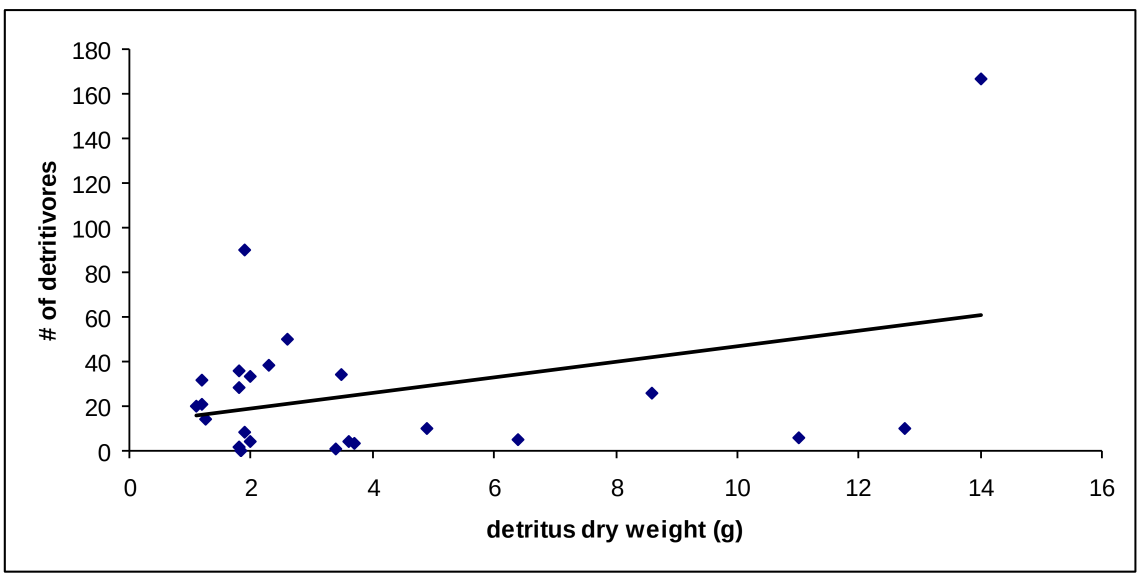

Figure 3. The simple regression for the # of detritivores and detritus dry weight. The data were taken from cloud forest bromeliads. This regression was not significant ($R^2 = 0.13$, P = 0.08, n=25).

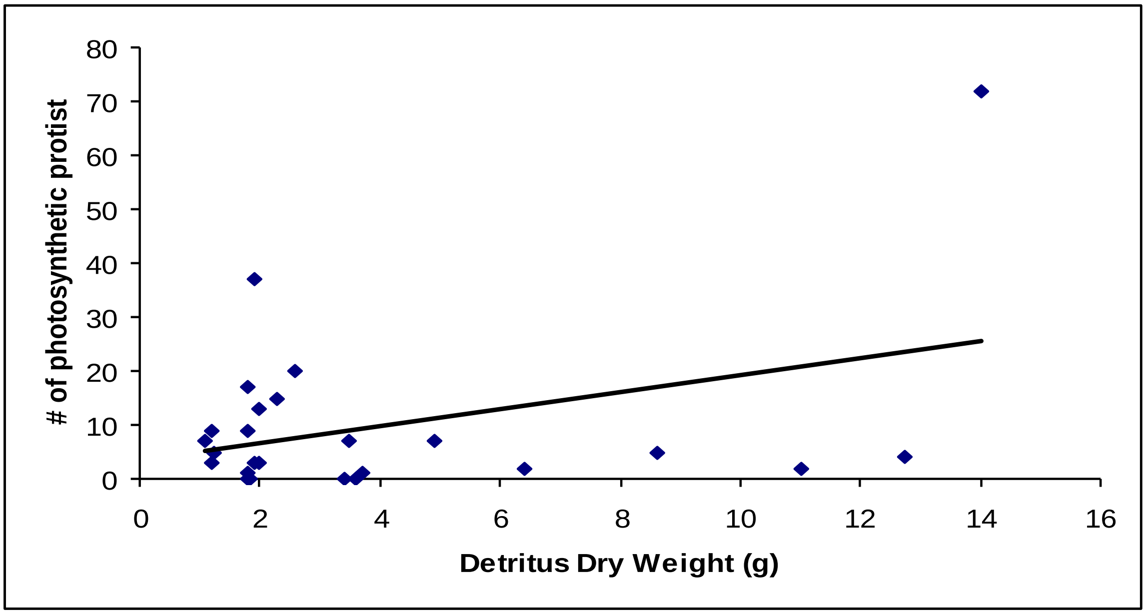

Figure 4. The simple regression for the # of photosynthetic protist and detritus dry weight. The data were taken from cloud forest bromeliads. This regression was not significant ($R^2 = 0.14$, $P = 0.06$, $n = 25$).

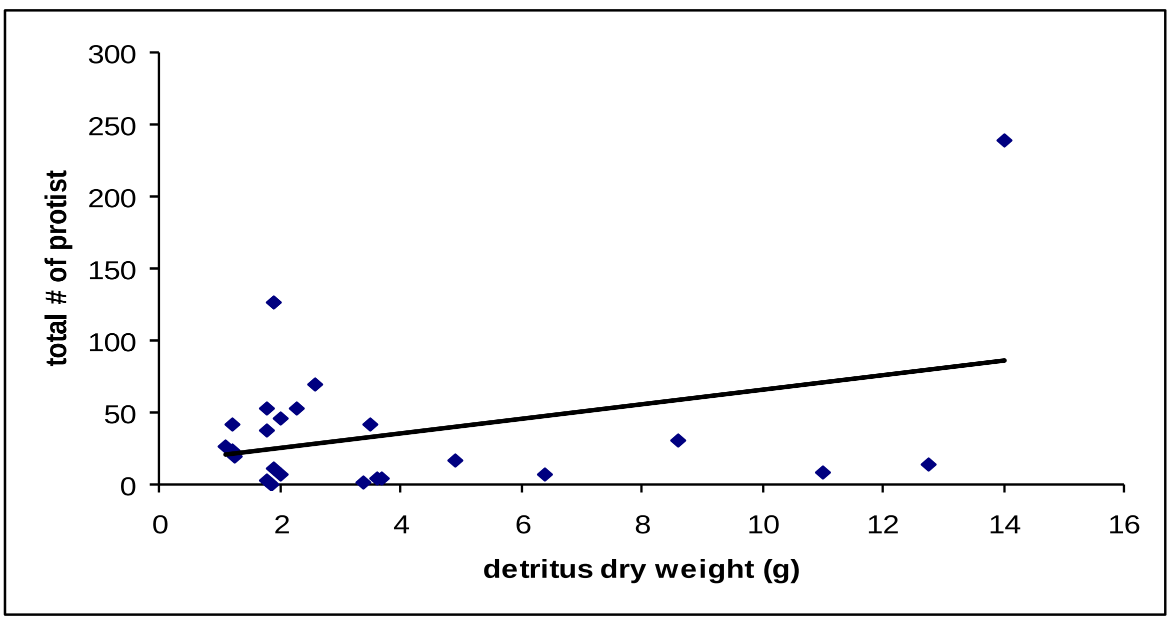

Figure 5. The simple regression for the total # of protist and detritus dry weight. The data were taken from cloud forest bromeliads. This regression was not significant ($R^2 = 0.13$, $P = 0.07$, $n = 25$).