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Supporting Online Material for

Predators Accelerate Nutrient Cycling in a Bromeliad Ecosystem

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Supporting Material –

Materials and Methods

Fertilization experiments. Experiments were conducted in Costa Rica (10˚59′ N, 85˚26′ W). A factorial fertilization experiment was conducted on the bromeliad *Guzmania scherzeriana* (n = 8), with two levels each of N (0N: no N added, 1N: 12 g L^{-1} KNO_3) and P (0P: no P added, 1P: 12 g L^{-1} NaH_2PO_4). Nutrient solutions (10 ml 4 d^{-1}) were added to bromeliad wells for 32 days, with leaf demography measured six months afterwards. For the insect experiment, potted *Conostegia xalapensis* Bonpl. (Melastomataceae) seedlings were fertilized (200 ml 2 wk^{-1}) for seven months with either nitrogen (12 g L^{-1} KNO_3), phosphorus (12 g L^{-1} NaH_2PO_4) or water (control) to produce leaf litter that is relatively enriched with either N or P. A factorial design of litter treatment (N, P, water) by species (one of the three major detritivore species: Tipulidae, Scirtidae, Chironomidae) was conducted (n = 10). One individual of standard length was placed in an artificial bromeliad (plastic leaf glued into a 50 ml centrifuge tube filled with water and covered with mesh) and provisioned with 0.7 g dwt of leaf litter (conditioned in water for 4 d). Water was changed (10 ml 2 d^{-1}) to simulate rain flushing and insect survivorship was monitored over 35 days.

Predator manipulations. Potted *Conostegia* seedlings were fertilized with $K^{15}NO_3$ (200 ml of 0.4 g L^{-1} $K^{15}NO_3$ pot^{-1} 2 wk^{-1}). Bromeliads (*Vriesea gladioliflora* H.Wendl.) were rinsed six months prior to the experiment, removing insect larvae and litter from the leaf wells, then exclosed with netting to prevent insect colonization. ^{15}N-enriched litter ($\delta^{15}N$ = 856 versus $\delta^{15}N$ = 1.8 in unmanipulated leaves) was added at the start of the experiment (4 g dwt per bromeliad). Detritivorous insects were added to a third of the bromeliads, while detritivores and predatory damselflies were added to another third and the remaining bromeliads were left without insects (n = 10 per treatment). Simulating oviposition, insects were again added three weeks later. After 40 days, the youngest leaves were collected from each bromeliad for isotopic analysis. Although different bromeliad genera were used for the fertilization and food web experiments, *Vriesea* and *Guzmania* have similar ecophysiologies, relationship with the insect community and use of leaf litter (S1, S2), and would be expected to respond similarly to these manipulations.

N:P ratios of detritivores and leaf litter. Over two months, detritivores were collected from bromeliads, pooling larvae within a bromeliad for each species (n = 6 for chironomid sp. A and scirtids, n = 4 for chironomid sp. B, n = 3 for tipulids). Falling leaf litter (n = 6) was collected for two weeks in mesh trays from positions formerly occupied by arboreal bromeliads.

Analyses. Phosphorus content was determined using the ammonium molybdate method after digestion with acid, while N content was measured using a LECO CHN analyzer. Isotopic analyses were conducted at the Environmental Isotope Lab, University of Waterloo. Data were transformed as necessary to fit statistical assumptions. GLMs used a log-link function and were based on Poisson errors. Scale parameters were used to correct for overdispersion.

Supporting Text

The N:P ratio of unfertilized bromeliads is extremely low (8.49 ± 1.28 by atom, mean ± SEM, n = 8, c.f. ref. S3), suggesting that the bromeliads are N-limited (S4). Experiments showed that addition of both N and P tended to increase the net production of leaves (Table S1). However, the two nutrients had different effects on leaf demography: addition of N increased the number of new leaves produced relative to the other treatments while P additions reduced the number of dead leaves. Bromeliad growth is therefore more strongly N-limited, although P affected leaf senescence. Nitrogen increased the survivorship of scirtid larvae (Table S2), but did not affect survivorship of tipulid or chironomid larvae. Phosphorus increased survivorship of both scirtid and, marginally, tipulid larvae, but not chironomid survivorship. Hence, while both N and P can limit insect productivity, there is no clear indication of overall N or P limitation for the detritivore community as a whole.

S1. D.H. Benzing, Bromeliaceae: Profile of an Adaptive Radiation (Cambridge Univ. Press, Cambridge, 2000).

S2. A. Reich *et al.*, *Oecologia* **137**, 587 (2003).

S3. J.J. Elser *et al*., *Nature* **408**, 578 (2000).

S4. W. Koerselman, A.F.M. Meuleman, *J. Appl. Ecol.* **33**, 1441 (1996).

Table S1. Results of two-way analyses of variance for the plant fertilization experiment. Degrees of freedom = 1, 27 for all F-values. The production of new leaves in bromeliads is more nitrogen-limited, while leaf senescence is more phosphorus-limited.

	Effect	F	p-value
Net change in number of leaves	N	3.86	0.06
	P	3.42	0.07
	N x P	0.202	0.66
New leaves	N	8.79	0.006
	P	0.452	0.51
	N x P	1.08	0.31
Dead leaves	N	0.218	0.64
	P	5.26	0.03
	N x P	0.135	0.72

Table S2. Results of GLM for insect fertilization experiment. Survivorship of the three most common detritivore insects was measured. Both nitrogen- and phosphorus-limitation of insect survivorship are observed, but no overall trend in nutrient limitation was observed for the detritivore community.

	Scirtid		**Tipulid**		**Chironomid**	
	z	p-value	z	p-value	z	p-value
N	-2.34	0.02	-0.86	0.39	-0.86	0.39
P	-2.28	0.02	1.85	0.06	0.01	0.99