What the Scientific Community Can Do

IN HIS EDITORIAL "SHOW US THE MONEY" (8 Dec. 2006, p. 1515), Donald Kennedy suggests that the scientific community should tell the Administration, the public, and Congress what it can accomplish for our society. As chairman and member of the executive committee of the Association of American Universities and as president of Northwestern University, which has made large investments in human and physical capital over the last decade, especially in the life and nano sciences, I want to do just that.

We can list many research-to-bedside accomplishments. A discovery in our chemistry labs by Richard Silverman led to the drug Lyrica, licensed to Pfizer, which has proved an effective neuropathic pain reliever for tens of thousands of patients. Many other universities can also point to new therapies and diagnostics that were discovered or developed in their lab.

The economic benefits of biomedical research are equally striking. One only has to look at the jobs created in the construction industry when we built the Robert H. Lurie Medical Research Center, the creation of many new biotech companies from our research efforts, or the mobilizing of private-donor support to see the economic benefits. The Chicago area has benefited mightily from our efforts, as Atlanta has benefited from Emory's efforts and Baltimore from those of John Hopkins.

Elias Zerhouni, director of NIH, is correct to note that we in the research community often take for granted the extraordinary return on investments in NIH ("NIH in the post-doubling era: realities and strategies," Policy Forum, 17 Nov. 2006, p. 1088). He refers to scientific and health care benefits. I can also point to the economic returns expressed in job creation and multiple effects of investment from the partnerships among the federal government, private donors, and the research universities.

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TECHNICAL COMMENT ABSTRACTS

COMMENT ON "Why Are There So Many Species of Herbivorous Insects in Tropical Rainforests?"

David A. Norton and Raphael K. Didham

Novotny *et al.* (Reports, 25 August 2006, p. 1115) argued that higher herbivore diversity in tropical forests results from greater phylogenetic diversity of host plants, not from higher host specificity. However, if host specificity is related to host abundance, differences in relative host abundance between tropical and temperate regions may limit any general conclusion that herbivore diversity scales directly with host-plant diversity.

Full text at www.sciencemag.org/cgi/content/full/315/5819/1666b

RESPONSE TO COMMENT ON "Why Are There So Many Species of Herbivorous Insects in Tropical Rainforests?"

Vojtech Novotny, Pavel Drozd, Scott E. Miller, Miroslav Kulfan, Milan Janda, Yves Basset, George D. Weiblen

Norton and Didham suggest that differences in plant abundance between tropical and temperate forests may influence the host specificity of herbivores in these forests. We agree in principle but show that this is likely only for very rare plant species in tropical forests. Studies of herbivores hosted by rare plant species would help our understanding of tropical plant-insect interactions.

Full text at www.sciencemag.org/cgi/content/full/315/5819/1666c

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Response to Comment on "Why Are There So Many Species of Herbivorous Insects in Tropical Rainforests?"

Vojtech Novotny,[1]* Pavel Drozd,[2] Scott E. Miller,[3] Miroslav Kulfan,[4] Milan Janda,[1] Yves Basset,[5] George D. Weiblen[6]

Norton and Didham suggest that differences in plant abundance between tropical and temperate forests may influence the host specificity of herbivores in these forests. We agree in principle but show that this is likely only for very rare plant species in tropical forests. Studies of herbivores hosted by rare plant species would help our understanding of tropical plant-insect interactions.

Norton and Didham (*1*) argue that differences in plant abundance between tropical and temperate forests may limit the general conclusion that herbivore diversity scales directly with host plant diversity. They point out that our study (*2*) did not include locally rare tree species. Our temperate/tropical comparison was standardized for sample size and plant phylogeny but not for plant abundance and, indeed, there are more rare tree species in tropical forest, including forests we studied (Fig. 1A).

Extremely rare plant species are expected to host fewer specialists, and herbivore species overall, as they represent a rare and scattered resource difficult to use by herbivores. However, it is not known what resource abundance is limiting for herbivorous insects. Specialized herbivores may be few in communities colonizing rare plants with unpredictable distribution in space and time, such as annual herbaceous species limited to brief, early stages of ecological succession after unpredictable disturbance events (*3*). It is less clear what represents extreme rarity for herbivores from large perennial plants, such as trees. Our study suggests that there is no impact of plant abundance on the species richness or the host specificity of their leaf-chewing communities for plant abundance characterized by the basal area from 0.01 to 10 m^2/ha (Fig. 1, B and C). This range included 117 out of the 151 plant species from 1 ha of the tropical forests (Fig. 1A). However, our study, similar to virtually all others from tropical forests (*4*), did not include rare species of plants.

Apart from methodological difficulties of sampling rare plant species for herbivores, there are other complications in the study of the effect of plant rarity on herbivores. Most insect herbivores prefer young foliage (*5*, *6*). The biomass of young leaves may be a better measure of resource abundance than the total plant biomass, which is mostly inedible to most of the herbivores. Low seasonality of leaf flush typical for many trees in tropical rain forests makes this resource available at lower densities for a longer time, compared with young leaves produced during a synchronized leaf flush in temperate forests. Young foliage in the nonseasonal tropics thus supports more herbivore generations, but possibly at lower population sizes, than similarly abundant but seasonal resources in the temperate forests.

The plant species with extremely high or low densities may also be unusual in other aspects of their ecology. For instance, monodominant forests offer an opportunity to study tropical herbivores feeding on exceptionally common tree species (*7*). However, these forests exist only in low-nutrient environments, such as sandy or swampy soils, which can also influence the quality of plant resources for herbivores. This is probably why the diversity of insect herbivores in these forests is low (*8*) and why they are not exceptionally host specific, contrary to expectations for an abundant resource (*9*).

The impact of plant abundance on herbivorous insects depends also on the colonization ability of the insects, which varies among species and clades. For instance, aphids are inefficient colonizers, which may explain their low diversity in tropical forests (*10*), whereas Lepidoptera typically disperse hundreds of meters to several kilometers in their lifetime,

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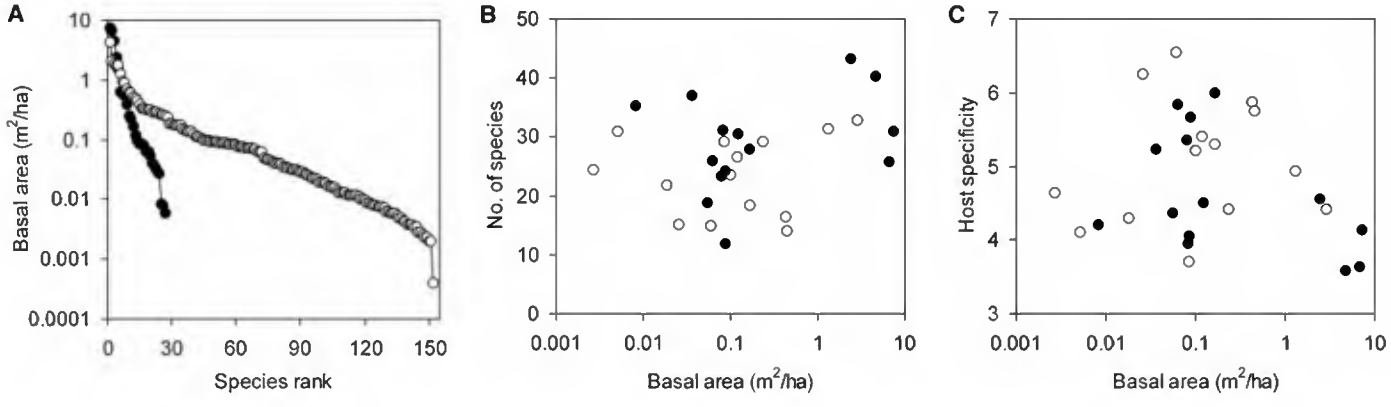

Fig. 1. The abundance of woody genera in temperate and tropical forests (**A**), and the relationship of plant abundance with species richness (**B**) and host specificity (**C**) of their folivorous herbivores. Plant abundance, expressed as basal area, that is, the combined area of the cross-section of all conspecific trees at 1.5 m above the ground, was estimated in 1-ha plots in the temperate (dots) and tropical (circles) forests at the study sites used by Novotny *et al.* (*2*, *14*). The number of folivorous species per 100 m^2 of foliage and the average number of host plant species of these herbivore species are shown for two sets of 14 tree species from respectively temperate and tropical forests (*2*). There is no correlation between the plant basal area and either of the herbivore variables in any of the two types of the forest (Pearson r, $P > 0.1$, both for the correlation using plant species as independent data points and for the independent contrasts analysis, taking into account statistical nonindependence of tree species due to their shared phylogeny).

although data from tropical forests are rare (*11*). Good dispersal ability of many tropical folivores is suggested also by their rapid colonization of pioneer trees recently established at disturbed sites (*12*) and of isolated plants in the forest (*13*).

Norton and Didham (*1*) point to an important, but for its technical difficulty so far neglected, problem—namely, the effect of plant rarity on the composition and ecology of herbivore communities in tropical forests. Finding what represents a rare species to a tropical insect herbivore will be important and interesting, but not easy.

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