Comment on “Disentangling the Drivers of β Diversity Along Latitudinal and Elevational Gradients”

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Kraft et al. (Report, 23 September 2011, p. 1755) analyzed two data sets and concluded that “there is no need to invoke differences in the mechanisms of community assembly in temperate versus tropical systems to explain these global-scale patterns of β diversity.” We show that their conclusion is based on inappropriate data and inadequate methods of analysis.

Understanding the mechanisms that drive β diversity—species compositional turnover among sites with respect to environmental variation and dispersal limitation—is an important step toward understanding global patterns of species diversity. Kraft et al. (1) related β diversity between ten 0.01-ha subunits of each of 205 transects to latitude or elevation and made a general conclusion on the mechanisms of community assembly in temperate versus tropical systems, which represent an ecological (largely temperature) gradient. Although the total area of each transect is fixed (0.1 ha) in (1), spatial extent varies among the transects because the ten 50-m-long subunits of each transect were placed in a random zig-zag pattern (2). Consequently, β diversity among transects is not comparable. In their study, each transect was sampled in such a way that a set of 10 subunits of the transect represented a relatively uniform segment of a forest community (2); environmental variation within the transect was therefore minimized. Because the largest distance separating any two subunits of a transect is usually much shorter than 500 m, β diversity between patches of a forest separated by such short distances is unlikely to be driven by environmental variation and dispersal limitation. Thus, their data cannot be used to test whether the ecological processes determining species composition differ among latitudes or altitudes.

It is widely recognized that latitude per se has little biological meaning. Statistical associations between species diversity and latitude are not directly causal but are derived from covaried environmental variables (3), primarily temperature. Temperature, in turn, is not constant at any given latitude and can vary dramatically both among and within regions. The same temperature can be found more than 20° of latitude apart at different longitudes (4), and species distributions and vegetation zones are known to reflect this (5). Furthermore, unique historical processes can result in substantial differences in the sizes of species pools and β diversity among regions with similar environmental conditions (6, 7). Consequently, when transects from different biogeographic regions are combined in a single analysis, as was done in (1), latitude is necessarily a poorer surrogate for the underlying environmental drivers of diversity than it would be if analyses were carried out within narrower longitudinal belts. When drawing ecological conclusions from their results, Kraft et al. did not take this constraint into account.

The majority of the 197 transects used in Kraft et al.’s (1) latitudinal analysis are located in South America. We reanalyzed Kraft et al.’s data points located in South America south of the equator [supporting online material (SOM) S1]. This subset data included 72 Gentry’s transects and are constrained within a single biogeographic region and a unidirectional equator-pole gradient. Our results show that there is a significant latitudinal gradient of β diversity after accounting for γ diversity (Fig. 1C), contrary to Kraft et al.’s conclusion.

Elevations vary greatly among the 197 Gentry’s transects used in (1), ranging from 20 to 2770 m (2), and the transects with high elevations are

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Fig. 1. Latitudinal trends in mean α and γ diversity (A), β diversity (B), β-diversity deviation without correcting for elevation difference (C), and β-diversity deviation after correcting for elevation difference (D) for woody plants in the 72 Gentry’s transects in South America south of the equator (SOM S1). The data for α diversity, γ diversity, β diversity (partition), and β deviation were obtained from the corresponding author of Kraft et al. and were used in their figures 1 and 3.
The latitudinal distribution of the 38 transects at 1000 m or higher elevations in the data set of the 197 transects used by Kraft et al.

exclusively located at low latitudes. For example, 38 of the 197 transects are located at 1000 m or higher elevations, and nearly all of these high-elevation transects are located in tropical regions. Moreover, the majority of the transects with elevations higher than 2000 m are located near the equator (Fig. 1A and Fig. 2). The average temperature lapse rate, at which the air temperature decreases with elevation, is about 6.5°C for every 1000-m rise in elevation (4). An upward shift of 100 m is predicted to translate into a polarward shift of 100 km in the temperate zone (8, 9). This prediction is consistent with the observation that the tree line declines ~100 m for every degree of latitude (5). Thus, a transect located at 2770 m near the equator is ecologically equivalent to a transect located at ~25°S or N in latitude at a low altitude. The failure to take into consideration the altitude-latitude relationship in (1) would have disfavored species richness at low latitudes and, thus, have undoubtedly biased their results and conclusions. After adjusting the latitudes of the 72 transects of South America south of the equator by using the 100-m elevation for 100-km latitude converter in our analysis, the relationship between latitude and β diversity is reinforced, regardless of whether β partition (β = −0.659, P < 0.001) or β deviation (compare Fig. 1C with Fig. 1D) is used.

Kraft et al.’s main conclusion is primarily based on the lack of linear relationships in the data presented in their figure 3C and figure 3D, where the relationships between β deviation and latitude/altitude tended to be unimodal (hump-shaped). Ecological factors that drive diversity patterns may have nonlinear relationships with latitude or altitude. The unimodal relationship shown in (1) may result from sampling and analysis biases and ecological mechanisms (SOM S2). For example, the unimodal relationship between β deviation and elevation in (1) is likely partly because their low elevation sites were located in areas with heavy human disturbances and do not represent the general conditions of forests at low elevations in the region (10) (SOM S2).

To illustrate the relationship between β diversity and latitude with γ diversity accounted for at a broad spatial scale, we analyzed a data set for woody plants (trees only) in North America (11–15). Our data set included 398 transects, each being 1100 km long and including 10 quadrats of 110 km by 110 km, which are approximately 1° by 1° latitude-longitude quadrats at the equator (SOM S3). β diversity for trees in North America is significantly and negatively correlated with latitude (β = −0.751, P < 0.001). After removing the statistical effect of γ diversity, latitude still explained a significant amount of the variation in β diversity (R² = 7.3%, P < 0.001) (SOM S3).

We conclude that the failure of finding the relationship between β diversity and latitude or elevation after accounting for the species pool in (1) resulted from the use of inappropriate data and inadequate methods. The mechanisms of community assembly that drive global patterns of β diversity remain open for investigation.

**References and Notes**

2. D. Phillips, J. S. Miller, Global Patterns of Plant Diversity: Alwyn H. Gentry’s Forest Transect Data Set (Missouri Botanical Garden Press, St. Louis, 2002).

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**Supporting Online Material**

www.sciencemag.org/cgi/content/full/335/6076/1573-b/DC1

SOM Text

Fig. S1

References

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