Hump-shaped species richness pattern along the elevation gradient in Taiwan: A result of mid-domain effect or heterogeneity?

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Introduction

Mid-Domain Effect **(MDE)** has two important concepts: one is the existence of hard boundaries and the other is the structure of species niche widths along the gradients. In this study, we hypothesized that the definition of hard boundaries may influence the relationship between pattern of woody species richness **(PWSR)** along elevations and MDE. And the heterogeneity **(HETE)** is one of the key factors which keeps the structure of species niche widths along elevations.

Our questions are:

1. **When the hard boundaries change into more reasonable ones with more sense of evolution, does the explanatory power of MDE on PWSR improve?**
2. **Does the HETE have better explanatory power for endemic PWSR than for non-endemic PWSR?**

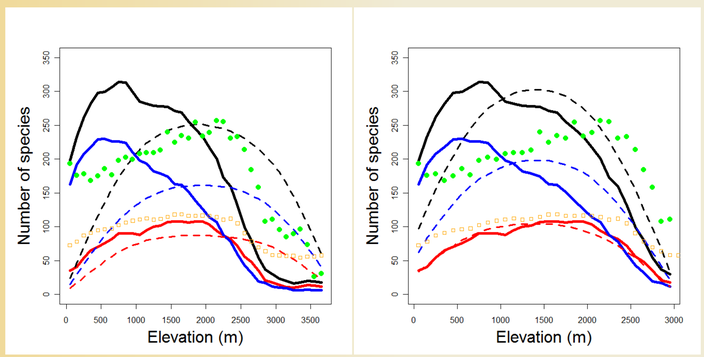

Figure 1. Distribution of dependent and independent variables along the elevation gradients. Black lines represent all species red ones are endemic species and blue ones are non-endemic species. Solid lines indicate the real species richness while the dashed lines are the null models. Green solid circle is the value of HETE and orange open rectangular is the ratio of species per genius. The left figure is derived from the dataset of scenario (I) and the right figure is derive from the dataset of scenario (IV).

Methods

Altogether 742 woody species and 6 549 plots were selected from Vegetation Database of Taiwan for calculating the PWSR and MDE. Fifteen GIS layers include 12 layers of monthly mean temperature from MODIS and 3 topographical layers from DTM. We calculated the variance of each layer within 100-m interval of elevation. After standardizing the variance, we summed these values together as HETE.

There are tow possible potential hard boundaries used here according to the history of evolution. One is 200 m under sea level which was the sea level during the glacial era. One is 3 000 m above sea level instead of 3 800 m (the timberline, now). This is the optimum of one dwarf bamboo, *Yushanina niitakayamensis*, which is a very strong competitor for all the other woody species. Thus the four hard boundary scenarios are: (I) **"0 m ~ 3 800 m"**, (II) **"-200 m ~ 3 800 m"**, (III) **"0 m ~ 3 000 m"** and (IV) **"-200 m ~ 3 000 m"**. We used GLM in finding the explanatory power of MDE and HETE on PWSR through these four scenarios.

Results

Table 1. The explanatory power of MDE, HETE and MDE x HETE on the pattern of woody species richness along the elevation gradient, as revealed by GLM. (I), (II), (III) and (IV) indicates four kinds of hard boundary scenarios. (sp. = species)

	MDE	HETE	MDE x HETE
(I) all sp.	3.17%	49.39%	62.28%
(I) endemic sp.	37.34%	81.17%	81.18%
(I) non-endemic sp.	--	32.63%	56.30%
(II) all sp.	12.10%	49.39%	56.60%
(II) endemic sp.	53.70%	81.17%	81.52%
(II) non-endemic sp.	2.05%	32.63%	47.81%
(III) all sp.	29.52%	11.23%	30.50%
(III) endemic sp.	88.98%	61.35%	90.73%
(III) non-endemic sp.	10.28%	1.55%	13.53%
(IV) all sp.	51.85%	11.23%	56.20%
(IV) endemic sp.	90.27%	61.35%	95.62%
(IV) non-endemic sp.	28.61%	1.55%	40.57%

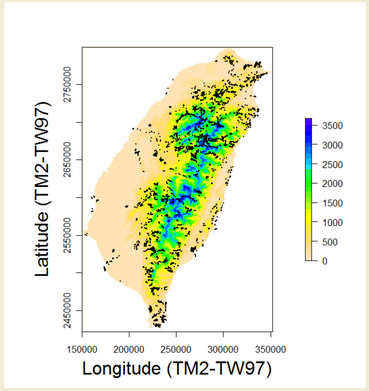

Figure 2. The geographical elevation gradient of Taiwan and the distribution of sampling plots (black dots).

Conclusion

When the hard boundaries change into 200 m under the sea level and 3 000 m above the sea level, MDE has the best explanatory power on the PWSR comparing to the other scenarios.

HETE has better explanatory power for the endemic PWSR than for the non-endemic PWSR.

MDE and HETE together form the hump-shaped diversity pattern along elevations. The hard boundaries was formed by the history of evolution and the structure of species niche width was formed by HETE.

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