The contribution of common and rare species to phylodiversity of communities across a global network of forest plots

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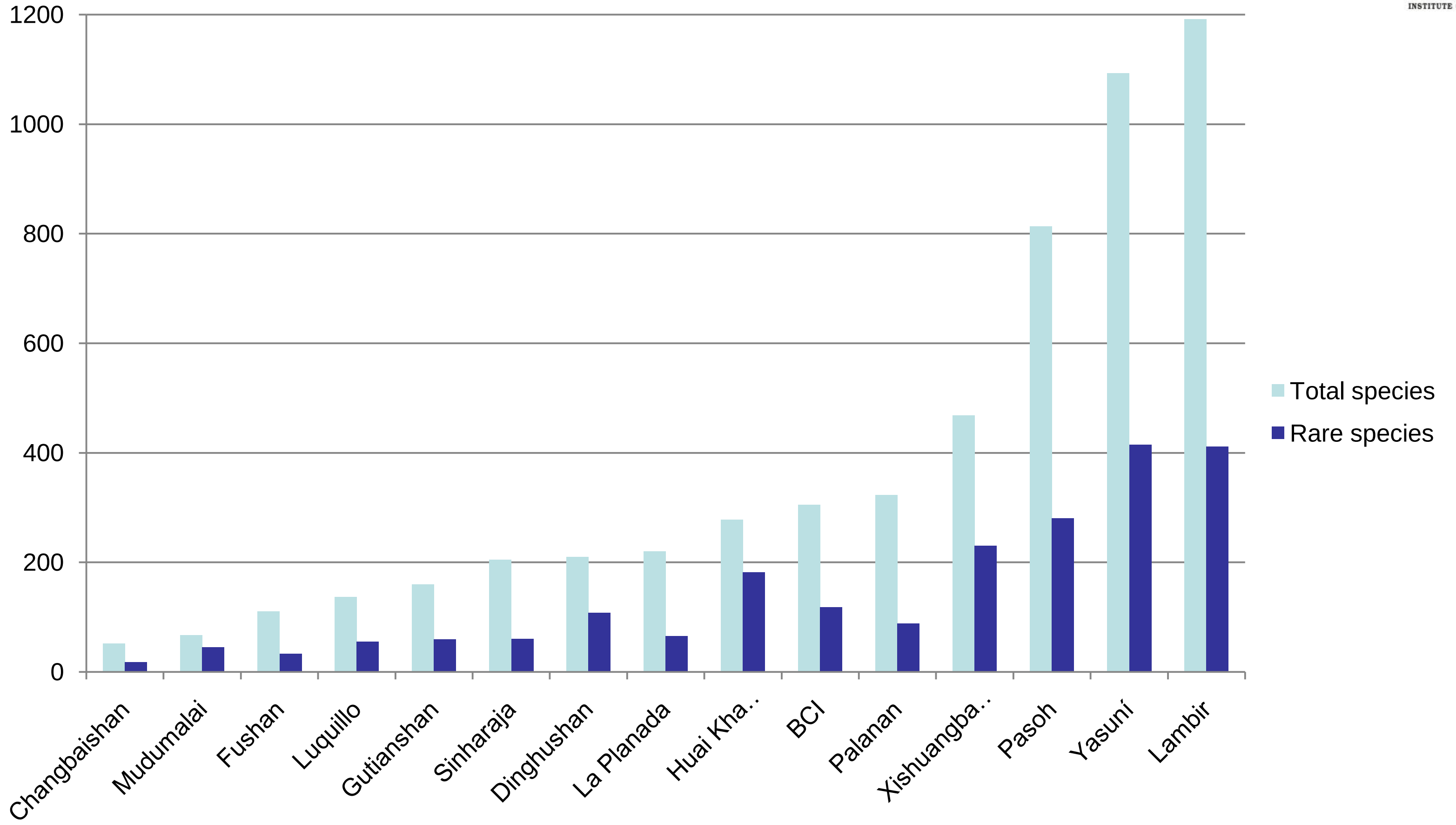
Introduction



Rare species account for 30-60% of species richness in temperate and tropical forest plots

Introduction

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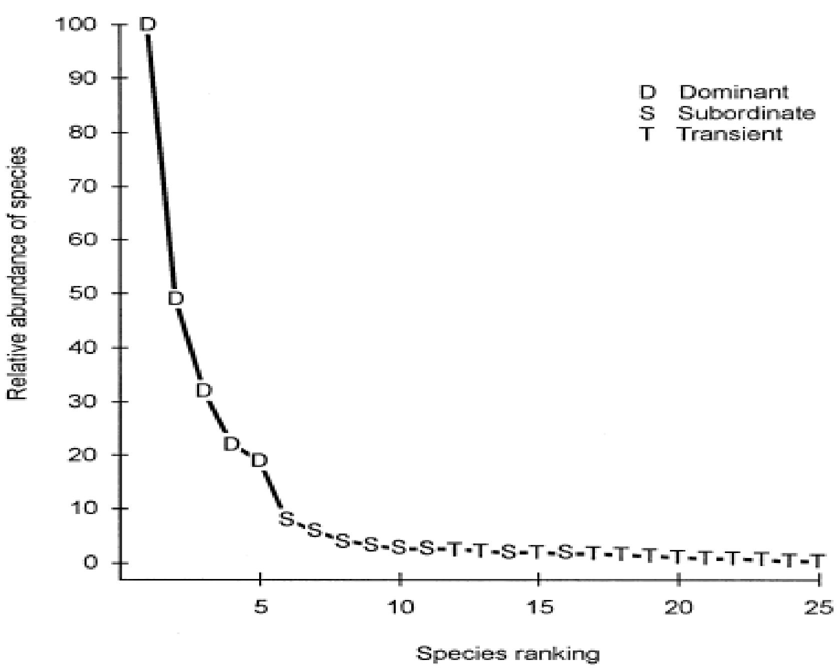
Mechanical explanation:

spatial niche difference:

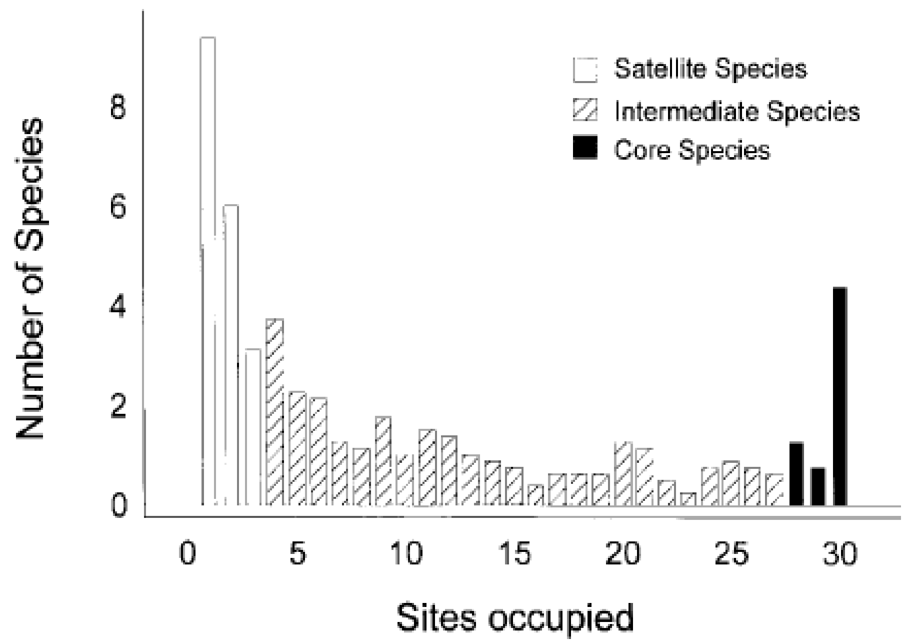
Niche position hypothesis (Gaston, 1994);

Dominants-subordinates-transients hypothesis (Grime, 1998);

Core-satellite species hypothesis (Hanski, 1982,1991);



From Grime, 1998, J. Eco., 86:902



From Gibson, 1999, J. Eco., 87:1064

Introduction

Mechanical explanation:

Temporal niche difference: Storage effect (Chesson, 2000; Kelly et al. 2001)

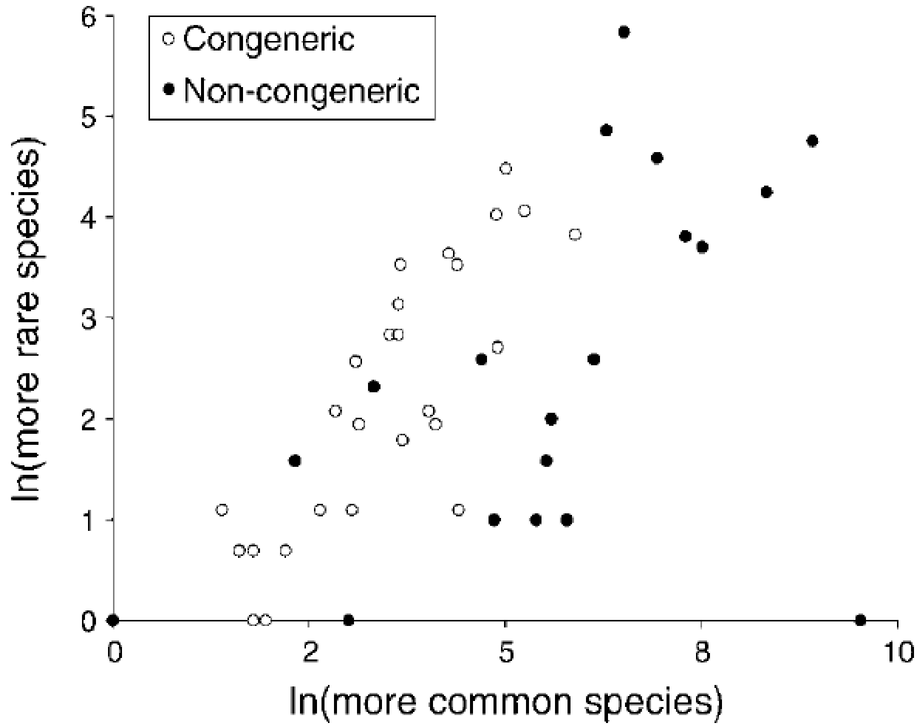
Neutral theory: Resource randomly assigned;

But testing these hypotheses is a methodological challenge:

1. **Niche differentiation could be an artifact when the examined species exclude each other competitively from parts of their fundamental niches in natural communities;**

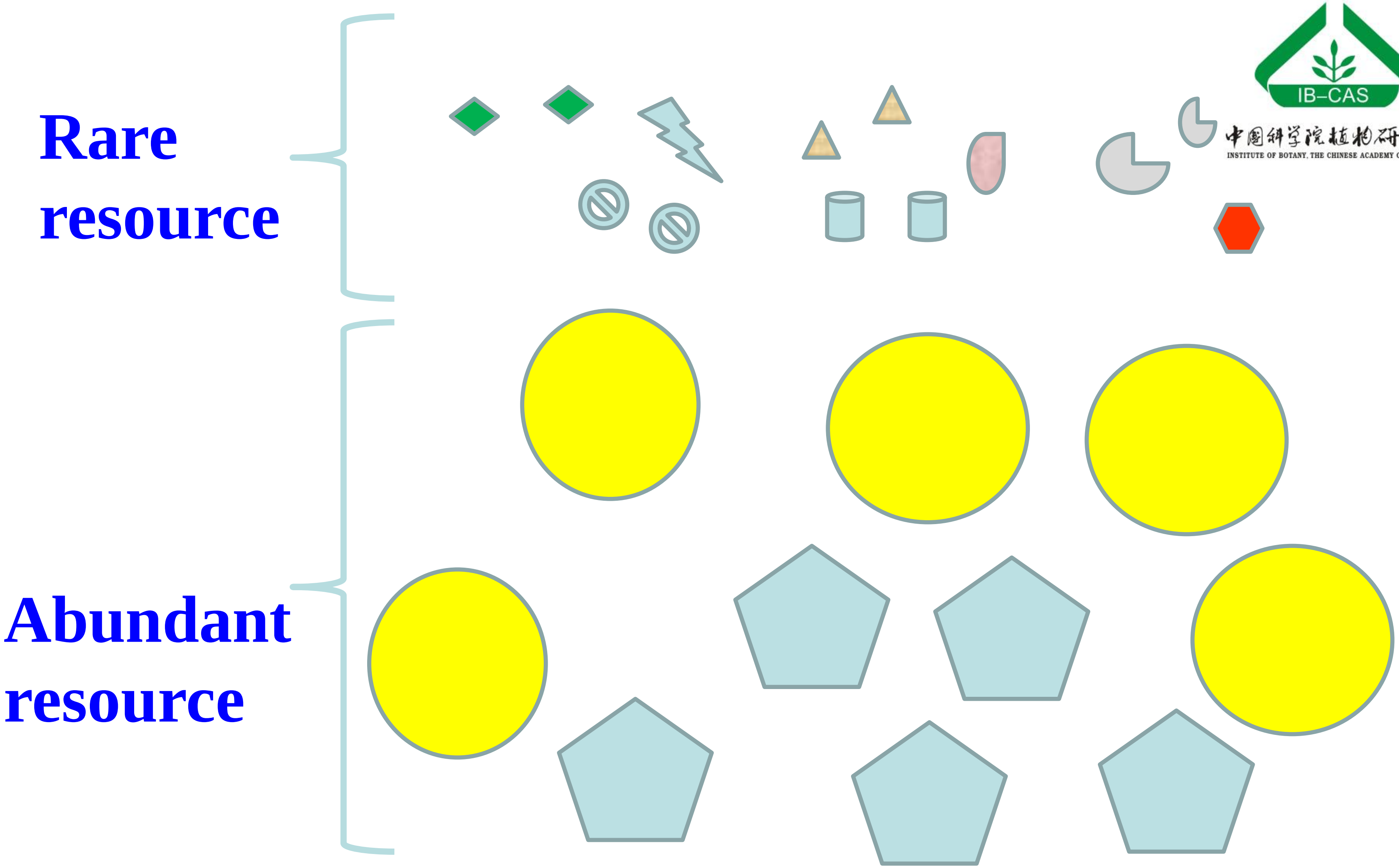
2. **Controlled experiments simplifies the environmental conditions and 'similar' niches in laboratory conditions may neglect multidimensional requirements of species niches;**

Phylogenetic distance-good substitute



Kelly et al., 2008

Kelly et al. (2008) found that abundance of trees is closely correlated with phylogenetic distance in a Mexican forest; Anderson et al. (2004) found that species abundance in yeast community also correlated with its genetic relatedness.



Following niche differentiation hypotheses, abundant species are distantly related to rare species, and rare species are distantly related to one another.

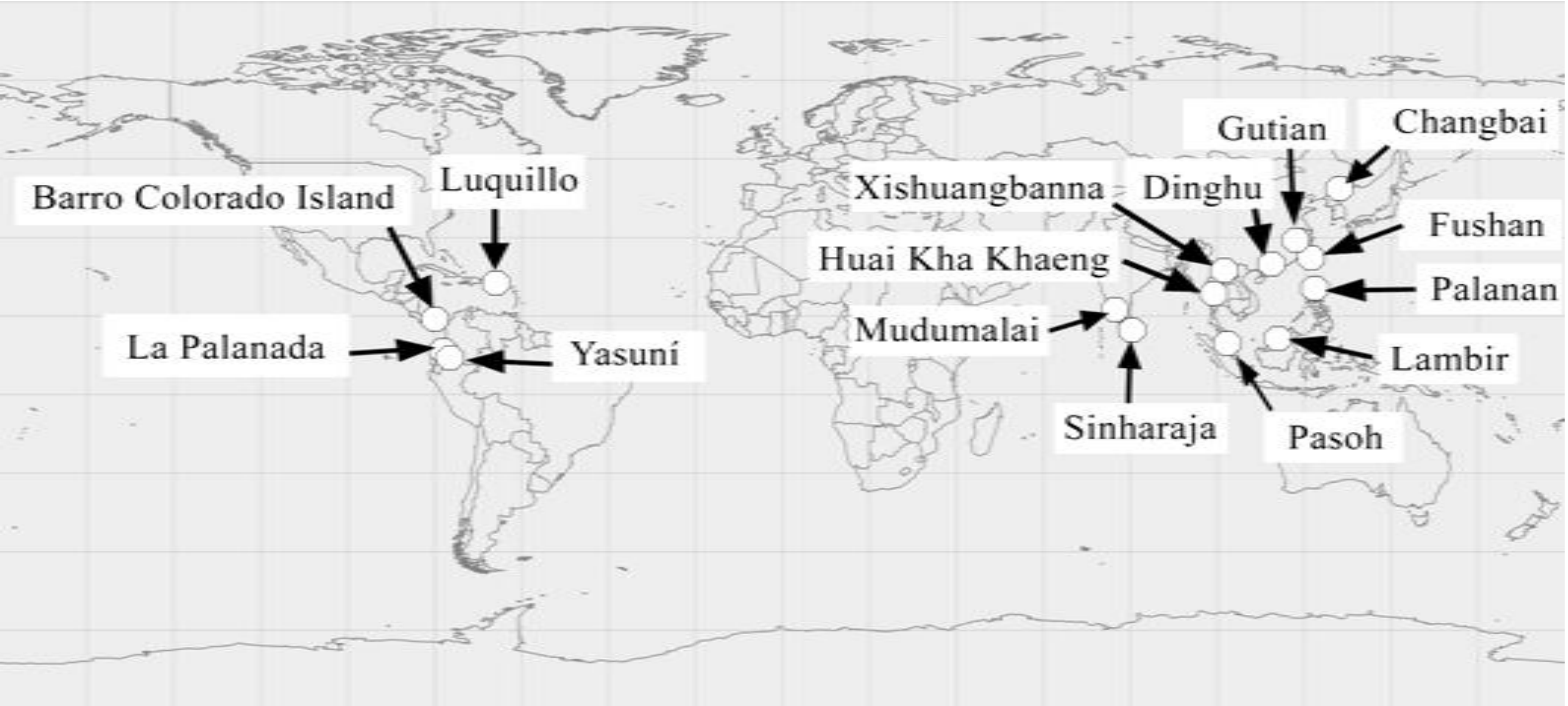
Niche differentiation hypothesis predicts:

1) **Rare species contribute more to the community phylogenetic diversity;**

2) **There is phylogenetic signal in abundance of communities;**

3) **Rare species would be dissimilar with common species, and rare species should be dissimilar with one another.**

2. Methods:
CTFS plots



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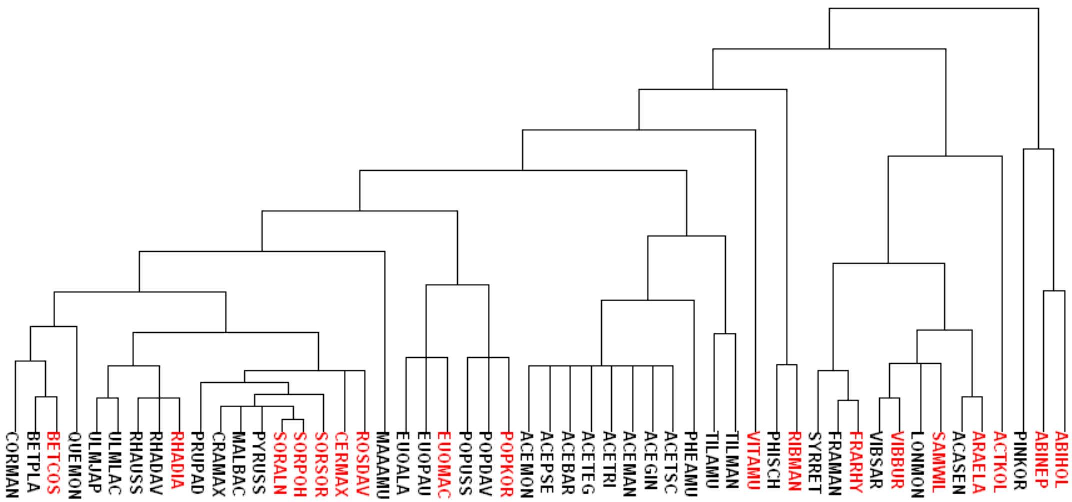
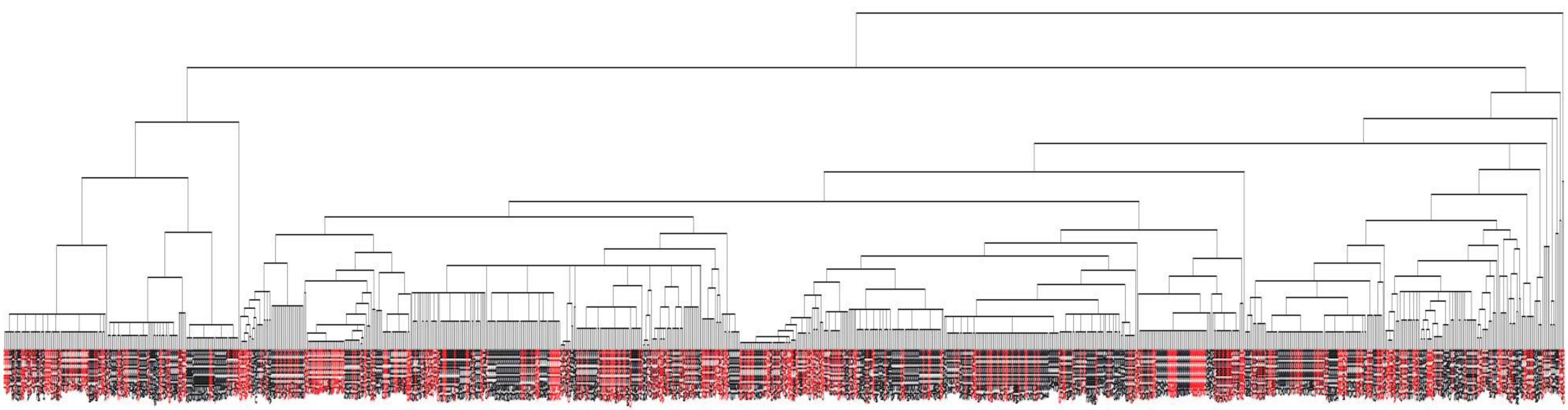
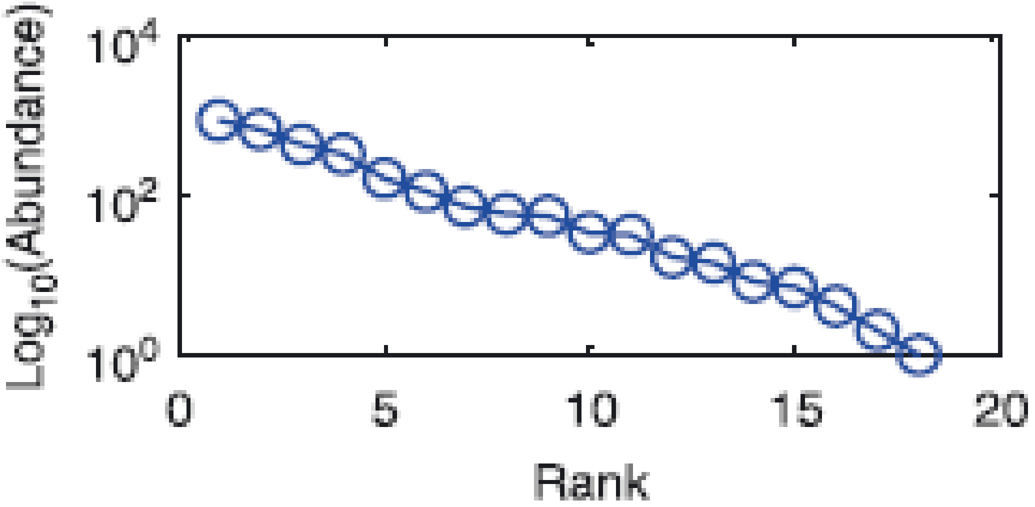
1. Phylogenetic trees were constructed using phylomatic under APG III.



Tree of Changbai plot, with 52 species belonging to 32 genera, and Yasuni with 1045 species to 339 genera:



Methods

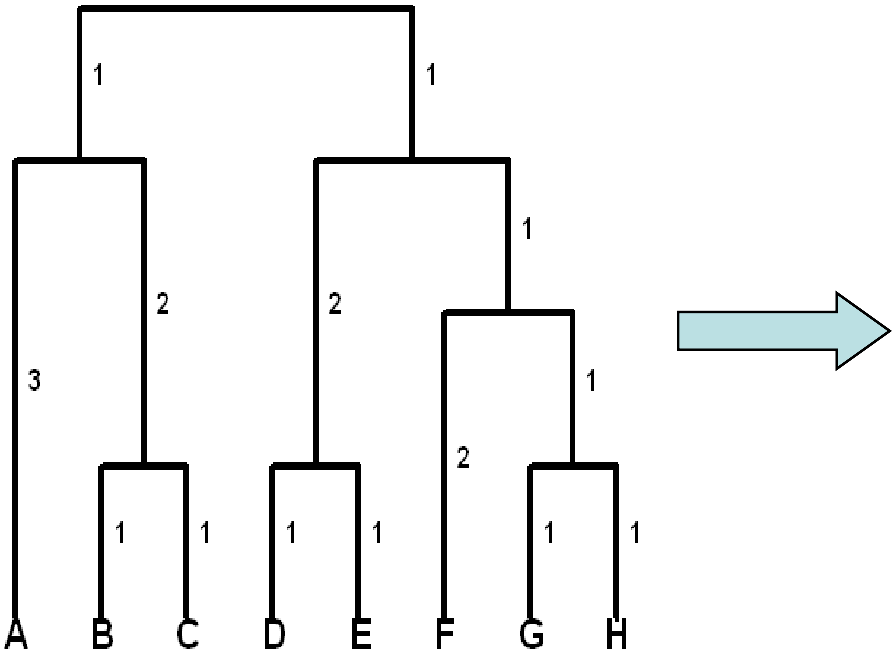


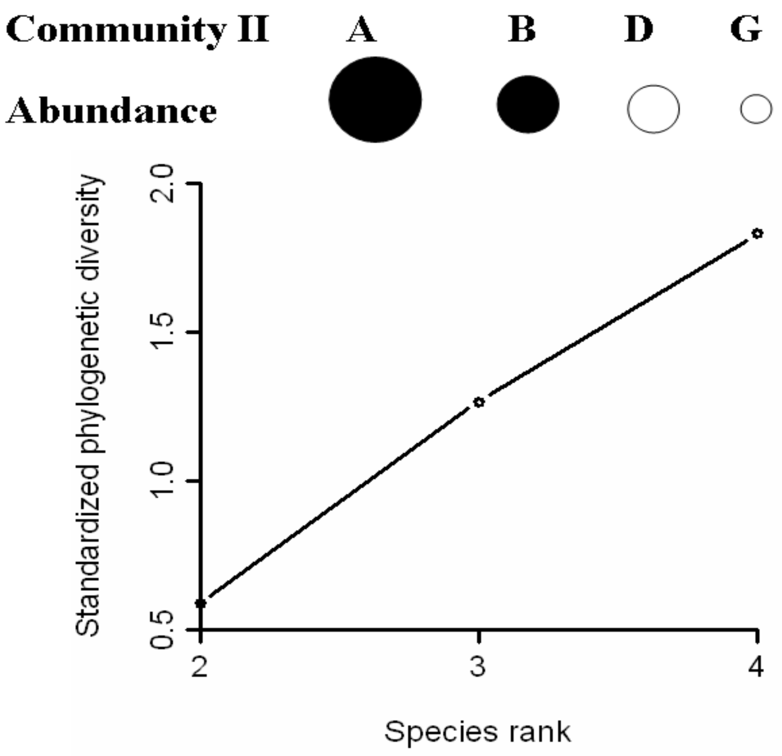
1) Species abundance rank - standardized phylogenetic diversity (SAPD) Curve:

$$StdPD_i = PD_i - mean(PD_{null})$$

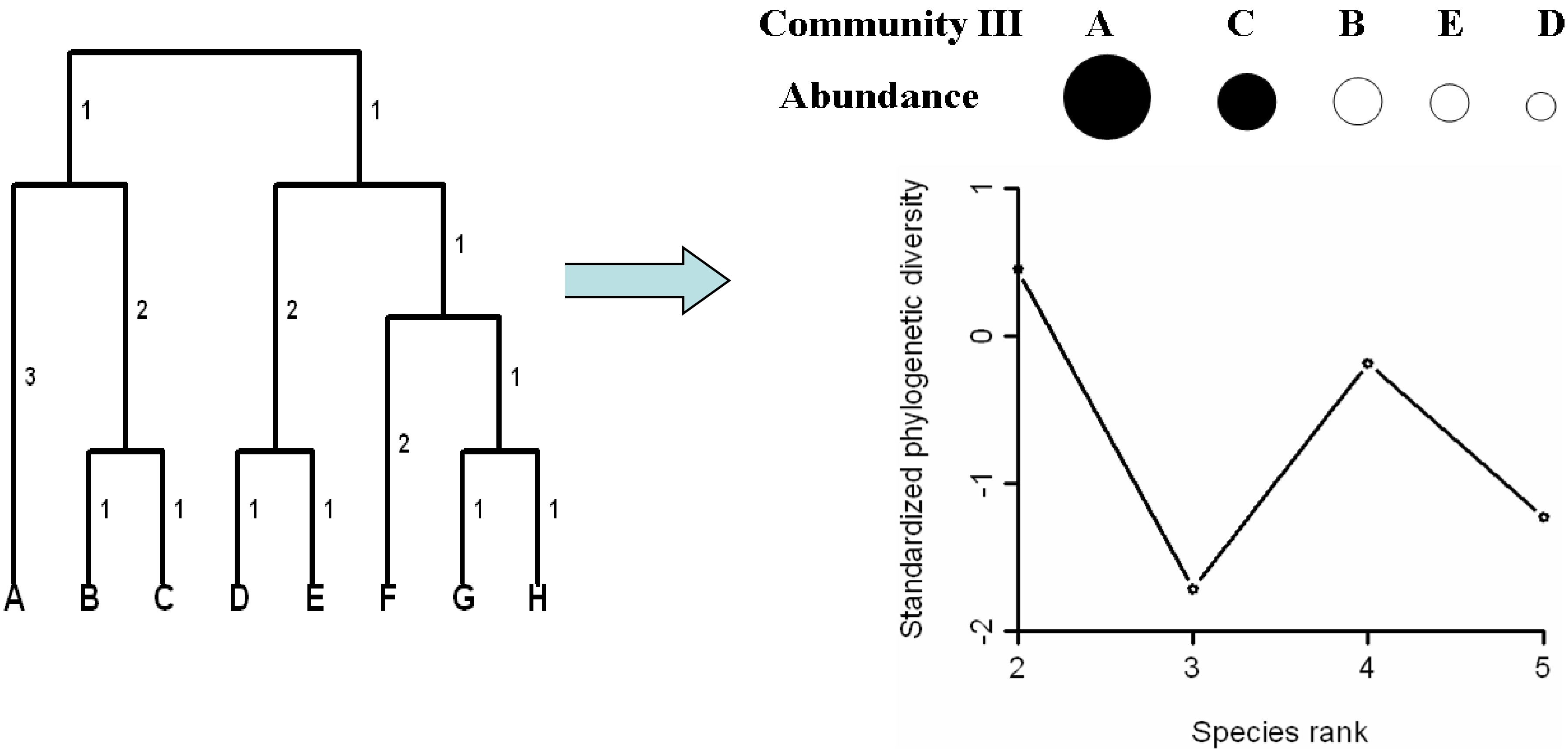
PD_i: standardized PD of the ith most abundant species;

Distant phylogenetic relatedness between common and rare species

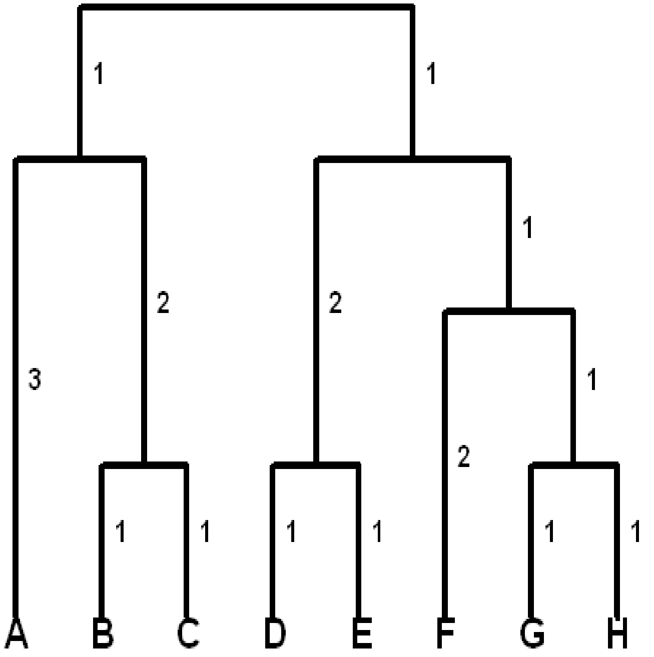


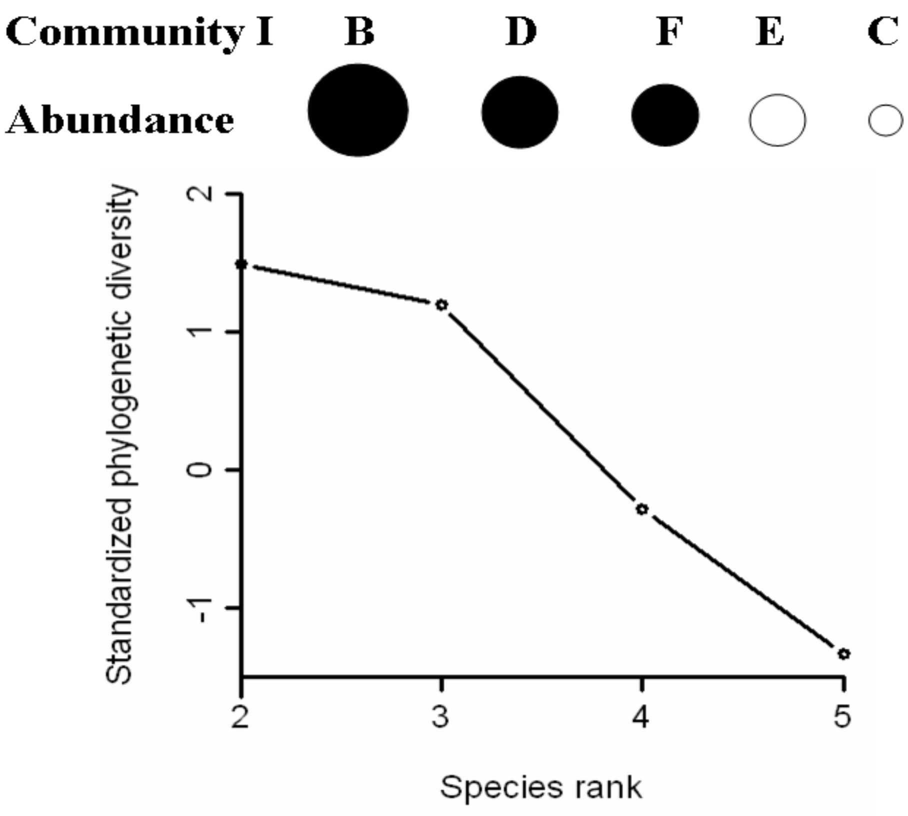


Random phylogenetic relatedness between common and rare species



Close phylogenetic relatedness between common and rare species





Close phylogenetic relatedness between common and rare species

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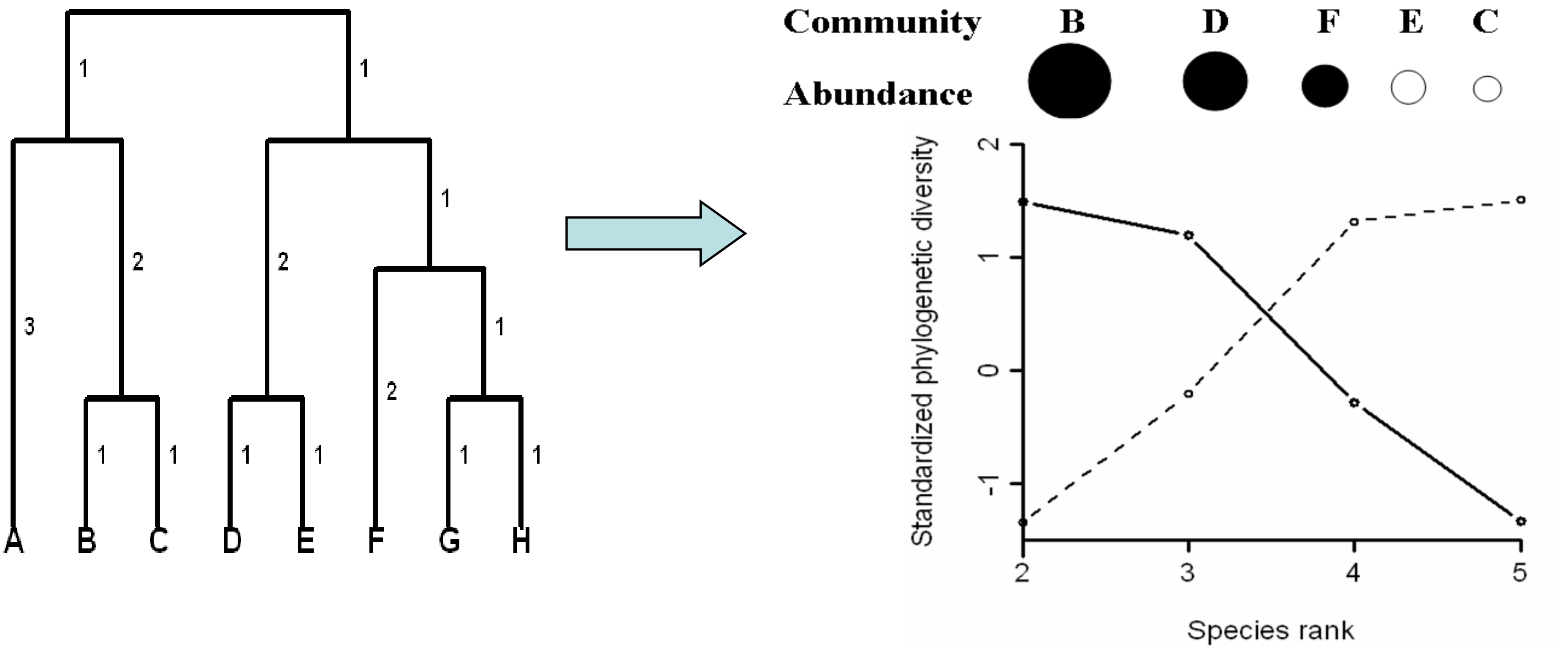
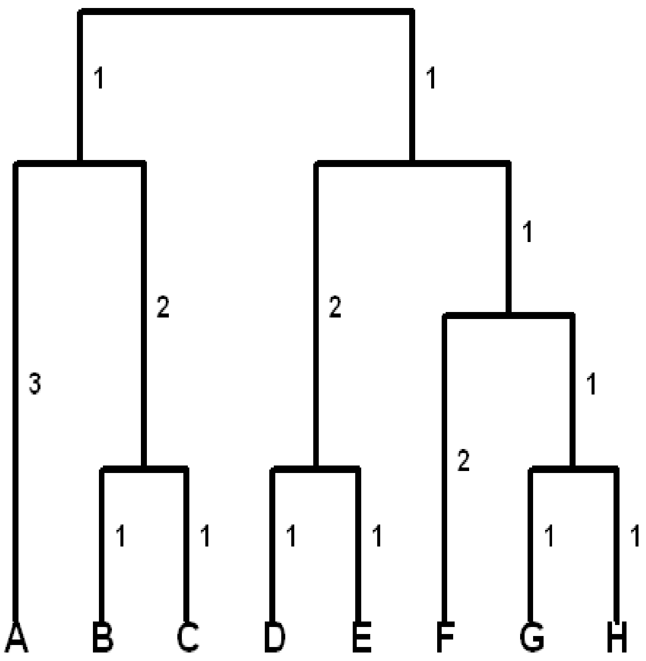
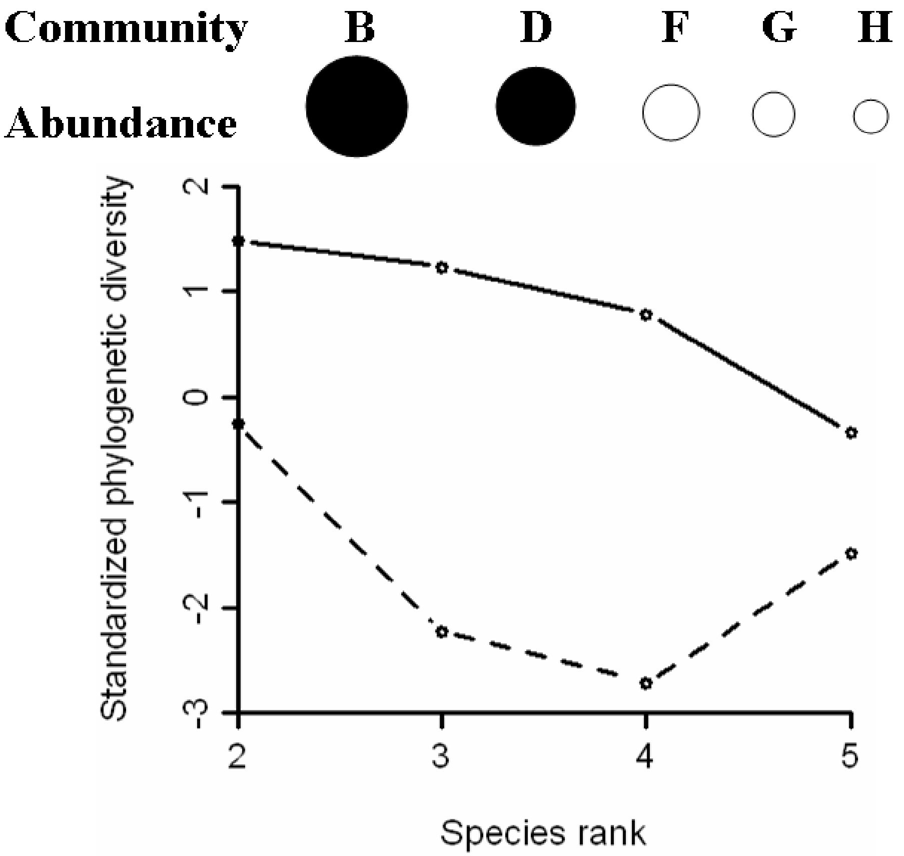


Close phylogenetic relatedness among rare species





Methods:

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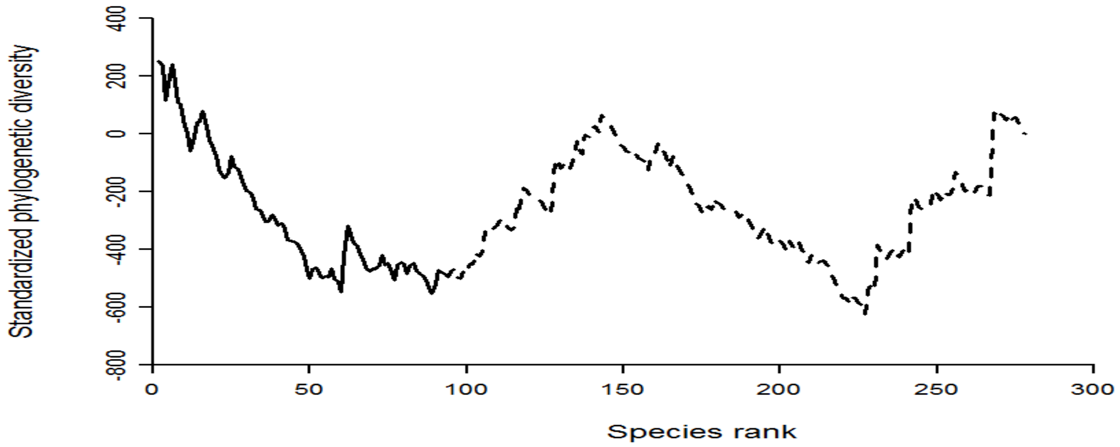


2) Piecewise regression

$$\mathrm{stdPD}_i = \beta_0 + \beta_1 i + \sum_{j \geq 2} \beta_j (i - \alpha_j) I(i > \alpha_j)$$

stdPD_i is the value of stdPD for ith species rank, α_j is the jth breakpoint (the turning point between subseries), and the slopes of the lines are β_1, $\beta_1+\beta_2$,…., and β_j is the difference in slopes, I is an indicator variable.

Methods:

3) Mann-Kendall trend test: test the increasing trend of *stdPDi* along species rank.

4) Phylogenetic signal analysis of species abundance
Quantify phylogenetic signal using K statistics of Blomberg et al. (2003).

$$K = \text{observed}\frac{\text{MSE}_0}{\text{MSE}} \Big/ \text{expected}\frac{\text{MSE}_0}{\text{MSE}}$$

If K>1, the species abundance have more phylogenetic signal than expected under Brownian motion;

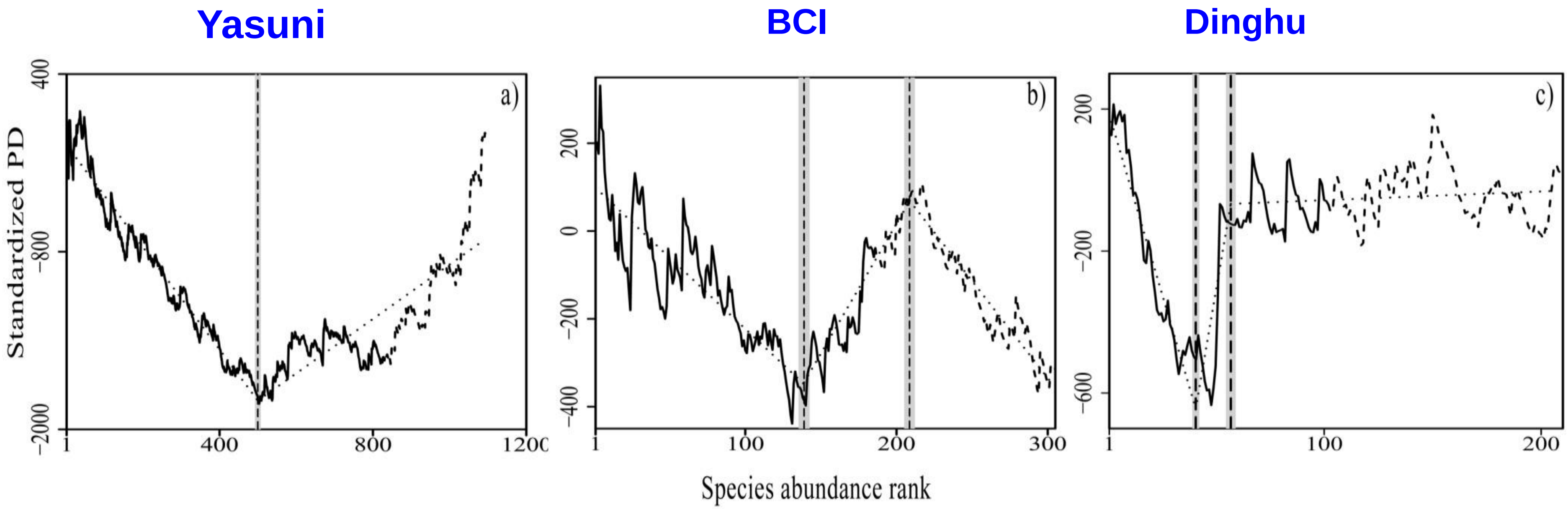
If K<1, the species abundance have less phylogenetic signal than expected;

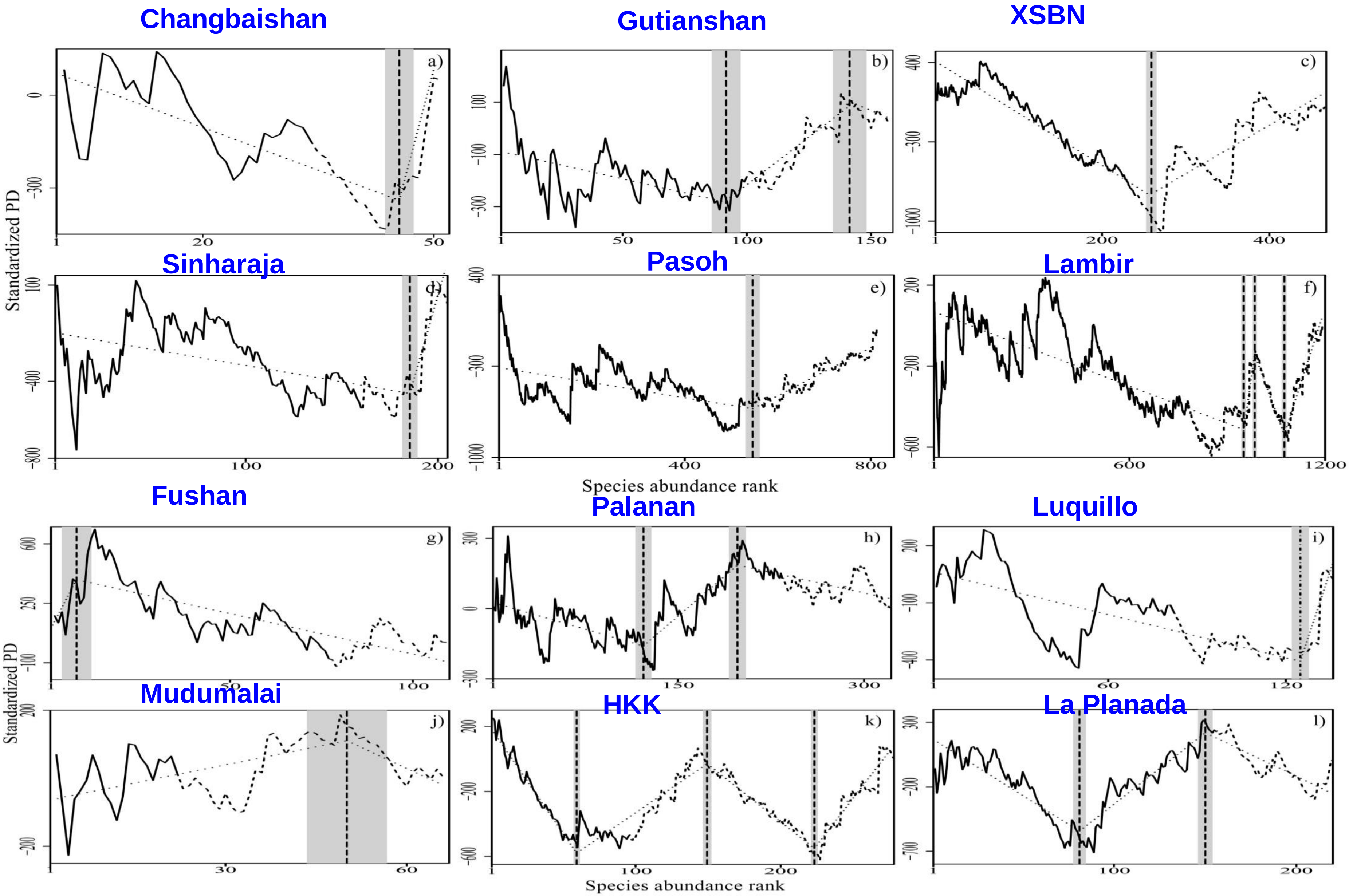
5) Nearest taxon index (NTI) was used to calculate phylogenetic dispersion of common and rare species.

$$D_{nn} = \frac{\sum_{i=1}^{n} \min \delta_{ir} + \sum_{j=1}^{m} \min \delta_{jc}}{2}$$

Results:

1. We detected three types of species rank-standardized phylodiversity curves (SAPD).





Changbaishan
Gutianshan
XSBN
Sinharaja
Pasoh
Lambir
Fushan
Palanan
Luquillo
Mudumalai
HKK
La Planada
a)
b)
c)
d)
e)
f)
g)
h)
i)
j)
k)
l)
Standardized PD
Species abundance rank

Mann-Kendall Tau and its probability of an observed trend index greater than trend indices from the null SAPD curves

Forest dynamics plot	Common species	Rare species
Changbaishan	-.308 (.285) (2-34)†	.118 (.703) (35-51)†
	-.848 (.057) (2-45)‡	.733 (.985)** (46-51)‡
Gutianshan	-.226 (.378) (2-102)†	.629 (.968) (103-158)†
	-.369 (.347) (2-92)‡	.765 (.994)*** (93-141)‡
		-.456 (.346) (142-158)
Xishuangbanna	-.746 (.020)** (2-238)†	.542 (.927) (239-467)†
	-.786 (.010)** (2-259)‡	.494 (.900) (260-467)‡
Sinharaja	-.267 (.282) (2-161)†	.418 (.880) (162-205)†
	-.340 (.202) (2-185)‡	.544 (.960) (186-205)‡
Lambir	-.455 (.152) (2-781)†	.408 (.823) (782-1191)†
	-.575 (.053) (2-950)‡	.482 (.904) (950-984)‡
		-.940 (.002)*** (985-1075)‡
		.735 (.985)** (1075-1191)‡
Pasoh	-.352 (.261) (2-533)†	.747 (.988)** (534-812)†
	-.332 (.249) (2-546)‡	.744 (.990)** (547-812)‡
Yasuní	-.738 (.021) (2-678)†	.634 (.940) (679-1092)†
	-.907 (.001)**** (2-500)	.649 (.976)** (501-1092)‡
BCI	-.402 (.392) (2-187)†	-.712 (.127) (187-304)†
	-.679 (.083) (1-139)‡	-.827 (.023)** (210-304)‡
	.747 (.995)*** (140-209)‡	
Huai Kha Khaeng	-.695 (.066) (2-96)†	-.056 (.518) (97-276) †
	-.878 (.005)*** (2-60)‡	.661 (.978)** (61-149)‡
		-.902 (.012)** (150-223)‡
		.774 (.996)*** (224-276)‡
La Planada	.091 (.626) (2-155)†	-.667 (.122) (156-219)†
	-.614 (.090) (2-81)‡	-.708 (.097) (151-219)‡
	.767 (.992)** (82-150)‡	
Dinghushan	.067 (.541) (2-102) †	-.087 (.536) (103-209) †
	-.822 (.015)** (2-41)‡	.213 (.699) (58-209)‡
	.294 (.762) (42-57)‡	
Fushan	-.526 (.095) (2-77) †	.182 (.738) (78-109) †
	.500 (.781) (2-8)‡	-.619 (.037) (9-109)‡
Palanan	.334 (.861) (2-235)†	-.040 (.568) (236-321)†
	-.346 (.265) (2-122)‡	-.404 (.313) (199-321)‡
	.584 (.939) (123-198)‡	
Mudumalai	.281 (.761) (2-22)†	.165 (.675) (23-66)†
	.381 (.992)** (2-50)‡	-.662 (.162) (51-66)‡
Luquillo	-.285 (.358) (2-82)†	-.011 (.601) (83-136)†
	-.493 (.087) (2-125)‡	.600 (.932) (126-136)‡

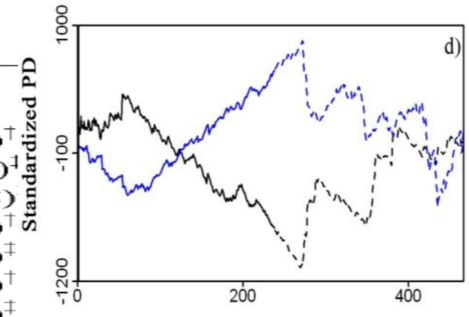


Table 3. The standardized phylogenetic diversity (stdPD) for common species and rare species

Forest dynamics plot	stdPD of common species	stdPD of rare species	stdED
Changbaishan	-151 (.225) (1-34)†	222 (.816) (35-52)†	136 (.747) (35-52)†
	-436 (.003)*** (1-45)‡	329 (.957) (46-51)‡	374 (.993)** (47-52)‡
Gutianshan	-187 (.224) (1-102)†	291 (.834) (103-159)†	233 (.844) (103-159)†
	-264 (.163) (1-92)‡	238 (.795) (93-141)‡	287 (.987)* (112-129)‡
		-25 (.477) (142-159)‡	
Dinghushan	-89 (.040) (1-102)†	189 (.708) (103-210)†	
	-517 (.042) (1-41)‡	51 (.542) (58-210)‡	
	306 (.913) (42-57)‡		
Xishuangbanna	-722 (.026) (1-238)†	630 (.958) (239-468)†	
	-921 (.002)*** (1-259)‡	724 (.988)** (260-468)‡	
Sinharaja	-528 (.031) (1-161)†	607 (.976)** (162-205)†	
	-409 (.017)** (1-185)‡	61 (.557) (186-205)‡	
Lambir	-377 (.111) (1-781)†	131 (.629) (782-1192)†	
	-457 (.067) (1-950)‡	731 (.984)** (951-984 and 1076-1192)‡	
		-698 (.004)*** (985-1075)‡	
Pasoh	-600 (.027) (1-533)†	665 (.968) (534-813)†	
	-528 (.033) (1-546)‡	706 (.979)** (547-813)‡	
Yasuní	-1337 (.002)*** (1-678)†	948 (.987)* (679-1093)†	
	-1768 (.002)*** (1-500)‡	1280 (.998)*** (501-1093)‡	
BCI	-59 (.590) (1-187)†	-434 (.092) (188-305)†	
	-373 (.119) (1-139)‡	-605 (.024)** (210-305)‡	
	811 (.992)*** (140-209)‡		
Huai Kha Khaeng	-470 (.047) (1-96)†	216 (.773) (97-278)†	
	-553 (.013)** (1-60)‡	750 (.999)*** (61-149 and 224-278)‡	
		-343 (.112) (150-223)‡	
La Planada	240 (.780) (1-155)†	-509 (.099) (156-220)†	
	-605 (.070) (1-81)‡	-543 (.064) (151-219)‡	
	1055 (.997)*** (82-150)‡		
Fushan	-80 (.359) (1-77)†	-110 (.361) (78-110)†	
	374 (.951) (1-8)‡	-296 (.034) (8-110)‡	
Palanan	132 (.715) (1-235)†	-152 (.284) (236-323)†	
	-213 (.194) (1-122)‡	-293 (.146) (199-323)‡	
	159 (.727) (123-198)‡		
Mudumalai	21 (.528) (1-22)†	-165 (.101) (23-67)†	
	152 (.953) (1-50)‡	-28 (.415) (51-67)‡	
Luquillo	-128 (.348) (1-82)†	162 (.701) (83-137)†	
	-356 (.050) (2-125)‡	347 (.935) (126-137)‡	

Table 4. Phylogenetic signal in species abundance data.

Forest dynamics plot	K value
Changbaishan	.295 (.01)
Gutianshan	.185 (.001)
Xishuangbanna	.227 (.032)
Sinharaja	.176 (.001)
Lambir	.104 (.001)
Pasoh	.103 (.001)
Yasuní	.074 (.001)
BCI	.099 (.001)
Huai Kha Khaeng	.199 (.001)
La Planada	.116 (.051)
Dinghushan	.136 (.059)
Fushan	.217 (.001)
Palanan	.128 (.021)
Mudumalai	.150 (.375)
Luquillo	.144 (.132)

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Table 5. Phylogenetic similarity within and between common and rare species

Forest dynamics plot	SES of D_{nn}	NTI of common species	NTI of rare species
Changbaishan	-1.620	.082	-.948
Gutianshan	-1.052	-.016	-1.083
Dinghushan	-.217	-.509	-.373
Xishuangbanna	-.169	1.009	-1.102
Sinharaja	-.624	1.514	-1.199
Lambir	-2.872***	.645	-.579
Pasoh	-.182	1.903*	-1.749*
Yasuní	-3.304****	2.358****	-1.096****
BCI	-.659	.453	.226
Huai Kha Khaeng	-3.323****	.941	-.059
La Planada	-1.174	-.971	1.092
Fushan	-.367	-.284	-.215
Palanan	-.534	-.976	-.051
Mudumalai	-1.633	-.749	1.293
Luquillo	.325	1.018	-.354

Conclusions:

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1. Rare species in Changbaishan, Gutianshan, Xishuangbanna, Pasoh, Lambir and Yasuní have significant higher cumulative PD than expected;
2. In BCI, the contribution of rare species to community PD is significantly less than expected;
3. In Dinghushan, Palanan, Luquillo, Fushan, Sinharaja, La Planada and Mudumalai, the contribution of rare species to community PD is not significantly different from random;
4. In HKK, some rare species contribute more, and some rare species contribute less

ECOLOGY

The importance of being rare

Uncovering the contribution of rare species to ecosystems is crucial to predicting the impacts of biodiversity loss. It seems that these species can be ecologically very different from their common relatives, but only in some cases.

KEVIN J. GASTON

of these species will have few individuals, the number of rare species that are present[2,3]. In

1. There was no reason to assume that all assemblages will be structured in generally the same way;
2. Their analysis did not address the influence of spatial scale on the observed ecological differentiation between rare and common species.

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