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ORIGINAL ARTICLE

Tree species diversity of a 20-ha plot in a tropical seasonal rainforest in Xishuangbanna, southwest China

Guoyu Lan · Hua Zhu · Min Cao

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Abstract We censused all free-standing trees ≥1 cm diameter at breast height (dbh) in a 20-ha plot established in a tropical seasonal rainforest in Xishuangbanna National Nature Reserve, southwest China. A total of 95,834 free-standing trees ≥1 cm dbh were recorded, and 95,498 individuals (accounting for 99.65% of the total), including 468 morphospecies in 213 genera and 70 families, were identified. Thirteen of 468 species (2.78%) had more than 1,000 individual ≥1 cm dbh, which represented 56.36% individuals of the total. On the other hand, 230 of 468 species (49.14%) had a mean density of ≤1 tree per ha, and 69 of 468 species (14.74%) were singletons in the 20-ha plot. The mean species richness, density and basal area per ha were 216.50 species, 4,791.70 stems and 42.34 m^2, respectively. *Pittosporopsis kerrii* (20,918 stems, ≥1 cm dbh) of Icacinaceae and *Parashorea chinensis* (7,919 stems, ≥1 cm dbh) of Dipterocarpaceae were the two most abundant species dominating the emergent layer and treelet layer, respectively. Compared with other 50-ha plots established in other equatorial regions, tree species richness per ha and tree abundance per ha of the plot were at the moderate level.

Keywords Diversity · Tropical seasonal rainforest · Xishuangbanna

G. Lan · H. Zhu · M. Cao (✉)
Key Laboratory of Tropical Forest Ecology,
Xishuangbanna Tropical Botanical Garden,
Chinese Academy of Sciences, Kunming 650223, China
e-mail: caom@xtbg.ac.cn

G. Lan
Rubber Research Institute, The Chinese Academy of Tropical Agricultural Sciences, Danzhou, Hainan 571737, China

Introduction

Since the late 1970s, the Center for Tropical Forest Science (CTFS) of the Smithsonian Tropical Research Institute has established 40 large-sized (ranging from 16 to 52 ha) forest dynamics plots in the tropical forests of the five continents. To date, CTFS monitors more than 3 million individual tropical trees, representing about 8,500 tree species, nearly 17% of the world's entire tropical tree flora. However, there was no such tropical forest dynamics plot in the mainland of China until 2007, although much of the old growth high diversity lowland tropical rainforests in China are located in the Xishuangbanna region of Yunnan Province (Cao et al. 2006). Due to its unique geographical location, Xishuangbanna is included in the Indo-Burma biodiversity hotspots and contains over 5,000 species of vascular plants, comprising 16% of China's total plant diversity (Cao et al. 2006). Naturally, the tropical rainforest of Xishuangbanna occurs at the limits in terms of latitudinal and altitudinal distribution of the southeast Asian rainforests (Wu 1987; Zhu et al. 1998). As a result of this, its flora composition is sensitive to climate change at a local scale (Zhu 1993). In order to monitor long-term changes in tree populations of tropical rainforest in this region and to test theories and hypotheses related to biodiversity maintenance of tropical forests, a 20-ha dipterocarp tropical seasonal rainforest dynamics plot was established in Xishuangbanna Nature Reserve in 2007. Its field protocol standard followed the 50-ha plot located in Barro Colorado Island in Panama established by Hubbell and Foster (Condit 1995).

This paper presented the results of the first census on the tree species diversity of the 20-ha plot in a tropical seasonal rainforest in Xishuangbanna, southwest China, trying to answer following questions: (1) how many tree species are

Table 1 Temperature and precipitation distributions of the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China

AMT (°C)	MTH (°C)	MTC (°C)	AP (mm)	PD (mm)	PR (mm)
21.0	24.6	15.2	1,531.9	281.6	1,250.3

Dry season: November–April, Rainy season: May–October

AMT annual mean temperature, *MTH* mean temperature of the hottest month, *MTC* mean temperature of the coldest month, *AP* annual precipitation, *PD* precipitation during dry season, *PR* precipitation during rainy season

there in the 20-ha plot of tropical seasonal rainforest, and how many are rare and how many are abundant, and (2) what are the similarities and differences between Xishuangbanna tropical seasonal rainforest and other tropical forest dynamics plots in tree species diversity?

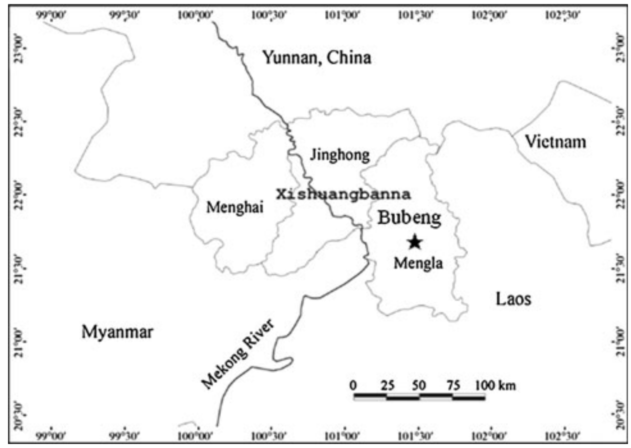

Fig. 1 Location (*star*) of the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China

Materials and methods

Study site

Xishuangbanna is predominated by a typical monsoon climate with an alternation between dry season and rainy season. Taking Mengla County (14 km from the study site where the 20-ha plot was established) as an example, the annual mean temperature is 21.0°C. Annual mean precipitation is 1,532 mm, of which about 80% occurs between May and October (rainy season) (Table 1). The dry season is from November to April (Zhu 2006; Lan et al. 2009). Under such climatic conditions, tropical seasonal rainforest is developed in the lowland, valleys and hills with a good water supply (Wu 1987; Zhu 2006; Zhu et al. 2006). This forest type was believed to maintain the highest tree species in this region (Cao and Zhang 1997). The site for the establishment of the 20-ha plot was chosen in a tract of the tropical seasonal rainforest at Bubeng village (101°34′26″–47″E and 21°36′42″–58″N), Mengla county, Xishuangbanna National Nature Reserve, southwest China (Fig. 1). It was dominated by *Parashorea chinensis*—a big stature tree species of Dipterocarpaceae.

Data collection

A 20-ha plot (400 × 500 m^2) was established in a *Parashorea chinensis* forest. This plot ranges from 709 to 869 m above sea level, indicating a heterogeneous habitat. It was sub-divided into 8,000 quadrats of 5 m × 5 m. All trees ≥1 cm in diameter at breast height (dbh) in the 20-ha plot were tagged with sequentially numbered aluminium tags. Tree diameters were measured at 1.3 m from the ground (Condit et al. 1996; Ayyappan and Prthasarathy 1999). In the case of buttresses, the dbh was measured at the lowest point where the trunk was back to normal. Trees with multiple stems were counted as a single individual, but each stem was also tagged and measured (Condit 1998). All free-standing trees ≥1 cm dbh were identified to species. The nomenclature of the tree species followed the English version of *Flora of China*, and the vouchers were stored at the herbarium of the Xishuangbanna Tropical Botanical Garden.

Data analysis

A six-capital letter code was assigned to the species with the first 4 letters denoting the generic epithet and the next 2 letters the specific epithet. Species (genus and family)–area curves were plotted for all trees (dbh ≥1 cm). Based on their abundance, the tree species were grouped into 5 categories (Ayyappan and Prthasarathy 1999), viz.: (1) predominant species [those with abundance (A) ≥1,000 stems in the 20-ha plot); (2) dominant species (A = 200–999), (3) common species (A = 20–199), (4) rare species (A = 2–19), and (5) very rare species (A = 1, also singleton species].

Fisher's α was calculated for trees of ≥1, ≥10 and ≥30 cm dbh. α was defined according to Fisher et al. (1943):

$$S = \alpha \times \ln(1 + N/\alpha) \quad (1)$$

where α was the diversity index, N was the number of trees, S was the number of species.

Relative density (FD), relative dominance (RA, using basal area) and relative frequency (RF) were calculated for each species in order to estimate the importance value (IV). Importance value was defined as (Curtis and Mcintosh 1950, 1951; Greig-Smith 1983; Linares-Palomino and Alvarez 2005):

Table 2 Summary of the inventories of the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China (336 unidentified individual trees were exclued in calculating the number of species, genera and families, but were included when calculating individuals and basal area)

Contents	No. of species	No. of genera	No. of families	No. of stems	Basal area (m^2)	Fisher's α
dbh ≥1 cm						
No. in 20-ha plot	468	213	70	95,834	846.86	63.99
Mean (ha^{-1})	216.50	131.80	53.60	4,791.70	42.34	46.64
Range (ha^{-1})	187–239	116–144	49–59	3,160–6,181	29.04–55.16	41.03–55.23
dbh ≥10 cm						
No. in 20-ha plot	339	171	63	12,331	733.36	64.46
Mean (ha^{-1})	123.50	84.80	43.50	616.60	36.66	46.54
Range (ha^{-1})	110–139	68–91	39–48	452–810	23.85–51.04	32.62–54.94
dbh ≥20 cm						
No. in 20-ha plot	227	146	58	4,644	598.72	61.32
Mean (ha^{-1})	74.3	56.05	32.3	232.2	29.93	33.65
Range (ha^{-1})	64–96	49–66	28–41	168–338	20.03–44.07	18.35–50.12
dbh ≥30 cm						
No. in 20-ha plot	215	119	51	2,232	496.41	58.67
Mean (ha^{-1})	42.70	35.00	23.70	111.60	24.82	25.28
Range (ha^{-1})	22–64	17–50	14–35	70–159	17.07–41.13	8.87–46.38

dbh diameter at breast height

$$\text{Importance value}: \ \mathrm{IV}_j = \mathrm{RF}_j + \mathrm{RD}_j + \mathrm{RA}_j \quad (2)$$

$$\text{Relative frequency}: \ \mathrm{RF}_j = 100 \times F_j / \sum_j F_j \quad (3)$$

$$\text{Relative density}: \ \mathrm{FD}_j = 100 \times D_j / \sum_j D_j \quad (4)$$

$$\text{Relative dominance}: \ \mathrm{FA}_j = 100 \times A_j / \sum_j A_j \quad (5)$$

where F_j was the number of 1-ha subplots containing species *j*; D_j the number of individuals of species *j*; A_j was the total basal area of species *j*. For trees with multiple stems, basal areas of multiple stems and main stem were calculated and summed as the basal area of a single individual.

We classified the species into five strata according to their estimated maximum height (Kenfack et al. 2007): treelets include all species with adults generally <10 m tall; understory trees are those with adults 10–20 m tall; lower canopy species have heights of 20–30 m; and upper canopy species are those often 30–45 m in height and emergent above the main canopy (>45 m). Information on the heights of the tree species was from Zhu (2006).

Results

Species richness

A total of 95,834 trees ≥1 cm dbh was enumerated in the 20-ha plot (Table 2). Ultimately, 95,498 individuals (99.65%) were identified to species (93,410 individuals, 97.47%), genera (2,079 individuals, 2.17%) and family levels (9 individuals, 0.01%). Among the 95,498 stems, there were 468 morphospecies in 213 genera and 70 families. In addition, 336 individuals (0.35% of the total) have not yet been assigned a morphospecies. Fisher's α of trees ≥10 cm dbh in the whole 20-ha plot was slightly greater than that of trees ≥1 cm dbh indicating that species were distributed more evenly among trees ≥10 cm dbh, because evenness among species would lead to higher diversity. But among trees ≥30 cm dbh, Fisher's α of 20 1-ha subplots varied from 8.87 to 46.38 revealing that tree species were unevenly distributed across the plot.

Species–area curves and species–abundance curves

Species–area curves for all trees with dbh ≥1, ≥10 and ≥30 cm in 20-ha plot of tropical seasonal rainforest were plotted (Fig. 2). In the range of 0–5 ha, the number of species increased rapidly with increasing area, whereas the increasing speed slowed down in the range of 5–10 ha. Approximately 80% of total species were included in the first 6 1-ha plots, 90% in the first 11 1-ha plots, and 99% in the first 18 1-ha plots. Species–area curves for dbh ≥10 and ≥30 cm were quite similar to those of dbh ≥1 cm, roughly parallel to one another.

We compared the plot of actual number of species against the number of trees with that predicted by the equation $S = \alpha \ln(1 + N/\alpha)$. There is little difference between the observed number of species and that of predicted for tress with dbh ≥1 and ≥10 cm (Fig. 3). However, for trees of dbh ≥30 cm, the observed number was much smaller than that of predicted. This may indicate that

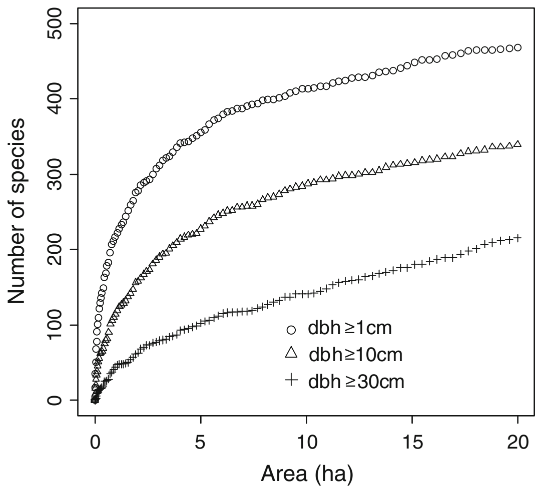

Fig. 2 Species–area curves for three tree sizes in the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China (*open circle* for *dbh* ≥*1 cm*, *open triangle* for *dbh* ≥ *10 cm*, *plus symbol* for *dbh* ≥*30 cm*). *dbh* diameter at breast height

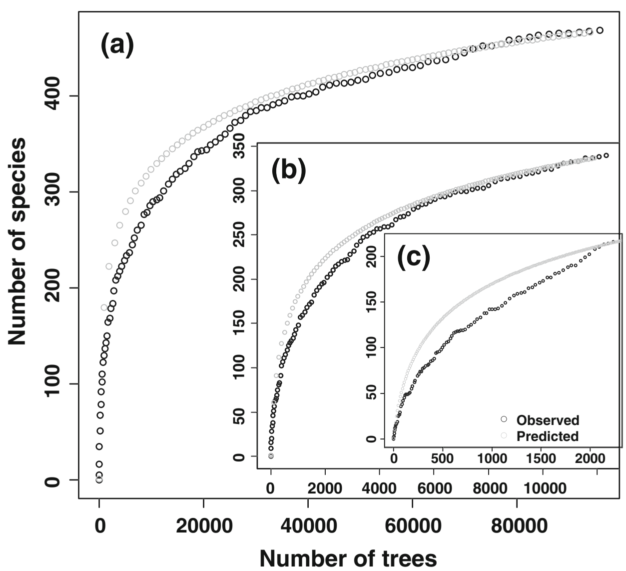

Fig. 3 Comparing the plot of the *observed* number of species against the number of trees with that *predicted* by the equation [$S = \alpha \times \ln(1 + N/\alpha)$, where α is the whole-plot, α for the appropriate size category; *a* diameter at breast height (dbh) ≥1 cm, *b* dbh ≥10 cm, *c* dbh ≥30 cm]

Fisher's α can only be used to measure diversity of small size of trees.

Species abundance

There were a few dominant species (>1,000 individuals; Table 2) in the 20-ha plot (also see Fig. 4). *Pittosporopsis kerrii*, the most abundant species in the study site, had 20,918 stems presenting 21.90% individuals of the total,

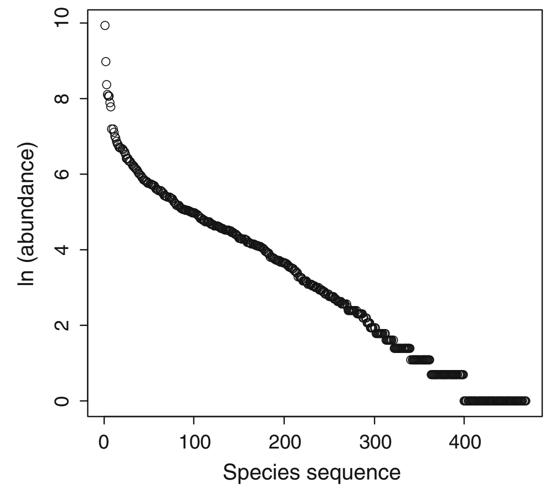

Fig. 4 Species sequence curve of the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China

while *P. chinensis* was next, and had 7,919 individuals accounting 8.29% (Table 3). At the other extreme, 230 of 468 species (49.14%) had a mean density of ≤1 tree per ha. The "long tail" of the species sequence curve indicated the very rare species (also singletons) in the plot (Fig. 4).

Species composition

The Lauraceae is the richest family with 52 species in 11 genera (Table 4). Icacinaceae is the most abundant family with 21,769 stems (Table 5), but Dipterocarpaceae has the largest basal area of 113.52 m^2. On the species level, *Pittosporopsis kerrii* is the most abundant species with 20,918 individuals, and its importance value ranked as first (Table 6). *Parashorea chinensis* has the largest basal area, but it has fewer individuals (7,919 individuals) than *Pittosporopsis kerrii*. The number of species in the ten richest families and genera is shown in Table 4. The number of species and basal area of top ten commonest families, genera and species is shown in Table 5.

The forest profile of the plot could be divided into five tree layers. The emergent (>45 m) layer was dominated solely by *P. chinensis* of Dipterocarpaceae (Table 6). *P. chinensis* had the largest basal area with 5.68 m^2 per ha. The upper canopy (30–45 m) was dominated by *Sloanea tomentosa*, *Pometia tomentosa*, *Semecarpus reticulata*, and *Barringtonia pendula* (Table 6). The lower canopy (20–30 m) was mainly composed of *Garcinia cowa*, *Knema furfuracea*, *Nephelium chryseum*, *Cinnamomum bejolghota*, *Diospyros hasseltii*, *Ficus langkokensis* and *Pseuduvaria indochinensis*. *Baccaurea ramiflora* and *Dichapetalum gelonioides* dominated the understory (10–20 m). The treelet layer (5–10 m) in the plot was mainly composed of *P. kerrii* and other representative species such as *Mezzettiopsis*

Table 3 Abundance classification in the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China (336 unidentified individual trees were excluded in calculating the number of species, but were included when calculating individuals)

Type	No. of species (%)	No. of individuals (%)
Predominant species (abundance (A) >1,000)	13 (2.78)	53,994 (56.34)
Dominant species (200 $\leq A <$ 1,000)	64 (13.68)	27,503 (28.70)
Common species (20 $\leq A <$ 200)	161 (34.40)	12,816 (13.37)
Rare species (2 $\leq A <$ 20)	161 (34.40)	1,116 (1.17)
Very rare species (A = 1)	69 (14.74)	69 (0.07)
Total	468 (100.00)	95,498 (99.95)

Table 4 Number of species in the ten richest genera and the ten richest families in the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China

Rank	The ten most diverse families			The ten most diverse genera	
	Family	No. of species	No. of genus	Genus	No. of species
1	Lauraceae	52	11	*Ficus*	22
2	Euphorbiaceae	38	19	*Elaeocarpus*	16
3	Moraceae	30	5	*Litsea*	14
4	Rubiaceae	28	19	*Syzygium*	13
5	Meliaceae	25	11	*Beilschmiedia*	9
6	Leguminosae	19	8	*Castanopsis*	9
7	Elaeocarpaceae	17	2	*Cinnamomum*	8
8	Annonaceae	15	7	*Mallotus*	7
9	Fagaceae	14	2	*Phoebe*	7
10	Myrtaceae	14	2	*Albizia*	5
Total		252	86		110

creaghii, *Saprosma ternata*, *Leea compactiflora*, *Phoebe lanceolata* and *Syzygium latilimbum*.

Discussion

There was an obvious inflexion at the 5th hectare in the species–area curve for dbh ≥1 cm, and 363 species representing about 78% of the total species were included in the first 5 ha. Total of 99% species were included in 18th hectare. And in the last 2 ha, only 1% species were added, indicating that the plot is large enough to represent tropical seasonal rainforest in Xishuangbanna, southwest China.

In comparison with two other large-sized plots established in China, the tree species richness in the Xishuangbanna's 20-ha plot (Xishuangbanna plot, 468 species) was over two times larger than in the Dinghushan (23°09′21″–23°11′30″N, 112°30′39″–112°33′41″N) 20-ha plot in subtropical evergreen broadleaved forest (210 species), and nearly three times as rich as that in the Gutianshan (29°15.102′–29°15.344′N, 118°07.010′–118°07.400′E) 24-ha plot in mid-subtropical evergreen broadleaved forest (156 species) (Lan et al. 2008; Ye et al. 2008; Zhu et al. 2008). Furthermore, species richness per ha of the present plot (216.5 species) was high as compared with some other 50-ha plots (for trees ≥1 cm dbh) in Barro Colorado Island (BCI plot, 168 species per ha), Panama, and in Huai Kha Khaeng, Thailand (HKK plot, 104 species per ha) (Plotkin et al. 2000; Condit et al. 2005) (Table 4), whereas species richness per ha in our plot was relatively the same as that of the Korup 50-plot (235 species per ha), Cameroon (Condit et al. 2005). However, the Xishuangbanna plot showed lower tree species richness per ha in comparison to those of plots in Asian equatorial tropical rainforests. For example, there were 497 tree species per ha with dbh ≥1 cm in the Pasoh plot (nearly two and half time as rich as that in the Xishuangbanna plot), and 618 species per ha in the Lambir plot (nearly three times as rich as that in the Xishuangbanna plot), Malaysia (Condit et al. 2005) (Table 7).

Compared to the BCI and HKK plots, the Xishuangbanna plot is located at a higher latitude, has a longer dry season and receives less precipitation, but the tree diversity is higher than those of the other two plots. One of the most important reasons is the dense fog which always exists during the entire dry season on the lower hills and in the valleys, averaging 146 foggy days per year and 1 mm

Table 5 Number of stems and basal area of the ten commonest families, genera and species in the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China

Rank	Stems						Basal area (m^2)					
	Family	Stems	Genus	Stems	Species	Stems	Family	Basal area	Genus	Basal area	Species	Basal area
1	Icacinaceae	21,769	*Pittosporopsis*	20,918	*Pittosporopsis kerrii*	20,918	Dipterocarpaceae	113.52	*Parashorea*	113.52	*Parashorea chinensis*	113.52
2	Euphorbiaceae	9,827	*Parashorea*	7,919	*Parashorea chinensis*	7,919	Fagaceae	106.33	*Castanopsis*	102.34	*Castanopsis echinocarpa*	48.60
3	Dipterocarpaceae	7,919	*Garcinia*	5,131	*Garcinia cowa*	4,333	Lauraceae	72.36	*Ficus*	42.07	*Sloanea tomentosa*	41.37
4	Lauraceae	7,302	*Knema*	3,778	*Mezzettiopsis creaghii*	3,300	Euphorbiaceae	59.27	*Sloanea*	41.37	*Pittosporopsis kerrii*	28.47
5	Guttiferae	5,150	*Mezzettiopsis*	3,300	*Baccaurea ramiflora*	3,212	Elaeocarpaceae	57.00	*Pittosporopsis*	28.47	*Mezzettiopsis creaghii*	25.28
6	Annonaceae	5,010	*Baccaurea*	3,212	*Knema furfuracea*	3,160	Moraceae	45.70	*Mezzettiopsis*	25.28	*Pometia tomentosa*	23.58
7	Rubiaceae	4,869	*Ficus*	3,088	*Saprosma ternata*	2,698	Sapindaceae	41.11	*Pometia*	23.58	*Garcinia cowa*	19.24
8	Myristicaceae	4,272	*Phoebe*	3,012	*Phoebe lanceolata*	2,409	Annonaceae	34.79	*Garcinia*	21.31	*Castanopsis hystrix*	18.90
9	Moraceae	3,315	*Saprosma*	2,698	*Cinnamomum bejolghota*	1,337	Icacinaceae	31.75	*Litsea*	18.05	*Castanopsis megaphylla*	18.24
10	Meliaceae	2,990	*Castanopsis*	1,885	*Ficus langkokensis*	1,337	Meliaceae	27.59	*Cinnamomum*	15.93	*Alseodaphne petiolaris*	14.44
Total		72,423		54,941		50,623		589.43		329.58		351.64

precipitation per foggy day (Zhu 2006). This compensates for the insufficient precipitation so that a tropical moist climate can form locally in spite of its relatively low mean annual precipitation.

Stem density of Xishuangbanna plot (4,791.7 trees ≥1 cm dbh) was moderate compared with other 50-ha plots, which ranged from 1,609 stems per ha in Huai Kha Khaeng, Thailand to 6,769 stems per ha in Pasoh, Malaysia (Bunyavejchewin et al. 2001; Kenfack et al. 2007), but similar to that of the plot on Barro Colorado Island, Panama (4,844 stems per ha) (Bunyavejchewin et al. 2001).

Hubbell and Foster (1986) defined rare species as those with a mean density of ≤1 tree per ha. According to this definition, the Xishuangbanna plot had a large proportion of rare species (230 rare species representing 49.14% of total species but only 1.24% of total individuals). For the sake of comparison, we defined rare species here as having fewer than 0.3 individuals per ha. In this case, the percentage of rare species (35.9%) of our plot was greater than those of the Pasoh plot (19.2%), Lambir plot (14.9%), BCI plot (25.6%) and Korup plot (29.2%) (Condit et al. 2005; Kenfack et al. 2007; Lan et al. 2008), but lower than those of the Ituri plot (48.40%) in Congo and the Huai Kha Khaeng plot (44.8%) in Thailand (Condit et al. 2005). As regards species dominance, the Xishuangbanna plot also had the most abundant species, *P. kerrii* with a dominance of 21.90%, which was much greater than those of the Pasoh plot (2.70%), Lambir plot (2.60) and BCI plot (15.70%) (Condit et al. 2005). Furthermore, the emergent layer of the forest in our study site was dominated solely by *P. chinensis*, which is unusual for tropical rainforests in Southeast Asia.

Conclusions

Our study presents tree species diversity and flora composition of a 20-ha plot in a tropical seasonal rainforest in Xishuangbanna, southwest China. A total of 468 morphospecies, contributing 213 genera and 70 families, was recorded in the plot. Fisher's α showed species among trees ≥10 dbh were distributed more evenly than were species among trees ≥1 and ≥30 cm dbh. Fewer predominant species (>1,000 individuals) but relatively more very rare species (singletons in the 20-ha plot) were found in the plot. Monodominance, both in the emergent layer and treelet layer, and a high percentage of rare species of the tropical seasonal rainforest in Xishuangbanna were unusual among tropical rainforests in south-east Asia. Species richness per ha and tree abundance per ha varied greatly across the plot. Tree species richness per ha of the plot was relatively low when compared with the equatorial

Table 6 List of the top 20 species with the greatest importance values in the 20-ha plot of tropical seasonal rainforest in Xishuangbanna, southwest China (336 unidentified individual trees were excluded in calculating the importance value)

Rank	Species	Strata	Abundance	Stems per ha	Basal area (m^2)	IV
1	*Pittosporopsis kerrii*	Treelet layer	20,918	1,045.90	28.47	25.78
2	*Parashorea chinensis*	Emergent	7,919	395.95	113.52	22.36
3	*Garcinia cowa*	Lower canopy	4,333	216.65	19.24	7.30
4	*Castanopsis echinocarpa*	Lower canopy	881	44.05	48.60	7.07
5	*Mezzettiopsis creaghii*	Treelet layer	3,300	165.00	25.28	6.92
6	*Sloanea tomentosa*	Upper canopy	502	25.10	41.37	5.90
7	*Baccaurea ramiflora*	Understory	3,212	160.60	14.01	5.50
8	*Knema furfuracea*	Lower canopy	3,160	158.00	11.24	5.12
9	*Pometia tomentosa*	Upper canopy	480	24.00	23.58	3.79
10	*Phoebe lanceolata*	Treelet layer	2,409	120.45	4.43	3.51
11	*Saprosma ternata*	Treelet layer	2,698	134.90	1.01	3.41
12	*Nephelium chryseum*	Lower canopy	1,098	54.90	12.97	3.16
13	*Castanopsis hystrix*	Lower canopy	244	12.20	18.90	2.93
14	*Cinnamomum bejolghota*	Lower canopy	1,337	66.85	8.76	2.91
15	*Castanopsis megaphylla*	Lower canopy	255	12.75	18.24	2.80
16	*Diospyros hasseltii*	Lower canopy	815	40.75	12.47	2.78
17	*Ficus langkokensis*	Lower canopy	1,337	66.85	7.64	2.78
18	*Semecarpus reticulata*	Upper canopy	619	30.95	10.40	2.35
19	*Alseodaphne petiolaris*	Lower canopy	178	8.90	14.44	2.33
20	*Castanopsis indica*	Lower canopy	351	17.55	10.97	2.10
Total			56,046	2,802.30	445.54	120.80

IV importance value, *treelet* 5–10 m, *understory* 10–20 m, *lower canopy* 20–30 m, *upper canopy* 30–45 m, *emergent* >45 m

Table 7 Comparison of species richness and density between Xishuangbanna forest dynamics plot and other forest dynamics plots

Plots	Plot size (ha)	Precipitation (mm)	Dry season (month)	Elevation (m)	Latitude (north)	Stems per ha (≥1 cm)	Species per ha (≥1 cm)	Species in the whole plot (≥1 cm)
Xishuangbanna, China	20	1,532	6	709–869	21.364°	4,792	216.50	468
Lambir, Malaysia	52	2,664	0	104–244	4.187°	6,687[b]	618.10[c]	1,179[c]
Huai Kha Khaeng, Thailand	50	1,476	6	550–640	15.632°	1,609[b]	103.90[c]	251[a]
Pasoh, Malaysia	50	1,788	0	70–90	2.982°	6,769[b]	496.50[c]	814[c]
Korup, Cameroon	50	5,272	3	150–240	5.065°	6,590[d]	235.10[c]	494[c]
Barro Colorado Island, Panama	50	2,551	3	110–140	9.152°	4,844[b]	168.00[c]	301[c]

[a] Plotkin et al. (2000)

[b] Bunyavejchewin et al. (2001)

[c] Condit et al. (2005)

[d] Kenfack et al. (2007)

rainforests of tropical Asia, but greater than tropical forest in BCI, Panama, and seasonal dry evergreen forest in Thailand.

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