

# Biogeographical affinities of the flora of southeastern Yunnan, China<sup>1</sup>

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**ABSTRACT.** Southeastern Yunnan has 4,996 species and varieties of 1,357 genera and 186 families of native seed plants recorded. Floristic attributes and biogeographical affinities of the flora were studied by analyzing its floristic composition and geographical elements. Tropical genera comprise a majority (68.83%) of the flora and those of tropical Asian distribution contribute to 27.34% of the total genera. The flora of southeastern Yunnan is similar in composition to the floras of southern Yunnan, southwestern Guangxi and Vietnam. They have similarities of more than 89% at the family level and more than 76% at the generic level. The flora of southeastern Yunnan, with the compared floras together, belongs to the same floristic unit and is suggested to be part of Indo-Malaysian flora at northern margin of tropical Asia. However, the taxa of strictly tropical distribution are still underrepresented in the flora of southeastern Yunnan compared to Indo-Malaysian flora, and the families of mainly subtropical to temperate distribution, such as Magnoliaceae, Theaceae, Cornaceae, Styracaceae, Symplocaceae, Aquifoliaceae and Caprifoliaceae, are well represented in the flora. Some characteristic families of temperate East Asia, such as Diapensiaceae, Dipentodontaceae, Eupteleaceae, Grossulariaceae and Toricelliaceae are also present in the flora of southeastern Yunnan. These suggest that the flora of southeastern Yunnan is related to Eastern Asian flora more than other compared floras. It is also revealed that the flora of southeastern Yunnan is biogeographically closer to the flora of southwestern Guangxi than that of southern Yunnan.

**Keywords:** Biogeographical affinities; Flora; Southeastern Yunnan.

## INTRODUCTION

Southern China is located at the northern edge of tropical Asia, and is composed of the southeasternmost part of Xizang (Tibet) (lower valleys of southern Himalayas), southwestern, southern and southeastern parts of Yunnan, southern Guangxi, southern Guangdong, southern Taiwan and Hainan Island. Southeastern Yunnan borders Vietnam, is situated in the southern extension of the Eastern Himalayas, and located at the demarcation line with tropical "SE Asia" to the south, temperate "Sino-Himalaya" to the north biogeographically.

Southeastern Yunnan is of extreme interest to botanists not only for its richness of primitive angiosperm taxa, such as species of Magnoliaceae and being a centre of palaeoendemism in China (Li, 1994), but also for its biodiversity richness, a hotspot for biodiversity of the world (Myers, 1998). The montane flora of southeastern

Yunnan is more of the nature of the temperate Sino-Himalaya flora, but the lowland flora is of the nature of the tropical Asian flora with representatives of Dipterocarpaceae.

The flora of south China and its tropical Asian floristic affinity have been discussed since the China-Russia expedition which penetrated deep into the areas of southwestern China in the late 1950s (Fedorov, 1957, 1958; Wu, 1965; Zhu, 1993, 1994a, 1994b, 1997, 2008a, 2008b; Zhu et al., 2001, 2003, 2004a, 2004b, 2006). However, most of the research on flora and vegetation in tropical southwestern China has been conducted in southern Yunnan. The flora of southeastern Yunnan and its biogeographical affinities are less known except some local works in nature reserves (Li et al., 2002; Zhang et al., 2003; Shui et al., 2003; Wang et al., 2006; Zhu et al., 2007a).

To better understand the flora and its biogeographical affinities, the floristic composition and geographical elements of southeastern Yunnan were analyzed at family and generic levels. The floristic relationships of southeastern Yunnan to its neighboring southern Yunnan, southwestern Guangxi and Vietnam, are discussed by

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comparing the revised floristic inventories and checklists of these regions in this study.

### Study site and topography

The area in southeastern Yunnan referred to in this study is located between the Tropic of Cancer and the Yunnan-Vietnam border, 22°26' ~ 23°26' N and 104°27' ~ 108°48' E (Figure 1). It borders Vietnam to the south, and has a mountainous topography with the mountain ridges running in a north-south direction, decreasing in elevation southeastward. The region, including the six counties of Pingbian, Hekou, Jingping, Luchun, Yuanyang and Honghe, is c. 14,389 km<sup>2</sup> in area and most of the area is limestone. Its altitude ranges from 74.6 m at the bottom of the lowest valley in the south (Hekou) to 3047.3 m at the top of Xilong Mountains in Jingping County.

### Climate

The region has a monsoon climate. From the climatic station in Hekou County at 136.7 m alt. in the south of the region, the annual mean temperature is about 22.6°C and the annual cumulative temperature (the sum of daily temperature means  $\geq 10^\circ\text{C}$ ) is 8322.8°C. Annual precipitation is 1777.7 mm, of which more than 80% of the rainfall is in the rainy season from May to October. The average relative humidity is about 86% (Yunnan Meteorological Bureau, 1983). However, the region has a strong climatic variation with altitude. For example, in Pingbian county at 1414.1 m alt., the annual mean temperature is 16.5°, and the annual cumulative temperature ( $\geq 10^\circ\text{C}$ ) is 5933.2°C, as well as the annual precipitation is 1621.4 mm, while in Fenshuiling of Jingping county at 2300 m alt., the annual mean temperature is 10.6°, and the annual cumulative temperature ( $\geq 10^\circ\text{C}$ ) is 2811.6°C, as well as the annual precipitation is 3287.4 mm (Xu, 2002).

### Soil

There are four main soil types in the region. Laterite soils occur in the area below 600 m altitude. Kanhaplohumult soils occur in the areas between 600-1,200 m altitudes with a deep solum, but thin humus horizon. Paleudult soils derived from sandstone substrate occur in the areas between 1,200-1,900 m altitudes. Hapludalf soils occur in the areas above 1,900 m elevation. There is a large area of limestone in the region. The limestone hills have soil derived from a hard limestone substrate.

### Vegetation

There are three main altitudinal zones of vegetation in the region. Below 800-900 m elevation is a seasonal rain forest in wet valleys and on lower slopes, and a monsoon forest in dry valleys. Between 900-2,000 m elevation is a lower montane rain forest in wet montane valleys, and an evergreen broad-leaved forest on slopes. An upper montane rain forest occurs on upper slopes

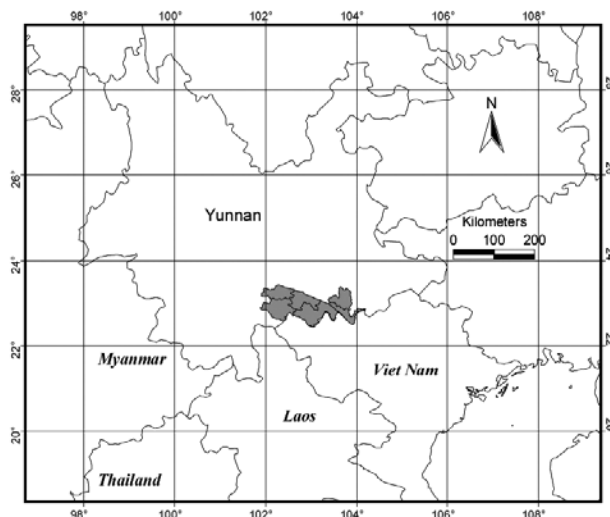


Figure 1. The study area in tropical southeastern Yunnan.

between 2,000-2,500 m elevations. Above 2,500 m elevation is a mossy dwarf forest and shrubs.

The seasonal rain forest, which is similar in forest profile, physiognomic characteristics and floristic composition to Southeast Asian rain forests, is a type of tropical Asian rain forest. It is characterized by tree species *Pometia tomentosa*, *Parashorea chinensis*, *Dipterocarpus retusus*, *Hopea mollissima*, *Lysidice rhodostegia*, *Saraca dives* and *Garcinia paucinervis*. The monsoon forest is a deciduous forest characterized by the deciduous tree species *Bombax malabaricum*, *Albizia chinensis*, *Erythrina stricta*, *Lannea coromandelica*, *Sterculia pexa*, *Mayodendron igneum* and *Stereospermum tetragonum*. The lower montane rain forest is characterized by tree species *Madhuca pasquierii*, *Altingia yunnanensis*, *Podocarpus imbricatus*, *Beilshchmiedia fasciata*, *Michelia foveolata* and *Lithocarpus truncatus*. The evergreen broad-leaved forest has a wide distribution and is the main montane vegetation type in the region. It is dominated by species of Fagaceae, Euphorbiaceae, Lauraceae and Theaceae, such as *Castanopsis calceathiformis*, *Castanopsis hystrix*, *Castanopsis fleuryi*, *Lindera communis*, *Machilus tenuipilis*, *Machilus longipedicellata* and *Schima wallichii*. The upper montane rain forest is characterized by the species *Castanopsis wattii*, *Lithocarpus xylocarpus*, *Machilus viridis*, *Schima sinensis*, *Hartia sinensis*, *Diplopanax stachyanthus*, *Rehderodendron macrocarpum*, *Rhodoleia henryi* and *Alcimandra cathcartii*. The mossy dwarf forest is characterized by *Lithocarpus pachyphylloides*, *Vaccinium mandarinorum*, *Rhododendron irroratum*, *Myrsine stolonifera* and *Pieris formosa*.

### MATERIALS AND METHODS

Shui (2003) published a checklist of seed plants from subtropical to tropical southeastern Yunnan. From Shui's work and references, we compiled a list of 4,996

species and varieties of native seed plants in 1,357 genera and 186 families from tropical southeastern Yunnan. Circumscription of families and species follows *w*<sup>3</sup> TROPICOS of Missouri Botanical Garden (<http://mobot.mobot.org/W3T/Search/vast.html>). Based on the plant list, the floristic and geographical attributes of the flora of southeastern Yunnan were analyzed. Patterns of seed plant distribution were quantified at the generic level based on Wu (1991). Adjacent southern Yunnan, southwestern Guangxi and Northern Vietnam are floristically similar to southeastern Yunnan. To discuss the floristic similarity and variation as well as biogeographical affinities among these regions, comparisons of floristic composition and geographical elements between southeastern Yunnan and neighbouring regions were made by using updated checklists of their floras. The checklist of the flora of southern Yunnan refers to the Xishuangbanna administrative region (Zhu, 2008). Southwestern Guangxi refers also to its tropical area that was recognised by referring distribution of tropical genera of seed plants (Zhu et al., 2007b) and the floristic regionalization of Fang et al. (1995), which extends to northern Vietnam and lies between 21°30'~23°10' N and 106°~109° E. The checklist of southwestern Guangxi was abstracted from the database of the Institute of Botany, CAS. The checklist of the Vietnamese flora (Le, 1999) was used for making comparisons, although Vietnam is floristically heterogeneous in its northern and southern parts.

## RESULTS

### Floristic composition

Four thousand nine hundred ninety six species and varieties in 1,357 genera and 186 families of native seed plants were recognized to occur in southeastern Yunnan. The families with highest species richness include Fabaceae (70 genera/285 species), Orchidaceae (83/276), Rubiaceae (60/235), Poaceae (92/219), Asteraceae (59/180), Lauraceae (15/141), Urticaceae (17/134), Euphorbiaceae (41/126), Rosaceae (26/124), Fagaceae (5/109) and Moraceae (7/104), Ericaceae (10/96), Lamiaceae (39/91), Cyperaceae (13/87), Acanthaceae (40/85) and Theaceae (9/81) (Table 1). Both the families of mainly tropical elements, such as Orchidaceae, Rubiaceae, Lauraceae, Euphorbiaceae, Moraceae and Acanthaceae, and the families of mainly temperate elements, such as Fabaceae, Poaceae, Asteraceae, Lamiaceae, Rosaceae and Ericaceae have high species richness. The families Fagaceae and Theaceae, which are the dominant families in the forest of East Asia, also have high species richness in the flora.

### Geographical elements at generic level

Patterns of seed plant distribution of the flora at the generic level are detailed in Table 2. The genera of tropical Asian distribution, such as *Alphonsea*, *Amoora*, *Pterospermum*, *Mitrephora*, *Mycetia*, *Aganosma*, *Chukrasia*,

**Table 1.** The families of species richness in the flora of southeastern Yunnan.

Family	Genus	Species	% of the total species
Fabaceae	70	285	5.70
Orchidaceae	83	276	5.52
Rubiaceae	60	235	4.70
Poaceae	92	219	4.38
Asteraceae	59	180	3.60
Lauraceae	15	141	2.82
Urticaceae	17	134	2.68
Euphorbiaceae	41	126	2.52
Rosaceae	26	124	2.48
Fagaceae	5	109	2.18
Moraceae	7	104	2.08
Ericaceae	10	96	1.92
Lamiaceae	39	91	1.82
Cyperaceae	13	87	1.74
Acanthaceae	40	85	1.70
Theaceae	9	81	1.62
Gesneriaceae	21	79	1.58
Liliaceae	22	64	1.32
Celastraceae	10	65	1.30
Araliaceae	16	64	1.28
Vitaceae	9	60	1.20
Verbenaceae	10	60	1.20
Myrsinaceae	4	60	1.20
Scrophulariaceae	26	59	1.18
Rutaceae	15	58	1.16
Melastomataceae	16	58	1.16
Annonaceae	12	54	1.08
Asclepiadaceae	23	53	1.06
Polygonaceae	5	52	1.04
Magnoliaceae	14	52	1.04
Araceae	18	52	1.04
Begoniaceae	1	51	1.02
Zingiberaceae	11	50	1.00
Apocynaceae	23	47	0.94
Smilacaceae	2	43	0.86
Sterculiaceae	11	41	0.82
Cucurbitaceae	13	41	0.82
Ranunculaceae	7	38	0.76
Caprifoliaceae	8	37	0.74
Aquifoliaceae	1	35	0.70
Piperaceae	3	34	0.68
Convolvulaceae	12	34	0.68
Commelinaceae	12	32	0.64
Oleaceae	6	30	0.60

*Crypteronia*, and *Knema*, show the highest percentage among all distribution types, contributing 27.34% to the flora. Genera of Pantropical distribution, such as *Gnetum*, *Cryptocarya*, *Capparis*, *Piper*, *Croton*, *Dioscorea*, *Uncaria*, *Morinda*, *Ardisia*, *Bauhinia*, *Marsdenia* etc., contribute 17.96% to the flora. Next are the genera of Old World tropical distribution, such as *Thunbergia*,

*Dracaena*, *Pandanus*, *Ventilago*, *Stephania*, *Fissistigma*, *Polyalthia*, *Barringtonia*, *Carallia*, *Canarium*, *Chasalia* and *Uvaria*, contributing 8.55%. Genera with distributions from tropical Asia to tropical Australia include *Hoya*, *Argyreaia*, *Dillenia*, *Lagerstroemia*, *Loesenneriella*, *Murray* and *Toona*. Genera of tropical Asian to tropical Africa distribution include *Bombax*, *Flacourtia*, *Bridenia*, *Premna*, *Strophanthus*, *Mitragyna*, *Garcinia*, *Anogeissus*, and *Cymbopogon*. Genera of tropical distribution in all (types 2~7) comprise 68.83% of the total number. The genera of Northern temperate distribution such as *Artemisia*, *Carpinus*, *Betula*, *Salix*, *Cornus*, *Corydalis*, *Pinus*, and *Sorbus* contribute to 8.18% of the total genera. The genera of East Asian distributions such as *Actinidia*, *Belamcandia*, *Aspidistra*, *Cephalotaxus*, *Choerospondia*, *Gardneria*, *Hovenia*, *Pegia*, *Skimmia*, *Stachyris*, *Pterocarya*, contribute to 8.84% of the total genera. Other genera include those which have a disjunct distribution in East Asia and North America, such as *Schizandra*, *Photinia*, *Nyssa*, *Osmanthus*, *Magnolia*, *Mahonia*, *Illicium*, *Castanopsis* etc., and Old World temperate distributions such as *Ajuga*, *Elsholzia*, *Herminium*, *Inula*, *Ligustrum*, *Paris* etc. There are 41 genera which are endemic or approximately endemic to China, including *Bretschneidera*, *Camptotheca*, *Cephalantheropsis*, *Craspedolobium*, *Delavaya*, *Dipteronia*, *Eleutharrhena*, *Emmenopterys*, *Glyptostrobus*, *Gymnotheca*, *Hemiboeopsis*, *Neohusnotia*, *Tapiscia*, *Tetrapanax* etc.

**Table 2.** Geographical elements of seed plants at the generic level in the flora of southeastern Yunnan.

Geographical elements at generic level	Number of genera	%*
1 Cosmopolitan	62	4.57
2 Pantropic	240	17.69
3 Tropical Asia and Tropical America disjunct	30	2.21
4 Old World Tropic	116	8.55
5 Tropical Asia to Tropical Australia	82	6.04
6 Tropical Asia to Tropical Africa	95	7.00
7 Tropical Asia	371	27.34
8 North Temperate	111	8.18
9 East Asia and North America disjunct	47	3.46
10 Old World Temperate	32	2.36
11 Temperate Asia	6	0.44
12 Mediterranean, W Asia to C Asia	3	0.22
13 Center Asia	1	0.07
14 East Asia	120	8.84
15 Endemic to China	41	3.02
Total no. of genera	1357	100

\*The no. of genera in each geographical element divided by the no. of genera of all geographical elements, then multiplied by 100%.

### Comparison of the floras of southern Yunnan, southwestern Guangxi of SW China and Vietnam

The floristic similarities at the family and generic levels between southeastern Yunnan and southern Yunnan (Xishuangbanna), southwestern Guangxi and Vietnam are given in Table 3. The similarities in the flora of southeastern Yunnan and those compared floras exceed 89% at the family level and more than 76% at the generic level. The flora of southeastern Yunnan shows a higher floristic similarity to the flora of southwestern Guangxi than to the flora of southern Yunnan at the family and generic levels.

**Table 3.** Similarity coefficients at family and genus levels between the floras of southern Yunnan, southeastern Yunnan, southwestern Guangxi and Vietnam.

Similarity coefficients	Southern Yunnan/ Southeastern Yunnan	Southwestern Guangxi/ Southeastern Yunnan	Vietnam/Southeastern Yunnan
At family level	163/89.6*	177/95.2	176/94.6
At genus level	939/79.9**	857/84.68	1036/76.34

\*Shared no. of families/ Similarity coefficients; \*\*Shared no. of genera/ Similarity coefficients.

Similarity coefficient between A and B = The number of taxa shared by both A and B divided by the number of taxa of A or B which has less taxa, then multiplied by 100%.

Data for tropical southwestern Guangxi is from the database of Institute of Botany, CAS, from which we compiled a plant list with 190 families and 1012 genera of seed plants. Data for southern Yunnan is from Zhu (2008), in which a plant list with 182 families and 1176 genera of seed plants were enumerated. Data for Vietnam is from Le (1999), from which a plant list with 214 families and 1817 genera of seed plants were compiled.

**Table 4.** The twenty families with most species richness among the tropical floras of southern, southeastern Yunnan, southwestern Guangxi and Vietnam.

Flora of southern Yunnan		Flora of southeastern Yunnan		Flora of southwestern Guangxi		Flora of Vietnam	
Family	Species %*	Family	Species %	Family	Species %	Family	Species %
Orchidaceae	9.82	Fabaceae	5.70	Fabaceae	6.06	Fabaceae	6.98
Fabaceae	6.32	Orchidaceae	5.52	Euphorbiaceae	3.90	Orchidaceae	6.90
Rubiaceae	4.25	Rubiaceae	4.70	Rubiaceae	3.90	Poaceae	5.73
Poaceae	3.95	Poaceae	4.38	Asteraceae	3.46	Rubiaceae	4.72
Euphorbiaceae	3.50	Asteraceae	3.60	Orchidaceae	3.09	Euphorbiaceae	4.50
Asteraceae	3.17	Lauraceae	2.82	Poaceae	2.94	Cyperaceae	3.61
Moraceae	2.19	Urticaceae	2.68	Lauraceae	2.53	Asteraceae	3.26
Lauraceae	2.10	Euphorbiaceae	2.52	Rosaceae	2.42	Lauraceae	2.71
Urticaceae	2.16	Rosaceae	2.48	Urticaceae	2.16	Fagaceae	2.37
Zingiberaceae	2.10	Fagaceae	2.18	Fagaceae	2.12	Acanthaceae	2.17
Acanthaceae	2.04	Moraceae	2.08	Moraceae	1.75	Annonaceae	1.87
Lamiaceae	1.83	<b>Ericaceae</b>	1.92	Rutaceae	1.71	Apocynaceae	1.72
Asclepiadaceae	1.74	Lamiaceae	1.82	Zingiberaceae	1.71	Myrsinaceae	1.56
Apocynaceae	1.53	Cyperaceae	1.74	Asclepiadaceae	1.67	Moraceae	1.53
Annonaceae	1.47	Acanthaceae	1.70	Gesneriaceae	1.67	Verbenaceae	1.46
Verbenaceae	1.44	<b>Theaceae</b>	1.62	Apocynaceae	1.60	Lamiaceae	1.42
Cucurbitaceae	1.38	Gesneriaceae	1.58	Liliaceae	1.60	Araceae	1.42
Rosaceae	1.38	Liliaceae	1.32	Myrsinaceae	1.56	Rosaceae	1.38
Vitaceae	1.35	<b>Celastraceae</b>	1.30	Lamiaceae	1.45	Zingiberaceae	1.38
Fagaceae	1.32	<b>Araliaceae</b>	1.28	Vitaceae	1.38	Melastomataceae	1.31

\*Species % indicates their percentage within the respective floras (the number of species for each family divided by the total number of species in the respective floras  $\times 100$ ). The families showed in bold are the top twenty families, which are only in the flora of the tropical southeastern Yunnan.

The comparisons of the twenty families with the most species among these floras are enumerated in Table 4.

The top ranking families in all compared floras are basically the same. The families Zingiberaceae and Apocynaceae represent in the floras of southern Yunnan, southwestern Guangxi and Vietnam among the top twenty families, but not in the top twenty in the flora of southeastern Yunnan. Annonaceae and Verbenaceae are in the top twenty ranking families of the floras of southern Yunnan and Vietnam, while Liliaceae and Gesneriaceae are in the top twenty ranking families of the floras of southeastern Yunnan and southwestern Guangxi. However, Ericaceae, Theaceae, Celastraceae and Araliaceae are only in the top twenty ranking families of the flora of southeastern Yunnan. On the other hand, some families with less species richness, such as the mainly temperate families Coriariaceae, Diapensiaceae, Dipentodontaceae, Eupteleaceae, Grossulariaceae and Toricelliaceae present in southeastern Yunnan, but not in the floras of southern Yunnan and Vietnam.

If we rank the families of high species richness (more than 20 species) by their species percentage in the total of the family (The number of species for each family in the respective floras divided by the total number of species of the family worldwide), we obtained a different ranking pattern (Table 5). Magnoliaceae ranks first in the floras of southeastern Yunnan, southwestern Guangxi and Vietnam among the top ten families, followed by Theaceae. Smilacaceae and Caprifoliaceae are shared by the floras of southeastern Yunnan, southwestern Guangxi in the top ten families, while Symplocaceae is shared by southeastern Yunnan and Vietnam. However, Cornaceae and Styracaceae are among the top ten families only in southeastern Yunnan.

Comparisons of geographical elements at generic level from these regional floras revealed that the tropical elements (type 2~7) contribute more than 68% of the total genera in all these compared floras, and that the highest proportion of the tropical elements occurs in the flora of southern Yunnan (comprising 78.3% of all the genera)

**Table 5.** Comparison of the families ranked by their species percentage of the total in the family in the regional floras.

Southern Yunnan	Species % of the family*	Southeastern Yunnan	Species % of the family*	Southwestern Guangxi	Species % of the family*	Vietnam	Species % of the family*
Urticaceae	6.86	<b>Magnoliaceae</b>	31.52	<b>Magnoliaceae</b>	14.55	<b>Magnoliaceae</b>	31.52
Menispermaceae	6.67	<b>Cornaceae</b>	23.33	Fagaceae	8.14	Fagaceae	30.43
Moraceae	6.64	Fagaceae	15.57	<b>Smilacaceae</b>	6.25	<b>Theaceae</b>	16.07
Meliaceae	6.55	<b>Smilacaceae</b>	13.44	<b>Caprifoliaceae</b>	6.19	Meliaceae	13.63
Zingiberaceae	6.36	<b>Theaceae</b>	13.28	<b>Theaceae</b>	5.90	<b>Symplocaceae</b>	12.80
Fagaceae	6.29	Urticaceae	12.76	Urticaceae	5.52	Ebenaceae	12.78
Cucurbitaceae	5.94	<b>Styracaceae</b>	12.50	Menispermaceae	4.89	Verbenaceae	13.79
Vitaceae	5.29	<b>Symplocaceae</b>	10.40	Vitaceae	4.35	Moraceae	12.55
Commelinaceae	4.84	Moraceae	9.45	Moraceae	4.27	Myrsinaceae	11.43
Verbenaceae	4.17	<b>Caprifoliaceae</b>	8.81	Zingiberaceae	4.18	Zingiberaceae	11.27

\* The number of species for each family in the respective floras divided by the total number of species of the family worldwide. The families showed in bold are the characteristic families of temperate East Asian flora.

**Table 6.** Comparison of geographical elements at generic level between the floras of southern, southeastern Yunnan, southwestern Guangxi and Vietnam (%)\*.

Geographical elements of genera	Flora of southern Yunnan	Flora of southeastern Yunnan	Flora of southwestern Guangxi	Flora of Vietnam
1 Cosmopolitan	5	4.57	5.43	4.35
2 Pantropic	21.3	17.69	20.06	18.00
3 Tropical Asia and Tropical America disjunct	2.6	2.21	2.96	2.92
4 Old World Tropic (Tropical Africa via Tropical Asia to Tropical Australia)	9.5	8.55	9.19	9.08
5 Tropical Asia to Tropical Australia	6.5	6.04	9.98	7.82
6 Tropical Asia to Tropical Africa	8.2	7.00	4.45	8.26
7 Tropical Asia or Indo-Malesia	30.2	27.34	23.22	29.33
8 North Temperate	5.1	8.18	7.71	6.49
9 East Asia and North America disjunct	2.7	3.46	3.95	3.08
10 Old World Temperate	2	2.36	2.96	2.48
11 Temperate Asia	0.4	0.44	0.49	0.50
12 Mediterranean, W. Asia to C. Asia	0.2	0.22	0.30	0.83
13 Center Asia	0.1	0.07	0.00	0.06
14 East Asia	5.3	8.84	7.11	5.12
15 Endemic to China	0.9	3.02	2.17	0.00
16 Endemic to Vietnam				1.71

Data for Southern Yunnan used here is from Zhu (2008) (1176 genera included); Data for tropical southwestern Guangxi used here is from database of the Institute of Botany, CAS (1012 genera included); Data for Vietnam is from Li (1999) (1817 genera included).

(Table 6). All the compared floras have very similar geographical elements except the flora of southeastern Yunnan which has a slightly higher proportion of the geographical elements of East Asia, North Temperate and endemic to China.

### Conclusions and discussion

Tropical genera comprise a majority (68.83%) of the flora of southeastern Yunnan. The dominant genera are those restricted to tropical Asia (27.34% of the total genera). This reveals that the flora of southeastern Yunnan is tropical in nature and has tropical Asian affinity although it occurs at the southern extension of the Eastern Himalayas.

The flora of southeastern Yunnan is similar to the floras of southern Yunnan, southwestern Guangxi and Vietnam in the families with the greatest species richness, and has high similarities to them at family and generic levels (more than 89% at the family level and more than 76% at the generic level). It is further confirmed that southeastern Yunnan, southern Yunnan, southwestern Guangxi and Vietnam are floristically continuous. The flora of southeastern Yunnan, along with these other floras, belongs to the same floristic unit and is part of tropical Asian or Indo-Malaysian flora in floristic regionalization. However, the families Ericaceae, Theaceae, Celastraceae and Araliaceae, which are well developed in East Asia, are in the top twenty ranking families of the flora of southeastern Yunnan only, while the more strictly tropical families, such as Zingiberaceae, Verbenaceae, Apocynaceae and Annonaceae are in the top twenty ranking families of the other compared floras. Some temperate East Asian families, such as Coriariaceae, Diapensiaceae, Dipentodontaceae, Eupteleaceae, Grossulariaceae and Toricelliaceae are exclusively present in southeastern Yunnan. These suggest that the flora of southeastern Yunnan is related to temperate Eastern Asian flora more than the other compared floras. The flora of southeastern Yunnan has also a lower percentage of tropical elements and more temperate elements than those of southern Yunnan, southwestern Guangxi and Vietnam. These features of the flora of southeastern Yunnan correspond well to the large cover of montane vegetation in the area.

Although tropical families and genera in a broad sense contribute most to its total flora, the taxa of strictly tropical distribution are still underrepresented in southeastern Yunnan, compared to the Malaysian flora. For example, Dipterocarpaceae has only four species of three genera respectively in southeastern Yunnan although they are the most abundant trees in some forest types. The flora of southeastern Yunnan is a marginal part of the tropical Asian flora.

In the families ranked by species percentage in the total of the family worldwide (Table 5), Magnoliaceae ranks the first in the flora of southeastern Yunnan, followed by Cornaceae, Smilacaceae, Theaceae, Styracaceae, Symplocaceae and Caprifoliaceae in the top ten ranking

families. These families are not only the characteristic families of the temperate East Asian flora, but also the ones well represented in the flora of southeastern Yunnan. The families with most species richness are not the same as the ones that well represented in the flora of southeastern Yunnan. These floristic patterns are quite different from those in Malesian floras, for example, in the flora of Malay Peninsula (Turner, 1995), the families Dipterocarpaceae, Zingiberaceae, Clusiaceae, Annonaceae, Rubiaceae, Apocynaceae, Arecaceae, Euphorbiaceae, Myrtaceae and Melastomataceae are the families with most species richness, but also the families that well represented in Malesia (Zhu and Roos, 2004). It is implied that the flora of southeastern Yunnan had a historical connection to Eastern Asian flora in origin, but deeply permeated by Malesian floristic elements. The flora of southeastern Yunnan has also a closer affinity to the floras of southwestern Guangxi and Vietnam than to the flora of southern Yunnan by sharing more of the well represented families in these regions. Studies on the geological history of SE Asia revealed that southeastern Yunnan and southwestern Guangxi were derived from South China Block or Yangzi Block, while southern Yunnan was part of Shan-Thai Block or Simao Block with Ailaoshan-Song Ma or Ailaoshan Belt being a suture zone (Feng et al., 2005; Metcalfe, 2006; Lepvriere et al., 2008). Our results could be well explained by the geological history of these regions. It is also revealed that direct land connection between mainland SE Asia and western Malesia existed until the early Pliocene (5 million years ago) (Hall, 1998), and there was no geographical barrier between Yunnan, mainland SE Asia and west Malesia during most of the Tertiary (Morley, 1998). The geological history may explain the high percentage of tropical floristic elements, including tropical Asian elements, in the flora of southeastern Yunnan.

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## 雲南東南部熱帶植物區系的生物地理親緣

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雲南東南部熱帶地區記錄有種子植物 186 科，1,357 屬，4,996 種及變種。通過分析其植物區系組成和地理成分，本文研究了該植物區系的特徵及其生物地理親緣。該植物區系熱帶成分占總屬數的 68.83%，其中，又以熱帶亞洲分佈屬比例最高，占總屬數的 27.34%。在與周邊雲南南部（西雙版納）、廣西西南部及越南植物區系的比較上，雲南東南部的熱帶植物區系與它們在科、屬水準上具有高的類似性，它們之間科的類似性在 89%，屬的類似性在 76% 以上。它們隸屬於同一植物區系分區單元，在植物區系分區中為熱帶亞洲或印度 — 馬來西亞植物區系的北緣部分。由於位於東南亞熱帶北緣山地及其地質歷史原因，雲南東南部的熱帶植物區系中嚴格熱帶分佈的成分不多，仍以邊緣熱帶成分為主，並有相對豐富的亞熱帶 - 溫帶科如木蘭科、山茶科、山茱萸科、山礬科、忍冬科、冬青科等以及一些東亞和喜馬拉雅特徵科，如岩梅科、十齒花科、領春木科、茶藨子科和鞘柄木科，顯示了它與東亞溫帶植物區系也有較多聯繫。與雲南南部、廣西西南部及越南熱帶植物區系比較，雲南東南部植物區系中熱帶地理成分的比例相對較低，並且與廣西西南部的聯繫強于雲南南部。

**關鍵詞：**生物地理親緣；植物區系；雲南東南部。

