The tropical flora of southern China and its affinity to Indo-Malesian flora

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Abstract

*H. Zhu[1] & M. C. Roos (The National Herbarium of the Netherlands, Leiden University branch, P.O.Box 9514, 2300 RA Leiden, the Netherlands. [1]Permanent address: Xishuangbanna Tropical Botanical Garden, the Chinese Academy of Sciences, Kunming 650223, P. R. China) 2004. The tropical flora of southern China and its affinity to Indo-Malesian flora.*Telopea *10(2): 639–648*. A comparative study of floristic composition of the vegetation in South China, i.e. southern Yunnan and Hainan Island, with those in Vietnam, Malay Peninsula and Brunei reveals that: (1) the flora of southern China consists mainly of tropical floristic elements which contribute about 60%, at the family level and more than 80 % at the generic level, of its total flora. The dominant geographical elements of the flora of southern China at the generic level are taxa with a distribution pattern in tropical Asia. This reveals that the flora of southern China is of tropical nature with a strong tropical Asian affinity; (2) most of the dominant families from the flora of southern China are also dominant in the Malesian flora except for the Urticaceae, Fagaceae, Theaceae, Rosaceae and Myrsinaceae. The floristic similarity between the flora of southern China and the flora of western Malesia is over 70% at the family level and more than 50% at the generic level, and between the floras of southern China and Vietnam is more than 84% at the family level and more than 69% at the generic level. This suggests that the tropical flora of southern China has a close affinity not only to the Vietnamese flora but also to the Malesian flora and supports the idea that the flora of southern China, together with the Indochina flora, belongs to Indo-Malesian floristic subkingdom of the Paleotropic kingdom suggested by Takhtadjan (1978) or the Malesian subkingdom of the Paleotropical kingdom as suggested by T.L.Wu et al. (1996); (3) situated at the northern margin of tropical Asia, on the other hand, it is also obvious that the flora of southern China comprises less strictly tropical elements whenc ompared to the Malesian flora, and consequently represents only a marginal type of Indo-Malesian flora; (4) the Vietnamese flora has a closer affinity to the tropical flora of China than to the Malesian flora and therefore is considered also to be a marginal type of Indo-Malesian flora; (5) the close affinity of the flora of southern China to the Indo-Malesian flora can be explained by the geological history of South-East Asia.

Introduction

Climatologically and biogeographically the tropical area of southern China is located at the margin of tropical Asia, and is composed of south-eastern Xizang (Tibet) (lower valleys of southern Himalayas), southern Yunnan, south-western Guangxi, southern Taiwan and Hainan Island separately. The largest tropical area still covered by forests is in southern Yunnan, the most south-western region of China; followed by south-western Guangxi, also in south-western China, and Hainan Island in south-eastern China. The tropical flora and vegetation of southern China, especially those of mainland south-western China, were only briefly mentioned by C.W. Wang in 1939 for the first time. It was little known until the late 1950s because of poor access. South-western China, for example southern Yunnan, is a mountainous area at the northern

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margin of mainland South-East Asia where there is a slightly lower mean annual temperature (c. 21°C) and lower annual precipitation (average 1500 mm) below 900 m altitude in comparison with the main tropical rainforest areas of the world. For a long time there has been discussion as to whether there is true tropical rainforest in southern Yunnan. If there is tropical rainforest in the region, it would probably be intermediate between classic tropical rainforests and monsoon forests as defined by Schimper (1903), or be a type of subtropical rainforest which differs in various aspects from the truly tropical rainforests described by Richards (1952). After the China-Russia expedition which penetrated deep into areas of south-western China, including southern Yunnan, in the late 1950s, some papers on the tropical rainforest vegetation (Fedorov 1958, Qu 1960, Wang 1961) and tropical flora (Fedorov 1957, Z.Y.Wu 1965) of this part of China were published. It was basically accepted that real tropical rainforests exist in south-western China, but these were considered of a type different from the ones in Indo-Malaysia because of the lack of representatives of Dipterocarpaceae, which dominate the rainforests of Indo-Malaysia . Botanists' interest in these areas was rekindled in the 1970's by the finding of a dipterocarp forest in southern Yunnan and south-western Guangxi. From that finding, the Indo-Malaysian affinity of the tropical flora of China was reconsidered. More and more results from biogeographical and ecological studies on the vegetation and flora of tropical southern China revealed that it is a part of the Indo-Malaysian flora (Zhu 1992, 1993a, 1993b, 1994a, 1994b and 1997, Zhu et al. 1996 and 1997, Zhang & Liu 1980, Fang et al. 1995, T.L. Wu et al. 1996). Also Whitmore (1982) felt that the birds in the tropical rainforest of southern Yunnan sang the same songs as to be heard in the tropical rainforest of Malesia when he was on a short visit to southern Yunnan and he laterconfirmed that there is true evergreen rainforest present in the southern fringe of China (Whitmore 1984).

Van Steenis (1950) recognised Malaysia as a distinct floristic unit, with well-defined demarcation knots, on the basis of generic distribution patterns. The NW frontier of the Malaysian floristic region is about the line Alor Star-Singora a little north of the political border between Malaysia and Thailand where 375 Malaysian genera have their northern-most limit and 200 mainland Asiatic genera have their southern-most limit. Johns (1995) reaffirmed Malesia as a distinct floristic unit. Southern China seems geographically far from the demarcation knot. However, the tropical flora of southern China shows closer affinity to the Malesian flora than to the East-Asian flora because the tropical flora of southern China shows more elements in common with the tropical Malesian flora than with the temperate eastern Asian flora.

In order to investigate the floristic characteristics of the flora of southern China and its affinities, the floristic composition of three well-studied regional floras of southern China, i.e. southern Yunnan, south-western Guangxi and Hainan Island, were concisely enumerated, and their geographical elements were analysed at the generic level. Also the floristic similarities between southern Yunnan and Hainan Island on the one hand, and Vietnam, the Malay Peninsula and Brunei on the other hand, were compared using revised floristic inventories and checklists.

General background

The tropical flora of southern China mainly consists of three disjunct regional floras, located in southern Yunnan, south-western Guangxi and Hainan respectively.

Southern Yunnan (Xishuangbanna) is the southern part of Yunnan Province in south-western China and lies between 21°09'– 22°32'N and 99°∞58'– 101° 50'E. The region has an area of 19690 km^2. It borders Burma and Laos, and has a mountainous topography with the mountain ridges running north-south and lowering in elevation southward.

Its altitude varies from 480 m at the bottom of the lowest valley in the south (Mekong River) to 2500 m at the highest mountain top in the north. The region has a typical monsoon climate. In its so-called lowland area, the annual mean temperature is 21 °C, and the annual precipitation is about 1560 mm, of which more than 80% falls during the rainy season, which starts in May and lasts till the end of October. Based on more than 40 years intermittent field collections, 3336 native species of 1218 genera and 207 families of seed plants have been found the region (Li 1996).

South-west Guangxi in south-western China borders on northern Vietnam and lies between 21°30'–23°10'N and 106°–109°∞E. The area has a typical limestone karst topography and most of its area is below 500 m alt. It has also a monsoon climate with an annual mean temperature of 22°C and an annual precipitation of 1200–1600 mm. 4303 species of 1294 genera and 225 families of seed plants are recorded from the region (Fang et al. 1995).

Hainan Island, located in southeastern China, between 18°1'–20∞0' N and 108°∞35–111°∞E, has a mountainous topography with the highest summit of 1867 m alt. In its lower hill area (Jian-fenglin), for example at 800 m alt., there is an annual mean temperature of 19.7°C, and an annual precipitation of 2650 mm. T. L.Wu (1994) recognised 3324 species of 1237 genera and 206 families of seed plants in Hainan Island.

Floristic composition of the tropical flora of southern China

There is no synthetic and complete floristic material available on the composition and size of the flora of southern China. However, from the available regional floras of southern Yunnan, south-western Guangxi and Hainan Island, a panorama of the flora of southern China can be depicted. The twenty most species-rich families in the floras of southern Yunnan, south-western Guangxi and Hainan are enumerated in Table 1.

It can be seen from Table 1 that the top ranking families in all three regional floras are basically the same. These three regional floras belong to the same floristic unit and represent the tropical flora of southern China. Further analysis shows that most dominant families from tropical southern China are also dominant in Indo-Malesia. For example, Orchidaceae, Rubiaceae, Euphorbiaceae, Lauraceae, Moraceae, Asclepiadaceae, Apocynaceae, Annonaceae, Zingiberaceae etc. are the large tropical families shared by both southern China and Indo-Malesia. The family Dipterocarpaceae is the most characteristic and a dominant family in the Malesian flora. It has only a small number of species in the tropical flora of southern China, but it is the dominant family regarding phytosociological importance (dominant in individuals). Other dominant families in the Malesian flora, such as Guttiferae, Meliaceae, Melastomataceae and Myristicaceae, show a similar pattern to the Dipterocarpaceae. Although the dominant families Urticaceae, Fagaceae, Theaceae, Rosaceae and Myrsinaceae in the tropical flora of southern China, are not among those dominant in Malesian flora, the tropical flora of southern China is basically of Indo-Malesian nature. Excluding cosmopolitan families such as Gramineae, Cyperaceae, Compositae, Labiatae etc., the floristic similarity of tropical southern China to Indo-Malesia is even more obvious.

Geographical elements at generic level

The distribution types of seed plants from China at the generic level were documented by the Chinese botanist C.Y. Wu (1991) based on the geographical distribution of all genera. From Wu's documentation, the distribution types from these three regional floras at the generic level are quantified and given in Table 2.

Table 1. The twenty families most species-rich among the floras of southern Yunnan, south-western Guangxi and Hainan.

Flora of southern Yunnan, south-western China				Flora of south-west Guangxi, south-western China				Flora of Hainan, south-eastern China			
Name of family	**No. of genera**	**No. of species**	**%of the flora**	**Name of family**	**No. of genera**	**No. of species**	**%of the flora**	**Name of family**	**No. of genera**	**No. of species**	**%of the flora**
Orchidaceae	96	334	10.01	Leguminosae	56	193	4.49	Gramineae	109	268	8.06
Leguminosae	56	182	5.46	Gramineae	87	174	4.04	Leguminosae	68	212	6.38
Rubiaceae	43	147	4.41	Rubiaceae	42	170	3.95	Orchidaceae	69	183	5.51
Gramineae	67	143	4.29	Compositae	62	150	3.49	Rubiaceae	51	155	4.66
Euphorbiaceae	38	119	3.57	Lauraceae	16	142	3.30	Euphorbiaceae	45	143	4.30
Compositae	59	107	3.21	Euphorbiaceae	38	141	3.28	Cyperaceae	23	133	4.00
Moraceae	6	77	2.31	Orchidaceae	50	124	2.88	Compositae	57	115	3.46
Urticaceae	12	72	2.16	Cyperaceae	22	97	2.25	Lauraceae	15	101	3.04
Lauraceae	12	68	2.04	Urticaceae	13	90	2.09	Asclepiadaceae	23	70	2.11
Zingiberaceae	15	67	2.01	Asclepiadaceae	24	83	1.93	Labiatae	27	59	1.77
Asclepiadaceae	25	62	1.86	Theaceae	10	79	1.84	Moraceae	12	58	1.74
Apocynaceae	27	61	1.83	Fagaceae	4	79	1.84	Fagaceae	4	58	1.74
Labiatae	29	59	1.77	Moraceae	8	71	1.65	Verbenaceae	13	55	1.65
Annonaceae	15	52	1.56	Rosaceae	19	69	1.60	Acanthaceae	26	54	1.62
Cucurbitaceae	17	50	1.50	Gesneriaceae	28	69	1.60	Urticaceae	11	53	1.59
Acanthaceae	32	49	1.47	Myrsinaceae	6	67	1.56	Annonaceae	18	51	1.53
Rosaceae	17	49	1.47	Apocynaceae	21	66	1.53	Theaceae	10	50	1.50
Fagaceae	6	45	1.35	Liliaceae	14	62	1.44	Myrtaceae	8	50	1.50
Araceae	16	43	1.29	Zingiberaceae	11	61	1.42	Myrsinaceae	6	49	1.47
Cyperaceae	13	43	1.29	Labiatae	28	58	1.35	Apocynaceae	26	46	1.38

The tropical Asian distribution, shown by the genera *Alphonsea, Amoora, Pterospermum, Mitrephora, Mycetia, Aganosma, Chukrasia, Crypteronia, Knema* etc., contributes 32.8%, 27.3 and 25.6% to these regional floras respectively and shows the highest percentage among all distribution types. The pantropic distribution, shown by *Gnetum, Beilschmiedia, Cryptocarya, Capparis, Piper, Croton, Dioscorea, Uncaria, Lasianthus, Morinda, Ardisia, Bauhinia, Marsdenia* etc., contributes 22.8%, 20.9% and 25.7% respectively and shows the second highest percentage. Next is the Old World Tropical distribution, shown by *Thunbergia, Dracaena, Pandanus, Ventilago, Stephania, Fissistigma, Polyalthia, Barringtonia, Carallia, Canarium, Chasalia, Uvaria* etc. The tropical Asia to tropical Australia distribution type pertains to genera such as *Ailanthus, Hoya, Argyreia, Dillenia, Lagestroemia, Loesenneriella, Murraya, Toona* etc. The tropical Asia to tropical Africa distribution type includes e.g. *Bombax, Flacourtia, Quisqualis, Bridenia, Premna, Urophyllum, Strophanthus, Mitragyna, Garcinia, Anogeissus, Cymbopogon* etc. The tropical distribution (types 1–6) from the three regional floras comprises 83.5%, 75.9% and 86.8% of the total number of genera respectively. Undoubtedly, the three regional floras are tropical in nature and have strong tropical Asiatic affinity.

Comparison of floristic similarities

The flora of southern Yunnan (representing the tropical flora of south-western China) and the flora of Hainan (representing southeastern China) are chosen for comparison with Vietnamese and Malesian floras. The Catalogue of the Vascular Plants of Malaya (Turner 1995) and the Checklist of the Flowering Plants and Gymnosperms of Brunei Darussalam (Coode et al. 1996) are the recently up-dated and relatively complete data bases on the regional flora of West Malesia. A revised checklist of plants of Vietnam (Le 1999) is also available. Therefore, a comparison of the floristic similarities at the family and generic levels between southern Yunnan, Hainan Island, Vietnam, Malay Peninsula and Brunei Darussalam was made so as to demonstrate the affinity between the tropical floras of southern China and mainland South-East Asia and Malesia.

Table 2. Comparison of the distribution-types of genera from the flora of southern Yunnan, the flora of south-west Guangxi and the flora of Hainan (%).

Distribution types (Geographical elements)	Southern Yunnan	South-western Guangxi	Hainan
Pantropic	22.8	20.9	25.7
Tropical Asia and Tropical America disjunct	2.4	2.4	5.0
Old World Tropic (Tropical Africa via Tropical Asia to Tropical Australia)	10.3	9.9	11.8
Tropical Asia to Tropical Australia	6.9	7.9	10
Tropical Asia to Tropical Africa	8.4	7.6	8.7
Tropical Asia or Indo-Malesia	32.8	27.3	25.6
North Temperate	5.2	7.2	4.3
East Asia and North America disjunct	3.1	3.7	2.5
Old World Temperate	1.5	2.7	1.5
East Asia	5.1	7.0	3.2
Endemic to China	0.7	2.8	1.1

Table 3. The twenty families most species-rich among the floras of Vietnam, Malay Peninsula and Brunei Darussalam.

Flora of Vietnam			Flora of Malay Peninsula			Flora of Brunei Darussalam		
Name of family	**No. of genera**	**No. of species**	**Name of family**	**No. of genera**	**No. of species**	**Name of family**	**No. of genera**	**No. of species**
Leguminosae	121	628	Orchidaceae	147	853	Rubiaceae	65	269
Orchidaceae	129	621	Rubiaceae	79	562	Euphorbiaceae	42	199
Gramineae	149	516	Euphorbiaceae	70	368	Dipterocarpaceae	9	177
Rubiaceae	84	425	Leguminosae	81	298	Orchidaceae	54	145
Euphorbiaceaee	67	405	Gramineae	92	238	Palmae	25	132
Cyperaceae	26	325	Myrtaceae	11	215	Araceae	28	120
Compositae	107	293	Lauraceae	16	214	Melastomataceae	25	115
Lauraceae	21	244	Annonaceae	36	202	Leguminosae	49	110
Fagaceae	5	213	Palmae	32	198	Annonaceae	31	96
Acanthaceae	53	195	Gesneriaceae	20	189	Zingiberaceae	13	88
Annonaceae	26	168	Melastomataceae	22	172	Moraceae	6	84
Apocynaceae	49	155	Cyperaceae	29	162	Lauraceae	14	82
Myrsinaceae	6	140	Acanthaceae	29	158	Myrtaceae	9	78
Moraceae	12	138	Dipterocarpaceae	9	156	Cyperaceae	20	73
Verbenaceae	25	131	Zingiberaceae	18	150	Guttiferae	7	70
Labiatae	45	128	Araceae	23	141	Gramineae	45	68
Araceae	27	128	Moraceae	10	138	Meliaceae	11	58
Rosaceae	20	124	Guttiferae	7	120	Myristicaceae	5	56
Zingiberaceae	24	124	Apocynaceae	31	119	Anacardiaceae	16	53
Scrophulariaceae	35	117	Asclepiadaceae	30	116	Gesneriaceae	4	53

The top twenty families regarding species richness from the floras of Vietnam, Malay Peninsula and Brunei Darussalam are listed in Table 3. Except for the Dipterocarpaceae, Melastomaceae, Myristicaceae, Palmae, Guttiferae and Meliaceae, the other species-rich families from Malay Peninsula and Brunei Darussalam are shared with the tropical flora of southern China in the top twenty families. The Vietnamese flora shows a strong similarity to the tropical flora of southern China in the top twenty families.

Comparisons of the floristic similarities at the family and generic levels between southern Yunnan, Hainan, Vietnam, Malay Peninsula and Brunei Darussalam are enumerated in Table 4 and Table 5. The floristic similarity between the floras of southern China and the regional floras of West Malesia is more than 70% at the family level and more than 50% at the generic level, and between the floras of southern China and that of Vietnam is more than 84% at the family level and more than 69% at the generic level. The flora of Hainan from SE China shows higher floristic similarity to the flora of Malay Peninsula than to the flora of southern Yunnan although it is closer to southern Yunnan geographically. These results strongly support the floristic affinity of southern China to Indo-Malesia.

Table 4. Comparison of floristic similarities at the family level between southern Yunnan, Hainan, Vietnam, Malay Peninsula and Brunei Darussalam.

	No. of families	**Southern Yunnan**	**Hainan Ilsland**	**Vietnam**	**Malay Peninsula**	**Brunei Darussalam**
		Shared/S.C.	Shared/S.C.	Shared/S.C	Shared/S.C.	Shared/S.C.
Southern Yunnan	207	100/ 100				
Hainan	206	181/ 87.86	100/ 100			
Vietnam	249	179/84.43	187/90.78	100/100		
Malay Peninsula	215	173/ 83.98	179/ 86.89	202/93.95	100/ 100	
Brunei Darussalam	164	119/ 72.56	115/ 70.17	147/89.63	161/ 98.17	100/ 100

Note: S.C. = Similarity coefficient (%)

Similarity coefficient between A and B = the number of taxa shared by both A and B divided by the lower number of taxa of A or B, multiplied by 100.

Table 5. Comparison of floristic similarities at generic level between southern Yunnan, Hainan, Vietnam, Malay Peninsula and Brunei Darussalam.

	No. of genera	**Southern Yunnan**	**Hainan Ilsland**	**Vietnam**	**Malay Peninsula**	**Brunei Darussalam**
	Shared/S.C.	Shared/S.C.	Shared/S.C	Shared/S.C.	Shared/S.C.	Shared/S.C.
Southern Yunnan	1218	100/ 100				
Hainan	1237	803/ 65.93	100/ 100			
Vietnam	1885	1251/69.06	1237/85.69	100/100		
Malay Peninsula	1547	786/ 64.53	844/ 68.23	1547/69.36	100/ 100	
Brunei Darussalam	917	446/ 47.80	480/ 52.34	917/65.98	789/ 86.04	100/ 100

Notes: S.C. = Similarity coefficient (%)

Conclusion and Discussion

To sum up our conclusions regarding the tropical flora of southern China:

(1) Tropical floristic elements both at the family and generic levels make a major contribution (about 60% at the family level and > 80 % at the generic level) to the total flora of southern China. The dominant geographical element at the generic level is of a tropical Asian distribution. This reveals that the flora of southern China is tropical in nature and has strong tropical Asian affinity.

(2) Most of the dominant families from the flora of southern China are also dominant in the Malesian flora. The floristic similarities between the regional floras of southern China and the regional floras of west Malesia are more than 70% at the family level and more than 50% at the generic level. T.L.Wu et al. (1996) state that the floristic similarity coefficient at the generic level between the flora of South China Sea Islands (with Hainan Island as its core area) and the flora of the Philippines is 78.2%, with Java is 75.0%, with Guangdong of mainland China is 82.3%, and with Taiwan is 70%. Although Hainan Island is almost connected to Guangdong of mainland China, the floristic similarity coefficient between them is just a little higher than the floristic similarity coefficient between Hainan and the far away Philippines and Java. This strongly supports the idea that the tropical flora of southern China is part of the Indo-Malesian flora and belongs to the Indo-Malesia or Malesian floristic region as suggested by Takhtadjan (1978) and T.L.Wu et al. (1996). Although there are clear generic demarcation points between Malesia and mainland SE Asia as found by van Steenis (and certainly there is this kind of demarcation point between southern China and Malesia) the high percentage of taxa shared by both suggests that they should be considered to belong to the same floristic region. This follows the conclusion of van Balgooy et al. (1996) that the number of taxa in common is the first step in surveying floristic affinity.

(3) The flora of southern China occurs on the margin of tropical Asia. Although tropical families and genera contribute most to its total flora, those with a strictly tropical distribution are still underrepresented compared to the Malesian flora. For example, Dipterocarpaceae has only a small number of species in the flora of southern China even though it is the dominant tree in some forest types of southern China. Many Malesian elements reach their northern limits in southern China. This implies that the flora of southern China is a marginal type of the Indo-Malesian flora.

(4) The flora of southern China, in particular south-western China, also has a very close affinity to the India-Burmese flora. Comparisons between regional floras of southern China and India-Burma are not made here because of the lack of up-to-date regional floristic inventories. However, it was demonstrated that the floristic similarity is 97.3% at the family level and 79.7% at the generic level in a comparison between the dipterocarp forest in southern Yunnan and a 10 ha dipterocarp forest in upper Assam of NE India (Zhu 1994a). Comparison between the flora of southern China and Vietnam for the twenty most species-rich families and their similarity at the family and generic levels, shows that the tropical flora of southern China has its closest affinity to the Vietnamese flora and that, floristically, both belong to the Indochina region of the Indo-Malesian subkingdom (as suggested by Takhtadjan (1978)), or of the Malesian subkingdom (as delimited by T.L.Wu et al. (1996)). Although the comparison between the flora of southern China and the flora of Thailand is not made here, the close floristic affinities between them should be high.

(5) From studies on the geological history of SE Asia, it is revealed that the direct land connection between mainland SE Asia and west Malesia existed until early Pliocene (5 million years ago) (Hall 1998), and there was no geographical barrier between

mainland South-East Asia and west Malesia during most of the Tertiary (Morley 1998). This could be the geological explanation for the close affinity between the flora of southern China and the flora of Malesia.

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