澜沧江下游/湄公河上游片断热带 雨林物种多样性动态

许再富¹ 朱 华¹ 王应祥² 杨 岚² 刘宏茂¹ 杨大荣¹ 杨大同²
李朝达² 陈志平² 文贤继² 王 洪¹ 马友鑫¹

(1 中国科学院西双版纳热带植物园, 云南勐腊 666303) (2 中国科学院昆明动物研究所, 昆明 650223)

摘 要 在澜沧江下游/湄公河上游的滇南西双版纳地区, 通过样方法比较了热带雨林的连片与 3 个小片断的物种多样性变化趋势。与连续森林比较, 片断热带雨林的植物物种丰富度和物种多样性指数都比较低, 而且有相当低比例的大高位芽、中高位芽和附生等生活型植物, 而藤本、小高位芽和矮高位芽等生活型植物的比例则较高。泛热带、热带亚洲至热带非洲的区系成分比例较高, 而当地成分则减少; 群落的上层树木比下层树木更加稳定。同样, 动物的物种多样性指数和均衡度在片断热带雨林中都较低, 与其密切相关的是片断热带雨林的环境质量, 而不是片断的大小。此外, 也探讨了片断热带雨林物种变化与森林小气候的关系, 阐明了由凉湿向干暖转化的“林内效应”是其物种变化的重要原因之一。

关键词 片断热带雨林 物种多样性动态 澜沧江下游/湄公河上游

SPECIES DIVERSITY DYNAMICS OF FRAGMENTED TROPICAL RAINFORESTS IN THE LOWER-LANCANG/UPPER-MEKONG RIVER BASIN

XU Zai-Fu¹ ZHU Hua¹ WANG Ying-Xiang² YANG Lan² LIU Hong-Mao¹ YANG Da-Rong¹
YANG Da-Tong² LI Chao-Da² CHEN Zhi-Ping² WEN Xian-Ji² WANG Hong¹ and MA You-Xin¹

(1 Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla, Yunnan 666303, China)

(2 Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming 650223, China)

Abstract Three fragments of tropical rainforest in Xishuangbanna, southern Yunnan and within the Lower-Lancang/Upper-Mekong River basin, were sampled to investigate species diversity patterns based on comparisons with a contiguous tropical rainforest. Compared with the contiguous forest, the fragments were lower in plant abundance, species diversity indices, a lower percentage of mega-phaanerophytes, meso-phaanerophytes, chamaephytes and epiphytes, but had a higher percentage of liana, micro-phaanerophytes and mini-phaanerophytes. The floristic composition was also different in the fragments with a greater percentage of pan-tropical and tropical Asia to tropical Africa elements increased, whereas the percentage of regional or local elements decreased. Meanwhile, tree species in the upper canopy layer were more stable than that in the lower layers of the fragmented forest. The animal species diversity and evenness were higher in the contiguous forest than in the fragmented forests, which apparently were due to better habitat size and quality. The relationship between changes in the microclimate of the forest fragments and species changes were also considered. The interior forest of the fragmented forests transformed from a wet-cool to dry-warm microclimate, called the internal effect, and was found to be an important mechanisms accounted for observed species changes.

Key words Rainforest fragments, Species diversity dynamics, Lower-Lancang/Upper-Mekong river basin

In recent years, the fragmentation of natural ecosystems has become an irreversible tendency, and it is one of the important factors for seriously threatened and rapid extinction of biodiversity on the earth (WRI *et al.*, 1992). Biologists have paid their special attentions to the researches of changed biodiversity in fragmented tropical

rainforests since 1980s (Bierregaard & Lovejoy, 1989; Klein, 1989; Leigh *et al.*, 1993; Laurance, 1994; Kattan *et al.*, 1994; Fonseca & Brown, 1994; Turner, 1996; Laurance & Bierregaard, 1997; Fox *et al.*, 1997; Malanson & Cairns, 1997; Laurans & Ferreira, 1998), while Smithsonian Institution of USA and Amazo-

nian Institution of Brazil carried out a joint research program of “ minimum ecosystem ”. In China , the first research program was carried out as “ green island effect of fragmented tropical rainforests and the regularity of species diversity change ” by Xu Zaifu , Xishuangbanna Tropical Botanical Garden , the Chinese Academy of Sciences in 1991 , and the first paper presented was “ The changing tendency of plant species diversity in different status of Xishuangbanna Holy Hills ” by Liu Hongmao *et al.* in 1993 (Liu *et al.* , 1993). After that , Xu Zaifu carried out two follow-up research programs dealing with the tropical rainforest fragmentation and biodiversity conservation in Xishuangbanna. Then many Chinese biologists also paid their special attention to the researches in Xishuangbanna , many papers have been presented(Xu *et al.* , 1994 ; Chen *et al.* , 1996 ; Wen *et al.* , 1997 ; Zhu *et al.* , 1997 ; Li *et al.* , 1997 ; Chen & Yang , 1997 ; Yang 1998 ; Ma *et al.* , 1998 ; Huang & Yang , 1998 ; Yang & Wu , 1998 ; Xu & Hu , 1999a ; Xu *et al.* , 1999b ; Yang & Sha , 2001 ; Yang *et al.* , 2001 ; Zhu *et al.* , 2000a ; 2000b ; 2001 ; Zhang *et al.* , 2000). This report is based on our researches and referred to other presented documents.

1 Study area

The study area is in Xishuangbanna , located in the basin of Lower-Lancang /Upper-Mekong River , which is the only area remained with large area of tropical rainforests in China , and is also one of the mega-biodiversity area of the basin. According to records , there were about 5 000 species of higher plants (Li *et al.* , 1996) and more than 700 species of vertebrates (Xu *et al.* , 1987) in Xishuangbanna , and many kinds of forest vegetations such as tropical rainforests , tropical monsoon forests , tropical mountain rainforests , south-subtropical evergreen broad-leaved forests , etc. are distributed in the area.

The study sites of fragmented tropical rainforests are the “ Holy Hill forests ” protected by Dai villages under

their traditional religious belief for a long time. Three fragmented tropical rainforests of the “ Holly Hill forests ” , a contiguous tropical rainforest , and a secondary tropical rainforest were selected for the research , and their environmental qualities are evaluated by the field survey and social investigation in quantitative terms on a scale from 1.0 to 5.0 , $\Sigma = a + b + c + d$, as the Table 1. In the three fragments , Chengzi has a better environment due to diverse habitat and a secondary tropical rainforest nearby , Manyuangguang ’ s environment is the worst one because it is surrounded by villages , paddy fields and rubber plantations .

Forest coverage of Xishuangbanna has rapidly decreased from about 65% to 30% since early 1950s due to deforestation. According to the data from remote sensing , the piece ’ s of forest fragments in the area had been increased from 256 in 1959 to 1 219 in 1998 , at the same time the total area of fragmented forests decreased from 1 370 000 hm² to 1 120 000 hm². It meant that the average area of one piece of forest fragment decreased from 5 350 hm² to 920 hm² during this period¹⁾.

2 Results

2.1 Change of plant diversity in fragments

2.1.1 Comparison between fragmented and contiguous forests

In the sample plot of 2 500 m² , there are 152 species of plants in contiguous forest , and 115 species in fragmented forests , and the species diversity index (SHN) is 4.27 in contiguous forest and 3.47 in fragments respectively. Fig. 1 shows the comparison of plant life form spectra between the fragmented and contiguous forests (Zhu *et al.* , 2000b). It shows that the plants of mega-phaanerophytes , meso-phaanerophytes , chamaephytes and epiphytes are decreasing , most of them are the climax elements of tropical rainforest , and the plants of micro-phaanerophytes , nano-phaanerophytes , herbaceous-phaanerophytes and liana-phaanerophytes , etc. .

Table 1 Environmental qualities evaluated for study sites

	Altitude (m)	Area index - a (hm ²)	Isolated age index- b	Isolated level index- c	Interfered level index- d	Integrated evaluation- Σ
Manyuangguang	700	2.0 (13.3)	3.0	1.0	2.5	8.5
Man ’ e	590	1.5 (4.0)	4.0	2.0	3.0	10.5
Chengzi	600	1.5 (3.0)	3.0	3.5	4.0	12.0
Secondary tropical forest	580	2.5 (90.0)	3.0	3.5	4.5	13.5
Contiguous tropical forest	680	5.0 (7 500)	5.0	5.0	5.0	20.0

1) Xu , J. C. 2001. The causes of land use and land cover change in Lancang-Mekong River Basin , Yunnan , SW. China. Presented on International Symposium on Biodiversity Management & Sustainable Development in the Lancang-Mekong River Basin , 4 - 7. Dec. Xishuangbanna , China

are increasing in fragmentary tropical rainforests.

Fig.2 shows the comparison of specific area-types between the contiguous and fragmented forests (Zhu *et al.*, 2000a). It shows that the area-types of endemic to Yunnan, Mainland SE Asia to S China, S Asia to Mainland SE Asia etc. are obviously decreasing, and the area-types of Tropical Asia to Tropical Africa, India-Malaysia, SW to S China and Pan-tropic, etc. are increasing. With widen distributing area, perhaps the later have larger ecological amplitude than the former.

Fig.1 Comparison of life-form spectra between the fragmented and continued forests
Ep : Epiphytes L : Lianas Megaph : Mega-phaenerophyte Mesoph : Meso-Phaenerophyte Microph : Micro-phaenerophyte Nanoph : Nano-phaenerophyte Hph : Herbaceous-phaenerophyte Ch : Chamaephyte G : Geophyte

Fig.2 Comparison of species area-types between the fragmentary and continued forests
1 : Pan-tropic 2 : Trop. Asia to tropical America disjointed 3 : Old World Tropic 4 : Tropical Asia to tropical Australia 5 : Tropical Asia to tropical Africa 6 : India-West Malaysia 7 : Mainland SE Asia to Malesia 8 : South Asia to Mainland SE Asia 9 : Mainland SE Asia to South China 10 : SW to SE China 11 : Endemic to Yunnan

2.1.2 Plant diversity change among the fragments

Fig.3 shows the comparison of species abundance and diversity index (SHN) in the fragmented forests of Chengzi, Man'e and Manyanguang. In the sample plots of 2 500 m², the species abundance and species diversity indexes in the three fragments are 135, 113, 97 and 4.21, 3.70, 3.37 respectively. Even if Manyanguang has bigger area (13.3 hm²) than Man'e (4 hm²) and Chengzi (3 hm²), but the figures of Manyanguang are the least. It means that the species richness and diversity index are closely related to the environmental qualities of fragmented tropical rainforests instead of their sizes.

Moreover, Table 2 shows that Chengzi has higher percentages of trees (DBH > 5 cm), herbs and epiphytes, and lower percentages of small trees (DBH < 5 cm), shrubs than those in Man'e and Manyanguang, due to stronger human activities allowing more invading species.

2.2 Temporal and spatial changes of fragments

The area of Manyanguang fragment was 20 hm² in 1959, and reduced to 13.3 hm² in 1991, and the number of plant species increased from 246 to 269. As the data in 1959 (Xiang, 1981) was incomplete owing to species identification, we can say that the number of species in the fragment did not change after 3 decades. After checking the two plant lists, we know that 55 species of plant in the lists of 1959 have disappeared from the fragment, and replaced by new species, the taxon cycle rate is as high as 22.4%. The replaced plants are mainly *magaph.*, *mesoph.*, *microph.*, and *liana.*, etc., or mainly climax elements and shade-love plants, etc..

In order to understand the temporal regularity of species structure change in the fragmentary tropical rainforest, we made a comparison of woody plants in 2 500 m² sample plot of Manyanguang fragment between 1959 and 1991. There were 70 species of woody plants in 1959, and 68 species in 1991. It also illustrates that species richness in the fragment had not changed after 30 years. However, we found some interesting results after analysis (Xiang, 1981; Xu *et al.*, 1994).

2.2.1 Tendency of species change in different stories of the community

Table 3 shows the relationship of changes for woody plants with their community characteristics in Manyanguang forest fragment from 1959 to 1991. The rate of preserving species (Rr) in tree stories (A. B. C) is higher than that in shrubs (D), and in the tree stories, it shows A > B > C. The rate of disappearing species (Dr) has a contrary result to Rr., and the rate of increasing species (Nr) is shrubs > trees, and in tree stories, it shows A < B < C. Moreover, the similarity index between 1959 and 1991 are 84.6 for A, 75.0 for B, 45.5 for C (A + B + C = 65.0), and 55.5 for D, which illustrate that A and B are more stable, and C and D are unstable with high disappearing rate and increasing rate of species.

2.2.2 Relationship between species growth-decline and species exclusiveness of communities

Table 3 also shows that species growth-decline is closely related with species exclusiveness of communities, (1) Rr = Ch > Pr > In < Ex; (2) Dr = Ch < Pr < In > Ex. It illustrates that characteristic species (Ch) are the most stable group in the fragment, followed by preferential species (Pr). Though it is an equilibrium between species disappearing and increasing, those disappearing and increasing plants are mainly indifferent and exotic species.

2.2.3 Changing tendency of species diversity index

Table 4 shows the comparison of species diversity

Fig.3 Comparison of species diversity among fragmented forests
MYG : Manyanguang CZ : Chengzi Mane : Man 'e

Table 2 Comparison of species abundance among fragmented forests

Fragments	Chengzi		Man 'e		Manyanguang	
	Species	%	Species	%	Species	%
Tree	70	51.9	61	54.0	49	50.0
DBH > 5 cm	52	38.5	37	32.7	18	18.6
DBH < 5 cm	18	13.3	24	21.2	31	32.0
Shrub	11	8.2	11	9.7	14	14.4
Herb	13	9.6	7	6.2	7	7.2
Liana	35	25.9	31	27.4	23	23.7
Epiphyte	6	4.4	3	2.7	4	4.1
Total	135	100	113	100	97	100

Table 3 The changes of woody plants in Manyanguang related to plant community characteristics (1959 – 1991)

Stories	Character sp.			Preferential sp.			Indifferent sp.			Exotic sp.			Subtotal sp.(%)			Sp. total
	R	Di	N	R	Di	N	R	Di	N	R	Di	N	R	Di	N	
A	4	–	1	7	2	–	–	–	1	–	–	–	11(85)	2(15)	2(15)	15
B	1	–	–	9	3	2	1	1	2	1	–	–	12(75)	4(25)	4(25)	20
C	–	–	1	5	5	9	4	3	3	1	2	1	10(50)	10(50)	14(58)	34
A + B + C	7			43			16			5			33(67)	16(33)	20(38)	69
D	1	1	–	5	4	1	2	3	5	2	1	1	10(53)	9(47)	7(41)	26
Subtotal Sp.(%)	6	1	2	26	14	12	7	7	11	4	3	2	43	25	27	95
Sp. total	9			42			25			9			95			

R = Preserving sp. Rr (Preserving rate %) = $R / (R + Di) \times 100$ Di = Disappearing sp. Dr (Disappearing rate %) = $Di / (R + Di) \times 100$ N = Increasing sp. Nr (Increasing rate %) = $N / (R + Di) \times 100$

Table 4 Species diversity index in different stories in Manyangguang fragment (50 m × 50 m)(1959 – 1991)

Year	No. of Sp.	Storey A	Storey B	Storey C	(A + B + C)	Storey D	A + B + C + D
1959	No. species	2	13	33	(37)	59	95
	No. plants	5	34	96	(135)	946	1 080
	Diversity index	0.971 0	2.524 3	4.536 4	(4.522 8)	4.645 0	5.234 6
1991	No. species	10	6	8	(16)	62	78
	No. species	21	21	16	(58)	2 414	2 472
	Diversity index	3.078 0	1.780 9	2.374 8	(2.988 0)	3.805 6	3.970 3
1991	No. species	+ 8	– 7	– 25	(– 21)	+ 3	– 16
I	No. plants	+ 16	– 13	– 80	(– 77)	+ 1 468	+ 1 391
1959	Diversity index	+ 2.107 0	– 0.743 4	– 2.161 6	(– 1.534 8)	– 0.839 4	– 1.264 3

indexes in different stories of Manyangguang fragment between 1959 and 1991. The index in 1959 is 5.236 46 , and 3.970 3 for 1991 , reduction by 24 % after 30 years. Excluding A , others are reducing , especially C reduced from 4.536 4 to 2.374 8 , about one half reduction. A is increasing due to the development of B in 30 years.

2.2.4 Tendency of changed population types

Table 5 shows that the relationship of changes for woody plant 's population types with their characteristics in Manyangguang forest fragment. There are 29 species belonging to the type of contiguous population(Cp) sharing 43% , 39 species of intermittent population (Ip) type , sharing 57% in 1959. After 30 years , only 12 species of Cp remained , sharing 18% , having 25% reduced , and 51 species of Ip , sharing 46% , and 25 species , sharing 38% of the disappeared from the fragment. Table 5 also shows the situation of A , B , C and D are different : Degraded population type = (A < B < C) > D ; Degraded species exclusiveness of community are : Ch < Pr < In > Ex and Preserving species = Ch < Pr > In > Ex.

2.3 Change of animal diversity in fragments

2.3.1 Species (taxa) richness and diversity change

Many kinds of animals including vertebrate and invertebrate were explored in the fields and identified in laboratories. Table 6 illustrates the taxa richness , diversity index (SHN) and evenness for animals in contiguous rainforest are higher than that in the fragments. And with-

in the fragments , No. of taxa , SHN and EV are obviously related to the environmental qualities of fragments such as Chengzi (or remained forest) > Man 'e > Manyangguang , instead of their size.

2.3.2 Response of different ecotype rodents to fragments

The No. of species , SHN and EV of Myomorpha rodents are also closely related to environmental qualities of fragments instead of their size. With perfect environment and community structure , and a longer distance from villages and farmlands , contiguous rainforest not only had more species of rodents , but also had higher percentage (75%) of forest species. Among the fragments , Chengzi fragment , which is either near a village or close to a forest , is a little farther from paddy fields , therefore , it had higher percentage (66.7%) of forest species than Man 'e (50%) and Manyangguang (25%) (Chen *et al.* , 1996).

2.3.3 Response of different ecotype amphibians & reptiles to fragment

Table 7 shows that the different ecotypes of amphibians and reptiles in the fragment. Owing to the perch habitat of amphibians and reptiles have four types as tree , earth , cave and water , therefore their distribution is closely related to diverse niches. There are no species of water type in the 3 fragments except secondary rainforest , because of a small stream and a small pond still existed in the secondary forest.

Table 5 Changes of woody plant population types in relation to their characteristics in Manyangguang fragment (1959 – 1991)

Storey	Character sp.			Preferential sp.			Indifferent sp.			Exotic sp.			Subtotal sp.(%)			Sp. total
	Rd	Id	Dd	Rd	Id	Dd	Rd	Id	Dd	Rd	Id	Dd	Rd	Id	Dd	
A	2	1	1	5	1	3	–	–	–	–	–	–	7(54)	2(15)	4(31)	13
B	–	–	1	7	–	5	1	–	1	–	–	1	8(50)	0(0)	8(50)	16
C	–	–	–	4	–	6	1	–	7	–	–	2	5(25)	0(0)	25(75)	20
A + B + C	5	31	10	3	2(42)	2(4)	27(54)	50								
D	1	–	1	2	3	4	2	–	3	1	1	1	6(32)	4(21)	9(47)	19
Subtotal	3	1	3	18	4	18	4	0	11	1	1	4	26	6	36	68
Sp.(%)	(43)	(14)	(43)	(45)	(10)	(45)	(27)	(0)	(73)	(17)	(17)	(66)	(38)	(9)	(53)	
Total Sp.		7			40			15			6			68		–

Rd = Remained population (Remained rate %) Id = Improved population (Improved rate %) Dd = Decreased population (Decreased rate %)

Table 6 Comparison of animal taxa diversity in different fragments

Samples		Contin. forest			Chengzi frag.			Man 'e frag.			Manyangg. Frag.			Data source
		TAX	SHN	EV	TAX	SHN	EV	TAX	SHN	EV	TAX	SHN	EV	
Vertebrate	Rodents (catches)	8(4)	1.944	0.972	6(1)	2.058	0.886	4(1)	1.350	0.851	4(1)	1.165	0.735	Chen <i>et al.</i> ,1996
	Birds (species)	89	3.619	0.806	38	2.805	0.771	38	2.876	0.791	30	2.375	0.698	Wen <i>et al.</i> ,1997
	Amphibians (genera)	29 *	—	—	9	—	—	13	—	—	10	—	—	Yang ¹⁾
	Reptiles (genera)	36 *	—	—	26	—	—	18	—	—	28	—	—	Yang ²⁾
Invertebrate	Butterfly (families)	45	3.595	0.947	31	3.000	0.877	19	2.694	0.901	29 *	2.826 *	0.840 *	Yang , 1998
	Lepidoptera (families)	33	1.833	0.891	23	0.349	0.667	14	0.761	0.519	17	0.969	0.667	Yang ²⁾
	Fig wasps (species)	17	—	—	7	—	—	—	—	—	15 *	—	—	Yang , 1998
	Soil animal (orders)	26	—	0.606	27	—	0.769	27	—	0.615	25	—	0.684	Li <i>et al.</i> , 1997
	Terres. molluskes	15	1.043	0.887	2	0.100	0.334	5	0.291	0.416	4	0.488	0.805	Chen & Yang , 1997
	Acridaidea	25	1.240	0.987	2	0.661 **		2	0.946 **		5			Huang & Wu , 1998
	Bees	31	1.215	0.815	9	0.929	0.823	5	0.641	0.917	8	0.836	0.956	Yang & Wu , 1998
	Ants	15	0.961	0.355	17	1.777	0.627	16	2.379	0.858	9	1.652	0.752	Zhang <i>et al.</i> , 2000

The figure in uncounted for SHN & EV * :The figure of secondary forest ** :The average for 3 fragments 1) Yang D.T. un-presented data 2) Yang D.R. un-presented data

Table 7 Different ecotypes of amphibians & reptiles in the fragment (No. sp./No. sp. %)

Samples	Ecotypes	Amphibians	Reptiles	Total
Secondary rainforest	Tree	8/28	11/31	19/29
	Earth	11/38	14/39	25/39
	Cave	2/7	8/22	10/15
	Water	8/28	3/8	11/17
	Total	29/100	36/100	65/100
Chengzi fragment	Tree	8/67	10/38	18/47
	Earth	1/8	13/50	14/37
	Cave	3/25	3/12	6/16
	Water	—	—	—
Man 'e fragment	Total	12/100	26/100	38/100
	Tree	8/62	9/50	17/55
	Earth	5/38	8/44	17/55
	Cave	—	1/6	1/3
	Water	—	—	—
Manyangguang fragment	Total	13/100	18/100	31/100
	Tree	8/80	11/39	19/50
	Earth	2/20	14/50	16/42
	Cave	—	3/11	3/8
	Water	—	—	—
	Total	10/100	28/100	38/100

3 Results analysis

3.1 Species equilibrium & taxon cycle of fragmented tropical rainforests

After the studies of island biological geography , MacAthur and Wilson(1967) illustrated the relationship between the number of species and size of islands , and created an“ equilibrium theory ” and a hypothesis of“ taxon cycle ” in 1960s. Even if the fragmented tropical rainforests as “ green islands ” caused from contiguous forests , and their isolation and interference from human action , which are quite different from ocean islands. However , the results of species migrating and disappearing in the “ green islands ” are similar to ocean islands. Manyang-

guang fragment can be an example , the community and the 2 500 m² sample plot had 246 species and 70 species respectively in 1959 , 30 years later , the numbers are 269 and 68 , i. e. migrating and disappearing are basic balance. Moreover , the “ green island ” also exists the taxon cycle ; the replacing rate of species is 22. 4% in 30 years. However , the results have shown that species diversity index (SHN) in the “ green islands ” is 18.9% , less than that in contiguous forest.

As mentioned above , species replacement in “ green islands ” has its own regularity , and is different from ocean islands. The comparisons between fragmented and contiguous forests , and Manyangguang fragment between 1959 and 1991 have illustrated that the species newly migrated into the fragments , most of them are indifferent species and preferment species. They distributed in other types of forest of the area , and some pioneer trees and weeds are related to farmlands and villages. Species disappearing from the fragments are mainly climax trees , shade-loving plants and the animals closely depended on forest environment for their survival. In 1959 , there were 45 species of tree (A. B. C) in Manyangguang fragment , among them 66.7% (30 species) belonging to the elements of tropical monsoon forests and south-subtropical evergreen broad-leaved forests. After 30 years , tree species increased to 51 species , but the elements of tropical monsoon forests and south-subtropical evergreen broad - leaved forests increased to 72.5% (37 species)(Xu *et al.* 1994). As the increase of migrating species and their strong competitive capacities , some species of fragmentary tropical rainforests will be replaced by other type ' s plants , such as tropical monsoon forests and subtropical evergreen broad-leaved forests , because the tropical rainforest of the area is a northern pattern of SE. Asia and the forests vegetations distribution is in the position of crisscross and mosaic.

3.2 Environment of fragmented tropical rainforests and change of biodiversity

As mentioned above ,the number of species ,diversity index and structure of species etc. in the 3 fragmented tropical rainforests are obviously related to their environmental qualities and niches ,instead of their size ,due to small area. Even if the size of Chengzi fragment (3 hm²) has only 22.5% of their Manyangguang size(13.3 hm²) , it has a higher number of species ,index of species diversity than Manyangguang , a higher rate of forest rodents (67. 7 %) than Manyangguang (25%) , and a higher number of amphibians (12 species) than Manyangguang (10 species). The bee community in Chengzi is similar to tropical rainforests , and Manyangguang is similar to paddy fields and rubber plantations (Li *et al.* , 1997 ;Yang & Sha ,2001). The main reason for the differences is better environment in Chengzi fragment. Moreover , excluding secondary forests ,there were no species of water type of amphibians and reptiles in the three fragments , which shows that environment change has made certain species losing their niches or habitats in fragments.

3.3 Relationship between climate changes and species replacement in fragmented tropical rainforests

The buffering capacity of forest to climate change being weakened due to tropical rainforest fragmentation have been studied in Panama , Amazonian and other rainforests (Laurance , 1991 ; Willians-Linera , 1992 ; Malacon , 1994 ; Camargo & Kapos , 1995 ; Murcia , 1995) , which cause the changes of main climax elements from edge to interior of fragment. The findings in Xishuangbanna show that the fragment edge influence the extent on temperature , relative humidity and light , up to 15 m and 25 m , even to 50 m into the forests from the edge at north-facing and south-facing direction respectively. The means of maximum air temperature(T_{max}) , daily range of air temperature(ΔT_s) , minimum relative humidity(RH) , maximum soil temperature(T_s) , daily range of soil temperature(ΔT_s) and velocity(V) of the fragmentary and continuous forests show in Table 8 and Fig. 4 (Ma *et al.* , 1998).

Table 8 and Fig. 4 show that the order of absolute differences of maximum air temperature (T_{max}) , maximum soil temerature(T_s) and relative air humidity(RH) is contiguous forest (6.1 $^{\circ}\text{C}$, 38.2 $^{\circ}\text{C}$, 37%) > Chengzi (8.7 $^{\circ}\text{C}$, 24.9 $^{\circ}\text{C}$, 31%) > Manyangguang (4.9 $^{\circ}\text{C}$, 19.6 $^{\circ}\text{C}$, 26%) > Man 'e (4.3 $^{\circ}\text{C}$, 14.3 $^{\circ}\text{C}$, 22%) ,

		Table 8 Comparison of microclimate between fragmentary and continuous forests in Xishuangbanna (1994 – 1995 , in cool & fog season)					
		$T_{max}(^{\circ}\text{C})$	$\Delta T(^{\circ}\text{C})$	$RH(\%)$	$T_s(^{\circ}\text{C})$	$\Delta T_s(^{\circ}\text{C})$	$V(\text{m}\cdot\text{s}^{-1})$
Chengzi	Open	34.7	23.2	19.0	47.7	36.7	0.6
	Edge	29.9	18.3	26.0	27.7	14.0	0.1
	Interior	26.0	14.3	50.0	22.8	9.2	0.1
Manyangguang	Open	35.0	25.5	19.0	49.4	38.5	0.6
	Edge	32.9	21.9	23.0	32.9	19.6	0.1
	Interior	30.1	18.9	(45)	29.8	15.9	0.0
Man 'e	Open	29.9	16.1	43.0	41.0	27.2	0.9
	Edge	28.3	14.9	44.0	35.1	20.1	0.4
	Interior	25.6	12.2	65.0	26.7	11.6	0.3
Contion	Open	31.9	20.9	27.0	50.7	42.1	1.1
	Edge	27.0	16.4	43.0	25.6	13.2	0.2
	Interior	25.8	14.5	64.0	22.5	8.2	0.3

Fig.4 Comparison of minimum humidity(RH) , maximum air temperature(T_{max}) and maximum soil temperature(T_s) between contiguous (CF) & Fragmented forest (MF)(Values from Table 8 , edge of the forests = 100%)

and the buffering function of contiguous forest is much better than that of fragmented forests. Chengzi is much better than Man 'e and Manyanguany among the fragments.

In other words, the horizontal gradient of temperature outside contiguous rainforests is much higher than that of the inside, and that of relative humidity is much lesser. Therefore it forms a "wet-cool effect" in internal forest and a "dry-warm effect" in the edge zone as a wide of 15–25 m, even 50 m in the study area. The fragmentary tropical rainforests for the study are as small as the areas of 13.3 hm², 4 hm² and 3 hm², the "dry-warm effect" of edge has spread to the central forest forming an internal effect (Xu *et al.*, 1994), where the climate being informed from "wet-cool" to "dry-warm". The study suggested that the mechanisms of species replacement in small fragmented tropical rainforests is the isolation and interference not only from human activities, but also from the edge effect and internal effect of forest climate, which influences those species. Most climax elements, depended on wet-cool and weak light for their regeneration and survival have being disappeared from the fragments and benefited those species suited to dry-warm and stronger light (Xu *et al.*, 1994).

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