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Distribution patterns of long-lived individuals of relict plants around Fanjingshan Mountain in China: Implications for in situ conservation

H.-Y. LIAO (廖洪英)[1] & M.-X. REN (任明迅)[2]

[1] Tongren Forestry Bureau, CN-554300 Tongren, China
[2] College of Horticulture and Landscape Architecture, Hainan University, CN-570228 Haikou, China

Author for correspondence: M.-X. Ren (rensanshan@hotmail.com)

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Abstract

Distribution patterns of long-lived individuals of relict plants around Fanjingshan Mountain in China: implications for in situ conservation.— The mountain areas in south-central China are widely recognized as refugia of relict plants during the late Neogene and Quaternary periods. In this paper, we try to explore the distribution patterns of natural habitats and to exactly locate the refugia of relict species around Fanjingshan Mountain using dendrological data of long-lived individuals (≥100 years old). Six typical relict plants were found around the mountain, i.e. *Cyclocarya paliurus*, *Ginkgo biloba*, *Liriodendron chinense*, *Pinus massoniana*, *Podocarpus macrophyllus*, and *Taxus chinensis*. The long-lived individuals were divided into three classes according to their ages: Class-I (≥500 years), Class-II (300–499 years), and Class-III (100–299 years). Our results showed that the south-west region to the mountain was the main distribution area of Class-I trees of *G. biloba* and *T. chinensis*, most of which occurring in the same small village (Yangliu Village of Yinjiang County). The north-east region harboured all the six relict species. Floristic analyses also indicated these two regions were very similar in tree growth as measured by DBH (diameter at breast height of 1.3 m). Thus, these two areas would have provided long-term suitable habitats for relict species. The south-west region, especially the small village Yangliu, should be given highest priority for in situ conservation of relict species and other rare and endangered plants. Attention should also be paid to the north-east region for its very high species diversity of relict species.

Key words: biodiversity; endemic plants; *fengshui* forests; glacial refugia; old trees.

Resumen

Patrones de distribución de individuos longevos de plantas relictas en los alrededores de la montana Fanjingshan en China: implicaciones para su conservación *in situ*.— Las áreas montañosas de la región centro-sur de China están ampliamente reconocidas por su papel como refugio de plantas relictas durante la última etapa del Neógeno y el Cuaternario. En el presente trabajo se intentan explorar los patrones de distribución de los hábitats naturales y la localización exacta de los refugios para especies vegetales relictas en los alrededores de la montaña Fanjinshan, mediante el empleo de datos dendrológicos de individuos longevos (≥100 años). En el área de estudio se encontraron seis especies vegetales típicamente relictas: *Cyclocarya paliurus*, *Ginkgo biloba*, *Liriodendron chinense*, *Pinus massoniana*, *Podocarpus macrophyllus* y *Taxus chinensis*. Los individuos longevos se dividieron en tres categorías de acuerdo con su edad estimada: individuos de Clase I (≥500 años), de Clase II (300–499 años) y de Clase III (100–299 años). Nuestros resultados muestran que la región situada al suroeste de la montaña se corresponde con la principal área de distribución de los árboles de Clase I de *G. biloba* y *T. chinensis*, localizándose la mayor parte de éstos en los alrededores de una pequeña aldea (Yangliu, en el condado de Yinjiang). La región situada al noreste de Fanjinshan alberga, por su parte, las seis especies relictas, y los análisis florísticos muestran una elevada similaridad entre ambas regiones por lo que respecta al crecimiento arbóreo medido como DBH [diámetro a la altura del pecho (1,3 m)]. Por consiguiente, estas dos regiones habrían proporcionado hábitats adecuados para la supervivencia de especies relictas. La región suroeste, y en especial la aldea de Yangliu, deben recibir la máxima prioridad para la conservación *in situ* de especies relictas (y otras especies raras y amenazadas). La región noreste también debe priorizarse dada su elevada diversidad de especies relictas.

Palabras clave: árboles longevos; biodiversidad; bosques *fengshui*; plantas endémicas; refugios glaciales.

摘要

中国梵净山周边地区孑遗植物古树分布格局：对就地保护的启示。— 中国中南部山区是广为人知的孑遗植物避难所，这些孑遗植物经历了地球最后一个大规模冰期，即第四纪冰期（约300万年前）。 在这篇文章中，我们试图通过分析梵净山周边地区孑遗植物的古树（大于或等于100年）的生长情况与地理分布格局，来解释这些孑遗植物自然生境及避难所的具体所在，并提出就地保护策略。数据主要来源于铜仁市林业局和印江县、松桃县以及江口县林业部门的野外调查结果。梵净山及周边地区自然分布着6种典型的孑遗植物：银杏（*Ginkgo biloba*）、鹅掌楸（*Liriodendron chinense*）、罗汉松（*Podocarpus macrophyllus*）、青钱柳（*Cyclocarya paliurus*）、马尾松（*Pinus massoniana*）、红豆杉（*Taxus chinensis*）。古树可根据树龄分为三级：I级是树龄不小于500年的古树；II级是指300-499年的古树；III级则包括100-299年的古树。我们发现，6个孑遗植物在梵净山的东北方向（松桃县）都有分布；梵净山西南方向则是银杏和红豆杉I级古树的主要分布区，尤其集中分布在印江县杨柳乡。植物区系相似度的分布结果也表明，这两个区的古树生长（以胸径度量）相似度很高。因此，这两个区很可能在较长时间一直保存着这些孑遗植物合适的生境。梵净山整个西部都分布着极高比例的I级古树，其中绝大多数都是银杏。可见，梵净山周围的西边和东北方向很可能长期保存着这些孑遗植物适宜的自然生境。梵净山的西南方向，尤其是杨柳乡，尤其应特别重视，可作为就地保护孑遗植物或其它珍稀濒危植物的一个首选地址。梵净山东北方向（松桃县及其与江口县临近地区）具有极高的孑遗植物物种多样性，也需给与特别保护。

关键词：生物多样性；特有植物；风水林；冰期避难所；古树。

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INTRODUCTION

Fanjingshan Mountain is located at Guizhou Province (south-western China), running in a north-east–south-west direction and having an approximate area of 570 km^2 (GFNNRAB, 2004). This mountain is part of the Three Gorges Region (Fig. 1), which is one of the three main biodiversity hotspots and endemism centres in China (Ying & Zhang, 1984; Ying, 2001; Li *et al*., 2009; López-Pujol *et al*., 2011*a*, *b*). The rich biodiversity in this hotspot is mainly a result of glacial refugia that existed in the area during late Neogene and Quaternary periods (Li, 1940; Axelrod *et al*., 1996; Qian, 2001; López-Pujol *et al*., 2011*a*). Consequently, this biodiversity hotspot is probably China's region with the highest concentration of relict species; most of these are "living fossils" at present surviving in a small part of it original distribution area due to range contraction as a result of the late Cenozoic global cooling.

Nowadays in Fanjingshan Mountain and its nearby regions, some wild individual or even wild populations of relict species can still be found (Axelrod *et al*., 1996; Tang *et al*., 2011, 2012), including *Davidia involucrata* Baill., *Ginkgo biloba* L., *Liriodendron chinense* (Hemsl.) Sarg., and *Metasequoia glyptostroboides* Hu & W. C. Cheng (GFNNRAB, 2004; Tang *et al*., 2011, 2012). This fact indicates that Fanjingshan Mountain provided long-term relatively stable habitats for these relict plants. The field surveys also revealed a considerable number of long-lived trees (≥100 years old) of these relict plants around the mountain (Zhang, 2004). The places where the natural long-lived individuals occur may indicate the locations of suitable habitats for relict species (probably as "refugia within refugia"; Wang *et al*., 2009). The frequencies and distribution patterns of these long-lived individuals can therefore be used to determine growth conditions and the nature of microhabitats for these relict species or other rare and endangered species, which is important for deciding in situ conservation sites and is of instructive significance for ex situ conservation.

MATERIALS AND METHODS

Data collection

Three local forestry governments surrounding the Fanjingshan Mountain—i.e. Songtao County, Jiangkou County, and Yinjiang County (Fig. 2)—had respectively carried out field surveys in summers of 2010–2012 on long-lived trees (≥100 years old) with plant scientists from universities and institutes. The reports of these surveys have not published yet but can be obtained from the local forest governments upon request.

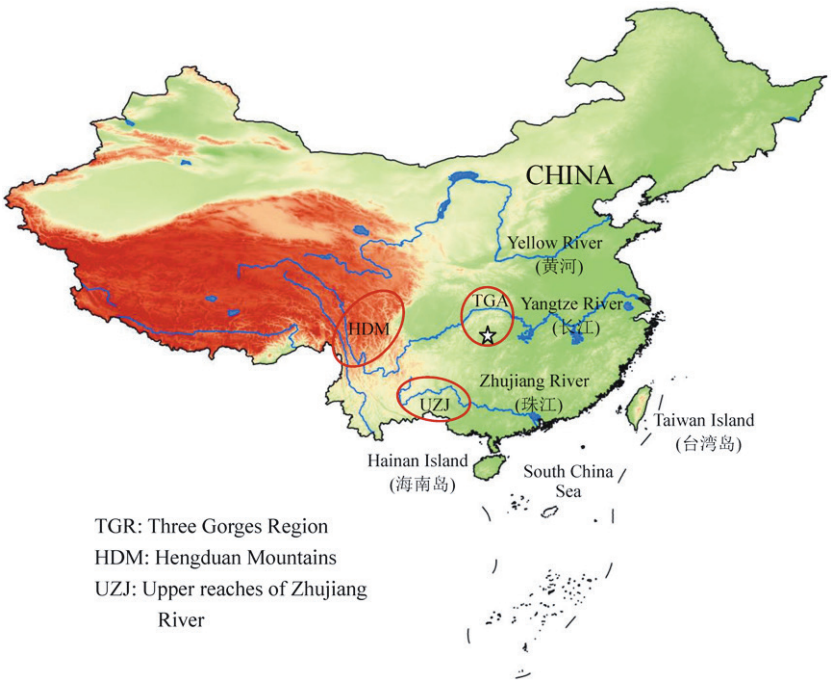

Figure 1. The location of Fanjingshan Mountain (star) and three main plant diversity centres in China (red circles). The three longest rivers of China are also indicated.

According to geographic and topographic characters, we divided the surroundings of the mountain into four regions, i.e. north-east (Songtao County), south-east (Jiangkou County), north-west (the north of Yinjiang County), and south-west (the south of Yinjiang County) (Fig. 2). The NW and SW regions were separated roughly by an expressway. The NE and SE were separated roughly by the Zhaiying and Xiaojiang rivers at the boundary of Songtao and Jiangkou counties (Fig. 2). We collected tree age and diameter at breast height (1.3 m) (DBH) for each long-lived tree.

Data analyses

The data of long-lived individuals were analysed separately for the four regions. Based on the national criterion, the long-lived trees can be divided into three classes: Class-I refers to trees of at least 500 years old; Class-II is trees with an age of 300–499 years, Class-III includes long-lived trees less than 300 years old. We focused our study on six widely-recognized relict plants (Figs. 2 and 3): *Cyclocarya paliurus* (Batalin) Iljinsk., *Ginkgo biloba*, *Liriodendron chinense*, *Pinus massoniana* Lamb., *Podocarpus macrophyllus* (Thunb.) Sweet, and *Taxus chinensis* (Pilg.) Rehder.

To detect the growth status of the trees, we estimated the relationship between tree age and DBH for each relict species respectively for the four regions. These data were also used to compare the habitat quality among four regions, e.g. the habitat can be assumed as of good quality if the DBH of long-lived trees increased steadily with age.

To explore the plant communities and habitat similarity among four regions, we draw the floristic similarity dendrogram according to Tang *et al*. (2011, 2012) using the PAST software (Hammer *et al*., 2001). The values of relative DBH for long-lived individuals of *Ginkgo biloba* and *Taxus chinensis* were applied in the similarity dendrogram analysis using Euclidean and group average clustering. The other relict species were not included into this analyses because they are too few and some are absent in one or two regions.

RESULTS

Distribution patterns

All the information about tree age, DBH, and tree height of long-lived individuals is available in the Appendix. The age classes and spatial distributions of these plants are shown in Fig. 2 and Table 1. *Ginkgo biloba* and *Taxus chinensis* were the most common species among the long-lived trees (Figs. 2 and 3, and Table 1), while the other relict species were restricted to a few small areas. Both SW and NE regions appeared to be the accumulation centres of long-lived

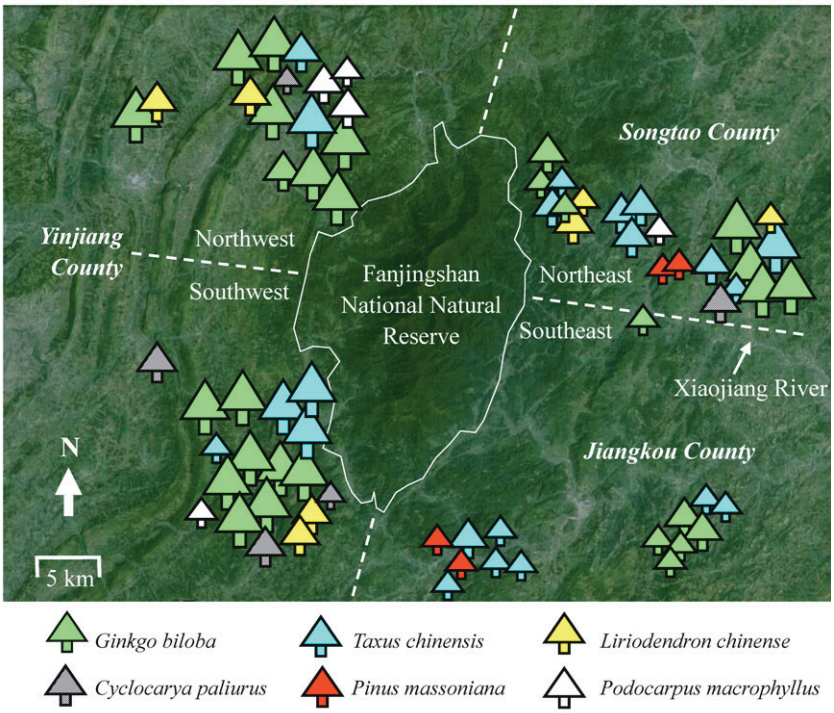

Figure 2. Spatial distribution patterns of long-lived trees of six relict species around the Fanjingshan Mountain. The dashed lines separate the surroundings of the mountain into four geographic regions. The three sizes of symbols correspond to the three age classes (i.e. Class-I trees are represented with the largest symbol). The number of symbols is just illustrative, and does not indicate the exact number of individuals.

trees (Fig. 2). Especially the SW region harboured a large proportion of Class-I long-lived trees of *G. biloba*, some of which were of ≥1000 years old (Fig. 4 and Appendix). For example, six ≥1000-year-old trees and eight Class-I trees of *G. biloba* were found at a small site (Yangliu Town) located at the south of this region (Fig. 2). Another distribution centre of *G. biloba* is the NW region, where three 1000-year-old trees and another five Class-I trees were found (Figs. 2 and 4, and Appendix).

The eastern side of Fanjingshan Mountain, especially the SE region, had fewer long-lived trees as compared with the other regions (Fig. 2 and Appendix). Only four Class-I trees of *G. biloba*

Table 1. Distributions of long-lived individuals (≥100 years old) of six relict species around Fanjingshan Mountain, China. The four boxes for each species and each age class correspond to the four geographic regions in which the surroundings of Fanjingshan Mountain have been divided (i.e. north-west, south-west, north-east, south-east; see Fig. 2).

Species	Age (years)					
	100–299		300–499		≥500	
Ginkgo biloba	36	29	8	9	8	4
	28	21	8	4	14	0
Taxus chinensis	17	25	9	1	5	2
	17	23	8	0	3	0
Pinus massoniana	3	2	0	0	0	0
	3	1	1	0	0	0
Liriodendron chinense	0	3	0	1	0	0
	0	0	0	0	0	0
Podocarpus macrophyllus	0	1	0	0	0	0
	0	0	0	0	0	0
Cyclocarya paliurus	0	1	0	0	0	0
	0	0	0	0	0	0

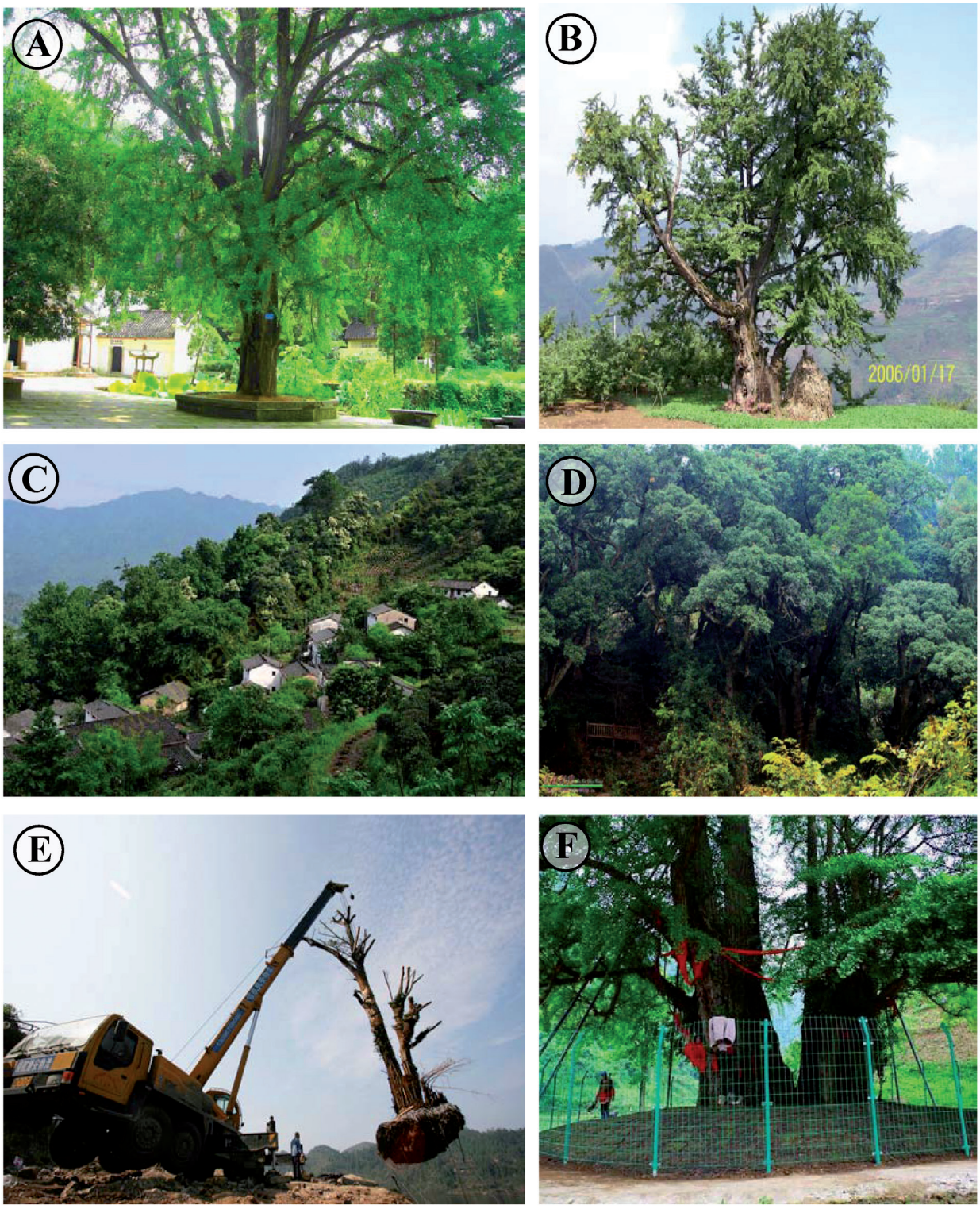

Figure 3. Long-lived trees of *Ginkgo biloba* (A) and *Taxus chinensis* (B) near a village in north-west region of Fanjingshan Mountain. Long-lived trees are often found in *fengshui* ("wind and water") forests (C) surrounding villages, and sometimes they form a community (D). Some long-lived trees are removed and transplanted (E) for ornamental use and/or ex situ conservation, but now it is strictly forbidden and in situ conservation is emphasized (F). The red cloth strips on the tree were hung by villagers for wishes of long life and good luck.

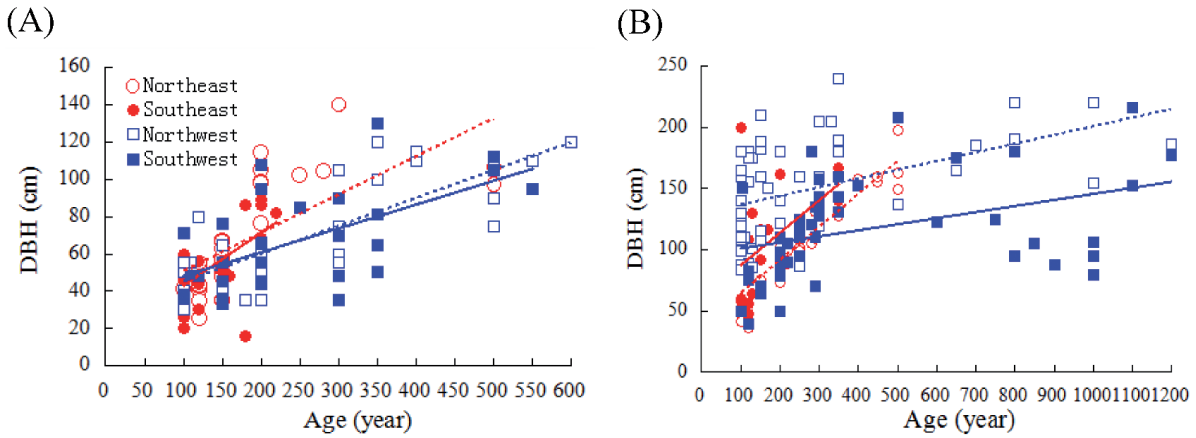

Figure 4. Relation of DBH (diameter at breast height) and tree age of *Taxus chinensis* (A) and *Ginkgo biloba* (B) in four regions around Fanjingshan Mountain. The other four relict plants have very few individuals and are not shown here.

occurred at the NE region, while no Class-I trees were found in the SE region (Fig. 2). All the six relict species were found in the NE region and most individuals grew along the east fringe of the mountain and the boundary with the SE region, where several small rivers and valleys occur. Compared to *G. biloba*, *T. chinensis* had much fewer Class-I trees and no trees were older than 600 years (Fig. 4). The distribution centres of *T. chinensis* were quite similar to *G. biloba*, located both at the NE region and the west side of the mountain.

Correlation of DBH and tree age

The DBH increased with the age more quickly in *G. biloba* than in *T. chinensis* (Fig. 4A, B) for long-lived trees below 600-year old. For *G. biloba* trees with an age of >600 years, DBH increased very slowly (Fig. 4B).

For *G. biloba*, the long-lived trees from NW region showed a relatively larger DBH than those from the other three regions (Fig. 4B). For *T. chinensis*, although the DBH values were similar among the four regions, these increased more quickly in trees from NE region compared to the other regions. Consequently, the long-lived trees at the north side to the mountain had relatively larger DBH values for both relict species.

Region similarity

The dendrogram showed that the SW and NE regions were the most similar regarding the DBH of long-lived trees (Fig. 5). The SE region was clustered as the sister group of SW and NE regions, whereas the NW region is the most dissimilar one (Fig. 5).

Grouping of long-lived trees

We also found that some long-lived trees were growing in groups (Fig. 3C, D). For example, many long-lived trees were found in *fengshui* ("wind and water") forests surrounding villages in the valley (Fig. 3C), which were well protected by local residents. Isolated long-lived trees usually occurred near villages (Fig. 3A) or farmlands (Fig. 3B), and some were regarded as "God trees" by local residents for good luck and long life (Fig. 3F).

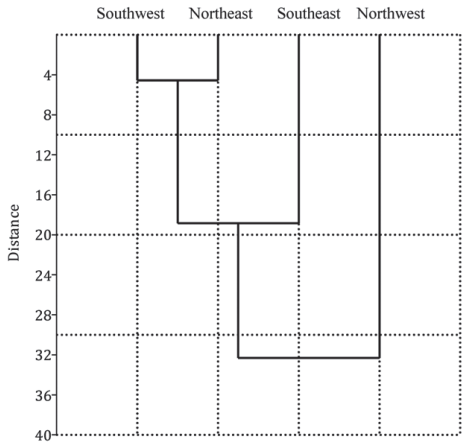

Figure 5. Similarity dendrogram using Euclidean and group average clustering for the four regions based on the diameter at breast height (DBH) of both *Ginkgo biloba* and *Taxus chinensis*.

DISCUSSION

Our data showed that the west side and the NE region around Fanjingshan Mountain are main distribution sites of long-lived trees and can be seen as the real stable natural habitats for relict species such as *G. biloba* and *T. chinensis*. Such information has significant implications for conservation of these "living fossils" and local ecosystems.

All the six relict plants can be found at the NE region to the Fanjingshan Mountain (Fig. 2 and Appendix). This pattern is probably the result from the evolutionary history and demographic dynamics of relict plants during glacial periods. Fanjingshan Mountain has an altitude of >2000 m and would have acted as a main refugium for various plants during the last three million years (Qian, 2001; López-Pujol *et al*., 2011*b*). During the glacial periods of the Quaternary, most parts of China were much colder than at present (Li, 1940), and only the mountainous areas with large altitudinal gradients provided opportunities and habitats for the plants to survive. The Fanjingshan Mountain is at the middle point between East and West China (Fig. 1) and probably is among the first stop-off sites when the plants retreated from the eastern lowlands. Therefore, deep valleys of the NE side of Fanjingshan Mountain are probably one of the main survival places of these relict species during their range contraction in the glacial periods (Ying & Zhang, 1984; Ying, 2001; Li *et al*., 2009; López-Pujol *et al*., 2006, 2011*a*, *b*). The SE region, however, have much fewer long-lived trees (Fig. 2); this region is mainly consisting of lowlands without deep valleys (GFNNRAB, 2004) having, thus, a very limited role as a refugium (i.e. plant species had less opportunities to track the climatic changes). Furthermore, the SE region is the main place for tourists entering Fanjingshan Mountain and some habitats for relict plants have been destroyed due to road and hotel construction (GFNNRAB, 2004).

Although the NE region is the area with highest species diversity of relict plants, the distribution centre of long-lived trees, especially the very old trees (Class-I and Class-II) is at the west side of the mountain (Fig. 2 and Table 1). A reason might be that the western surrounding regions are well protected by the mountain from the cold winds. and thus the habitats would have remained more stable than in the eastern side. This is probably why the west side of the mountain, including NW and SW regions, has much more Class-I trees, some of which are >1000 years old (Fig. 4 and Appendix).

Most Class-I and other long-lived trees in the SW region were found in a small village named Yangliu (more than 90% Class-I trees of *G. biloba* and *T. chinensis* grew at this village; Fig. 2). Recruits of these long-lived trees can be also found near the trees or at very close sites (H.-Y. Liao, pers. obs.). This information indicates that this place probably constitutes a long-term stable habitat for these relict species or other similar relict plants. Two additional scenarios can also explain the high occurrence of long-lived trees in this small village. First, the village is in a deep valley, far away from intense human activities. Second, the local residents of Yangliu Village are largely belonging to ethnic minorities including Tujia and Miao (GFNNRAB, 2004); these communities normally protect big and long-lived trees as "God trees" for long life or good luck (Fig. 3F) but also protect groups of long-lived trees as *fengshui* forests for environmental safety and good living conditions (Fig. 3C). Therefore, Yangliu Village should be given highest priority for in situ conservation, not only for its high diversity of long-lived trees but also for its stable habitats that are protected by local residents.

Although the ethnic minorities usually protect trees around their villages, they also utilize the mountain plant resources directly, such as fuelwood gathering and burning grass in fields to clear and fertilize soils (GFNNRAB, 2004; Wandersee *et al*., 2012). Recently, the mountain is experiencing rapid changes in land use and forest cover due to tourism, timber harvesting, and road construction (GFNNRAB, 2004; Wandersee *et al*., 2012). Some long-lived trees were also be transplanted to cities for their commercial value (Fig. 3F). All these activities have the potential to seriously affect rare and endangered plants, particularly long-lived trees. This is probably why many long-lived trees are now only found in the protected *fengshui* forests near villages (Fig. 3A, C). Therefore, it is necessary to set up several suitable sites in this village or nearby places for in situ conservation of these relict species or other rare and endangered plants. Fortunately, reforestation programs from national and local governments, such as the Natural Forest Conservation Program (NFCP) and the Grain-to-Green Program (GTGP), were

carried out since about one decade ago (GFNNRAB, 2004; Liu *et al*., 2008; Wandersee *et al*., 2012). The NFCP is geared to protect forests, water, and soil for environmental safety and biodiversity (Li, 2004; Wandersee *et al*., 2012). The GTGP aims to plant trees on steep slopes where were once used by farmers as croplands, and the farmers are compensated through cash or foodstuff (Feng *et al*., 2005).

In conclusion, our data suggest that, although the Fanjingshan Mountain (which is a National Natural Reserve) is the main distribution region of rare and endangered plants including relict species, the surrounding places are also of conservation value due to their large number of long-lived trees of relict plants and the primaeval habitats protected by local residents. We should not only protect the local biodiversity within the limits of the natural reserve, but also pay enough attention to the rare and endangered species that occur out of the range of the reserve.

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Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China.

Region	Species	Age (years)	DBH (cm)	Height (m)
North-east	*Ginkgo biloba*	500	149.61	25
	G. biloba	500	162.34	22
	G. biloba	500	197.35	27
	G. biloba	500	162.34	21
	G. biloba	450	155.97	32
	G. biloba	450	159.15	27
	G. biloba	400	152.79	32
	G. biloba	400	157.56	30
	G. biloba	350	143.24	28
	G. biloba	350	143.24	32
	G. biloba	350	130.51	15
	G. biloba	350	128.92	18
	G. biloba	350	127.32	20
	G. biloba	250	122.56	24
	G. biloba	100	41.39	25
	G. biloba	200	90.72	20
	G. biloba	220	89.13	36
	G. biloba	220	98.68	37
	G. biloba	105	101.86	31
	G. biloba	250	101.86	26
	G. biloba	250	111.41	31
	G. biloba	250	95.49	29
	G. biloba	250	93.58	15
	G. biloba	250	122.87	20
	G. biloba	250	92.95	24
	G. biloba	120	82.76	16
	G. biloba	120	74.80	14
	G. biloba	250	98.68	30
	G. biloba	200	77.99	28
	G. biloba	150	63.66	28
	G. biloba	280	120.96	25
	G. biloba	280	105.04	22
	G. biloba	290	109.18	24
	G. biloba	290	120.96	30
	G. biloba	250	124.14	28
	G. biloba	290	130.51	30
	G. biloba	200	73.21	25
	G. biloba	200	108.86	21
	G. biloba	120	36.61	21
	G. biloba	150	74.80	26
	G. biloba	200	101.86	26

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
North-east	*G. biloba*	200	101.86	28
	Taxus chinensis	500	106.63	18
	T. chinensis	500	97.08	21
	T. chinensis	300	140.06	22
	T. chinensis	100	41.38	18
	T. chinensis	250	102.18	16
	T. chinensis	150	49.34	22
	T. chinensis	150	50.93	19
	T. chinensis	150	47.75	15
	T. chinensis	120	25.46	12
	T. chinensis	150	35.33	17
	T. chinensis	150	57.30	21
	T. chinensis	200	76.39	19
	T. chinensis	150	54.11	23
	T. chinensis	200	114.59	20
	T. chinensis	200	105.04	21
	T. chinensis	200	98.68	18
	T. chinensis	200	98.04	23
	T. chinensis	120	52.52	13
	T. chinensis	150	56.98	14
	T. chinensis	120	40.74	10
	T. chinensis	120	42.97	10
	T. chinensis	280	104.41	15
	T. chinensis	120	43.61	7
	T. chinensis	120	35.01	7
	T. chinensis	150	67.48	15
	T. chinensis	150	62.71	16
	T. chinensis	120	55.39	15
	T. chinensis	150	66.85	14
	Liriodendron chinense	350	160.75	31
	L. chinense	280	111.41	30.5
	L. chinense	200	82.76	17
	L. chinense	200	98.68	18
	Pinus massoniana	150	75.44	25
	P. massoniana	100	79.90	29
	Cyclocarya paliurus	150	60.48	24
	Podocarpus macrophyllus	150	49.66	15
North-west	*Ginkgo biloba*	1200	186.48	33
	G. biloba	1000	154.23	35
	G. biloba	1000	220.00	28
	G. biloba	800	220.00	31

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
North-west	*G. biloba*	700	185.00	15
	G. biloba	800	190.00	27
	G. biloba	650	165.00	25.50
	G. biloba	500	136.48	30
	G. biloba	350	189.00	29
	G. biloba	300	125.00	18
	G. biloba	300	205.00	22
	G. biloba	350	180.00	13
	G. biloba	330	205.00	32
	G. biloba	300	160.02	28
	G. biloba	300	120.05	27
	G. biloba	350	240.10	25
	G. biloba	170	150.25	20
	G. biloba	120	180.05	19
	G. biloba	120	89.50	38
	G. biloba	120	156.20	16
	G. biloba	100	105.55	27
	G. biloba	150	160.35	31
	G. biloba	130	175.15	27
	G. biloba	100	88.05	29
	G. biloba	100	110.00	30
	G. biloba	100	160.58	15
	G. biloba	100	160.50	16
	G. biloba	100	140.35	22.50
	G. biloba	100	100.10	22
	G. biloba	200	110.25	21
	G. biloba	100	84.50	18
	G. biloba	200	122.95	16
	G. biloba	150	115.50	16
	G. biloba	150	182.25	15
	G. biloba	130	101.10	29
	G. biloba	200	180.35	33
	G. biloba	130	86.55	34
	G. biloba	150	107.50	28
	G. biloba	200	140.35	19
	G. biloba	100	128.20	17
	G. biloba	110	110.30	26
	G. biloba	250	87.60	24
	G. biloba	120	175.50	19
	G. biloba	150	188.10	31
	G. biloba	100	110.15	30

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
North-west	*G. biloba*	150	210.50	25
	G. biloba	250	160.00	25
	G. biloba	100	99.80	22
	G. biloba	100	130.50	19
	G. biloba	100	165.55	26
	G. biloba	100	180.65	18
	G. biloba	100	120.50	17
	Taxus chinensis	600	120	11
	T. chinensis	500	90	9
	T. chinensis	550	110	16
	T. chinensis	500	75	12
	T. chinensis	500	108	21
	T. chinensis	300	60	18
	T. chinensis	350	120	15
	T. chinensis	400	115	15.50
	T. chinensis	350	100	15
	T. chinensis	400	110	14.50
	T. chinensis	300	55	13
	T. chinensis	300	105	14
	T. chinensis	300	55	16
	T. chinensis	300	75	18
	T. chinensis	100	55	22
	T. chinensis	200	60	19
	T. chinensis	150	35	17
	T. chinensis	250	85	17
	T. chinensis	200	60	15
	T. chinensis	180	35	15
	T. chinensis	150	42	15
	T. chinensis	100	30	12
	T. chinensis	110	55	24
	T. chinensis	100	38	21
	T. chinensis	100	40	21
	T. chinensis	200	50	23
	T. chinensis	200	35	27
	T. chinensis	150	65	18
	T. chinensis	100	50	18
	T. chinensis	100	55	16.50
	T. chinensis	120	80	19
	Pinus massoniana	150	77	22
	P. massoniana	100	65	22.50
	P. massoniana	100	60	21

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
South-west	*Ginkgo biloba*	1000	106.63	28
	G. biloba	1000	79.58	27.55
	G. biloba	1100	216.45	19
	G. biloba	1200	176.66	12
	G. biloba	1000	95	16
	G. biloba	1100	152.79	18
	G. biloba	900	88	24
	G. biloba	850	105	23
	G. biloba	600	123	31
	G. biloba	800	95	33
	G. biloba	750	125	28
	G. biloba	650	175	26
	G. biloba	800	180	15
	G. biloba	500	207.86	15
	G. biloba	350	159.15	15.50
	G. biloba	400	152.79	16
	G. biloba	300	157.56	12
	G. biloba	350	143.24	24
	G. biloba	300	143.24	23
	G. biloba	350	130.51	22
	G. biloba	300	128.92	19
	G. biloba	300	127.32	21
	G. biloba	250	122.55	30
	G. biloba	100	50	18
	G. biloba	200	92	17.50
	G. biloba	220	90	16.50
	G. biloba	220	105	18
	G. biloba	105	150	18
	G. biloba	250	120	19
	G. biloba	300	135	21
	G. biloba	250	95	22
	G. biloba	200	90	25
	G. biloba	250	122	15
	G. biloba	200	98	27
	G. biloba	120	83	24
	G. biloba	120	75	14
	G. biloba	250	110	23
	G. biloba	200	78	34
	G. biloba	150	64	19
	G. biloba	280	121	15
	G. biloba	280	180	20

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
South-west	*G. biloba*	290	110	21
	G. biloba	290	135	31
	G. biloba	250	125	15
	G. biloba	290	70	18
	G. biloba	200	80	17
	G. biloba	120	39	17
	G. biloba	150	70	25
	G. biloba	200	50	24
	G. biloba	200	110	22
	Taxus chinensis	500	112	16
	T. chinensis	550	95	16.50
	T. chinensis	500	105	15
	T. chinensis	350	81	15
	T. chinensis	350	50	15
	T. chinensis	300	35	15
	T. chinensis	300	90	20
	T. chinensis	300	70	21
	T. chinensis	350	65	28
	T. chinensis	350	130	18
	T. chinensis	300	48	14
	T. chinensis	200	108	15
	T. chinensis	200	44	19
	T. chinensis	100	71	13
	T. chinensis	200	66	9
	T. chinensis	150	35	25
	T. chinensis	150	55	26
	T. chinensis	100	38	27.50
	T. chinensis	100	36.50	31
	T. chinensis	120	48	33
	T. chinensis	150	33	18
	T. chinensis	150	76	17.50
	T. chinensis	110	48	21.50
	T. chinensis	250	85	22.50
	T. chinensis	200	95	22
	T. chinensis	150	45	18
	T. chinensis	200	55	15
	T. chinensis	200	45	14
	Pinus massoniana	300	24	13
	P. massoniana	100	15	16
	P. massoniana	200	27	16
	P. massoniana	150	13	11

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
South-east	*Ginkgo biloba*	350	167	18
	G. biloba	300	131	25
	G. biloba	300	134	33
	G. biloba	350	140	18
	G. biloba	170	116	43
	G. biloba	120	108	46
	G. biloba	120	48	26
	G. biloba	120	56	32
	G. biloba	100	58	16
	G. biloba	150	116	48
	G. biloba	130	130	30
	G. biloba	100	60	15
	G. biloba	100	200	25
	G. biloba	100	60	15
	G. biloba	100	60	15
	G. biloba	100	140	20
	G. biloba	100	100	15
	G. biloba	200	110	18
	G. biloba	100	84	18
	G. biloba	200	122	24
	G. biloba	150	66	21
	G. biloba	150	92	17
	G. biloba	130	64	26
	G. biloba	200	162	27
	G. biloba	130	86	31
	Taxus chinensis	180	16	7
	T. chinensis	200	86	32
	T. chinensis	220	82	21
	T. chinensis	200	68	25
	T. chinensis	160	48	20
	T. chinensis	100	40	9
	T. chinensis	100	60	15
	T. chinensis	100	40	15
	T. chinensis	100	20	10
	T. chinensis	100	60	15
	T. chinensis	100	60	15
	T. chinensis	100	46	14
	T. chinensis	100	26	12
	T. chinensis	100	60	15
	T. chinensis	100	40	15
	T. chinensis	100	50	15

Appendix. Age classes, tree height and diameter at breast height (DBH) of long-lived trees for the six relict plants around Fanjingshan Mountain, China (cont.)

Region	Species	Age (years)	DBH (cm)	Height (m)
South-east	*T. chinensis*	100	40	15
	T. chinensis	150	50	11.5
	T. chinensis	120	56	13
	T. chinensis	120	44	10
	T. chinensis	200	89	11
	T. chinensis	180	86	15
	T. chinensis	120	30	17
	Pinus massoniana	150	38.20	28