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Modern pollen distribution and its relationship with environmental difference in southwestern China

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Abstract: Quantitative relationships between pollen and vegetation in the Longitudinal Range-Gorge Region (LRGR) are studied based on the pollen records of 35 surface soil samples and 7 vegetation quadrates. The spatial distribution of the pollen and the relative control of environmental factors are analyzed. Results are: (1) The *R* values, which designate the representation of pollen to vegetation, indicate a good quantitative relationship between surface pollen assemblages and local vegetation. (2) Significant differences in diversity of pollen flora, pollen amounts, major taxa, and vegetation between the east and the west sides of Ailao Mountain, an important geographical dividing line in LRGR, are recognized. (3) Obvious spatial differences of pollen assemblages are relevant to different regional topography and climatic conditions. These results suggest that the spatial differences between pollen assemblages would be caused by the different pattern of hydrothermal condition in the unique topography of the LRGR. The barrier function of the vertical mountain ranges, especially by the Ailao Mountain, may be a main factor in such environmental differences. Two separate monsoon circulations occurring in Pacific and Indian oceans result in different hydrothermal characteristics causing the regional differentiated patterns in the pollen assemblages in the study area.

Key words: pollen distribution, environmental difference, southwestern China

1. INTRODUCTION

Vegetation is one of the most sensitive elements to show environmental condition and is usually used to get the environmental information (Davis, 1963). However, the modern vegetation has been seriously destroyed by the human activities such as over-logging, land coverage changes, and so on. Consequently, it is difficult to use the modern vegetation in studying the environmental conditions. Among all the environmental proxy studies, the pollen analysis is one of the useful and important methods for restoring the vegetation and environmental information due to small size, high production, stable chemical composition, and preservability (Wang and Xu, 1988).

As the pollen analysis and identification technique has been developed, as well as ^{14}C dating techniques and numerical methods, the Quaternary palynology has been greatly advanced. Especially in recent decades, when vegetation destruction, environmental deterioration and global climate change have been aggravated by population growth and industrial progress, palynologists began to pay more attention to the study of relationship among pollen assemblages, vegetation and the modern environment.

There are many studies which have demonstrated good relationships between surface pollen and the environment from different sites or regions (e.g., Wright, 1967; Huntley and Birks, 1983; El-Moslimany, 1990; Guiot et al., 1993; Sugita, 1994; Hjelmroos and Franzen, 1994; Prentice and Webb, 1998; Hjelle, 1999; Prentice, 1985; Jackson and Kearsley, 1998; Brayshay, 2000; Yu et al., 1998, 2000, 2004; Davies and Fall, 2001; Pardoe, 2001, 2006). In China, most studies undertaken so far have established the relationships between surface pollen and the major/indicative plants of the vegetation. These studies focused on different vegetation communities including forests (Li et al., 2000), forest-grassland transitional regions (Li and Jie, 2006), grassland-desert transitional regions (Tong et al., 1996), grasslands (Wang et al., 1996), arid areas (Chen et al., 2004) and wetlands (Xu et al., 2004). The study areas referred to northeast (Li et al., 2000; Tong et al., 1996; Sun et al., 2003), north (Yao, 1989; Zhang et al., 1996; Yu and Liu, 1997), northwest (Yan, 1993), east (Yu and Han, 1995; Liu et al., 2006), central (Li, 1991), and south China (Wu and Sun, 1987; Wu et al., 1989). Related studies have also been reported in southwestern China (Tong et al., 2003).

The Longitudinal Range-Gorge Region (LRGR) lies in southwestern China (Fig. 1). It is composed of Hengduan Mountain, which is related to the Tibetan uplift, and the

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adjacent longitudinal range-gorge regions (He et al., 2005). Great mountain chains and deep-incised valleys develop in the south to north direction, which serve significant “corridor-barrier” function to the geographical elements. This “corridor-barrier” effect of physical components makes the region to be ecological corridor for portrait migration and barrier for horizontal compiling of lives. This effect has also caused particular ecological features, including great variability on form and spatial dimension of ecological system types and community. Especially, the Ailao Mountain range which is one of the most important barriers from the east to the west is an important geographical dividing line. The east and the west sides of Ailao Mountain show significant environmental differences.

The relationships among pollen distribution, vegetation and environmental differences are studied in this paper, based on analysis of the spatial distribution of pollen assemblages and the relative control of environmental factors affecting pollen assemblages in the east and the west sides of Ailao Mountain, respectively. The differences of diversity of pollen flora, major taxa, and vegetation were analyzed. Then the relationship between pollen distribution and environmental difference was discussed. It is of great significance for recognizing the regional environmental differences to study the relationship between pollen distribution and natural environment.

2. MATERIALS AND METHODS

2.1. Field Sampling and Analysis

35 pollen samples from the top 5 cm of surface soil were collected from 7 sites in LRGR with about 100 km intervals. Seven plant quadrates were also investigated. Samples and investigation were made from the east to the west, including Xiaoqiaogou of Xichou (S1), Daweishan of Pingbian (S2), Pingzhangshan of Xinping (S3), Ailao Mountain of Zhengyuan (S4), Daxueshan of Yongde (S5), Dahuzhai of Shuangjiang (S6), and Zhulin of Zhenkang (S7). The altitude range is from 1500 to 3000 m. The sampling route is shown in Figure 1. Floral composition was investigated with seven 20 m × 20 m quadrants, where plant taxa and abundance were recorded.

These samples were processed using standard HF/acetolysis procedures (Feagri and Iversen, 1989). A known quantity of exotic spores (*Lycopodium*) was added to the samples prior to chemical processing and these were tabulated along with the surface pollen and spores. Then samples were treated with hydrochloric acid to remove calcium and carbonates and with hydrofluoric acid to remove silicates, heated gently to the boiling point, and then immersed in a heavy liquid (specific gravity = 1.9) to separate organ-

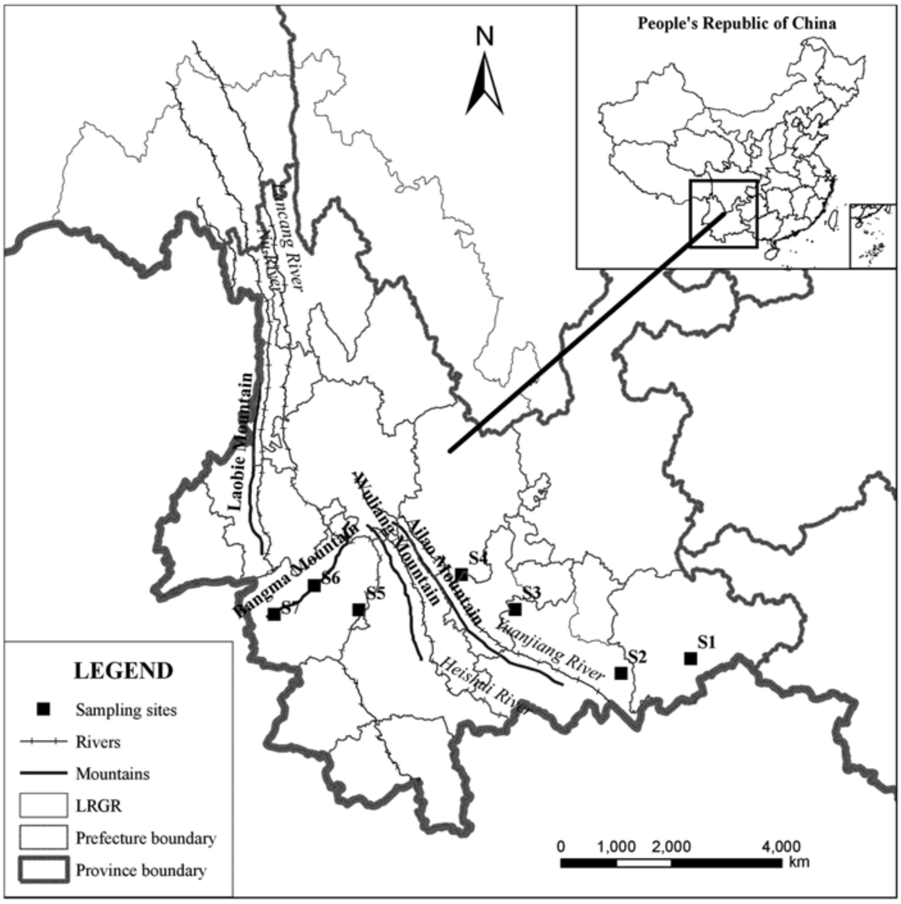

Fig. 1. Location of study area and the sampling sites.

ics from additional unwanted inorganic traces. After that, acetic acid and a fresh mixture (ca. nine parts acetic anhydride and one part sulfuric acid) were added to remove unwanted organics and to clean residues on fossil surfaces. After each aforementioned step, the sample was repeatedly washed with water up to neutrality. Finally, pollen and spores were identified and counted under a stereomicroscope. In each sample, pollen of terrestrial plants were counted up to 200 grains, except those with a little number of pollen in the samples. Percentages and concentrations were calculated for each sample.

2.2. Environmental Data

Monthly observations of meteorological data, including temperature, precipitation, sunshine duration, wind speed at 2 m height, average evaporation, etc. have been collected at 78 stations in the region from 1971 to 2000. Meteorological data and station latitudes and elevations were provided by the Climatic Data Center (CDC), National Meteorological Information Center (NMIC) of China Meteorological Administration (CMA). Digital elevation model (DEM) data at 1 km resolution was provided by the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC).

2.3 Methods

2.3.1 *R* value

The *R* value, which is the ratio between pollen and spores and the sampled plant community, has been used to express the representation of pollen and spores (Davis, 1963). The model is,

$$R = \frac{P}{V} \tag{1}$$

where P is the percentage of pollen and spores; V is the percentage of the plant in community. $R > 1$ means over-representative, and $R < 1$ means under-representative.

2.3.2 Diversity indices

Three diversity indices including palynological richness index (S) (Magurran, 1988), Simpson's diversity index (D) (Simpson, 1949) and Shannon–Wiener's diversity index (H') (Shannon, 1948) were caculated.

Palynological richness index (S) is the total number of species (or genus, family) in every pollen sample.

Shannon's index (H) was calculated as

$$H = \sum_{i=1}^{n} P_i \ln P_i . \tag{2}$$

Simpson's index was calculated as

$$H' = 1 - \sum_{i=1}^{n} P_i^2 \tag{3}$$

where n is the total number of species (or other units), P_i is the ratio of the number of individuals in the ith species (n_i) to the total number of individuals in the sample (N), namely $P_i = n_i/N$. $\ln P_i$ is the natural logarithm of P_i.

2.3.3 Pollen percentage

The percentage of each family or genus was calculated with one sampling site as a unit. The formula is:

$$P_1 = \frac{Q_1}{X_1} \times 100\% \tag{4}$$

where P_1 is the percentage of woody or herbaceous pollen (%), Q_1 is the amount of woody or herbaceous pollen (grain), and X_1 is the total amount of the pollen (not containing fern spores) in each site.

$$P_2 = \frac{Q_2}{X_2} \times 100\% \tag{5}$$

where P_2 is the percentage of fern spores (%), Q_2 is the amount of fern spores (grain), X_2 is the total amount of the spores (not containing woody or herbaceous pollen) in each site.

2.3.4 Pollen concentration

The pollen and spore concentrations were calculated by means of exotic pollen, and the formula is,

$$C = \frac{L_t}{L_f} \times \frac{Q}{M_0} \tag{6}$$

where C is the surface pollen and spores concentration (grain/g), L_t is the amount of exotic pollen added to the sample, L_f is the statistical amount of exotic pollen, Q is the amount of pollen and spores in each sample soil (grain), and M_0 is the mass of each sample soil (g).

3. RESULTS

3.1. Quantitative Relationship between Pollen Flora and Modern Vegetation

The total number of pollen and spores identified in the 35 samples is 12,242 grains and about 229–540 grains of pollen and spores per sample. The number of pollen and spores for each sampling site were: 2288 grains in S1, 1743 grains in S2, 1356 grains in S3, 1866 grains in S4, 1309 grains in S5, 1672 grains in S6, and 2008 grains in S7. A total of 89 families and genera were identified. The percentages of the major taxa of pollen and spores are shown in Table 1.

The closer *R* value is to 1, the more representative it is, so the *R* value represents the representation of pollen and spores to vegetation. The *R* value is the basis for reconstructing past vegetation using pollen and spores data. Here, we use *R* value to describe the representation of pollen and spores in LRGR (Table 2).

Table 1. Percentages of representative pollen taxa in southwestern China

Pollen taxa	S1	S2	S3	S4	S5	S6	S7
Pinus	6.23	1.23	23.94	11.89	3.50	3.53	6.21
Tsuga	0.09	/	/	/	6.89	5.45	0.07
Alnus	5.87	2.12	15.38	10.23	9.96	5.74	9.53
Carpinus	1.28	3.07	1.75	0.37	0.32	7.29	1.33
Fagus	3.67	0.14	0.08	0.09	0.21	/	/
Quercus	26.40	55.73	4.15	4.79	8.90	7.07	19.89
Castanopsis	17.87	/	28.26	16.41	12.18	0.15	11.09
Hamamelidaceae	2.47	1.30	0.58	2.67	5.19	13.92	0.89
Chionanthus	1.47	/	2.16	12.53	5.08	4.42	6.58
Myrica	1.56	4.37	0.50	2.40	0.64	1.03	1.55
Elaeocarpaceae	2.02	4.64	1.66	0.65	1.17	0.44	4.36
Ericaceae	0.37	7.31	0.33	1.20	2.12	3.39	0.37
Theaceae	2.38	/	1.08	/	/	/	/
Llex	0.64	0.61	0.42	0.28	3.81	8.84	1.63
Artemisia	4.40	2.73	1.33	1.66	2.86	3.17	2.14
Gramineae	1.37	0.14	0.33	0.83	4.45	5.52	1.26
Araliaceae	2.29	0.07	1.00	2.58	5.72	8.10	1.18
Rubiaceae	1.65	/	0.08	0.83	1.91	0.81	1.33
Cyatheaceae	2.88	8.21	/	1.27	2.65	9.55	11.22
Cibotium	6.31	5.13	/	0.36	0.44	/	1.92
Davalliaceae	1.26	25.13	44.23	11.39	15.93	9.55	14.42
Dicranopteris	57.84	31.28	0.96	0.36	2.21	3.02	1.60
Lepisorus	1.08	2.56	3.85	/	/	2.51	9.29
Athyrium	0.72	/	/	/	/	/	0.64
Selaginella	0.18	/	11.54	/	/	/	/
Lycopodium	0.36	2.56	/	/	/	3.52	0.64
Onychium	/	/	/	/	/	25.63	0.32
Thelypteridaceae	0.18	/	/	/	/	/	/
Dennstaedtiaceae	/	/	5.77	/	/	/	8.65

The woody pollen such as *Pinus, Tsuga*, *Alnus*, *Fagus*, and *Castanopsis* are over-representative with *R* values over 1.1, but *Quercus, Carpinus Myrica* Elaeocarpaceae, Ericaceae, Theaceae and *Llex* are under-representative with *R* values under 0.9. The herbaceous pollen such as *Artemisia* and Rubiaceae are over-representative, while others such as Gramineae, and Araliaceae are under-representative. The pollen of a certain taxon in different vegetation zones has different *R* values. The *R* values of pollen flora which are far away from the main pollen sources are lower than those near the main pollen sources. Generally, there is a good corresponding relationship between surface pollen assemblages and the local vegetation in LRGR.

3.2. Spatial Distribution of Pollen Assemblages

3.2.1 Diversity of Pollen flora

In order to analyze the difference of the pollen assemblages, this paper adopted three diversity indices including palynological richness index (*S*), Simpson's diversity index (*H*), and Shannon–Wiener's diversity index (*H'*) to estimate the pollen flora diversity (Fig. 2). We found that the pollen flora richness in the west side is higher than that in the east side, so do the Simpson and Shannon–Wiener's diversity indices. There are clear horizontal differences in diversity from the seven sampling sites. Not only the total but also the respective numbers of woody, herbaceous, and fern taxa in the east side (including S1, S2, S3, and S4) are lower than those in the west (including S5, S6, and S7). The Ailao Mountain serves as a dividing line of the pollen flora diversity between the east and the west sides. In the 4 sites from the east side, the largest number of woody taxa is 12 (S1), while in the 3 sites from the west side, the number reaches 18 (S5). The same as woody taxa, the largest number of herbaceous taxa in the east side is only 6 (S2, S3) but the number is 12 (S5) in the west. The lowest numbers of woody and herbaceous taxa in the west side go up to 15 (S6) and 7 (S6) respectively, which are both higher than the numbers in the east. The fern spores show similar distribution pattern.

3.2.2 Dominant Pollen and Spore taxa

The difference of dominant pollen taxa from the seven

Table 2. *R* values of representative pollen taxa in southwestern China

Pollen taxa	Evergreen broad-leaved forest	*Quercus* forest	Montane moist broad-leaved forest	Pinus Yunnanens forest	Abies fabri forest	Mean *R* value
Pinus	2.13	2.47	1.92	0.93	0.97	1.68
Tsuga	/	/	/	1.17	1.78	1.48
Alnus	1.21	1.34	1.07	1.01	1.18	1.16
Carpinus	0.87	0.92	0.79	0.66	/	0.81
Fagus	1.42	/	1.28	/	/	1.35
Quercus	0.76	0.87	0.63	/	/	0.75
Castanopsis	1.18	1.24	0.92	/	/	1.11
Hamamelidaceae		1.56	1.25	/	/	1.41
Chionanthus	1.27	1.19	1.38	/	/	1.28
Myrica	0.45	0.67	0.39	/	/	0.51
Elaeocarpaceae	0.89	0.65	0.74	/	/	0.76
Ericaceae	0.91	0.86	0.88	0.76	0.89	0.86
Theaceae	0.39	/	/	/	0.45	0.42
Llex	0.77	0.71	0.68	/	0.67	0.71
Artemisia	1.35	1.66	1.44	/	1.86	1.58
Gramineae	0.68	0.75	0.72	0.69	/	0.71
Araliaceae	0.83	0.78	0.67	0.63	/	0.73
Rubiaceae	0.88	1.25	1.36	1.09	/	1.21
Cyatheaceae	5.78	5.36	6.13	7.81	/	6.27
Athyrium	16.01	/	/	/	8.34	12.18
Selaginella	21.84	/	/	19.37	/	20.61
Lycopodium	12.35	/	/	/	/	12.35

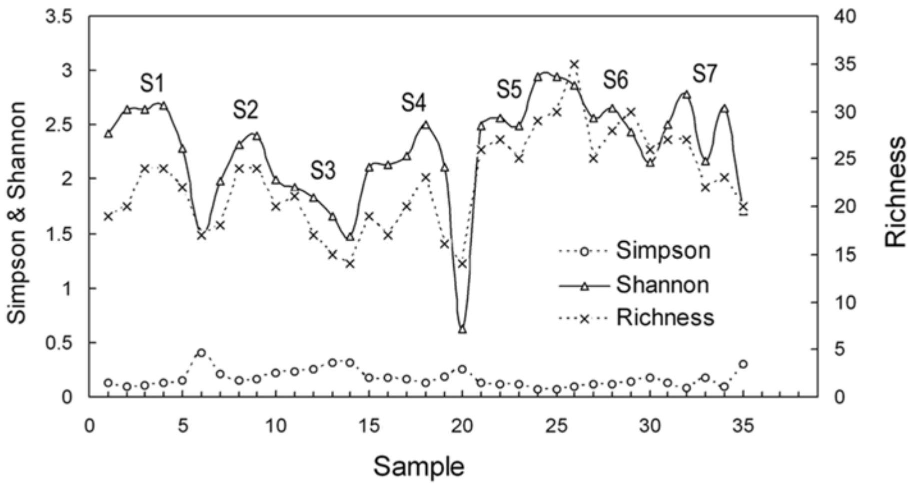

Fig. 2. Palynological diversity indices of several representative pollen in LRGR.

sampling sites is also significant (Table 3). In the sites from the east side of Ailao Mountain, there are only 5 taxa whose percentages are higher than 5% in S1, and 4 of them are higher than 10%. The total percentage of the 6 dominant taxa is over 67% in S1. In S2, there are only 3 taxa whose percentages are higher than 5%, but their total percentage comes up to 66.73%. Furthermore, the percentages of 2 taxa in the S2 are higher than 10%, reaches 27% and 29% respectively whose dominant position is very evident. The proportion of dominant taxa in the S3 and S4 sites also reaches higher than 10%.

The pollen assemblages of the three sampling sites in the west side of Ailao Mountain have different characteristics from those in the east sites. In S5, 7 taxa have been found whose proportion are higher than 5%, but only 2 of them are over 10%. The total percentage of the 7 taxa reaches 64.51%. In S6, there are 8 taxa whose percentages are higher than 5%, but only 1 of them is higher than 10% and the proportion of the 8 taxa is 61.05%. In S7, 7 taxa are found whose percentages are higher than 5%, but only 3 are higher than 10%, with 76.27% in total.

From the comparison between the two sides of Ailao

Table 3. Dominant pollen taxa percentages from S1 to S7

	S1		S2		S3		S4		S5		S6		S7	
	Taxon	%	Taxon	%	Taxon	%	Taxon	%	Taxon	%	Taxon	%	Taxon	%
Percentage of Dominant Taxa	*Castanopsis*	18	*Quercus(D)*	29	*Castanopsis*	28	*Lithocarpus*	26	*Lithocarpus*	19	*Hamamelidaceae*	14	*Lithocarpus*	23
	Quercus(D)	15	*Quercus(E)*	27	*Pinus*	24	*Castanopsis*	16	*Castanopsis*	12	*Llex*	9	*Quercus(D)*	14
	Quercus(E)	12	*Ericaceae*	7	*Alnus*	15	*Chionanthus*	13	*Alnus*	10	*Araliaceae*	8	*Castanopsis*	11
	Lithocarpus	10			*Lithocarpus*	14	*Pinus*	12	*Tsuga*	7	*Carpinus*	7	*Alnus*	10
	Pinus	6					*Alnus*	10	*Araliaceae*	6	*Lithocarpus*	6	*Chionanthus*	7
									Chionanthus	5	*Alnus*	6	*Quercus(E)*	6
									Hamamelidaceae	5	*Gramineae*	6	*Pinus*	6
											Tsuga	5		
Total		67		63		81		77		65		61		76

Moutain, the pollen assemblages' characteristics in the west sites can be concluded as "larger dominant taxa number with relative lower percentages". The percentages of most taxa are between 5~10% and seldom higher than 10%; however, the characteristics of the east sites can be concluded as "smaller dominant taxa number but higher percentages." The percentages of most taxa in the east are higher than 10%. This suggests that the dominant taxa in the west side are more plentiful than those in the east side, while the dominant taxa of the east florae are more centralized and prominent.

3.2.3. Comparison of percentages and concentrations in different sampling sites

Pollen percentages and concentrations are two indices which are often used to represent the characteristic of pollen and spores assemblages. The pollen percentages in different sites show different change trends. However, the changes

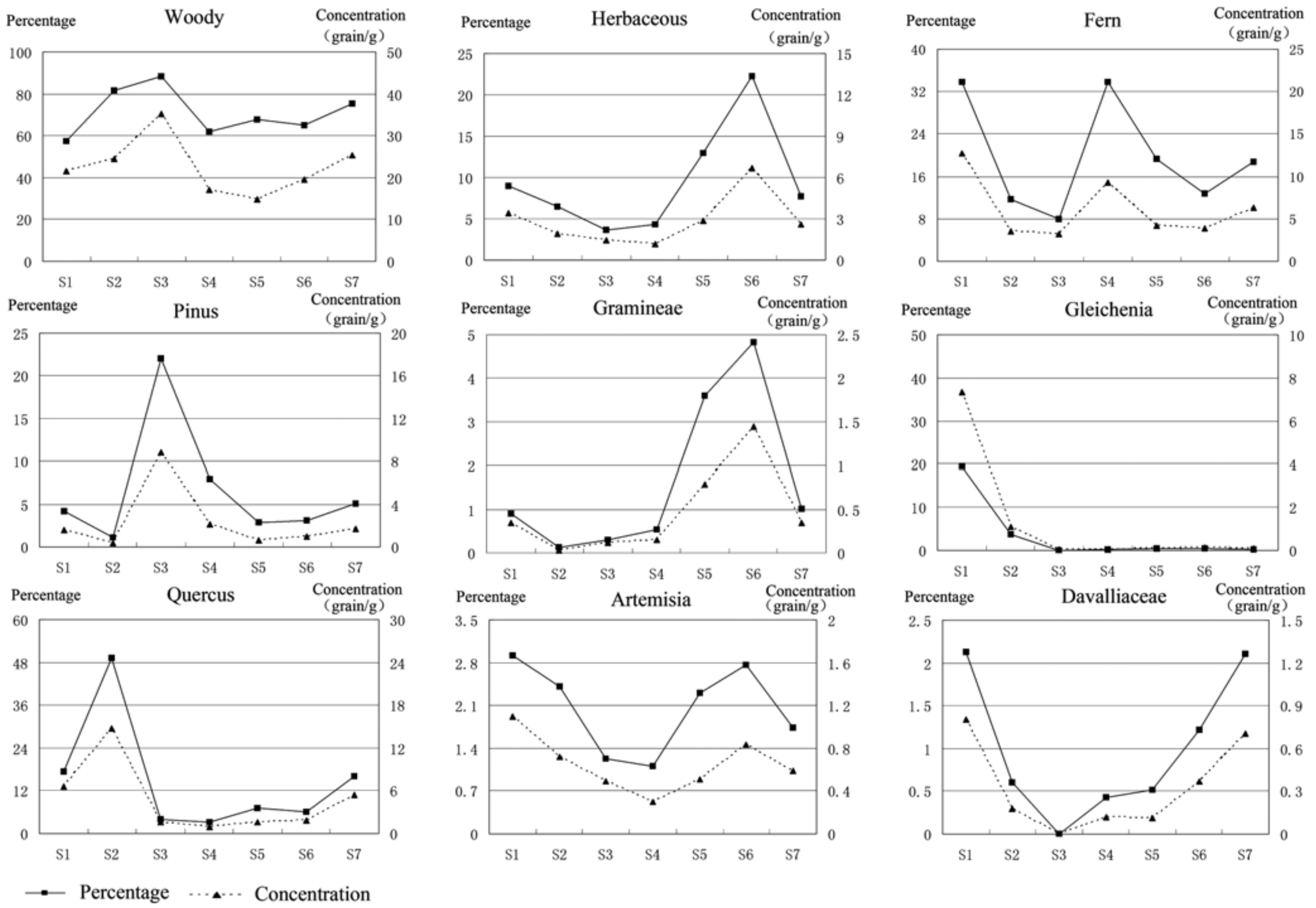

Fig. 3. Comparison between percentages and concentrations of several representative pollen in LRGR.

are not independent and influenced each other. So the pollen percentage changes don't always stand the true changes of vegetation. In order to overcome this deficiency, Davis (1966) gave out the concept of pollen concentration which represents the number of pollen in per unit volume or per unit mass. Here the pollen concentration is calculated by means of exotic pollen and the result is also compared to the pollen percentage (Fig. 3). Comparing the percentages and concentrations between the two sides of Ailao Mountain, we found that there are apparent differences in the 7 sampling sites. The percentages and concentrations of woody pollen in the east side of Ailao Mountain are relative higher than those in the west, such as *Pinus* and *Quercus*. The percentages and concentrations of herbaceous pollen in the east side of Ailao Mountain are relatively lower than those in the west, such as *Artemisia* and *Gramineae*. As for fern, the percentages and concentrations in the west are higher than those in the east, such as *Dicranopteris* and *Davalliaceae*. The surface pollen and spore concentrations show corresponding changing trends with the percentages.

3.2.4 Comparison of native taxa between the east and the west sides of Ailao Mountain

In order to highlight the regional differences of pollen and spore assemblages, the pollen and spore number of the native taxa between the east (S1 to S4) and the west (S5 to S7) sides of Ailao Mountain is shown in Table 4.

Concerning woody pollen, Table 4 shows that *Fagus* pollen were found in the east, which are especially plentiful in S1, but none were found in the west. Contrarily, quite plentiful *Llex* pollen were found in the west side but only two grains were found in the east**,** one in S3 and S4 respectively and none in S1 and S2. A little number of *Moraceae* pollen were found in the east, but *Palmae* pollen were found in the west. When coming to herbaceous taxa, plentiful *Rubiaceae* pollen were found in the west side of Ailao Mountain, with *Euphoribiaceae* and *Chenopodiaceae* pollen, but *Rubiaceae* in the east occurs only in S1. A variety of fern spores, such as *Cyatheaceae*, *Cibotium*, *Lepisorus*, *Pyrrosia* and *Athyrium* were found in the west side but none in the east.

Table 4. Comparison of native taxa between the east and the west sides of Ailao Mountain

Pollen taxa	S1	S2	S3	S4	S5	S6	S7
Fagus	24	/	1	/	/	/	/
Llex	/	/	1	1	8	13	1
Moraceae	/	2	1	/	/	/	/
Palmae	/	/	/	/	1	/	2
Chenopodiaceae	/	/	/	/	1	2	1
Euphoribiaceae	/	/	/	1	/	1	/
Rubiaceae	1	/	/	2	8	1	/
Cyatheaceae	/	/	/	/	/	/	2
Cibotium	/	/	/	/	1	/	1
Lepisorus	/	/	/	/	/	4	/
Pyrrosia	/	/	/	/	/	1	1
Athyrium	/	/	/	/	/	/	2

3.3. Relationship between Pollen Distribution and Environmental Differences

In order to explain the difference of pollen distribution between the east and the west sides of Ailao Mountain, we compared several environmental elements from the east to the west including average temperature of January and July, precipitation of dry and wet seasons, sunshine hours and wind speed at 2 m above ground (Fig. 4). The western side of Ailao Mountain is mainly influenced by the southwest monsoon coming from Indian Ocean. However, the east side of Ailao Mountain is mainly influenced by the southwest monsoon. Meanwhile, the geomorphological terrain is different in the two sides of Ailao Mountain. The east corresponds mainly to flat plateau, but the west does mainly to mountains and rivers. As a result, the climate shows apparent regional difference in LRGR. In dry season, the whole region is controlled by tropical continental air mass. The environmental difference is not very distinct. In rainy season, the LRGR is controlled by tropical ocean air mass. The total precipitation in rainy season occupied the 80~90% of the year precipitation. As LRGR is simultaneously controlled by the southeast monsoon and the southwest monsoon, the 101.5ºE line became the boundary of the east and the west region. The precipitation in the east is lower than that of the west apparently. The 101.5ºE line lies just on the Ailao Mountain area. The other climate elements show also same regional differences. The average temperature of hottest month (July) is mostly higher than 21 ºC in the west area of Ailao Mountain, while it is lower than 21 ºC in the east. The average temperature of coldest month is mostly higher than 11 ºC in the west, while it is lower than 11 ºC mostly in the east. The year sunshine hours in the west area are higher than that of the east too. Consequently, the hydrothermal condition of the west area is much better than that of the east area. As a result, the pollen and spores in the two sides of Ailao Mountain show distinct differences. For comparison of the pollen flora and climatic condition in the west and the east sides of Ailao Mountain, vegetation type in each site was reconstructed by pollen assemblages. The results are: S1 is subtropical coniferous forests, S2 is subtropical evergreen broad-leaved forests, S3 is subtropical cool temperate conifer forests, S4 is montane moist evergreen broad-leaved forests, S5 is conifer and broad-leaved mixed forests, S6 is conifer and broad-leaved mixed forests and S7 is montane moist evergreen broad-leaved forests.

4. DISCUSSION AND CONCLUSIONS

Vegetation is a sensitive indicator of the environment,

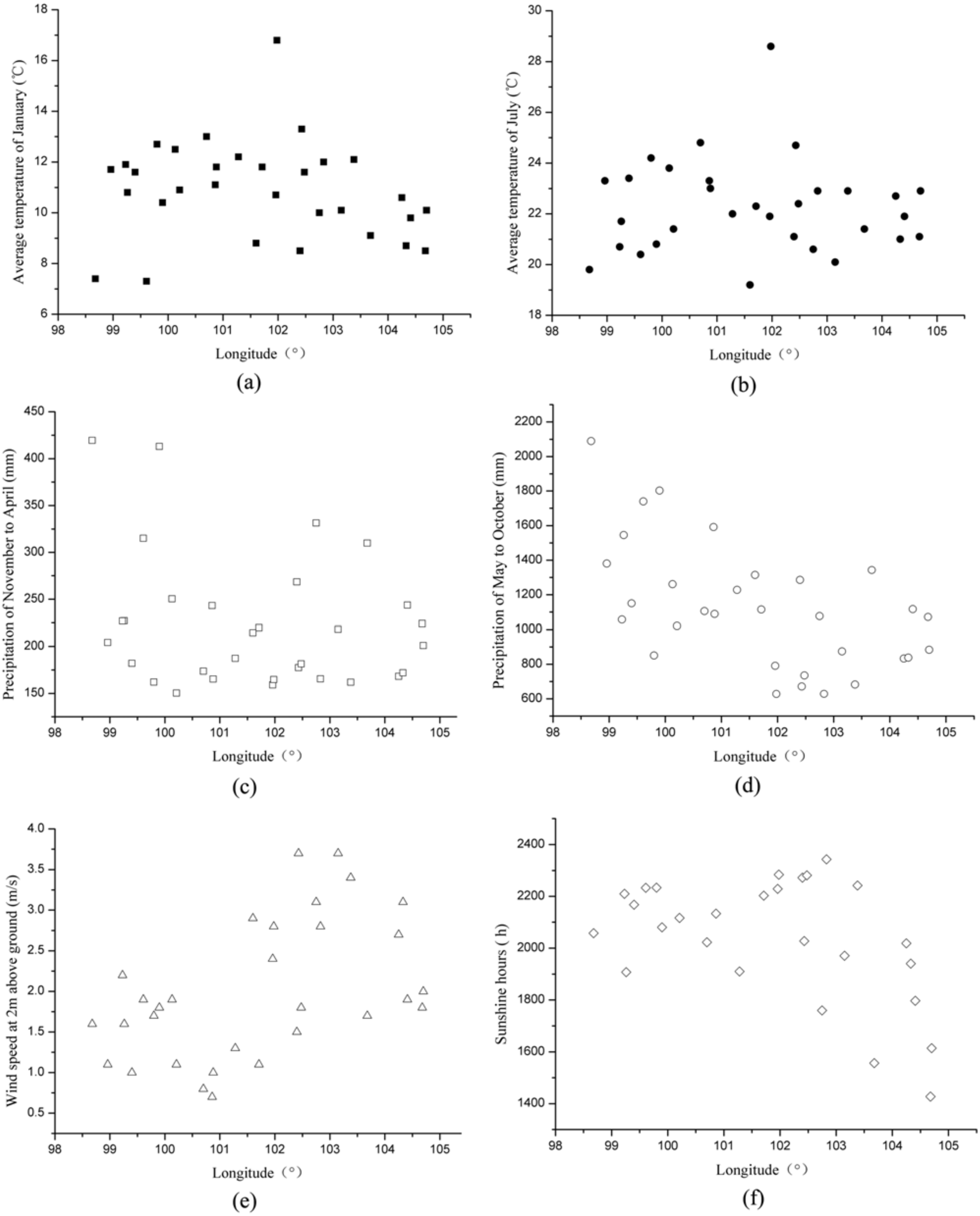

Fig. 4. Spatial pattern of the meteorological elements in LRGR.

which can provide much valuable environmental information. As important proxy data of vegetation information, pollen and spore assemblages reflect the spatial patterns of natural environmental condition. Pollen and spore assemblages in LRGR show apparent horizontal differences between the west and the east sides of Ailao Mountain such as pollen flora diversity, pollen amounts, dominant taxa, pollen percentage and concentration, etc.

Pollen production and exotic pollen are two major factors that influence the *R* value. The added exotic pollen will increase the total amount of pollen grains, reduce the pollen percentage and decrease the *R* value as a result. The *R* value of some families and genera, such as subtropical evergreen broadleaved or deciduous broadleaved trees, are relatively low. The pollen in vegetation belt of lower slope or piedmont may come from the top of mountains by the wind or some else external forces; however, the genera of cool temperate plants on the top of mountains usually have high *R* values due to low amounts of exotic pollen. In addition, the high pollen-productive genera often have high *R* value correspondingly, and they often present over-representative, such as *Artemisia* here. *R* values for the same taxon varies among different samples. It is under-representative when samples are far away from pollen sources. In contrast, it is over-representative when the samples are near sources. For example, the *R* value of *Carpinus* and *Castanopsis* are 0.87 and 1.18, respectively, in monsoon evergreen broad-leaved forests, 0.92 and 1.24 in *Quercus* forests, 0.79 and 0.92 in montane moist broad-leaved forests.

The pollen flora richness in the samples of the west is higher than those in the east. The dominant taxa are more centralized and prominent in the east side of Ailao Mountain, while they are not prominent but more multiple in the west. Both the percentage and concentration of pollen and spores show clear regional differences. The native pollen taxa in the east and the west are different.

Percentages and concentrations of pollen and spores in LRGR show corresponding change trends which means both of them can express the pollen assemblages. The differences of pollen percentages and concentrations are corresponding to the environmental difference.

The spatial distribution of pollen and spores is closely related to the differences of natural environment. The southeast monsoon (or Pacific Monsoon) and the southwest monsoon (or Indian Monsoon) meet in LRGR, which brings different climate systems in the east and the west separately. Ailao Mountain is an important geographical dividing line of the two monsoons. In summer, the LRGR is located in the west of the west-extending subtropical high air pressure and the east of Indian low pressure, prevailing the southwest monsoon. The southwest warm-wet air current derived from the Indian Ocean, brings plentiful precipitation which provides preferable living conditions for the plants in the west. LRGR was in the southwest of the centre of subtropical high air pressure when the centre moves into central China. At this time when LRGR is under control of the southeast monsoon, another moisture source for LRGR's rainy season, which derives in the West Pacific Ocean, brings rich water vapor. On the process of moving on, both of the two airflows were weakened gradually by the barrier function from the series of longitudinal ranged mountains. As a result, the hydrothermal conditions in the west and the east of Ailao Mountain have apparent differences which may cause the pollen spatial differences.

Generally, both the intensity and duration of the southwest monsoon are greater than those of the southeast monsoon. It means that the rainy season duration and rainfall intensity of the west area controlled by the southwest monsoon are longer and greater than those of the east area. Consequently, the diversity in the west is higher than that in the east.

Ailao Mountain is an important climatic and vegetation dividing line in the southwest of China, which has obvious barrier function to the distribution of other geographic elements. By this function, the annual average precipitation, monthly average temperature and annual average solar radiation in the west are all higher than those in the east. In conclusion, by both the southeast monsoon and the southwest monsoon, the hydrothermal environmental condition in the west is superior to the east, which results in the distinct spatial vegetation pattern and the spatial distribution of the pollen and spores assemblages in LRGR.

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