ORIGINAL PAPERS

The climatic regionalization of the distributional region of *Castanopsis hystrix*

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Abstract *Castanopsis hystrix* is one of the important evergreen broad-leaved tree species in south China forest. A climatic distribution zoning of *C. hystrix* was conducted using principal component analysis and cluster analysis based on 1950-2000 climate data worldwide from 22 climatic sample plots of their distribution region. The results showed that there were close correlations between latitude and seasonal temperature, the lowest temperature in the species distribution areas with correlation coefficients of 0.71 and –0.72, respectively. The precipitation of driest month was closely correlated to annual temperature range and the average temperature of the driest quarter with correlation coefficients of 0.72 and –0.71, respectively. Principal component analysis indicated that four climatic factors (precipitation of coldest quarter, mean temperature of warmest quarter, precipitation of warmest quarter and maximum temperature of warmest month) were the most important parameters discriminating variation among the 22 climatic samples. The distributional region of *C. hystrix* could be divided into four climatic regions: south subtropical region, mid-subtropical region, West Asia tropics region and north tropical region, which are differentiated by precipitation and temperature.

Keywords *Castanopsis hystrix* · Climatic region regionalization · Principal component analysis · Cluster analysis

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Introduction

Castanopsis hystrix is a broad-leaved evergreen tree species of Fagaceae family. It is a local precious tree species for timber and many other functions in southern China. The specie mainly distributed in Guangxi Autonomous Region, Guangdong province, Hainan province, and Yunnan province in China (Zhang et al. 2011). *C. hystrix* has the characteristics of fast growth, excellent timber quality, wide adaptation, and high efficiency. The timber is red, straight, hard, and high in corrosion resistance. Its wood could easily be processed without crack or deformation. Due to its high quality, *C. hystrix* is widely used for construction, shipbuilding, furniture, wooden flooring, military supplies, and sports equipment. The seeds of *C. hystrix* are rich in starch, therefore being a source for food, feed, and brewing materials. Its shells are rich in tannins which is raw material of tonic. *C. hystrix* has dense foliage with high shade tolerance, being an ideal companion species mixing with coniferous trees.

The development and utilization of *C. hystrix* began in the late 1970s, and the early study focused on the natural resources inventory, cultivation and nursery technology development (Huang et al. 1998; Lu et al. 1999; Zhu 1993). Since the 90s in the 20th century, series of researches on elite trees selection (Zhu et al. 2002), physiological characterization (Jiang et al. 2013; Lv et al. 2006), wood properties (Jiang et al. 2012; Chen et al. 2012), progeny test based on families (Zhang et al. 2006), provenance test (Zhu et al. 2005; Zhu et al. 1997; Xia et al. 2006) and genetic diversity (Wang et al. 2006; Wang et al. 2009; Xu et al. 2008; Yang et al. 2012) were performed gradually. In the *C. hystrix* distribution area, the terrain and climatic conditions are complex. The water and heat conditions are found to affect the growth and development of *C. hystrix* in the distribution area. Therefore, it is of theoretical and practical significance to study the geo-climate relation with its natural distribution of *C. hystrix*, to understand the variation distribution of *C. hystrix*, zoning its seed sources.

Materials and methods

Castanopsis hystrix resource inventory

To determine *C. hystrix* resources and its distribution area, we conducted an inventory of 14 areas with relatively concentrated distribution of *C. hystrix*. 10 to 30 trees at ages of 15–35 were selected from each species with totally 306 individuals selected (Table 1). Multiple

Table 1 Summary information on the main distribution area, the number of superior trees, growth provenances of *Castanopsis hystrix* resource

Provenance	Sample point	Producing area	Latitude	Longitude	Number of trees	DBH (cm)	H (m)	CBH (m)	CW (m)	H /DBH	CBH /H
Huafeng, Fujian	32	Huafeng, Fujian	25°01′	117°54′	12	108.20	26.00	7.50	30.00	0.24	0.29
Jinshan, Fujian	31-1	Zhangzhou, Fujian	24°93′	117°55′	10	59.00	24.50	11.00	17.20	0.42	0.45
	31-2	Jinshan, Fujian	24°88′	117°47′	9						
Gaozhou, Guangdong	22-1	Gaozhou, Guangdong	21°93′	110°85′	8	39.01	18.05	7.68	11.69	0.43	0.43
	22-2	Gaozhou, Guangdong	22°13′	110°96′	5						
	22-3	Gaozhou, Guangdong	22°02′	110°07′	6						
Luhe, Guangdong	23	Luhe, Guangdong	23°29′	115°66′	35	39.16	21.49	9.41	8.25	0.55	0.44
Shixing, Guangdong	24	Shixing, Guangdong	24°96′	114°08′	17	138.56	25.78	6.00	6.40	0.19	0.23
Xinyi, Guangdong	21	Xinyi, Guangdong	22°47′	110°79′	12	43.04	16.55	4.8	13.5	0.38	0.29
Bobai, Guangxi	12-1	Bobai, Guangxi	22°17′	109°68′	6	33.58	19.43	8.13	6.85	0.58	0.42
	12-2	Bobai, Guangxi	22°16′	109°64′	12						
	12-3	Bobai, Guangxi	21°89′	109°78′	2						
Donglan, Guangxi	17	Donglan, Guangxi	22°85′	108°28′	20	26.50	18.93	5.21	6.70	0.71	0.28
Pubei, Guangxi	11-1	Pubei, Guangxi	22°19′	109°46′	9	27.24	17.50	5.29	6.00	0.64	0.30
	11-2	Pubei, Guangxi	22°54′	109°85′	6						
	11-3	Pubei, Guangxi	22°09′	109°34′	4						
Rongxian, Guangxi	13-1	Rongxian, Guangxi	22°74′	110°77′	10	30.94	17.20	8.00	7.10	0.56	0.47
	13-2	Rongxian, Guangxi	22°65′	110°58′	7						
Changjiang, Hainan	62	Changjiang, Hainan	19°27′	109°05′	15	73.57	22.33	5.04	11.25	0.30	0.23
Jianghua, Hunan	41	Jianghua, Hunan	25°12′	110°92′	22	33.05	16.50	6.5	8.75	0.50	0.39
Jinghong, Yunnan	81	Jinghong, Yunnan	22°25′	101°05′	15	46.60	19.90	8.60	8.30	0.43	0.43
Simao, Yunnan	82	Simao, Yunnan	22°08′	100°96′	12	35.80	16.00	5.61	10.21	0.45	0.35

tree parameters were surveyed including tree height (H), diameter at breast height (DBH), crown width (CW), clear bole height (CBH), height-diameter ratio (H/DBH) and bole height - height ratio (CBH/H).

Meteorological data

Climate data are extracted from the World Climate Database the average of climate information around the world from 1950 to 2000 (Hijmans et al. 2005). A total of 19 climate variables related to temperature and precipitation were selected including mean annual temperature, mean monthly temperature range, isothermality, temperature seasonality, maximum temperature of warmest month, minimum temperature of coldest month, temperature annual range, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality, precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmest quarter, and precipitation of coldest quarter. In addition, 22 meteorological datasets were collected from sampling sites of 14 *C. hystrix* concentrated distribution areas(Table 1).

Data analysis

After calculating the arithmetic mean of the indicators of each origin,the correlation coefficients of growth parameters with corresponding longitude, latitude, altitude and mean annual rainfall in their distribution area are calculated as follows.

$R = \mathrm{COV}(X, Y) / (Q_X \times Q_Y)$

Where COV (X, Y) is the covariance, Q_X and Q_Y are the variance (Huang et al. 2001). The climate variable data of each meteorological sample were extracted using DIVA-GIS software, and the statistical analysis was carried out with R software. The correlation analysis on the meteorological variables, tree growth parameters and environmental factors (longitude, latitude, altitude, annual mean temperature, and annual precipitation) were conducted using “hmisc” R package. The principal component analysis and clustering analysis were carried out, and the clustering analysis was based on the Euclidean distance method.

Results and analysis

Status and correlation analysis of resource growth in *C. hystrix* concentrated distribution area

Based on our inventory of *C. hystrix* in concentrated distribution areas (Table 1), tree growth in Huafeng county in Fujian province and Shixing county in Guangdong province are the highest, with the growth more than 1 m in DBH and 25 m in tree height respectively. Slightly lower than the two counties, the growth of *C. hystrix* in Gaoche county and Jinshan county in Fujian province, and Changjiang in Hainan province are relatively good, with 50–80 cm in DBH and 20 m in tree height. In Gaozhou, Luhe Xinyi, Jinghong and Simao, the growth is medium, with the DBH ranged from 35 to 50 cm and the tree height in the range of 16–21 m. In the other distribution areas, the growth is least (25–35 cm in DBH and 16–20 m in tree height).

The correlation results showed that the ratio of H/DBH and the ratio of CBH/H were positively correlated with the annual mean temperature and annual mean precipitation. A negative correlation with longitude and latitude was found but did not reach a significant level. The H/DBH and the CBH/H were not significantly correlated with the longitude, latitude, mean annual temperature and mean annual precipitation.

Table 2 Correlation analysis of H/DBH, CBH/H and environmental factors of origin

Index	Longitude	Latitude	Mean annual temperature	Annual precipitation
H/DBH	−0.35	−0.23	0.16	0.12
CBH/H	−0.12	−0.11	0.24	0.11

Correlation between different geographical factors and climatic factors in distribution area

The correlation matrix of 21 variables calculated from 22 sampling data (Table 3) suggests that there was a significant positive correlation between latitude and temperature seasonality with the correlation coefficient of 0.71, and the latitude was also negatively correlat-

Table 3 Correlation analysis of different factors in the main distribution areas of *Castanopsis hystrix*

Index	Latitude	Longi-tude	MAT	MMTR	IT	TS	MTWM	MTCM	TAR	MTWEQ	MTDQ	MTWAQ	MTCQ	AP	PWEM	PDM	PS	PWQ	PDQ	PWAQ
Longitude	0.55**																			
MAT	−0.63**	0.06																		
MMTR	0.04	−0.65**	−0.45*																	
IT	−0.44*	−0.76	−0.09	0.85																
TS	0.71**	0.63*	−0.21	−0.50*	−0.87															
MTWAM	0.16	0.51*	0.59**	−0.47*	−0.56**	0.55**														
MTCM	−0.72**	0.08	0.95	−0.51*	−0.05	−0.35	0.40													
TAR	0.86	0.26	−0.6**	0.22	−0.32	0.73**	0.25	−0.79												
MTWEQ	−0.61**	−0.09	0.82	−0.56*	−0.27	0.00	0.46	0.75	−0.49*											
MTDQ	−0.78	−0.21	0.88	−0.14	0.32	−0.63**	0.21	0.91	−0.82	0.65**										
MTWAQ	−0.06	0.54*	0.75	−0.74	−0.67**	0.49*	0.92	0.62**	−0.04	0.69**	0.36									
MTCQ	−0.82	−0.24	0.86	−0.08	0.38	−0.68**	0.17	0.90	−0.84	0.59**	0.99	0.31								
AP	0.39	0.31	−0.20	−0.03	−0.24	0.27	0.03	−0.28	0.31	−0.05	−0.20	0.00	−0.29							
PWEM	0.18	−0.26	−0.34	0.53*	0.37	−0.19	−0.30	−0.39	0.21	−0.29	−0.12	−0.44*	−0.16	0.61**						
PDM	0.68**	0.51*	−0.34	−0.45*	−0.83	0.97	0.38	−0.45*	0.72**	−0.02	−0.71**	0.34	−0.76	0.29	−0.14					
PS	−0.74	−0.85	0.17	0.57**	0.87	−0.88	−0.50	0.22	−0.57**	0.12	0.52*	−0.47*	0.57**	−0.28	0.33	−0.83				
PWEQ	−0.04	−0.44*	−0.22	0.46	0.37	−0.26	−0.38	−0.29	0.05	−0.04	0.00	−0.41	−0.05	0.64	0.86	−0.18	0.45			
PDQ	0.79	0.65**	−0.30	−0.43*	−0.83	0.96	0.47*	−0.41	0.75	−0.08	−0.66**	0.39	−0.72**	0.44*	−0.05	0.95	−0.90	−0.16		
PWAQ	−0.37	−0.54**	0.07	0.12	0.20	−0.26	−0.33	0.02	−0.24	0.39	0.21	−0.19	0.15	0.44*	0.48*	−0.17	0.48*	0.80	−0.21	
PCQ	0.85	0.74	−0.37	−0.38	−0.79	0.93	0.40	−0.47*	0.76	−0.24	−0.70**	0.31	−0.75	0.47*	−0.08	0.90	−0.94	−0.18	0.96	−0.31

Note:MAT: mean annual temperature; MMTR: mean monthly temperature range; IT: isothermality; TS: temperature seasonality; MTWM: maximum temperature of warmest month; MTCM: minimum temperature of coldest month; TAR: temperature annual range; MTWEQ: mean temperature of wettest quarter; MTDQ: mean temperature of driest quarter; MTWAQ: mean temperature of warmest quarter; MTWEQ: mean temperature of wettest quarter; MTDQ: mean temperature of driest quarter; MTWAQ: mean temperature of warmest quarter; MTCQ: mean temperature of coldest quarter; AP: annual precipitation; PWEM: precipitation of wettest month; PDM: precipitation of driest month; PS: precipitation seasonality; PWEQ: precipitation of wettest quarter; PDQ: precipitation of driest quarter; PWAQ: precipitation of warmest quarter; PCQ: Precipitation of coldest quarter.

ed with the minimum temperature of coldest month (–0.72). The precipitation of driest month was significantly correlated with annual temperature range and mean temperature of driest quarter with correlation coefficients of 0.72 and –0.71 respectively. Moreover, annual temperature range was significantly correlated to temperature seasonality with a correlation coefficient of 0.73.

Principal component analysis on *Castanopsis hystrix* main producing areas

The results of the principal component analysis showed that the cumulative contribution rate of the first four principal components (PC1, PC2, PC3 and PC4) is 93%. As shown in Table 4, the coefficient of precipitation of coldest quarter was the highest (0.98) in principal component PC1 and the coefficient sighs of precipitation of coldest quarter, latitude and longitude are same, indicating that the principal component PC1 is the comprehensive factor representing the coldest season precipitation. The coefficient of the mean temperature of warmest quarter in the principal component PC2 is the highest and its sign is different from that of the latitude, indicating that the principal component PC2 is the comprehensive factor representing the mean temperature of warmest quarter. The coefficient of maximum precipitation of warmest month in the principal component PC3 is the highest and its sign is different from that of the longitude and latitude, indicating that the principal component PC3 is the comprehensive factor representing the precipitation of warmest quarter. The coefficient of maximum temperature of warmest month in the principal component PC4 is the highest, indicating that the principal component PC4 is the comprehensive factor representing the maximum temperature of warmest month. The results show that the precipitation of coldest quarter, the mean precipitotion of warmest quarter, the maximum precipitation of warmest quarter and the maximum temperature of warmest month are the main factors affecting the natural distribution of *C. hystrix*.

According to the comprehensive scores of PC1 and PC2, a sort map was drawn for *C. hystrix* 22 samples sites (Fig. 1). Based on the sample density degree, the main natural distribution area of *C. hystrix* could be roughly divided into four regions: Area I mainly includes four counties in Guangxi Autonomous Region(-Pubei, Bobai, Rong and Donglan) and three cities in Guangdong province(Xinyi, Gaozhou and Luhe); Area II mainly includes Huafeng town and Jinshan town in Fujian province, Shixing city in Guangdong province and Jianghua county in Henan province; Area Ⅲ mainly includes Jinghong county and Simao county in Yunnan province; Area Ⅳ mainly includes Changjiang county in Hainan province.

Cluster analysis

The distribution of the sample points in the *C. hystrix* distribution area is more concentrated and has a strong correlation with its geographical position (Fig. 2 and Fig. 3). The distribution could be zoned to four regions based on climates, including the south subtropical climate zone(I), the central subtropical climate zone(Ⅱ), the west subtropical climate zone(Ⅲ) and the tropical zone in the north tropical zone(Ⅳ). Sample density in distribution area that spread in climate zone Ⅲ and climate zone Ⅳ is smaller than that in climate zone Ⅰ and Ⅱ.

Description of climate characteristics of each zone

The core distribution area of *C. hystrix* are mainly located in Guangdong province, Guangxi Autonomous Region, and southern Fujian province. Due to the large area and complex terrain situation, the climate characteristics vary with different zones (Table 5).

South subtropical zone

The climate zone, covering an area between 108°28’—115°66’ E and 21°89’—23°29’ N, consists of the southeastern part of the Guangxi Autonomous Region and the southwest of Guangdong province. The area is abundant in heat with an average annual temperature of 21.72 ℃. The water conditions in this climate zone is abundant, with annual precipitation of 1 595.86 mm.

Central subtropical regions

The climate zone (110°92′—117°55′E and 24°88′—25°12′N) covers the northeastern part of the Guangxi

Table 4 Principle analysis of 21 factors in main distribution area of *Castanopsis hystrix*

	Factors	Principle component				Variance interpretation of correlation
		PC1	PC2	PC3	PC4	
Eigenvector	Latitude	0.88	–0.31	–0.04	0.27	0.95
	Longitude	0.68	0.47	–0.05	0.34	0.80
	MAT	–0.47	0.84	0.19	0.16	0.98
	MMTK	–0.33	–0.81	–0.12	0.29	0.86
	IT	–0.76	–0.56	–0.17	0.22	0.96
	TS	0.94	0.24	0.12	–0.12	0.96
	MTWAM	0.35	0.74	0.14	0.36	0.81
	MTCM	–0.55	0.82	0.07	0.09	0.98
	TAR	0.82	–0.37	0.02	0.15	0.83
	MTWEQ	–0.31	0.73	0.45	–0.31	0.93
	MTDQ	–0.79	0.54	0.17	0.22	0.98
	MTWAQ	0.23	0.92	0.21	0.12	0.95
	MTCQ	–0.83	0.51	0.06	0.22	1.00
	AP	0.35	–0.22	0.78	0.25	0.85
	PWEM	–0.08	–0.64	0.6	0.34	0.89
	PDM	0.92	0.11	0.14	–0.29	0.96
	PS	–0.91	–0.33	0.06	–0.06	0.95
	PWEQ	–0.23	–0.58	0.76	0.05	0.97
	PDQ	0.96	0.13	0.2	–0.04	0.98
	PWAQ	–0.37	–0.24	0.78	–0.38	0.95
	PCQ	0.98	0.07	0.11	0.06	0.98
Eigenvalue		9.45	6.3	2.63	1.16	
IV (%)		0.45	0.3	0.13	0.06	
CRAV (%)		0.45	0.75	0.88	0.93	

Note:MAT: mean annual temperature; MMTR: mean monthly temperature range; IT: isothermality; TS: temperature seasonality; MTWAM: maximum temperature of warmest month; MTCM: minimum temperature of coldest month; TAR: temperature annual range; MTWEQ: mean temperature of wettest quarter; MTDQ: mean temperature of driest quarter; MTWAQ: mean temperature of warmest quarter; MTCQ: mean temperature of coldest quarter; AP: annual precipitation; PWEM: precipitation of wettest month; PDM: precipitation of driest month; PS: precipitation seasonality; PWEQ: precipitation of wettest quarter; PDQ: precipitation of driest quarter; PWAQ: precipitation of warmest quarter; PCQ: precipitation of coldest quarter IV: Interpretation variance; CRAV: contribution rate of accumulated variance.

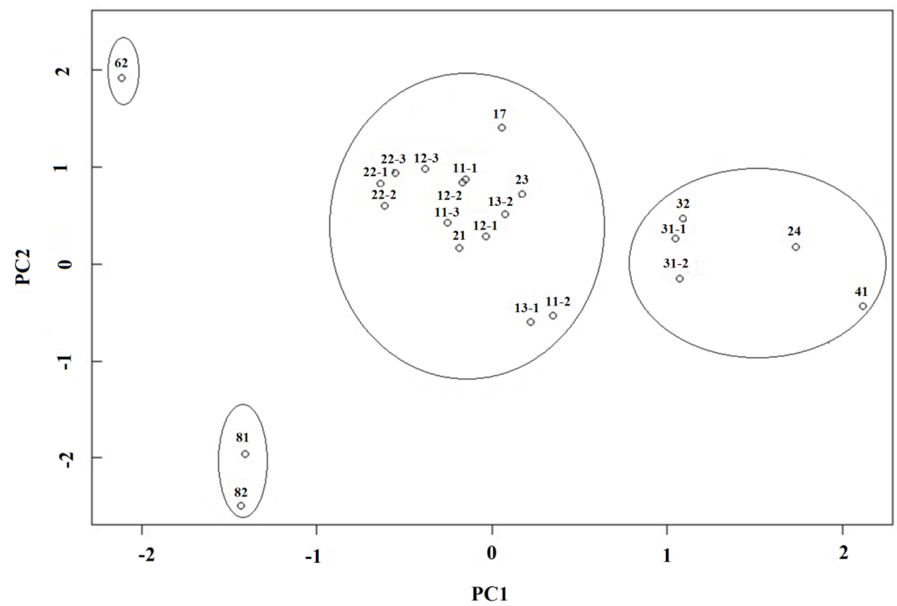

Fig. 1 Diagrams of the first two principal components of different factors in main distribution area of *Castanopsis hystrix*

Note: Number 32 represents the provenance of Huafeng in Fujian province, 31-1 represents the provenances of Zhangzhou in Fujian province, 31-2 represents the provenances of Jinshan in Fujian province, 22-1, 22-2, 22-3 represents the provenances of Gaozhou in Guangdong province, 23 represents the provenances of Luhe in Guangdong province, 24 represents the provenances of Shixing provenance in Guangdong province, 21 represents the provenances of Xinyi in Guangdong province, 12-1, 12-2, 12-3 represents the provenances of Bobai in Guangxi, 17 represents the provenances of Donglan in Guangxi, 11-1, 11-2, 11-3 represents the provenances of Pubei in Guangxi, 13-1, 13-2 represents the provenances of Rongxian in Guangxi, 62 represents the provenances of Changjiagn in Hainan, 41 represents the provenances of Jianghua in Hunan, 81 represents the provenances of Jinghong in Yunnan, 82 represents the provenances of Simao in Yunnan.

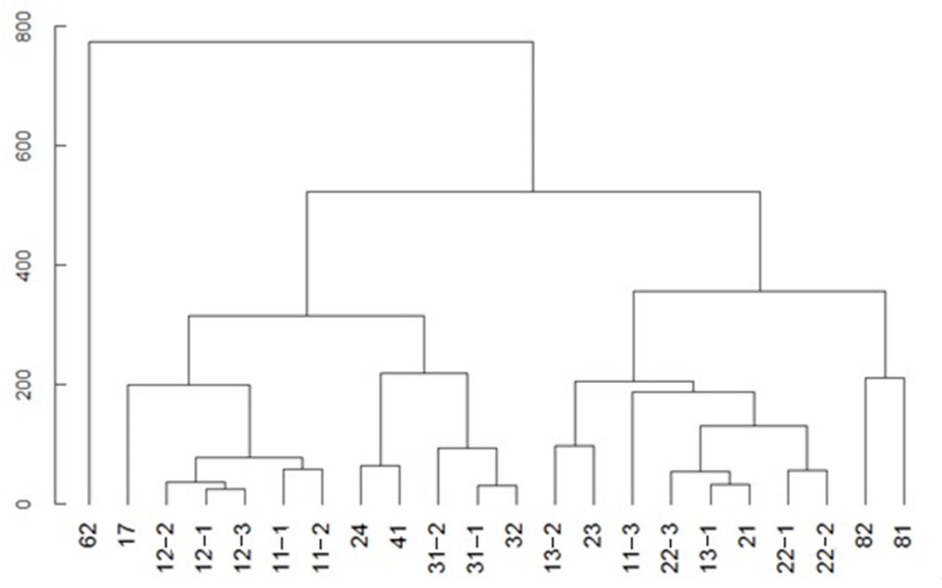

Fig. 2 Clustering of 22 climate sample sites in main distribution area of *Castanopsis hystrix*

Note: Number 32 represents the provenance of Huafeng in Fujian province, 31-1 represents the provenances of Zhangzhou in Fujian province, 31-2 represents the provenances of Jinshan in Fujian province, 22-1, 22-2, 22-3 represents the provenances of Gaozhou in Guangdong province, 23 represents the provenances of Luhe in Guangdong province, 24 represents the provenances of Shixing provenance in Guangdong province, 21 represents the provenances of Xinyi in Guangdong province, 12-1, 12-2, 12-3 represents the provenances of Bobai in Guangxi, 17 represents the provenances of Donglan in Guangxi, 11-1, 11-2, 11-3 represents the provenances of Pubei in Guangxi, 13-1, 13-2 represents the provenances of Rongxian in Guangxi, 62 represents the provenances of Changjiagn in Hainan, 41 represents the provenances of Jianghua in Hunan, 81 represents the provenances of Jinghong in Yunnan, 82 represents the provenances of Simao in Yunnan.

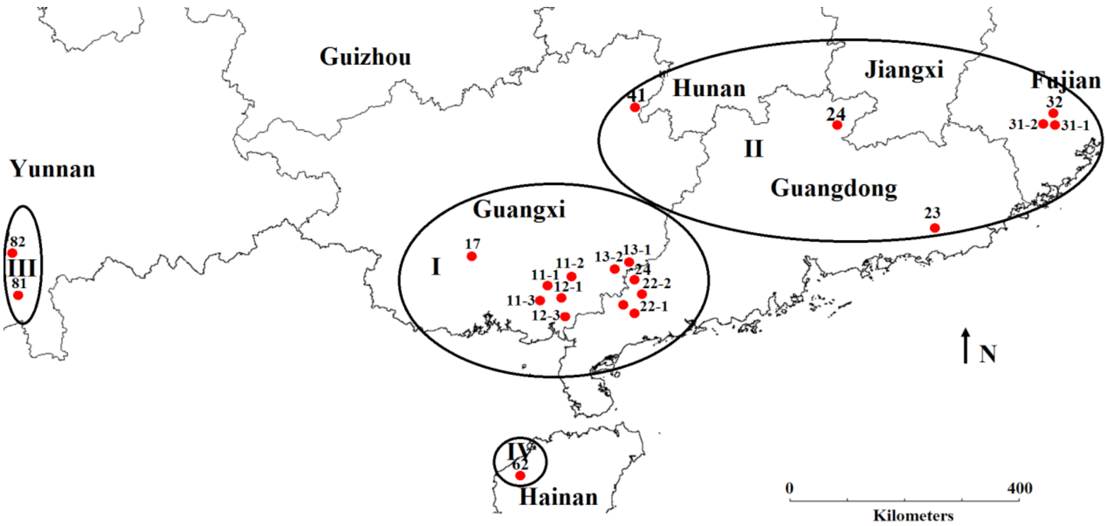

Fig. 3 Four climate zones of *Castanopsis hystrix* distribution area

Note: Number 32 represents the provenance of Huafeng in Fujian province, 31-1 represents the provenances of Zhangzhou in Fujian province, 31-2 represents the provenances of Jinshan in Fujian province, 22-1, 22-2, 22-3 represents the provenances of Gaozhou in Guangdong province, 23 represents the provenances of Luhe in Guangdong province, 24 represents the provenances of Shixing provenance in Guangdong province, 21 represents the provenances of Xinyi in Guangdong province, 12-1, 12-2, 12-3 represents the provenances of Bobai in Guangxi, 17 represents the provenances of Donglan in Guangxi, 11-1, 11-2, 11-3 represents the provenances of Pubei in Guangxi, 13-1, 13-2 represents the provenances of Rongxian in Guangxi, 62 represents the provenances of Changjiagn in Hainan, 41 represents the provenances of Jianghua in Hunan, 81 represents the provenances of Jinghong in Yunnan, 82 represents the provenances of Simao in Yunnan.

Autonomous Region, the northern part of Guangdong province and the southwest of Fujian province. The temperature seasonality of the area is 649.18, the maximum temperature of warmest month is 32.40 ℃, the mean annual temperature is 25.72 ℃, the precipitation of driest month, precipitation of driest quarter and precipitation of coldest quarter are 36.00, 133.20 and 175.20 mm, respectively.

West subtropical region

The climate zone covers southern Yunnan province, with the geographic coordinates of 100°96′—101°05′E and 22°25′—22°80′N. The mean annual temperature and minimum temperature of coldest month are lowest in the four climate zones, which are 19.14 and 5.75 ℃, respectively. The most obvious isothermal is 51.87. The precipitation of wettest month, precipitation of warmest quarter and precipitation seasonality in west subtropical region were the highest among the four climate zones, which are 318.50, 87.58 and 773.00 mm, respectively.

North tropical zone

The climate zone consists of the northwest of Hainan province, with the geographic coordinates of 109°05′ E and 19°27′ N. The mean annual temperature, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter and mean temperature of coldest quarter in north tropical zone were the highest among the four climate zones (24.37,27.78,19.15,28.38 and 19.15 ℃ respectively), but the value of other factors in precipitation are lower than the other three regions.

Conclusion and discussion

There are close linear relationships among different factors in the main producing areas of *C. hystrix*. The latitude is significantly correlated with temperature seasonality (0.71) and minimum temperature of coldest month (–0.72). The precipitation of driest month is significantly correlated with temperature annual range (0.72) and mean temperature of driest quarter (–0.71). The results of climate zoning in the distribution area using principal component analysis and cluster analysis showed that the most important hydrothermal climatic factors are the precipitation of coldest season, mean temperature of warmest quarter, precipitation of warmest quarter and maximum temperature of warmest month. Previous study on the natural distribution and suitable conditions of *C. hystrix* indicate that with the increase of the longitude and the decrease of temperature, the growth rate of *C. hystrix* decreased gradually. However, the influence of the longitude was less than that by the latitude (Qiu et al. 2006).

Principal component analysis is a multivariate statistical method that converts a set of possibly correlated variables into a few independent variables. In this study, only the macroscopic climatic factors were selected for the principal component analysis, and the local microclimatic effects such as topography and altitude are yet to be analyzed. Taking the soil elements, soil types and other factors into consideration to conduct a comprehensive division, the application of this study will have a greater significance for production. To make the clustering results of *C. hystrix* in main distribution area more accurate and reliable, further studies will analyze the tree growth traits, shoot shape and leaf shape variation of different provenances.

In the four climatic regions, the climatic conditions between the climatic zones were significantly different, and the growth of *C. hystrix* varied with different climatic regions. *C. hystrix* is mainly distributed in Guangdong province, Guangxi Autonomous Region, and southern regions of Fujian province, where it has a better performance. In the areas of northern and northwestern climates, *C. hystrix* are mostly scattered and poorly grown. It indicates that the *C. hystrix* adapts to a wide range of climatic conditions but a better growth could only achieve in the climatic conditions closer to its optimum range. This study will provide important foundations for the selection of the elite proven provenances of *C. hystrix* for production industry.

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