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The eco-geographic distribution of wild grape germplasm in China

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Summary

Chinese wild *Vitis* species are mainly distributed in four major eco-geographic regions: (1) The Changbaishan Mountains and Xiaoxing'anling Mountains Region, (2) The Qinling Mountains Region, (3) The Mid-downstream Yangtze River Region and (4) The Guangxi Region. One, eighteen, thirty-two, and thirteen *Vitis* species have been found in these four regions, respectively. The Qinling Montains, the Bashan Montains, and the provinces of Jinagxi, Hubei, Hunan, and Guangxi have high *Vitis* diversity totaling over 30 species, indicating that these regions may be a major center of origin for *Vitis*. The range of distribution varies much among the species: *Vitis pentagona*, *Vitis flexuosa*, *Vitis davidii*, and *Vitis wilsonae* have a wide eco-geographic distribution; *Vitis hancockii*, *Vitis bellula*, and *Vitis sinocinerea* distribute more narrowly. The wild *Vitis* species of China are differentiated and adapted to local climates. We hope that this review familiarizes more researchers with the distribution of the wild grapes of China and will lead to more efficient collection and informed development of this germplasm.

K e y w o r d s : China, grapes, *Vitis species*, wild germplasm, eco-geographic distribution.

The wild Chinese grape germplasm is molded by China's complex terrain of plains, valleys, basins, mountains, loess highlands, lakes, rivers and deserts, forming a diverse eco-geographic range that is home to an unusually high genetic diversity of wild grape germplasm (HE 1999 a and 1999 b; LI 1998; QU and SUN 1990). In general, the land terrain of China rises from the lower east to the higher west. It is classified into three grades from east to west (YANG 1990; WU 1998) as shown in the Figure. The First Grade

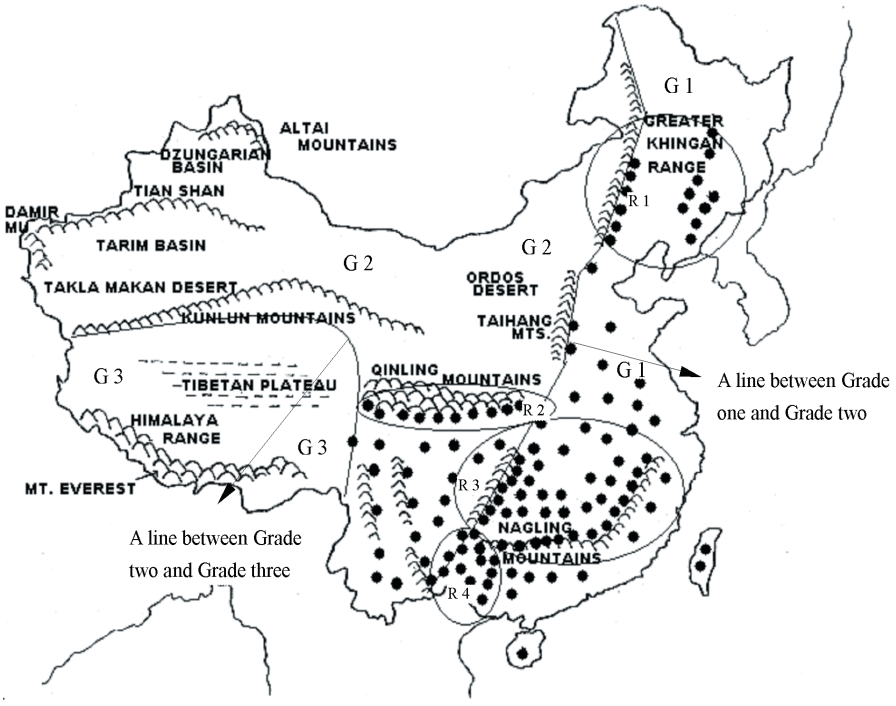

Figure: A map showing wild grapes distributed in China (the original version of this map was downloaded from: http://afe.easia.columbia.edu/china/geog/maps.htm#1b). ●: for sites of Chinese wild grape distribution; G 1, G 2, and G 3: for terrain grades of China, Grade one, Grade two, and Grade three; R 1, R 2, R 3, and R 4: for four major eco-geographic regions of Chinese wild grape distribution in the context, Region one (the Changbaishan Mountains and Xiaoxing'anling Mountains Region), Region two (the Qinling Mountains Region), Region three (the Qinling Mountains Region), and Region four (the Guangxi Region). Circles or ellipses in the map representing the four major eco-geographic regions that Chinese wild grapes are mainly distributed.

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Terrain (Grade one), the "East Plain and Hilly Region", has an elevation less than 450 m above sea level in most areas and receives abundant rainfall predominantly during the summer. The First Grade Terrain includes the Liaosong Plain, the North China Plain, the Mid-down-stream Yangtze River Plain and the Zhujiang River Delta. The Second Grade Terrain (Grade two), "Highland and Mountains Region", has an elevation of 1,000 to 2,000 m above sea level and abundant rainfall in most areas. The Second Grade Terrain contains a complex mixture of plains, mountains, highlands, deserts, and basins. The Third Grade Terrain (Grade three), "the Qing-Tibet Highland", has an elevation more than 4,000 m above sea level and receives little rainfall in most areas because the high elevation prevents the moist air from entering. This grade includes Tibet and partial Qinghai, and Sichuan and contains many huge mountains.

From the late 1970s to the middle 1990s the government of China funded floristic surveys that were carried out regionally by scientists at the provincial research institutes distributed across China's provinces who surveyed the flora in their own provinces. In the 1990s, much data was published in Chinese. Though much research has been focused on the survey of the flora distribution cross the country and the taxonomy on the Chinese *Vitis* species in the last decades, this germplasm is waiting for the large-extent collection, development and use. Unfortunately, much of the native germplasm is being threatened by population pressure, rapid industrialization, city enlargement and cultivar introductions. It is essential to develop and apply policies and technologies conducive to the conservation and use of this germplasm for breeding Because Chinese wild grape species have enormous economic potential for grape breeding and because the Chinese scientific literature is quite inaccessible to western scientists, we summarize the data in the Chinese literature pertaining to wild *Vitis* species in the hope that greater familiarity with the distribution of China's wild grapes will lead to more efficient collection and more informed development of this germplasm.

General distribution of grape germplasm resources in China: The Chinese wild grapes are mainly distributed across four major eco-geographic regions (Figure). (1) The Changbaishan Mountains and Xiaoxing'anling Mountains Region (Region one). This region ranges between 40-48°N and 124-132°E and covers the Xiaoxing'anling Mountains in the provinces of Liaoning, Jilin, and North Heilongjiang in Northeast China and parts of Daxing'anling Mountains in Northeast Inner Mongolia. This region is located in the First Grade Terrain and has abundant rainfall averaging 650-870 mm annually, the soils are rich in organic matter, and the lowest winter temperatures reach -35 to -40 °C (HUANG 1983). The genetically very diverse *V. amurensis* is the only species found in this region but is widely distributed (LI 1998, WANG *et al.* 2000 a, KONG 2004).

(2) The Qinling Mountains Region (Region two). The Qinling Mountains Range is located in the lower Second Grade Terrain and runs through the provinces of Shaanxi (south), Henan (northwest), and Gansu (southeast). It is 600 km from east to west and 200-250 km from south to north. Its elevation ranges from 1,000 m to 2,000 m. This range is the dividing line between the subtropical and the temperate climate zones in China. North Qinling has a temperate climate, with the annual average temperature of 10-13 °C and an annual rainfall of 500 to 700 mm, occurring mostly during the summer and fall. South Qinling belongs to the cool subtropical climate, with the annual average temperature of 11-15 °C and an annual rainfall of 500 to 1,000 mm (HUANG 1983). The areas north to Qinling Mountains are dry and cool and only few wild grapes grow in these areas; the climate in the areas south of the Qinling Mountains is moist and warmer and is home to a rich grape flora (HE *et al.* 1983, WANG 1989, QU and SUN 1990, HAN *et al.* 1995, HE 1999 b, WANG *et al.* 2000 b, KONG 2004). The Qinling Mountains Region is among China's most diverse with respect to wild grapes: 18 species are found there. The most widely distributed species are *Vitis pentagona*, *Vitis piasezkii*, *Vitis romanetii*, followed by *Vitis bryoniaefolia, Vitis flexuosa, Vitis pseudoreticulata*, and *Vitis davidii* with a narrower distribution (LI 1998, HE 1983, HAN *et al.* 1995, KONG 2004). The species *Vitis qinlingensis* P. C. He, *Vitis bashanica* P. C. He, *Vitis xunyangensis* P. C. He, and *Vitis shenxiensis* C. L. Li were found to be uniquely distributed in this region (NIU and HE 1995, KONG 2004).

(3) The Mid-down-stream Yangtze River Region (Region three). This region is situated from 24°N to 34°N and 103°E to 123°E, ranging from the Qinling Mountains in the north to the Nanling Mountains in the south, and from the Wushan Mountains and the Xuefengshan Mountains in the west to the East China Sea. This region is located in the First Grade Terrain and includes the six provinces, Hunan, Jiangxi, Zhejiang, Hubei, Anhui, Jiangsu and a district of Shanghai. This region has a monsoon-dominated subtropical climate, with the annual average temperature of 12-20 °C and the annual rainfall of 1,200 to 2,000 mm. This regions has an extremely high diversity of wild grapes (WEI *et al.* 1991, HAN *et al.* 1995, LI 1998, HE 1999 b, KONG 2004) with approximately 32 species, or 80 % of China's *Vitis* species, being present there. *Vitis pentagona*, *Vitis davidii*, *Vitis pseudoreticulata*, *Vitis adenoclada*, *Vitis hancockii*, *Vitis erythrophylla*, *Vitis bellula*, and *Vitis chunganensis* are the species most widely distributed in this region (HAN *et al.* 1995, HE 1999 b, KONG 2004).

(4) The Guangxi Region (Region four). The high mountains around the province Guangxi form a basin-like topography. West Guangxi is the transition zone from the hilly lower elevations to the Yungui Highland. Guangxi has a subtropical climate with annual average temperatures of 17 to 23 °C and 1,200 to 2,000 mm annual rainfall (HUANG 1983). This region also has high *Vitis* diversity (Wang 1979, He 1999 b, KONG 2004) with thirteen species and four varieties found in this region. Of these species, *Vitis pentagona* and *Vitis adenoclada* are the most abundant, concentrating in counties of Yongfu, Luocheng and Du'an (LI 1998, KONG 2004). *Vitis bryoniaefolia* has the widest distribution in this region. *Vitis luochengensis* and *Vitis piasezkii* Maxim. var. *angustata* are endemic species (WANG 1979, LI 1998).

Discussion and Conclusion

Based on research performed in the past three decades on the eco-geographic distribution of China's *Vitis* species, we now discuss topics that may be useful for the future development and use of this germplasm resource.

Distribution of diversity: China's wild *Vitis* species are found predominantly in the areas of the First Grade Terrain and the lower Second Grade Terrain (Figure). Specifically, the Qinling Mountains, the Bashan Mountains, and the provinces of Jinagxi, Hubei, Hunan, and Guangxi have relatively high diversity with over 30 *Vitis* species found in these areas. This concentration of number of species present has been used to suggest that this region may be one of the major centers of *Vitis* origin (Wei *et al.* 1991, Li 1998, Kong 2004). Decreasing numbers of *Vitis* species are found with increasing distance from this region (Figure), only one or two species present in the three provinces of Northeast China, and Tibet.

Species ranges: The distributional range varies much among China's wild grape species. Some species such as *Vitis pentagona*, *Vitis flexuosa*, *Vitis davidii*, and *Vitis wilsonae* have a wide eco-geographic distribution. Others, such as *Vitis hancockii*, *Vitis bellula*, and *Vitis sinocinerea* distribute narrowly (Li 1998, Kong 2004)

Adaptations: Chinese wild *Vitis* species are likely differentiated and adapted to local climate. Species located mainly in subtropical middle China (Grade one, Region three) have likely a tolerance for high moisture and have little cold-hardiness. *V. adenoclada, V. romanetii, V. wilsonae*, and *V. davidi* are examples of such species. Species with strong moisture and heat tolerance, such as *V. pseudoreticulata*, *V. chunganensis*, *V. balanseana*, and *V. retordii* are mainly found in Southeast China or South China (Grade one, Region three or four). The species *V. piasezkii*, *V. bryoniaefolia* and *V. yeshanensis* have strong winter hardiness as indicated by their distribution in North China. *V. amurensis*, the most cold-hardy species, concentrates in Northeast China (Li 1998, Kong 2004, Han *et al.* 1995). Species are also likely adapted to fungal diseases. Species, such as *V. romanetii, V. pseudoreticulata, V. balanseana, V. adenoclada, and V. davidi* have high resistance to grape diseases epidemic in warm-humid areas, such as powdery mildew and ripe rot.

The distribution of diversity, species ranges and known or likely adaptations to local climates and diseases suggest productive strategies for germplasm development and use. Given that the accumulation and study of the wild Chinese gape germplasm in *ex-situ* collection is in its infancy, it is important to build up the collection to include all species as well as a broad range of diversity within each species so that research on and use of this germplasm can proceed unhindered by the lack of materials. Future collection should probably initially focus the main effort on regions with high species diversity which likely provides the highest return of overall genetic diversity for a given effort. However, it is important to make the additional effort to also sample less hospitable areas that are more sparsely populated by grapes to collect potentially unique genetic diversity and possibly desirable adaptations. The goal should be many accessions that come from throughout a species' geographic and ecological range. The full range of wild *Vitis* distributions in China is probably still unknown, thus new explorations should also include remote, difficult-to-access, or just unexplored areas.

Some species are known to harbor disease resistance, abiotic (such as cold or drought) resistance, good enological traits related to berry quality. Examples are *Vitis davidii* with high disease resistance and tolerance to wet climate, *Vitis pentagona* with fair disease resistance and high quality berries suitable for making wines, *Vitis amurensis* with strong winter hardiness and good wine quality (He 1999 a, b). These species are already used in breeding in China as well as in the west such as in the United States, and Germany (He 1999 a, b). However, the full spectrum of useful traits inherent in China's many wild *Vitis* species has not been explored. Also unknown is the extent of intraspecific variation in known useful traits. The large-scale distributional and ecological information summarized in this paper will be useful not only in designing future germplasm collection but also in guiding both traditional genetic as well as molecular genomics research aimed at elucidating characteristics of economically important traits for the eventual use in developing new and better grape varieties. Such expanded knowledge will likely lead to an increased appreciation of the China's wild grape germplasm and a better understanding which germplasm is most in need of conservation to assure future progress. Progress on all fronts, collection, conservation, research and use of China's wild grape germplasm will be much facilitated by an increase in international collaboration to increase exchange of knowledge and germplasm.

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