Evidence for early viticulture in China: proof of a grapevine (Vitis vinifera L., Vitaceae) in the Yanghai Tombs, Xinjiang

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ABSTRACT

A stem was discovered in the Yanghai Tombs, Turpan District in Xinjiang, China. Anatomical features showed it to be of grape (Vitis vinifera L.). Radiocarbon dating indicates it to be nearly 2300 years old, which would suggest that there was grape cultivation at least from that time. To date, this is the earliest physical evidence of V. vinifera cultivation in China.

1. Introduction

As an important fruit, grape is appreciated by the majority of people throughout the world. The fresh berry is delicious and rich in glucose, which is easily absorbed and is also the most important energy resource of our body. Wine, a fermented product, is a healthy beverage enjoyed by a great number of people. The dried grape, called raisin, may be eaten raw or used in cooking and baking. To date, the estimated 10,000 cultivars of grape in the Old World are thought to have been derived from a single species, Vitis vinifera L. (Vitaceae) (Olmo, 1995a). V. vinifera is the type species of the genus. It is a perennial, woody liane climbing by coiled tendrils. Moreover, it was one of the first soft fruits to be domesticated in the Mediterranean area (Zohary and Hopf, 2000). The domesticated subspecies, V. vinifera ssp. vinifera L. (Syn. V. vinifera ssp. sativa; or V. sativa), which is hermaphroditic, is considered to be derived from its wild ancestor, V. vinifera ssp. sylvestris (C.C. Gmelin) Berger (Syn. V. sylvestris C.C. Gmelin). The latter is dioecious and naturally distributed from the Atlantic coast to Tadzhikistan and the western Himalayas (Zohary and Hopf, 2000) (Fig. 1).

Reflecting its natural distribution, plant remains of V. vinifera were mainly discovered in the Mediterranean areas and the Near East (Rivera Nunez and Walker, 1989). The cultivated grape was transmitted to East Asia fairly recently. According to Shi ji, a book on Chinese history before the 2nd century BC (formerly Han Dynasty), the cultivated grape (V. vinifera ssp. vinifera) was first introduced into China about the late 2nd century BC. General Qian Zhang, who traveled twice to the countries northwest of ancient China during 138 BC and 119 BC respectively, found that viniculture was fairly prosperous in an ancient country named Da wan (Ferghana, today’s Fergana Basin of Uzbekistan). The indigenous people made wine from grape, and then stored and drank it. From then on, grape seeds were transmitted to the capital of ancient China (Chang’an, now Xi’an City) via the famous Silk Road (Laufer, 1919; Liu, 2005). Later, plants of V. vinifera became cultivated and propagated firstly near the imperial palace, and then gradually introduced into other areas of China. So if Shi ji represents a trustworthy record of the history of plants which were transmitted by the envoys of ancient China from Da wan, viticulture should have been introduced into China around 100 BC.

Apart from the literature, scholars have searched for physical evidence of early grape cultivation in China. Grape-shaped designs on the textile (Specimen No. M01:3902) (Fig. 2) were unearthed in...
Room 01 in the Sampula Cemetery of Xinjiang (Fig. 3) (XUARM, 1995, also see the detailed description of the Sampula Cemetery in Jiang et al., 2008). Based on the above evidence, Yang (2003) concluded that: 1) the earliest grape cultivation in China occurred in the western and southern parts of the Tarim Basin; 2) grape cultivation was probably introduced into Xinjiang around the 4th to 3rd century BC. The grape-shaped design in the Sampula Cemetery may have been created by local people, but may also have been transmitted from another culture in the Eurasian Steppe. The plant remains unearthed in the Sampula Cemetery include *Coix lacryma-jobi* var. *lacryma-jobi* L., *Prunus persica* Batsch., *Armeniaca vulgaris* Lam., *Panicum miliaceum* L., *Hordeum vulgare* var. *nudum* Hook. f., *Juglans regia* L., *Elaeagnus* sp., but never a piece of grape seed was discovered (XUARM and XIA, 2001; Jiang et al., 2008). Moreover, radiocarbon dating showed that Room 01 of Tomb No. 1 was 2085 ± 80 calendar years BP (XUARM and XIA, 2001, see also Jiang et al., 2008), which is close to the year of General Zhang’s expedition. Accordingly, the significance of the grape-shaped design in the Sampula Cemetery for tracing the earlier grape cultivation in China is still uncertain.

Turpan lies in the eastern part of Central Asia. Some of the archaeological sites are located in the stony desert, and many plant remains are well preserved due to the dry environment. Starting in 2004, systematic archaeobotanical studies have been undertaken in the Yanghai Tombs. Many plant remains of great significance have been discussed and published elsewhere, such as the *Cannabis sativa* L., *Lithospermum officinale* L., *Capparis spinosa* L., etc. (Jiang et al., 2006, 2007a,b). All the above remains indicated that the ancient, indigenous people of Turpan played important roles in cultural exchange between East and West. In the present study, the ancient grapevine of *V. vinifera* discovered in the Yanghai Tombs sheds new light on tracing early viticulture in ancient Xinjiang, NW China.

### 2. Site description

The Yanghai Tombs are located in the Turpan Basin, Shanshan Country, Turpan District (Fig. 3). They lie at the base of the Flaming Mountains (*Huoyan Shan*), the foothills of the Heavenly Mountains (*Tian Shan*). The Yanghai Tombs were discovered in the early 1970s when the local villagers were repairing the karez. In 2003, more than 500 tombs were excavated by a joint working group of the Xinjiang Institute of Archaeology (XIA) and the Bureau of Cultural Relics of Turpan Prefecture (BCKTP) under the direction of Prof. E.-G. Lü, one of the authors of the present paper. All of the tombs were located on the fringe of the oasis, and were grouped into Nos. 1–3 artificially by the archaeologist based on their different locations (see details in Jiang et al., 2007a).

The Turpan District is characterised by a typical continental desert climate. The average maximum temperature in July is 37.2–39.5 °C, with an extreme annual extreme maximum air temperature of 49.6 °C (during 1975). However, the temperature in the winter can be as low as −28 °C (in 1978). Due to the high mountains around the Turpan Basin, little or no rain falls. The annual precipitation here is only 25.2 mm, but the evaporation rate is as high as 2500 mm. As a result, the climate of the Yanghai Tombs is so dry that many mummies and plant remains were well preserved without decaying.

The people living in the oasis nearby are mainly Uighurs. Some of them practice seasonal transhumance to the meadows of the
Heavenly Mountains, but they mostly lead an agricultural and sedentary life in the oasis. They mainly plant cotton (Gossypium hirsutum L.), grape (V. vinifera L.), broomcorn (Sorghum bicolor (L.) Moench, Meth.), watermelon (Citrus lanatus (Thunb.) Matsumura et Nakai), sweet melon (Cucumis melo L.), as well as Chinese jujube (Ziziphus jujuba Mill.), apricot (Armeniaca vulgaris Lam.), and pomegranate (Punica granatum L.), etc. The natural vegetation tends to be homogeneous across vast areas of the desert. The dominant shrub is camel throne (Alhagi pseudalhagi (Bieb.) Desv.). In the oasis nearby, drought-adapted shrubs and scattered grasses, including Tamarix sp., Calligonum mongolicum Turcz., Capparis spinosa L., Elaeagnus sp., Glycyrrhiza sp., Haloxylon ammodendron (C.A. Meyer) Bunge, Phragmites australis (Cav.) Trin. ex Steud., Lycium ruthenicum Murr., Sophora alopecuroides L., Apocynum venetum L., Kareliniacaspia (Pall.) Less., are to be found.

3. Materials and methods

Room M2069 belonging to Group No. 2 consisted of three layers. The skeleton of a child lay at the bottom. In the middle and upper layers a skeleton of an adult male had been buried. The bodies had been covered by some wood of Populus euphratica Oliv., and some branches, mainly consisted of Salix sp. (lower layer), and then grass, mainly consisted of P. australis (middle layer), and then earth (upper layer). A piece of stem considered to belong to a grapevine was discovered among the sticks (Fig. 4).

3.1. LM (Light Microscope) examination

Part of the stem was trimmed into a segment. It was subsequently boiled for 3 days discontinuously, and then embedded in Polyethylene Glycol at a temperature of 60 °C for two days. Then it was sectioned on a sliding microtome at 15 μm interval. After that, the sections were stained with a 4% solution of safranin. Three types of sections were made: transverse, tangential, and radial. The slides were observed under a Leica DM 2500 microscope, and then photographed with a Nikon COOLPIX 4500 digital camera.

3.2. Dating

The specimen was dated with an accelerator mass spectrometer (AMS) at Peking University, then calibrated using IntCal04 (Reimer et al., 2004) and OxCal v3.10 (Ramsey, 2005).

3.3. Terminology

Plant nomenclature follows the revised English edition of Flora of China. The botanical terms for structural descriptions of the secondary xylem followed the definitions given in the published literature (e.g. Fahn et al., 1986; IAWA, 1989; Schweingruber, 1990; Wheeler and LaPasha, 1994; Sun et al., 2006). Three online databases were also used, i.e. the Inside Wood Database (http://insidewood.lib.

Fig. 3. Map of China, showing location of sites mentioned in text.
which are 73–285 mm in diameter, the vessels can be divided into two types: the large ones, of 2–11 mm, usually more than 4, rarely solitary. Depending on the number of cells in the early wood, and usually combine with smaller ones to produce radial files; the smaller ones, with a tangential diameter of 14–57 mm (Fig. 5a), are mainly to be found in the late wood, although some also occurred in the early wood. These are grouped, into radial files and small clusters (Fig. 6a).

4. Results

4.1. Radiocarbon dating

The Yanghai Tombs belong to the Subeixi Culture, which prospered between 3000 BP and 2000 BP, among the nomadic tribes of ancient Turpan (Jiang et al., 2007b). The AMS date obtained from the wood of the ancient grapevine was 2245 ± 35 14C years BP (about 2300 calendar years ago) (Table 1). The ancient grapevine is now deposited in the Turpan Museum, with the inventory number M2069:5.

4.2. Description

The ancient grapevine is blackish-purple in color, and a little curved. Only part of the bark is still adhering to the wood. The bark is also blackish-purple, and showed no remarkable ornamentation. The stem was approximately 116 cm long, 2.3–2.7 cm wide, and 1.1–1.5 cm thick (Fig. 5a and b). The transverse section is elliptical. One side of the secondary xylem is well developed, while the other side is not.

4.2.1. Transversal section

Six annual rings are recognizable in the transverse section. Growth rings distinct, boundaries undulate. Secondary xylem ring-porous. Vessels elliptical, seldom circular, mostly in radial multiples of 2–11, usually more than 4, rarely solitary. Depending on the diameter, the vessels can be divided into two types: the large ones, which are 73–285 mm in diameter (X = 197 mm, N = 60), mainly occur in the early wood, and usually combine with smaller ones to produce radial files; the smaller ones, with a tangential diameter of 14–57 mm (X = 33 mm, N = 60), are mainly to be found in the late wood, although some also occurred in the early wood. These are grouped, into radial files and small clusters (Fig. 6a).

4.2.2. Radial section

Simple perforation plates in oblique end walls of large vessels (Fig. 6c). Rays heterogeneous, mainly procumbent, some square and upright (Fig. 6d). The height of the square cells similar to the procumbent ones, while height of the upright cells higher than those of procumbent ones (Fig. 6d). Rays perforated (Fig. 7a). Parenchyma cells paratracheal, 7–12 cells high. Inter-vessel pits scalariformly perforated, usually 1 row, but multiple rows in larger vessels. Vessel-ray (Fig. 7c) and vessel-parenchyma pits (Fig. 7d) half-bordered, elliptical in outline. Vessel member length 333–861 μm (X = 678 μm, N = 60).

4.2.3. Tangential section

Multi-seriate rays, 2–16 cells wide. Fibers 463–1278 μm (X = 808 μm, N = 60) long, fairly thick-walled, septate (Fig. 6b), with simple pits in radial and tangential walls. Inter-vascular pit rays scalariformly perforated, in one to multiple rows (Fig. 7b).

4.3. Comparison

According to the revised Flora of China, there are 36 species of Vitis which have a natural distribution in China (Ren and Wen, 2007). By adding another two, namely Vitis jacquemontii Parker from Pakistan (Naimuddin and Qaiser, 1982), and V. vinifera, there are 38 species of Vitis known from Eurasia (excluding Japan). However, most of them, such as Vitis balansana Planch., Vitis chunganensis Hu, and Vitis hancockii Hance, etc., only occur in the subtropical zones where it is hot and humid. Without a long period of domestication, they would be unable to grow outside their natural distribution area (Zohary and Hopf, 2000). These species are unlikely to have been introduced into Turpan, as they not only have no economic value, but also because of ecological and geographical barriers. In the temperate regions of Eurasia, there are another three species: Vitis amurensis Rupr., Vitis flexuosa Thunb., and Vitis bryoniaefolia Bunge (Syn. Vitis thunbergii Sieb. et Zucc. var. adstricta (Hance) Gagnep.). However, the wood structure of V. amurensis is diffuse-porous, while those of V. flexuosa and V. bryoniaefolia are semi ring-porous (http://f030091.ffpri.affrc.go.jp/fmi/xsl/home-E.xsl). The wood structure of our specimen (ring-porous) is different from those of the above 3 species, which are moreover of no value for cultivation. As the ancient grapevine was discovered in Xinjiang, where there is no natural distribution of plants of Vitaceae, the grape must have been introduced into Turpan and then cultivated. Furthermore, the wood structure of our specimen is very similar to that of V. vinifera and unlike those of the other species. Accordingly, we identified our specimen as V. vinifera L. (Vitaceae).

5. Discussion

To date, few grapevines have been unearthed, the seeds (pips) being the main remains found in archaeological sites. However, the stem remain of V. vinifera is more significant than the seeds (Miller, 2008). Although the fresh and juicy grape cannot be carried for long distances, the seed remains may originate from imported raisins (Williams, 1977; van Zeist, 2003). However, the existence of a piece of grapevine wood “represents the parent plant” (McGovern, 2003).
One example discovered in the Jordan Valley was taken as evidence of grape cultivation in that area (Zohary and Spiegal-Roy, 1975), as it lies beyond the natural distribution of the wild grape (*V. vinifera* ssp. *sylvestris*). Charred grapevine wood remain of *V. vinifera* was also reported in an early second millennium BC site of Nosiri in western Georgia (McGovern, 2003). Although no wood anatomical illustrations were shown in his report, these specimens are unlikely to have been wrongly identified as there is only one species, *V. vinifera*, occurring naturally in that area. Wood of *V. vinifera* was also reported from the Neolithic II period (1700–1000 BC) at Burzahom in Kashmir (Lone et al., 1993). However, both the transverse section (TS) and tangential section (TLS) are atypical. For example, the ray cells in the tangential section are in 2–4 cells wide instead of multiples. Moreover, the vessels in the transverse section are diffuse-porous instead of ring-porous. A re-examination of this specimen is therefore necessary. In this present study, we made a detailed examination of the wood structure of the ancient grapevine, which enabled us to identify it more precisely. In this way we are in a position to trace its palaeoethnobotanical significance in Turpan 2300 years ago.

*Vitis* originated in three centres: East Asia, Europe, and North America. As one of the three gene centres, China is rich in *Vitis*. Plants of *Vitis* were already recognized by the ancient Chinese. Two types of *Vitis*, *V. flexuosa* and *Vitis* sp. (?), were mentioned in the classical book named *Shi jing* (*Poem*) (Ho, 1969), which was written nearly 500 BC. In the archaeological site of Jiahu, located in Henan Province, it was considered that the relics of the tartaric acid/tartrate on the wall of an earthenware pot, which contained the earliest (nearly 7000 BC) wine of the world, may partly come from the berries of the indigenous wild type of *Vitis* sp. (McGovern et al., 2004), as seeds of *Vitis* were unearthed together with seeds of Chinese hawthorn (*Crataegus pinnatifida* Bge.) (Mr. Chang-Jiang Liu, Pers. Comm., 2006). Seeds of *V. bryoniaefolia* were unearthed in the archaeological sites located in the middle part of the Yangtze River, such as the Bashidang Site (8000 BP) (HPIACR, 2006) and the Chengtoushan Site (6500–6000 BP) (Liu and Gu, 2007). There were also seeds of *Vitis* sp. uncovered in the Zhuangqiaofen, Bianjiashan, Jianshanwan Sites (5000–4000 BP), and the Qianshanyang Site (3900–3500 BP) of the lower part of the Yangtze River (Zheng and You, 2006) (Fig. 3 and Table 2). All these cases indicate that fruits of

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**Fig. 6.** (a) Transverse section showing the ring-porous vessels and their two classes. Scale bar = 500 μm. (b) Tangential section showing the multi-seriate rays and the septate fibers. Scale bar = 200 μm. (c) Radial section displaying vessel with simple perforation. Scale bar = 40 μm. (d) Radial section displaying the heterogeneous and usually procumbent rays. Scale bar = 75 μm.
Vitis must have been known and consumed by the ancient Chinese. However, all these wild species have fairy small, astringent, and acid-tasting berries, which were an obstacle to domestication and mass cultivation. At present, only plants of *V. amurensis* have been tentatively exploited. The plant is selected as a stock for its cold resistance. Moreover, its fruit is rich in pigment, and is thus selected for wine production. However, it is poor eating, and has never been cultivated on a large scale. The coming of the *V. vinifera* from the western countries enriched not only the plant resources of East Asia, but also revitalized the life style of the ancient people in Turpan.

*V. vinifera* is very productive and produces juicy fruits of good quality. It can survive in hostile conditions such as an arid environment, and can adapt to different types of soil (Mayerson, 1959). However, it is susceptible to cold. Grape prefers sunny conditions, and suffers from long-term humidity, which encourages different types of fungal disease. The weather should be warm and dry while the grape is developing, as in the Mediterranean regions. In Turpan, the annual accumulation of heat (>10 °C) can be as high as 4874–5513 °C, while sun shines for a total of 2926–3032 h, thereby ensuring the growth and development of the plants, especially the flowers and the fruits (Anon., 2004). Moreover, the karez network

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**Table 2**

<table>
<thead>
<tr>
<th>Period</th>
<th>Site</th>
<th>Type</th>
<th>Preserved condition</th>
<th>Species</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
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<td>8000 BP</td>
<td>Bashidang</td>
<td>Seeds</td>
<td>Charred</td>
<td><em>V. bryoniaefolia</em></td>
<td>HPSACE (2006)</td>
</tr>
<tr>
<td>300 BC</td>
<td>Yanghai Tombs</td>
<td>Wood</td>
<td>Desiccated</td>
<td><em>V. vinifera</em></td>
<td>This paper</td>
</tr>
<tr>
<td>0 AD</td>
<td>Sampula Cemetery</td>
<td>Grape-shaped designs</td>
<td>On the textile</td>
<td><em>V. vinifera (?)</em></td>
<td>XUARM (1995)</td>
</tr>
</tbody>
</table>

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Fig. 7. (a) Radial section displaying a perforated ray cell. Scale bar = 30 μm. (b) Tangential section showing scalariformly perforated inter-vessel ray pits. Scale bar = 70 μm. (c) Radial section displaying the partly bordered vessel-ray pits, which are elliptical in outline. Scale bar = 75 μm. (d) Radial section showing the vessel-parenchyma pits also half-bordered and elliptical in outline. Scale bar = 50 μm.
ensures a rich supply of water when necessary. During maturation, there is little or even no rainfall. As a result, Turpan became an unparalleled area for grape cultivation in China. Today, Turpan is still the prime grape producing area in China (Wang, 1991). Consequently, it is by no means strange that Turpan became the first place where the European grape (V. vinifera) was successfully grown.

Compared with agriculture, horticulture needs special techniques. The grape requires support and should be pruned occasionally to keep it in shape and to promote fruiting (Olmo, 1995b; Renfrew, 1995; Zohary and Hopf, 2000). Moreover, as the climate in Turpan is so dry, this precious grapevine was probably grown in an irrigated garden. This would suggest that the ancient horticulturist led a sedentary life instead of being a hunter-gatherer. Based on the annual rings, the grape was 6 years in age before it was cut, which means that it was allowed to grow in Turpan for this period of time. The grape usually produces fruits in the 3rd or 4th year, which indicates that the ancient horticulturist enjoyed the exotic but delicious fruits for at least 2 or 3 years. However, in winter the temperature in Turpan can be as low as −28 °C, which is quite different from that of the Mediterranean regions. As the grape has only limited winter hardiness, its stem would have to be protected against frost damage. In today's Turpan, the whole grape plant is usually grown in a trench and covered by soil during the dormant winter season. Presumably the ancient grapevine was also carefully protected by the brilliant and observant horticulturist, possibly the tomb owner, who would have been well-acquainted with the technique of grape cultivation. However, as no physical evidence of grape reman was found in other tombs of the same age, it is reasonable to suppose that the ancient grape was just for private consumption rather than mass cultivation, and the grape would be considered a luxury fruit by the ancient Yanghai people, even the wealthier classes.

6. Conclusion

By the studying of the ancient grapevine, we have gained new insight into the viticulture in China. Based on the physical evidence, we have been able to confirm one of the conclusions drawn by Yang (2003), namely that the cultivated grape (V. vinifera) was introduced into Xinjiang around 300 BC. On the other hand, we would also argue that the earliest grape cultivation in China was not in the western and southern part of the Tarim Basin, but in the Turpan Basin, based on the evidence to date. The high mountains and the extensive desert by no means prevented the cultural exchange between the different localities. As an important city on the Silk Road, Turpan played a key role in the cultural exchange between East and West.

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