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New archaeobotanical evidence for *Medicago* from the Astana Cemetery in Turpan, Xinjiang

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Abstract

The study of crop dispersal and their cultivation technique communication can provide a valuable insight into the history of cultural exchange in ancient Eurasia. Previous studies have focused predominantly on the cereals, with few being carried out on fruit, vegetable and forage crops. This paper reports on legume remains found at three tombs of the Astana Cemetery, Turpan, Xinjiang, which dated to the Jin and Tang dynasties (about third to ninth centuries). The exceptional state of preservation of the desiccated remains allowed their unambiguous determination to species level. By comparing the morphological characteristics of the *Medicago* remains with published references, they were ascribed to *Medicago sativa* and *Medicago lupulina*. This is the first archaeobotanical evidence of *M. lupulina* in China and the earliest relevant physical material so far found. In addition, combined with the record of unearthed documents, our study shed new light on the early history of *M. sativa* cultivation and use in Turpan and further underlined its important role in cultural exchange between the West and the East in antiquity.

Keywords: *Medicago*, Forage, Animal husbandry, Astana Cemetery, Turpan

Introduction

In recent years, the process and impact of crop dispersal in Eurasia have been of increasing concern. Research has demonstrated that a great number of economic plants, mainly starchy staples diffused across Eurasia between about 7000 and 4000 years ago [1, 2]. Notably, wheat and barley originating in southwest Asia expanded to East Asia during those millennia, and millets from China spread towards Europe simultaneously [3–5]. The second episode of extensive crop trans-Eurasian exchange was the foundation of the Silk Road. Different from the previous one happened in prehistory, primarily fruits, vegetables and forage crops, including grape, pomegranate, garlic, coriander, cucumber, sesame and alfalfa, etc., were transmitted through this cultural exchange channel during the historical time [6, 7]. In despite of that the emergence of the Silk Road was initiated in Han dynasty (202 BC–AD 220) and there have been some relevant sporadic records in the textual resources, the exact temporal-spatial dissemination processes of these plants into East Asia are still little known. The reason under this phenomenon is mainly due to the lack of excavated physical evidence.

It is well established that alfalfa, which originated from Southwest Asia [8], was introduced into China owing to the opening up of Silk Road. According to *Shiji* (Historical Records, written in 104–91 BC) and *Han Shu* (History Book of the Han dynasty, written around AD first century), alfalfa was introduced into China after General Zhang Qian's two travels to the countries of the Western Regions (today's Central Asia and Xinjiang) [9, 10]. Since then, alfalfa has been regularly recorded in numerous Chinese material medica and agronomic books, such as *Bencao Yanyi* (Augmented Materia Medica, AD 1116), *Nongsang Jiyao* (The Collation and Annotation of

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the Summary of Ancient Farming and Sericulture, AD 1273), *Jiuhuang Bencao* (Materia Medica for Famines, AD 1406), *Bencao Gangmu* (Compendium of Materia Medica, AD 1578), and so on [11–14]. However, most of these historical literatures focused on the time span after the Tang dynasty (AD 618–907), and the early history of alfalfa cultivation and use in China was seldom recorded. In addition, due to the limits of preservation and use pattern, rare archaeobotanical findings of alfalfa have been reported, except for the Xuanquanzhi site in Dunhuang of Gansu, and Zagunluk (Zhagunluke) cemetery in Xinjiang [15, 16]. More tangible evidence and written records would be needed to improve our understanding of ancient alfalfa use. Recent systematic archaeobotanical study in Astana Cemetery provides such a good opportunity.

The Astana Cemetery is located in the Turpan Basin of Xinjiang (Fig. 1), which is considered as the driest place in China and a communication center on the ancient Silk Road. During the Jin and Tang dynasties, the cemetery continuously served as the public graveyard for local inhabitants. To date, more than 500 tombs and 10,000 artifacts have been excavated from the Astana Cemetery by the archaeological organizations of Xinjiang. Owing to the extremely arid climate condition, abundant organic funerary objects, including wooden wares, textiles, mummies, paper documents, plant and food remains are well preserved [17]. Notably, a few archaeobotanical remains of *Medicago* were discovered in three tombs of the Astana Cemetery. Here we aim to investigate the introduction of *Medicago sativa* and *Medicago lupulina* into Turpan and the early history of their cultivation and use in Xinjiang. In addition, combined with the unearthed documents, we can attempt to define the economic status of *Medicago sativa* in Turpan during the Jin and Tang dynasties.

Materials and methods

The *Medicago* samples were extracted from tombs 2004TAM409, 73TAM214 and 73TAM519 manually, and labeled as No. 1, 2, 3, 4 respectively. Key information and references for these three tombs are presented in Table 1. After excavated, the *Medicago* samples were stored in the Xinjiang Uyghur Autonomous Region Museum. All the samples were measured using a vernier caliper, and then observed and identified under a Nikon SMZ 1000 stereomicroscope with a built-in digital camera.

Botanical nomenclature for *Medicago* was based on the revised English version of *Flora of China* (http://www.efloras.org/flora_page.aspx?flora_id=2). Taxonomic identification relied on the description provided in the previous publications [18, 19].

Results

All the samples were preserved so well by desiccation that they could be identified into species level. The legume of sample 1 and 4 is brown and in a spiral shape, which is tightly coiled three times. They are

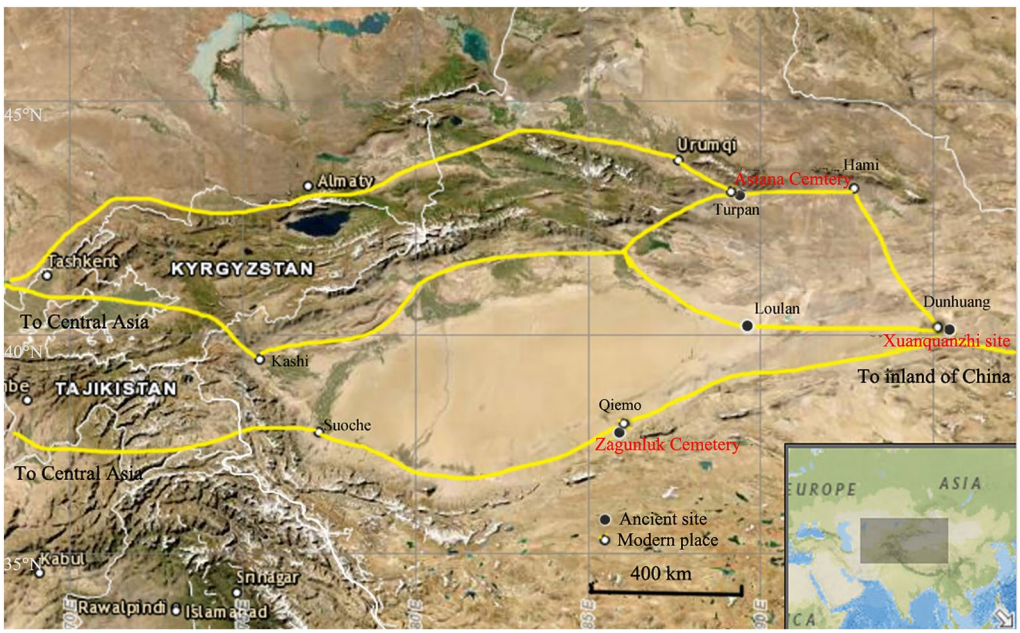

Fig. 1 Locations of the Astana Cemetery, Zagunluk Cemetery and Xuanquanzhi Site. The yellow lines show the main routes of the ancient Silk Road. The base map was from https://www.ncei.noaa.gov/maps/bathymetry/

Table 1 Detailed information of the four *Medicago* samples

Sample code	Plant species	Plant organ and quantity	Tomb number	Location	Age	Origin of age	References
1	*Medicago sativa*	Six broken pods	2004TAM409:10	A pottery basin	AD 304–439	Structure of the tomb and characteristic of the unearthed cultural relics	[20]
2	*Medicago lupulina*	Two pods	73TAM214:75	Unclear	AD 665	Unearthed epitaph with a dating text of AD 665	[21, 22]
3	*Medicago lupulina*	Three pods	73TAM214:143	Unclear	AD 665	Unearthed epitaph with a dating text of AD 665	[21, 22]
4	*Medicago sativa*	Numerous chopped stems and leaves as well as intact pods	73TAM519:10	A pillow	AD 642	Unearthed epitaph with a dating text of AD 642	[21, 23]

4.8–7.7 mm in diameter, with thin and inconspicuous veins on the surface (Fig. 2d, f). The seed is yellowish-brown and reniform in shape (Fig. 2e). Compared with the referees (Fig. 2a, b), sample 1 and 4 are consistent with the morphological characteristics of *Medicago sativa*. The sample 2 and 3 are reniform-shaped on the whole and dark brown in color, with distinct concentric and arcuate veins (Fig. 2c). The dimension of them is 2.7–3.0 mm in length and 2.0–2.2 mm in width. The sample 2 and 3 were identified as belonging to *Medicago lupulina* [18].

Discussion

The timing of alfalfa being introduced into Turpan

As noted before, according to *Shiji* and *Han Shu*, alfalfa and grape were introduced into China from the *Dayuan* state after Zhang Qian's two diplomatic missions to the Western Regions (139 BC and 119BC). Examining these records in more detail, we can found that these two plants were actually firstly cultivated in the vicinity of imperial palace, which situated in Chang'an (today's Xian city; [9, 10]). Based solely on the record of textual sources, we still know little about the early history of alfalfa cultivation in other places of China. Turpan is located in Xinjiang, which belonged to the geographical range of the Western Regions and was near Central Asia. An ancient grapevine

Fig. 2 Photographs of alfalfa remains recovered from the Astana Cemetery and modern samples. **a** Pods of the *Medicago sativa* from modern sample; **b** Seeds of the *Medicago sativa* from modern sample; **c** Pods of the *Medicago lupulina* from sample 2; **d**, **f** Pods of the *Medicago sativa* from sample 4; **e** Seeds of the *Medicago sativa* from sample 4. Scale bar = 2 mm

was discovered in the Yanghai Cemetery, which demonstrated that cultivated grape was introduced into Turpan as early as 300 BC and before the travels of Zhang Qian [24]. How about the spread timing of alfalfa into Turpan? Since 2004, systematical archaeobotanical studies have been applied on the archaeological sites of Subeixi culture (1200 BC–AD 100), including Yanghai Cemetery, Shengjindian Cemetery, Jiayi Cemetery and Yuergou Site. Large quantities of plant remains of economic and cultural significance have been identified, such as *Vitis vinifera*, *Cannabis sativa*, *Artemisia annua*, *Capparis spinosa*, *Xanthium strumarium, Lithospermum officinale* and various cereal crops [24–33]. However, no archaeobotanical remains of alfalfa have been discovered to date. Previous studies indicated that the indigenous people of Turpan mainly subsisted on animal husbandry, with agriculture and hunting supplemented, during the period of Subeixi culture [34, 35]. Consequently, forage plant should naturally play a vital role in the daily life of Subeixi people and it is reasonable to assume that if alfalfa had been introduced into Turpan during this time span, there would be some archaeobotanical finds of it in those archaeological sites. In these connections, we deemed that alfalfa was probably brought in Turpan after the opening up of the Silk Road. To clarify this issue clearly, more archaeobotanical studies should be conducted on the archaeological excavation in Turpan.

With reference to the *Flora of China*, there are 13 species of *Medicago* in China currently, including *Medicago sativa*, *Medicago polymorpha*, *Medicago lupulina*, *Medicago falcate*, and so on. In the Zagunluk cemetery, only remains of *M. sativa* were discovered [16]. As the *Medicago* remains of Xuanquanzhi site of Han dynasty, a military site near Dunhuang of Gansu Province, have never been scientifically identified, their source of species is unclear [15]. Thus, this present work represents the earliest and sole archaeobotanical finding of *M. lupulina* in China to date. Although there are quite a few historical literatures recording *Medicago* plant, the overwhelming majority of them didn't name specific species and more likely referred to *M. sativa*, which is the most important species of *Medicago*. To the Ming and Qing dynasties (AD 1368–1912), several ancient texts, such as *Jiuhuang Bencao*, *Bencao Gangmu*, *Zhiwu Mingshi Tukao* (An Illustrated Book of Plants, AD 1841–1846), briefly depicted the morphological characteristics of some taxa of *Medicago* [12, 13, 36]. However, these records have raised great controversy up to now. For example, Laufer noted that the two kinds of wild species of *Medicago* recorded in the *Zhiwu Mingshi Tukao* were *M. lupulina* and *M. falcate* [7], while Sun et al. considered them as *M. polymorph* and *M. falcate* [37]. Based on the written resources, the history of other species of *Medicago*, except for *M. sativa*, can be only traced back to the Ming and Qing dynasties. Our study demonstrated that *M. sativa* has been introduced into Turpan during the Jin and Tang dynasties.

The early cultivation and use of alfalfa in Turpan

According to historical sources, alfalfa has been used in many aspects by ancient Chinese from early on. Its tender leaves were used as vegetable and selected for making soup. The seeds of alfalfa were sometimes served as cereal. In addition, different parts of alfalfa have pharmaceutical values and it was utilized as an important traditional Chinese medicine [38, 39]. As in other areas, the most important utilization of alfalfa was used as fodder for ancient Turpan people. The remains of *M. sativa* (Sample 1) were uncovered with large amounts of cereal fruits, such as broomcorn millet, foxtail millet, wheat, hulled barley and naked barley. Some Kharosthi documents (The documents were written in the Kharosthi script, which was a writing system originally developed in today's Pakistan and Afghanistan) unearthed from the Niya site (first century BC to fourth century AD) recorded that purple flowered alfalfa (*M. sativa*) was an important fodder in the *Jingjue* state and it was sometimes mixed with cereal crops to feed livestock [40, 41]. The combination of coarse and fine feed could provide more comprehensive and balanced nutrition for livestock and reduced the consumption of cereal crops. This feeding method could also be used by the Turpan people. On the other hand, considering that the remains of sample 1, 2, 3 were small in number, we couldn't rule out the possibility of unintentional introduction. As to sample 4, they were found inside of a pillow, which indicated that *M. sativa* were not only used as forage but also pillow filler in ancient Turpan. In addition, previous studies demonstrated that wheat and naked barley straw were the most common materials for making pillow filler in the Astana Cemetery [42]. It seems likely that the indigenous people preferred to use the by-products of agriculture and animal husbandry as pillow filler, which were cheap and easy to get.

After the opening up of Silk Road, Turpan was established as an important *tuntian* (state-organized farming system) settlement and military garrison for the Han dynasty to control the Western Regions [43]. With large numbers of Han people migrated to Turpan, various advanced agricultural techniques and tools spread there and significantly improved local agricultural production [44, 45]. The available evidence indicated that the subsistence strategy of Turpan people had turned into a largely agricultural economy by the Jin and Tang dynasties [42]. Nevertheless, due to the special geographical location and environmental condition, many

aspects of Turpan society was influenced by the surrounding nomads and animal husbandry still occupied a certain position in the local economy. According to *Liangshu*, Turpan was famous for producing fine horse during the period of Gaochang kingdom (AD 460–640; [46]). In addition, unearthed animal figurines and remains as well as relevant records of paper documents from the Astana Cemetery demonstrated that cattle, sheep, pig, donkey and camel were also raised in Turpan at that time [17, 47, 48]. It seems that besides cereal crops, alfalfa was the most important fodder for livestock. An unearthed document dating to the Northern Liang dynasty (AD 397–439) recorded that the children in school were asked to harvest alfalfa, suggesting that alfalfa played an important role in the daily life of local inhabitants [44]. In addition, a document of tax account unearthed from Turpan detailed the items levied from common people of *Kanshi* Gaochang kingdom (AD 460–488), including firewood, grape, wine, alfalfa and so on [49]. These articles were provided to the king of *Yanqi* state (today's Yanqi county of Xinjiang) and his attendants, who were on their way to the imperial court of *Rouran* (the nomadic people who inhabited the Mongolian Steppe during the fourth to sixth centuries; [50]). As a crucial transit point on the Silk Road, numerous merchants, emissaries and travelers would passed by Turpan every year and needed various supplies, especially food and fodder.

By the Tang dynasty (AD 618–907), with the further growth of local population, the scale of animal husbandry in Turpan appeared to have been expanded. In another official history book, *Xintangshu*, it recorded that there were 8000 households and 4000 horses in Turpan in AD 640, which means on average every two households had a horse [51]. During this period of time, Turpan was incorporated into the direct management of central government and became one of the most important military strongholds in the northwest frontier. A large army was stationed in Turpan and the amount of allocated warhorse was also quite huge. Moreover, in order to ensure the smooth flow of the Silk Road and maintain the effective connection between the central dynasty and Western Regions, *Changxingfang*, a specialized transportation organization with thousands of livestock was established [52]. In addition, it was very prevalent for the indigenous inhabitants in Turpan to raise livestock during the Tang dynasty. The most common domestic animal seemed to be sheep. Both the archaeological finds and unearthed documents from the Astana Cemetery illustrated that the meat of sheep have been eaten as one of the main food source, its leather and wool were used for making clothing, and even the dung could be used as manure. Meanwhile, owing to the need for ploughing and transportation, cattle and horse were also raised on a large scale among the common people [53–55].

According to the record of unearthed documents from Turpan, the livestock were mainly reared in captivity, occasionally grazed on the pasture and the main fodder for them included wheat, hulled barley, naked barley, broomcorn millet, foxtail millet and alfalfa [48, 54, 56]. An unearthed document recording the land operating situation in a county of Turpan demonstrated that there were fields exclusively planted with alfalfa and its cultivated area was only outnumbered by mulberry, grape and Chinese jujube among cash crops [57]. Alfalfa is not only a high nutritional forage, but also a plant with strong regeneration capacity, which have been early recognized by the ancient Chinese people. According to *Qimin Yaoshu* (Arts for the Common People, AD 533–544), a famous agricultural book, alfalfa could be cultivated and collected three times a year [58]. In Turpan, alfalfa was also harvested several times in order to provide enough hay fodder for livestock. An unearthed document noted that the Puchang county handed over a certain amount of alfalfa, which was harvested in autumn, to the higher authority and these hay fodder would be stored for the livestock of *Changxingfang* to get through the coming winter [56]. Another document recorded the price of alfalfa reaped in spring [59]. Additionally, due to its nitrogen-fixing abilities, alfalfa was usually used to improve soil fertility from antiquity to the present. In numerous agricultural books of the Ming and Qing dynasties, it is recorded that alfalfa could be highly effective in mix or rotation cropping system [38]. Notably, a document excavated from the Astana Cemetery recorded that alfalfa was planted before hemp in a county of *Xizhou* government, which illustrated that the local people of Turpan have been well-acquainted with its attribute of fertilizing soil by the Tang dynasty. Taking into account all these written resources relating to alfalfa together, we could draw a conclusion that the production scale of alfalfa in Turpan was rather huge during the Jin and Tang dynasties.

Conclusion

The discovery of well-preserved desiccated remains of *M. sativa* and *M. lupulina* from the Astana Cemetery in Turpan has interesting implications. On the one hand, it further corroborated the hypothesis of the introduction of *M. sativa* into China after the opening up of the Silk Road and added new key information about the history of *M. lupulina* in East Asia, which demonstrated that Turpan played a crucial role in the cultural and economic interactions across Eurasia. On the other hand, in conjunction with the record of unearthed documents, our study indicated that *M. sativa* was extensively cultivated in Turpan and acted as one of the most

important forage plants for indigenous inhabitants during the Jin and Tang dynasties, which substantially improved the development of local animal husbandry.

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Author contributions
TC conducted the experiment and wrote the original draft. BW provided the plant samples and background information. HEJ supervised the entire process and review the paper. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated during this study are included in this published article or are available from the corresponding author upon reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

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