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Changing patterns of plant-based food production during the Neolithic and early Bronze Age in central-south Inner Mongolia, China: An interdisciplinary approach

Li Liu [a, b, *], Neil A. Duncan [b], Xingcan Chen [c], Hao Zhao [a, b], Ping Ji [d]

[a] Department of East Asian Languages and Cultures, Stanford University, USA
[b] Stanford Archaeology Center, Stanford University, USA
[c] Institute of Archaeology, Chinese Academy of Social Sciences, China
[d] Inner Mongolian Institute of Archaeology, China

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ABSTRACT

This paper examines the long-term change of plant use from the Neolithic to the early Bronze Age (ca. 4800–1000 BC) in central-south Inner Mongolia to reconstruct the transitional process from foraging and low-level food production to agriculture. We employed an interdisciplinary approach, including starch analysis, phytolith analysis, and usewear analysis, correlated to changes in tool types used over time. The results show that this region experienced several waves of social transformations resulting from a combination of local social development, interactions with surrounding regions, and changing climatic conditions. The initial Neolithic development was a result of population expansions from the Central Plain, which introduced domesticated millets and arguably Job's tears to the region. However, cereal-based farming before 3500 BC appears to have been rather insignificant in the economy. Instead, it appears that various underground storage organs (USOs), wild or cultivated, including yams, lily bulbs, snake gourd roots, and occasionally cattail rhizomes, were staple foods. By ca. 3500–3000 BC, subsistence favoring USOs began to give way to cereal-based farming as millets and Job's tears became a more important source of starchy foods. This shift was parallel with a rapid population increase in the region and may be related in part to the need for additional high-calorie foods as would be provided by cereals. During the late Neolithic and the early Bronze Age (ca. 2500–1000 BC), cereal farming appears to have become a dominant starch-based subsistence strategy. In addition to millets and Job's tears, wheat and/or barley may have been introduced to the region. The population in this region may have played a crucial role for the introduction of wheat and/or barley from the steppes to China.

1. Introduction

Studies of residue and usewear patterns on stone tools, together with macrobotanical studies, have greatly improved our understanding of prehistoric plant-based subsistence economy in North China. During the late Pleistocene, Paleolithic hunter-gatherers adapted broad-spectrum subsistence strategies, collecting a wide range of starch-rich plants, which include tubers, roots, beans, acorns, and grasses (Liu et al., 2011, 2013a; Bestel et al., 2014; Guan et al., 2014). Similar plants were continuously being exploited during the early and middle Holocene when domestication of cereals was underway (Yang et al., 2009; Liu et al., 2010; Y. Zhang et al., 2011; Yang et al., 2012; Liu et al., 2013b; Zhao, 2014). These studies demonstrate a very long transition from foraging to domestication of certain cereals and an enduring use of a variety of other plants when farming was already in practice, a situation referred to as low-level food production (Smith, 2001). The transition from low-level food production to intensive agriculture therefore is a crucial part of the process of Neolithization in Chinese archaeology.

The Neolithic is generally defined as the presence of a series of technological and social developments including domestication of

* Corresponding author. Department of East Asian Languages and Cultures, Stanford University, USA.
E-mail address: liliu@stanford.edu (L. Liu).

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plants and animals, the practice of sedentism, and the use of pottery and ground stone tools (Childe, 1950). In North China, the first sign of possibly cultivated millet, *Setaria italica* (L.) P. Beauv., appeared at Donghulin near Beijing, dating to 10,000 years ago. Subsequently, the morphologically domesticated foxtail millet, *S. italica* (L) P. Beauv. subsp. *italica*, and broomcorn millet, *Panicum miliaceum* L., became widespread along the Yellow and Liao Rivers by 6000 BC (Zhao, 2011, 2014). Following domestication, sedentism and technological developments marked the early Neolithic period (ca. 7000–5000 BC).

China is characterized by a great diversity of climate and landscape, therefore varied subsistence adaptations developed among human populations in different regions. For example, in the Central Plain of North China millet-based farming communities were established during the middle Neolithic period (ca. 5000–3000 BC) as indicated by millet remains dominating the macrobotanical assemblages (Lee et al., 2007; Zhao, 2011). However, the timing and adoption cultivars leading to agricultural intensification may not have followed the same pattern in other regions of North China. It is important, therefore, to document the regional variation in the transition to agriculture.

In this study we focus on one region, central-south Inner Mongolia. By using an interdisciplinary approach, we examine long-term changes in plant use from the Neolithic to the early Bronze Age (ca. 4800–1000 BC) to reconstruct the transitional process from low-level food production to agriculture and to investigate the social and environmental dynamics involved.

2. Regional setting and research questions

2.1. Environmental background

Central-south Inner Mongolia refers to a region centered in the Hohhot Plain and south of the Yin Mountains; the Ordos highland is in the west, Huangqihai and Daihai with hilly landscapes and two lakes, are in the east (Fig. 1). It is the northern margin of the East Asian Monsoon area, thus it is sensitive to the intensity of the summer monsoon rains and related fluctuations in precipitation patterns (An et al., 2000). This is also the transitional region between semi-humid and semi-arid areas in the middle temperate zone of China. Therefore, it has been traditionally characterized as the agro-pastoralist transitional zone. In the Daihai region today, mean annual temperature is 5.1 °C and mean annual precipitation is 423 mm. Southern temperate steppe vegetation composed of forest on the mountains, alpine meadows, grasses and herbs on the hilly areas, and meadows over the lakeshore plain and the frontal fringes of diluvial fans characterize the modern day ecoregion (Xiao et al., 2004).

In contrast to the present day, the middle Holocene in this region was generally characterized by warm and wet conditions; the climate became variably drier and cooler since the late Holocene (Feng et al., 2006; J. Zhang et al., 2011). Pollen data from Daihai Lake reveal that precipitation was 50–100 mm lower in the early Holocene, 100–200 mm higher in the Mid-Holocene, and 50–100 mm lower again in the late Holocene than at present. The mean annual temperature was 1–2 °C lower in the Early Holocene and 1–3 °C higher in the Mid-Holocene than today. Several cold and dry events occurred about 8200, 6000, and 4400 cal BP, with an annual precipitation less than 400 mm and a mean annual temperature colder than 4.5 °C, respectively (Xu et al., 2010).

2.2. Archaeological background

During the late Pleistocene and early Holocene, the arid and semi-arid areas of North China were occupied by hunter-gatherers, whose material culture is characterized by microliths (Bettinger et al., 1994; An, 2000). Evidence of Neolithic elements first appeared in the study area at the beginning of the fifth millennium BC, such as sedentary villages, pottery, ground stone tools, and grinding stones (the slab-handstone complex), with microliths as a minor component. The origins of Neolithic material culture can be traced to the Central Plain, most likely as the result of waves of northward population expansions coming from the core areas of Neolithic farming communities of the Yangshao culture there (ca. 5000–3000 BC). The flourishing Neolithic culture in the study area also coincided with the wettest and the warmest climatic interval (ca. 4200 to 3100 BC), when annual precipitation was greater than 550 mm and mean annual temperature higher than 6.5 °C (Xu et al., 2010). Settlement distributions in the study area show periodic fluctuations in number of sites through time and many sites reveal signs of sudden abandonment. These disruptions seem to coincide with several episodes of climatic fluctuation, underlining fragile ecological conditions of the region (Han, 2003; Tian and Guo, 2004; Dong, 2013). Chronologically, the Neolithic cultures (ca. 4800–2000 BC) and the early Bronze Age (ca. 2000–1000 BC) in the study area parallel the Yangshao, Longshan, Erlitou, Shang, and early Western Zhou cultures in the Central Plain (Table 1).

Table 1
Archaeological chronology in the central Inner Mongolia[a].

Date BC	Archaeological cultures in central-south Inner Mongolia	Sites studied in this paper	Contemporary cultures in the Central Plain
4800–4000	Early Yangshao (Yangshao Phase I)	Shihushan II in Daihai (4800–4500 BC) Shihushan I in Daihai (6530–6440 cal BP)	Hougang I variant, Yangshao culture Hougang I & Banpo variants, Yangshao culture
4000–3500	Early Yangshao (Yangshao Phase II)	Wangmushan poxia in Daihai (5710 ± 200 cal BP)	Banpo-Miaodigou transition phase, Yangshao culture
3500–3000	Late Yangshao (Yangshao Phase III)	Miaozigou in Huangqihai	Dasikong variant, Yangshao culture
3000–2500	Early Longshan	–	Miaodigou II culture
2500–2000	Late Longshan	Yuanzigou in Daihai (2500–2300 BC) Pulawusu in Huade	Late Longshan culture
2000–1400	Zhukaigou	–	Terminal Longshan, Erlitou, Early Shang
1300–1000	Xicha	Xicha in Ordos	Late Shang to Early Western Zhou

[a] Chronology and periodization based on Han 2003; Tian and Guo 2004, with modifications.

2.3. Research questions

The location of the study area between farming communities to the south and hunting-gathering and pastoral populations to the north establishes Central Inner Mongolia as a crucial area of cultural and economic interaction and dispersal. Of particular interest is understanding how the Neolithic migrants from the south introduced and practiced millet-based agriculture in this region. Also, it has been

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