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Plant utilization at the Jiangxigou site during the middle Holocene

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ABSTRACT

Agricultural activities on the Qinghai–Tibetan Plateau (QTP) are difficult due to the hostile environment. Despite the difficulties, recently early agriculture has been documented by Holocene plant remains on the QTP. The details of the time, place, and mechanisms of agricultural origin as well as the evolution of agriculture on the QTP are still lacking. The Jiangxigou site (JXG2) contains artifacts dominated by microliths from the early to middle Holocene and provides important information on agricultural origins and evolution of prehistoric culture on the QTP. Here we report ancient starch grains and pollen extracted from ceramics and deposits excavated from each layer. The starch remains include 21 grains identical to starches from millets (*Setaria* spp. and *Panicum* spp.), probably including 24% domesticated foxtail millet (*Setaria italica*), indicating that humans at 3000 m above sea level (masl) in the northeastern margin of the Qinghai–Tibetan Plateau (QTP) began to use millets ca. 5600 cal BP. Considering archeological evidence, the reasons for millet utilization by plateau residents may be associated with the expansion and influence of the Yangshao culture via the Loess Plateau.

1. Introduction

The Qinghai–Tibetan Plateau (QTP), known for its extreme cold and oxygen-limited environment, is the highest plateau in the world. Although undertaking agricultural activities on the plateau is difficult, current evidence suggests that agriculture began on the northeastern QTP from the middle to late Holocene (Chen et al., 2015). Current evidence particularly documents this process on the northeastern margin of Qinghai–Tibet Plateau. In this region, we find sites of the Yangshao culture (7000–5000 cal BP), which is the earliest Neolithic culture of the QTP. Prehistoric humans in the region cultivated millet along river valleys. Their agriculture has been documented by evidence of carbonized foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) (e.g. Xie, 2002) at sites of the Majiayao Culture (5300–4000 cal BP). Furthermore, results of bone isotopic analysis of ancient humans associated with the Zongri Culture (5600–4000 cal BP) in the upper Yellow River valley indicate that local residents consumed C4 plants (presumably mainly foxtail millet and broomcorn millet) as staples (Cui et al., 2006), even though we still lack direct crop evidence (Chen et al., 1998).

To date, many studies have shown that agriculture first appeared on the northeastern margin and east of the QTP, and then appeared in the interior part of the plateau; meanwhile edible crops increased in diversity (Chen et al., 2015; Fu, 2001; D'Alpoim Guedes et al., 2014). Some scholars think that edible crops on the QTP first included foxtail millet and broomcorn millet, and later changed to a mixture of foxtail millet, naked barley, and wheat (Jia et al., 2012). Other researchers illustrate that wheat and barley rapidly replaced millets and became the main crops around 4000 cal BP. However, details on the time, place, and mechanism of agricultural origins as well as the evolution of agriculture on the QTP are still lacking.

The Jiangxigou2 (JXG2) site contains continuous, relatively complete cultural strata from the Paleolithic to the Neolithic era and therefore is different from other sites, many of which have been destroyed by strong erosion on the QTP (Brantingham and Gao, 2006). Consequently, the JXG2 site is an important site for studying plant use of prehistoric humans from the Paleolithic to the Neolithic era on the QTP. A series of microliths, ceramics and other artifacts have been unearthed at the JXG2 site. Ceramics are closely associated with cooking, eating, and other activities (Piperno et al., 2000; Yuan, 2002; Yang and Jiang, 2010; Craig et al., 2013), and the interior walls of ceramic wares often contain lipid molecules, proteins, tartaric acid, starch grains, DNA, and other residues from prehistoric use (Craig et al., 2000; Zarrillo et al., 2008). In the present study, starch grains extracted from residues on unearthed ceramics were analyzed to reveal their function and the use of plants by ancient residents of JXG2 (the following methods described in Yang et al., 2012).

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2. The Jiangxigou site

The JXG2 site (36°35′25″N, 100°17′47″E) is located at 3312 masl on the southern shore of Qinghai Lake, 118 m above the lake level, and lies at the junction between the plains near Qinghai Lake and the hills leading to the Qinghai Nanshan mountains. The cultural deposits at the site are exposed on the edge of the associated terrace (Rhode et al., 2007).

The profile of cultural layers at JXG2 is about 120 cm thick (Fig. 2) and contains a relatively large amount of microliths, animal bone fragments, as well as charcoal and ceramics. Stratigraphic subdivisions were conducted during fieldwork by close examination of the color, texture, and structure in the JXG2 profile. A combined pedological and stratigraphic description of the JXG2 profile is presented in Table 1. (See Fig. 1.)

According to the color and particle size of soil, the profile is divided into four strata: Layer 1 (0–30 cm; pale yellow in color; with loose soil) consists of the modern soil, a relatively large amount of roots and sand, and a small number of microliths; the brightness value of the chrominance index is high and the degrees of redness and yellowness relative to the entire profile are high. Layer 2 (30–75 cm; dark gray; brown silty clay, relatively firm) contains a comparatively large number of microliths, bone fragments, and ceramics. The degrees of brightness, red and yellow in the chrominance index of this stratum are all low. The degree of redness and yellowness of sediments is related to the content of hematite and goethite respectively and are related to pedogenesis, which, in turn, is a product of climate. The brightness of soil is related to carbonate content, water content, roughness, and other factors, and reflects relative precipitation.

Layer 3 (75–114 cm; gray; brown silty clay, hard and firm) contains a relatively large number of microliths and bone fragments. It is the lowest stratum in the profile that contains significant quantities of artifacts. All three aspects of chrominance have high values. Layer 4 (below 114 cm; typical loess) contains a very small number of microliths and bone fragments. Compared with the previous layers, the brightness value of the chrominance index is low, while the degrees of redness and yellowness are significantly higher.

3. Materials and methods

3.1. Materials

Wearing clean disposable plastic gloves, the operator used trowels to excavate in 1.5 m × 0.5 m quadrats. Potsherds were excavated from archeological strata at intervals of 10 cm and then washed. All necessary permits for the described field investigations were obtained by Qinghai Normal University. After wet-screening, microliths, animal bone fragments, ceramics, and charcoal were collected from the 11 layers (the 0–10 cm layer is the ground surface layer, which is disturbed by modern human activities and hence which was not studied) (Table 2). A total of 59 environmental samples (pollen, color) were collected along the profile at intervals of 2 cm, starting with 2 cm below the surface. Five pottery sherds were excavated from the profile (at depths of: 39 cm, 46 cm, 50 cm, 61 cm, and 75 cm), while another six sherds were collected from flotation samples (depths: 30–40 cm, 40–50 cm, 50–60 cm, and 60–70 cm). On the whole, ceramics were unearthed at 30–75 cm, with four pieces unearthed at 40–50 cm, hence, the ceramics are relatively concentrated in their associated depth. The deepest ceramic was an orange fragment unearthed at 75 cm. Two charcoal samples collected from the JXG2 were sent to the Accelerator Mass Spectrometry Laboratory of Peking University.

Eleven sherds, whose serial numbers are JXG2:P1-JXG2:P11, were examined. Four sherds with charred residues were selected (Fig. 3 a–d). Charred residues were extracted by gently scraping the material from the interior and external surfaces onto aluminum foil squares. Then the charred residues were collected in the storeroom at the Qinghai Normal University.

Eight sediment samples were analyzed as control specimens, including one from the dust of the storeroom where the artifacts were stored, and seven others from the seven cultural layers (42, 46, 48, 50, 52, 61, and 65 cm depths) where the sherds were collected.

3.2. Methods

Pollen grains were extracted from the sporopollen samples collected from JXG2 by using the heavy liquid flotation method detailed elsewhere (Li et al., 2006). Detailed steps for analyzing starch grains from the residues found on the ceramics are as follows (after Yang et al., 2010, 2012):

1. Before analysis began, all experimental implements including test tubes and glass stirring rods were cleaned with an ultrasonic bath, and then boiled for 15 min to avoid any possible contamination of the archeological samples.
2. Organic matter was removed by adding H_2O_2 (concentration: 6%), then ultra-pure water was added. This was followed by centrifuging the sample (3500 r/m, 10 min). This process was repeated multiple times until the liquid became neutral.

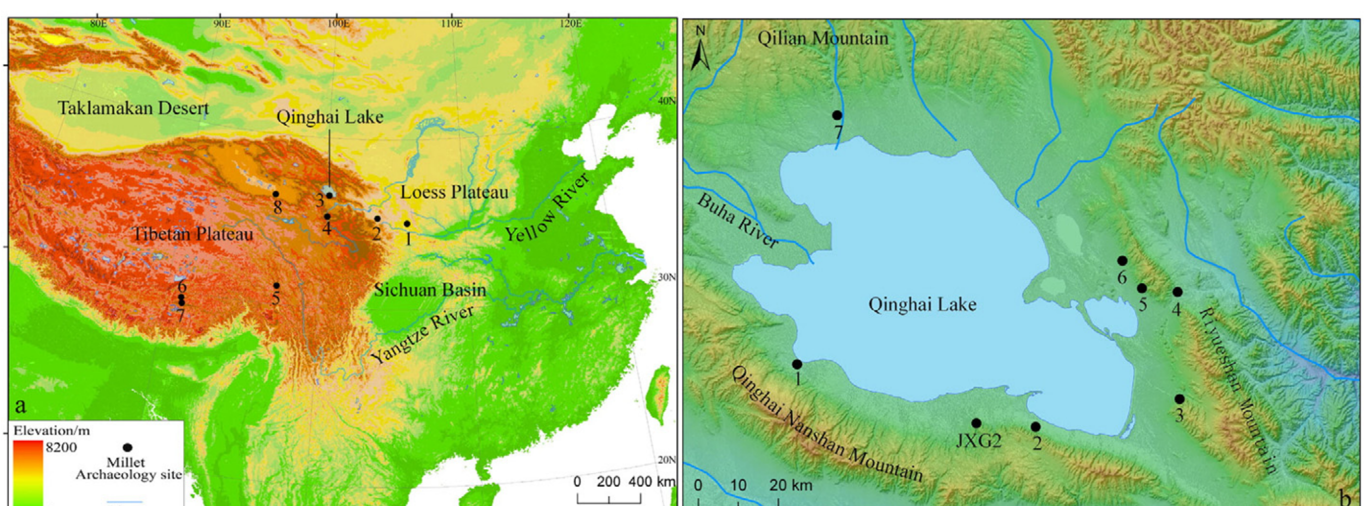

Fig. 1. Outline map of Eastern Asia and the Qinghai lake Basin. a. Numbers refer to sites discussed in text 1. Dadiwan, 2. Majiayao, 3. Jiangxigou2, 4. Zongri, 5. Karuo, 6. Qugong, 7. Changguogou, 8. Nuomuhong. b. Main archeological sites at Qinghai Lake. 1. Heimahe, 2. 151 site, 3. Loula reservoir, 4. Yantaidong, 5. Bronze Wire, 6. Baifosi, 7. Shaliuhe.