Research on Chenopodium in ancient Southwest China

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Abstract Located in the southwest hinterland of China, southwest China has a diversity landform consists of plains, mountains, intermountain basins, plateaus. Since the late Neolithic, people living in southwest China have created diverse cultures. As for the basic subsistence strategies, agriculture facilitated the long-term occupation of settlements. While compared to central China, the ecological environment and geomorgraphy in southwest China seem more tough. According to the archaeological evidence, the Chenopodium has been used in most of the archaeological sites. Chenopodium has been cultivated and domesticated in northeast America since Neolithic until nowadays, it is still used in most areas of the world. Whether it was domesticated in ancient China is still not clear, the archaeobotanical evidence indicates that since the late Neolithic period, the genus of Chenopodium has been exploited by ancestors in southwest China, which provides the most direct evidence for the utilization of Chenopodium. The utilization of weeds such as Chenopodium in ancient southwest China suggests the diversity acquirement methods for ecological resources, which is of great significance to understand the early civilization process in ancient southwest China.

1.Introduction
Agriculture in Southwest China began at around 5000 BP with millet-based agriculture [1-2]. Afterward, at 4500 BP, the agricultural pattern has changed, in Chengdu plain, rice was dominant, millet became the auxiliary crop [3-5]. While in southwest Sichuan and Northwest Yunnan, the mixed millet and rice agriculture were prevalent [6-8]. Subsequently, with the introduction of wheat and barley at around 3000 BP, the agriculture pattern was alternated again. In the mountainous area, the agricultural system was easily affected by the new species. The original crop system was broken after the wheat and barley were introduced. While in the plain areas the stable agricultural system based on rice and auxiliary millet was still lasting, which is not readily impacted by exotic crops [4-6, 8-11].

It is worth note that in addition the crop remains, almost all of the sites have also identified Chenopodium seeds. However, most of them are regarded as an entirety relative to the crops. With the increase of the archaeobotanical materials, it is necessary to comb the Chenopodium in the sites. Given Cultivation and domestication is a long-term story, the understanding of the utilization before the plants were cultivated by human is beneficial for us to consider how humans explored and intervened with the botanical resources.
2. Study Area
The range of southwest China including Tibet Autonomous Region, Sichuan Province, Chongqing Municipality, Guizhou Province, and Yunnan Province (Fig 1). The geography of this area is complex, encompassing such diverse landscapes as basins, mountains, and plateaus. The whole area exhibits a subtropical monsoon climate that, since the Holocene, has greatly influenced its terrain [12-13]. This complicated natural environment had an impact on the region’s culture and population. The southwest China was long considered to have been a barbarian area since the archeology of Southwest China developed at quite a later date than that of central China. However, archaeological work indicates that although the Neolithic Age started relatively late in this area, its population enlarged rapidly, and developed into a complex society in a short amount of time [3, 14].

![Fig.1. Location of sites mentioned in text](image)

3. Chenopodium Remains in Archaeological Sites
The genus of Chenopodium Linn. (Family-Chenopodiaceae) is an annual or perennial species which could be used by human for multiple approaches such as vegetable, medicine, the food resources of herds and tools. As a common weed, it has diverse habitats, including the roadside, the edge of the field and even the hostile environment like mild saline-alkali land. Recently, The archaeobotanical evidence shows that since the late Neolithic period, the genus of Chenopodium has been exploited by ancestors in southwest China [8, 15]. No matter the plain areas or mountainous areas in western Sichuan [2, 5,15], up to Yunnan-Guizou Plateau [11, 16] and Tibetan plateau [1], Chenopodium seeds account for a high proportion amongst the weed remains. In spite of the low amount of crop remains yielded in some cases, Chenopodium seeds are still the largest group (Table 1).

| Site          | Date (BC)  | Seed Amount | Source                                      |
|---------------|------------|-------------|---------------------------------------------|
| Yingpanshan   | 3500-2700  | 2405        | Zhao and Chen,2011                          |
| Guiyuanqiao   | 3100-2600  | NA          | Sichuan Institute of Cultural Relics and Archaeology,2015 |
| Karuo         | 2700-2300  | 44          | d’Alpoim Guedes,2014                        |
| Karuo         | 1665-1518  | 633         | Gao,2013                                    |
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| Phase/Phase | Start-End | Year | Reference |
|-------------|-----------|------|-----------|
| Baiyangcun phase1 | 2650-2300 | 43 Martello et al., 2018 |
| Baiyangcun phase2 | 2200-2050 | 54 Martello et al., 2018 |
| Baodun | 2550-2250 | 56 Chengdu Institute of Cultural Relics and Archaeology, 2011 |
| Zhonghaiguoji | 2250-1750 | 44 Chen, 2015 |
| Haimenkou | 1750-1050 | 2165 Jin, 2013 |
| Guangfentou phase1 | 800-500 | 88 Li and Liu, 2016 |
| Guangfentou phase2 | 500-200 | 4515 Li and Liu, 2016 |
| Guangfentou phase3 | 206-220 AD | 698 Li and Liu, 2016 |
| Bangga | 820-595 | 174865 (Chenopodiaceae + Chenopodium) Tang, 2018 |
| Yubeidi | 500-200 | 35 Yang, 2016 |
| Heposuo | 500-200 | 53 Yang, 2016 |
| Xueshan | 500-200 | 158 Wang, 2014 |

4. Ethnographic Evidence

In the modern Himalaya region, species including *Chenopodium album* L. and *Chenopodium giganteum* D. are still used by local residents. However, for those people who live in the lower altitude and with lower income, have more consumption on Chenopodium. Besides, there are various methods to consume the Chenopodium, such as ground into powder for bakery, mixed with cornflour for soup, used in preparing a fermented beverage, or as fuel. Sometimes, it’s also blended with pumpkin as cattle feeds. As for the cropping pattern, Chenopodium is mainly grown in mixed cropping association with crops [17].

Chenopodium has a long cultivation history in some regions of China, for example, in Taiwan, *Chenopodium formosanum* has been cultivated by the aborigines as vegetable and yeast for millet wine. Similarly, it has a mixed cropping pattern, usually, plant with mung bean (*Phaseolus radiatus*) and millet (*Setaria italica*) [18]. In addition, Chenopodium is used as a potherb in China as well. Especially the species of *Chenopodium album* L., typically called “Hui Cai” or “Hui Tiao” in mandarin. And remarkably, as the “Roof of the world”, Tibetan Plateau is famous for its harsh ecological environment, which is disadvantageous for vegetable planting. While the Chenopodium album L. is recorded as a potherb in both plateaus and low lands [19].

5. Discussion

In North America, the use of Chenopodium could be dated back to 6500 BC, although it still showed the wild character of thick testa [20]. Archaeological evidence suggests Chenopodium had been domesticated in northeast American since Neolithic, where was thought as an independent domestication center before the introduction of cultivens from Mesoamerica [21-22]. By 3800 BP at the latest, Chenopodium along with seed-bearing plants such as sunflower (*Helianthus annuus var. macrocarpus*), bottle gourd (*Lagenaria siceraria*) have been developed the domestication assemblages, the multiple pathways of resources acquirement were benefit for local residents to adapt the resource-rich environment and facilitated the long-term occupation in Northeast America [23-24].

It worth noting that the sites with a high proportion of Chenopodium or Chenopodiaceae are always accompanied by the mixed agriculture pattern of millet (both foxtail millet and broomcorn millet), rice and wheat in the later period. The relationship between millet agriculture and Chenopodium has been aware by scholars [6, 8]. In southwest China, the population enlarged rapidly since the late Neolithic, and some areas such as Chengdu plain developed into a complex society in a short amount of time [14]. The development of sites is correlated to the need for sufficient food resources at the heart of human
From this point of view, the development of agriculture was crucial in achieving the stability of subsistence. From the late Neolithic, millet agriculture was the main subsistence strategy within the region under study. As proposed by d’Alpoim Guedes [3], millet cultivation might have facilitated the spread of agriculture in southwest China with a high elevation and poor ecological condition. At the same time, botanical resources such as Chenopodium can survive in most of the ecological environment and doesn’t cost too much time to take care, in addition, the harvesting time doesn’t conflict with the crops, as for the yield, take the Chenopodium album L. as an example, every single plant could yield 3000-20000 seeds (Data from CABI). Similarly, with millet, the Chenopodium is also a pioneering resource for the ancient human to explore their living environment.

In addition as humans consumed plants, charred seeds could also be brought into sites by dung burning behavior. As common weeds, Chenopodium is palatable for herbivores, so the undigested seeds could be preserved in their dung. In some part of the world such as West Asia, Andes Plateau, Tibetan Plateau, the use of dung fuel has a quite long history. As a result, the high percentage of Chenopodium in charred plant assemblages in these areas is thought to be related to the dung fuel [25-27].

As discussed by Flannery [28], the botanical resources are abundant in the large range of Mesoamerica, the food acquirement systems vary in different regions and driven by 2 factors, “seasonality” and “scheduling”. Unlike the distinctive procession from the gathering period to cultivated period in Mesoamerica, the botanical resources utilization in southwest China was based on crops. The emergence of agriculture is not only the appearance of agriculture itself but also the change of social system, the organization, and movement of the labor force to complete the activities of agriculture [29].

The harvest time in southwest China is concentrated in Autumn, While some of the wild plant resources like Chenopodium seeds could be gathered in the early Summer. As for the wild fruits such as plum, peach and other high-altitude plants, the harvest season is around August and September, which is roughly the same as the crops. Similar to the crops, the wild fruits need to be picked in a short period of time, so it involves the distribution of labor. In the settlement, Some people need to harvest crops near their sites, while others need to gather wild fruits in the mountains, and may also hunt animals. Therefore, it is necessary not only to arrange the time reasonably but also to organize the labors reasonably.

Actually, the tradition of Chenopodium exploitation was prevalent no matter in the plateaus, or in the lowlands in southwest China. Together with the small-scale agriculture, hunting and gathering economies, constitute the subsistence complex. The diverse resources utilization also reflect the environment adaption of ancient residents in southwest China. As the population and scale of settlements increased, the per-capita share of resources decreased, creating the need for new strategies of subsistence. This is expressed both internally and externally. Internally, resources needed to be consolidated through the expansion of catchment areas, the increase of resource types, or even the introduction of new crops. Externally, it was reflected in the emergence of new settlements, and human migration, which reflected by the translocation of archaeological culture and agriculture.

6. Conclusion

The plant remains in archaeological sites include a diverse array of non-crop food plants. These wild plants sometimes are underestimated. With the accumulation of archaeobotanical materials, in addition to figure out how the agriculture emerged and developed, equally important is to understand how humans took advantage of the local botanical resources. After integrating the wild botanical materials in southwest China from Neolithic to the Bronze age, we suggest that Chenopodium has the potential utilization as potherb and pasture. In conclusion, in order to expand the utilization of ecological resources, the ancient residents in southwest China have already taken advantage of the weed resources, Chenopodium provides a good perspective for the research of botanical resources utilization in ancient southwest China.
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