

# The subsistence of hunter-gatherers from the perspective of scientific and technological archaeology

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## Abstract

**Hunter-gatherers are the earliest and longest-lasting survival mode in human history, and studying hunter-gatherers is of great significance to understanding human cultural behavior and its evolution. Based on the current academic research, this paper reviews and explores the dietary sources and environmental adaptability of hunter-gatherers from the perspective of scientific and technological archaeology, and emphasizes the importance of organic residue analysis technology of archaeological pottery, palaeoproteomics techniques (taking MALDI-TOF's peptide mass fingerprinting technology as an example), palyological analysis and stable isotope technology in this field in order to deepen our understanding of early human adaptation strategies, social dynamics, and cultural evolution.**

## Keywords

**Science and technology archaeology, Hunter-gatherers, Means of subsistence, Dietary sources, Environmental adaptation.**

## 1. Introduction

In the vast river of human history, hunter-gatherers, as the basic unit of early society, directly obtained food resources from the natural environment, and shaped the unique survival strategy of human adaptation and utilization of the environment. Human behavior is the product of long-term evolution, the product of human adaptation to the environment and the spontaneous development of human behavior [1]. As an interdisciplinary discipline, scientific and technological archaeology utilizes modern technology to provide unprecedented depth and breadth in our understanding of the economic models of hunter-gatherer societies, technological innovation, and the transition to agricultural civilization. Therefore, exploring the subsistence of hunter-gatherers from the perspective of scientific and technological archaeology can transcend the limitations of traditional archaeology and reveal how ancient humans adapted to and transformed nature when faced with survival challenges. The multi-dimensional and interdisciplinary technical approach helps to depict the whole picture of the subsistence of hunter-gatherers within a broader time-space framework, helping us to better understand the survival wisdom and social complexity of early human beings, and thus providing a solid scientific basis for exploring the long-term development trajectory of human society.

## 2. Literature Review

In recent years, hunter-gatherers have been a central topic in the exploration of the early stages of human history and social development. Researchers are widely distributed in the fields of archaeology, social anthropology, biological anthropology and environmental science, carrying out in-depth and diversified researches. For archaeology, the study of hunter-gatherers is fundamental to understanding human adaptation, the evolution of social structures, and the

development of culture. Stone artifacts, as the key material and cultural relic, have become an important basis for inferring the mobility strategies of prehistoric hunter-gatherers. Chao ZHAO believes that the morphological characteristics of stone products can reflect the range of activities and movement patterns of hunter-gatherers, but there are limitations in inferring mobility characteristics from this perspective [2]. In terms of regional studies, hunter-gatherers in the middle and low latitudes have become the focus. The present study combines unearthed site remains with ethnological data and model simulation studies [3] to explore the survival strategies, technological changes and adaptability of hunter-gatherers in this region to the high-altitude environment from multiple perspectives, such as tonomy, zooarchaeology, ecology and statistics [4], and also to explore their ideas, values and behavioral adaptation patterns [5]. Much attention has also been paid to the economic models of hunter-gatherer societies, technological changes, and the dynamics of their transition to agricultural societies. Through cross-cultural observation [4], analysis of the evolution of technological tools [6], and the combination of isotope, fauna, and proteomic data [7], scholars have enriched traditional human understanding of origins of agriculture, emphasizing the active adaptation and diversity of hunter-gatherer societies during this transition. On the whole, these studies build a more comprehensive picture of hunter-gatherer populations, emphasizing the dynamic interactions between culture, technology, environment, and human adaptation strategies, and providing reference value for in-depth understanding of social changes and civilization process in early human history.

Although the current academic researches on hunter-gatherer have made remarkable achievements, they still face shortcomings and challenges. Existing studies mostly rely on theory construction and simulation, which helps to build a macro framework and test hypotheses, but ignores the impact of regional cultural specificity and ecological diversity on the actual behavior patterns of hunter-gatherer societies. In addition, despite steady progress in the mining and analysis of physical evidence, the lack of standardization and systematic integration in cross-regional and cross-cultural comparative studies has limited a comprehensive understanding of the complexity and adaptability of hunter-gatherer societies. This paper attempts to summarize and review the existing research results, and emphasizes the importance of using modern scientific and technological means in hunter-gatherer researches. Future researches should more actively adopt the application of technologies such as ancient DNA analysis, isotope labeling, and geographic information systems to enhance collections and analysis of empirical materials. At the same time, we should further deepen the research in this field from subjective, diachronic and interdisciplinary perspectives, and further integrate the knowledge and methods of archaeology, anthropology, environmental science, genetics and other fields, in order to build a more three-dimensional and comprehensive research system framework of prehistoric archaeology.

### 3. Means of subsistence

For more than 99% of long evolutionary history, humans existed in hunter-gatherer groups. Mobility is a central adaptation strategy for hunter-gatherers and nomadic groups [8][9]. In the broad perspective of Neolithic archaeology, scholars generally believe that subsistence is the key to understanding the social structure and lifestyle of hunter-gatherers. The way of subsistence not only determines the survival and reproduction of these groups, but also profoundly affects their social dynamics, cultural exchanges and even their adaptation and transformation to the environment. When discussing survival strategies of hunter-gatherers, dietary sources and environmental adaptation constitute two cornerstones of the survival and reproduction of hunter-gatherers. This paper focuses on combing and exploring the current academic researches on the ways of hunter-gatherers to obtain food sources and the strategies of adaptation to the environment through modern scientific and technological methods, so as

to understand the life modes and adaptation mechanisms of hunter-gatherers from a comprehensive and in-depth perspective.

### **3.1. Dietary Sources**

#### **3.1.1. Organic Residue Analysis Technology of Archaeological Pottery**

In recent years, numerous archaeological discoveries and scientific studies have shown that pottery was present in hunter-gatherer groups around the world long before the transition to agriculture, and is one of a series of technological innovations in which prehistoric people adjusted their livelihood strategies to adapt to environmental changes [10]. Organic residue analysis technology of archaeological pottery takes pottery as a carrier to extract organic matter in it for chemical analysis, determine the source of organic matter qualitatively, and understand the function of the ware and the types of animal and plant resources processed [11]. Because of their strong hydrophobicity, lipid molecules can still be well preserved after long-term burial, and are the main objects of organic residue analysis technology of archaeological pottery [12]. In the analysis, the sample is separated by vaporization, and then entered into the mass spectrometer for mass analysis, so as to determine the structure of the compound and reveal the use function and processing history of potteries. Taking the sites of Dayan and Dingsishan in Guangxi as an example, through the analysis of lipid residues of 55 pottery fragments, the study found that phytolipids accounted for 85% of the total, which proves that these potteries were mainly used for processing edible plants and had cooking functions, emphasizing the important role of plants in the economic life of prehistoric residents in Southern China. Although there are no clear biomarkers of animal lipids, the distribution and combination characteristics of fatty acids and their isomers, long-chain ketones and animal sterols generally reflect the mixed animal sources of ruminants and non-ruminants, and prove that there are signs of the utilization of animal resources by hunter-gatherers at that time [13]. In short, organic residue analysis technology of archaeological pottery, as a powerful scientific and technical method, not only reveals the basic function of pottery as a cooking utensil, but also paints a detailed picture of the food of prehistoric hunter-gatherers. Via systematic analysis, we can not only confirm the central role of plant resources in the diet of early humans, but also capture traces of animal resource utilization, thereby demonstrating the extensive adaptation and efficient use of ecological environments by hunter-gatherer societies.

#### **3.1.2. Palaeoproteomics Techniques (taking MALDI-TOF's peptide mass fingerprinting technology as an example)**

Peptide Mass Fingerprinting (PMF) is a technique for identifying proteins by the mass of peptides produced after digestion by enzymes, and is suitable for analyzing samples containing one or more major proteins, such as collagen in bones or keratin in wool and feathers. The development of soft ionization methods Matrix-Assisted Laser Desorption or Ionization (MALDI) has made it possible to ionize large non-volatile molecules for downstream mass spectrometry without destroying the sample. Therefore, ZooMS technology, which uses MALDI-TOF mass spectrometry system combined with Time of Flight (TOF) analyzer to analyze Peptide Mass Fingerprint (PMF), can effectively compensate for the defects of animal bones that are difficult to identify due to damaged feature points or after processing, and plays a key role in exploring the sources of hunter-gatherers' hunting objects, namely diet [14]. A large number of animal bone fragments were unearthed at Shimao Site in northern Shaanxi Province. The researchers conducted ZooMS analysis on the fragments lacking morphological characteristics and speculated that the animal was deer or cotton. Based on the analysis results of fatty acid monomer isotope of animal bones unearthed at Shimao Site and Gaojiawa Site, the scholars speculated that in the late Neolithic age, hunter-gatherers in northern Shaanxi had mastered a variety of livestock rearing patterns, including the combination of free range and captive breeding, the coexistence of cattle, sheep, pigs and other domestic animals, and the interaction

with wild deer [15]. The Wulausi Site in Inner Mongolia was an important site for activities of hunter-gatherers in the early and middle Holocene in the steppe region of northern China. ZooMS analysis method was conducted on the broken bones of the site lacking morphological characteristics, and the animal species was presumed to be Cervidae, Antilopinae or Aepyceros. Combined with the morphological analysis results, Mongolian gazelle of Antilopinae were the main source of meat for the population at the site. ZooMS analysis method not only overcomes the limitations of traditional morphological identification in dealing with broken, worn or processed animal bones, but also can efficiently and accurately identify animal species consumed by ancient humans through direct analysis of collagen fingerprints in bones, and has become an indispensable tool for exploring the dietary habits and economic behaviors of ancient hunter-gatherer societies [16].

## **3.2. Environmental Adaptation**

### **3.2.1. Palyological Analysis**

Palyological Analysis is an analytical method for studying spores and pollens of plants. The sporopollenin in the outer wall of sporopollen have acid-base resistance properties, which allow the sporopollen to be preserved for a long time in most environments, and can be preserved in some sediments for hundreds of millions of years. The sporopollen is small in volume, light in weight, large in yield and wide in propagation. The sporopollen mixes with each other during propagation to form the sporo-pollen complex, which can basically reflect the appearance of vegetation and paleoclimate in the region at that time [17]. By acid-base treatment and heavy liquid flotation on the outer wall of the sporopollen, researchers can observe the morphology of sporopollen and pollen combinations under the microscope, and then determine the plant species. In the study and analysis of Lajia Site in Qinghai Province, researchers reconstructed the paleo-vegetation types, climate characteristics and living environment of the site through chemical analysis and counting species and proportion of sporopollen, combined with the geological background of sediments. The analysis results show that the climate of Lajia site was mild and humid in the early stage of Qijia Culture, and the vegetation was mainly mixed forest grassland, which was suitable for the development of animal husbandry. In the later stage of the Qijia Culture, the climate became colder and drier. On this occasion, the pollen of coniferous plant increased significantly while broad-leaved plant pollen decreased, indicating that the climate became colder and drier, resulting in stream trenching and the decrease of groundwater level, which had an adverse impact on the dry farming dominated by millet. Despite negative impacts of climatic conditions on crop yields, local people have not completely abandoned agricultural production, but may have increased their reliance on livestock. The paper speculates that without the exchange and migration of prehistoric eastern and western cultures in Eurasia, the Lajia ancestors would have relied more on hunting, gathering, and fishing as a supplement to their agricultural economy. Therefore, the mixed pattern of agriculture and animal husbandry of the Qijia Culture at the Lajia Site is the result of environmental change and cultural exchange [18]. The changes in vegetation and climate revealed by Palyological Analysis, combined with pottery usage and human food sources found at the site, represent how ancient populations adjusted their livelihood strategies to the challenges of the natural environment, including possible plant resource utilization and changes in animal feeding practices. Palyological Analysis is not only an important tool to reveal paleo-vegetation and paleo-climate, but also a key means to understand how ancient hunter-gatherers adapted to environmental changes and adjusted their subsistence activities. The case study of Lajia Site illustrates that changes in the natural environment drove the transformation of human social and economic forms, cultural exchanges and migrations provided additional paths for such adaptive changes.

### 3.2.2. Stable Isotope Technology

As a scientific research method, stable isotope analysis can reveal the diet composition of ancient people, and provide important information for exploring their livelihood strategies, living environment and migration patterns [19]. The principle of stable isotope analysis holds that the stable isotope composition of the body tissues of an organism (human, animal) directly depends on the stable isotope composition of the food it ingests [20]. The analysis of stable isotopes of carbon and nitrogen in human and animal bones is one of the main research methods in archaeological circles to reveal the food structure of ancient populations and understand their survival strategies. Plants can be divided into C<sub>3</sub>, C<sub>4</sub> and CAM types due to different ways of photosynthesis. The mean  $\delta^{13}\text{C}$  values of C<sub>3</sub> and C<sub>4</sub> plants were -26.5‰ and -12.5‰, respectively [21]. During the digestion and absorption of food, isotopes are fractionated, and  $\delta^{13}\text{C}$  is enriched by about 5‰ and  $\delta^{15}\text{N}$  is enriched by about 3-5‰ in the conversion from food to collagen [22][23]. In the field of isotope bioarchaeology, C and N isotope analysis of biological bone collagen is usually combined, and the main food types and nutrient levels of ancient humans and animals can be inferred by analyzing the stable isotope ratios of carbon and nitrogen in the samples [24]. In the study of rettestone and Dayan sites in Guilin City, researchers utilized the method of carbon and nitrogen stable isotope analysis to analyze human and animal bones unearthed from the sites. The results showed that C<sub>3</sub> plants dominated the plant community in Southern China in the early and middle Neolithic Age, indicating that the climate conditions in this area were warm and humid, and the ecological environment was relatively stable. Carbon and nitrogen isotope data show that the food of the early Neolithic population contained a large number of freshwater resources, such as freshwater fish, which is consistent with the archaeological discovery of a large number of shellfish deposits and fishing and hunting tools, indicating the population's dependence on aquatic resources at that time. At the same time, the high concentration of food sources in various regions may reflect that in order to cope with the survival pressure of equal distribution of food resources, people constantly adjusted the food acquisition strategies to achieve efficient utilization of resources [25]. In the middle period, the decline in  $\delta^{15}\text{N}$  indicates that food sources became more diverse and that local hunter-gatherers reduced their reliance on aquatic resources in favor of greater use of terrestrial resources [26]. As a powerful tool, Stable Isotope Technology not only provides direct evidence for understanding the interaction between ancient humans and nature, but also opens up new perspectives for studying the complex adaptation mechanisms of hunter-gatherer societies, highlighting the ability of populations to maintain survival and development by flexibly adjusting food resources under different ecological environments and time nodes.

## 4. Conclusion

Scientific and technological archaeology provides a multi-dimensional perspective and in-depth insight into the subsistence of hunter-gatherers. By organic residue analysis technology of archaeological pottery, palaeoproteomics techniques (taking MALDI-TOF's peptide mass fingerprinting technology as an example), palyological analysis and stable isotope technology, we can reconstruct the food sources, dietary patterns, environmental adaptation strategies, and changes in economic models of prehistoric humans. These studies reveal how hunter-gatherers effectively used resources in different ecological environments, and how they adjusted their survival strategies in the face of environmental pressures, and gradually transitioned from hunter-gatherers relying solely on nature to agricultural societies. In the future, with the further development of interdisciplinary disciplines such as plant archaeology, animal archaeology and remote sensing archaeology, we are expected to obtain a richer and more detailed picture of the life of hunter-gatherers. Interdisciplinary cooperation and the

application of comprehensive analytical methods will enable us to more fully understand the survival wisdom and social complexity of early human history, reveal the deep mechanisms of interaction between hunter-gatherers and the environment, and how cultural exchanges and migrations influenced the transformation of human socio-economic patterns in the early eras of human civilization. The continuous development of scientific and technological archaeology will undoubtedly continue to deepen our understanding of early adaptation strategies, social dynamics and cultural evolution in human history, and provide an indispensable scientific basis for exploring the long-term development trajectory of human society.

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