Journal of Anthropological Archaeology 45 (2017) 131–141

Contents lists available at ScienceDirect

Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

Efficiency of gathering and its archaeological implications for an European Early Palaeolithic population

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ARTICLE INFO

Article history:
Received 18 May 2016
Revision received 19 December 2016
Accepted 19 December 2016

Keywords:
Bioenergetics
Acorn gathering
Foraging efficiency
Hunting
Middle Pleistocene
Europe

ABSTRACT

We evaluate the efficiency of acorn gathering as a foraging method for a middle Pleistocene human population living in mid-latitude European territory. An innovative experimental approach measures how much energy an average female spends gathering nuts in a natural environment, comparing this value with the caloric return of this vegetable resource. The gathering activities were performed by 9 volunteers and showed that gathering 3 kg of acorns in 1 h represents a moderate activity in energetic terms, consuming not more than 300 kcal. Thus, due to their high energetic content, gathering nuts is a highly efficient foraging method. The energetic return obtained by gathering acorns, one of the more abundant nuts in the Mediterranean landscape, is favourably compared with the return provided by hunting. Acorns were a seasonally abundant resource at these ecosystems 300 kya and were rich in nutrients and relatively easy to store, making them a highly attractive food for the Palaeolithic inhabitants of this landscape.

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1. Introduction

From an archaeological point of view, gathering has not been afforded sufficient attention as a foraging method in spite of the numerous contemporary hunter-gatherers who mostly rely on plant resources as their main feeding source (Binford, 2001; Lee, 1981; Milton, 2000; Sih and Milton, 1985). Most of the ethnographic examples are based on tropical or subtropical latitudes where these hunter-gatherers currently live (for instance: Bunn and Ezzo, 1993; Hawkes et al., 1982; Hill et al., 1987; Lee, 1981; Lupo, 2006; Marlowe and Berbesque, 2009; Speth, 1989). Nonetheless, there are few archaeological or ethnographical cases centred on middle latitude areas (Allué et al., 2015; Barlow and Metcalfe, 1996; Bettinger et al., 1997; Bigga et al., 2015; Byers and Ugan, 2005; Henry et al., 2014; Holst, 2010; Revedin et al., 2010; Talalay et al., 1984), which we build upon in our research. On the other hand, hunting and scavenging, as well as meat consumption, have been assumed to be the key to important steps in the evolution of the genus *Homo* (Bunn and Ezzo, 1993; Bunn and Pickering, 2010; Domínguez-Rodrigo et al., 2014; Mann, 2000; Milton, 1999, 2003), thus relegating gathering as a residual practice and forgetting that a varied diet is likely a modern human characteristic we inherited from our ancestors (Lee-Thorp et al., 1994, 2000; Speth, 1989; Sponheimer and Lee-Thorp, 1999). Numerous anthropological and ecological studies (Belovsky, 1987; Hawkes et al., 1982; Hill et al., 1987; Smith, 1981; Winterhalder, 1981) have been carried out since the 1980s to establish parameters for understanding the different subsistence strategies adopted by hunter-gatherer societies, i.e., foraging models. The main conclusion is that feeding decisions are conditioned by the efficiency of the acquired resources regarding the energy invested to get them (Bettinger et al., 1997; Smith, 1983).

Following this research line, our purpose is to study gathering as a foraging method for a Southern European Middle Pleistocene population, taking into account the availability of resources, the characteristics of the Mediterranean environments, the energy expenditure necessary to acquire resources and the energy return of their consumption. With the intention of giving a case study, we estimate the energy required for gathering nuts in the Sierra de Atapuerca environment (Burgos, Spain), where several Early Palaeolithic archaeological sites are located (Rodríguez et al., 2011), applying an experimental method based on energetics. This methodology has a long trajectory in medicine research (Shephard and Aoyagi, 2012) and was developed during the second decade of the last century for biological anthropology research (Leonard, 2012). Moreover, it has been applied recently to the field of human

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http://dx.doi.org/10.1016/j.jaa.2016.12.002
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evolution to investigate the energetic consequences of the different anatomical and physiological features of hominin species (Aiello and Key, 2002; Aiello and Wells, 2002; Froehle and Churchill, 2009; Leonard and Robertson, 1997; Leonard et al., 2007; Mateos et al., 2014; Snodgrass and Leonard, 2009; Sorensen and Leonard, 2001; Wall-Scheffler, 2012; Watson et al., 2008; Wheeler, 1991). This approach may also be used to measure the energy requirements of activities that are essential for the survival of a Palaeolithic population, such as raw material catchment (Vidal-Cordasco et al., in press) or the efficiency of gathering as a foraging method, as we seek to do here.

To reach this aim, we focus our attention on the European Mediterranean area in the Middle Pleistocene, were the environment has been reconstructed and well studied (Rodríguez et al., 2011). The paleoecological reconstructions agree with a Pleistocene Mediterranean Europe dominated by open landscapes with sparse forests and slight fluctuations between warm and humid, and cold and dry conditions (Cuenca-Bescós et al., 2011; Palombo, 2010). In accordance with this reconstruction and following the data provided by pollen analyses, the tree flora would be very similar to the present one, composed of conifers and broadleaves founded nowadays in the meso-Mediterranean bioclimates (de Rigo and Caudullo, 2016; Pividori et al., 2016). We dedicate our attention here to those trees that are nut producers, more concretely acorn producers, since acorns have never been studied as a potential food resource for Early-Middle Pleistocene populations. Acorns are produced by species in the genus *Quercus*. One of this species is the holm oak or evergreen oak (*Quercus ilex L.*) which natural distribution includes the central-western part of the Mediterranean basin, (from Portugal and Morocco, to the Aegean Islands and western Turkey, Italy and France and on the coast of the Black Sea in Anatolia) (see Map 1 in de Rigo and Caudullo, 2016). Two subspecies of holm oak are documented: *Quercus ilex* subsp. *rotundifolia,* restricted to parts of the Iberian Peninsula and Morocco, and *Quercus ilex* subsp. *ilex* extended for the remaining areas (de Rigo and Caudullo, 2016). Interestingly, *Quercus ilex rotundifolia* produces sweet acorns, which can be eaten raw, without any complex handling or processing requirements, as is discussed below in more detail. Since it is unnecessary to use fire in order to make these acorns edible, we may assume they were consumed along the entire Palaeolithic. It is accepted that the generalized control and production of fire in Europe is no older than 300–400 ka (Roebroeks and Villa, 2011; Stahlschmidt et al., 2015), but see the earliest evidence in Europe for use of fire in 800,000 years ago at the Spanish site of Cueva Negra, and at Gesher Benot Ya'aqov (Israel) a short time later (Goren-Inbar et al., 2004; Walker et al., 2016). Thus, our conclusions can be directly applied to all the populations inhabiting the area of distribution of *Q. ilex rotundifolia* along the Early and Middle Pleistocene.

As a case study, we obtained the archaeological implications of acorn gathering using data from the Gran Dolina archaeological site (Sierra de Atapuerca, Burgos, Spain). The Sierra de Atapuerca was chosen as the location to carry out the experimental reenactment of the gathering activities because this area provides abundant information to recreate the Southern European Pleistocene environments, the availability of food resources, and the behaviour and palaeobiology of the hominins inhabiting the area (Allué et al., 2015; Bennàsar et al., in press; Blain et al., 2008, 2009; Blasco et al., 2013; Cuenca-Bescós et al., 2011; Expósito et al., 2015; Huguet et al., in press; Rodríguez et al., 2011, 2014; Rodríguez-Gómez et al., 2013, 2014; Rodríguez-Hidalgo et al., in press, 2015; Van der Made et al., in press). The Sierra de Atapuerca is located 15 km to the NE of the city of Burgos (Spain) and contains several archaeological sites dating from the Early Pleistocene to the Holocene (Rodríguez et al., 2011). Within the Sierra de Atapuerca, the Trinchera de Ferrocarril includes three sites: Sima del Elefante, Gran Dolina and Galeria. We will focus our attention on Gran Dolina site, divided into 11 stratigraphic units named TD1–TD11 from bottom to top (Campaña et al., in press; Parés and Pérez-González, 1999) which represent a timespan from the Early Pleistocene to the Middle Pleistocene (Rodríguez et al., 2011). The abundant literature available about these archaeological sites includes studies on pollen, herpetofauna, and small and large mammal remains that provide reliable environmental reconstructions for the period from 1.2 Ma to 200 ka. Within the wide timespan that refers to the Middle Pleistocene, we will focus our attention on the period around 300 ka. This period is well represented by the TD10-1 bone bed level from the Gran Dolina site, a well-studied fossil assemblage. Environmental reconstructions for TD10-1 are available in Blain et al. (2009) and Cuenca-Bescós et al. (2011), and animal resources have been studied by Blasco et al. (2013), Rodríguez et al. (2011, 2014), Rodríguez-Hidalgo et al. (2015). The dominant landscape reconstructed from the TD10-1 assemblage was a savannah-like open environment with small forest patches, where the most abundant tree taxa were, in order of dominance, deciduous and evergreen *Quercus* (oaks and holm oak) and *Corylus* (hazelnut) (Garcia Antón and Sainz Ollero, 1991; Rodríguez et al., 2011), all nut producers. Thus, acorns and hazelnuts might represent an important energy source for the populations inhabiting Europe and, especially Atapuerca, during the Middle Pleistocene, represented by the Sima de los Huesos (SH) hominin sample (Arsuaga et al., 2015). Obviously, due to their organic composition, we do not have evidence of nut consumption at any archaeological site of this age. Still, on the basis of the ethnographic record, nuts are one of the foods preferred by humans when available (Belovsky, 1987; Binford, 2001; Cordain et al., 2000; Hawkes et al., 1982; Hill et al., 1987; Holst, 2010; Milton, 2000; Murray et al., 2001; Talalay et al., 1984). Interestingly, despite the abundant literature on the palaeoeconomy of those populations, nuts and other vegetable resources available on the environment have not been treated as potential food items until now. Although we acknowledge the widely documented importance of game hunting and/or scavenging for the Middle Pleistocene hominines at Atapuerca (Blasco et al., 2013; Rodríguez-Hidalgo et al., in press, 2015), the intention of this study is to draw attention to the importance of vegetables as a nutritional resource. Moreover, we assume that, as is the case with modern humans, SH hominins required a varied diet, including plant foods rich in fatty acids and other essential nutrients, to fulfil their daily metabolic requirements while maintaining a healthy physiological state.

The experiment was planned using ethnographic evidence found in the scholarly literature. Male and female groups participate actively in obtaining resources in most hunter-gatherer societies, but it seems that certain activities are performed principally by men and others by women (Bird, 1999; Gurven and Hill, 2009; Hawkes et al., 2010; Stiner and Kuhn, 2009; but see Bailey and Aunger, 1989; Endicott, 1999). The necessity of maintaining varied diets may motivate this gender difference in terms of foraging efficiency, social provisioning and food sharing (Hawkes, 1991; Hill, 2002; Hurtado and Hill, 1990; Kaplan et al., 1984; Marlowe, 2007; Stiner and Kuhn, 2009; Winterhalder, 1986). In addition to efficiency, there are other possible explanations for the collaborative labour observed among recent hunter-gatherers. Men and women allocate their time differently in response to risk-energy trade-offs, especially with respect to providing for offspring and childcare. Women may have high contributions in low-variance resource types and men may have contributions to very high-energy resources, depending on the availability of edible resources (Codding et al., 2011). It is important for women and children to avoid the more dangerous subsistence pursuits, thus protecting the reproductive core of the population from undue risk and exposing "expendable" male individuals to the more dangerous tasks. Finally, the demands of

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