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When and where do dogs improve hunting productivity? The empirical record and some implications for early Upper Paleolithic prey acquisition

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ABSTRACT

Recent archeological finds of protodogs dating to 35,000 years ago have ignited controversy over the function of canids in early Upper Paleolithic societies. Reconstructions nominate the use of proto and early dogs in hunting and hauling as underwriting changes in subsistence technology, catalyzing human population growth and supporting the spread of modern humans at the expense of Neanderthals. These reconstructions assume that the use of canids in hunting will always have profound impacts on human subsistence. In this paper, I summarize existing quantitative data derived from the ethnographic record to evaluate productivity gains derived from the use of dogs in hunting. To augment this sparse information, I present some of the only data on the deployment of unspecialized Central African dogs (basenji's) by hunter-gatherers. These data show that while dogs can enhance hunting returns in certain circumstance, their overall impact on hunting productivity is highly variable and often restricted to specific prey types. Furthermore, the complex circumstances surrounding the emergence and spread of dogs globally precludes simple applications of these data to the archaeological record. These data invite a reexamination of when and how we expect dogs to have a significant impact on human subsistence and the circumstances that supported the emergence and spread of canids as effective hunting aids.

1. Introduction: Early Upper Paleolithic dogs as collaborative hunting aids

It is widely accepted that dogs were derived from Pleistocene wolves (*Canis lupus*) and traditional reconstructions based on archaeological evidence from Central Russian place the earliest appearance of domesticated dogs some 16–17,000 years ago (Sablin and Khlopachev, 2002; Morey, 2014). But recent archaeological and biomolecular evidence suggest that dogs might have diverged some 15,000 years earlier (Freedman et al., 2014; Skoglund et al., 2015; Thalmann et al., 2013; Vilà et al., 1997; Wang et al., 2016). Biometric and morphological analyses of skeletal remains from early Upper Paleolithic sites in the Czech Republic, Belgium, the Ukraine and Siberia (Germonpré et al., 2009, 2012, 2015, 2017; Ovodov et al., 2011; Thalmann et al., 2013) identify incipient protodogs as early as 36,000–33,500 years ago (Germonpré et al., 2009, 2012; Ovodov et al., 2011). These analyses are bolstered by recent aMtDNA analysis of a fossil canid skull dating to 33,000 years BP from Razboinichya Cave, Altai Siberia that suggests it is more closely related to dogs than Pleistocene wolves (Druzhkova et al., 2013). Assemblage characteristics such as the co-occurrence of high abundances of mammoth (*Mammuthus primigenius*) and carnivore remains, specialized treatment of certain canid skulls, and isotopic evidence indicating that at least some of the putative protodogs consumed special meat (Bocherens, 2015) suggest the early emergence of a commensal and potentially incipient domesticated canid population in northern Europe. Because of the rarity of these finds and temporal gap between these early protodogs and later domesticated dogs, the early Upper Paleolithic specimens are viewed as possible failed attempts at domestication (Ovodov et al., 2011) that failed because human populations were too mobile to create the anthropogenic niches (i.e., garbage middens) that attracted and tethered canids to human settlements (Coppinger and Coppinger, 2001). These finds have not only ignited intense controversy over the identity of the fossils (see Boudadi-Maligne and Escarguel, 2014; Crockford and Kuzmin, 2012; Germonpré et al., 2013, 2015), but also the roles that these early protodogs might have played in Upper Paleolithic societies (see Perri, 2016b; Perri et al., 2015; Shipman, 2015a, 2015b).

The conventional view has always been that early domesticated and/or protodogs served utilitarian functions, particularly as a means of transporting gear and food and/or as cooperative hunting partners (e.g., Clutton-Brock, 1981, 1995; Downs, 1960; Fiedel, 2005; Shipman, 2012; Shipman, 2015a; Speth et al., 2013; Turner, 2002). Based on taphonomic evidence and mammoth age

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profiles from Upper Paleolithic so-called mammoth megasites in Eurasia dating between 40 and 15,000 years ago, Shipman (2015a) argues that these wolf dogs (or semi-domesticated canids) transported meat to residential sites and collaboratively hunted mammoths with modern humans who possessed complex projectile technology (also see Germonpré et al., 2012). These purported collaborations led to increased prey acquisition rates and a growth in human population size that supported the spread of modern humans at the expense of the Neanderthals (Shipman, 2015a, 2015b) and the emergence of a cooperative interspecies communication system between canids and humans (Hare and Tomasello, 2005; Miklósi and Soproni, 2006). Germonpré et al. (2017) envision wider generalized roles with protodogs transporting gear and raw materials, guarding camps and carcasses, and assisting in the capture of large and dangerous carnivores, as well as mammoths.

Central to these hypotheses is the idea that early canids work collaboratively with humans and will greatly enhance hunting productivity. Assuming these scenarios are correct invites a reconsideration of why protodogs and later early dogs were not immediately adopted by all groups, why it took so long for dogs to become widespread fixtures in human settlements, why dogs were never adopted or used by some populations, and the tradeoffs that hunter-gatherers made when dogs were deployed for other purposes such as haulage. One path towards explaining variation in dog deployment can be gained by understanding how and when dogs significantly impact hunting productivity, thereby allowing researchers to develop testable hypotheses for the archaeological record.

2. Evaluating changes in hunting productivity associated with dogs

Increases in hunting productivity associated with the introduction of new technologies, such as dogs, are frequently cited as sources of change in the archaeological record but researchers often have difficulty identifying expectations about how these changes will be manifested in the material record. In this paper, I assume that hunting productivity or efficiency can be evaluated with rationale derived from the diet breadth model. The diet breadth model assumes that resources can be ranked along a single dimension of profitability (usually kcals obtained per unit of handling time or the post-encounter return rate). The basic assumption is that foragers attempt to maximize the long-term net rate of energy acquisition by adding resources into their diet in rank order from highest to lowest until the return rate per unit of time is maximized (e.g., MacAuthur and Pianka, 1966; Pulliam, 1974; Smith, 1983). The costs of resource acquisition are usually partitioned into two opposing costs curves: search and handling. Since search is assumed to be randomized, the time devoted to searching for a resource is generalized across all the resources in the diet. Handling time includes the time spent pursuing, processing and consuming the prey after it has been encountered. Changes in the position of the two costs curves relative to one another resulting from technological change or other factors have important implications for the diet breadth (see Hawkes et al., 1982; Winterhalder, 1978, 1981). Winterhalder's (1978) analysis of how contemporary and historic technological changes influenced hunting and diet breadth among the Cree in Ontario is exemplary (Fig. 1, after Winterhalder, 1978:506). In this case, he showed how the advent of high-velocity motorized search technology in recent times (snowmobiles and motorized boats; Fig. 1a) lowered the search costs of high-ranking prey and narrowed the diet. One expectation is that under circumstances where introduced technology lowers the search costs of high ranking resources, the diet should become narrowly focused on those resources with an increase in productivity. Search often comprises the largest portion of the costs of acquisition, especially for game resources where acquisition is constrained by prey distribution and abundances, and reductions in search are one of the few ways that foragers can realize greater efficiency (e.g., Hawkes et al., 1982). But some larger-sized and potentially high value prey, such as mobile animals and some megafauna, also have very high handling costs rendering them low ranked options relative to other prey (Bird et al., 2009; Lupo and Schmitt, 2016). Expensive and sometimes dangerous prey are often associated with prolonged pursuits and/or have especially low rates of success (i.e., high rates of hunting failure where pursuits fail). Reductions in the search costs will not necessarily influence the abundance of expensive prey in the diet because acquisition of these animals is constrained by handling costs (Lupo and Schmitt, 2016). Novel technology that reduces the handling (but not search) costs of expensive prey may change the ranking of these resources relative to others in the diet, but the diet should remain relatively broad. Moreover, certain expensive resources that were previously rarely exploited may be better represented in the diet. Reduced handling costs of expensive prey will not necessarily narrow the diet if the search costs and encounter rates for those items remain unchanged. However, some of the most profound dietary impacts should result if the introduced technology reduces both the search and handling costs of highly valued and/or expensive prey. In this case, the diet should become narrowly focused on those resources with the latter becoming much more abundant in the diet and potentially greatly increase foraging efficiency.

Dogs can realize a decrease in search costs and an increase in prey encounter rates by flushing and finding animals. These characteristics may be especially important with pedestrian hunts where prey resources that are highly dispersed or have low densities, are cryptic or fossorial, and/or occupy biomes with heavy vegetation and rugged terrain. Reductions in search costs become less beneficial with prey that use habitual paths or runways or that are highly predictable in location and where hunting require stealth and ambush strategies and the use of some stationary technology (traps, snares). Dogs can also reduce the handling costs associated with prey acquisition by distracting or baying dangerous animals, pursing wounded prey and finding carcasses of animals that have been killed. The latter characteristics are especially advantageous with the use of certain kinds of dispatch technology that do not always immediately kill the animals, such as poisoned arrows (Lupo and Schmitt, 2016) or in heavily vegetated areas and rugged terrain where locating dead animals is difficult. The ability of dogs to chase and locate a wounded and dying animal or the carcass of one that has died from its wounds is a crucial factor that reduces the chances of hunting failure and improves success (see Lupo and Schmitt, 2016). However, the benefits derived from deploying canids vary in response to the advent of other dispatch and transport technologies (i.e., horses, snowmobiles) (Osaki, 2005), prey characteristics, canid breed characteristics, and ecological contexts (i.e., vegetation types, terrain) (Koster and Noss, 2014; Perri, 2016a). Consequently, the advantages of hunting with dogs are not uniformly applicable to all circumstances and increases in productivity associated with the acquisition of particular species cannot be extended to all prey.

3. Hunting and dogs in the ethnographic and ethnohistoric record

While there is no doubt that dogs are frequently used as adjunctives to hunting in the ethnographic record, quantitative data demonstrating how and when the use of dogs improve productivity in small-scale societies are surprisingly limited (but see Koster,