Initial Cultivation from Hunters' Perspective

Serge Svizzero

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Serge Svizzero
University of La Réunion
serge.svizzero@univ-reunion.fr

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ABSTRACT

Most theories of the transition to agriculture have to use strong assumptions to explain initial cultivation given its low productivity and high risk. We propose an alternative explanation in which initial cultivation is viewed from hunters' perspective, i.e. is part of an hunting strategy, namely baiting. Indeed, the hunt of large preys has been prized in foragers societies of all epochs. According to niche construction theory, Holocene hunters have had to create open-spaces in the dense vegetation since their rich edges attract wild game, especially large herbivores. To enhance this attractiveness, it is likely that hunters have developed food plots by transplanting and cultivating some wild plants, including the progenitors of future domesticates. As an alternative to hunt drive, another advantage of baiting is that, when food plots are corralled, it may lead to the capture of animals. The latter were kept alive either to be slaughter later or to be tamed. The hunting strategy based on baiting through initial cultivation may therefore have also contributed to the prey pathway to initial domestication. The hunting and the domestication processes of Near-Eastern wild caprines provide archaeological evidence supporting our view.

Key words: hunter-gatherer, Neolithic revolution, niche construction, hunting strategies, baiting, domestication.

INTRODUCTION

The transition from foraging to farming is one of the most debated topic among scholars. Until the 1990s, the various existing theories were categorized as push or pull models according to whether this transition was either forced or intentional. Since the last two decades, new data and new ideas have appeared (Price and Gebauer, 1995; Bellwood, 2005; Price and Bar-Yosef, 2011). Although the push/pull models highlighted important mechanisms - such as resource depression, population pressure, social competition or cognitive changes - they have been progressively dismissed since they were based on mono-causal factor explanation which, moreover, did not fit well with archaeological evidence. In addition to anthropologists and archaeologists, new scientists (economists, geneticists, biologists...) have recently paid attention to the Neolithic revolution. The resulting "new" theories favor multi-causal factor explanation. Among these new theories, two approaches are of great interest. On the one hand is the study of human/environment interaction and thus the developments derived from Behavioral Ecology. This has led to two competing theories: Optimal Foraging Theory (Winterhalder and Kennett, 2006), based on asymmetrical adaptation, and Niche Construction Theory which assumes symmetrical adaptation (Smith, 2007, 2015; Zeder, 2009, 2015). On the other hand is an approach focusing on the role of

institutions. Among the latter, the role of property rights and their assumed co-evolution with farming is considered as central in the emergence of agriculture (North and Thomas, 1977; Bowles and Choi, 2013, 2016; Gallagher et al., 2015).

Despite their respective relevance, all these theories - the "old" and the "new" - do not lead to the definition of a unified theory of the transition from foraging to farming. Indeed, each existing theory provides a convincing but still incomplete explanation of the neolithization process. We believe that this shortcoming can be overcome by considering the situation in which HG (Hunter-Gatherer) were actually living before the advent of agriculture. In other words, we believe that the transition to farming must be conceived from a HG's perspective. Indeed foraging and farming are, in existing theories, conceptualized in a restricted manner. Of course foraging and farming are two different technologies or economic systems through which food resources are obtained. In the foraging system, predation is central. HG get their food procurement by means of various techniques such as hunting, gathering, fishing but all the food resources are produced by the nature. On the contrary, in the farming system food resources are produced by human by means of plant cultivation and animal rearing. In fact, the main problem in the academic literature is about the assumed relationships between foraging and farming. Three main relationships between foraging and farming are assumed in the academic literature about the origin of agriculture.

The first one is widespread; it assumes that foraging and farming are two independent and subsequent economic systems. In other words, foraging and farming are alternatives means humans can used to get food resources. Since foraging existed before farming and has progressively vanished after the Neolithic revolution, it has long been assumed that both systems were subsequent stages of development (Morgan, 1877; Adam Smith, as recall in Meek et al., 1978). In order to strengthen this vision of foraging and farming considered as alternatives, both systems have often been stereotyped in the academic literature. For instance, foraging is associated with a nomadic lifeway while farming is linked with sedentism. Similarly, sharing or communal property is considered as a central feature of simple HG societies (Lee, 2004; Lee and Daly, 2004; Benz, 2010; Widerquist and McCall, 2017) while it is assumed that farming requires exclusive property rights (Bowles and Choi, 2013, 2016).

The second relationship is more recent in the academic literature and has appeared since the early 2000s. Once again foraging and farming are supposed to be independent but not necessarily subsequent stages. Indeed, it is now clear that foraging and farming have coexisted during millennia. According to Smith (2001) such mixed economies in which at least 50% of the diet came from foraging have been labeled "low-level food production". While the existence of such mixed economies is now commonly agreed, there is still a debate among scholars concerning their meaning. For some authors (Smith, 2001) such mixed economies have lasted long because they provided - especially during the early Age of agriculture - a strategy of risk reduction. For others, mixed economies may last long only in marginal environments, not well suited for agriculture, and therefore they only represent an unstable and intermediate stage of development in the course to the advent of agriculture (Bellwood and Oxenham, 2008; Bowles and Choi, 2016: section 3.4). Whatever their meaning, it is important here to note that although foraging and farming are contemporaneous in mixed economies, they are still considered as two independent economic processes of food procurement.

By contrast to the two previous ones, the third relationship introduces some dependence between foraging and farming. More specifically, it is assumes that agriculture entails what

economists called a positive externality[i] on hunting. In other words, agriculture concentrates food resources in cultivated fields and these crops attract wild game. Farmers may therefore hunt easily wild game in their fields or in their vicinity. In the academic literature such situation has been called the "garden hunting model" (Linares, 1976). Some degree of crop loss to animal pests is considered acceptable, since the net effect is to concentrate the animals in the gardens and fields and thus reduce the expenditure in time and energy in hunting them. Moreover, the biomass of certain species increases when permitted access to cultivated crops. In garden hunting, protein from wild animals becomes a by-product of farming. Garden hunting is assumed to have existed in various contexts, such as in the Neolithic mosaic of the north European plain (Bogucki, 1989). A small number of studies has given evidence of garden hunting in the Neotropics (Neuseus, 2008; Clinton and Peres, 2011). Moreover, these studies have demonstrated that, depending on the return of their agricultural production, farmers may hunt either selectively or opportunistically (when they are more in need of food resources). It should be noted that although foraging and farming are not independent, such dependence is asymmetrical. Indeed, foraging (hunting in fact) appears now as a by-product of farming.

We believe that in addition to the three previously stated relationships between foraging and farming, a fourth one should be considered. According to the latter, foraging and farming could be dependent economic systems and, furthermore, it is farming which would be dependent on foraging. More precisely, initial cultivation[ii] can be envisioned as a mean introduced by HG in order to attract wild game in special location and therefore to improve the return of their hunting activity. In such scenario, initial cultivation was not dedicated to feed human population, it was only an input of the hunting process. It is only when the hunt fails - whatever the reason - that HG have harvested the plants they had cultivated and have decided to use the product of their cultivation in order to complement their diet.

In the sequel of the present paper we present several arguments, as well as archaeological evidence, which support our view. We thus provide an original explanation of initial cultivation; such explanation derives from the fact that we have initially considered the transition to farming from a HG's point of view. We have to recall that even though foraging activities and societies were very diverse (Kelly, 1995), hunting is central in all foraging societies, from the far past to the most recent ones. Three evidences support this claim.

First, HG have always favored animal food in their diet and of course animals have first to be hunted (except when meat comes from scavenging). As demonstrated by Cordain et al. (2000: 682), whenever[iii] and wherever it was ecologically possible, hunter-gatherers have always consumed high amounts (45–65% of energy) of animal food. Most (73%) of the worldwide hunter-gatherer societies derived >50% (56–65% of energy) of their subsistence from animal foods, whereas only 14% of these societies derived >50% (56–65% of energy) of their subsistence from gathered plant foods. In other words, the biological goal of foragers leads them to consider hunting as a crucial economic activity.

Second, in all societies (of foragers, farmers or else) and at least until the last decades (of the twentieth century), hunting has always been associated with social competition and prestige. This was especially true for pre-Neolithic foragers since hunting was the only mean to get animal food. We recall that even though foraging societies are considered as egalitarian, there was some degree of labor division and specialization based on gender: the men hunted and the women gathered. Hunting was therefore a male activity and even in a egalitarian society a good hunter had special advantages such as more mating. Most hunter-gatherers prefer to hunt

for big game, even though big game is treated as common property of the band regardless of who kills it. Social approval, prestige, and competition for wives seem to be adequate incentives to get males to hunt for the whole band (Hawkes, 2001). For instance, Hawkes (1991) uses the Ache people of Paraguay as evidence for the "Show-off hypothesis", i.e. the concept that more successful men have better mate options. Food acquired by men was more widely distributed across the community and inconsistent resources that came in large quantities when acquired were also more widely shared.

Third, the central importance of hunting in HG's society is also confirmed by the ubiquitous presence of animals and hunting scenes in parietal art[iv] of the upper Palaeolithic period (see e.g. Clottes and Lewis-Williams, 1998) while plants or fish are absent of cultural manifestation until the Neolithic period.

Finally, and as pointed out by Frison (1998: 14578), despite the abundance of animal remains that were hunted during the prehistoric period, their taphonomic analysis tells us very little about the actual procurement strategies involved. This has led many archaeologists to have relied on rock art of hunting episodes. However the latter violate many rules of intelligent hunting and thus lead to inaccurate and false impressions of predator-prey relationships. Therefore, there is no reason to *a priori* exclude, among the possible prehistoric hunting strategies, the cultivation of food plot in order to attract wild game, either to kill them or to capture them into corrals.

TRANSITION THEORIES BASED ON HUMAN/ENVIRONMENT INTERACTION

As explained previously, foraging and farming are in most theories of the transition considered as alternatives. Therefore, the attention is focused on the choice made by HG between both. This has led to two different visions, according to whether this choice is either forced or intentional.

Non-Intentional Change and Optimal Foraging Theory

From a chronological perspective, the theories that have assumed that the shift to farming was constrained have been labeled as "push models". These models are clearly part of a Darwinian or neo-Darwinian perspective since farming is the result of human adaptation to external forces or constraints. Various models have highlighted the role of external constraints which can be categorized as either resource depression due to climate change (Childe, 1936; Dow et al., 2009: Bar Yosef, 2011) or population pressure (Binford, 1968; Cohen, 1977, 2009). Despite their relative interest to provide global narratives of the Neolithic revolution, these push models have been progressively dismissed since they exhibited two shortcomings. First, each of these models was based on a mono-causal factor explanation while most recent archaeological studies have proven several causal factors should be taken into account. Second, these push models were assuming external constraints which - based on archaeological evidence - were not present when the transition to farming has occurred. More precisely, farming was initiated in declining not growing populations and the Neolithic agricultural revolution took place under increasingly farming friendly climatic conditions not under climatic adversity (Price and Bar-Yosef, 2011; Bowles and Choi, 2016).

During the last decades, another school of thought relying on human adaptation has emerged, namely the Optimal Foraging Theory (OFT; see Winterhalder and Kennett, 2006). According to this human behavioral approach, HG behave as optimizers. Indeed they decide what to

forage, when and where, in order to maximize the net energy they get, i.e. the difference between the calories they spend for foraging and the calories they get by consuming the wild resources they have foraged. Based on such behavior, OFT has led to the Diet Breadth Model (DBM). Diet breadth is a classic OFT model from human behavioral ecology (HBE). Different resources, ranked according to their food value and processing costs, are distributed in the environment in different densities. Foragers search for resources and decide to take them according to rank. A forager will preferentially take highest ranked resources, i.e. resources providing the highest net return. Within increasing dietary stress - owing to resource depression and/or population pressure - a forager will be willing to take a wider variety of resources at different ranks. It is thus assumed that some of these lower rank resources - defined as such due to their low energy value and high processing costs - could be proto-domesticates plants, such as wild cereals or pulses. In other words the DBM establishes the conditions under which lower-ranking resources, like the progenitors of crop plants, will enter the diet of foragers prior to their eventual domestication. Although the DBM provides an explanation of the reasons that bring foragers into contact with potential domesticates, it fails to explain the how and the why of their subsequent initial domestication (Smith, 2015). As for the "push models" previously presented, and even though it is also based on human adaptation, the DBM fails to give a complete and convincing explanation of the transition from foraging to farming.

Intentional Change and Niche Construction Theory

The failure of non-intentional choice models to explain the shift to agriculture has led some scholars to consider what could happened when this choice was intentional. A first generation of theories has been labeled as "pull models". In these models (Bender, 1978; Hayden, 1990) it is mainly social competition and the search of prestige among HG that lead them to adopt agriculture. Since agriculture is assumed to produce more surplus than foraging, it is well suited and preferred for feasting and thus to socially promote people who organize such feasts. However, these models suffer a chicken-and-egg problem. It is sure that once agriculture exists it will be preferred to foraging if it provides more surplus. Nevertheless, nothing in these theories explains the how and the why of the first domestication, i.e. the reason explaining why agriculture has initially emerged.

Niche Construction Theory (NCT) was developed directly out of macroevolutionary theory in the mid-1980s. Contrary to the Darwinian and neo-Darwinian approaches previously presented, NCT centers on the issues of directionality and intent in evolution. In other words, adaptation is considered as being symmetrical, i.e. human adapt to environmental changes (as in the Darwinian approach) but human also adapt the environment according to their needs. The core principle of NCT is therefore the deliberate engineered enhancement of ecosystems. For explaining the transition to farming, it is assumed that pre-Neolithic foragers living in resource-rich environment and in small-scale societies have developed resource management systems. Experimentation and trial-and error process have allowed these HG to identify resources which could be enhanced through human manipulation and some of these manipulations have subsequently led to the initial domestication of plants and animals (Zeder, 2009; Smith, 2007, 2015).

Contrary to the DBM, the NCT, as stated above, seems to explain the how and the why of the Neolithic revolution. However, we believe that, despite it provides a convincing story, this approach presents also some shortcomings. First, we have to recall that pre-Neolithic people were foragers with a strong interest for hunting. Therefore, if they did some resource management systems, it should have been first to improve the return of the hunting activity.

This gives rise to two additional question. On the one hand, we have to identify how it was possible, from a pre-Neolithic hunter point of view, to improve the return of hunting. We have various evidence that the niche construction efforts of small-scale human societies may modify vegetation communities in ways that result in the capture of a larger percentage of an ecosystem's total biotic energy. For instance Smith (2009) provides explanation on how the white-tailed deer (*Odocoileus virginianus*) was managed by hunters in the Mississippi River Valley corridor. On the other hand we have to establish which links could exist between such improvement and the occurrence of initial cultivation (more on this in sections 4 and 5). The second shortcoming of the explanation of the transition to farming based on the NCT is pertaining to the efficiency and the duration of the domestication process. On the one hand, several recent publications have demonstrated that farming was less productive than foraging during the early Age of agriculture (Harlan, 1992; Bowles, 2011; Berbesque et al., 2014). If HG have developed some experimentation with respect, for instance, to plants, why have they pursued these low-return experimentation? Indeed, it is sure that HG have developed experimentation based on trial-and error process, but when an experiment provides a lower return than the return you are use to get (for instance from hunting), it becomes an error to pursue such experiment and any rational people should give up such experiment after a certain number of repetitive failures. On the other hand, several recent publications (Larson et al., 2014; Zeder, 2015) have demonstrated that domestication was a very long process, i.e. it took millennia from initial cultivation to domestication, the latter being defined as genetic or morphological changes in plant and animal species. For instance and according to Larson et al. (2014: 6142), "*In wheat, barley, and rice, it took 2,000–4,000 y to fix the nonshattering spikelet phenotype, a key indicator of cereal domestication*". What is important here to note is that without the nonshattering spikelet phenotype - i.e. dehiscent or without seed retention - the harvest of cereals is very difficult since seeds readily fall off the stalk. Rather than stalk-harvesting with a sickle, the "solution" is thus to beat the seed heads into baskets but such solution requires much more labor. Moreover such harvest requires the constant vigilance as the field ripens. Indeed, if people want to harvest before the cereal is ripe, the harvested grains could not be stored because moisture would develop and the stored grains would have rotten. Similarly, if people want to harvest too later, it would be impossible since most seeds would have already fallen on the ground. Thereby, the harvest of cereals with shattering seeds has a very low productivity and it is difficult to imagine that the first farmers have cultivated such plants during 2 to 4 millennia in order - as their main goal - to sustain their own diet.

The previous story may be different if we assume that the foragers did cultivated wild cereals - even with shattering seeds - and that such production was not harvested and not dedicated to feed human but it was grown in food plots in order to attract wild game. This explanation is also consistent with the observed low productivity of early farming. Indeed, the cultivation of food plots required efforts from the HG and moreover such food production had low return. Why some HG have therefore started such costly cultivation? The answer is simple, it is because the losses supported by the HG - corresponding to cultivation effort leading to low yield plus the part of crop fields destroyed by wild animals - were offset by the gains provided by the increased return of hunting.

PROPERTY RIGHTS AND THE TRANSITION TO AGRICULTURE

There is among scholars an ancient and ongoing debate about what is the main source of socio-economic development in modern as well as in past societies. Two schools of thought are present and focus on the role of either nature or culture. On the one hand is a vision

defined as "environmental determinism" (Diamond, 1997; Olsson and Hibbs, 2004). According to the latter, economic development is primarily dependent on ecological and geographical conditions (e.g. climate conditions, soil quality, the existence of plants and animals suitable for domestication). On the other hand is a vision centered on the role of institutions (North, 1990; Acemoglu and Robinson, 2012). While in modern societies these institutions are numerous and diverse, they were quite limited in number during the prehistoric period and the regime of property rights was probably a central institution. From this point of view, it is usually claimed that - past as well as modern - HG societies did not develop beyond bands to tribes and chiefdoms because they did not have the required institutions to do so. Indeed, sharing or communal property is the social norm of HG societies and for mobile HG common property also includes land and its resources (Lee, 2004; Benz, 2010). Symmetrically, some authors (North and Thomas, 1977; Smith, 1993; Bowles and Choi, 2013, 2016; Gallagher et al., 2015) have argued that farming societies did develop from tribes to chiefdoms and ultimately to states because they had introduced exclusive property rights. More precisely these authors claim that there is a mutual dependence or a coevolution of farming and exclusive property rights and consider, as two premises, that farming requires private property, and that private property requires farming[v] (Bowles and Choi, 2013: 8831).

Agricultural Long-Term Investments

The rationale of the first premise is then explained as follows. Contrary to most[vi] foraging activities - which correspond to an immediate-return economy (Woodburn, 1982) - farming is inherently defined as a delayed-return economy. This means that before being able to harvest the crops they have planted or to slaughter the animals they have reared, farmers have first to incur some investment (measured in units of time devoted to labor). If they accept to do so, it is precisely because property rights are private, i.e. farmers have the guarantee that they will own in the future the crops of the fields they cultivate (or the animals they rear). So, the main difference between common and private property rights is that the latter provide more incentive, i.e. they foster farmers to do more effort than foragers usually do. We may hardly challenge the impact of the regime of property rights on incentives. However, what is dubious is the existence of the assumed long-term investments that farmers have to undertake, especially if we consider the early age of agriculture. Let us turn to what could be these investments.

First we all have in mind that farming requires the existence of fields and therefore that some forest clearance have first of all to be done. Although this cannot be contested, it is not sure that forest clearance necessitated a lot of effort since it was mainly based on the use of fire. Second, we know that farming requires some tillage which could be another source of important investment in labor. However it was not likely to occur for the first farmers. Indeed, the first cultivation have started along alluvial plains in which the soil is usually soft. Sowing seed was therefore possible through simple broadcasting or by using a digging stick; the wooden plow (called the ard or scratch-plough) has been introduced much more later in Mesopotamia, about 4,000 to 6000 BC, according to Lal et al. (2007: 2). Third, it is well known, as illustrated by the first agrarian civilizations of Mesopotamia, that agriculture has required the building of complex and costly irrigation systems. However such requirement was not necessary for the first cultivators who, once again, had chosen to cultivate alluvial plains, i.e. had located their fields in well-drained places, near rivers or lakes. Fourth, there are evidence that Neolithic farmers have tried to enhance soil fertility but since the first cultivators did used livestock manure as fertilizer, it cannot be considered as an important investment (Bogaard et al, 2013). Moreover alluvial plains are naturally enriched by deposits loams and therefore do not require the enhancement of soil fertility.

To sum up, and as supported by archaeological evidence, many sites of early agriculture were settings where crops could be sown with a minimum of labor. The most striking case is what is known as "flood-retreat" agriculture—broadcasting seed on the soft and fertile silt left on a riverbank by the receding annual floods. Since neither clearing, tilling, irrigating nor manuring were necessary or associated with long-term investment for the first cultivators, a central question is remaining : which investment do the first cultivators actually had to incur? An obvious answer is then that they had to protect their cultivated fields from predation.

The Protection of Cultivated Fields

In fact the previous answer should be twofold since fields have to be protected from predation by human and by wild animals. Let us turn to these two possible sources of predation.

We may consider a situation in which a small group of HG, say a band, is sedentarized and organizes its settlement as an hamlet. Then some of these HG decide to cultivate crops in gardens and fields located around their settlement. Do they have to worry about the destruction of their planting by other humans? In fact we have to distinguish between two sources of predation by humans. First the predation could be done by some people belonging to the same band, i.e. living in the same hamlet. However this can hardly happen. Indeed, although private property already existed among HG - through deference to possession - and concerned personal items such as clothes, weapons, tools and settlements, land and its standing resources stocks were considered by HG as commons even after the Neolithic revolution (Lee and Daly, 2004; Krier, 2009). In fact farming does not necessarily require private property in land which emerges when agricultural land becomes scarce under pressure of growing population (Boserup, 1965: 78). More generally, the development of common property or private property regimes depends on economic defendability (Acheson, 2015). Furthermore what matters is not the private ownership of land *per se* but the right to use a plot of land exclusively and the right to own privately the products of cultivation. Both rights do not necessitate particular efforts or investments for their enforcement since planting and harvesting had the effect of marking plots of land with unambiguous signs of possession. These signs were sufficient to provide deference to possession between cultivators of a same hamlet and thus defendability of cultivated plots was not necessary. Second, predation could come from people belonging to another group, be they either foragers or cultivators. However, any hamlet of first cultivators was socially organized as a band of HG, i.e. group members were relatively few in number, known to each other, share common interests, interact repeatedly and moreover were often tied by kinship. These features facilitate cooperation, i.e. close-knit groups have advantages in overcoming obstacles to constructive collective action. It is thus likely that members of a same group defended all the cultivated plots of land on a territoriality basis[vii] as they did for their hunt territory. The defendability of cultivated fields and gardens with respect to foreigners was therefore collectively supported, meaning that the defense-cost incurred by each cultivator was very low. In other words, plots of cultivated land were hold privately within the band but were hold as common property with respect to non members of the band. This is because, for any cultivator, the costs of exclusion of non members are high relative to the value of resources, then the probability of a common property regime being developed or maintained is high.

Since the predation of cultivated crops by human was not (a major) problem, let us consider predation by wild animals. Here the story is different because it is certain that wild game were attracted by cultivated crops and it is also certain that they were not prone to have any sort of deference to human possession. In other words wild game was an obvious threat for

cultivators. In order to tackle such threat, cultivators had two possible strategies The first is to use traps and snares in order to prevent wild game to destroy the cultivated crops. The second strategy is to prevent wild game to enter into the cultivated fields by fencing. Technically both strategies were possible but they were not from an economic point of view. Traps and snares may indeed catch or prevent some of the wild game but not all, and in one night a cultivated field can be completely destroyed for instance by a herd of deer or wild boars. If the purpose of the cultivator was to grow crops in order to feed his family, this strategy was very risky, i.e. famine was likely to occur. Fencing was possible, especially for small garden, but for large fields - such as the ones required to get a large production for feeding a whole family - the cost of fencing, plus the maintenance cost of the barriers, would have been very excessive. Then, when the costs of exclusion are very high relative to the value of resources, open access will likely result.

From the previous statement, we reach - for a different reason - a conclusion similar to that of the previous section: the purpose of the first cultivators was not agricultural production *per se*. Indeed, these first cultivators were perfectly aware that wild game was a threat. Using traps was too risky and fencing fields was too costly. In addition farming had a very low productivity in its early age (Bowles, 2011). Despite all these drawbacks, some HG have nevertheless initiated cultivation; therefore their purpose was not to produce food resources in order to feed their families since it was more productive and less risky to do so by means of foraging activities. We believe that their purpose was linked to the hunting process.

THE EVOLUTION OF HUNTING STRATEGIES DURING THE PLEISTOCENE-HOLOCENE TRANSITION

We have recall in the introduction of the present paper that hunting, especially of large preys, had a central role in HG societies for biological reason - to sustain their diet - as well as for socio-cultural reasons - to get prestige and reputation (Hawkes, 1991). The hunting process includes the hunting strategies used for locating, targeting, and killing a targeted animal, but also the species hunted and the main challenges faced by the hunters. It appears that the transition from the Pleistocene to the Holocene has implied deep modifications of the hunting process. Indeed the climate change has induced environmental changes (Roberts, 2004) which in turn have modified the animal species that could be hunted and thus the hunting strategies. In the sequel of the present paper we focus on the hunting of large game (ungulates) since they were prevalent in Middle and Late Pleistocene archaeo-faunas. Such focus does not mean that we neglect the importance of small-game hunting, as highlighted for instance by Stiner et al. (2000).

Pleistocene Hunting: The Dominance of "Pursuit Modes"

During the Pleistocene the climate was cold (or glacial) and therefore the ecosystems were dominated by steppes and grasslands. In such environment most animals were large herds of big mammals (such as reindeer, bison, gazelle...). In such context, the main challenge for hunters was not to locate animals since they were numerous (large herds) and were evolving in steppes where they were easily visible. Instead, the main challenge for hunters was to get sufficiently close (few meters) to the animals in order to shoot them by using spears. The problem was that if the animals detected the hunters before they shoot, they were escaping in any direction. To overcome this challenge, hunters have used various strategies. Some were passive such as trapping, blind or stand hunting, i.e. waiting for animals in a concealed or elevated position (see e.g. O'Shea et al., 2013). Other strategies were more active, such as

stalking, but the widespread strategy used by hunters was driving, i.e. to surround the herd - especially of migratory animals, such as bison or reindeer - since at least some hunters would be able to shoot the preys if they escaped in their direction. Hunters have built elaborate drive structures, using stones and brush, with the goal of driving large number of big mammals into narrow lanes, water, cliffs, valleys nets or corrals. In the Levant for instance, such stone structures, called "desert kites", are numerous. They have been used for mass harvesting of wild ungulates and have likely contributed (in the post Neolithic period) to the extirpation of some species, such as the Persian gazelle (*Gazella subgutturosa*) (Bar-Oz et al., 2011). It should be noted that driving, i.e. the herding of wild animals in a particular direction, required a large number of hunters, i.e. driving was mainly a collective task - and thus a costly hunting strategy.

Holocene Hunting: The Dominance of "Search Modes"

The global warming of the Holocene has deeply modified the environment. In the temperate area, the steppes have been removed by dense forests. In such ecosystems, large herds of big mammals have been replaced by smaller herds of large game (deer, wild boar), and small game (e.g. hare, tortoise, beaver, birds and fowls). Since all these animals were now living in dense forests, the hunters have faced several new challenges. The first one was first to locate these animals. For this purpose, hunters have had to improve their knowledge of animal habits, such as their seasonal behavior pertaining to feeding, migrating and breeding. Passive hunting strategies, such as trapping, became more widespread. It should be noted that the dog was the first domesticated species of animal. Gray wolves, the source species, are asserted to have first evolved into dogs in East Asia c. 15,000 BP, during the latter stages of the most recent Ice Age (Savolainen et al., 2002). Since dogs have been domesticated especially during the Pleistocene-Holocene transition, one may surmise that it was mainly to use them as hunting companions (Schmölcke, 2013). When animals were located, a second challenge for hunters was to be able to shoot them before they escape. For this purpose, hunters have developed new weapons - such as atlatls and bows - able to shoot spears and arrows on longer distance. However, throwing a spear or an arrow in a wooden forest is a third challenge. Indeed, spears and arrows can be diverted from their target by the brush and the tree branches. In order to tackle this third challenge, Holocene hunters had to hunt in open-spaces such as glades. Here comes the final challenge for hunters, it was to attract wild game in such open spaces. In other words, baiting, i.e. the use of food to attract targeted animals outside of their forest dwelling, became a widespread hunting strategy.

Managing the Vegetation to Attract Wild Game through Trophic Cascade

It is certain that pre-Neolithic HG have practiced an integrated overall strategy of restructuring vegetation communities in ways that enhanced and expanded the habitats of many important food sources. According to such perspective, hunting and forest fragmentation are correlated as open-space promote sustained hunting, a point also advocated for gardens by Linares (1976). In all ecosystems, including the Neotropics (Stahl, 2008), habitat mosaics that are created and maintained as open-space - and later as gardens and fallowed fields - are prime locations for procuring animal prey. In Central Brazil for instance, the Kayapo´ do not fell large trees with honey combs simply to gather honey, but expressly for creating large forest opening, which attract game animals and provide spaces into which useful plants are subsequently introduced. In fact, most large game (deer, elk...) have an important part of their diet which consists of the twigs, shoots, and leaves of low growing shrubs and bushes. Therefore, their population densities are low in climax forest situations where a closed canopy has been established, and are high in early successional situations that have small areas of varying types, producing maximum edge areas between habitat zones. As

a result, medium levels of human clearance of vegetation would actually have improved their habitat and increased carrying capacity levels (Smith, 2009).

Pollen and phytolith studies provide evidence of forest clearing. From a long time ago, human have used fire to transform their landscape, having noticed that fire cleared older vegetation and encouraged a host of quick-colonizing grasses and shrubs—many of them bearing desired fruits, berries, and nuts. They especially have noticed that fire later stimulated the browse that attracted game. In fact fire acts as a powerful magnet, bringing a suite of desirable flora and fauna closer to HG's settlement, the resulting concentration of foodstuffs and game leading to the reduction, in proportion, of the necessary radius of hunting and gathering.

Corralling Wild Animals: Driving vs Baiting

By the restructuration of vegetation communities, HG have thus indirectly increase, through trophic cascade, the relative abundance of wild animals, especially of a wide range of browsing herbivores that they highly valued as food resources. Besides these efforts, more direct strategies to reduce effort and increase the predictability of high-value animal species were also possible. In fact two hunting strategies may have a high return since they both lead to corralling a large number of animals which may be easily killed or captured. Although the end is similar, these two strategies use different means to lead animals into the corral.

The first one is driving. Although it was the dominant form of hunting strategy during the Pleistocene, it remained a hunting strategy for Holocene hunters. It consists in channeling and constraining animals' movement to allow for easier harvesting. For such purpose, some natural features of the landscape have been used by HG, such as headcuts in arroyos, parabolic sand dunes, and narrow, deep, steep-sided valleys or corridors (Frison, 1998: 14580). When such natural features of the landscapes were not available or insufficient, structural modifications of the landscapes have been created and maintained by HG, often over long periods of time. For instance, this includes terrestrial fences - made either of stones, brush or wood - placed to facilitate the driving of large herbivores into corrals for killing (Smith, 2011).

The second possible strategy is baiting. While HG have improved the habitat of many of the animals they hunted by burning and clearing forests, they may also have attracted these animals by planting crops in dedicated areas, the so-called food plots. Such hunting strategy is defined as baiting. Baiting is the use of decoys, lures, scent or food to attract targeted animals. Although all these different means were existing for HG, we focus here on the use of food to attract wild game. Baiting large herbivores by means of cultivated food plots can be a strategy HG have adopted once they had domesticated the dog. Indeed, the dog (and possibly also the wild pig, but later) has been domesticated through a commensal pathway, i.e. it has been involuntary attracted to feed on refuse or other animals (other commensals, such as rodents) attracted to human settlements. In other words, it is food, involuntary used by HG as a bait, that as attracted dogs to come into initial contact with humans. Afterward, HG may have adapted and transposed such strategy to attract herbivores. Animals attracted to food plots have a special set of characteristics. Certain animals, such as white-tailed deer and turkey, are drawn to disturbed environments such as food plots or forest edges because of the concentration of crops and weedy plants.

Even though food plots have existed in the pre-Neolithic period, one question is remaining: why HG should have cultivated in these food plots plants such as wild cereals and pulses? Two reasons may explain this choice. First we believe that the first cultivators had strong

incentives to grow crops - e.g. wild cereals and pulses - in their food plots. Indeed, as it is confirmed by still current recommended method to plant a food plot, cereals and pulses are highly prized by ungulates and are also very attractive for several species including birds, hares, rabbits and wild boars. Second, the initial cultivation of food plots was probably very rudimentary, i.e. before they actually develop planting - e.g. by sowing seeds - HG had a simpler solution, namely the transplantation of some of the plants preferred by herbivores. The transplantation of plants and their subsequent cultivation - even on a large scale - is clearly attested in various prehistoric contexts, e.g. it concerns agave in the American southwest (Smith, 2011: 843). Of course some preconditions for transplantation to be possible are that the concerned plants were resistant, easy to be removed from the soil, to be carried from their natural habitat to be planted into the food plot. Cereals and pulses were perfect candidates.[viii]

ATTRACTING WILD GAME: THE GOALS OF SEDENTARIZED HUNTERS

For HG, attracting wild game in special locations can be explained by several different reasons. The most obvious, is twofold - as explained previously - i.e. to reduce the search cost of animals in the forest and to position the hunter in the best situation for shooting the animals. Here the purpose is simply to kill the prey and to eat it on the spot.

Killing Animals: Meat Procurement and the Quest of Prestige

For sedentarized HG, the ultimate goal of the hunt is the same, i.e. killing the prey to eat it, but the proximate goal is different. Indeed, it is well known that some HG have given up their nomadic way of life and have adopted a sedentary way of life in resource-rich environment (see e.g. the Natufians in the Levant; Bar-Yosef and Belfer-Cohen, 1989; Kuijt and Goring-Morris, 2002; Goring-Morris and Belfer-Cohen, 2011). In such environment, edible wild plants - such as cereals and pulses - were abundant and easy to gather. However hunting was still necessary for two reasons.

First, wild plants provide carbohydrates but a balanced diet also requires proteins which are mainly associated with meat and fish. Sedentarized foragers have therefore hunted in the vicinity of their settlement - the resource catchment zone - leading rapidly to the overexploitation of animal species, especially those with low reproductive rate. Such source–sink dynamics may occur in landscapes where hunting is intense and spatially heterogeneous. However some species, such as deer and rabbits, can recover quickly from overexploitation and other population pressures.[ix] Because they provide more meat, hunting was likely concentrated initially on big game and later HG have had to diversify and hunt a wider range of smaller taxa to supplement their diets.

Second, and despite the diversification of hunting - and more generally the diversification of food resources according to the so-called "Broad Spectrum Revolution" - hunting large game was still very attractive, especially because such hunt provides a lot of prestige and reputation to hunters, according to the show off hypothesis (Hawkes, 1991, 2001). Such hypothesis has been confirmed in various settings. In north America for instance, the hunting of large mammals by Early Paleoindian, presumably by men, may have been motivated more by social and political factors than by the need to regularly and reliably provision a family or band with food (Speth et al., 2013). As stated by Codding et al. (2010), predictions from the prestige hunting hypothesis suggest that an increase in the social payoffs of large game hunting should lead to a diachronic increase in the archaeological visibility of large prey relative to small

prey, but also by an increase in the logistic mobility of foragers caused by hunters having to travel further to acquire large preys at higher costs. Indeed large game do not like human-disturbed habitats and therefore they were remaining in the cover forest, far from HG's settlements.

Both reasons previously stated explain why HG have had to organize long-distance hunting trips which of course are as costly as the distance is long. Indeed, a basic tenet of resource-catchment analysis is that the farther one moves out and away from a central place, the greater the amount of energy that must be expended for the procurement of resources (Smith, 2012). An alternative strategy was thus to attract big game close to HG's settlement through the clearance of land - providing the opportunity for an increase in the abundance of high-quality edible vegetation - and later by the cultivation of food plots. The latter option led to an increase in animals attracted to these cleared areas with edible cultivated crops. Such strategy is typical of niche construction by small-scale societies since it is designed to increase the relative abundance and reliability of preferred wild species of animals within resource-catchment areas, and to reduce the amount of time and energy to harvest them (Smith, 2012: 266). In fact, the composition and spatial arrangement of habitat patches in the landscape often have a strong influence on the population dynamics of species, i.e. source–sink dynamics of hunted populations can have ecological and management implications. Wildlife management traditionally monitors demographic rates to evaluate the sustainability of hunting, but the size and spatial arrangement of areas with and without hunting should be considered as well. Hunting can produce attractive sinks if dispersing individuals select good habitats with abundant resources but with high human-related mortality (Novaro et al., 2005).

The Capture of Animals: The Prey Pathway to Animal Domestication

The two previous reasons, explaining why HG have attracted wild game, have a common ultimate goal, namely to kill the prey immediately. However, there is a third reason explaining the choice of baiting as a dominant hunting strategy, namely to capture animals alive. In doing so, HG were able to keep fresh meat for a while, i.e. to slaughter after few days the animals they had caught. When the hunt was good, it was therefore unnecessary to hunt in the subsequent days until the animals previously caught were all consumed. For such purpose, the animals should not be injured during the hunt otherwise they would be dead rapidly after their capture. It was thus necessary to attract "softly" the game in a dedicated location such as a corralled field within which wild crops were cultivated. Once a sufficient number of animals was grazing into the still open corralled food plot, HG had simply to use a gate to close the corral. Of course it was also possible to organize a drive towards a corralled area but calling and flushing would have frightened all the animals - especially those not caught by the drive - for a long period of time and the next drive would have failed. For instance, although they inhabit brushy or wooded edge areas during most of the year, deer respond to increased hunting pressure with highly effective avoidance behavior, which includes prolonged hiding into the deep forest and a shift to nighttime feeding. Thus, baiting was preferred rather than driving.

Baiting has another advantage which probably was not initially predicted by HG. It allowed HG to catch animals alive, including very young animals. Indeed, the taming of wild animals, and subsequently their domestication, whatever species are concerned, is easier when young animals are in contact with human. In other words, initial cultivation of food plots dedicated to attract wild game and to keep some of these animals alive has surely contributed to the domestication process of animals. This is consistent with a vision based on niche construction in which domestication emerged out of coherent preexisting resource management systems

(Smith, 2007). This may explain why, contrary to what was believed until recently, the domestication of plants and animals is now considered has having occurred roughly at the same time, with signs of initial management of morphologically wild future plant and animal domesticates reaching back to at least 11,500 cal BP, if not earlier (Zeder, 2011: S230).

The Initial Management of Wild Caprines in the Near East: Archaeological Evidence and Pending Issues

Animal domestication must be considered as a process starting from free-living populations, to managed ones (which can still revert to a wild state), to animals unable to survive outside of the domestic partnership. Such process is mainly based on the selection for reduced wariness and low reactivity (Zeder, 2012). It is now agreed that the first herbivores that were domesticated are goats and sheep and that this has occurred in the Near East, more precisely in an geographical area encompassing the Taurus mountains and the Zagros mountains, around 10,000 BP. Domestic goats (*Capra hircus*) derive from wild bezoar (*Capra aegagrus*) goats that were brought under initial human management in a region that stretches from the eastern Taurus to the southern Zagros and Iranian Plateau. Domestic sheep (*Ovis aries*) derive from different populations of wild mouflon (*Ovis orientalis*), an animal with a current range that extends from Anatolia to southeastern Iran. However it is only at a later stage of the domestication process that human societies in the Taurus and the Zagros Mountains had intervened to a significant extent in the life cycle of goat and sheep herds, and had taken control of their reproduction. Indeed, it is now considered that the initial phases of the transition from hunting to herding in this region may also reach back to about c. 12,000 to 13,000 ago.

From free-living to their initial domestication, it is believed in the academic literature that these animals have entered into domestication through a prey pathway (Zeder, 2012). In other words, these animals were primary prey animals and subsequently HG have developed hunting strategies designed to increase prey availability. More precisely, there has been a transition from generalized hunting to specialized hunting mostly targeting prime-age animals, and progressively hunting larger number of juvenile caprines (Atici, 2009). Such specialized hunting strategies may have helped to restock local herds of wild caprines, i.e. are considered as game management strategies. Over time and under certain circumstances, these game management strategies develop into herd management taking place within the natural habitats of wild progenitor species. Despite its interest, the previous explanation of the prey pathway to domestication presents some shortcomings.

First, selective hunting leading to game management means that HG had - either unconsciously or consciously - chosen to hunt caprines which seemed unsuitable (or less suitable) to management, i.e. those exhibiting wariness and high reactivity, and have spared the others. However, by definition these animals are the most difficult to be hunted. If we refer to optimal foraging theory, hunter behave in order to maximize the energy return and therefore they should have hunted animals with reduced wariness and low reactivity. Thus, the selective hunting of non docile animals cannot be considered as an unconscious strategy. Moreover, selective hunting can be interpreted differently than as a game management strategy. Indeed, and as pointed out by Allendorf and Hard (2009), human harvest of phenotypically desirable animals from wild populations imposes "unnatural" selection. In other words, the changes observed over time in observed populations (e.g. the reduction of body size) can be the result of "unnatural selection" , i.e. selection, by means of hunting, against desirable phenotypes (e.g. body size, coat color, weapons or ornaments such as horns and antlers).

Second, one has to explain how the remaining docile - but still wild - animals have been captured. We have previously seen (section 4) that in order to capture animals alive without injuring them, they have to be corralled. For such purpose, two strategies, driving and baiting, were possible. Driving may have occurred but it was not well-suited for the capture of wild caprines. Indeed, the wild bezoar is a species that lives in high rocky region - from the Taurus mountains into Pakistan - and the wild mouflon occupies somewhat lower, more rolling elevations along the same mountain arc. Thus the ecosystem of the wild caprines is very different from the steppic one - such as in the north American plains or the Levantine deserts - in which the organization of drives is clearly attested (Frison, 1998; Bar-Oz et al., 2011; O'Shea et al., 2013) and where the hunted animals were large herds of migratory artiodactyl (bison, pronghorn, reindeer, gazelle). Even though they are gregarious and highly social, the Near Eastern wild caprines are not migratory species, leading to two consequences. On the one hand, it is not possible to predict, from past observations, what will be their "migratory road" and to organize the drive along such road. On the other hand, their herd encompass few dozen of animals, compared to several hundred and even thousands, for herds of migratory animals; thus if the drive was not well structured and that most of the herd escaped, it became an actual problem for the hunters who thus were only able to kill few animals. In other words, hunting wild caprines by mean of a drive was very risky. Moreover, Near Eastern wild caprines were living in a non steppic ecosystem - hills and mountains, with patchy areas of brush, forest, and rock - not well suited for the organization of drive hunting. All the reasons previously stated explain why, rather than with drive, the capture of wild caprines was probably easier and less risky through the cultivation of food plots toward which these animals were attracted and corralled. A final and not the less important reason can be added, the organization of a drive requires a large number of hunters (standers and drivers), especially if it takes place in a forest area. It is thus very costly and necessitates some collective coordination while baiting - through the cultivation of a food plot - can be done by very few persons - so it is less costly - and is also less risky, especially because if the hunt fails, the remaining cultivated crops can be harvested and consumed by the cultivators of the food plot.

CONCLUSION

The existing theories of the transition to agriculture are all developed from a farmer's point of view. Indeed, they all assume, even though it is for different and various reasons, that cultivation was initiated for a unique goal, i.e. to feed people. We depart from such approach, since cultivation could have been initiated for another purpose, to feed wild animals. Indeed, even though we agree with the meaning of Niche Construction Theory, we believe it should be applied to the transition to agriculture from hunters' point of view, simply because whoever was the first cultivator, he was previously a forager. In other words, plant cultivation should be viewed as the result of strategies developed by foragers to increase their food procurement. One interpretation is therefore that initial cultivation has been developed in food plots dedicated to attract wild game - large herbivores - and thus leading to increase the return of the hunt. This is consistent with Niche Construction Theory since such food plots simply mimic and enhance the attractiveness of glades and open spaces in the vegetation featured by rich edges. We even argue that such food plots could have been corralled, leading to the capture of animals alive. Then, baiting - by mean of initial cultivation - could be also viewed as a contributor to the prey pathway toward animal domestication.

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ENDNOTES

[i] Externalities exist when one person's actions affect the payoffs going to other people.
[ii] According to Price and Bar-Yosef (2011: S165) we differentiate "cultivation" (defined as intentional preparation of the soil for planting wild or domesticated plants) and "domestication" (defined as morphological or genetic changes in plant and animal species).
[iii] I.e. even from the so-called "Broad Spectrum Revolution" featuring the Mesolithic period during which HG have diversified their diet and especially increased their consumption of plants and marine resources (fish, shellfish).
[iv] Defined as the non-mobile works that include paintings, drawings, engravings, and reliefs on cave walls.
[v] Except in special circumstances such as when foragers (called "complex HG") are evolving in a resource-rich environment with abundant resources locally concentrated (e.g. an animal migratory road, a good fishing site, a natural orchard, a field of wild cereals...).
[vi] It should be noted that, according to Woodburn (1982), some foragers (especially the complex HG) are - as farmers do - living in a delayed-return economy.
[vii] Usually defended territories are coincident with watersheds, with boundaries running along drainage divides and encompassing the full range of altitudinal zones.
[viii] Depending on the cereal considered, the number of primary roots varies (e.g. from one in the warm climate cereals maize, rice, and sorghum, to six or seven in the cool climate cereals, triticale and wheat), and a complex root system architecture - rather than a taproot - facilitates transplantation.
[ix] For instance, white-tailed deer have a theoretical maximum reproductive rate or biotic potential of about sixty percent per year (Smith, 2009: 170).