NATURE'S ROLE IN THE ORIGINS OF AGRICULTURE

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Robert Braidwood'un, ilk olarak 1950'lerde, tarımın başlangıcını araştırmaya başladığından beri gerçekleştirilen yeni buluşlar, bu 'devrim'de değişen iklimin ve atmosferin ne denli sürükleyici bir rol oynadıklarına dikkatleri çekmiştir. Aynı zamanda, Braidwood'un da üzerinde durduğu gibi, insanlık evcilleştirmeyi sağlayacak aletleri yapacak ortamı da yaratmıştır.

In this brief essay, I take up a theme that occurs repeatedly in Robert Braidwood's writings. This is the relative roles played by the natural environment, and human needs and abilities, in the origins of agriculture. Some fifty years after the inception of the Iraq-Jarmo Project, because of new insights and information, these factors continue to be debated. Just when it seems that the problem has been settled, new information shakes us from our complacency. I emphasize that new scientific information is the critical aspect, for there have been no new ideas about the role of culture for some time. Nevertheless the basic problem remains the same: why and under what conditions did humans first domesticate crops and come to depend upon agriculture, after our ancestors had successfully passed several millions of years as hunter-gatherers? The phrasing of the question predisposes us to seek answers in the cultural domain for ultimately it was humans acting on their best interests, who carried out domestication. If domestication had occurred once and spread from a single point of origin around the world, one might be content with a purely cultural explanation: a genius set off a world-wide revolution. To the contrary, however, domestication occurred nearly simultaneously in many different parts of the world, with very different crops. The global distances between these events and the specific techniques needed to implement domestication seemingly preclude any possible cultural transmission. Thus we are left with the realization that there must have been an "X" factor that operated globally. Nature must be that factor, despite literary tradition and legends that attribute agriculture to a "gift from the gods." Before I discuss possible natural factors, I will give a short review of the ways that Robert Braidwood conceived and approached the problem, which in many ways was his defining issue. In his popular book, *Prehistoric Men*, Braidwood referred to an "intensification of adaptiveness, this 'receptiveness,'" of people after the Pleistocene who seemingly were now experimenting with new materials and tools.

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This was the precursor to the change toward agriculture. Admitting that we do not know **how and why** the revolution took place, he reasoned that "the answers will concern some delicate and subtle interplay between humans and nature. Clearly, both the level of culture and the natural condition of the environment must have been ready before the change itself could come about." He goes on to remark that "the general level of culture in many parts of the world seems to have been ready for change" (Braidwood 1975: 93). That this is true is suggested by the fact that post-glacial conditions had existed previously in human history, but did not lead to agriculture. In short, humans were the agents of domestication.

Braidwood fully recognized that although humans domesticated the species, this could occur only where the requisite plants and animals existed and this, in turn, hinges on climate and topography. To help resolve the role of nature, Braidwood sought help from zoologists, botanists and geologists. Indeed, the Iraq-Jarmo Project was one of the first to incorporate these scientists into the field team. Interestingly, Alphonse de Candolle had argued in the late 19th century that a multidisciplinary approach was necessary to investigate agricultural origins, but Braidwood was the first field archaeologist to take up this suggestion (Candolle 1884).

The role of climate, especially of desiccation, in forcing migration was first investigated by Raphael Pumpelly who, as a result of his excavation of Anau in Turkmenistan, formulated the 'oasis theory' of agricultural origins (Pumpelly 1908) that was later popularized by Gordon Childe in his influential publications (Childe 1936, 1942). This theory stated that during the Ice Age, the Near East was fertile and green but that as the ice receded and the storm tracks shifted northward, the Near East began to dry out causing the species living there to seek oases and river valleys. During the enforced propinquity of man, plants and animals, people would have learned to value some species over others and to manipulate them to their advantage. As Braidwood recognized, similar previous climate episodes had not led to domestication so there clearly was another part to the equation. Moreover, climatologists could not accurately determine what the climate had been in the Near East - Childe had only taken up an interpretation made earlier by the climatologist Brookes (Brookes 1925). Herbert Wright's extended evaluation of the evidence that existed in the 1950s noted that we can't state with certainty what changes affected which places. He concluded, "that the gradual evolution of culture, with increasing complexity and perfection of tool technology, may have been a more potent factor in bringing about this economic revolution than was the climatic change at the end of the glacial period" (Wright, 1960: 97). In the absence of explicit knowledge of climate, Braidwood built his project on what he **did** know – that there was a modern convergence of domesticable species in the foothills of the Taurus-Zagros and there were also late Paleolithic caves and early villages in the same region.

Everyone recognizes that domestication would not have occurred in the absence of the desired species; therefore, from an archaeological point of view it is critically important to know where these would have been. This is a purely environmental issue that has to do with climate, precipitation and topography, all of these quite independent of where people may have been or what they were doing. Using the best judgments of his assembled experts in the natural sciences, Braidwood sought the origins of agriculture in the "hilly flanks of the Fertile Crescent." This is the region of the present day distribution of the four animals and the eight plants that comprise the Near Eastern Founder Complex. In Braidwood's terms this was the **nuclear area** in which domestication could have occurred. Since his initial formulation of this idea, which clearly argued against Childe's oasis hypothesis, he has acknowledged that the nuclear area is much broader, a realization based on the results of his own research in southern Anatolia and that of others in the Levant (Braidwood 1979).

Within the nuclear zone, Braidwood essentially adopted Childe's argument that propinquity, fostered by prosperity that allowed some semi-sedentary settlement, almost inevitably led to domestication. In a sense he saw people being "pulled" into domestication, almost inadvertently and probably unconsciously. Braidwood's enthusiastic endorsement of cultural factors has been followed by almost no subsequent theorist. Rather, most feel that people were "pushed" into agriculture as a result of some dire necessity - farm or famine.

We can now fast-forward to the "modern" era. Since the 1940s, when Braidwood began to investigate the origins of agriculture there have been three fundamental advances in our understanding. The first of these, radiocarbon dating, has allowed us to firmly date in calendar years, both the archaeological and environmental changes. The second is detailed knowledge of how climate and environment changed from the end of the Pleistocene to the establishment of the village farming communities across the near East. The importance of the third fundamental change has only recently been recognized. This is the rapid and large increase in atmospheric CO2 just at the time the first domestication was taking place.

It is not surprising that these innovations, particularly the last two, have given rise to new theories of agricultural origins. Even in the 1960s, the first significant challenge to the prevailing idea that the Near Eastern environment had not changed much since the end of the Pleistocene, was overturned by results of deep sea coring. Indeed, as a result of this, I carried out a survey to test whether agriculture might not have started on the Mesopotamian plain rather than the hilly flanks (Hole, 1962). Although this did not answer the question it did lead to the excavation of Ali Kosh, a site well outside the presumed nuclear area. Only recently have we managed to overcome what Braidwood called the "whimsical nature" of the radiocarbon dates and verified that the early villages of the Zagros lag their counterparts to the west by a thousand years (Hole 2000).

The prevailing wisdom when Braidwood began the Iraq-Jarmo Project was that the Near East had probably been wetter during the Pleistocene, as Childe had postulated, and then shifted toward modern levels well before the advent of agriculture. That was overturned by the combined results of pollen cores taken from Lake Zeribar and other sites, and their dating by radiocarbon (van Zeist 1967). These clearly showed that the Pleistocene had been drier and colder than today, thereby reversing the previous interpretations (Wright 1980, 1983). The specifics of post-glacial climate and environment have still to be worked out in detail for each region, but the general picture is clear: following a Bolling-Allerod warming, the Younger Dryas plunged the region back into arid, near glacial conditions, after which a Climatic Optimum set in with substantially warmer and wetter conditions than today. A point to emphasize is that each broad region of the Near East has its own climatic history: that of the Zagros and Taurus differ in magnitude, timing and vegetational changes from the eastern Mediterranean. We now know that people in the Levant were making use of potentially domesticable plants during the Bolling-Allerod (Kislev, et al. 1992) and that morphologically domesticated plants turn up in sites at the end of, or just after, the Younger Dryas (Bar-Yosef and Belfer-Cohen 1989). These facts once again raise the issue of the role of climate change and there are at least two ways to consider this. One concerns the effects of climate itself on the vegetation; the other focuses on the disruptive effects of the Younger Dryas.

The Eastern Mediterranean and most of the rest of the Near East is dominated by a Mediterranean climate, one in which precipitation falls during the winter months that are relatively mild, and fails entirely during the hot summer months. This strongly seasonal climate is exacerbated by prevailing dry conditions. Such a climate favors plants that can grow during the short daylight months in winter-spring and withstand the desiccation of summer. Large seeded annuals and trees and shrubs with leathery leaves thrive under these conditions. Botanists believe that the characteristic Mediterranean vegetation would have developed only after the Pleistocene and would have been seriously compromised during the Younger Dryas (McCorriston and Hole 1991). The "broad spectrum" of plants and animals captured by the last of the hunter-gatherers, during the time that Braidwood sensed experimentation and innovation, may have resulted from the opportunities newly afforded by this vegetation complex. Whatever the case may have been, it seems that new resources were available to humans.

The second factor concerns the effects of the Younger Dryas. We now know, as a result of a number of excellent excavations and reports, that some sedentary life was possible well before there is good evidence for domestication (Bar-Yosef 2001). These places were especially rich ecotone areas, around fresh-water lakes or streams. As early as 3,000 BP at Ohalo II on the edge of the Sea of Galilee, people had collected a number of economic plant species, but it is not clear what use they made of them. The important fact is that, although some sedentary Natufian communities had developed by the time of the Younger Dryas in the southern Levant, they no longer existed **during the Younger Dryas**. Nevertheless, thereafter, we find the first morphological evidence that plants were domesticated (Nesbitt 2002). Several authors have concluded that the Younger Dryas was a precipitating factor in forcing people to adopt agriculture and we may equally argue that the advent of the Climatic Optimum, allowed agriculture to spread beyond the narrow confines of its local niches (Hassan 2000; Hillman 2000; Moore and Hillman 1992; Willcox 1996).

The recognition that Mediterranean climate was a post-glacial phenomenon and that potentially economic plants were absent from most of the Near East until the Holocene, led Joy McCorriston and me to propose that domestication began first in the southern Levant (McCorriston and Hole 1991). The argument was based on various lines of evidence. First, the oldest archaeological sites and all of those with clear domesticates, occurred in this region. Second, the highly varied topography of the Levantine Rift, and its proximity to the Mediterranean Sea, provided suitable refugia for plants even during the most severe climates. Third, climate amelioration and strong seasonality would have favored the economic plants and made it necessary for people to store food in order to survive the dry season. People had already begun to use plant food and had developed tools such as grinding stones to make it palatable. In brief, need, opportunity and ability coincided and resulted in the most fundamental transformation of the human diet that was seen until the most recent era.

This scenario has been reworked and modified as new information has come to the fore but in essence it still holds. The process of domestication was both a natural and a cultural event. This explains the enigma of why it had not happened previously when climates may have been similar. The short answer is that people were not, as Braidwood always maintained, "ready." During the last interglacial Neanderthals and early moderns roamed Europe and the Near East. Both had identical tool kits, developed to process meat, and their social organization seems to have been based on small, mobile groups. Most importantly, they did not have the requisite skills to deal with an abundance of vegetable food, even had it been available.

Actually the question has been posed more broadly. Why did people trade the free-roaming life of the hunter-gatherer for one that required routine, back-breaking labor and a monotonous diet? Flannery answered this is reference to our research in Deh Luran. "Dry farming of wheat in northern Khuzistan, for example, yields an average of 410 kilos per hectare (Adams 1962). This is equal to the weight of usable meat from sixteen sheep, or the weight of more than 400 million small legume seeds. There is probably no other food in the Bus Mordeh phase debris which will produce as many kilos from so small an area as cereals" (Flannery 1971: 64). This example of the relative efficiency of agriculture over hunting-gathering is expressed more theoretically by (Richerson, 2001:395).

Despite the apparent advantages of agriculture in providing nutrition, a question that has nagged at researchers is whether humans are truly adapted to eat domesticated cereals and milk products. The question arises because neither food was part of the human diet prior to domestication and a large proportion of human populations today have an allergic reaction or intolerance to one or both of these. It seem certain that in the absence of domestication, people would not have been able to ingest non-human milk products on a regular basis and it has been only since agriculture that grains have been processed in bulk, at least those that were ripe and required grinding or prolonged soaking. Grinding stones appear sporadically early in the post-Pleistocene, but it is not certain they were used for grain rather than to pound nuts and berries or to pulverize meat. The reaping knives, abundant milling stones and mortars, and storage facilities that appear after agriculture are convincing evidence of a dramatic shift in diet. It is well-known that bread is a rich source of carbohydrates and that these convert quickly to glucose, an energy source. Bread has several virtues: it tastes good, is easily masticated and gives a quick burst of energy, and it is a good source of protein. Moreover, bread is filling and can be made on demand. Some go so far as to say that there are "potentially psychoactive substances" in cereals and milk that may make them "chemically rewarding." Wadley and Martin question whether these properties led people to become "addicted" to these foods. If so, they reason, this may explain why people adopted agriculture so quickly (Wadley and Martin 1993).

Readers may remember that Braidwood and colleagues considered, in "Did man once live by bread alone?" whether a beer industry might not have fostered agriculture (Braidwood, et al. 1953). The results of this inquiry and subsequent investigations by Katz and Voigt (Katz and Voigt 1986) were inconclusive, but do give food for speculation. In short, there may be more to grain than nourishment for the stomach.

The most important new hypothesis concerning factors that may have led to domestication examines the role of rising CO_2, a factor that had been totally overlooked by previous theorists. It has been long established that CO_2 is a kind of fertilizer for many plants, stimulating photosynthesis and resulting in an increase in leaf mass and structure (Bazzaz 1990). Experiments have shown that plants can respond dramatically to increases in CO_2 (see Sage 1995). As a result of analyses of air trapped in cores taken from Arctic and Antarctic ice it has recently been possible to directly measure the concentration of atmospheric CO_2 from modern times well back into the Pleistocene (Barnola, et al. 1987). We now know that CO_2 was generally much lower than today during the Ice Ages and that it increased 33% just at the time that agriculture was beginning in the Near East. Rowan Sage has proposed that agriculture would not have been possible until the rise in CO_2 made the economic plants much more productive than they had been (Sage 1995). Consequently it opened a new opportunity for foragers.

This idea, along with considerations of the instability of Pleistocene climates, was later picked up by Richerson, Boyd and Bettinger who asked, "Was agriculture impossible during the Pleistocene but mandatory during the Holocene? (Richerson, et al. 2001). This hypothesis focuses on the unusually benign climate of the

Holocene, as well as the rise in CO_2. In combination these contributed to an increase in both productivity and predictability, conditions that enabled people to intensively exploit plant resources and achieve a measure of residential stability, even in the absence of cultivation. Their theory is based on some general evolutionary propositions. Animals that consume the primary production, plants, can be more numerous than carnivores. Therefore, if people learn to eat plant food efficiently they will out-compete hunter-gatherers and take over territories that are suitable for more intensive exploitation. They describe a "competitive rachet, as successively more land-efficient subsistence systems lead to population growth and labor intensification" (Richerson, et al. 2001, 395). The scenario they describe is one where the advantages of using cereals and legumes were evident and appreciated. In effect, the resource was so compellingly attractive that it was irresistible and hence, agriculture was mandatory [cf Hillman, 1996]. It is hard to argue that this did not happen, for case after case appears to conform, and it is inescapable that agriculture has taken over subsistence world-wide. In a sense this moots the question raised by Wadley and Martin whether cereals and milk are natural foods for humans. While some products may have drug-like qualities, it has not been demonstrated that they all do, unless they are fermented and consumed in a liquid form. Rather it seems that economic efficiency in the senses discussed by Flannery and Richerson was the "draw" for hunters-gatherers around the world. Agriculture conferred an advantage over people who did not have it.

Agriculture would not have happened, as Braidwood said, until people were "ready." They had to have the tools and organization to exploit plant foods efficiently enough to make them dietary staples. They also had to have the "opportunity." The development of the Mediterranean climate after the Pleistocene no doubt fostered the growth of the economic plants, while the rise of CO_2 increased production to sustainable levels. The role of the Younger Dryas is less certain. Whether it served as a "shock" that impelled foragers to begin tending cereals and legumes, or whether it merely interrupted a trajectory that was heading toward agriculture already cannot yet be determined. We now know that agriculture began in the Levantine corridor, not in the hilly flanks, but the corridor may stretch from the Dead Sea into southern Anatolia. (Nesbitt 2002) One of the most pressing issues remaining is to determine the precise vegetation history of this elongate region in order to know where the economic species would have been. Considerably more excavation needs to be carried out in northern Levant, especially in Syria. While most evidence points to the Levantine corridor, we must not lose sight of the middle Euphrates where excavations have shown settlements that apparently bridge the time of domestication. An expansion of a nuclear area to this region raises the possibility of parallel developments.

Robert Braidwood set the agenda for a series of investigations in the Near East and elsewhere focused on agricultural origins. He would be pleased to see how far we have come in understanding the Great Transformation, but he would be surprised if new discoveries do not continue to enlarge our thinking and even overturn the best ideas of today.

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