



The Tangled Roots of Agriculture

A once-popular view that climate change led the Near East's ancient Natufians to begin domesticating plants and animals is under increasing attack, but alternative paradigms are still being formed

PARIS—About 20,000 years ago, when the last ice age was at its peak, sparse populations of hunter-gatherers roamed the largely treeless steppes of the eastern Mediterranean region in highly mobile bands of perhaps 15 to 50 people. For thousands of years, they eked out a marginal existence, traveling widely to gather tubers and nuts and hunt deer and gazelles. Then, about 14,500 years ago, the climate warmed suddenly. Woodlands of pistachio, olive, and oak, along with lush fields of wild wheat and barley, began to take over the steppes. Just as suddenly, hunter-gatherers in what is now Israel, Jordan, Syria, and Lebanon began doing things they had rarely, if ever, done before. Although they continued to hunt, they built permanent houses of stone and wood, and buried their dead in and around them with elaborate rituals. They ground up wild cereals with mortars and pestles, made tools and art objects from animal bones, and perhaps even practiced Shamanism. And they gathered in sedentary or semisedentary communities of up to several hundred people.

These were the Natufians, a culture so different from what came before that archaeologists once thought they were invaders from afar. Their large, socially complex communities “represent a key development in human settlement history,” says archaeologist Phillip Edwards of La Trobe University in Victoria, Australia. In the Near East, Natufian culture was the next-to-last stop on the long road to

farming, and many of its features seem to foreshadow the Neolithic epoch, when the earliest farmers built densely populated villages of stone and mud brick, painted their walls with art, and buried their dead under the floors. “Many of the activities present in the early Neolithic had their roots in the Natufian,” says zooarchaeologist Natalie Munro of the University of Connecticut, Storrs.

But the warmth that ushered in the Natufian era didn't last long. About 13,000 years ago, smack in the middle of the Natufian cultural florescence, a sharp, 1300-year-long cold and dry spell called the Younger Dryas reversed the post-ice age warming. For some archaeologists, the Natufian response to this sudden cooling holds the clues to one of archaeology's central mysteries: why former hunter-gatherers settled down and invented agriculture. According to a once-popular hypothesis, the Younger Dryas created an environmental crisis that forced the Natufians or whoever replaced them to begin domesticating plants and animals to ensure that they had enough to eat (*Science*, 20 November 1998, p. 1446), thus spurring the world's first experiments with agriculture.

Back in 1989, when archaeologists Ofer Bar-Yosef of Harvard University and

François Valla of the University of Paris in Nanterre convened the world's leading Natufian experts for a meeting, the Younger Dryas model was well on its way to becoming a leading paradigm for agricultural origins. But when Bar-Yosef and Valla called the Natufian mavens back together for a meeting in Paris last fall,* opinions had shifted. In talks and recent journal articles, many researchers rejected the idea that the Younger Dryas forced Near Eastern hunter-gatherers to become farmers—or that the Natufians themselves were precocious farmers, as some had suggested.

“Agriculture was not driven by climate change,” says Lisa Maher, an archaeologist at the University of Cambridge in the United Kingdom. Nor, says Arlene Rosen, a geoarchaeologist at University College London (UCL), was Natufian culture simply a way station on the road to farming: “The Natufians were not on a trajectory to agriculture. In fact, they carried on ... for 1300 years as successful foragers during the Younger Dryas.” Nevertheless, researchers say, the Natufians' successful adaptations to what nature threw at them, and their many cultural innovations, may have helped make agriculture possible when the weather was more conducive to it.

Follow the lunate

The Natufians were discovered and named in 1928 by the legendary British archaeologist Dorothy Garrod. At Shuqba Cave north-

*The Natufian Culture in the Levant II, Paris, 7–11 September 2009.

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Michael Balter.

First farm? The excavators of Abu Hureyra in Syria think rye was domesticated there.

east of Jerusalem and at el-Wad Cave on Mount Carmel, Garrod unearthed distinctive, crescent-shaped flint tools called lunates, as well as grinding stones and mortars, figurines and jewelry, the remains of stone buildings, and burials of dozens of individuals.

Today, about 60 Natufian sites are known, ranging from larger, villagelike “base camps” to smaller “mobile camps.” Archaeologists divide the culture—often identified by the presence of the lunates, probably used as arrowheads and for cutting plants—into two periods: a more sedentary Early Natufian, characterized by larger encampments and elaborate group burials adorned with ochre and jewelry; and a more mobile Late Natufian, with smaller camps and undecorated, individual burials.

Archaeologists agree that the milder, post-ice age climate conditions helped transform mobile hunter-gatherers into the more sedentary Natufians. In the early years of Natufian research, archaeologists had only a rough idea how old their sites were, in part because of the lack of a suitable radiocarbon calibration curve

(*Science*, 15 September 2006, p. 1560). But new dating shows that the Natufians appeared right around the time of the Bølling-Allerød interstadial warm period, which began 14,500 years ago and lasted until the beginning of the Younger Dryas. “There is clearly a striking correlation between the emergence of the larger-scale Natufian settlements and the beginning of the warm and moist Bølling-Allerød,” says UCL archaeologist Andrew Garrard. During colder times, this region was mostly a treeless steppe dotted with shrubs and grasslands, and new forests expanded rapidly, presumably providing the Natufians with nuts and other calorie-rich plant resources and encouraging them to settle down.

Nevertheless, researchers have had little evidence on Natufian use of plants, which preserve poorly in the Mediterranean’s wet winters and hot, dry summers. “We have had almost no direct data on plant use in this period,” says Garrard.

New research at Dederiyeh Cave in northwest Syria is helping to fill that gap. In unpublished work presented here, archaeologist Yoshihiro Nishiaki of the University of Tokyo reported the remains of stone buildings occupied between 14,000 and 13,000 years ago, one of which was heavily burnt, charring and preserving many plant remains. So far, archaeobotanist Ken-ichi Tanno of Japan’s Research Institute for Humanity and Nature in Kyoto has found that nearly 90% of the 12,000 plant fragments he studied come from pistachio and almond trees. Tanno also found significant amounts of wild wheat, one of the main cereals domesticated in the region during the later Neolithic period. The finds at Dederiyeh show that Natufian plant use was “intensive, knowledgeable, and complex,” says Maher. But there’s no sign that the Natufians actually cultivated plants at Dederiyeh rather than simply collecting them wild.

There is also plentiful evidence of Natufian hunting, particularly of the mountain gazelle. Just outside el-Wad Cave, for example, where archaeologist Mina Weinstein-



Spirit world. This 12,000-year-old burial at Hilazon Tachtit in Israel might have been that of a shaman woman.

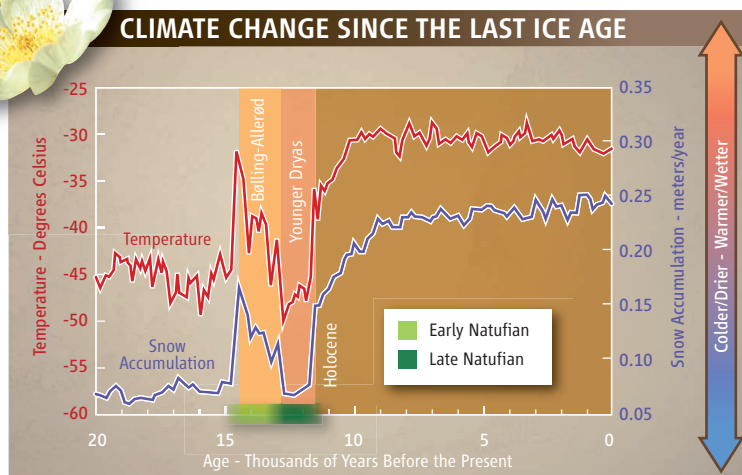
hunting continued unabated during the Younger Dryas, according to studies by Bar-Oz, Munro, and others, a finding they say is inconsistent with decreases in the Natufian population.

A paradigm gone dry?

The Younger Dryas, named for the sudden return to more southern latitudes of the cold-adapted plant *Dryas octopetala*, has been precisely dated from isotopic ratios of oxygen, nitrogen, and other elements in the Greenland ice cores, which vary with changes in temperature and moisture. These records indicate that the Younger Dryas stretched from 12,900 to 11,600 years ago;

pollen cores and other proxy climate indicators suggest that at least parts of the Near East also experienced this cold, dry spell. The Younger Dryas dates correspond closely to the calibrated dates for the Late Natufian, thought to have begun about 13,000 years ago. This period, archaeologists agree, is marked by at least a partial return to the more mobile lifestyle that preceded the sedentary Early Natufian. Beginning in the late 1980s, Bar-Yosef, Anna Belfer-Cohen of The Hebrew University of Jerusalem, and other researchers argued influentially that the Late

Natufian culture was a response to the cold, dry conditions, which shrank the resource-rich forests and made wild cereals such as wheat and barley more scarce. They argued that the region’s hunter-gatherers turned to agriculture, planting and cultivating fields of the now-precious grains, in a hypothesis often repeated in journal articles and popular books, not to mention on Wikipedia.



Stormy weather. Records from Greenland ice cores suggest that the Late Natufians of the Near East had little trouble surviving the cold and dry Younger Dryas (named after the arctic plant *Dryas octopetala*, inset, top).

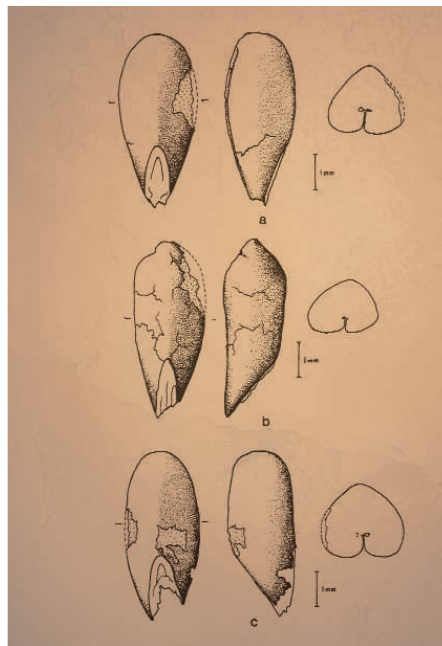
Evron of the University of Haifa in Israel has led renewed excavations since the mid-1990s, Haifa zooarchaeologist Guy Bar-Oz found that gazelle made up about 75% of the animal bones. Moreover, some researchers say that the pattern of gazelle hunting argues against the idea that a harsh climate during the Younger Dryas caused Natufian population levels to crash. The intensity of gazelle

The strongest evidence for this idea comes from the site of Abu Hureyra in Syria, excavated during the 1970s by a team led by archaeologist Andrew Moore, now at the Rochester Institute of Technology in New York state. They found plump rye seeds, which suggested to them that humans had selected over time for large grains. Based on this and other lines of evidence, Moore and UCL archaeobotanist Gordon Hillman argued that rye and perhaps other cereals were domesticated at Abu Hureyra about 13,000 years ago, roughly at the beginning of the Younger Dryas. If true, that would make it the earliest evidence of farming in the world. Supporting evidence came from indications that the Late Natufians intensified their processing of plants. For example, a 2004 study of three Natufian sites in Israel by archaeologist Laure Dubreuil of Trent University in Peterborough, Canada, found more grinding stones in the Late than Early Natufian, as well as evidence from use wear that the stones were increasingly used to grind cereals and legumes. However, the grinding stones could also have been used for working animal hides and grinding ochre for ritual burials, according to a follow-up study published in *Antiquity* late last year by Dubreuil and archaeologist Leore Grosman of Hebrew University.

Despite the Younger Dryas's 20-year run as a leading explanation for the rise of agriculture, many scientists remained skeptical, and the idea has come under increasing attack. "The so-called impact of the Younger Dryas was always a matter of belief, not a matter of science," says Valla. Archaeobotanist George Willcox of the Archéorient research center in Jalès, France, says that "there is only one site where [the younger Dryas explanation] could possibly work, and that's not enough." That site is Abu Hureyra, but Willcox isn't convinced that the nine fat rye seeds reported there really represent domesticated grain. "There are so few of them," he says, adding that "the general consensus is that plump grains are not good evidence for domestication."

Other archaeologists see little evidence that the Late Natufians actually faced an environmental crisis. Archaeologist Nicholas Conard of the University of Tübingen in Germany and his co-workers have found considerable evidence at Baaz rock shelter in Syria that Natufians ate freshwater fish, which points "to the presence of stable sources of flowing water at a time when we are supposed to be in an environmental crisis due to aridity."

And newer calibrated radiocarbon dating suggests that the Natufians did reasonably



Rounded rye. The Abu Hureyra team argues that these plump rye grains were domesticated.

well during the entire Younger Dryas, Grosman argued in a talk here. The calibrated dates now stretch the Natufian period from about 2300 uncalibrated years to well over 3000 calibrated years and make the Late Natufian even longer than the Early Natufian. To have survived the return to harsh conditions for so long, Rosen says, the Late Natufians must have had a "stable adaptation" to the Younger Dryas. Moreover, Munro says, the increased mobility of the Late Natufian was not a likely "trigger for agriculture" and may have in fact postponed it.



Galloping gazelle. Natufians probably hunted their favorite prey using lunates (*inset*) as arrowheads.

Some Younger Dryas advocates are not convinced by this logic. Bar-Yosef argues that many of the first Neolithic sites, which cropped up just as both the Late Natufian and the Younger Dryas ended about 11,500 years ago, are "more than 10 times as large as the biggest Natufian sites. Where did they come from if food supplies were not improving during the late centuries of the Younger Dryas?" And Moore says that although the Younger Dryas was not the only catalyst for farming, at Abu Hureyra it "provided a key trigger." As evidence he cites not only the rye grains but also other signs, such as a rise in weeds typically found in cultivated fields and an increase in legumes such as lentils, which Moore says could not have survived the dry Younger Dryas unless they were deliberately cultivated. Moore also points to increasing evidence that early farmers engaged in "predomestication cultivation" long before cereals and other plants took on the domesticated morphology that makes them recognizable to archaeobotanists (*Science*, 29 June 2007, p. 1830).

But if the dissenters are right and the Younger Dryas did not trigger the rise of agriculture in the Levant, what did? Many archaeologists have concluded that farming began not during the cold, dry climate that hit Natufian culture at its height, but only later—after warm, moist conditions were restored 11,600 years ago. In this view, says Rosen, prehistoric peoples were both "pushed" into agriculture by growing populations that fostered renewed sedentism and "pulled" by the increased rainfall and milder climates that made farming more attractive and less risky. Only then, Rosen says, was nature in full "come-hither mode," making agriculture not only possible but also desirable.

Willcox, whose own research suggests that both cultivation and domestication didn't start until the Holocene, says he "agrees 100%" with this viewpoint. But although the Natufians may not have invented agriculture, many archaeologists say, their many cultural innovations—in art, technology, architecture, and possibly experimentation with wild plant cultivation—probably made later developments possible. In a sense, says anthropologist Donald Henry of the University of Tulsa in Oklahoma, the Natufians were "preadapted" for farming—even if, as Valla puts it, "they had no clue what was to follow."

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