Comment on “Agriculture facilitated permanent human occupation of the Tibetan Plateau after 3600 B.P.”

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Chen et al. (Reports, 16 January 2015, p. 248) argued that early Tibetan agriculturalists pushed the limits of farming up to 4000 meters above sea level. We contend that this argument is incompatible with the growing requirements of barley. It is necessary to clearly define past crop niches to create better models for the complex history of the occupation of the plateau.

In recent years, there has been much interest in understanding the mechanisms by which humans adapted agricultural subsistence patterns to high-altitude environments on the Tibetan Plateau and in the Andes (1–8). Chen et al. (1) bring important new data derived from the northeastern Tibetan Plateau (NETP) to bear on this issue.

Ecological factors can place heavy constraints on humans, particularly in areas of high altitude, because even small changes in temperature, precipitation, and land cover can have a major effect on what crops can be grown. Understanding what factors influence crop growth is key to producing more realistic models of past human behavior. Early studies of the mechanisms underlying the spread of wheat and barley considered a single aspect of crop growth patterns: length of the growing season (2). They argued that this factor slowed the spread of wheat and barley (2, 3) and facilitated the spread of millets (2). A more complete estimate of agricultural potential can be constructed using thermal niche modeling (4, 5, 8, 9). In particular, models based on a crop's accumulated heat requirements—growing degree days (GDD)—predict that wheat and barley are more adapted to growth in high-latitude and high-altitude Eurasia than millets (4, 5). Millets were able to flourish only in select niches on the southeastern Tibetan Plateau (SETP) and only during the warmer Holocene climatic optimum (although even here, models indicate that their potential success was low (5)). In contrast, the frost tolerance and lower GDD requirements of wheat and barley enabled these crops to be rapidly adopted as staples on the Tibetan Plateau and its margins (4, 5, 8). Local ecology and climate, coupled with crop phenology, thus had a marked impact on crop adoption in high-altitude environments, one that differed substantially from the lowlands (10).

New data from the NETP provide strong support for the important role played by barley in facilitating agricultural practice on the Tibetan Plateau (1). However, as with politics, all agriculture is local and depends on specific local conditions. Thus, a clear understanding of constraints on crop growth in any given locale is crucial to the development of archaeological models for human behavior (4, 9). Examination of the thermal niche occupied by barley on the NETP (Fig. 1) shows that growing barley at an altitude of 4000 m above sea level (masl)—a claim made in Chen et al. (1)—was unlikely to have been successful in the average year. In the NETP, they could be reliably grown only up to 3000 masl, and the highest site from which they document barley remains is at 3341 masl (table S1 in (1)). Although it is possible that climatic variations could have increased the elevation at which crops could be grown in certain years or that there were particularly favorable micro-environments in otherwise inhospitable zones, the social memory of crop failure and the risks associated with it would have likely driven humans away from farming in such environments.

Furthermore, seeds can arrive on archaeological sites via a wide range of mechanisms; their presence at a site should not be taken as evidence of in situ agriculture. Both hunter-gatherers and pastoralists can be involved in complex patterns of exchange with agriculturalists, trading resources available to them for domestic grain [e.g., (11)]. Finally, agriculturalists and agropastoralists can reside in areas well outside of where crops can be grown, while still cultivating fields within an agriculturally productive niche.

Until recently, hunter-gatherers have been relatively invisible in discourses on agricultural and pastoral origins in China, even though evidence shows that they were present on the plateau well into the late Holocene [e.g., (12)]. The potential for both hunter-gatherers and pastoralists to move grains outside of the cultivated niche means that caution should be exercised when discussing when and where agriculture was carried out on the Tibetan Plateau and with what permanence it was occupied. There is a need not only to develop

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Fig. 1. Thermal growing niche of barley based on accumulated heat requirements (GDD) in the NETP. A GDD base temperature of 0°C is used for barley. Barley can be grown with certainty in regions shaded red. Regions covered by different minimal estimates of growing conditions are shaded white. Barley cannot be grown in the regions shaded blue. The black contours denote elevation above sea level. Lakes and major rivers are shown in gray. [Figure prepared using methods from (4) and data from (14) and (15)].
the tools to identify and characterize more mobile populations but also to view these populations as important and active actors in the spread of agriculture and pastoralism throughout East Asia (13). Disentangling how agricultural crops and pastoral animals spread onto and across the Tibetan Plateau requires not only better evidence and robust models upon which this evidence may be brought to bear but also more complex narratives to interpret the mismatch between archaeological data and models for human behavior.

REFERENCES


12 December 2014; accepted 3 March 2015 10.1126/science.aaa4819
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Science 348 (6237), 872.
DOI: 10.1126/science.aaa4819