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评述与展望
Review and Progress

大麦起源与传播的争议

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摘　要　大麦是禾本科(Gramineae)大麦属(*Hordeum*)的一种禾谷类作物，拉丁学名为 *Hordeum vulgare* L.，是新月沃地最早驯化的谷物之一。最新的研究表明，西藏不是世界大麦演化中心，意味着新月沃地是唯一公认的世界大麦演化中心。在公元前 5 000 年至公元前 1 500 年间，旧大陆历过一次可被称为“主粮全球化”的历史过程，大麦也因此传向世界各地。其中由新月沃地向西传播至欧洲的年代和路线已经被学者大量讨论，达成较为一致的共识，而向东传播至中国和印度的年代和路线因缺乏相应的证据，至今仍存在争议，特别是关于大麦传入中国的路线。最近，华盛顿大学等机构的学者对来自中国及周边的 70 个大麦遗存样本进行放射性碳(^{14}C)分析，确定各个样本的年代，确定至少在公元前 2 000 年大麦就已传入中国，但是传入中国的路线仍未确定。
关键词　大麦, 大麦属, 新月沃地, 起源与传播

Controversy on the Origin and Spread of Barley

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Abstract　Barley is a cereal crop belonging to Genus *Hordeum* of the family of Gramineae with the Latin name as *Hordeum vulgare* L., is one of the first domesticated grains of the Fertile Crescent. The latest research shows that Tibet is not the center of world barley evolution, meaning that the Fertile Crescent is the only recognized center of world barley evolution. Between 5 000 BC and 1 500 BC, the Old World experienced a historical process that could be called "Food Globalisation in Prehistory", and barley was spread to all parts of the world. The era and route from the Fertile Crescent to the west to Europe have been discussed by scholars and reached a consensus. The era and route of spreading eastward to China and India are still controversial due to lack of corresponding evidence. Especially regarding the route of barley to China. Recently, scholars from universities such as the University of Washington conducted radiocarbon (^{14}C) analysis of 70 barley samples from China and surrounding areas to determine the age of each sample. It was determined that at least in 2 000 BC, barley was introduced to China, but it was introduced. The route in China is still undetermined.
Keywords　Barley, *Hordeum*, Fertile Crescent, origin and Spread

大麦(*Hordeum vulgare* L.)是禾本科(Gramineae)大麦属(*Hordeum*)的一种禾谷类作物，与小麦一样，是新月沃地最早驯化的谷物之一(Badr et al., 2000)。自驯化至今，大麦种植遍布全球温带气候区域，其一个变种－青稞则在海拔 4 000 m 的青藏高原已有 3 500~4 000 年的驯化历史，已经完全适应了极端高

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寒气候(Li et al., 2019)。

野生大麦(*H. spontaneum*)是驯化大麦的祖先，具有独特的基因、等位基因和调控因子，而这些遗传信息在提高栽培大麦抵御生物或者非生物胁迫和适应气候变化有着巨大的潜力(Wang et al., 2018)。野生大麦的穗易碎，成熟时，小穗分开，便于种子扩散。而驯化的大麦则有不易碎的穗，使成熟的大麦更容易被收获(Zohary and Hopf, 2000)。研究表明，驯化大麦穗不易碎是由 *BT1* 和 *BT2* 是两个紧密连锁的基因中的一个突变引起的，许多大麦品种同时存在这两种突变。穗不易碎的条件是隐性的，因此表现出这种条件的大麦品种是突变等位基因的纯合子(Zohary and Hopf, 2000)。

那么，存在野生大麦的地区会是大麦的起源中心吗？

1 新月沃地是大麦的起源中心

一些学者认为考古背景下野生大麦最早的证据来自新月沃地加利利海南端旧石器时代晚期的 Ohalo II 遗址，发现的大麦遗存可追溯到公元前 8 500 年；另一些学者则认为野生大麦最早的证据来自库尔德斯坦的耶莫遗址(Jarmo)，也就是今天的伊拉克地区，同样在新月沃地。目前，新月沃地是国际上公认的大麦等作物的起源中心(Zohary and Hopf, 2000)。

自 1938 年瑞典植物学家 Åberg 在中国四川甘孜首次发现并报道了六棱野生大麦的存在，科学家们在青藏高原各地都陆续发现了野生大麦。此外，在西藏还发现了从野生大麦(二棱皮)到青稞(六棱裸)的各种中间型大麦，例如二棱裸大麦和六棱皮大麦，很多中国青稞研究者将它们称之为西藏半野生大麦(Tibetan semi-wild barley) (Hsu, 1975; Dequan and Tingwen, 1988)。因此，中国的一些青稞研究者则普遍认为，青稞是西藏本土的野生大麦演化而来，西藏也是世界大麦演化中心之一 (Hsu, 1975; Dequan and Tingwen, 1988; Dai et al., 2012)。

然而，最新的研究表明，西藏不是世界大麦演化中心，在西藏发现的西藏六棱野生大麦和西藏半野生大麦并非真正的野生大麦，而是栽培大麦野化起源或是杂交和野生大麦自然杂交起源(Konishi, 2001; Tanno and Takeda, 2004; Zeng et al., 2018)。

2 大麦的传播

旧大陆在公元前 5 000 年至公元前 1 500 年间，经历过一次可被称为“主粮全球化”(Food Globalisation in Prehistory)的历史过程(Jones et al., 2011; Liu and Jones, 2014; Fuller and Lucas, 2017)，起源于不同地区的农、牧产品、人口、思想与物质形式交织成一个巨大的欧亚网络，成为青铜时代古代世界的基础。这一过程中，新月沃地的农业与农人向外传播是其中最重要的组成部分。

当前，关于起源于新月沃地的各种作物向外传播的研究和讨论日渐增长，主要有两大背景。一是学者对早期“主粮全球化”日益增长的学术兴趣(Jones et al., 2011; Fuller and Lucas, 2017)；二是推动外来作物适应现有农业体系的驱动因素(Liu and Jones, 2014; Liu et al., 2014; Zhuang et al., 2017)。

来自新月沃地的各种作物向外传播有两条主路线，一条是向西传播至欧洲，还有一条是向东传播至印度和中国。其中向西传播的年代和路线已经被学者大量讨论(Lister and Jones, 2012; Zohary et al., 2012)，而最近的研究试图阐明这些作物向东传播的年代和路线(Flad et al., 2010; Dodson et al., 2013; Spengler et al., 2014; Liu et al., 2016)。

2.1 大麦向西传播

大麦作为“新石器时代基础作物”(the Neolithic founder crops)，与新月沃地其它作物(小麦, 燕麦, 豌豆, 小扁豆, 蚕豆, 胡麻等)共同向西传播，经地中海沿岸，直至欧洲各地(Colledge and Conolly, 2007; Zohary et al., 2012)。

学者普遍认为大麦等谷物栽培是在公元前 7 000 年传入欧洲东南部的，在接下来的 3000 年时间里，通过两条路线传至欧洲各地。一条沿着多瑙河和莱茵河河谷穿过中欧，进一步进入北欧平原；另一条则沿着地中海海岸，途经意大利到达伊比利亚半岛(Bogucki, 1996; Davison et al., 2006; Tresset and Vigne, 2011)。

大麦往西传播的路线和年代在学术界已经达成较为一致的共识，那么大麦又是怎么往东传播的呢？

2.2 大麦向东传播

大麦从新月沃地向东传播的路线和年代和小麦存在极大的一致性，特别是在传入中国之前 (Liu et al., 2017)。

早在公元前 6 500~3 000 年，大麦从新月沃地传入土库曼斯坦(Miller, 2003; Harris, 2010)，在公元前 6 000~3 000 年进入巴基斯坦(Petrie, 2010; Petrie, 2015)。此后，公元前 3 000年左右，大麦向东传入印度

北部地区(Weber, 1999; Fuller, 2006; Fuller and Murphy, 2014)。公元前 3 000~2 000 年向北沿着“Inner Asian Mountain Corridor”传入阿富汗，塔吉克斯坦，哈萨克斯坦和吉尔吉斯斯坦 (Spengler and Willcox, 2013; Motuzaite Matuzeviciute et al., 2015; Spengler, 2015)。

然而，关于大麦传入中国的路线却存在较大的争议。在 2011 年，中国社科院考古研究所赵志军教授提出，西亚作物进入中国存在三条可能的路径：北方草原路线、中纬度的丝绸之路以及南方海洋路径(Zhao, 2011)。那么，大麦到底是通过哪条路线进入中国的？

3 大麦传入中国的路线

最近发表于 PLoS One 杂志，题为“Journey to the east: Diverse routes and variable flowering times for wheat and barley en route to prehistoric China”的文章试图理清西亚新月沃地作物在公元前 5 000 年后，继续向东，进入古代印度与古代中国的年代和路径(Liu et al., 2017)。

华盛顿大学等机构的学者共收集了 70 个大麦遗存样本，来自中国各地的有 54 个样本，印度的有 12 个样本，吉尔吉斯斯坦 1 个样本和巴基斯坦 3 个样本。对这些样本进行放射性碳(^{14}C)分析，确定各个样本的年代(图 1)。

青藏高原南侧许多大麦遗存的年代为公元前 3 000 年以后。其中年代最早的是来自印度西北部哈里亚纳邦的 Masudspur VII (公元前 2 832~2 474 年)，其次是 Burj (公元前 2 581~2 349 年)。在恒河流域，年代最早的是 Damdama (公元前 2 832~2 303 年)，而在印度南部，年代最早的是 Sannarachamma (公元前 1 951~1 765 年)。很显然，大麦在印度境内的传播路线总体是自北向南的。

而在青藏高原的北侧，最早的大麦遗存年代是公元前 2 000 年以后。其中中亚最早的大麦遗存来自吉尔吉斯斯坦的 Aigyrzhar−2(公元前 1 630~1 497 年)，其次是土库曼斯坦的 Ojakly (公元前 1 617~1 498年)。哈萨克斯坦塔斯巴发现的一种大麦可以追溯到公元前 1 437 年到 1 233 年之间。在中国，西部新疆地区发现最早大麦遗存是四道沟遗址，可追溯到公元 975 年至公元前 831 年；但是在青藏高原东北部的甘肃黑水国遗址最早的年代是公元前 1 880~1 693 年，相邻的青海则发现中国最古老的大麦遗存，可追溯到公元前 2 118~1 894 年；而中部和东部地区最早的年代是山东，公元前 895 ~ 751 年(图 1)。

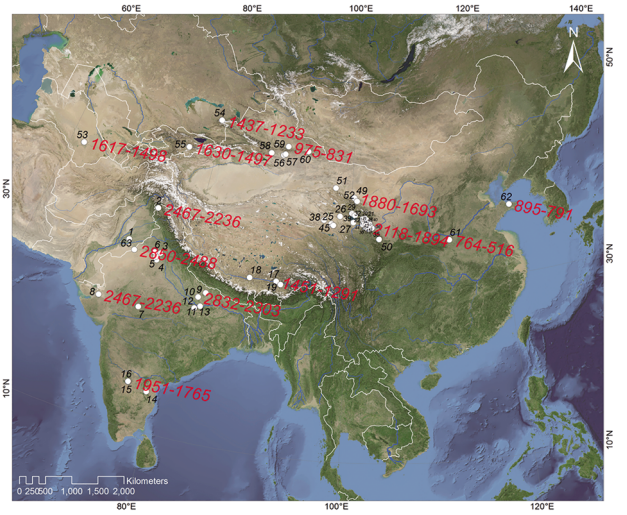

图 1 大麦遗存进行直接放射性碳测量的地点(摘自(Liu et al., 2017))

注: 标出每个地区最古老的大麦遗存年代

Figure 1 Location of barley remains for direct radiocarbon measurements (Adopted from (Liu et al., 2017))

Note: Mark the oldest barley relics in each region

因此，要阐明一条可靠的大麦传入中国的路线是相当具有挑战性。大麦遗存确切的年代顺序整体呈现为南亚早于东亚，青海早于中亚和新疆。虽然沿着青藏高原北线，从阿富汗的 Shortughai，塔吉克斯坦的 Sarazm 和哈萨克斯坦的 Begash 发现了裸大麦遗存，包括谷物和谷壳，所有这些都可能追溯到公元前三、二千年，但这些大麦遗存至今还没有确定具体年代(Willcox, 1991; Frachetti et al., 2010; Spengler et al., 2013)；沿着南线，缺乏来自青藏高原南部公元前 3 000 年的大麦遗存证据，这可能与青藏高原东北部的数据点有关。

目前，关于大麦传入中国的年代，从统计学的角度讲，至少在公元前 2000 年就已传入中国，而关于其传入的路线则还缺乏强有力的证据，需要进一步调查。或许作物遗传学可能是揭示大麦传入中国路线的有效候选方法(Jones et al., 2012)。

4 大麦传播的环境挑战和开花时间的遗传控制

众所周知，作物为了完成它们的生命周期，其开花的时间需要与有利的天气条件相一致，以避免敏感的花组织在极端的温度或干旱中受到破坏。在大麦的原产地新月沃地，大麦需要在夏季干旱到来之前完成它们的生命周期，这时候春/夏季到来时增加白天的长度来诱导开花来实现的(Cockram et al., 2007; Jones et al., 2016)。当大麦传播到新的纬度和高度时，

这种季节性反应可能被证明是不适应的，例如在青藏高原高海拔地区(Chen et al., 2015; d'Alpoim Guedes et al., 2013; 2015)和北欧高纬度地区(Jones et al., 2012)，大麦的春季生长习性和光周期不敏感是适应当地极端气候的关键因素。那到底是什么导致大麦适应新的维度和高度呢？

植物在极端纬度和高度栽培时，会对其季节反应基因造成选择压力。在2005年，英国约翰纳斯研究中心(John Innes Centre, JIC)的科学家首次发现控制大麦开花期基因 Photoperiod-H1 (Ppd-H1)，相关研究成果发表在 Science 期刊(Turner et al., 2005)。Ppd-H1 基因位点的突变已被证明会导致大麦光周期响应的关闭，从而使大麦能在不同的季节性模式下生长(Turner et al., 2005; Jones et al., 2008; Liu et al., 2017)。在极端纬度和高海拔地区的寒冷的气候有利于春季播种作物的“春季生长习性”。

作者贡献

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