第 25 卷 第 3 期
2006 年 8 月

人 类 学 学 报
ACTA ANTHROPOLOGICA SINICA

Vol. 25 ,No. 3
Aug. ,2006

中国晚更新世—早全新世过渡期狩猎采集者的适应变迁

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摘要: 晚更新世之末到全新世之初是史前人类适应行为发生急剧改变的重要时期,其代表性的变化就是食物生产的起源。考古发现的证据与生态模拟的预测、推导相对比,显示出良好的耦合性。考古证据还显示这个时期的狩猎采集者采用了多样的适应模式以应对环境变化的挑战,食物生产并非唯一的选择;与此同时,食物生产的产生对环境和文化系统的初始条件具有强烈的依赖性。尽管晚更新世之末迅速的环境变化促进了食物生产的起源,但是考古材料与模拟的耦合、狩猎采集者适应变迁的多样性、食物生产起源的特殊机制都显示出这个时期的人类文化行为系统在生计模式的选择之间保持着一定的张力,以最好地适应环境的变化。

关键词: 环境变化; 生态模拟; 适应行为模式; 狩猎采集者; 食物生产

中图法分类号: K871.1 **文献标识码**: A **文章编号**: 1000-3193 (2006) 03-0195-13

前 言

晚更新世之末,即从末次盛冰期到全新世开端的这段时间,全球气候在波动之中逐步转暖,从前为冰川覆盖的土地又有了植被,新的生态空间形成,也就为史前的狩猎采集者提供了新的生态位[1];与此同时,已经有人居住的环境也发生了重大变化,对人类的适应行为提出了新的挑战。

人类行为是长期进化的产物,是人类对于环境的适应与人类行为自组织发展的产物。有关晚更新世之末古人类行为变迁比较经典的研究有中东食物的生产起源[2,3],最早的美洲人与其狩猎适应[4],欧洲中石器时代的广谱适应[5]等。我国幅员辽阔,生态环境复杂多样,晚更新世之末的史前人类行为变化更加丰富多彩,很难如中东、北美、欧洲那样用一个典型的模式来概括。

目前我国在对于史前人类适应的讨论主要在材料发现与器物组合层面上进行,不过正在向行为层面上转移[6],但对人类适应行为变化的机制尚缺乏必要的探索。在本刊 2006 年第一期"中国狩猎采集者的模拟"一文中(以下简称上文)笔者介绍了 Binford 运用 395 个狩猎采集者的材料与 2000 多个全球气象站的气候材料建立起人类行为模式与环境之间关系

收稿日期: 2006-03-24; **定稿日期**: 2006-05-24

基金项目: 国家自然科学基金(40472016)

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的参考框架[7],但他关于中国的材料比较缺乏,笔者作了一些弥补[8,9]。本文是在此基础上,具体讨论:(1)在模拟基础上提出的预测和推导与考古证据之间的耦合关系;(2)中国晚更新世之末狩猎采集者适应行为模式的多样性;(3)中国晚更新世之末狩猎采集者适应行为变化的动力机制。

1 考古证据与狩猎采集者模型的对比

上文在参考 Binford 对近现代 395 个狩猎采集者的研究的基础上计算出狩猎采集的生计条件下可利用的植物资源量和可利用的动物资源量这两个变量,进一步得出纯粹利用陆生动植物资源的人口密度分布[7](图 1)。在这个图上,可以看到如果依靠狩猎采集的方式生活,那么在我国人口密度最高的地区应该在西南,次之是华南和内蒙古中南部地区。大西北地区自然食物资源贫瘠,人口最为稀少。最值得注意的是处在温带地区的我国北方环渤海地区、关中地区,还有处在亚热带的长江中下游地区,这些如今人口拥挤的地方倒是人口密度较低。也就是说,如果说这些地区古人类依赖狩猎采集为生的话,它能支持的人口密度要低于西南、内蒙古的中南部一带。再进一步说,当食物资源同步减少或者人口增加时,这

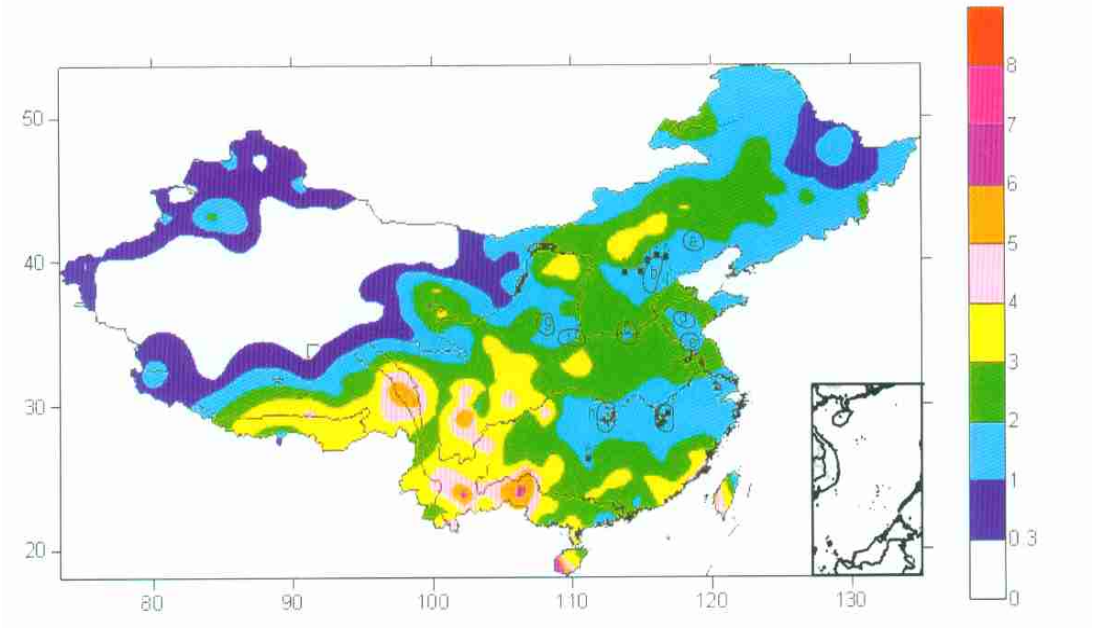

图 1 陆生资源模型预测的狩猎采集者的人口分布与考古发现的对比(人口密度:人/百平方公里)

Comparison between distributions of population density depended on terrestrial resources and archaeological evidence(population density: person/hundred square kilometer)

最早期的新石器时代遗址(Incipient Neolithic sites):1. 于家沟(Yujiagou)、马鞍山(Maanshan)等,2. 南庄头(Nanzhuangtou),3. 镇江营(Zhenjiangying),4. 东胡林(Donghulin),5. 转年(Zhuannian),6. 玉蟾岩(Yuchanyan),7. 仙人洞(Xianrendong)、吊桶环(Diaotonghuan);早期新石器文化(Early Neolithic cultures):a. 兴隆洼文化(Xinglongwa Culture),b. 磁山文化(Cishan Culture),c. 裴李岗 - 贾湖文化(Peiligang-Jiahu Culture),d. 后李文化(Houli Culture),e. 小山口文化(Xiaoshankou Culture),f. 老官台 - 李家村文化(Laoguantai-Lijiacun Culture),g. 大地湾一期文化(Dadiwan I Culture),h. 彭头山文化(Pentoushan Culture)

些地区将更早遭遇到人口的压力,即自然食物资源的不足。因此,人类如果要生存下去就必须改变适应行为,一个有效的适应策略就是进行食物生产。

上文中提到从事食物生产的基本环境条件是有效温度(Effective Temperature)不低于12.75度,低于这个温度阈值而高于11.43度时,狩猎采集者只能主要以狩猎为生,因为可食用植物的生产力只能满足作为辅助食物的要求,而不可能作为主要食物来源;而当有效温度低于11.43度时,无论依赖植物还是动物资源,狩猎采集者都无法生存;15.25度是要求储藏的最高有效温度值,低于这个温度值,就要求有食物储藏,以度过食物匮乏的季节[7]。所以食物生产最有可能出现的地带是有效温度不低于12.75,同时不高于15.25的地区,因为这些地区一般以植物为主要食物资源,而且有储藏的习惯。我国最早期的新石器遗址与早期的新石器文化分布都在这个温度区域范围之内(参考上文图10)。

目前的考古证据还显示,早期新石器时代有确切食物生产的文化主要分布于环渤海地区、关中地区、黄淮海地区和长江中下游地区(图1),也正好在模拟的范围之内。同样地,最早期的有食物生产迹象(包括定居的结构、陶器、磨制的工具、墓葬等标志)的遗址分布也在模拟的范围之内[10—17],不过他们更趋向于在模拟范围区的边缘地区。这种趋向大体反映最早期的食物生产起源于盆地、谷地和山麓这些森林与草地的交界地带,而待食物生产的技术较为成熟之后,才进入了平原地区(图2)。以华北地区为例,在晚更新世之末的旧石器文化中可以见到耐用的锛状器,如下川[18]、籍箕滩[19]、孟家泉[20],和搬运中容易破碎的陶器,如于家沟[16],这些都显示出此时狩猎采集者的流动性已降低,他们有能力或者说不得不在有限的范围内寻找更多的食物。如果不能如此,食物生产就成了唯一的选择。

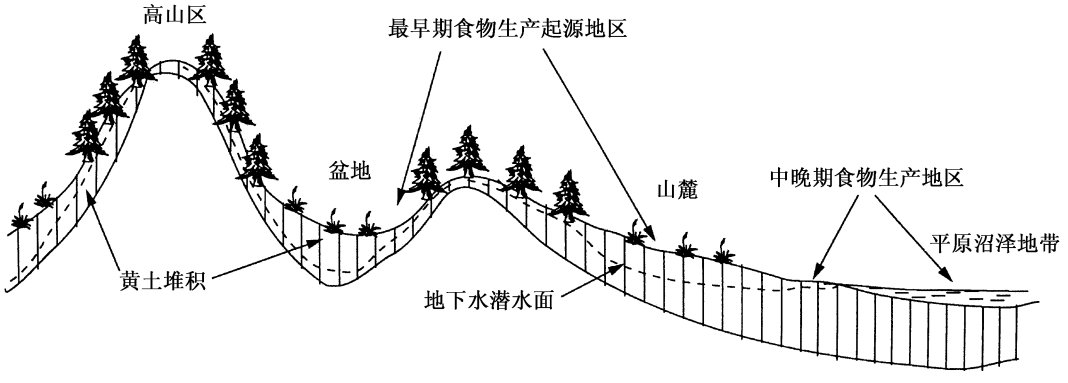

图2　华北食物生产起源与扩张(地形剖面示意图)

The origin and diffusion of food production in North China(topographic section)

从图2来看,气候较干旱的黄土高原地区的植被类型和黄土高原厚度关系密切。森林植被分布于基岩山地和薄层黄土区,黄土有效水孔隙度高,水分入渗浅,土壤蒸发消耗水分较多,厚层黄土区的土壤水分条件不能满足森林植被的需要,因此厚层黄土区无森林植被分布。基岩山地和薄层黄土区的植被以林木为主,厚层黄土分布区以浅根草灌为主[21]。旧石器晚期的狩猎采集者一般选择森林边缘地带生活,因为这个地带是生态系统的交接地带(Ecotone),资源多样性最强[22]。既可以狩猎,也方便采集。冬季到河谷可避严寒,夏季上山坡以避蚊虫,这个地带也可以说是狩猎采集生计的最佳地带(Optimal Zone),人口也最为密集,文化的积累也最为充分。当狩猎采集经济难以为继的时候,人类就在山麓和盆地边缘地

区开始最早的食物生产[23],如前文提到的于家沟、转年、东胡林、南庄头等遗址;当食物生产经济开始成熟之后,山麓、盆地边缘地带土地过于狭小和崎岖的弊端就出现了,人类就向平原地区迁移,如磁山文化的遗址;到食物生产经济更加成熟之后,人类便开始利用平原上的沼泽地带,如华北新石器中晚期的遗址。

在长江中下游地区我们同样可以看到类似于华北的食物生产的起源过程。最早期有食物生产迹象的遗址如玉蟾岩、仙人洞都分布于山麓地带,而到新石器早期的彭头山文化,食物生产经济开始扩张到了湖岸平原的地带,这个趋势进一步加强。到新石器时代中晚期,具有食物生产经济的遗址已遍布湖岸平原地带[24]。

2 狩猎采集者适应行为模式的多样性

在晚更新世之末到早全新世这个过渡期除了华北和长江中下游地区向食物生产转型之外,还有其他若干个文化生态单元[9]如东北、西南、岭南、青藏高原、西北戈壁沙漠与内蒙古草原地区并没有采用食物生产经济,而是继续保持狩猎采集的生计,当然这些地区狩猎采集生计的模式也发生了丰富多彩的变化。按上文的模拟预测和推导,狩猎采集资源条件最好的西南地区依靠较为丰富动植物自然资源可以把狩猎采集这种生计方式继续下去,相比而言,以动物狩猎为主的内蒙古中南部地区与以植物采集为主的华南地区相对更容易遭遇人口的压力。广大的西北地区、高寒的青藏高原腹地,植物资源贫瘠,动物分布稀散,依赖狩猎采集是难以谋生的,这是由狩猎采集者的流动能力所决定的[25],所以这两个地区基本是无人居住的地带。最后,东北森林地带能支持的狩猎采集人口密度处于中等偏上的水平,由于气候条件的限制,食物生产困难,狩猎采集的生计将不得不延续;但以狩猎为主,人口压力比较大,当地人群可以通过利用水生资源如鱼类来缓解人口压力。水生资源,尤其是海岸水生资源和陆生资源具有不同季节规律,可以有效缓解依赖狩猎采集为生群体的人口压力,如北美西北海岸地区[7,26]。

而从考古证据来看,西南地区的狩猎采集持续的时间最长,一直延续到近现代时期。西北与青藏高原腹地最早的人类活动证据迄今还不是很确凿,但理论上说都应该是食物生产起源之后的事。东北地区的狩猎采集的生计也进入到历史时期,同时捕鱼是非常重要的生计内容,即使有了一定的食物生产之后(考古证据如昂昂溪[27]、大布苏[28]、新开流[29]、后洼[30]等)。

从考古证据来看,最早的食物生产在山前地带出现后,经过两千年以上的时间发展成熟,然后向平原地区扩张。从新石器时代中期开始,在北方以粟为主的旱作农业向周边地区大规模扩张,这其中既包括单纯技术的传播,也包括人口的扩散。大约在六、七千年前后,人类才进入到青藏高原的腹地[31](图 3)。

在我国南方,稻作农业不断向南与西南方向扩散,并与当地已有的初步的食物生产技术相结合,发展出当地的稻作农业(如昙石山文化),长期流行的云贵高原稻作起源说[32]不仅理论上不成立,从考古发现的证据中也得不到支持,类似的如印度稻作独立起源说也不成立[33]。相反食物生产在西南地区遭到较长期的抵抗,狩猎采集在当地人口的生计中占有农业普及地区难以比拟的重要性。

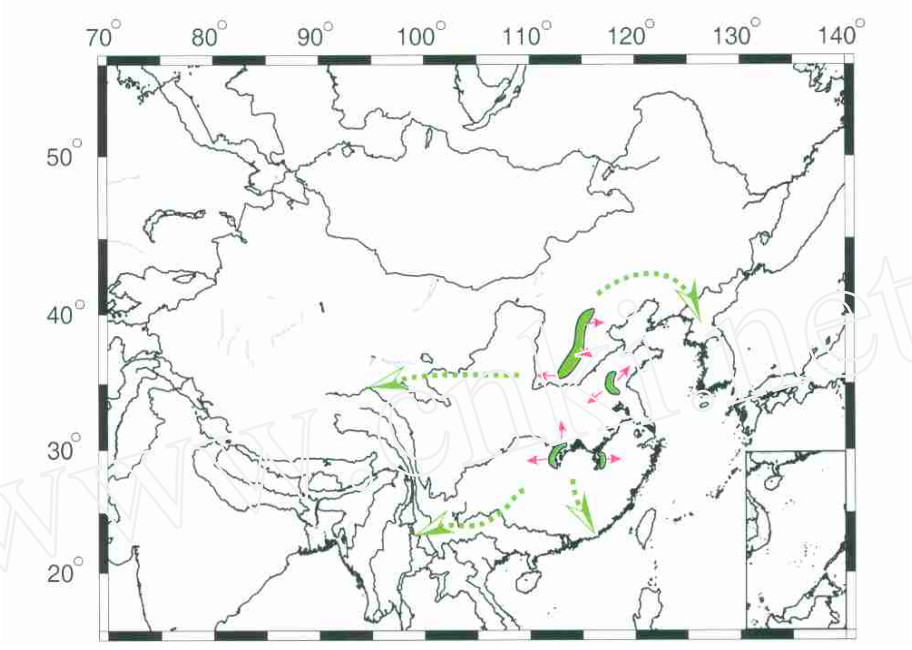

图 3　食物生产的起源与传播 The origin and diffusion of food production

环形表示最早食物生产起源的区域,实箭头表示早期新石器时代食物生产的传播,空心箭头表示食物生产在新石器时代中期之后的传播。The circled areas represent core regions in the origins of food production. Solid arrows show the diffusion of food production in the early Neolithic period while empty arrows mean the diffusion after the middle Neolithic period.

3　人类适应行为改变的原因与机制

3.1　初始条件—古环境的变迁

从现代气象材料基础上建立的模拟与考古发现证据出人意料的耦合意味着两个可能性:一是晚更新世之末的环境状况与现代没有本质区别;另一可能性是环境变迁对于此时的古人类的行为演化影响不是决定性的,食物生产是人类行为自组织演化(Self-organizing Evolution)的结果,或者说人类在这个阶段已经逐步摆脱了环境影响机制,如同工业革命的产生。而实际情况是这两种可能性是并存的,差别在于理解的视角上。

晚更新世之末如果从最大盛冰期(LGM)算起到全新世开始,这个时间段中是环境急剧变化的时期,主要表现于:

(1)海平面的迅速上升,从前的陆地被海水淹没,古人从事狩猎采集的空间大大被压缩。这个影响在北方尤为明显。现在整个黄淮海平原的面积不过387 000km^2,而最大盛冰期时暴露的黄海和渤海大陆架达到457 000km^2[34]。因此可以说对于晚更新世末在平缓草原狩猎采集的古人类而言,他们的生活空间在几千年之间被压缩近一半,其结果是增加这些地区的人口密度,即使人口不增长,密度也会翻一倍。同样,东海在最大盛冰期时有 55 %的面积暴露,更加重要的是长江的溯源堆积导致中下游地区湖泊的形成,长江中下游地区古人狩猎采集的空间也会减小。

(2) 古季风的影响。与降水相关的东亚季风最大期在北方出现于10 000 —7 000BP ,在长江中下游地区出现于8 000 —7 000BP ,而在我国西南地区由于受西南季风的影响降水最大期出现于12 000 —10 000BP[35] ,这是有利于食物生产起源与发展的条件。

(3) 动植物群的变化。气温的回升 ,植被迅速被替代 ,有证据表明在我国北方落叶阔叶林替代针叶林可能不到 500 年[36] ,过程相当迅速。而于动物群而言 ,最为明显的变化是相当多的大中型有蹄类灭绝 ,在我国北方有 14 种晚更新世常见种灭绝 ,占总数的 35 %[8] ,这会导致生计压力的提高。

(4) 季节性的加强。在12 000 —8 000BP 之间冬夏之间的太阳辐射差比现在要大[7] ,对于季节性本来就很分明的我国北方和长江中下游流域 ,其季节性进一步加强 ,对于储备的要求也相应提高。

(5) 新仙女木事件的突然性被认为是中东食物生产起源的主要原因之一[2] 。新仙女木事件发生在几十年间 ,并持续了大约1 500年 (从11 700到10 200BP) ,进入典型的全新世气候[38] 。格陵兰冰芯更准确地显示在北极以外的地区新仙女木事件发生于11 660BP[39] ,突然的气候变化会加剧生计压力。

晚更新世之末的环境变化无疑是急剧而且波动的 ,和全新世的环境有很大的不同 ,尤其表现于动植物的变化上。但是基本的气候格局如温度、降水只有纬向和经向上数度的变动 ,而没有整个格局的颠覆。如在北方 ,暖温带的边界有五个纬度左右的迁移[40] ,尤其在晚更新世的最后阶段 ,即新仙女木事件前后 ,气候及环境的其他因素已和全新世相当接近。另外 ,类似的变化在整个更新世中并不是独一无二的 ,环境变化作为动力要素构成人类文化系统发生变化的一个初始条件。

3.2 人类行为系统的自组织演化

食物生产并不是人类的专利 ,蚂蚁会利用蚜虫生产食物。食物生产对于狩猎采集者来说并不陌生。澳大利亚的土著[41] ,北美西南的印第安人[42] ,亚马孙丛林的印第安人[43] 都会移植和管理他们需要的植物。食物生产的产生需要相应的机制来诱发与维持 ,直到这一生计策略完全成熟并取代从前的狩猎采集适应。

对于晚更新世的狩猎采集者而言 ,低于有效温度 15.25 ,他们就必须有必要的储备 ,以渡过食物资源短缺的季节 ;而当有效温度低于 12.75 时 ,依赖植物性食物为生就变得不大现实。最早的食物生产者必然是依赖植物性食物为生而且有储备习惯的狩猎采集者。当然仅有这些还是不够的 ,狩猎采集者基本以两种适应策略来生存 :一种是通过不断的迁徙来发现新的资源 ,完全的居无定所 ,即所谓的 Forager 策略 ;另一种是有一定的固定营地 ,然后派出任务小组出去采集和猎获食物 ,名为 Collector 策略[44] 。在热带及那些资源分布较均匀的地区 ,Forager 策略较常见 ,而与资源高度斑块分布的地区 ,Collector 策略更为有利 ,温带区域物种的种类没有热带丰富 ,但单个物种的数量较大 ,更有季节性。运用 Collector 策略生存的狩猎采集者 ,他们不得不学会营建更结实的建筑 ,因为他们在一个地方可能呆更长的时间 ;他们不得不发展更耐用的工具 ,包括食物加工工具、储存工具等 ;又因为他们为了利用高度季节性的资源并避免失败的风险 ,他们不得不发展更有效更可靠的工具。此外这种生计策略让他们更适应人口相对集中的定居生活 ,他们对于定居导致的疾病传播有更好的免疫力。这就是为什么有的狩猎采集者能够开始进行食物生产 ,而有的狩猎采集者不能进行食物生产的主要原因之一 ,也就是他们初始的行为适应基础不一样 ,这是由他们过去的发展过程所

决定的。

非常值得注意的是晚更新世之末西南地区狩猎采集者适应变迁与环境变化的同步性。西南季风带来最大的降水出现于12 000—10 000BP,但此时的温度还没有达到典型的全新世气候的水平,即这一地区温度较现在要低。现有的考古发现证据表明这一地区与食物生产起源紧密相关的因素如磨制的工具、陶器、甚至是定居的结构等都出现得相当早[45—47]。然而随着全新世气候的回暖,这个地区的史前人类又放慢了走向食物生产的步伐,真正意义上的食物生产往后拖延了数千年。气候回暖使食物的季节性减弱,食物生产的必要性也随之消退。另一个史前人类的适应变迁与环境变化高度同步的地区是燕山-长城南北地区,这种变化在全新世表现得十分明显,古人在狩猎采集与食物生产之中来回波动。气候适宜时进行食物生产,不合适时就回到狩猎采集的生计方式。这个地区处在环境的过渡带上,对气候的变化非常敏感,它是原始食物生产的北部边缘地带。古人应时而动,通过生计行为的调整来适应环境的变化。这两个地区的例证表明食物生产并不是远古狩猎采集者的必然选择,人类行为在自组织的成长与环境变化中保持着一定的张力。

4　结　论

简言之,我们可以作出以下结论: (1) 尽管食物生产代表人类适应的进步,但它并不是史前狩猎采集者面临社会与自然环境压力的唯一选择,他们根据资源条件的变化在食物生产与狩猎采集中作出有利于自己的选择,模拟与考古证据都支持这点; (2) 食物生产的出现要求自然环境和文化系统具备必要的初始条件,比如生活在有效温度的阈值范围之内和采用 Collector 适应策略,不是任何地区的狩猎采集者都可以采用的,这也是为什么早期食物生产在我国只出现于华北和长江中下游的主要原因; (3) 晚更新世的气候环境变迁促进了食物生产的发生,但它只是文化系统发生变化的初始条件,模拟与考古证据的耦合、狩猎采集者适应的多样性、食物生产起源的独特机制等都反对将人类行为模式的变迁简单归因于环境变化。

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Adaptive Changes of Hunter-Gatherers during the Late Pleistocene-Early Holocene Transition in China

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Abstract: Food production is recognized as one of the most significant events that marks the transition from the late Pleistocene to early Holocene. However, not all hunter-gatherers appeared to accept this subsistence strategy immediately. A previously published model (see Vol. 25: 42 - 55) predicted that forager strategies would be seen in the plant-dependents of South China and Southwest China, as well as the animal dependents of the northeast-southwest transitional zone, which has the highest hunting resources. In addition, collector strategies would be used by peoples who were dependent on plants in North and Central China, where food production emerged. This research compares the model with archaeological evidence, and explores the relationship between them. In addition, this paper also evaluates hunter-gatherer subsistence diversity of those who did not initially utilize food production at the end of late Pleistocene. Finally, I discuss possible mechanisms of adaptive changes of late Pleistocene-early Holocene hunter-gatherers in China.

Comparison between Modeling and Archaeological Evidence

Comparing the terrestrial model with the archaeological record, it is found that they almost perfectly coincide with each other (see Figure 1) when we exclude those fundamentally environmental constraints such as the subpolar bottleneck (ET = 11. 43) and the threshold of plant dependence (ET = 12. 75). All food production took place in the areas where the ET is between 12. 75 and 15. 25, and at which storage has been used. Most interesting, all early Neolithic cultures are distributed in the areas where population density is relatively lower, when only supported by terrestrial resources. When putting all known early Neolithic cultures and all known incipient Neolithic sites on the map, it is very surprising that there is no exception. The Incipient Neolithic sites are distributed in the two large areas of North and Central China, i. e., the middle and lower Yangtze valley and circum-Bo Sea region. This is coincident with the centers of domestication origin: millet in the north and rice in the south. So far only one early Neolithic culture is found in the middle and lower Yangtze valley, but the incipient sites such as Xianrendong and Diaotonghuan have a long sequence extending from the incipient Neolithic to

the late Neolithic, and they include some phases belonging to the early Neolithic. It is because of the limited materials and the lack of identifiable data that we cannot define an early Neolithic culture. It is possible though to find another early Neolithic culture in the middle and lower Yangtze valley. Close to the mouth of the Yangtze River, there is a middle Neolithic culture, called Hemudu, at which was found a large number of rice remains and complex architectural structures. It is still unknown if there is a third middle Neolithic culture. Archaeological records also suggest that the earliest evidence of food production in China is found in the ecotonal zones of North and Central China. With increasing sophistication of food production, the centers of domestication moved towards the fluvial plains (see Figure 2). However, owing to paleoenvironmental changes that led to the movement of the ecotonal zones, the early centers of diversification and intensification drifted northwards with the warming process since the Last Glacial Maximum.

Diversity in Cultural Adaptive Patterns of Prehistoric Hunter-Gatherers

Food production was not the unique and the best adaptive choice to all hunter-gatherers during the transition from the terminate Pleistocene to Holocene, when environmental changes led to different niches for them. Prehistoric hunter-gatherers kept certain tension between food production and hunting-gathering subsistence. From the terrestrial model, we expect to see most hunter-gatherers are in Southwest China, then Inner Mongolia, then the two islands of Hainan and Taiwan, and then in some mountainous areas. This is also highly correspondent with ethnographic records. Today most of the minor nationalities of China are distributed in Southwest China and the two islands, and they still have some cultural remains of hunting and gathering. Probably, Inner Mongolia is an exception, since hunting and gathering were replaced by pastoralism in the second millennium BC. But Northeast China had hunter-gatherers for a long period, until the last century. This area lies outside the threshold of ET 12.75, and its northern part lies below the subpolar bottleneck (ET 11.43). This means that food production is generally not feasible in its early stage. Similarly, it is most unlikely to find early archaeological remains of food production in Northwest China and Tibet. More than that, most of Northwest China and Tibet, at least one third of the country, is uninhabitable for hunter-gatherers. The peopling of these lands is totally a phenomenon after the emergence of food production. Only with the aid of grains or domesticated animals could people migrate there and use the land. Very limited production in primary production could support a similarly limited secondary animal biomass, among which the scarce and fast-moving ungulates are beyond the reach of hunter-gatherers. The typical hunters can only survive along the transitional zone that extends from the northeast to the southwest. Archaeological discoveries indicate that there are definitively not early and late Upper Paleolithic sites in Northwest China and Tibet, except in their northern peripheries and the eastern fringe of Tibetan Plateau.

Projected Causes and Mechanism of Hunter-Gatherer Adaptive Changes

1. Initial conditions-Paleoenvironmental changes

1) The rise of sea level

When considering the influence on the eastern half of China, i.e., North China, Central China

and South China, from the rise of sea level, it is reasonable to see both animals and hunter-gatherers would have had to migrate westward along the same latitudes when the exposed shelves were inundated by sea transgression. Then they could stay in the habitats similar to the one being inundated. In North China, about half of the fluvial plains of North China were lost to the sea around 10 000BP so that the population density of hunter-gatherers would be easily doubled, even if there were no population growth. Although retreating population moved inland in waves, they would have stopped in front of the mountains, where they would not move any more because the mountains represent different habitats. The hunter-gatherers groups were like sand being depositing on beach, and they increased the population in the hillside zone. This is a kind of ecotone that had been used by populations of relatively high density. Similarly, sea transgression inundated the 350 000km^2 continental shelf of the East China Sea. After the LGM the headward channel aggradation, resulting from sea level rise, could have reached as much as 1 750km above the present estuary, and have reached a height of 40 m above present sea level along the Yangtze River channel. At the boundary of the Pleistocene-Holocene, there are still no huge lakes in the middle and lower Yangtze River except those expanded by seasonal floods, which inundate more land than in the previous period.

2) The influence of monsoon

From a variety of climatic data, it suggests that the earliest appearance of a precipitation peak from the LGM is Southwest China ca. 12 000BP, almost 3 000 years before the East Asian monsoon maximum. The maximum precipitation/effective precipitation occurred ca. 12 000—10 000 years ago in Northeast China, ca. 10 000—7 000 years ago in North China, and ca. 8 000—5 000 years ago in the middle and lower valley of the Yangtze River. Contrary to the southward transgression in precipitation and effective moisture, the enhancement of East Asian summer monsoon continuously moves northward until ca. 6 000BP, i. e., the maximally northern limit, while the south limit of winter monsoon retreat.

3) Vegetational changes

At 18 000BP of the LGM, most of China was cold and dry. Frozen steppes covered almost all of North China, and the southern limit of continuous permafrost in the east moved 11 degrees south. The vegetative change from 12 000 to 9 000BP is abrupt and remarkable according to the pollen data. In particular, this challenge would occur in the boundary zones of vegetation. Hunter-gatherers probably had to practice a lifeway as 'niche chasers' in order to procure habitually used resources, and began to utilize the new resources. Vegetative replacement at the same time presents the opportunities to intensify some resources that have the greatest potential to increase production, i. e., the wild predecessors of crops.

4) Faunal extinction

The total species of herbivore found in the Upper Paleolithic sites of North China (see Table 5. 5), and find that 13 of 40 species disappeared, i. e., a 32. 5 % extinct rate. There is possibly an abrupt increase of the extinction rate at the very end of the Pleistocene. From the archaeological records, these herbivores are commonly found in the EUP sites, but dramatically decrease in the LUP sites, especially in North China. The abrupt and rapid environmental change after the LGM may have been the last straw. The drastic reduction of large mammals in size and quantity, especially herbivores, is another

initial condition to Holocene adaptations.

5) The Younger Dryas

The research from ice cores of Greenland suggests that some climate proxies associated with middle-latitude sources appear to have changed about 15 years before climate proxies associated with more northerly regions. The ice records show that the transition to the Younger Dryas occurred in a few decades, and that it took about 1 500 years (from ca. 11 700 to ca. 10 200BP) to reach the typical Holocene climate. Moreover, a near annually resolved, multi-parameter record from the cores of Summit, Greenland, indicates that most of the transition occurred in series of steps with the durations of only about 5 years. Therefore, the beginning date of the Younger Dryas is set at 11 645BP in higher latitudes and 11 660BP outside of the Arctic. This episode terminated as rapidly as it was initiated, in a 50-year period, so that the environmental changes that it led to, were abrupt, and undoubtedly significantly influenced the adaptation of hunter-gatherers. The lacustrine data from the Beijing area, where are located almost all incipient Neolithic sites of North China, suggests two short transitions toward a cold and dry climate, ca. 11 600—11 300 and ca. 10 950—10 480BP respectively. The research at the joint zone between Northwest and North China also witnesses the Younger Dryas as a period of cooler dryer conditions marked by widespread aeolian deposition.

6) Seasonality

The increase of seasonality is seen between 12 000 and 8 000BP in terms of the difference of summer-winter solar radiation relative to the present. In the LGM, one can expect the high-seasonality areas to move southward, but most of North China and the whole Central China are still in the scope of high-seasonality. In this sense, high seasonality is also a kind of initial condition for the origins of food production.

2. Self-organizing evolution of cultural adaptive systems

Food production is not completely strange for some hunter-gatherers, but it could only originate among those, who used a collector-strategy. Durable tools, long-term settlements, storage facilities are generally required when hunter-gatherers specially depend on plant foods. The difference of adaptive strategies can explain why only some hunter-gatherers could begin food production, and others not. South China ever had the earliest marks of Neolithic period such as pottery, polished tools, but food production was not used until several thousand years later than Central China. This pause of evolution of cultural adaptive systems could be traced back to the rapid improvement of environmental conditions for hunting-gathering in the early Holocene. In the transitional zone of the Yan Shan-Great Wall, archaeological evidence suggests that hunter-gatherers came to use food production when environmental conditions permitted, and they turned back to be hunter-gatherers when the climate deteriorated. As a self-organizing cultural adaptive system, hunter-gatherers kept a certain tension between food production and food foraging.

Conclusion and Implication

In sum, several conclusions can be made from this discussion:

(1) Although food production definitely represents a progress of human adaptation in energy controlling, this does not mean that it is an exclusive subsistence choice when prehistoric hunter-gatherers confront with pressures from social and natural environments. Instead, they would select their own strategy between food production and hunting-gathering, in order to best adapt resource changes. This argument is supported by both modeling and archaeological evidence.

(2) The emergence of food production requires some initial conditions of environments and cultural systems such as living in the area where effective temperature is below the threshold and using the collector strategy. As matter of fact, not every area has this kind of condition for hunter-gatherers who lived there. It probably could explain why food production only appeared in North China and the Yangtze Valley.

(3) Undoubtedly, climate changes of the terminate Pleistocene urged the emergence of food production, but they only played in the role as one of initial conditions. Environmental changes cannot simply explain the adaptive change of prehistoric hunter-gatherers, since the correspondence between modeling and archaeological evidence, adaptive diversity of hunter-gatherers, and the uniquely emerging mechanism of food production, all rejects this simple argument.

The coincidence of theoretical explanation and modeling prediction with the archaeological record has partly proven the significance of this research, and furthermore this research can guide future archaeological study. Most of all, it shows what archaeologists can expect in different cultural-ecological regions, and then allow us to put our limited funds and time into the most productive aspects. As Binford said, it would not be productive to prove that the earth is flat, and thus, a correct direction is needed for fruitful research.

Key words: Environmental changes; Ecological modeling; Adaptive patterns; Hunter-gatherers; Food production