Quaternary International xxx (2016) 1–8

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Technological radiation and the process of technological change at the end of the Levantine Lower Paleolithic

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ARTICLE INFO

Article history:
Available online xxx

Keywords:
Adaptive radiation
Lower Paleolithic
Technological evolution
Levant

ABSTRACT

The systematics of Paleolithic stone tools often borrows the concept of lineage from biological evolution. The goal of this paper is to explore the applicability of the concept of adaptive radiation that plays a critical role in evolutionary biology for the study of Paleolithic technology. It is proposed that the concept of technological radiation might be a useful addition to the emphasis on lineages found in the work of Simondon, Leroi-Gourhan, and Boëda. The idea of a technological radiation is then applied to the later stages of the Lower Paleolithic of the southern Levant, particularly the coastal plain of Israel, and the transition to the Middle Paleolithic.

1. Introduction

Paleolithic archaeologists often draw on concepts from evolutionary biology in developing higher level systematics for stone tool industries. This borrowing from biology is frequently based on the assumption that variability in stone tools map directly onto biological lineages. Thus for example, Francois Bordes attributed the evolution of technology to the “development of the brain and of its complexity, until 'Modern man level' was attained” (Bordes, 1971:5, for a more recent example see; Foley and Lahr, 2003). It is notable that in his influential work Bordes made a distinction between an industry which reflects a phylogenetic relationship (tradition or phylum) as opposed to the facies which is indicative of variations due to adaptation (mode de vie), age, or climate (Bordes, 1953a,b). The problem inherent in approaches to stone tools that are based on methodologies borrowed from evolutionary biology is that stone tools are not replicating organisms and thus the basic assumptions of biological evolution do not apply to these objects. Yet even when we recognize the distinctiveness of artifacts there might be a basis for the adoption of biological concepts that capture the dynamics of change over time not in a single entity (whether ontogeny for a biological organism or the *chaîne operatoire* of an artifact) but rather in a series of objects linked by ‘descent’. For sexually reproducing biological organisms, descent is a relation based on sexual reproduction while for stone tools descent is the result of the serial reenactment of learned technical knowledge and skills, both by a single individual and multiple individuals linked by the transmission of skill and knowledge through teaching and learning. Just as there are aspects of evolutionary dynamics in biological organisms that transcend the individual or adaptive responses to a particular environmental context the same might be true, in an analogous fashion, for artifacts. Thus, there is a basis for the employment of concepts such as lineage, analogy, and homology in the context of artifacts, while recognizing that the processes in the evolution of technological objects are distinctive. Boëda (2013) has recently coined the term *techno-logique* to express the distinctiveness of evolution in the technological as opposed to the biological realm due to the obvious differences between sexual reproduction and the transmission of learned knowledge and skill. Following Boëda, the reality of trajectories of evolutionary change in the technological realm is recognized and allowed to play an active role in our understanding of human evolution. Drawing on Simondon (1958) and to a lesser extent on Leroi-Gourhan's (1945) concept of *tendance*, Boëda emphasizes the application of the concept of lineages to Paleolithic artifact assemblages. The goal of this paper is to explore the applicability of the concept of adaptive radiation that plays a critical role in evolutionary biology to the study of Paleolithic technology and whether the concept of *technological radiation* might be a useful addition to the emphasis on lineages found in the work of Simondon, Leroi-Gourhan, and Boëda. The idea of a technological radiation is then applied to the later stages of the Lower Paleolithic of the southern Levant, particularly the coastal plain of Israel, and the transition to the Middle Paleolithic.

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http://dx.doi.org/10.1016/j.quaint.2016.01.067
1040-6182/

Please cite this article in press as: Chazan, M., Technological radiation and the process of technological change at the end of the Levantine Lower Paleolithic, Quaternary International (2016), http://dx.doi.org/10.1016/j.quaint.2016.01.067

2. Adaptive radiation and technological radiation

Paleoanthropologists are familiar with the concept of adaptive radiation in the hominin lineage during the period leading up to the emergence of genus *Homo* during which there were multiple co-existing genera of hominins (Leakey et al., 2001). An adaptive radiation is defined as the evolutionary divergence of members of a single phylogenetic lineage into a variety of different adaptive forms (Futuyma, 1998). Adaptive radiation refers to those evolutionary groups that have exhibited an exceptional extent of adaptive diversification into a variety of ecological niches, with such divergence often occurring extremely rapidly (Gavrilets and Losos, 2009). There are a number of aspects of adaptive radiations that are worth emphasizing. The first is that the extent of variation can be spectacular. The classic example of diversity in radiation is found among the African cichlid fish with an estimated 1000–2000 speciation event over the past 5 million years (Seehausen, 2006). Secondly, adaptive radiations are often associated with migration, however easily dispersing species rarely develop radiations. The lack of radiation following the dispersal of genus *Homo* suggests a high degree of mobility for members of this genus. There are also cases of replicated adaptive radiation where *ecomorphs*, distinct types related to an adaptive ecological context, evolve recurrently. An example of ecomorphs are found among the 'spiny leg' clade of *Tetragantha* spiders found on the islands of Hawaii (Blackledge and Gillespie, 2004). Spiny leg *Tetragantha* ecomorphs "of different color and size … can be mapped directly onto one of four ecological roles" (Blackledge and Gillespie, 2004: 357). DNA analysis indicates that these ecomorphs have multiple independent evolutionary origins on the different islands. It is interesting that multiple independent evolutionary origins are also evident for webspinning behavior among *Tetragantha* spiders in what are designated as *ethotypes* as they refer to behavior rather than anatomy. There are indications that there are temporal dynamics characteristic of adaptive radiations (Losos, 2010). In the case of the ecomorphs of *Tetragantha* it is suggested that rapid speciation following island colonization was followed by a decline in the rate of speciation (Blackledge and Gillespie, 2004).

By analogy to adaptive radiation a technological radiation is defined here as a significant increase in diversity of lithic assemblages in terms of both products and methods of production in a geographic region within a constrained time span. To be clear it is not suggested that the underlying mechanisms of technological radiation are the same as those underlying an adaptive radiation. Rather the use of this concept by analogy provides an expansion of evolutionary perspectives on technology beyond the constraining emphasis on lineages. Technological radiation may result from colonization but might also be a product of the internal dynamics of technological evolution. Boëda (2013) defines technological lineages as trajectories trending towards increased integration of the elements of a tool, or using the terminology developed by Simondon as a shift from concrete to abstract. Technological radiation might be a response to the process of transition between technological lineages. This would essentially be a period where aspects of an existing technological lineage are combined with elements from a new emerging lineage. The increase in diversity would then provide the selective context for the emergence of a new technological trajectory.

3. The Late Lower Paleolithic of the Levant: terminology and chronology

It has long been apparent that the late stages of the Lower Paleolithic of the Levant are distinctive. Even when chronometric dating methods were unavailable the excavations at the deeply stratified sites of Yabrud and Tabun made it clear that in the upper levels attributed to the Lower Paleolithic there was a shift towards a highly developed flake tool industry. In systematizing the Lower Paleolithic of the Levant, Bar-Yosef (1994: Fig. 2) presented a tripartite division of the Acheulean (Lower, Middle, and Upper) followed by the Acheulo-Yabrudian (see also Jelinek, 1981). Some authors suggested including the Acheulo-Yabrudian in the Middle Paleolithic but this suggestion has not been widely adopted. The systematics proposed by Bar-Yosef were developed in the virtual absence of chronometric data and before the recent excavations at Qesem Cave (Barkai et al., 2003; Gopher et al., 2005; Shimelmitz et al., 2011; Stiner et al., 2011; Shahack-Gross et al. 2014), Revadim (Marder et al., 1998, 2011; Malinsky-Buller et al., 2011a,b; Rabinovich et al., 2012), and Misliya Cave (Weinstein-Evron et al., 2003; Zaidner et al., 2006; Yeshurun et al., 2007; Valladas et al., 2013), along with the publication of the earlier excavations at Holon (Porat et al., 1999; Chazan and Horwitz, 2006, 2007; Monchot et al., 2012). Taken together the new research provides the basis for reassessing the systematics of the later stages of the Lower Paleolithic.

While the Acheulo-Yabrudian remains in widespread use there is some reason to question this practice and the term Late Lower Paleolithic has been proposed as an alternative to describe the entire range of industries between MIS 9 and OIS 7, thus includes all industries from the terminal stages of the Lower Paleolithic of the Levant (Porat et al., 2002; Horwitz and Chazan, 2016). There is no inherent importance to the terminology adopted, however the meaning implicit in the Acheulo-Yabrudian (or alternatively the Mugharan tradition) is problematic because this taxon is linked to both a period of time and a perceived cultural cohesiveness. The cultural uniformity of the Acheulo-Yabrudian has long been recognized as problematic and has led to the identification of a series of facies within the Acheulo-Yabrudian —Yabrudian, Acheulo-Yabrudian, Amudian. As discussed above, for Bordes (1953a,b) the term industry has a clear connotation of phylogenetic relationship while facies reflects 'way of life'. Although there has been very little explicit discussion of what is actually meant by facies and industry (or time period) in the context of the Acheulo-Yabrudian the use of this nomenclature has had the effect of distorting the emerging archaeological record in an effort to fit all data into the existing schema of the Acheulo-Yabrudian and its facies.

In contrast, the term 'Late Lower Paleolithic' frees us from this rigid scheme. The advantage of this approach to the taxonomy of lithic industries is that it allows us to consider the technological repertoire of a time period without prior assumptions about cohesiveness of the lithic assemblages. As a result a very wide range of variability becomes apparent. There is then room to consider the possibility that the end of the Lower Paleolithic in the Levant is not represented by a single lineage with a variety of facies but rather by a technological radiation. We are then in a position to consider the longer term dynamics that led to the emergence of the Levantine Middle Paleolithic characterized by a highly specialized reliance on variants of the Levallois method.

Research over the past twenty years on the Late Lower Paleolithic of the Levant draws heavily on the application of new dating techniques, primarily Thermoluminescence (TL), Optically Stimulated Luminescence (OSL) and Electron Spin Resonance (ESR) (Porat et al., 1999; Mercier and Valladas, 2003; Rink et al., 2004; Mercier et al., 2013; Valladas et al., 2013). All three methods rely on uptake of radioactive energy from the surrounding sediments and thus require local dosimetry. The impact of the application of TL, OSL and ESR cannot be understated however it is also important to consider the limitation in the precision of these methods when applied to archaeological assemblages.

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