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A study of hominin dispersal out of Africa using computer simulations

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Abstract

A study of hominin dispersal out of Africa using computer simulations is presented. Attention is focused on the joint probability of the colonization of Western Europe later than 1 Ma and that of Eastern Asia prior to 1.6 or 1.8 Ma, as current archaeological estimates suggest. We found that the determinant factor to hominin dispersal is the mode of hominin movement. If the movement of all populations is uniform and their number great enough, greater than 300 in our models, then such movement favors the colonization of Eastern Asia and Western Europe at more or less the same time. On the other hand, the colonization acquires prominent probabilistic features if the number of populations migrating is small enough, smaller than 10 in our models, or when all hominin populations may move but there are only a few with much higher mobility. In this case, the joint probability for the earliest dispersals of hominins in Western Europe after 1 Ma and Eastern Asia prior to 1.6 Ma ranges from 0.02 to 0.05. The single probability of colonization of Western Europe after 1 Ma is very high, about 0.5 for the majority of the colonization routes, whereas the corresponding probability of the colonization of Eastern Asia prior to 1.6 Ma is ten times lower, about 0.05. The least probable event is the earliest colonization of Java prior to 1.6 Ma, to which our simulation attributes a probability of ca 0.01. Deserts, mountains, and mountain ranges may delay the arrival at a certain location; nevertheless, their effect on the joint probability is very small.
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Keywords: Hominin dispersal; Colonization; Computer simulation

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Introduction

Our knowledge of hominin dispersals out of Africa has been considerably advanced during the last decades. However, there are still crucial aspects that call for further investigation. For example, it is not clear if the earliest colonization has been conducted at the dates proposed by the existing archaeological data, which in many cases are controversial. Also unclear are the combined effects of various environmental factors on the colonization of Eurasia and the routes this expansion followed. Finally, we can only speculate about the effect on the colonization from alterations in hominin behavior as a result of their evolution or adaptation to various environmental and dietary conditions.

An interesting approach, subsidiary to conventional archaeological methods of examining hominin dispersal, is the use of computer simulations, a developing field that has produced a number of noteworthy studies so far. A simulation of hominin dispersal may be transacted either by solving Fisher's classic equation (Fisher, 1937), a diffusion type equation, or by applying lattice models. The first approach has been developed by the work of Williamson (1996), Shigecada and Kawasaki (1997), as well as Young and Bettinger (1995). An application of this method has been carried out by Steele et al. (1998) concerning Paleoindian dispersals, that is hominin dispersals in North America from 13,000 to 10,000 years ago. This method presumes the knowledge of the environmental carrying capacity and the diffusion coefficient estimated by ethnographic and archaeological data. Diffusion coefficients of early *Homo* have been estimated by Antón et al. (2000, 2002). The second approach, that of the lattice models, is based on the theory of cellular automata (Hogeweg, 1988) and the most interesting application to model hominin dispersal out of Africa has been realized by Mithen and Reed (2002). These authors have examined the combined effect of a variety of parameters such as colonization rates, paleoenvironmental conditions, topographic barriers, land-bridges, and hominin environmental and dietary preferences on the colonization of Eurasia. Their study concludes that the different hominin types occupying Western Asia have led to a more variable fossil record than that of Europe and affirms the colonization of Europe prior to 1.5 Ma (mega annum), contrary to the archaeological evidence which suggests that this happened only after 1 Ma (Carbonell et al., 1995, 1999). Although there is some discussion of early lithic sites in Spain (Martínez-Navarro et al., 1997; Oms et al., 2000) providing evidence for human occupation in Southern Europe around and prior to 1 Ma, in general, the model's predictions about the colonization dates of both Western Europe and Eastern Asia do not converge with the corresponding archaeological data.

Mithen and Reed's study focuses on distributions of arrival dates at certain target sites and compares these with current archaeological data. However, the distributions are rather narrow and leave no probability for rather extreme events like the great difference between the earliest colonizations of Eastern Asia and Western Europe. The narrowness of these distributions might be due to the small number of iterations used in their model (30), and/or to the way that Mithen and Reed modeled hominin movement.

In the present study, our primary goal is to attempt to estimate the various *probabilities* of events associated with the earliest dispersal of hominins throughout Eurasia. At this point we should clarify that the hominin dispersal out of Africa is a typical probabilistic experiment. Hominins are moving from one place to another on the basis of certain probabilities determined from environmental factors. But their dispersal is a probabilistic "experiment" that has occurred just once and it shall never be repeated. This rules out any possibility of knowing whether the colonization has proceeded through the most probable route or if it has followed one of the least likely routes. When a random experiment takes place once, any result can be realized provided that it belongs to the set of all possible results of this experiment. Therefore, undoubtedly, neither this nor any other simulation model can give final answers as to what exactly has happened in the past. The only thing we can do by means of simulation models is to estimate the probability of

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