Quaternary International 300 (2013) 22–31

Contents lists available at SciVerse ScienceDirect

Quaternary International

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

The Water Optimisation Hypothesis and the human occupation of the mid-latitude belt in the Pleistocene

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ARTICLE INFO

Article history:
Available online 30 March 2013

ABSTRACT

A hypothesis – the Water Optimisation Hypothesis – is proposed to predict the occupation of sites by *Homo*. The hypothesis proposes that *Homo* occupied intermediate positions in the humidity spectrum. A consequence is that many suitable areas coincided with semi-arid to sub-humid rainfall regimes. *Homo* should therefore have located its sites in relation to water sources. Analysis of 357 sites occupied by *Homo* between 200,000 and 10,000 years ago confirms the prediction and reveals no difference in behaviour between *Homo sapiens sapiens* and the Neanderthals (*H. s.neanderthalensis*), indicating that the water-attachment of sites is a universal feature of the genus. It is proposed that a belt of similar characteristics, sometimes severed by climate, stretched from south-west Iberia to south-east Australia and was the cauldron of modern human evolution. Geographical expansion of *Homo* is predicted to have followed river courses and, only occasionally, coastlines.

1. Introduction

The aim of this paper is to establish whether there have been, in the course of the evolution of *Homo sapiens* and its contemporaries, particular regions of the Earth – hotspots – that have been extensively and repeatedly occupied. If we are able to establish that there have been, then the subsidiary aim is to determine whether these hotspots had features in common. We will then be in a position to ask if those features were of the universal kind (Lévi-Strauss, 1963) that characterised all humans. The role of water has received relatively little attention (Nicholas, 1998; Finlayson et al., 2008, 2011) in comparison to studies of diet and technology. Yet it is of prime consideration when understanding the survival of humans, particularly in arid tropical and subtropical environments where water is at a premium. For this reason, in this paper I will place particular emphasis on the importance of water as a limiting factor in human dispersion and dispersal.

2. Theoretical framework – the Water Optimisation Hypothesis

The working hypothesis behind this paper, which I have termed the Water Optimisation Hypothesis (WOH), is that humans, have been constrained by physiological and energetic factors. On a humidity gradient, humans would be best suited to occupying intermediate portions of the gradient, optimality falling on either side but more rapidly towards the humid than the arid end (Fig. 1). On the hyper-arid side of the gradient, humans would have been constrained by physiology in situations of high water deficit and by energetics, where food sources would have been severely limited (Whittaker, 1975). The situation in the hyper-humid end of the gradient would have constrained humans for reasons of food availability and accessibility in situations dominated by dense forests, which characterise areas with high rainfall regimes (Le Houérou, 2009). I suggest that the conditions allowing access to resources would drop more rapidly towards the hyper-humid end as forest closed access up. The broad spectrum of rainfall regimes falling in between the two extremes would have offered ample opportunities for humans. These would have included arid and semi arid portions of the gradient. The further to the left of the x-axis in Fig. 1, the greater the need to have the necessary skills to tap ephemeral, seasonal and highly variable (often hidden) water sources (*H. sapiens sapiens*; Finlayson, 2004). The further to the right, the greater the need to have skills that allowed for the exploitation of energetic resources in situations of increasing cover (Neanderthals; Finlayson, 2004). I have highlighted *sapiens* and *neanderthalensis* because they represent two opposite poles in terms of ability to move over large distances on account of their morphology (Raichlen et al., 2011). Such differences would have

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1040-6182/$ – see front matter © 2013 Elsevier Ltd and INQUA.
http://dx.doi.org/10.1016/j.quaint.2013.03.040

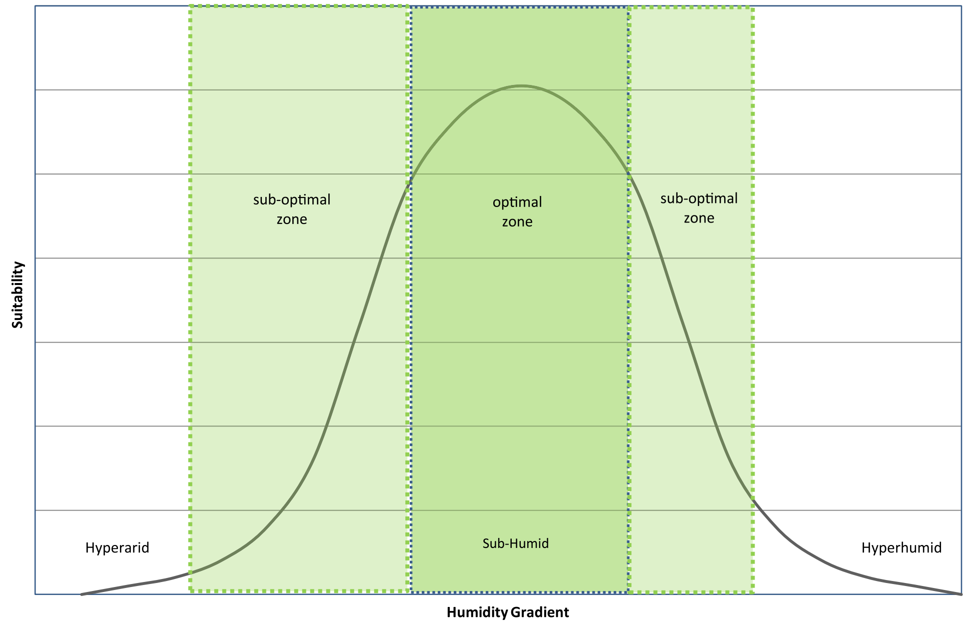

Fig. 1. The Water Optimisation Hypothesis. *Homo* is expected to have occupied an optimal zone in a humidity gradient ranging from Eremitic to Hyperhumid. Suitability of sites is expected to drop away from the optimal zone. In the context of this paper the Eremitic category would be defined as having mean annual rainfall under 50 mm and effectively 0 days of rainfall/year and Hyperarid would have 50–100 mm/year and <5 rain days/year. Hyperhumid, at the other end, would be defined as having mean annual rainfall >1500 mm, with >270 rainy days in the year. The optimal zone would be marked by a sub-humid climate having a mean annual rainfall between 600 and 1000 mm and between 150 and 240 days of rain/year. Sub-optimal zones would fall at either end of the optimal zone but it is proposed that the width of the suboptimal zone on the arid side (Semi Arid, rainfall 400–600 mm/year, 120–150 rain days/year; Arid, rainfall 100–400 mm/year, 90–120 rain days/year) would be greater than that on the humid side (Humid, rainfall 1000–1500 mm/year, 210–270 rain days/year) (Le Houérou, 2009).

been critical in the exploitation of widely scattered water sources. It follows that we would expect *H. s. neanderthalensis* to have been more susceptible to water shortage than *H. s. sapiens*.

3. Methods

357 Palaeolithic sites from across the world were selected for this study (Supplementary Table 1), covering the period 200 to 10 ka (thousand years ago), within the period of existence of *H. sapiens* and its contemporaries and prior to the advent of agriculture. The sites were chosen if they presented evidence of persistent occupation or were sites that revealed intensive occupation at a particular moment. The reason for such choice was to try and identify sites that could be regarded as source populations, in metapopulation biology terminology (Hanski and Gilpin, 1997). When considering archaeological sites it is assumed that human presence at a site indicates that the location was a favourable one but this need not be the case (Finlayson, 2004). A site might have held a sink population, which was maintained by immigration from a source population; in such a scenario this population would have been at risk of extinction. So mixing source with sink sites could obscure, even distort, patterns. Here, I assume that the sites chosen were source populations on the basis of the selection criteria used.

A series of variables was recorded for each of the sites: cave/open air site; proximity of site to lake, river, marsh, coast or other wetland (within 5 km); recorded presence of large terrestrial mammals, small terrestrial game, rocky habitat mammals, marine/freshwater mammals, or marine/freshwater small game (Supplementary Table 1). The latter category included molluscs. In the case of coastline, the distance was estimated to the coastline when the site was occupied.

4. Results

The sites in Supplementary Table 1 may be conveniently divided into general regions, from which we are able to identify areas with particularly high densities of sites (Fig. 2). It is recognised that sampling intensity may bias the observed pattern although largely in the direction of poorly represented regions as those with high site density must reflect a high level of human occupation. The important result is that areas of site concentration are identifiable, in keeping with the idea that hotspots existed during the Pleistocene time frame under discussion. Twelve hotspots are identified, accepting that others may emerge in the future. These are: 1. southern Africa; 2. The Levant; 3. south-western Iberia; 4. Central Mediterranean; 5. North-west Iberia/south-west France; 6. Circum-Alpine region; 7. Northern Caucasus/Black Sea; 8. southern Siberia; 9. southern Australia; 10. Coastal California; 11. Coastal Peru; and 12 Coastal Chile.

The 357 sites were grouped by broad geographical zones. Some zones encompass more than one hotspot while others are single hotspots. Number of sites was a criterion determining whether or not hotspots were clustered. The broad geographical areas were: 1. Eastern Africa, including the Levant (AFR: including hotspots 1 and 2 and sites in between); 2. south-western Iberia (SWIB); 3. Central Mediterranean (CMED); 4. North-west Iberia/south-west France (PYRE); 5. Circum-Alpine region (ALPS); 6. Eurasian Plain (SIBE) including hotspots 7 and 8; 7. Australasia (AUST); 8. Pacific Rim (PAC) including hotspots 10, 11 and 12; and 9. North American Plain (NAME).

Were there regional differences in the characteristics of sites occupied by humans? Sites were frequently caves in many areas. The frequency of caves sites was much lower on the Eurasian and North American Plains (Fig. 3) suggesting that human occupation of these vast high latitude regions may have required alternative sources of shelter. The circum-Alpine Region occupied an intermediate position suggesting that independence from caves may have originated here (or in another mountain-plains ecotone) and spread afterwards onto the plains. Coastal sites dominated in southern regions: AUST, AFR, PAC, SWIB and CMED (Fig. 4). The proportion of coastal sites decreased in PYRE and was low in ALPS,