Archaeo-riddle Proposal

Trying methods to improve archaeological inference

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1 Research Question

RQ3. What was the rate of dispersal of poppy chewers?

2 Proposed Approach

Behind all large-scale human dispersals, such as the spread of the Neolithic in Europe or the Bantu Expansion in sub-Saharan Africa, lies a body of literature seeking to categorise this movement as demic migration vs. acculturation. In the land of Rabbithole we are faced with a similar problem: uncovering the dispersal model of poppy chewers and their farming subsistence strategies amidst a pre-existing hunter-gather population, the rabbit skinners.

One of the standard tools archaeologists use to examine the dominant mechanism of dispersal is the calculation of dispersal rates. The slowest dispersal rates being associated with cultural diffusion, while faster rates with demic models and the fastest with a mixture of demic and cultural diffusion [1].

Whether dispersal rates alone can be used to determine the underlying mechanism of dispersal remains up for discussion, and framing dispersal debates in this way are not always helpful. It rigorously restricts to only two ways of movement: the migration of the social group as a self-contained entity, or the borrowing of ideas by local populations without any population admixture. The reality in any human migration is far more complex: the units of migration (individuals, families, communities), as well as the localised tempo and direction of dispersal frequently shifted [2].

My proposed approach for Archaeo-riddle is to focus on local variations in the tempo of the dispersal within smaller geographic regions of Rabbithole, which will hopefully capture some of the regional complexity in the predominant modes of dispersal.

3 Methods

Estimating dispersal rates in archaeology has typically followed a regression-based method [3, 4, 5, 6, 7, 8, 9] or, more recently, Bayesian phase models [10, 11, 12, 13]. The objectives of both methods are slightly different: the former is used to estimate the speed of the diffusion process, while the later to gain accurate estimates of arrival times.

Current regression-based benchmarks for the neolithic transition have found $0.6-1.3$ km/year for Europe [5, 14, 1], and 2.4 ± 1.0 km/year for South Africa [15] [1]. There are three major limitations to this method: (i) the analysis is dependent on the spatial scale, how one selects local sample sizes and defines the origin, (ii) the method uses mean calibrated dates and does not take measurement uncertainty into account, (iii) typically (as in [8, 9]) the use of linear regression yields single dispersal rates, which dramatically generalises movement dynamics − the method can be adapted[2] but it remains difficult to determine if the variations in calculated dispersal rates are genuine and not caused by measurement uncertainty, calibration error, or sample size. However, recent advances, such as

[1] Although it must be remarked that the latter study was based on an extremely small sample size ($n = 17$ dates).

[2] The easiest example of which would be to use nonlinear regression

Bayesian hierarchical Gaussian process quantile regression used in [13], mitigate some of these limitations. This is the method I aim to use in order to examine local dispersal rates of poppy chewers in Rabbithole. If time allows, examining a Bayesian phase model might offer more insights into the dispersal process.

4 Strategy to select Additional Data

As part of our solution, we are allowed to request five additional areas of information. I am not yet sure which spatial modeling process I am going to use to predict the most interesting regions to survey – potentially some form of Kriging or Gaussian Process. As can be seen from figure (1, right), there are seven high probability environmental fitness 'hotspots', corresponding to squares $7-8$, $28-29$, 12, $38-48$, 45, 62, 98 on the online Archaeo-riddle Shiny app. Square 45 is already publicly available. In addition, we are given elevation information figure (1, left).

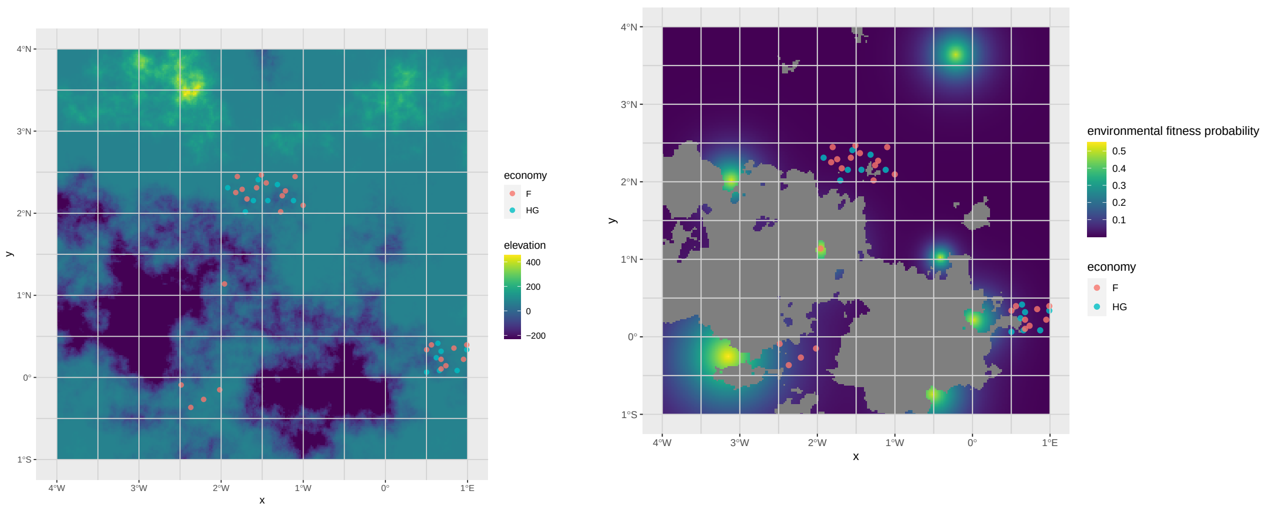

Figure 1: Left: Elevation map of Rabbithole with 14 rabbit skinner (HG, blue) and 25 poppy chewer (F, red) known sites. Right: Environmental fitness probability map with the same 39 known sites.

5 Preliminary Results

Based on the initial data available (squares 14, 30, 45, 65, 66), we find a preliminary result of an average poppy chewer dispersal rate between $1-1.9$ km/year over the entire Rabbithole region[3]. `nimbleCarbon` was used for the MCMC analysis. As we discuss in section (3), this is benchmark. We will also examine localised dispersal rates.

[3]This is highly likely to change as we refine the model and add in the addition data (see Section (4)).

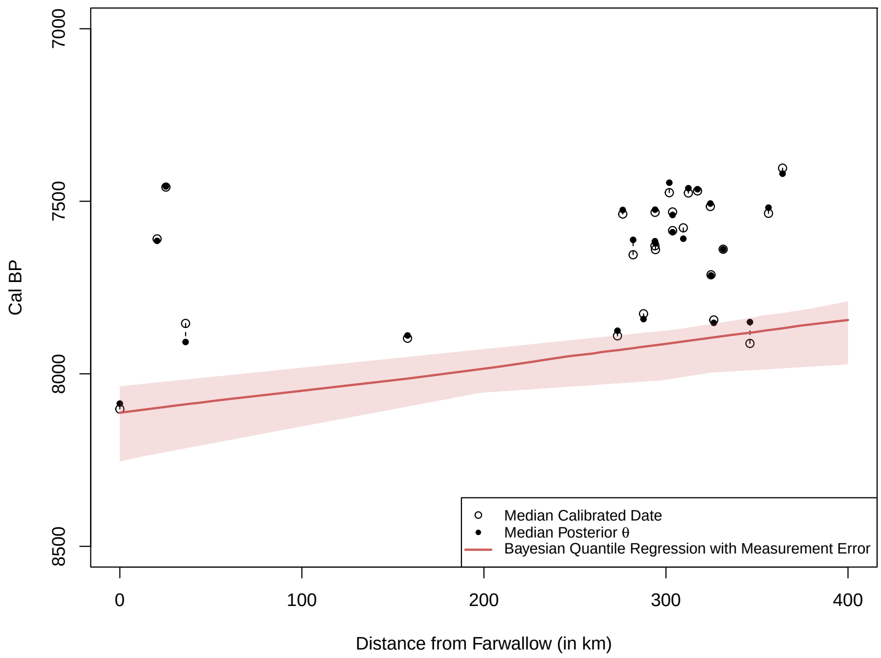

Figure 2: **Preliminary result**: Bayesian quantile regression model fitted on median calibrated dates (red line), the median calibrate dates associated with poppy chewer occupation (hollow dots), and the median posterior of the Bayesian overall model (filled dots).

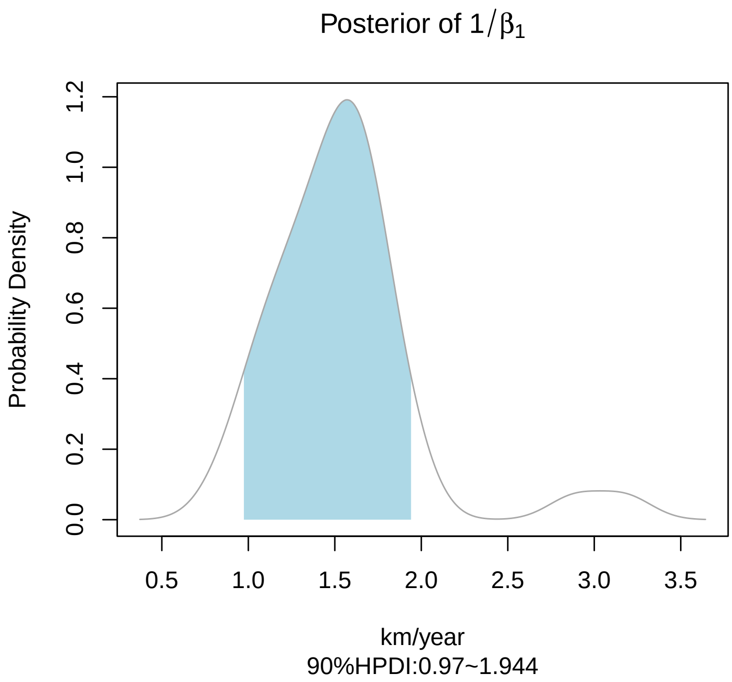

Figure 3: **Preliminary result**: overall estimated dispersal rate for the spread of poppy chewers (and their associated agricultural subsistence strategy) in Rabbithole using Bayesian quantile regression.

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