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## The spread of farming economy in the Western Mediterranean: a short reply to Ammerman 2021

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### Abstract

Manen et al. provide here a reply to the critical comment published by A. J. Ammerman regarding their article “The Neolithic Transition in the Western Mediterranean: a Complex and Non-Linear Diffusion Process—The Radiocarbon Record Revisited”, published in 2019 in *Radiocarbon*. They also use this occasion to reaffirm the need to elaborate novel interpretive frameworks that combine both geo-chronological and cultural data.

*Radiocarbon* has invited us to respond to A. J. Ammerman’s comments and criticisms of our article published in 2019, “The Neolithic Transition in the Western Mediterranean: a Complex and Non-Linear Diffusion Process—The Radiocarbon Record Revisited”. Foremost, we would like to thank *Radiocarbon* for the opportunity. Our reply will be short, as the form of this commentary is not particularly conducive to constructive scientific debate. Here we will simply lay out a few facts in order to enlighten the readers of *Radiocarbon*, who will then be sufficiently informed as to form their own interpretation of the topic at hand. Among the six specific points underlined, three warrant our attention and therefore a concerted response; the three others represent the author’s personal reflections and a presentation of the research context in which his work on the Neolithic transition in Europe has developed.

### FROM ONE MISUNDERSTANDING TO ANOTHER

The central theme of Ammerman’s commentary concerns the question of the rate of spread of early farming in Europe, the demic diffusion hypothesis, and the wave of advance model that he developed and promoted, as we are reminded via multiple citations. Before moving forward, let us first underline that these points correspond to about 3 % of the content of our initial article, the purpose of which was not to discuss these topics in particular but to present a new corpus of dates and, using new evidence, discuss their relevance to our collective understanding of the spatiotemporal and cultural dynamics at play during the Neolithisation of the Western Mediterranean. This was the purpose of our article, and we therefore underlined the important role of radiocarbon data for this research topic while citing numerous works, including Ammerman and Cavalli-Sforza’s 1971 article. Contrary to the author’s assertions, we have neither an *idée fixe* (fixed idea) nor a *bête noire* (pet peeve), we were simply resituating our results within a historiographical context, as is necessary for archaeological research. Moreover, and as we highlighted in the introduction of our article, the richness and diversity – and often divergent (!) – works on the Neolithic transition in Europe demonstrate that it simply makes little sense to position oneself *a priori* for or against any particular hypothesis. In the few lines that specifically concern the wave of advance model, Ammerman suggests we distorted his words and misunderstanding both the underlying mathematical principles and the necessary vocabulary for discussing the aforementioned model. As already mentioned, we touch upon this model briefly and succinctly in our article. We mention it in our introduction, within the context of a historiographical review that underlines the 1971 article as foundational. The wave of advance model is then evoked in the conclusion in order to present a contrast with some of our results, which we will develop in our next point. The author criticizes us for not having cited the entirety of his works and restricting ourselves to the 1971 article. Once again, our objective was not to conduct a review of these hypotheses. Furthermore, when we evoke them in the discussion, we wrote, “Therefore, these data diverge from the hypothesis of a progressive and regular diffusion of the Neolithic economy, which is sometimes perceived at a European scale (Ammerman and Cavalli-Sforza 1971 for the *princeps* model and Pinhasi et al. 2005, for example)”. The 1971 article is cited as it is foundational, but we also cite further extensions of the model that can be seen in the 2005 article, contrary to Ammerman’s claim.

Regarding our supposed distorted and erroneous presentation of his hypotheses, the author concentrates on our use of the word “constant”. We use this term exactly once in our historiographical introduction, again while making specific reference to the 1971 article: “The result is a constant diffusion speed in time and space (1 km/year). This “wave of advance” model explains the Neolithic transition by a regular movement of populations as a result of an ever-increasing demography contributing to the segmentation of group”. We have been criticised for our erroneous use of this term in 2021, yet the same use and similar turns of phrase can be found in the original 1971 article we were citing, for example:

- p. 681: “These results thus imply that the rate of diffusion was remarkably constant over a wide range of time and space, in spite of local variations which regional analysis may reveal”
- p. 687: There is good agreement between the measured rate and the constant rate of advance predicted by the model which will be referred to as that of the diffusional population wave of advance or simply “wave of advance”.

Of course, in later publications these analyses were expanded and developed, but as we have already highlighted, our introduction was not devoted to works on the question of the rate of spread of early farming in Europe, but rather, to the importance of radiocarbon data for understanding the process of Neolithisation.

## **LOOKING TO THE FUTURE**

Moving on, we would now like to address two of Ammerman’s specific criticisms:

1. *They believe that their new results diverge from previous studies and that no other group of scholars has yet to undertake a regional study in the Western Mediterranean. Of course, this is incorrect: we recently published just such a study in PNAS, as mentioned before.*

This is particularly erroneous – and our bibliography demonstrates this – as we reference this work and others. We could just as easily return the volley, as Ammerman seems unaware of several elements of the bibliography on Southern France, including the monography of Pont de Roque-Haute published in 2007 (Guilaine et al. 2007).

2. *The claim by the authors that emphasis should be placed on short-life samples in radiocarbon dating is not something new. This position has been around for some time (e.g., Zilhão 2011).*

We agree, and we cite the works of Zilhão at several occasions, and these works can be situated within the line of Waterbolk 1971 or of Van Strydonck et al. 1999. What we underline in the article and merits further discussion, is that the dates on single charcoal fragments are not systematically affected by the old wood effect. The sites of Peiro Signado and Pont de Roque-Haute are good demonstrations of this. In both cases, the dates obtained on cereal seeds are older than those obtained on charcoal. It thus seems that the systematic rejection of AMS dates on charcoal is not *a priori* systematically justified, even if each series obtained on charcoal must be critically examined. Furthermore, the question of potentially different chronometric scales between bone and cereal grain samples has recently been brought to light (Pardo-Gordó 2020). This hypothesis requires further testing at a broader scale, yet these such an interrogation is important, as it could also have considerable implications for the chronology of the diffusion of the Neolithic.

Let us now move on to the general framework of our research and the data that supports it. Ammerman underlines that he was one of the first to promote a quantitative approach in archaeology, and in so doing introduced major interpretive frameworks for research on the Neolithisation in Europe. This is also what we underlined in the introduction. As field archaeologists, however, we implement a more holistic approach that integrates geochronological data as well as cultural data that describes the material production of these past societies, their economies, etc. It is upon this data-driven basis that one of us formalized the arrhythmic diffusion model, which is characterized by rapid displacements at distinct moments followed by “stops” (breaks or periods of slow down) that generate periods of latency in the spread of the farming economy (Guilaine 2001, 2003, 2013, 2019). This model provided the basis for our arguments favouring a complex and non-linear diffusion process in the Western Mediterranean in the article. As we described, “If we superimpose data from the characterization of technical systems with audited and contextualized radiocarbon data, it becomes possible to bring to light complex and multifaceted processes of the emergence and development of the Neolithic economy and to deliver a much more informative historical narrative”. Several recent research programs (PROCOME, directed by C. Manen, but also MENEMOIA directed by T. Perrin and CIMO directed by D. Binder) have allowed us to revise the chronometric framework in which the Neolithisation of the Western Mediterranean occurs, in addition to permitting us to deepen our knowledge regarding the socio-cultural aspects of this process. Quite logically our results converge with those presented in Isern et al. 2017: the Neolithisation of the Mediterranean was a rapid process where the role of the Mediterranean Sea was, without a doubt, fundamental. This fact has been regularly underlined for several decades now (Guilaine 1996, 2003, 2018). Yet as soon as material and economic data are added to the mix, the story complexifies and greatly expands our interrogations of the pathways (multiple itineraries, diverse zones of origin, local adaptations to the receiving natural and cultural environments), the mechanisms at play (system of pioneers and colonizers versus short distance movements with progressive expansion, transmission of raw materials, of knowledge and of know-how), and the possible interactions between social groups. Here we will cite a few examples of these recent works without into detail:

- The geochronological data available for the last hunter-gatherers and the first farmers, as well as detailed and critical analyses of their potential interactions, illustrate the diversity of regional interaction

scenarios (Perrin and Manen 2021) that are likely in part responsible for the cultural, economic, and biological mosaic (Rivollat et al. 2020) that characterizes the societies of the 6<sup>th</sup> millennium BCE.

- In regards to the dispersal of Mediterranean Impressed wares between Italy and the Gulf of Lion, new dates have recently been obtained for the peninsula (Binder et al. 2017). Results highlight a clear tightening of the chronology in the so-called nuclear area (Apulia, Basilicata, Calabria) and a pioneer dispersal at a record speed. This apparent speed is all the more relevant as, at the time being, the oldest dates from Southern Italy do not exceed 6000 BCE (Guilaine et al. 2019).
- Moreover, compared to Central Italy, the first evidence of Neolithic farming in Southern France is earlier, by at least one century, around 5800 cal. BCE. Of course, new data in the Tyrrhenian zone could fill out the general lack of milestones on the western side of Italy in Lazio, southern Tuscany, and in the great Tyrrhenian islands. A significant proportion of the researchers that contributed to our article have also worked in Cyprus and know how a single discovery can push back the history of Neolithic diffusion on the island by several millennia. For example, for a long time the Neolithisation of Cyprus was understood via the island's Khirokitia culture, but the discovery and study of the Shillourokambos and Klimonas sites, which cover the long PPNA-PPNB sequence known in the Levant, pushed back this chronology by nearly two millennia (Guilaine et al. 2000; Vigne et al. 2012).
- In this context, the analysis of ceramic production, which can act as proxies for human migration and interaction, reveals another research question. The identification of distinct manufacture sequences and decorations between communities in Southern Italy and those in the North-Western Mediterranean, if we base our understating on the fact that these sequences and decorations are material manifestations of cultural values and social relations, demonstrates that the expansion of farming into Southern Europe was not a continuous and homogeneous process (Gomart et al. 2017).
- In a similar vein, we must underline that the economic and cultural foundations of Impressa and Cardial societies are very different (Bouby et al. 2020; Vigne 2007; Guilaine and Manen 2007) and correspond to distinct mechanisms of Neolithisation, which, logically, need to be taken into account when considering the rate of spread of early farming in the Western Mediterranean. In fact, Impressa communities in Southern France demonstrate long-distance mobility phenomena that can be linked to a process of pioneer colonization (circulation of obsidian, of pottery, and of livestock over 1000 km; Gabriele et al. 2019; Rowley-Conwy et al. 2013; Vigne 2008). Within Cardial communities, which develop afterwards, these long-distance networks disappear and the natures of both ceramic and lithic production systems, as well as the management of vegetal and animal resources, diversify and their territorial distribution expands. This abrupt shift could be the result of an economic and social reorganization of communities as they face new environments (Guilaine 2018). In fact, this possibility of an early continental pathway in the diffusion of the first farming is exemplified by novel old dates obtained from the Balma Margineda site (Manen et al. 2019) and others situated several hundreds of kilometres from the current coastline. It is therefore our opinion that it isn't methodologically pertinent to disconnect analyses of Neolithic diffusion from the societies and cultures that were the material vectors of said process. In this sense, and in regards to the Western Mediterranean, confusing the dates between the Impressa and Cardial cultures, when the latter chronologically followed the former, is not valid.

These few examples, even as presented briefly here, demonstrate that it is not only highly reductive, but also illusory, to attempt to estimate a rate of progression using only decontextualized chronometric data. For us, the strength and modernity of the archaeological method reside in its interdisciplinarity and in the often contradictory debates that such interdisciplinarity provides, especially when we confront data from the field, from analyses, and from syntheses. This is why we avoid all exclusive and reductionist approaches that tend to oversimplify the undeniable complexity of the facts, and prefer to take the challenge of deciphering the complexity of these systems head on. As Ammerman wrote in his comment, "the data, the methods, the models and the working hypotheses can all change as time's arrow moves forward". We share this perspective: moving forward the combination of geochronological criteria with technical, cultural, and economic expressions, all within the same quantitative framework, now seems unavoidable (Bernabeu et al. 2017; Rigaud et al. 2018). To finish, we would simply like to reiterate that in our work we wish to highlight and bring to the table the diverse arguments illustrating the complexity of the Neolithization scenarios in the Western Mediterranean.

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