Global processes, regional dynamics? Radiocarbon data as a proxy for social dynamics at the end of the Mesolithic and during the Early Neolithic in the NW of the Mediterranean and Switzerland (*c.* 6200–4600 cal BC)

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ABSTRACT – *The goal of this paper is to discuss the validity of radiocarbon dates as a source of knowledge for explaining social dynamics over a large region and a long period of time. We have carefully selected* c. *1000 ^{14}C dates for the time interval 8000–4000 cal BC within the northwestern Mediterranean area (NE Iberian Peninsula, SE France, N Italy) and Switzerland. Using statistical analysis, we have modelled the summed probability distribution of those dates for each of the analysed ecoregion and discussed the rhythms of neolithisation in these regions and the probability of social contact between previous Mesolithic and new Neolithic populations.*

KEY WORDS – *Mesolithic-Neolithic transition; ^{14}C; chrono-geostatistics; Bayesian analysis; GIS*

Globalni procesi, regionalna dinamika? Radiokarbonski podatki kot nadomestek družbenih dinamik ob koncu mezolitika in v času zgodnjega neolitika v SZ Sredozemlju in Švici (ok. 6200–4600 pr. n. št.)

IZVLEČEK – *Namen tega prispevka je razpravljati o veljavnosti radiokarbonskih datumov kot vira znanja, s katerimi razlagamo širjenje družbenih dinamik na večjem območju in v daljšem časovnem obdobju. Skrbno smo izbrali ok. 1000 ^{14}C datumov, ki sodijo v časovno obdobje med 8000-4000 pr. n. št. na območju severozahodnega Sredozemlja (SV Iberski polotok, JV Francija, S Italija) in v Švici. S pomočjo statistične analize smo za te datume modelirali vsoto porazdelitve verjetnosti za vsako od analiziranih ekoregij, v razpravi pa se osredotočamo na ritme neolitizacije na teh območjih ter na verjetnosti socialnih stikov med prejšnjimi mezolitskimi in novimi neolitskimi populacijami.*

KLJUČNE BESEDE – *prehod med mezolitikom in neolitikom; ^{14}C; krono-geostratistika; Bayesova analiza; GIS*

 DOI: 10.4312/dp.47.10

Introduction

The historical change from hunter-gatherer to farmer economy is one of the main historical transformations in human behaviour. In Europe, this change happened as a consequence of the arrival of farming populations originating from southwest Asia. This process started in the Aegean around 6500 BC and lasted for about 2500 years. Hunter-gatherer populations inhabited Europe at that time, and despite the fact that the spread of farming seems to be a global process, the diverse ecological, topographic, climatological and social contexts might have resulted in a mosaic of regional dynamics. Several theories aiming to explain this process have been proposed over time. These range from a migration model, where population waves were the main agent of change (*Cavalli-Sforza, Cavalli-Sforza 1995; Childe 1925*) to proposals emphasizing an endogenous origin of the Neolithic way of life (*Cruz Berrocal 2012; Plucienník 1998*). Currently, the hypothesis with greatest acceptance is the so-called diffusionist or integrationist model. With this, some degree of interaction and coexistence between the last hunter-gatherers and the first farmers is expected in most parts of Europe (*Bernabeu Aubán, Martí 2014; Bogucki 1996; Guilaine 1976; 2000–2001; Zilhão 2001; Zvelebil 1986; 2000*), although there were some exceptions (*Morales, Oms 2012*). In any case, it is important to take into account the extremely low density of the hunter-gatherer population in most areas of Europe (*Shennan 2018*), which makes its related archaeological record virtually invisible.

For more than 50 years this topic has often been studied using radiocarbon data. John Grahame Douglas Clark (*1965*) presented the first historical approach to the Euroasiatic neolithisation process by plotting on a map the earliest evidence for agricultural activities, as estimated by the available radiocarbon dates at that time. The study focused on the Danubian route from the Near East, and also considered other parts such as the Mediterranean route, and some isolated points in Northern Africa. With this model, Clark gave statistical validity to the hypotheses based only on material culture, brought forward by other pioneering scientists since the beginnings of the 20th century.

The classical Albert J. Ammerman and Luigi L. Cavalli-Sforza (*1971*) wave of advance model that was characterized by an assumed homogenous and regular spread of innovations and adaptations, can be criticized on the basis of more thorough and precise chronological coverage and better understanding of the complexity of the interactions of farmers with different environments and indigenous populations. This process is now understood as arrhythmic, with phases of both stasis (*Guilaine 2000–2001*) and acceleration (*Isern* et al. *2017*), and the integration of local dynamics is required to understand the global processes (*Fort 2018*).

Recent genetic studies (particularly with whole-genome analyses) have revealed interactions between local hunter-gatherer and incoming farming populations (*Villalba-Mouco* et al. *2019*). Even contacts between Neolithic populations from the Mediterranean and Central European regions have been suggested by aDNA of human bones (*García-Martínez de Lagrán* et al. *2018*). Therefore, from our point of view and as highlighted in previous works (*e.g., Perrin* et al. *2009*), it would be misleading to understand the process of the adoption of farming economies without taking into account the last hunter-gatherer indigenous groups. In the same way, we cannot assume the absolute independence of the central European and the Mediterranean routes of neolithisation.

It is in this sense that the SNF-Funded AgriChange project (*Antolín* et al. *2018*) investigates the area between the northwestern Mediterranean region (NE Iberian Peninsula, SE France and North Italy) and Switzerland. This area potentially covers the contact zone between the Danubian and the Mediterranean routes of neolithisation from the Near East, and thus potentially different patterns of interaction with diverse indigenous hunter-gatherer groups. It is an intensively investigated area but it suffers from either a very local/regional focus or a strictly western Mediterranean or Centro-European perspective, which we want to avoid in this paper. In order to grasp the end of the Mesolithic and the whole neolithisation process, we consider the timeframe between 8000 and 4000 cal BC. The aim of this paper is to trace where, when and how the transition phenomena between Mesolithic and Early Neolithic groups took place in the region mentioned above. The questions we intend to solve in this paper are as follows: (i) Can a robust radiocarbon dataset for a global region allow us to define different local scenarios of interaction for the neolithisation process? (ii) Was neolithisation a homogeneous process all along this region? Our premise is that interaction took place when evidence of hunter-gatherer and farming populations are found together at the same place and at the same moment. The problem lies, obviously, on the incomplete nature of the archaeological record itself, because in many circumstances one of these populations may be archaeologically invisible. The results of our investigation are consequently limited by the availability of well-dated archaeological contexts. Undated or unreliably dated archaeological contexts have not been included in this discussion. If the absolute quantity of dated contexts was too small, the study would have no meaning. However, given the high number of dated contexts in our database, we can assume the studied sample is a representative unbiased sample of the original population. In that sense, we have followed suggestions in the specialized literature about the minimum number of radiocarbon dated archaeological contexts for population inferences (*Williams 2012*).

Study area and archaeological framework

The study area of this paper stretches between the mouth of the Ebro River, the Po River and the upper Rhine River, thus encompassing the northwest Mediterranean area and Switzerland. In order to overcome any limitations derived from modern political borders, we have subdivided the study area into 14 ecologically circumscribed regions, termed ecoregions (Fig. 1). They have been defined according to the modelled potential vegetation and climate (*Brus* et al. *2012; Hijmans* et al. *2005* and Supplementary Material 1 at http://dx.doi.org/10.4312/dp.47.10) and using criteria established by the European Environment Agency (*2017*). Topography and geography were also considered, and thus coastal areas and river valleys have been emphasized since they facilitate rapid movement. On the other side, mountain ranges above 1000m asl have been integrated into single units, since archaeological evidence in these environments is at the moment very sparse and we can assume very irregular human movement and interaction.

Those ecoregions can be integrated into four main biotopes: mountains, coastal areas, valleys and their low-elevation hinterlands.

In the late Mesolithic context, two different cultural spheres can be defined, according to differences in their respective technocomplexes: there is a technological tradition present in the Alps, Apennines, Jura, Swiss plateau, Rhone valley, shores of the Adriatic Sea, and Mediterranean coast north of parallel 43°, and a different one in the southern Pre-Pyrenees, Pyrenees, and Mediterranean shores south of parallel 43° (Fig. 2).

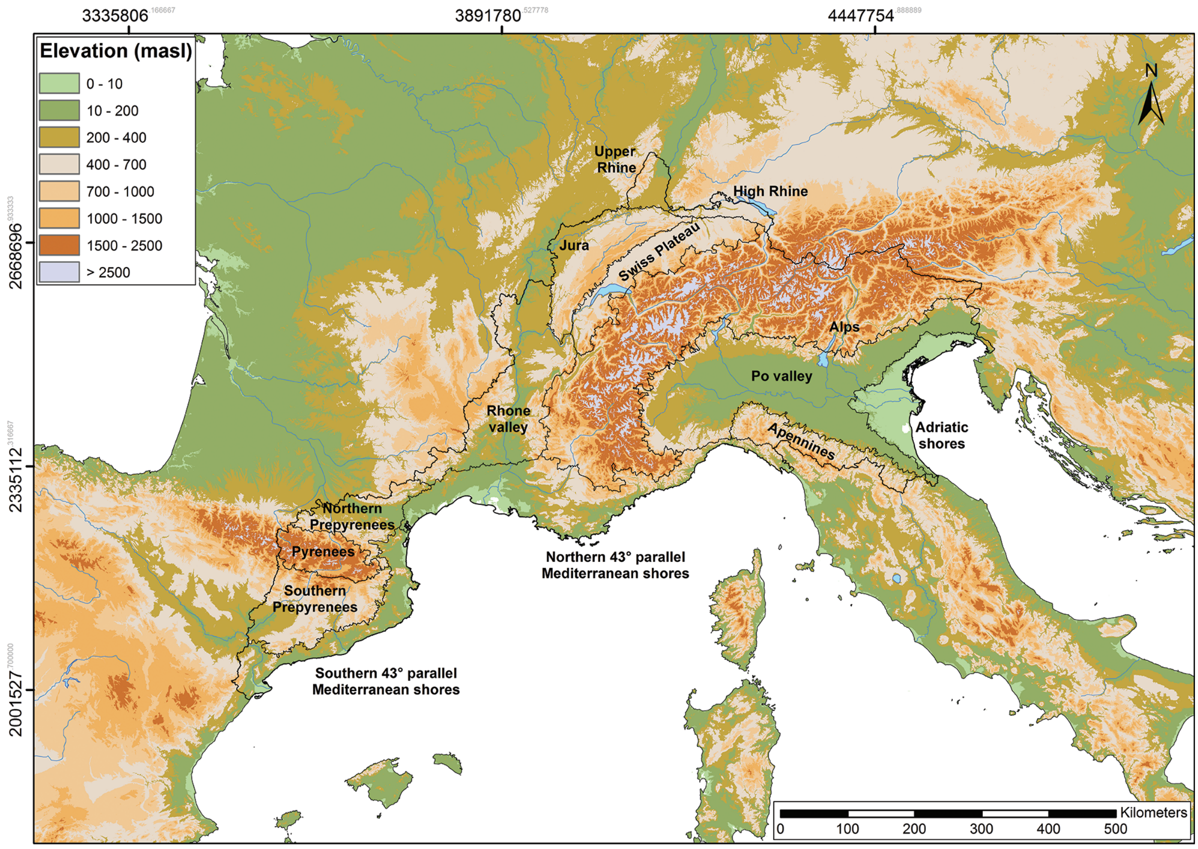


Fig. 1. Study area with the defined ecoregions.

For the northern part of the studied area, the period is traditionally integrated into a so-called '2nd Mesolithic', and it has been characterized by the presence of trapezoidal arrow points in archaeological assemblages. This characteristic lithic industry is the consequence of blades obtained from the knapping of big cores, and a successive modification of laminar supports (*Perrin, Defranould 2016*). The distribution of sites for this technocomplex is represented in Supplementary Material 2 at http://dx.doi.org/10.4312/dp.47.10.

On the other hand, in the southwestern parts of our study area – the Mediterranean shores south of parallel 43°, the southern Pre-Pyrenees and Pyrenees – the lithic industry is quite different. Archaeological assemblages are characterized by the presence of notches and denticulates obtained from rough flakes (*Martínez-Moreno* et al. *2006; Vaquero 2006*). This is the so-called 'Mesolític d'Osques i Denticulats'. We must stress that this seems to be a local phenomenon, since archaeological sites along the Ebro valley, for instance, show a different lithic industry with different features, more similar to the geometric laminar items typical of the northern regions (*e.g.*, Cabezo de la Cruz, *Rodanés, Picazo 2013*; Forcas II, *Utrilla, Mazo 2014*; Valcervera, *Utrilla* et al. *2016*).

Starting with the beginning of Early Neolithic cultural traditions, lithic industry homogeneity disappears and we find instead significantly greater diversity and regionalization. Pottery is now the most visible innovation, although similarities between some of these groups may be observed in other technological and economic aspects (Fig. 2).

Along the north-western Mediterranean shores, small nuclei of occupation are characterized by the *Impressa* type of pottery (*e.g., Guilaine, Manen 2005; Manen* et al. *2019a*) first, and the *Cardial* style later. During the latter phase, there is a visible expansion in the number of sites and occupied areas (*Manen 2002*). In comparison, along the Adriatic Sea shores the *Impressa* pottery documented is of a particular type (*Biagi 2003*). In the same area, and also along the Po valley, up to six different technocomplexes are recognizable: the Fagnigola, Fiorano, Vhò, Gaban, and Isolino groups (*Pessina, Tiné 2008; Starnini* et al. *2018*). We will refer to all of them under the label Neolitico Inferiore Padano Alpino (from now on, NIPA), although we are aware of the complex settlement history of this region. An undefined NIPA is attributed to the canton of Ticino in Switzerland, in the southern slopes of the Alps (*Stöckli 2016*). Only in the northernmost parts of our study area, around the Upper Rhine ecoregions, is there LBK evidence (*Stöckli 2016*), suggesting a possible relationship between the Central European and the Mediterranean penetration routes of early farming economies.

Also related with the interaction between north and south zones, in the upper course of the Rhone River, La Hoguette pottery has been documented in some sites, although the interpretation of this remains controversial (*Manen, Mazurie De Keroualin 2003*). The Néolithique Ancien Valaisan (NAV), in the upper stretch of the Rhone valley, between Lake Geneva and the Alps, seems to be related to the complex interaction networks between differentiated zones (*Gallay* et al. *1983*).

Review: contact Mesolithic-Neolithic populations in the study region

For a long time, archaeologists have debated the evidence of contact between hunter-gatherer and farming populations. It is difficult to present hard facts that prove exchanges or influences, because the available record is scarce and well-dated, undisturbed contexts that can contribute to this discussion have not been available up to now. We do not intend to do a thorough review here, but it is necessary to summarize the state of the art on this issue.

In the northeastern Iberian Peninsula, previous evaluations of the current radiocarbon evidence suggest that no contact between the last Mesolithic and first Neolithic populations was possible due to a marked chronological hiatus between Mesolithic characteristic lithic industries and the assemblages with characteristic Neolithic pottery (*Morales, Oms 2012*). However, this conclusion is not considered as definitive by all researchers, and it is still open to debate. Some authors argue about taphonomic bias affecting the archaeological record of the 7th millennium (*Oms* et al. *2018b*). In some cave deposits, tentatively assigned to Mesolithic chronology, remains of domesticated plants or animals have been localized. In the absence of radiocarbon dates, this data has been speculatively interpreted either as contamination or evidence of mixed economies, depending on the theoretical assumptions of the scholars. As an example, in Can Sadurní Cave (*Blasco* et al. *2011*) cereal grains have been reported in Mesolithic layers c.19 and c.20. These have been regarded as contamination from superposed Neolithic deposits, which are particularly rich in cereal remains (layer c.18) (*Anto-*

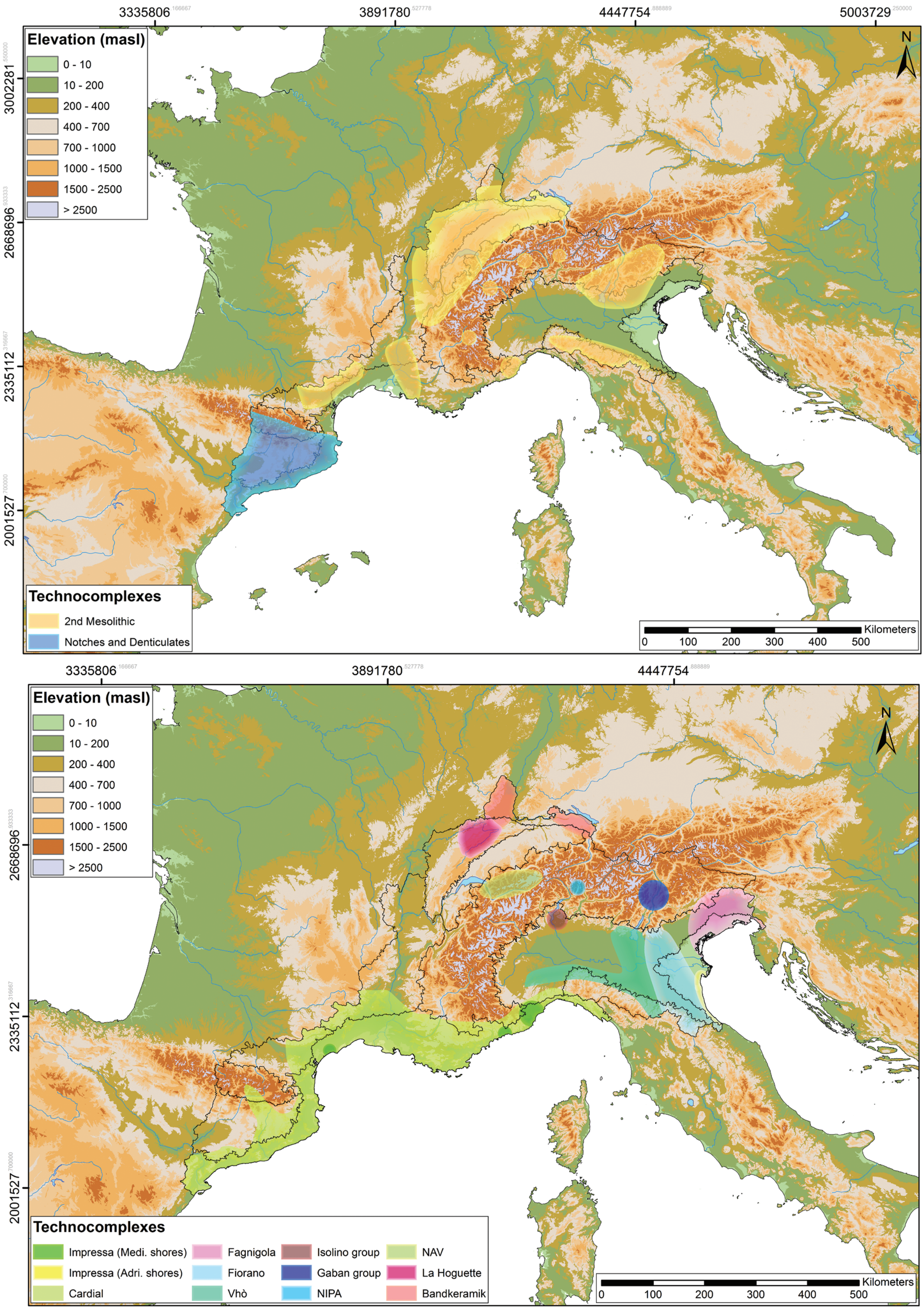


Fig. 2. Map with the Mesolithic (top) and Early Neolithic (bottom) technocomplexes of the study area. NAV – Néolithique Ancien Valaisan; NIPA – Neolitico Inferiore Padano Alpino.

lín 2008; Antolín, Buxó 2011). We have dated two of these cereal grains from Mesolithic contexts, and the results confirmed that both were contaminations from layer c.18, dated to *c.* 5400 cal BC[1].

In the Adriatic shores of northern Italy and the Mediterranean shores of southern France and Liguria, a similar scenario has been observed. Mesolithic groups abandoned at least some of the coastal areas before the arrival of the first Neolithic groups (*Binder* et al. *2017b; Starnini* et al. *2018*), although it is unclear if some groups of Mesolithic populations remained in some spots of eastern Ligurian and the Maritime Alps. Former hypotheses regarding cultivation or herding practices in Mesolithic contexts – mostly in cave sites – are being disregarded by most scientists (*Binder* et al. *2008*).

In Switzerland, there is evidence regarding a possible contact between late Mesolithic and early Neolithic groups (*Erny-Rodmann* et al. *1997; Tinner* et al. *2007*). In this area, as we will discuss below, some authors suggest the acculturation of local Mesolithic groups, who could be responsible for the first agricultural practices and the acquisition of knowledge with regard to pottery technology. One of the most remarkable finds is the *pintadera* recovered in La Souche rockshelter (*Mauvilly* et al. *2008*), with a date associated to the second half of the 7th millennium cal BC[2]. Unfortunately, the reliability of this date does not fulfil our quality criteria (see the material and methods section) and we cannot be sure that the *pintadera* has such an old chronology. The closest parallels for this object should be looked for in the first Neolithic settlements of the southern Balkans, and there are no other similar objects in our study region until much younger periods (*e.g.*, the first half of the 5th millennium cal BC in Arene Candide).

A complete evaluation of the chronology of pollen evidence of early farming practice would have required a different methodology, and it is out of the scope of this paper. The fact is that very early (*c.* 6200–5800 cal BC) cereal-type pollen grains have been documented in Switzerland and other regions of our study area, such as the Ligurian coast (*Binder* et al. *2018; Binder 2018*). Such findings are as problematic as the discovery of wheat DNA in off-site sedimentary cores in the English Channel (*Smith* et al. *2015*): the evidence is scarce and inconclusive, and the absence of a well-defined settlement context (reaping tools, charred cereal grains, *etc.*) prevents its use as a direct evidence of local agriculture.

The 6.2ka BC climatic event has been considered as a potential factor explaining the abandonment of the area by hunter-gatherer populations (*Berger, Guilaine 2009*). Nevertheless, recent revisions of the paleoenvironmental, geological and archaeological records suggest that this event had no global climatic impact, but limited and regional impact only (*Magny* et al. *2003*), with different consequences at different places (*Alley, Ágústsdóttir 2005*). Therefore, considering the current state of research, the absence of late Mesolithic sites cannot be explained in terms of adverse climatic conditions on a global scale.

Material and methods

This paper builds upon the radiocarbon database that we are generating within the framework of the AgriChange Project. In addition to a systematic dating program of new sites – details of which are out of the scope of this paper – we have critically reviewed all published Neolithic dates for the study region in order to better understand the chronology of the adoption of farming technology in the area.

The critical analysis of already published dates concerns, among other features, the reliability of the radiocarbon estimate. There are archaeological criteria for deciding this reliability, but there is also an additional criterion based on the standard error of the estimate. The higher the error, the less the reliability of the date. Often, archaeologists define the acceptance of a radiocarbon date in absolute terms (*e.g.*, dates with a lab error (standard deviation) <100). Problems can arise when the time range of the studied period is long. A standard error of 100 years is not as relevant when considering a time range of 2500 years or another of 800 years. We have thus followed an acceptance criterion relative to the central tendency of the estimate before calibration:

$$\% = (SD/BP) \times 100$$

where SD is the standard deviation of the BP lab estimation before calibration. In this way, we have defined three degrees of accuracy: those with highest precision (equal or lower than 0.99%), medium precision (1–1.99%) and lowest precision (equal or higher than 2%) (Fig. 6).

1 ETH-88890, 6451±26, sa, A / ETH-88891, 6434±26, *Triticum dicoccum*.
2 Ua-33243, 7225±60, charcoal

The radiocarbon database and filtering criteria

For each date, we refer to the published bibliographic reference for archaeological criteria of relevance. When this primary reference could not be consulted, we relied upon the information coming from secondary references quoting the original one (*e.g., Pearce 2013; Stöckli 2016*) or we used information from the database containing that dated sample (*Perrin 2019*). The following aspects were considered as filtering criteria.

Disturbed archaeological contexts
This refers to the stratigraphic relationships of the archaeological context the dated sample comes from (*Bernabeu Aubán 2006; Zilhão 2001; 2011*). It has required a detailed site-by-site analysis of postdepositional, taphonomic and stratigraphic issues (as far as the publications give details of these issues) to consider possible stratigraphic inversions and/or contaminations (*Bernabeu Aubán* et al. *1999; 2001*).

Charcoal samples
In order to avoid the 'old-wood effect' (*Zilhão 2001*), we have only considered charcoal fragments identified as branches, twigs or the innermost parts of the growth rings coming from open contexts. However, we have not discarded unidentified charcoal fragments from clearly defined spatial structures such as hearths, because we understand this charcoal as the most reliable source to date the event.

No burnt bones
The implications of using dates from burnt bones in a chronological model are similar to the 'old-wood effect' (*Olsen* et al. *2008; Pardo-Gordó 2015*), and therefore we have avoided samples from this kind of material.

No marine reservoir effect
We have discarded samples of marine origin (malacofauna and ictiofauna) and any other item considered to have had a high maritime contribution. Several works have addressed this problem (*Alves* et al. *2018; Ascough* et al. *2005; Soares, Dias 2006*), concluding that the reservoir effect fluctuates in space and time, and the variation in the calculation of the reservoir effect is still highly significant.

Taxonomic identification
This is important to identify short-lived samples, but also to be sure that we are dating samples directly related to activities of farming or hunting-gathering and not some random natural element present in a site for unknown reasons. It may involve the use of the ZooMS technic (*Buckley* et al. *2010*) to define whether a bone sample corresponds to a wild or domestic goat, for instance (*Martins* et al. *2015*).

Laboratory effect
A critical evaluation of the result provided by the laboratory is also essential, and any errors or systematic offset produced by laboratories has been taken into account to filter out dates (*Lull* et al. *2015; Nielsen 2009; Sjögren 2011*).

Statistical methods

To analyse the radiocarbon dated samples retained for explanation, we have used methods based on the summation of probability density distributions (SPD[3] and KDE models[4]) and Bayesian statistics (*Bayes 1764*). We use OxCal v4.3.2 (*Bronk Ramsey 2017*) and the IntCal13 calibration curve for terrestrial samples (*Reimer* et al. *2013*).

We have followed the most recent methodology for summarizing dated contexts using the SPD method and its variants for answering relevant hypotheses about long-term social dynamics (*Armit* et al. *2013; Kerr, McCormick 2014; Shennan* et al. *2013; Silva, Vander Linden 2017*), also taking into account critical approaches to the method (see *Contreras, Meadows 2014; Williams 2012*). The degree of the reliability of the statistical results has been plotted in the graphs for their critical evaluation.

Limitations implicit with the SPD method are:
- excessively noisy results that are difficult to explain;
- an over-smoothing of data, when statistical techniques are used to remove random noise;
- failure to address the random variation and the effects of the calibration curve irregularity, unless SPD analysis is combined with other forms of Bayesian analysis.

These issues, and a possible solution, were addressed by Bronk Ramsey (*2017*) with the introduction of Kernel Density Estimation (KDE) (in OxCal 4.3.2., the KDE_Model command). This attempts to narrow the final probabilistic distribution taking into account the variation of measurement uncertainty, and the variation correlated with peaks and valleys

3 Summed Probability Density
4 Kernel Density

in the calibration curve. In our case, to define the proper temporal range of the last Mesolithic populations and the first Early Neolithic occupations in each region and to test for potential phases of coexistence, we have defined different Bayesian models of two partially overlapped phases, assuming a trapezoidal distribution for each one (*Bronk Ramsey 2009; Lee, Ramsey 2012*). The same approach was considered in previous investigations of the same historical problem (*Binder* et al. *2017a; Manen* et al. *2019a; Oms* et al. *2016*). We add the assumption of a trapezoidal distribution model to take into account the most probable hypothesis of change as a non-abrupt transformation (*Lee, Ramsey 2012*). To visualize the results, the youngest Mesolithic sites and the oldest Early Neolithic sites in each ecoregion, based on the results of the Bayesian analysis, have been plotted separately in a series of maps temporally organized, with one time step every 200 years, beginning in 6200 cal BC and ending in 4600 cal BC. Maps have been created using the ArcMap 10.6 software (*ESRI 2018*).

Results

A total of 948 radiocarbon dated archaeological contexts has been recovered from the bibliographic description of 187 different sites (Tab. 1 and Supplementary Material 3 at http://dx.doi.org/10.4312/dp.47.10). At a general scale, *c.* 40% of the radiocarbon dates have passed our filtering criteria for quality and reliability.

Around 75% of retained dates can be assigned to Neolithic contexts, and the remaining 25% to Mesolithic occupations, according to the nature of the published archaeological material. We have no reliable radiocarbon dates in the Upper Rhine ecoregion.

Five ecoregions (Alps, Jura, Mediterranean shores north of parallel 43°, southern Pre-Pyrenees and Swiss Plateau) concentrate *c.* 75% of the retained Mesolithic dates. Eight-five percent of these are concentrated in the Alps, Mediterranean shores north of parallel 43°, the Rhone valley and Swiss Plateau; however, reliable radiocarbon dates are scarce in the Jura and both Pre-Pyrenees. No reliable dates were found in the Adriatic shores, Apennines, High Rhine, Po valley, Pyrenees and Mediterranean shores south of parallel 43°.

Sixty-five percent of the reliable radiocarbon dated contexts assigned to the Early Neolithic come from archaeological sites in the Alps, Mediterranean shores and Po and Rhone valleys. The best represented ecoregions are the Mediterranean shores, the Rhone and Po valleys and the northern Pre-Pyrenees, concentrating *c.* 85% of the retained Early Neolithic dates.

Chronostatistical analysis – Summed Probability Density distribution

We have calculated the summed probability density distribution (SPD) for each ecoregion and period. Each graph plots three curves in Figure 3, corresponding to the different accuracy ratios mentioned in the previous section (red: it shows all the available radiocarbon dates; green: it shows selected dates with medium degree of precision; blue: it shows selected dates with high degree of precision; for all the graphs see Supplementary Material 4 at http://dx.doi.org/10. 4312/dp.47.10). The goal was to observe in SPDs the effects of filtering criteria and the accuracy degrees depending on the magnitude of lab error. In this way, we may decide whether the minimization of accuracy and reliability of dates – and hence the maximization of the number of retained dates for analysis – produced larger biases than the ones produced by other methodological inaccuracies. In Figure 3 we show as an example the case of the number of dates and their accuracy levels for the Mesolithic occupations in the Alps.

The results are very similar in all groups. When discarding the dates that have not passed the filtering criteria – those with the lowest accuracy – the resulting distribution is more robust, reducing ambiguity and uncertainty by pruning excessively long tails.

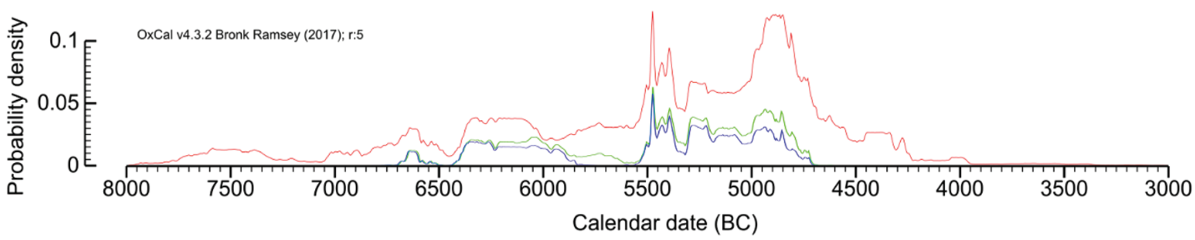


Fig. 3. Distribution dates for the Alps as an example of an SPD. Lines = unfiltered data (red); filtered data with an accuracy between 0–1.99 (green); filtered data with an accuracy between 0–0.99 (blue).

Chronostatistical analysis – Kernel Density Estimation

Considering preliminary results and the inherent statistical limitations of the SPD methodology, we have applied the KDE technique to the datasets constituted by the most precise dates (SD ≤0.99) (Fig. 4; for all graphs and table results see Supplementary Material 5 and 8 at http://dx.doi.org/10.4312/dp.47.10).

A common trend is detectable when analysing the KDE results for the Mesolithic dated contexts. In all those cases where enough dates were available to create a model, most of the high peaks created by the SPD appear to be the result of spurious effects of noise (random or correlated with the wiggles of the calibration curve). Likewise, the long tails of the SPD distributions are pruned.

In the case of KDE results of dated contexts assigned to the Early Neolithic, and hence to the beginnings of farming economy, a similar pattern arises, compatible with the trend observed in the KDE analysis of the Mesolithic dates joint distribution. Given that the temporal range of the early farming period is shorter that the temporal range of the last hunter-gatherer occupations, the smoothing of the statistical distribution is more marked.

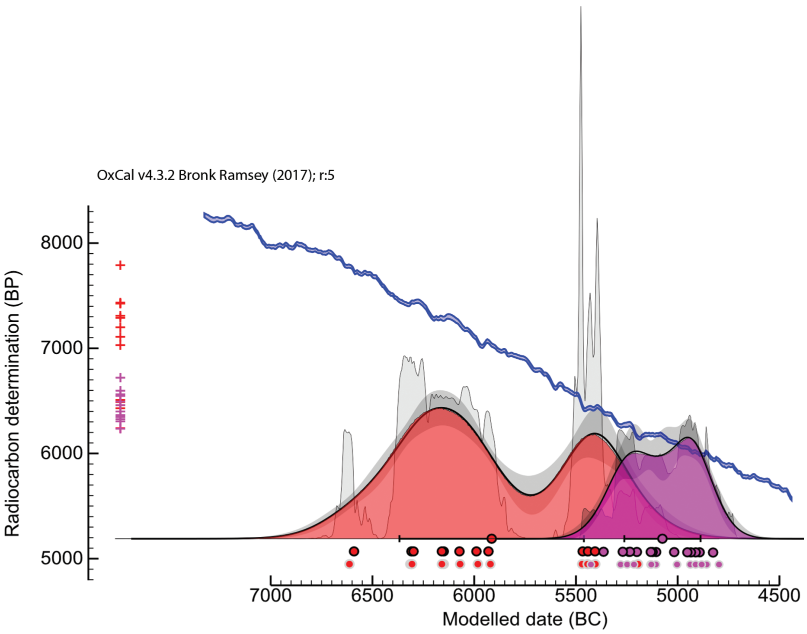


Fig. 4. KDE_Model of the dates for the Alps. The light grey curve is the SPD distribution and the red (Mesolithic) and pink (Neolithic) curves are the sampled KDE estimated distribution. For further information on the graph legend see* Bronk Ramsey 2017.182*).

In any case, the results are somewhat different at different ecoregions. Where the Mesolithic occupations are well represented and well dated, it is possible to observe chronologically differentiated hunter-gatherer occupations, and not only a chronologically uniform distribution. The KDE distribution signals the highest probability of occupation in the Jura, Mediterranean shores south of parallel 43°, and the Swiss Plateau.

In the early farming distributions with large datasets we see how the distributions are quite similar. There is a high probability increase in a short time at the extreme $\mu-\sigma$, a robust and well-defined μ and a decrease in the gradual probability over a considerable time at the end of the $\mu+\sigma$ extreme.

Chronostatistical analysis – Bayesian

Bayesian analysis[5] (for details see Supplementary Material 6 at http://dx.doi.org/10.4312/dp.47.10) makes it possible to better determine the precise time interval when the latest Mesolithic and the first Early Neolithic occupations occurred, and whether some degree of contemporaneity – and hence supposed cultural contact – between both populations is possible in terms of radiocarbon evidence. Plotting the boundary for the end of the Mesolithic time range and the boundary for the start of the Neolithic time interval, and using the means and standard deviations associated with such temporal boundaries, we have defined two different scenarios: regions where the first evidence of farming economy is not contemporary with Mesolithic occupations, regions where the first evidence of farming economy appears to be partially contemporaneous with Mesolithic occupations in the area. In some cases, we have not been able to establish any scenario due to the lack of reliably dated archaeological contexts that could be assigned to Mesolithic or Neolithic occupations (Fig. 5). Graphs without any relevant overlapping in the time intervals for each dominant econo-

5 All models are statistically valid. However, Adriatic shores, High Rhine, Po valley, Pyrenees and Mediterranean shores south of parallel 43° only have reliable early Neolithic dates (see Supplementary Material 9 at http://dx.doi.org/10.4312/dp.47.10).

my (hunter-gatherer and farming) can be interpreted in a more straightforward manner than those in which distributions partially overlap. Such overlapping might be a mere spurious statistical side effect of probability intervals with extremely long tails. Therefore, KDE and SPD plots must be interpreted with care, as hypothetical or potential scenarios.

The areas without any temporal overlap between the last hunter-gatherers and the first farmers are the Mediterranean shores north of parallel 43° and the northern and southern Pre-Pyrenees. In this last region, there is a temporal hiatus of 500 years between the last hunter-gatherers and first farmers, whereas this temporal difference is reduced to 100 years north of the Pyrenees. It is important to remark that this difference could be the consequence of the older age of early farming along Mediterranean shores north of parallel 43°. In the northern Pre-Pyrenees, Mesolithic occupations seem to end at a later date than in other regions.

A time interval overlapping scenario of *c.* 100 and 300 years, respectively, seems evident in the Rhone valley and Alps ecoregions. Here, the earliest farming evidence is as old as in the southern regions, but hunter-gatherer sites subsist until a younger age, which generates the observed overlap in their respective time intervals.

In the Jura and Swiss Plateau cases, as suggested by the SPDs, a possible overlap can be detected. However, there are not enough reliable dates to make a Bayesian model, and thus the conclusion is hardly definitive.

Along Mediterranean shores south of parallel 43° and the Adriatic shores, but also in the Po valley, Apennines and possibly also in the High Rhine as well, the end of the Mesolithic occupations could not be fixed but the presence of early farming occupations is very clear. The most probable explanation of this fact is the abandonment of the region by local hunter-gatherers well before the arrival of early farmers. Nevertheless, it is important to take into account that the absence of evidence is not necessarily an evidence of absence.

Geospatial analysis

We have created a series of maps separated every 200 years based on the results of the Bayesian analysis, to test whether the temporal contemporaneity of the last hunter-gatherers and early farmers was evidence of coexistence on a reasonably small spatial scale.

In the first map, which refers to the time step 6200–6000 cal BC (Fig. 6a), before the adoption of any

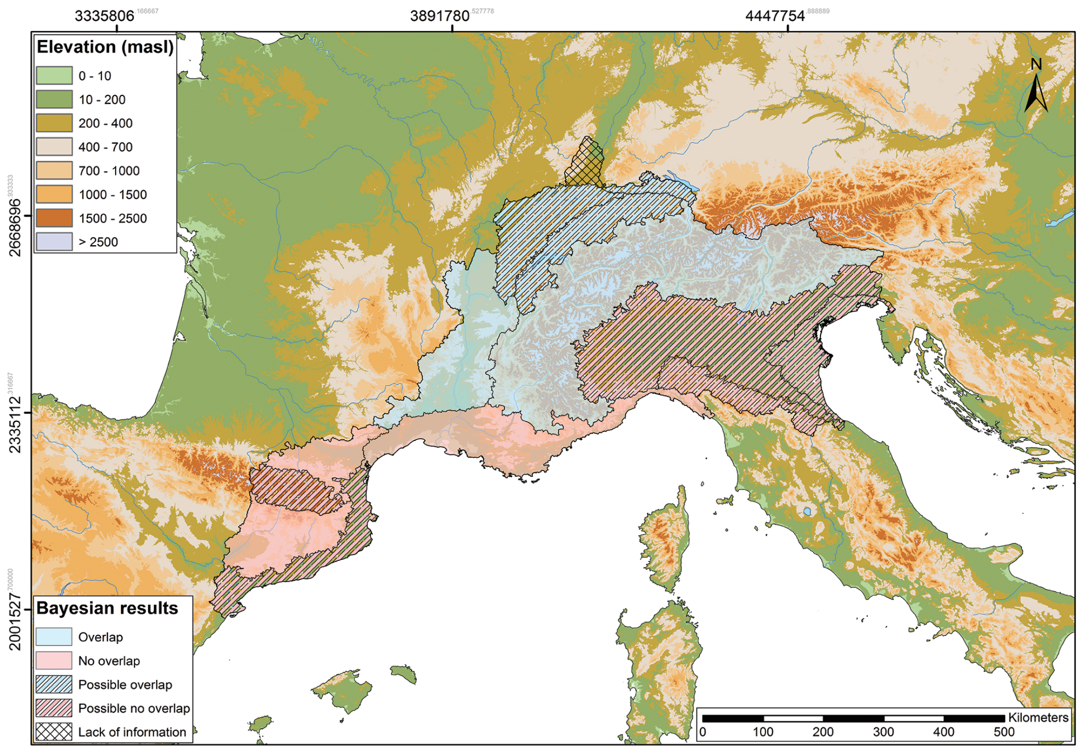


Fig. 5. Bayesian results. In the map is highlighted the possible relation between the last Mesolithic and the first Neolithic groups by ecoregion.

attributes of early farming, we see only hunter-gatherer occupations in the Rhone valley and Alps – Baume de Montclus (*Perrin* et al. *2009*), Lalo (*Marchand, Perrin 2017*), Grande Rivoire (*Nicod* et al. *2010*) and Château d'Oex (*Crotti* et al. *2016*). In the next time step (6000–5800 cal BC, Fig. 6b), only Mesolithic occupations are detected in mountain areas of Alps and Pyrenees, and their surroundings – Grande Rivoire (*Perrin 2019*), Château d'Oex (*Nielsen 2009.143*), abri du Roc de Dourgne (*Perrin 2019*), and Abri La Souche (*Mauvilly* et al. *2008*).

The earliest farming evidence is depicted for the first time in the third time step (5800–5600 cal BC, Fig. 6c), along the Mediterranean shores north of parallel 43° (Languedoc, Provence- and Liguria), where *Impressa* type pottery appears in open-air and rockshelter/cave sites like Peiro Signado and Pont de Roque-Haute (*Binder* et al. *2017b; Briois, Manen 2003*), San Sebastiano di Perti (*Biagi, Starnini 2016*), Abri Pendimoun (*Binder* et al. *2017b*), and Arene Candide (*Maggi, Chella 1999*). At the same time step, Mesolithic occupations continue in the northern areas of the Alps (Abri La Souche, *Mauvilly* et al. *2008*) and the Jura (à Daupharde, *Séara* et al. *2002*).

Between 5600–5400 cal BC (Fig. 6d) Neolithic occupations continue along the Mediterranean shores north of parallel 43°, and appear for the first time along the Mediterranean shores south of parallel 43°, and in the Rhone and Po valleys. There are still Mesolithic occupations in the lower part of the Rhone valley, Baume de Montclus (*Binder* et al. *2017a*), and in the alpine foothills near this valley, Grande Rivoire (*Nicod, Picavet 2011*).

There is a relevant increase in the number of dated contexts assigned to the Neolithic in the 5th time step, 5400–5200 cal BC (Fig. 6e). This growth of evidence is well-attested along the Mediterranean coast, both north and south of parallel 43°, with the beginning of a clear expansion towards their hinterlands. There is also the earliest evidence of Neolithic occupations in the alpine foothills closest to the Rhone valley, the Grande Rivoire (*Perrin 2019*), and in the Po valley, Isolino Virginia (*Banchieri 2009*). In addition, Neolithic occupations are also documented for the first time in the Apennines, as Cecima (*Starnini* et al. *2018*), and in the Adriatic shores, at Piancada (*Skeates, Whitehouse 1999*). In the Swiss Plateau, at Abri La Souche (*Guidez 2018*), there are still Mesolithic occupations.

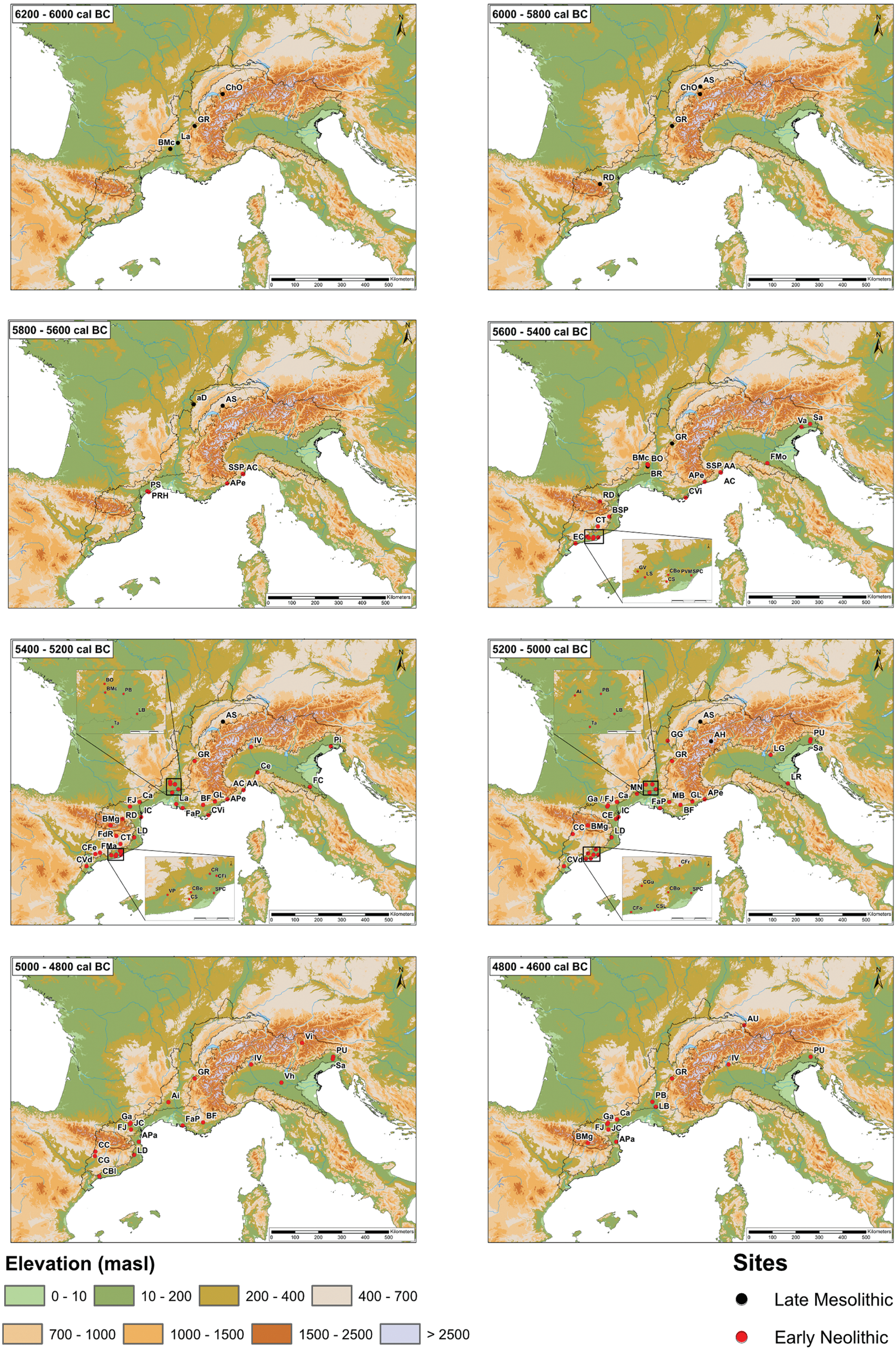
The growth and territorial expansion of Mediterranean and Adriatic Neolithic occupations continues in the next time step, 5200–5000 cal BC (Fig. 6f). At this moment, evidence of farming economy is well attested in relatively remote areas like Grotte du Gardon (*Voruz, Perrin 2009*), located in the area between the upper Rhone valley and the Jura mountains, or Cova Colomera (*Oms 2008*) in the southern Pre-Pyrenees. Contemporaneous Mesolithic occupations are documented in the Alps, at Alp Hermettji (*Curdy* et al. *1998*), and in the Swiss Plateau, at Abri La Souche (*Mauvilly* et al. *2008*).

In the next time steps (5000–4600 cal BC, Figs. 6g, 6h), Neolithic groups expanded until occupying almost the entire study area.

Methodological discussion

Regarding the strict selection criteria applied to the dataset, the most accurate models have been obtained using only the dates with an SD/BP ratio ≤0.99. The noise created by the excess of unreliable dates is notorious, particularly in the tails of the probability distributions, where the highest accuracy is needed. Nevertheless, restricting the analysis only to highest quality dates implies the absence of data for

Fig. 6. Geographical distribution of the sites with radiocarbon dates of the last Mesolithic and the first Early Neolithic occupations in the NW Mediterranean and Switzerland between 6200–4600 cal BC: **AA *Arma dell'Aquila,* AC *Arene Candide,* aD *à Daupharde,* AH *Alp Hermettji,* Ai *Aigle,* APe *Abri de Pendimoun, Apa Aspres del Paradis,* AS *Abri la Souche,* AU *Abri Unterkobel,* BF *baume de Fontbrégoua,* BMc *Baume de Montclus,* BMg *Balma Margineda,* BO *Baume d'Oullins,* BR *Baume de Ronze,* BSP *Bauma de Serrat del Pont,* Ca *Camprafaud,* CBl *Coll Blanc,* Cbo *Cova Bonica,* CC *Cova Colomera,* Ce *Cecima,* CE *Cova de l'Esperit,* CF *Les Coves del Fem,* CFi *Turó de Can Filuà,* CFo *Cova Foradada,* CFr *Cova del Frare,* Cgu *Cova de la Guineu,* CGr *Cova Gran,* ChO *Château d'Oex,* CR *Can Roqueta II,* CS *Can Sadurní,* CSL *Cova de Sant Llorenç,* CVd *Cova del Vidre,* Cvi *Centre Ville,* EC *El Cavet,* ET *El Toll,* FaP *Font aux Pigeons,* FC *Fornace Cappuccini,* FdR *Font del Ros,* FJ *abri de Font-Juvénal,* FMo *Fiorano Modenese,* FMa *Font Major,* Ga *Gazel,* GG *Grotte du Gardon,* GL *Grotte Lombard,* GR *La Grande Rivoire,* GV *Les Guixeres,* IC *Ile de Corrège,* IV *Isolino Virginia,* JC *Jean Cros,* La *Lalo,* LB *Le Baratin,* LD *La Draga,* LG *Lugo di Grezzana,* LR *Lugo di Romagna,* LS *La Serreta,* MB *Le Mourre de la Barque,* MN *Mas Neuf,* PB *Les Petites Bâties,* Pi *Piancada,* PRH *Pont de Roque-Haute,* PS *Peiro Signado,* PU *Pavia di Udine,* PVM *Plaça Vila de Madrid,* RD *abri du Roc de Dourgne,* Sa *Sammardenchia,* SPC *Sant Pau del Camp,* SSP *San Sebastiano di Perti,* Ta *Taï,* Va *Valer,* Vh *Vhò,* Vi *Villandro,* VP *Vinya d'en Pau.***


6200 - 6000 cal BC
ChO
GR
La
BMc
6000 - 5800 cal BC
AS
ChO
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RD
5800 - 5600 cal BC
aD
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SSP
AC
APe
PS
PRH
5600 - 5400 cal BC
Va
Sa
GR
BMc
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FMo
SSP
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5400 - 5200 cal BC
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5200 - 5000 cal BC
AS
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5000 - 4800 cal BC
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IV
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Sa
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JC
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BF
FJ
APa
CC
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CBl
4800 - 4600 cal BC
AU
IV
PU
GR
PB
LB
Ga
Ca
FJ
JC
BMg
APa
Kilometers
0 100 200 300 400 500
Elevation (masl)
0 - 10
10 - 200
200 - 400
400 - 700
700 - 1000
1000 - 1500
1500 - 2500
> 2500
Sites
Late Mesolithic
Early Neolithic

some ecoregions. This is a problem in the case of Mesolithic occupations along the Adriatic shores, in the High Rhine, Po valley, Pyrenees, Apennines and Mediterranean shores south of parallel 43°. In the same way, there are only a few reliable dated Neolithic sites in the Jura, Swiss Plateau, Pyrenees, High Rhine and Apennines. The beginning of the Neolithic in those areas is very uncertain. Consequently, we cannot exclude that some of the explanatory models presented in the previous section are biased and historical explanation of the transition from hunting-gathering to early farming will be only tentative until the quality and quantity of chronological knowledge improves.

Comparison of the density of summed dates and potential periods of hunter-gatherer and farmer coexistence

To sum up our results using Bayesian analysis of high accuracy radiocarbon dated archaeological contexts, we can say: the earliest farming communities appeared at first in very limited areas, always near the coast, and within a relative short time interval of *c.* 200 years. Cultural contact or interaction between the last hunter-gatherer populations and these new first farming communities has not been detected where the Neolithic is older, in the Mediterranean shores north of parallel 43°. A short hiatus of *c.* 100 years between the last hunter-gatherer occupations (dated to *c.* 5900 cal BC) and the first farming sites (dated to *c.* 5800 cal BC) can be detected in this area, which can be explained in terms of a Neolithic colonization of an abandoned region.

In the neighbouring Pre-Pyrenean ecoregions, both south and north of the Pyrenees, and even in the central Pyrenees region, this period without apparent occupation between the last Mesolithic and earliest Neolithic would be longer, *c.* 500 years, given the later entry in these territories of populations with a farming economy. This situation has already been highlighted by other authors, especially for the southern Pre-Pyrenees (*Oms* et al. *2018b*).

Current data also suggests the probability of the hypothesis of no co-existence between hunter-gatherers in the Po valley and along Adriatic shores. This hypothesis is very dependent on the lack of properly dated contexts, however. Here, the period of apparent abandonment can be situated around 5500–5400 cal BC. One of the reasons why no late Mesolithic occupations have been identified in these areas may be of a taphonomic nature, related to erosive processes such as those detected along the Po valley (*Starnini* et al. *2018*), due to several hard affections during the Atlantic climatic period (*Antonioli* et al. *2009*). Both the Po valley and the Adriatic coast share similar sedimentological patterns and geomorphological characteristics that make it quite complicated to determine whether the absence of data actually reflects the contemporaneous absence of human activity.

The coexistence of hunting-gathering and farming communities can only be suggested in the Rhone valley and the Alps. In the first one, available reliable radiocarbon dates indicate an interval of 100 years, around 5500 cal BC, and mainly focused on the lower Rhone valley, during which Mesolithic and Neolithic sites seem to be synchronous. In the Alps, this period of coexistence would have been longer, around 300 years, and a bit later, between 5400 and 5100 cal BC. However, data for the Rhone valley comes from very few sites, such as the Montclus, Oullins and Ronze shelters, all of which are in the lower Rhone valley area. Unfortunately, there are not enough reliable late Mesolithic dates to confirm this hypothetical coexistence or even cultural contact. In the upper part of Rhone valley, and probably also in the Jura, there is a similar lack of reliable archaeological information. The possible coexistence period would have occurred a bit later than in the lower valley. In the Alps the data comes mainly from La Grande Rivoire and Alp Hermetjji, two very different sites. While Alp Hermetjji is in the middle of the Alps, above 2000m asl, La Grande Rivoire is located in an area of lower altitude, at 1000m asl and very close to the middle/upper Rhone valley. Consequently, this last site seems to be more related to what happened in the Rhone, with earlier Neolithic occupations and shorter coexistence, rather than the situation in the central Alps area. Alp Hermatjji proves that hunter-gatherer groups in the innermost areas of the central Alps lasted for a longer time, due to less pressure, both ecological and social, and the later arrival of populations with farming economies.

Interpretation of geospatial patterns: contact zones, interaction, non-interaction

If we focus on the Mesolithic sites, as depicted in Figure 6, we can suggest, hypothetically, that Mesolithic groups abandoned coastal areas well before 6000 cal BC, moving towards the interior and mountains. What we cannot prove for the moment, given the existing reliable chronometric information, is whether they retreated because of the arrival of a new population or as a consequence of climatic factors negatively affecting coastal areas. Did the new Holocene climate conditions make a purely hunter-gatherer way of life in the coastal territories impossible, forcing these populations to migrate to the hinterlands? Or was it due to Neolithic populations pushing them back to these hinterlands because they were primarily interested in the coastal lands?

In order to better evaluate the advance of Neolithic populations, an Empirical Bayesian kriging interpolation (*Krivoruchko, Gribov 2019*) has been calculated (Fig. 7, and Supplementary Material 7 and 10 at http://dx.doi.org/10.4312/ dp.47.10).

At a macro-scale level, the Mediterranean drift of the expansion of farming (the new Neolithic communities) becomes obvious and its impact in the studied territory is readily traceable using radiocarbon dates. If we take a more regional look, more nuanced trends, rhythms and speeds are detectable.

According to our data, there are four *foci* for the spread of farming practices: the Gulf of Lion and the Gulf of Genoa, *c.* 5800–5700 cal BC, and the northern part of the Adriatic Sea and the central Catalan shores, *c.* 5600–5500 cal BC. This reinforces previous observations on the maritime route for the entry of Neolithic populations (*e.g., Isern* et al. *2017; Zilhão 2001*). Such trends also suggest that the neolithisation of the Po valley arrived from the east, from earlier communities along the Adriatic coast. There is also some probability that some populations entered the Po valley from the west, across the Apennines, but at a slower speed. This suggests that the maritime spread of the Neolithic would have been split into two different drifts from the Salento Peninsula, one towards the Adriatic Sea, and another one towards the Ionic and Tyrrhenian seas (*Guilaine* et al. *2016; Natali, Forgia 2018*).

Although we still need more and better data, the Adriatic drift seems to have been slower than the Tyrrhenian drift, reaching its northernmost shores later than the first arrival of farming at the Ligurian coast. The Tyrrhenian drift also had a more multidimensional nature, with different final destinations (Gulf of Lion and in the Gulf of the Genoa (*Gabriele* et al. *2019*; Fig. 6). The Levantine area of Iberian Peninsula, south of our study area, should also be considered as a preliminary destination of the same route (*Bernabeu Aubán* et al. *2003; 2009*).

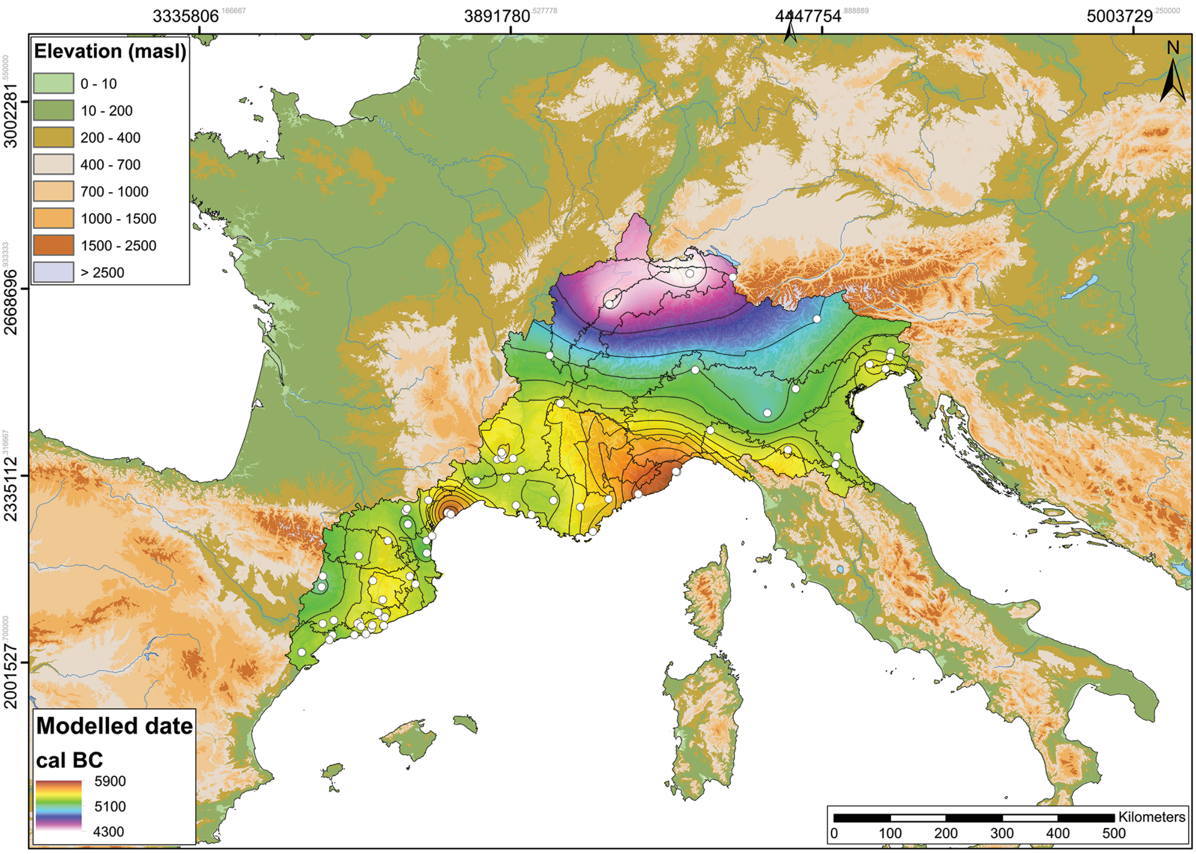

Fig. 7. Interpolated map model for the neolithisation process in the western Mediterranean and Switzerland. Each isochron represents an average of c. 80 years. (The points refer to the dated sites used for the interpolation – see Supplementary Material 10 at http://dx.doi.org/10.4312/dp.47.10).

This has been named the leapfrog model of colonization, based on a discontinuous settlement pattern with a non-continuous littoral distribution (*Binder 2013; Zilhão 1993*). Eventually, the Mediterranean drift from the Gulf of Lion continued towards the central Catalan shores.

After the first arrival to the coast, and also at different directions and with different speeds, an expansion towards the interior occurred. Both the spread from the Adriatic shores and from the Mediterranean shores south of parallel 43° towards their respective hinterlands seem to have been a rapid and continuous advance. Neolithic populations coming from the Adriatic coast occupied the Po valley up until the southern alpine lakes area, the southern foothills of the Alps and some parts of the Apennines. Those from the Mediterranean shores south of parallel 43° mainly occupied the littoral and pre-littoral corridors, as well as the southern Pre-Pyrenees and some parts of the Pyrenees (*Oms* et al. *2018a*). The relationship of these areas with Neolithic sites further south (Alacant), which started a bit earlier *c.* 5700 cal BC, is still a matter of further research (*Bernabeu Aubán* et al. *2003; 2009*).

On the other hand, two differentiated expansion processes can be detected from the northern shores of the Mediterranean towards its hinterland. From the Gulf of Lion, Neolithic populations seem to have expanded towards the west, to the northern Pre-Pyrenees and some areas of the Pyrenees. This expansion would have been slow and over a reduced area. From the Gulf of Genoa, the expansion adopted an eastern direction, towards the Apennines and the easternmost areas of the Po valley (*Starnini* et al. *2018*). The colonization of the Rhone valley and expansion towards further north is more likely to have originated from the Gulf of Genoa than the Gulf of Lion. However, the evidence that it was a very fast spread (*Perrin 2008*) suggests that the Rhone corridor may have been used by both original populations as an access to the hinterland. The fast expansion of farming groups along the valley only decelerated when arriving to the southern Jura and the access to the Swiss Plateau (*Hafner, Suter 2003*). The northern alpine areas probably witnessed the arrival of Neolithic farmers coming from the north, connected to the LBK groups (*e.g., Zizers* et al. *2012*).

Global processes, regional dynamics?

The last hunter-gatherer communities confronted changing climate and environmental conditions at the beginning of the Holocene, which probably affected their ways of acquiring subsistence and the necessary raw materials. The archaeological record suggests that their economic activity was specialized in the hunting of small animals that were probably less available with diminishing forests and the opening of woodland in Early Holocene (*Battentier* et al. *2018*). The arrival of people with a different way of life and specific needs for their economic and social reproduction also negatively affected local inhabitants of Western European regions. A combination of both factors pushed the last Mesolithic groups back from coastal and pre-coastal areas into hinterland and mountain zones. At a date around 5100 cal BC, residual hunter-gatherer groups only subsisted in the more marginal areas of the Alpine mountains, with an associated technocomplex that had not experimented with any relevant developments in more than two millennia.

All this means that neolithisation in the northwestern Mediterranean was an exogenous process, in which original hunter-gatherer local populations had no relevant role. The fact that the hypothesis of strict contemporaneity and possible coexistence has support only in a few areas gives more support to this statement.

Nevertheless, current data suggests that the process of neolithisation was not homogeneous all across Western Europe. The arrival of new farming populations of southwestern Asian ancestry into Central Europe following the Danube route was very much circumscribed by the use of a specific kind of soil – loess soil – adapted to a specific kind of farming economy. This kind of soil has only been detected in few parts of our study area, notably in its northernmost part. Our data allows us to consider as much more probable a general trend moving from the south and east towards the north and west for understanding the new colonization of the region from the Ebro River to the Po River, and from the Mediterranean coast towards the Pyrenees and Alps. The Mediterranean expansion route was therefore more decisive for this region. With these results, the possibility of contacts between LBK and cardial groups as suggested from human genetic data obtained in the Pyrenees seems to be unlikely (*García-Martínez de Lagránet* et al. *2018*).

One of the main characteristics of the earliest Neolithic sites in Western Mediterranean is their establishment along the seashores and influence areas. Our data reveal that the process was fairly similar, but with particular local dynamics in the Gulfs of Lion and Genoa, central Catalan coasts and the northern part of Adriatic shores (*Manen* et al. *2019a; 2019b*). Expansion towards the closest interior territories from these pioneer areas was somewhat different in Provence and the Ligurian zones than on the Catalan coast. In this last territory, data suggest a deep abandonment of the area prior the arrival of the new population, and therefore the expansion towards the interior was faster and more intense than in areas were local groups of hunter-gatherers subsisted, like in the northern Pre-Pyrenees, upper Rhone valley and pre-alpine areas. Nevertheless, this explanation may be biased if we do not take into account the possible disturbance of the archaeological record in a time of ecological and climatic turmoil.

A similar phenomenon could have developed along the northern coast of the Adriatic Sea and in the Po valley, where Neolithic occupations seem to occur in an almost unsettled territory. However, the density of archaeological sites is very low – lower than in northeastern Iberian Peninsula – and the hypothesis remains untested.

In the Valais and Geneva regions, beyond the Rhone valley, Neolithic evidence is attested *c.* 5400–5300 cal BC (cardial/Epicardial and La Hoguette). These groups would have been the main agents for the expansion of farming economy towards the Jura and Swiss Plateau areas. The connections between these sites and the original groups with *Cardial* pottery from the Mediterranean coast has already been highlighted (*Manen, Mazurie De Keroualin 2003*).

The lack of a single uniform scenario in the study area leads us to conclude that to understand the neolithisation process we should always take into account local dynamics. More intensive research is thus needed to identify late hunter-gatherer groups; however, existing radiocarbon dates seem to be enough for suggesting the general traits of the process. This preliminary hypothesis can be evaluated using additional information (archaeological material or aDNA from human remains). Therefore, we cannot exclude the possibility of an admixture of new faming populations with local hunter-gatherer communities at some places (see *Shennan 2018* for a recent global review).

Conclusions

In this paper we have used a selection of highly precise and reliable radiocarbon dates to investigate the regional rhythms of neolithisation in a specific part of Western Europe. The analysis shows that broad-scale approaches can hardly grasp the historical scenario of the beginning of farming in the region, but broad trends are necessary in order to detect local specificities. We have argued the relevance of different mechanisms of expansion and adoption of innovations at a local scale, subdividing the study area into different regions with homogenous ecological features. We know that the quantity and quality of data is not yet what we would need for a reliable historical explanation. This is particularly clear for the Mesolithic in the north-eastern Iberian Peninsula and northern Italy, and for the Early Neolithic in the northern parts of our study area.

From the chrono- and geostatistical interpretation of available radiocarbon dates, we have been able to define the chronological boundaries of the Mesolithic and Neolithic in each region. The possibilities of potential coexistence and interaction between hunter-gatherer and farming populations has also been asserted. This scenario is more probable in the northern parts of the study area, in the Rhone valley and around the Alps. Mesolithic communities relocated at some moment, abandoning the coastal territories and remaining in the hinterlands and mountains. Whether this process started well before the arrival of new populations with a different economic system is still unclear in many parts of our study area. Our investigation also confirms that Early Neolithic communities were founded earlier along the coasts, expanding later towards the interior. We observed that despite a clear global trend towards territorial expansion, Neolithic colonization had different spatial and temporal dynamics, due to the local geographical conditions, the possible presence of local hunter-gatherer populations and the limitations and local needs of farming populations in their initial hotspots.

Further research has already been designed for evaluating these preliminary results. We intend to analyse archaeobotanical and archaeozoological data from the same study area, using the same division in ecological areas. The idea is to consider how the distribution and accessibility of resources at a local scale may have affected the possibilities of coexistence between hunter-gatherers and farmers in the early days of agriculture and herding.

ACKNOWLEDGEMENTS

We thank Berta Morell for sharing the database generated during her PhD (2019) and to the anonymous reviewers for their critical comments, which greatly improved this paper. This research took place under the project funded by the Swiss National Science Foundation entitled "Small seeds for large purposes: an integrated approach to agricultural change and climate during the Neolithic in Western Europe" (Agri Change Project, SNSF Professorship grant number: PP00P1_170515, PI: F. Antolín).

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