

A graphical simulation of the 2,000-year lag in Neolithic occupation between Central Anatolia and the Aegean basin

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Abstract The current distribution of radiocarbon dates for the Neolithic in the Anatolian peninsula indicates a significant time lag, of up to 2,000 calibrated years at two standard deviations, between the start of Neolithic occupation on the central Anatolian plateau and in the Aegean basin. This chronological discrepancy appears to match that existing between later aceramic societies in Central Anatolia and Early Neolithic societies in Greece—suggesting that the region now referred to as Western Anatolia, including the Pisidian Lake District, the Eastern Marmara and the Aegean coast, was part of a much broader horizon of Neolithic expansion, extending across the whole of the Aegean basin up to Thrace. This article provides a graphical simulation of the chronological imbalance in the radiometric dates, based on a sample of 848 uniformly recalibrated ^{14}C dates from 59 sites. The evidence supports a model in which the westward spread of farming was punctuated by major ‘halts’, one of which occurred in the highlands of Anatolia.

Keywords Neolithic · Chronological lag · Frontier zone · Radiocarbon calibration · Anatolia · Southeast Europe

Introduction

There is a growing body of evidence to suggest that the westward spread of Neolithic economies from the Near East into Europe did not involve a single wave of advance,

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expanding at a steady rate across the whole of Europe (contra Ammerman and Cavalli-Sforza 1984). Instead, recent archaeological and demographic models highlight a more dynamic process in fits and starts, or “booms and busts” (Shennan and Edinborough 2007; Shennan et al. 2013), involving phases of rapid expansion over vast landscapes, typically spanning multiple modern countries, followed by centuries-long stases in key frontier regions, such as the Great Hungarian Plain and the southern Adriatic coast (e.g. Whittle 1996; Zvelebil and Lillie 2000; Forenbaher and Miracle 2006). Chronological boundaries support traditional distinctions between culture regions, such as the Bandkeramik of Central Europe and the Balkan Neolithic, the Western Mediterranean Impresso-Cardial tradition and the Aegean Neolithic. One implication of this pattern is that it involved prolonged standoffs between Mesolithic and Neolithic communities, acting as autonomous groups on either side of a fault-line—a situation in which opportunities existed for complex and potentially transformative interactions (Zvelebil 1998, 2001; Zvelebil and Lillie 2000). The driving force behind the eventual ‘push’ of Neolithic economies, in other words the trigger or triggers for the Neolithic expansion, remains unclear and one cannot exclude a combination of factors to explain the punctuated patterns observed in the record. Models of explanation currently range from changes in the requirements of the farming regime across different ecological zones (e.g. Sherratt 1980, 2007), abrupt climate change (e.g. Weninger et al. 2006) and rapid population growth, perhaps exceeding regional carrying capacity (e.g. Bocquet-Appel and Bar-Yosef 2008; Bocquet-Appel 2011).

This article is concerned with one of the oldest such fault-lines, situated between the central and western parts of the Anatolian peninsula, in present-day Turkey. The significance of this region as a prehistoric ‘land-bridge’ between Southwest Asia and Europe has been first established by Vere Gordon Childe (Childe 1950). This region lies at the juncture

of two distinct Neolithic phenomena or processes, which appear to have been segregated spatially: long-term adaptation through plant and animal domestication on the one hand, introduction of an exogenous ‘package’ of crops and animals on the other hand (Zeder 2008, 2011; Colledge et al. 2004, 2013; Colledge and Conolly 2007). Although a chronological lag between Neolithic sites in Central and Western Anatolia has featured in a number of pan-regional models and simulations (e.g. Gronenborn 2007; Bocquet-Appel et al. 2009), these reconstructions were based on a lack of data from Western Anatolia rather than on real regional variation. As such, the chronological fault-line under review in this paper has not received detailed scholarly attention until recently (Schoop 2005; Düring 2013).

With the notable exception of Hacilar in the Pisidian Lake District, about 200 km from the Aegean coastline, Western Anatolia was until two decades ago considered a blank on the map of Neolithic expansion from the Near East to Europe (Mellaart 1970). Our knowledge of this region has changed dramatically, thanks to ongoing excavations in the Pisidian Lake District, the Eastern Marmara and the Aegean coast of Turkey (Özdoğan and Başgelen 1999, 2007; Özdoğan et al. 2012; Krauß 2011). Sites include Bademağacı, Höyücek and Kuruçay in the Lakes region (Duru 1994, 2003a, b, 2007, 2012; Duru and Umurtak 2005; see Duru 2008 for a recent overview); Fikirtepe, Pendik and Yenikapı in Istanbul (Bittel 1971; Özdoğan 1999, 2007, 2011; Kızıltan 2010; Kızıltan and Polat 2013); Ilıpınar, Menteşe and Barcın near Iznik (Roodenberg 1995; Roodenberg and Thissen 2001; Roodenberg et al. 2003; Roodenberg and Alpaslan Roodenberg 2008; Özbal and Gerritsen 2010; Gerritsen et al. 2013); Aktopraklık near Bursa (Karul 2009, 2011; Karul and Avcı 2011); Ulucak, Yeşilova and Ege Gübre around Izmir (Çilingiroğlu et al. 2004, 2012; Çilingiroğlu 2012; Derin 2005, 2012; Sağlamtimur 2012; Sağlamtimur and Ozan 2012) and Çukuriçi near Ephesus (Horejs 2008, 2012). The breadth of research in Western Anatolia is reflected, for instance, in the overall number of Neolithic sites which have produced radiocarbon dates, 14 in total, compared to only 12 in Central Anatolia. On the other hand, Central Anatolia has also been the target of a number of major prehistoric projects investigating the origins of sedentism and agriculture, notably the Konya Plain Regional Survey (Baird 1996) and more recent excavations at Pınarbaşı, Boncuklu and the basal levels of Aşıklı (Watkins 1996; Baird 2010; Baird et al. 2011; Özbaşaran 2011, 2012). Ongoing research has confirmed a late 9th millennium BC cal. date for the advent of food production in Central Anatolia, consistent with an earlier series of dates obtained from Aşıklı (Todd 1976).

This paper aims to highlight in graphical form the chronological lag between Central Anatolia and the Aegean basin at the onset of the Neolithic, by plotting the distribution of 848 uniformly recalibrated dates from four regions in a purpose-

built interface, the ^{14}C Backbone. To keep the programme as simple as possible, intervals are placed side by side in the ^{14}C Backbone, without consideration of quality or phasing. As such, it involves little manipulation by the author, other than the current division into four broad regions and colours, and the choice of more secure statistical intervals, expressed at two standard deviations. The reconstruction attempted here is intended to supplement, rather than replace, the quality assessment through selective sampling already undertaken by the author (Brami and Heyd 2011).

Method

The ^{14}C Backbone has been developed with the purpose of facilitating comparison of 848 radiocarbon dates from 59 Neolithic sites in four regions of Anatolia and Southeast Europe during the interval 9,000–5,500 BC cal. (Fig. 1). The dates were collected from publications and databases, in particular the Central Anatolian e-Workshop (CANeW) database compiled by Laurens Thissen and Agathe Reingruber (Reingruber and Thissen 2005; Thissen 2006; Gérard and Thissen 2002) and the radiocarbon CONTEXT database of the University of Cologne (Böhner and Schyle 2008). Additional ^{14}C dates were kindly made available by Amelie Scheu and Bernhard Weninger (Scheu 2012; Clare and Weninger 2014). The dates were recalibrated uniformly using the IntCal09 atmospheric curve (Reimer et al. 2009) in OxCal 4.2 (Bronk Ramsey 2013). The database of radiocarbon dates can be found in the supplementary material section (ESM 1). Dates which have been ascribed to Epipalaeolithic/Mesolithic levels by the excavators or which fall outside the interval 9,000–5,500 BC cal. at 2σ were excluded from the Backbone. In case of duplicates, the earlier reference was preferred. Figure 2 shows the distribution of all radiocarbon-calibrated intervals as they appear in the ^{14}C Backbone. Figures 3 and 4 highlight specific regional patterns by combining the data series of Central and Western Anatolia on the one hand, Western Anatolia, Greece and Thrace on the other hand.

One advantage of this display is that it does not prejudice the quality of the dates, which are simply placed side by side in the excel diagram with a secure confidence margin of two standard deviations (95.4 % probability). The dates are arranged in chronological order from the oldest to the youngest date BP and are given one of four colour codes, corresponding to Central Anatolia (red), Western Anatolia (blue), Greece (orange) and Thrace (green). The division into four broad regions and colours is arbitrary and has been adopted for the sake of clarity and to enhance the visual output. The user may decide to change this grouping by checking or unchecking selected sites or regions in the excel interface (ESM 2). Although the distribution of calibrated intervals instantly flags out isolated dates or statistical outliers, which appear either too

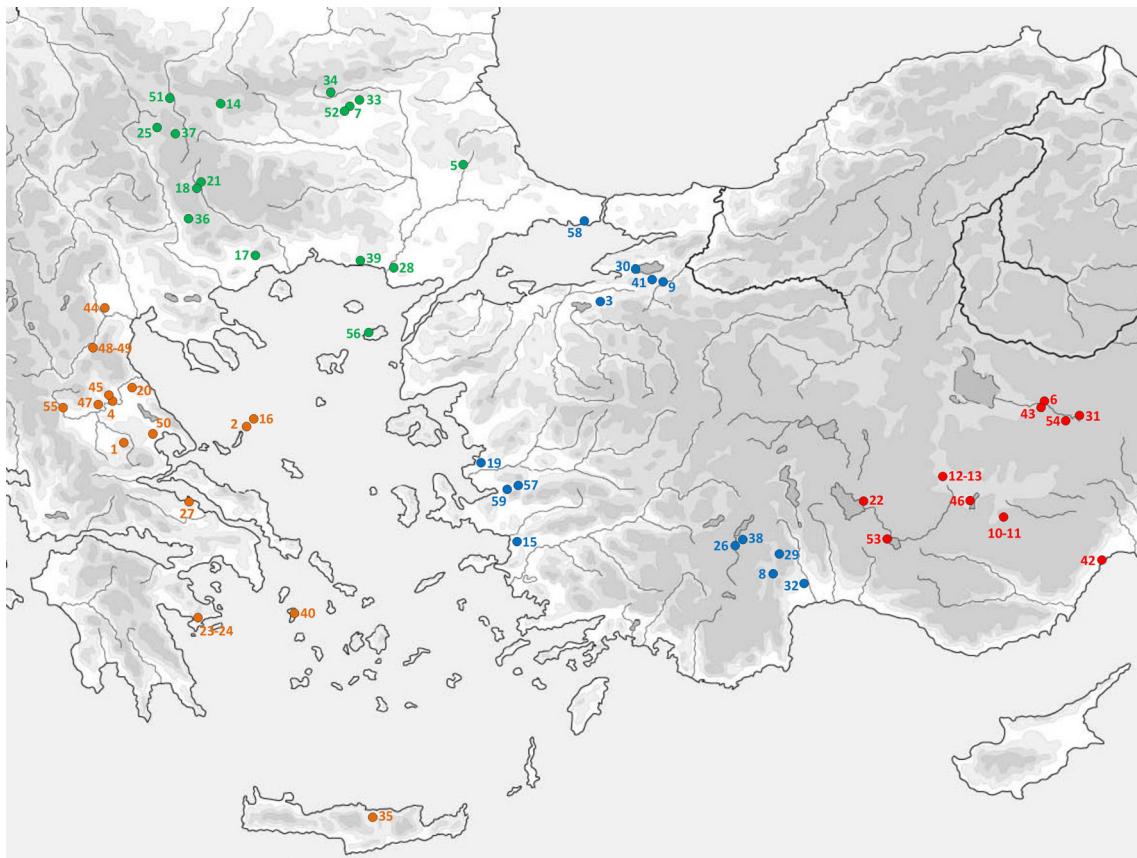


Fig. 1 Geographical distribution of 59 radiocarbon-dated Neolithic sites in Anatolia and Southeast Europe. The sites are divided up in four regional groups according to their colour code in the ^{14}C Backbone interface: Central Anatolia (red), Western Anatolia (blue), Greece (orange) and Thrace (green). 1. Achilleion; 2. Agios Petros; 3. Aktopraklık; 4. Argissa; 5. Aşağı Pınar; 6. Aşıklı Höyük; 7. Azmak; 8. Bademağacı; 9. Barcın Höyük; 10. Can Hasan I; 11. Can Hasan III; 12. Çatalhöyük East; 13. Çatalhöyük West; 14. Çavdar; 15. Çukuriçi Höyük; 16. Cyclops Cave; 17. Dikili Tash; 18. Dobriniste; 19. Ege Gübre; 20. Elateia; 21. Elešnica; 22. Erbaba; 23. Franchthi Cave; 24. Franchthi

Koilada Bay; 25. Gäläbnik; 26. Hacilar; 27. Halai; 28. Hoca Çeşme; 29. Höyücek; 30. Ilıpınar; 31. Kaletpe; 32. Karain Cave; 33. Karanovo; 34. Kazanlık; 35. Knossos; 36. Kovačevo; 37. Kremenik; 38. Kuruçay; 39. Makri; 40. Maroulas; 41. Menteşe Höyük; 42. Mersin-Yumuktepe; 43. Musular; 44. Nea Nikomedeia; 45. Oztaki Magoula; 46. Pınarbaşı B; 47. Platia Magoula Zarkou; 48. Servia; 49. Servia-Varytimides; 50. Sesklo; 51. Sofia-Slatina; 52. Stara Zagora – Okražna Bolnica; 53. Suberde; 54. Tepecik-Çiftlik; 55. Theopetra Cave; 56. Uğurlu; 57. Ulucak Höyük; 58. Yarımburgaz Cave; 59. Yeşilova Höyük

old or too young in the diagram, the risk is that a plain accumulation of dates, without consideration of quality, may generate false patterns (Zilhão 2001).

As this problem has been addressed elsewhere (Reingruber and Thissen 2009; Bami and Heyd 2011), it is only useful to repeat a few potential biases, which are likely to affect our interpretation of the results. First of all, the bulk of calibrated dates from Greece, which were processed in the early years of radiocarbon dating, is characterised by large standard deviations comprising between 200 and 400 calibrated years at 2σ . In contrast, the majority of dates from Western Anatolia, which were processed only recently, present smaller intervals of between 100 and 200 calibrated years (Bami and Heyd 2011, 173). It follows that, placed side by side in the ^{14}C Backbone, dates from the Greek side appear anomalously old; that is, if one considers the endpoint, and not the mean value. Another bias to take into account is that all regions did not contribute equal amount of radiocarbon dates to the database.

Within the interval 9,000–5,500 BC cal., Central Anatolia contributed 310 dates, Western Anatolia 182, Greece 172 and Thrace 184. The distribution is skewed towards recognition of bigger sites, such as Çatalhöyük East, Ilıpınar and Aşıklı, which produced over 50 dates each.

The majority of dates listed in the ^{14}C Backbone stem from charcoal samples, rather than samples of grains and/or bones of domesticates. Besides inherent problems associated with charcoal samples, such as ‘old wood’ effect, this material is sensitive to stratigraphic disturbance (Zilhão 2001, 14181; Cessford 2001, 720). Charcoal samples do not date the advent of Neolithic economy itself, only building-phases or levels ascribed to the ‘Neolithic’ by the excavators. Cave sites, which occasionally span Mesolithic and Neolithic occupations, should be treated with particular caution. The cave of Theopetra in Western Thessaly, for instance, has produced two series of dates, one clustering c. 7,000 BC cal., the other c. 6,300 BC cal., separated by a hiatus. Although the dates are

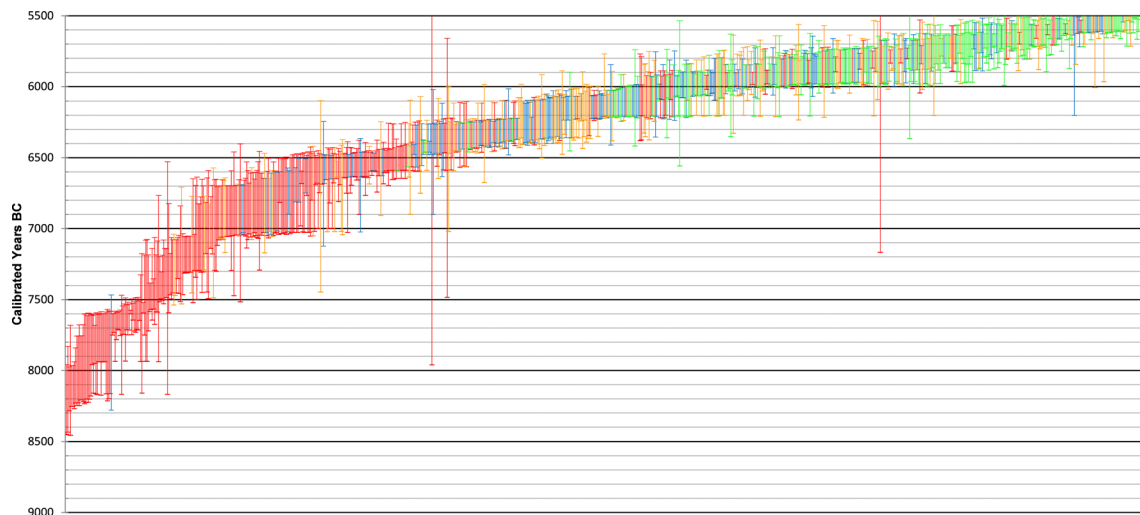


Fig. 2 ^{14}C Backbone distribution of 848 calibrated radiocarbon intervals, at 2 standard deviations (95.4 % probability), from 59 Neolithic and Early Chalcolithic sites in Central Anatolia (red), Western Anatolia (blue), Greece (orange) and Thrace (green) during the interval 9,000–5,500

BC cal. The dates were recalibrated using the IntCal09 atmospheric curve (Reimer et al. 2009) in OxCal 4.2 (Bronk Ramsey 2013). The intervals are ranked in chronological order from the oldest to the youngest date BP

reliable on principle, the existence of a hiatus raises questions about the stratigraphy of the cave (Facorellis et al. 2001, 1040; 1044; Manolis and Stravopodi 2003). The suggestion is that the earlier series may in fact relate to a later Mesolithic horizon. This result awaits confirmation by dating of the domesticates themselves. On the other hand, none of the open-air sites in the study region demonstrates such a continuity between Mesolithic and Neolithic occupations, and it is safe to assume that they were all ‘Neolithic’ from the start.

While the ^{14}C Backbone offers the advantage of allowing comparison of individual sequences of sites and regions (app 2), it does not reflect the statistical distribution of the dates during the interval 9,000–5,500 BC cal. Table 1 shows the

distribution of the mean values of 848 calibrated radiocarbon dates during selected time intervals. In addition, a diagram showing the summed distribution of calibrated radiocarbon intervals in each of four regions (Fig. 5) was created to highlight major trends in the data. In this case, a basic level of quality control is necessary to avoid overrepresentation of larger statistical intervals in the diagram. Thus, radiocarbon dates with intervals superior or equal to 100 years BP are not included. The remaining intervals are expressed at one standard deviation (68.3 % probability) and ranked in 50 years interval marks. Notice that Fig. 5 should not be used as a proxy for demographic patterns, given that none of the four regions under review has provided the minimum threshold of

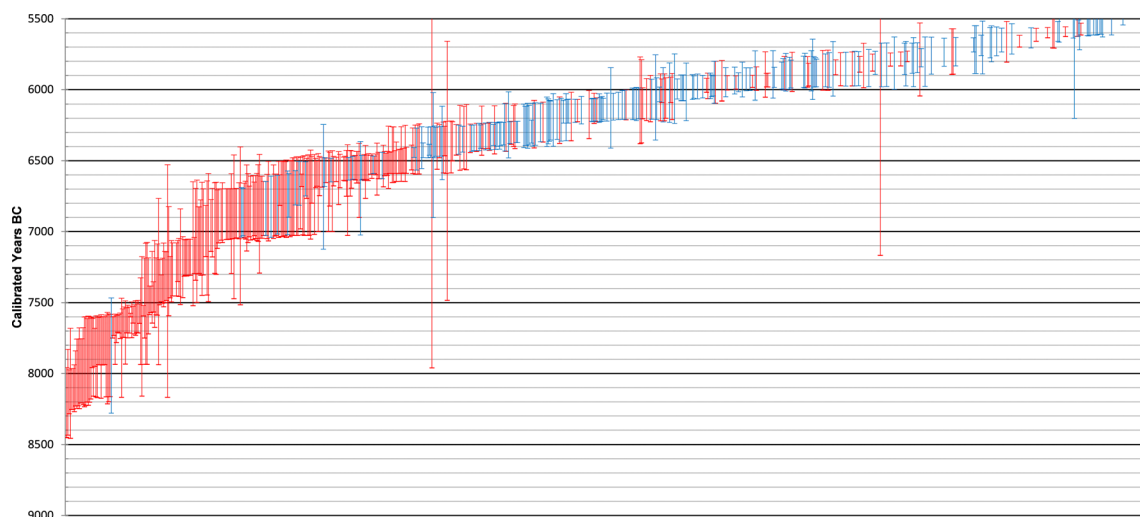


Fig. 3 ^{14}C Backbone distribution of 492 calibrated radiocarbon intervals, at 2 standard deviations (95.4 % probability), from 12 sites in Central Anatolia (red) and 14 sites in Western Anatolia (blue) during the interval 9,000–5,500 BC cal. The dates were recalibrated using the IntCal09

atmospheric curve (Reimer et al. 2009) in OxCal 4.2 (Bronk Ramsey 2013). The intervals are ranked in chronological order from the oldest to the youngest date BP

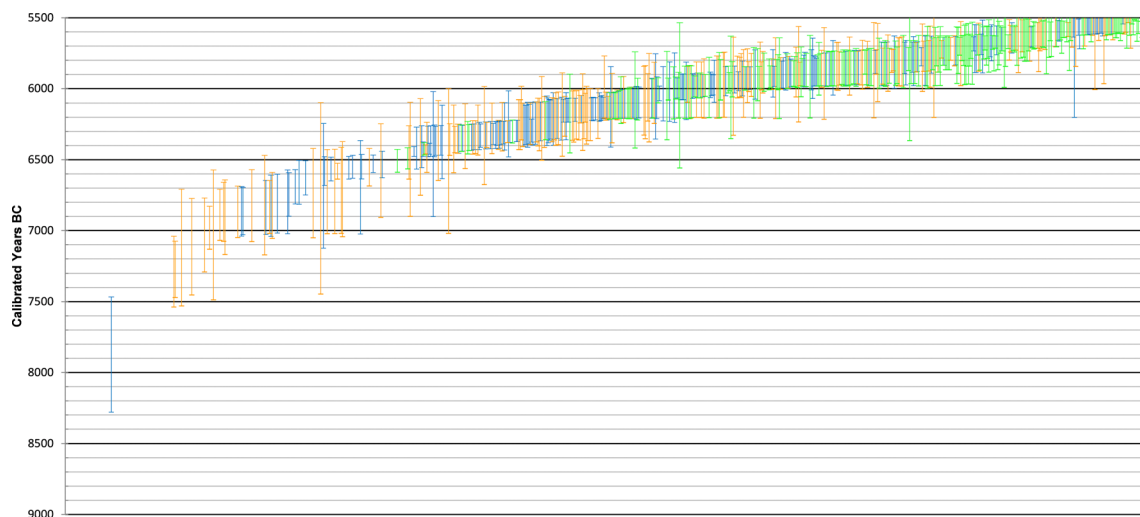


Fig. 4 ^{14}C Backbone distribution of 538 calibrated radiocarbon intervals, at 2 standard deviations (95.4 % probability), from 14 sites in Western Anatolia (*blue*), 17 sites in Greece (*orange*) and 16 sites in Thrace (*green*) during the interval 9,000–5,500 BC cal. The dates were recalibrated using

the IntCal09 atmospheric curve (Reimer et al. 2009) in OxCal 4.2 (Bronk Ramsey 2013). The intervals are ranked in chronological order from the oldest to the youngest date BP

500 radiocarbon dates usually accepted for such an analysis (Williams 2012). In this case, too, the distribution is skewed towards recognition of sites with a greater date count, especially Çatalhöyük East.

Results

One of the most important results that may be drawn from Fig. 2 is that there was a broad synchronicity at two standard deviations (95.4 % probability) between the advent of Neolithic societies in Anatolia and in Europe, hence the absence of ‘floating’ intervals or dates in the diagrams and the shape of the intervals distribution, in the form of a sturdy backbone. Any new date inserted, for instance, in the ^{14}C Backbone, may not add to, but only refine this pattern. On the other hand, four emerging trends invite a closer inspection of Neolithic dynamics in the following section:

- (1) Twelve Neolithic sites in Central Anatolia (in red in the diagram) produced a total of 310 radiocarbon dates

spanning the horizon 8,500–5,500 BC cal. at 2σ . Out of these, 105 (33.9 %) have a mean value contained within the interval 8,500–7,000 BC cal.; 205 (66.1 %) fall within the interval 7,000–5,500 BC cal. (Table 1).

- (2) In contrast, only one radiocarbon interval from Western Anatolia (0.5 % of the regional count), which belongs to Aceramic Hacilar V, has a statistical average inferior or equal to 7,000 BC cal. (BM-127: 8,281–7,467 BC cal. at 2σ). In Greece, six dates (3.5 %) have mean values that fall within the interval 8,500–7,000 BC cal. All relate to old excavations, dating back to the initial years of radiocarbon dating.
- (3) The summed distributions of Greek and Western Anatolian Neolithic dates appear to match each other to a significant extent (Fig. 5). At present, a start in the first half of the 7th millennium BC cal. appears plausible, though not certain. Nineteen dates from Greece and 19 dates from Western Anatolia, accounting respectively for 11.0 % and 10.4 % of the total regional count, have mean values comprised between 7,000–6,500 BC cal. After a peak during the interval c. 6,300–5,800 BC cal. (Fig. 5),

Table 1 Distribution of mean values of 848 calibrated radiocarbon dates from Neolithic sites during selected intervals

Interval BC cal.	Central Anatolia	Western Anatolia	Greece	Thrace	Total
8,500–7,000	105	1	6	0	112
7,000–6,500	112	19	19	1	151
6,500–6,000	54	77	62	28	221
6,000–5,500	39	81	78	132	330
>5,500	0	4	7	23	34
Total	310	182	172	184	848

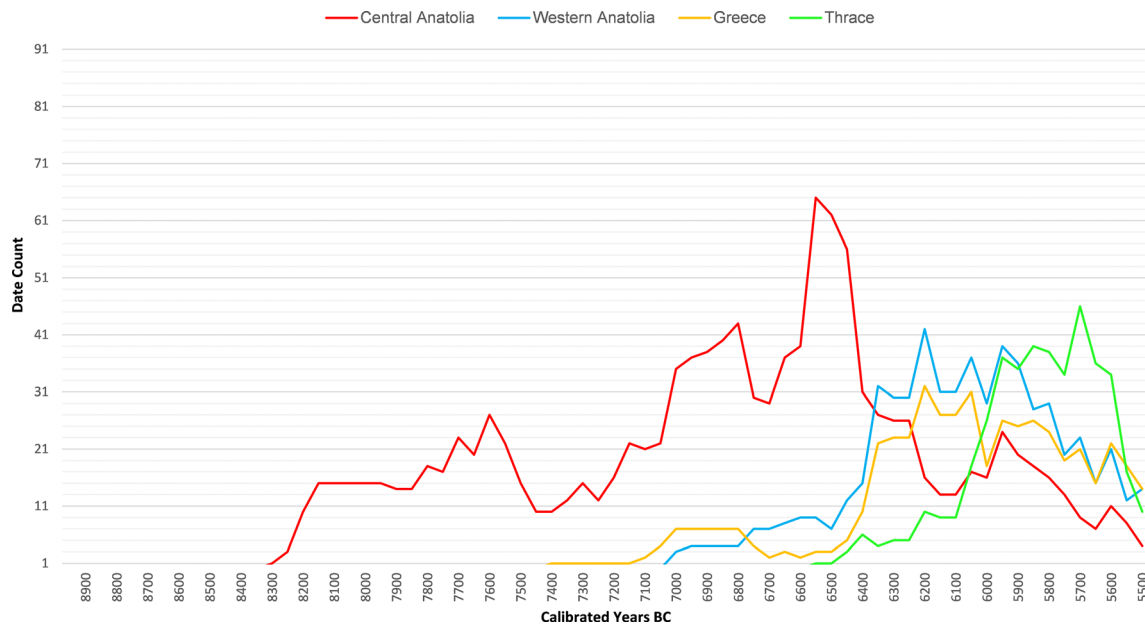


Fig. 5 Summed distribution of calibrated radiocarbon dates from four regions of Anatolia and Europe during the interval 9,000–5,500 BC cal. Intervals are expressed at one sigma (68.3 % probability) and ranked in 50 years interval marks. Dates with intervals ≥ 100 years BP are not included

in which over 50 % of the dates in Greece and Western Anatolia cluster, one observes a decline in the distribution of dates in both regions.

- (4) The Thracian Neolithic appears to be 3- to 500-calibrated years younger on average than the Greek and Western Anatolian Neolithics, highlighting perhaps a second fault-line between the Aegean basin and the Balkan hinterland. In this case, only 28 radiocarbon dates, accounting for 15.2 % of the regional count, have mean values comprised within the interval 6,500–6,000 BC cal. Significantly, pre-6,000 BC cal. dates stem almost exclusively from Aegean sites, such as Dikili Tash, Hoca Çeşme and Uğurlu.

Discussion

How to account for the remarkable time lag, of up to 2,000 calibrated years, between Neolithic societies in Central and Western Anatolia identified in this paper? This section first outlines a punctuated model of Neolithic expansion, involving a moving frontier between Anatolia and Europe, then highlights potential biases in the sampling. The current imbalance in radiometric data suggests that Central Anatolia was neolithised first, after c. 8,500 BC cal. at 2σ , Western Anatolia second, in the period between c. 7,000–6,500 BC cal. If one was to draw a line between these two horizons, it would probably be situated at the level of the Beyşehir-Suğla area of Southwest Turkey, or a little further west, depending on our

acceptance or not of an aceramic phase at Hacilar (see below). Another conclusion, which arises from the data, is that the Greek and Western Anatolian Neolithics ran broadly concurrent during the interval 7,000–5,500 BC cal., as indicated by similar peaks and troughs in chronological distribution (Fig. 5). Widespread disruptions in Southwest Anatolia after c. 5,800 BC cal. may have coincided with the transition from Early to Middle Neolithic at Sesklo (Çilingiroğlu 2009). This assertion remains open to scrutiny. The method used only allows for general comparisons to be made; a move towards generational-scale chronology through Bayesian modelling would be necessary to demonstrate that both regions experienced the same influx of Near Eastern innovations or farmers and that they operated in concert during the early Holocene, as suggested elsewhere in the literature (Reingruber 2008). In contrast, the Neolithic in Thrace appears to be significantly younger in date, especially North of the Rhodopes Mountains. This pattern hints at the existence of a second chronological fault-line between the Aegean basin and inland Thrace.

In a Neolithic frontier model, the transition to farming is expected to be slow and gradual, with some form of convergence between Mesolithic and Neolithic lifeways (Zvelebil 1998, 2001). Such a transitional phase is currently missing in Western Anatolia. Our understanding of Mesolithic or Epipalaeolithic occupation in the region is limited to scatters of lithics on the Black Sea shore, usually referred to as the ‘Ağaçlı Group’, while cave sites, such as Yarımburgaz Cave in the outskirts of Istanbul, are marked by significant hiatuses between Upper Palaeolithic/Epipalaeolithic and Neolithic levels (Özdoğan and Koyunlu 1986, 12). On the other hand,

surveys north of the Anatolian Plateau and around the Sea of Marmara have identified several prehistoric findspots, which demonstrate remote connections with the Pre-Pottery Neolithic horizon in the Near East, such as, for instance, opposed-platform ‘naviform’ cores (Özdoğan and Gatsov 1998; Brami and Heyd 2011, 186; 190–193). Regrettably, these surveys and recent excavations at Keçiçayırı in the Eskişehir region lack a sound chronological basis, and have not produced, for instance, any new radiocarbon dates (Efe et al. 2012, 229–230). Another area of uncertainty concerns the dating of Hacilar and, by extension, of the Pisidian Lake District, which is located at the western end of the central Anatolian plateau. The evidence relies on one radiocarbon date from Aceramic Hacilar V, BM-127 (8,281–7,467 BC cal. at 2σ). Notwithstanding the size of the interval, the date derived—presumably—from a short-lived sample (‘hearth throwout’) and cannot be easily discounted. The level in which it was found was virtually without pottery and contained features, such as red lime-plastered floors and curated skulls, which point to later aceramic occupation on the plateau and in Southeast Anatolia (Duru 2003a, b, 589–591). Unless new excavations are carried out at Hacilar, it may not be possible to prove or disprove the existence of an aceramic phase at the site.

While admitting that there may have been earlier ‘Neolithic’ dispersals in Western Anatolia, as yet uncharted, the balance of evidence suggests that these isolated and short-lived ‘visits’ did not contribute in any major way to the remarkable explosion of sites in this region and in Greece after c. 7,000 BC at 2σ (see discussion of “failed attempts” in Brami and Heyd 2011, 193; Düring 2013). With a possible exception at Hacilar, seventh millennium levels in the Aegean basin were founded directly upon the bedrock in what appears to be previously unoccupied locations. Identification of Central Anatolia as a Neolithic frontier zone is warranted by the long-term internal dynamics of the Neolithic on the Central Anatolian Plateau, characterised by a succession of sites spanning the horizon from c. 8,500–5,500 BC cal.; that is, for comparison, a period comprised between the Early Pre-Pottery Neolithic B to the Halaf period in the Northern Levant. Judging by the evidence, it may be necessary to reconsider the role of Western Anatolia as a recipient, as well as a sender of Near Eastern innovations, while Central Anatolia is afforded a much more creative role. Reasons behind the delayed adoption of Neolithic economies in Western Anatolia were not addressed in this paper; the reader is referred to the syntheses by Ulf Schoop (2005) and Bleda Düring (2013) for a preliminary discussion of different models of explanation—ecological, climatic and cultural.

The relevance of a graphical interface, including all the dates, regardless of their quality or phasing, arises from a significant discrepancy in the data—in this case, a lag of considerable duration between Neolithic sites in two regions. The robustness of this approach lies in the absence of direction

imposed on the data, which is merely described graphically. It does not detract, however, from the value of a thorough quality assessment, nor from a combination of absolute and relative dating methods, to establish more precise chronological patterns and interactions.

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