

Intramural burials in Neolithic Anatolia: What do they tell us about social organisation?

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Zusammenfassung

**Intramurale Bestattungen im neolithischen Anatolien:
Was sagen sie uns über die soziale Ordnung aus?**

Ein gängiges Modell des sozialen Wandels während des Neolithikums geht davon aus, dass sich die Gesellschaften zunächst in Kernfamilien und später in Großfamilien organisieren, wobei patrilineale und patrilokale Traditionen zunehmend vorherrschen. Für dieses Modell gibt es zwar ethnografische Belege, aber nur indirekt, und eine ausführliche Bewertung wäre nur möglich, wenn man die sozialen Strukturen prähistorischer Gesellschaften im Neolithikum entschlüsseln würde. Die Messung der genetischen Verwandtschaft zwischen Gruppen räumlich geclusteter intramuraler Bestattungen (unter dem Fußboden) im neolithischen Südwestasien bietet eine einzigartige Gelegenheit, die Gültigkeit dieses Modells zu untersuchen.

Wir fassen hier die Ergebnisse von zwei neueren archäogenomischen Studien zusammen, die fünf Siedlungen umfassen. In allen drei untersuchten frühneolithischen Fundstellen (ca. 8500–7500 v. Chr.) – Aşıklı, Boncuklu und Çayönü – umfassen Co-Bestattungscluster häufig enge genetische Verwandte. Im Gegensatz dazu handelt es sich bei den beiden spätneolithischen Fundstellen (ca. 7000–6000 v. Chr.) – Çatalhöyük und Barcın – bei den untersuchten Bestattungen meist um Jugendliche (subadult), die viel seltener miteinander verwandt sind. Die veröffentlichten Stichproben sind zwar klein, deuten aber insgesamt auf einen zeitlichen Wandel der Traditionen hin. Wir finden auch erwachsene Frauen, die häufig mit ihren genetischen Verwandten auf frühneolithischen Fundstellen bestattet wurden. Wir diskutieren die Ergebnisse im Zusammenhang mit Modellen der neolithischen sozialen Organisation und des Wandels.

1. Introduction

The emergence of sedentary life and food production involves one of the most dramatic transformations in the history of our species. During this transformation, human beings began to engage with their social and natural environments in radically new ways, which in the long run resulted in the development of increasingly more complex social organisations with various forms of social inequality, private property, and central authority. At the very centre of this transformation was the emergence of a new social and economic unit, i.e., »the kin-related household«, which was frequently organised along patrilineal authority. In this chapter, we summa-

Summary

A common model of social change during Neolithic transitions involves societies first organised along nuclear family lines and later organised as extended families, with an increasing prevalence of patrilineal and patrilocal traditions. Ethnographic evidence can be found in support of this model, but is indirect. An in-depth evaluation would only be possible by deciphering the social structures of prehistoric societies undergoing Neolithic transitions. Measuring genetic relatedness among groups of spatially clustered intramural burials (sub-floor burials) in Neolithic Southwest Asia provides a unique opportunity to address the validity of this model.

We here summarise results from two recent archaeogenomic studies covering five settlements. In all three early Neolithic (c. 8500–7500 BC) sites investigated, Aşıklı, Boncuklu, and Çayönü, co-burial clusters frequently comprise close genetic relatives. In contrast, in the two late Neolithic sites (c. 7000–6000 BC) studied, Çatalhöyük and Barcın, burials studied are mostly subadults and these are much less frequently related. The published sample sizes are small but overall suggestive of a temporal change in traditions. We also find adult females frequently buried with their genetic kin in early Neolithic sites. We discuss the results in the context of models of Neolithic social organisation and change.

rise current genomic evidence on the social organisation of early and late Neolithic societies in Anatolia and North Mesopotamia and the temporal dynamics of this transformation.

1.1. Social organisation of foragers versus food-producers: the ethnographic evidence

The shift towards a greater role of biological relatedness in social organisation in food-producing societies can be inferred from ethnographic studies of modern-day foragers and traditional agriculturalists or horticulturalists. For instance, data from various forager bands, which usually comprise

some dozens of individuals, suggest relatively fluid relations within a band, with a significant fraction of group members being biologically unrelated. Moreover, post-marital residence choices appear devoid of a clear bias towards joining the family of one gender, i. e., patrilocality or matrilocality¹. Conversely, in traditional food-producing societies, biological family ties bear significance for social coherence and cooperation; patrilineal and patrilocal traditions are also predominant. Historical and archaeological records, as well as linguistic data, also suggest that patrilineal organisation was widespread (even if not universal) throughout the history of agricultural societies (reviewed in Marlowe 2004; Ember 2011; Bentley 2022).

Multiple lines of evidence thus suggest a change that either accompanied or followed the shift to food production, and which fundamentally reorganised relationships: relatively fluid relationships among foragers versus frequently genetic kin-based and patrilineal or patrilocal organisation in food producers. Although this is not an absolute dichotomy – e.g., matrilineal organisation can be frequently observed in traditional horticulturalist societies (Shenk et al. 2019) –, we can see a general distinction in dynamics between these two types of societies. An enticing question is how this shift in social organisation toward biologically related, kin-based household and family organisations materialised over time in sedentary, food-producing societies.

1.2. Archaeogenomic insights into prehistoric social organisation

Already a decade ago, archaeogenetic studies using mitochondrial DNA (mtDNA) and the Y-chromosome had begun to reveal the presence of biological family members in co-burials or multiple burials in Europe, providing early support for the prevalence of patrilocal traditions in Neolithic and post-Neolithic societies (Haak et al. 2008; Simon et al. 2011; Szécsényi-Nagy et al. 2015). This line of work has advanced rapidly with the advent of archaeogenomics (Racimo et al. 2020). The evidence can be deduced in various ways. One involves the direct estimation of genetic kinship levels (i. e., the degree of genetic relatedness) between individuals co-buried in the same spaces using genome-wide data. Another involves studying whether genetic relatedness between generations follows the male or the female lines. A third approach involves testing whether female or male burials within a locality show higher degrees of genetic variation, which would be consistent with female or male exogamy, respectively.

For instance, M. Sikora et al. (2017) reported genetic data from three co-burials at Upper Palaeolithic Sunguir in Siberia, in which the interred were accompanied by rich burial gifts. None of the pairs turned out to be close relatives. The lack of close relatedness among plausibly socially related individuals would be in line with the notion of genetic kinship not being central to forager social organisation, even though the sample size was too small to allow generalisation. In contrast,

data from various studies on Late Neolithic and Early Bronze Age Europe² showed strongly patrilineal relationships among individuals buried in the same or similar contexts, with multiple generations nearly exclusively being linked via the male line. Female exogamy in Neolithic and Bronze Age Europe is also supported by the observations of non-local strontium isotope signals in females (Bentley et al. 2012; Knipper et al. 2017; Mittnik et al. 2019).

The picture of Neolithic and Bronze Age social organisation in Europe thus appears largely homogeneous, at least given current archaeogenomic and isotopic evidence. Agriculturalist groups in this continent had probably already adopted family-based and patrilocal organisations by the time of their arrival.

What then remains to be investigated genetically is how the earliest Neolithic societies in West Eurasia first underwent an organisational shift. In other words, how were the first Neolithic societies in the early Holocene Fertile Crescent, i. e., sedentary foragers, organised, and how did their organisation patterns change through the Neolithic Transition?

1.3. The question of social organisation in the Neolithic Fertile Crescent

Archaeological analyses suggest an early biological family-focused shift in social organisation during neolithisation, already by the Pre-Pottery Neolithic (PPN). K. V. Flannery (2002), mainly inspired by ethnographic studies, suggested that the earliest sedentary PPN communities may have been structured as nuclear family groups, because in communal forager societies »[f]ood storage is out in the open and shared by all occupants of the settlement [...]. There is little incentive to intensify production in such societies, since whatever is produced must be shared« (Flannery 2002, 421). K. W. Alt et al. (2013) similarly argue that »[...] open access to resources and land – had to be reduced to a circumscribed group before regular farming and herding could be successfully established. [...] [F]amilial relationships might have become influential or decisive« (Flannery 2002, 1). Flannery (2002) suggests that at some stage in the PPN, villages were organised around nuclear families living in rectangular buildings with private storage and later-arriving societies were organised around extended families. Others have further developed this model of increasing household autonomy, again suggesting that Pottery Neolithic (PN) period societies were organised as extended-families (Kuijt et al. 2011; Atakuman 2014).

Despite widespread reference to the Flannery and I. Kuijt model of household formation, empirical evidence from Neolithic societies has been sparse. Indeed, the architecturally visible »house« is probably the primary context defining the »household« in the Neolithic Fertile Crescent, but archaeologically, it has not been easy to define the nature of relations among the household members: were the co-residents genetically kin, or was household membership defined with reference to other criteria such as gender, age, or task orientation?

1 Marlowe 2004; Wilkins/Marlowe 2006; Hill et al. 2011; Bailey et al. 2014; Walker 2014; Dyble et al. 2015.

2 Szécsényi-Nagy et al. 2015; Sánchez-Quinto et al. 2019; Mittnik et al. 2019; Cassidy et al.

2020; Fowler et al. 2022; Villalba-Mouco et al. 2022.

Direct answers to these questions are not available, and arguably the most promising source of information derives from subfloor burials in the Neolithic Fertile Crescent (see below).

Hence, the last decade has seen a number of attempts to study biological kinship among subfloor burials in Neolithic south-west Asia. The earliest of such studies were analyses of dental traits and mtDNA. Studying dental traits at Levant PPNB sites, two studies by Alt and colleagues reported patterns consistent with endogamy (Alt et al. 2013) and with matrilocality (Alt et al. 2015), while a pilot analysis of mtDNA fragments from PPNB Tell Halula, north Syria did not yield any clear patterns (Fernández et al. 2008). Surprisingly, a study on the Anatolian PN site of Çatalhöyük, involving a large dataset of c. 300 adult skeletons, found no evidence of higher biological relatedness among burials within the same building compared to burials in different buildings (Pilloud/Larsen 2011; Larsen et al. 2019). The authors interpreted this pattern as evidence of a type of »social kinship« governing Çatalhöyük society, or at least Çatalhöyük burials. Another study using this dataset also reported higher dental trait variability in females than in males, implying a patrilocal residence pattern (Larsen et al. 2015). Meanwhile, in 2019, an ancient mtDNA study on 10 individuals buried across three Çatalhöyük buildings found no single individual with the same haplotype (Chylenski et al. 2019), which is also in line with the lack of biological clustering among co-burials and/or patrilocality. However, given high amounts of noise in dental analyses, the limited information provided by mtDNA, and the small number of sites studied, the issue of the organisation of Neolithic societies and the role of biological relatedness in burial choices have remained largely open.

2. Archaeogenomic insights into social organisation in Neolithic Turkey

2.1. Intramural co-burials in Neolithic Turkey

Over the last years, we have been producing genomes from Neolithic period Turkey with the goal of understanding both interregional mobility and also within-settlement traditions, including genetic kinship between co-burials. We are particularly fortunate that a considerable number of Neolithic north Mesopotamian, Central Anatolian, and west Anatolian settlements observed the tradition of intramural burial, i.e. interring some of their dead within settlements, and frequently within buildings (beneath floors), or next to buildings during a structure's use. This tradition is also found in other parts of Neolithic south-west Asia, such as the Levant and south Caucasus.

Intriguingly, intramural and subfloor burial traditions appear to have accompanied the development of permanent dwellings during the PPN period. However, these traditions varied significantly in both space and time. For instance, excavation at the Late Epipaleolithic-PPNA layers of north Mesopotamian Körtektepe revealed over 1000 subfloor burials (Erdal 2015), while no such dominant pattern has been found in other PPNA sites, such as at Göbeklitepe (Gresky et al. 2017). In contrast, pioneer PPNB sites, such as north Mesopotamian Çayönü, or Central Anatolian Aşıklı and Boncuklu, revealed modest frequencies of subfloor burial, suggesting that some

individuals were selected for subfloor burials, while others were buried in communal buildings and graveyards; e.g., the Skull Building of Çayönü houses remains from hundreds of individuals (Özdoğan/Özdoğan 1989). Studying more than one hundred burials from north Syrian PPNB Tell Halula, Guerrero and colleagues have described a highly standardised interment tradition, placing bodies upright and in flexed form in the main entrance to the buildings (Guerrero et al. 2009). These authors have also highlighted the notable variability of burial practices among PPNB settlements in south-west Asia, such as the lack of burials outside buildings in some sites, or the lack of burial gifts in the south Levant.

Selective intramural burials are also observed in Late Neolithic Turkey, although not at all sites. In north Mesopotamian Hakemi Use, subadults and adult females are overrepresented among its c. 100 excavated intramural burials (Erdal 2013). In Central Anatolia, Çatalhöyük has frequent subfloor burials, with c. 800 excavated and including both subadults and adults of both sexes; nevertheless, the excavators believe not all burials were intramural (Larsen et al. 2015). Only infants were found in late PN Central Anatolian Köşk Höyük subfloor graves, small numbers of adults in south-west Anatolian Bademağacı, and either no burials or rare infant burials in west Anatolian sites, such as Ulucak and Çukuriçi. In north-west Anatolia, intramural burials are more frequent at some sites, where individuals were either buried in open spaces between houses (e.g., Barcın, Pendik, Bahçelievler) or in extramural graveyards at the edges of the dwelling areas (e.g., Ilıpınar, Aktopraklık, Yenikapı); rarely, infants were also found in subfloor graves at some of these sites (Düring 2011; Erdal/Takaoğlu 2021).

In addition, there appears to be a trend towards more female burials in various sites (e.g., in Aşıklı) and for a temporal increase in relative female frequencies among adult burials as estimated by osteological analyses (Fig. 1). What is also clear is that intramural burial customs varied with respect to both sex and age, both among contemporaneous villages, and over time, during the transition from sedentary hunter-gatherers to intensive farming communities.

Irrespective of this temporal variation, many Neolithic intramural burials are found in spatial clusters where they are associated with specific spaces, usually buildings. Frequently, these clusters do not represent simultaneous burials, but burials in proximate spaces across multiple decades. We term these clusters »co-burials«. Archaeologists commonly assume that these clusters comprise socially-related individuals.

Whether these intramural co-burials represent genetically related individuals has been a major question for the archaeology of the Neolithic Fertile Crescent (Hodder 2011). The observations on Çatalhöyük dental remains by Pilloud and Larsen (2011) found no evidence for genetic similarity within buildings and has consequently further fuelled the debate. We have recently started investigating this question in a systematic manner and here we will present a summary of results from two recent publications, by R. Yaka and colleagues (2021) and by N. E. Altınışık and colleagues (2022). These studies surveyed genetic kinship across five Neolithic sites: three from the Aceramic/PPN period, namely Aşıklı Höyük and Boncuklu in Central Anatolia and Çayönü in north Mesopotamia; and two from the PN period, Çatalhöyük in Central Anatolia and Barcın in west Anatolia (see map and timeline in Fig. 2).

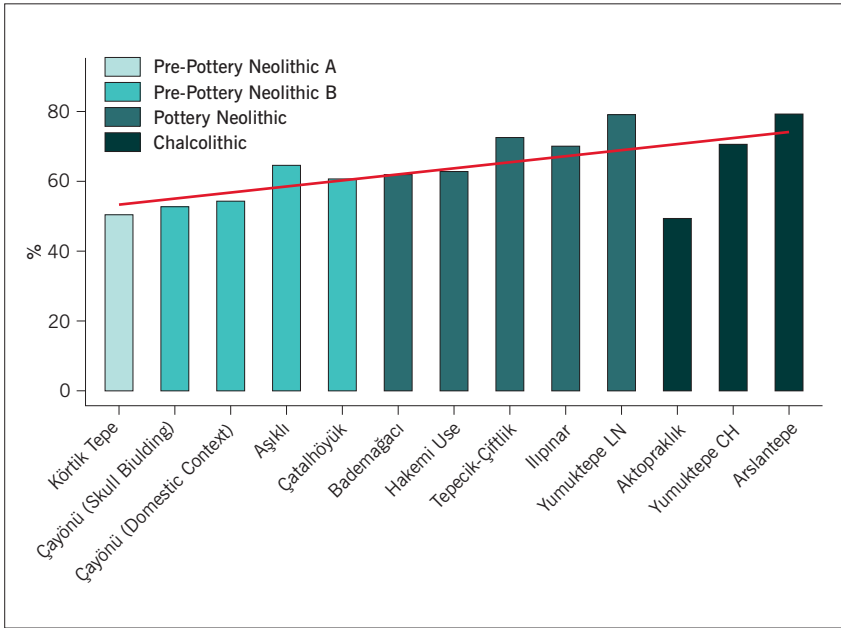


Fig. 1 The proportion of females among burials with osteologically identified sex in Neolithic sites in Turkey.

Abb. 1 Der Anteil an weiblichen Bestattungen mit osteologisch bestimmtem Geschlecht von neolithischen Fundstellen in der Türkei.

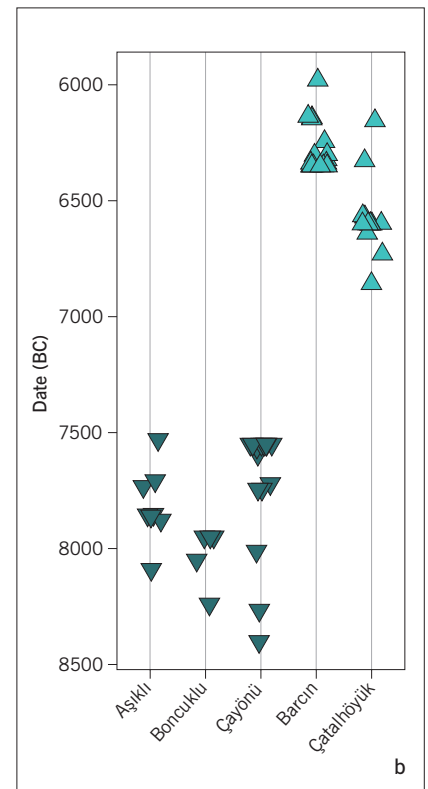


Fig. 2a–b Map and timeline of Neolithic sites analysed for genetic kinship among co-burials. Published genomes from the PPN/Aceramic period sites are shown as dark green triangles while those from the PN/Ceramic period sites are shown as turquoise triangles.

Abb. 2a–b Karte und Zeitachse neolithischer Fundstellen, die auf genetische Verwandtschaft unter den Mehrfachbestattungen analysiert wurden. Veröffentlichte Genome von Fundstellen der vorkeramischen Periode sind als dunkelgrüne Dreiecke dargestellt, diejenigen von Fundstellen der keramischen Periode als türkise Dreiecke.

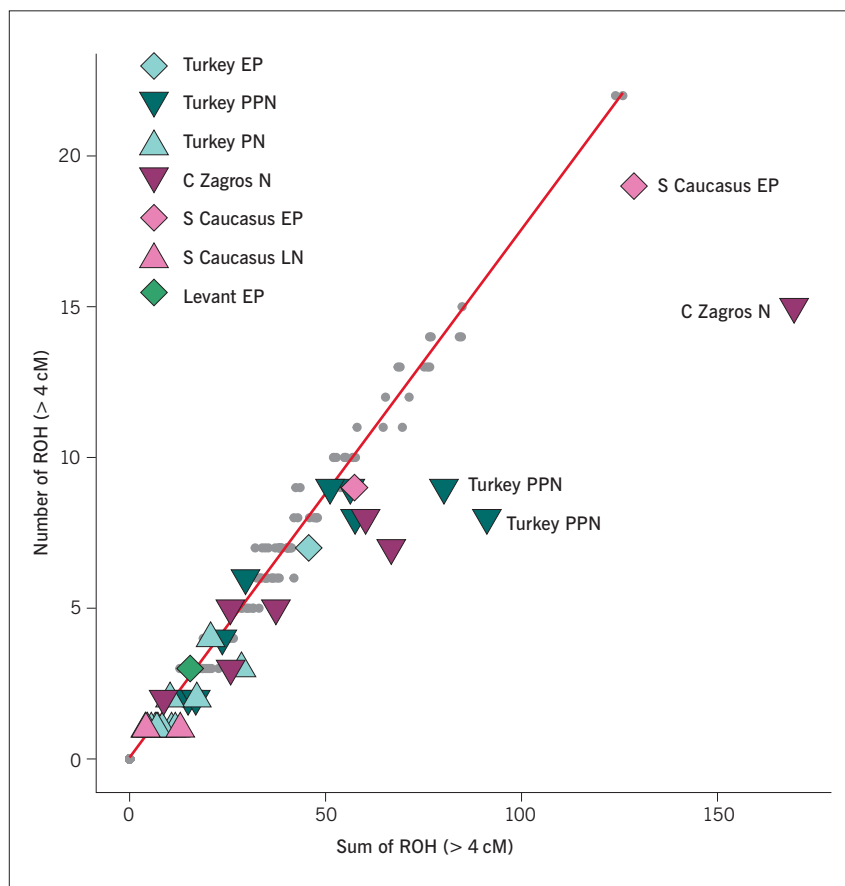
2.2. Estimating genetic kinship degrees and consanguinity in Neolithic settlements

The two studies used a total of 64 genomes from the five Neolithic sites mentioned. Most of the genomes were of low coverage (<0.3x). The majority (61%) was produced by our group in Ankara; these were based on direct shotgun

sequencing and whole genome capture (Kılınç et al. 2016; Yaka et al. 2021; Altınışik et al. 2022). Meanwhile, some of the Boncuklu and all of the Barcin genomes were published by other laboratories; a few of these were shotgun sequenced (Hofmanová et al. 2016) but mostly were SNP capture-generated genomes (Mathieson et al. 2015; Feldman et al. 2019).

Fig. 3 Number versus sum of runs of homozygosity (ROH) in published late Pleistocene and early Holocene south-west Asian genomes. The red diagonal line was computed using short ROH values (4 to 8 cM) in present-day West and Central Eurasian individuals to represent individuals with no consanguinity, with shifts towards longer ROH, to the right, suggesting consanguinity (see Altınışık et al. 2022). A PPN individual (c. 7500–7000 BC) from Wezmeh Cave in Central Zagros (Broushaki et al. 2016) shows the strongest deviation, while two individuals from PPN Central Anatolia show only modest shifts. In none of these genomes, however, do ROH levels reach that expected for first cousin offspring.

Abb. 3 Anzahl im Vergleich zur Summe von Homozygotesequenzen (ROH = Runs of homozygosity) in veröffentlichten spätpleistozänen und frühholozänen südwestasiatischen Genomen. Die rote Diagonallinie wurde mit Hilfe von kurzen ROH-Werten (4 bis 8 cM) in heutigen west- und mitteleurasianischen Individuen berechnet, um Individuen ohne Blutsverwandtschaft darzustellen; Verschiebungen hin zu längeren ROH-Werten nach rechts deuten auf Blutsverwandtschaft hin (siehe Altınışık et al. 2022). Ein vorkeramisches Individuum (ca. 7500–7000 v. Chr.) aus der Wezmeh Höhle in Zentral-Zagros (Broushaki et al. 2016) zeigt die stärkste Abweichung, während zwei Individuen der vorkeramischen Periode C in Anatolien nur geringe Verschiebungen zeigen. In keinem dieser Genome erreichen die ROH-Ergebnisse den Wert, den man für Nachkommen von Cousins ersten Grades erwartet.



Estimating correct genetic kinship degrees using low-coverage genomes is a challenge, therefore we resorted to using multiple methods in parallel. These included specifically: READ, which uses the pairwise genetic distances in the sample for normalisation and direct estimation (method-of-moments) of relatedness level (Monroy Kuhn et al. 2018); lcMLkin (Lipatov et al. 2015) and ngsRelate (Hanghøj et al. 2019), which both use population allele frequency estimates and a probabilistic framework for relatedness estimation and TKGWV (Fernandes et al. 2021), which also uses population allele frequency estimates but performs direct estimation of relatedness.

These methods are theoretically also sensitive to varying levels of inbreeding in the sample. Pairs who are highly consanguineous may be inferred to be related at higher degrees than their direct relationship. Previous work has identified cases of relatively high consanguinity in Neolithic societies³. We have accordingly analysed the available genome sample from Neolithic Turkey using the hapROH method (Ringbauer et al. 2021), which includes 18 individuals from the aforementioned five sites with sufficient genome coverage to calculate runs of homozygosity. Some individuals from Late Pleistocene and early Holocene sites have relatively high levels of ROH due to small population sizes. Meanwhile, although modest levels of consanguinity can be observed in the sample (Fig. 3), no individual was identified with high

consanguinity (e.g., first cousin mating). This contrasts with common consanguinity observed today in modern-day populations in south-west and Central Asia (Bittles/Black 2010; Ceballos et al. 2021; Ringbauer et al. 2021).

2.3. Genetic kinship in co-burials in PPN/Aceramic Neolithic sites

Our sample from Boncuklu (Baird et al. 2018), in the Central Anatolian Konya Plain, included a single cluster of burials in two proximal buildings (Yaka et al. 2021) (Fig. 4). Buildings here are small and round, with the burials dated to c. 8300–8000 BC. Published aDNA data (Kılınç et al. 2016; Feldman et al. 2019) was available in a co-burial cluster of five individuals, four adults and a perinatal baby. The adults were estimated to be related as a sibling pair and a parent-offspring pair. Surprisingly, the perinatal baby, buried in the same grave as a middle-aged adult female, was unrelated to everyone else in the sample (Yaka et al. 2021).

In Aşıklı (Özbaşaran 2011; Özbaşaran/Duru 2012), from the Cappadocia region in Central Anatolia, we encountered a similar picture (Yaka et al. 2021) (see Fig. 4). The sample included a single co-burial cluster in two proximate round buildings. This represents the early phase of Aşıklı Höyük occupation (c. 8200–7700 BC), which later continues with

³ Broushaki et al. 2016; Cassidy et al. 2020; Ceballos et al. 2021; Ringbauer et al. 2021.

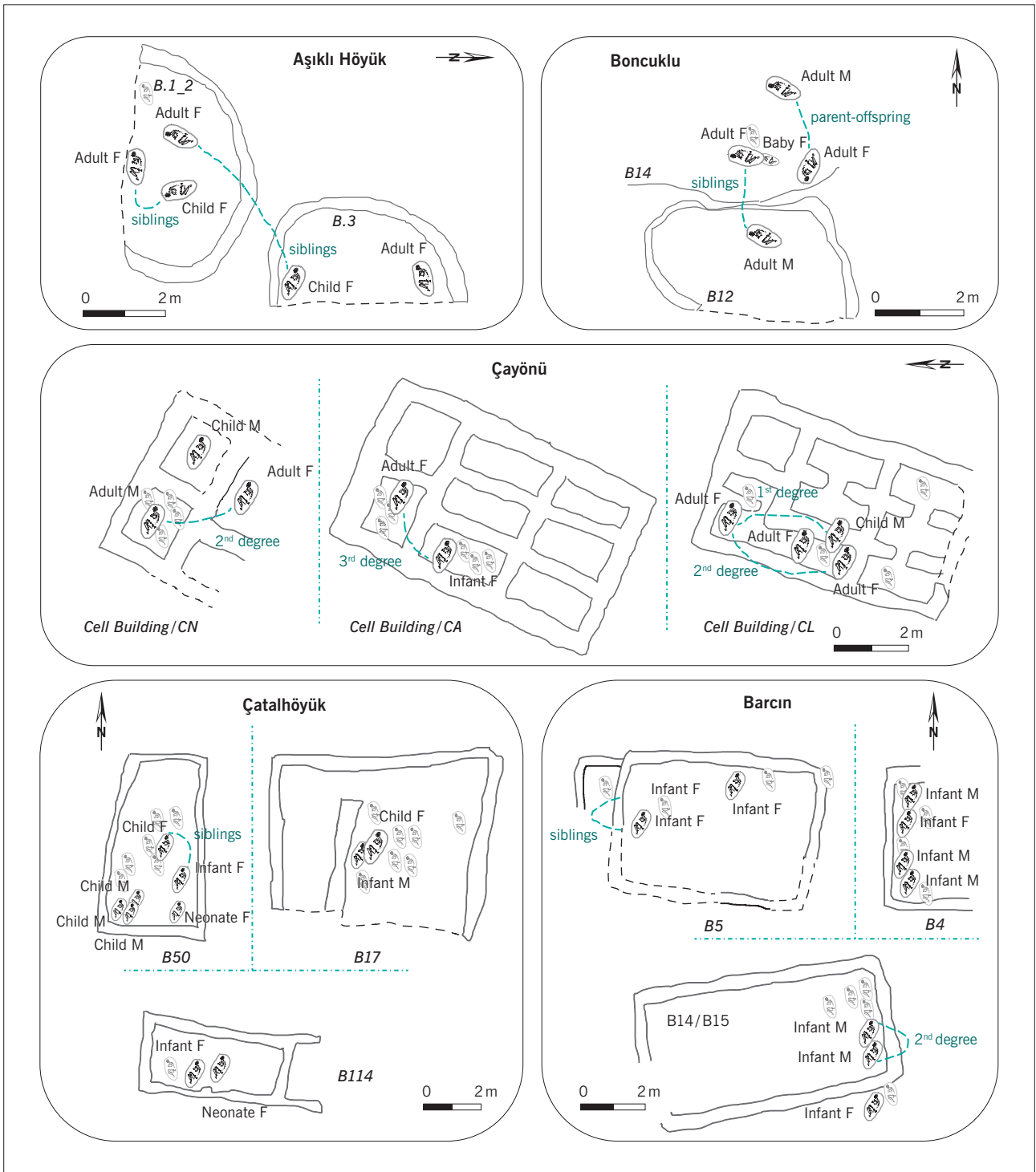


Fig. 4 Genetic kinship among intramural burials across five Neolithic sites. The figure was recreated based on related figures from Yaka et al. (2021) and Altınışik et al. (2022). Buildings and subfloor burials are represented symbolically (not to scale). Estimated close genetic relationships between individual pairs are shown as dashed lines. Flexed skeleton symbols in dark grey indicate individuals with sufficient aDNA data, which are also marked by their age and sex. Flexed skeleton symbols in light grey indicate individuals who were not sampled for aDNA, or did not yield sufficient aDNA (age or sex not shown). Building numbers are shown in italics.

Abb. 4 Genetische Verwandtschaft bei intramuralen Bestattungen an fünf neolithischen Fundstellen. Die Abbildung wurde auf der Grundlage ähnlicher Abbildungen aus Yaka u. a. (2021) und Altınışik u. a. (2022) neu erstellt. Gebäude und Bestattungen unter dem Fußboden sind symbolisch dargestellt (nicht maßstabsgetreu). Vermutete enge genetische Beziehungen zwischen einzelnen Paaren sind als gestrichelte Linien umgesetzt. Symbole für gehockte Bestattungen in dunkelgrau bezeichnen Individuen mit ausreichenden aDNA-Daten, bei denen auch Alter und Geschlecht bestimmt sind. Symbole für gehockte Bestattungen in hellgrau zeigen Individuen an, die nicht für aDNA beprobt wurden oder nicht genügend aDNA lieferten (Alter und Geschlecht nicht angegeben). Gebäude-nummern sind kursiv gesetzt.

rectangular and larger buildings. We could obtain usable aDNA from five individuals from within the co-burial cluster. All five were females. Two pairs (4 out of 5) were esti-

mated to be siblings (both were adult-child pairs). One of the sibling pairs was buried in neighbouring buildings (B.1_2 and B.3), and another in the same building (B.1_2). Only one

individual here, a young female buried in B.3, had no identified relatives (Yaka et al. 2021).

In north Mesopotamian Çayönü (Özdoğan/Özdoğan 1989), our sample included three co-burial clusters within separate three rectangular buildings, all from the Cell Building subphase (c. 7500–7200 BC) (Altınışık et al. 2022). Genomes with sufficient aDNA data to allow kinship estimation comprised nine individuals in total, a small subset of the total number of 29 individuals interred within the same buildings. Seven of these nine had 1st, 2nd or 3rd degree-related kin identified in the same buildings (see Fig. 4).

Notably, in all three sites adult females were found buried with relatives, including siblings and potential nephews. This is interesting because it does not align with expectations under female exogamy (see Discussion).

2.4. Genetic kinship in co-burials in PN/Ceramic Neolithic sites

Our sample from Çatalhöyük in the Central Anatolian Konya Plain (Düring/Marciniak 2005; Hodder 2007) included three co-burial clusters in separate buildings (see Fig. 4). The burials have been dated to c. 7000–6500 BC (Yaka et al. 2021). We studied ten individuals, all subadults. Interestingly, only one pair of these ten subadults were estimated to be siblings. None of the rest had identified relatives within the sample.

In Barcın, from north-west Anatolia (Gerritsen/Özbal 2019), we again had three co-burial clusters, with infants buried within, or next to, three separate buildings and which were dated to c. 6500–6000 BC (Yaka et al. 2021). Two pairs of relatives were found in two of these clusters (a sibling and a second-degree pair), while the rest of the individuals had no relatives identified.

3. Discussion

The current set of genomic data published in these two studies is admittedly small, but it already implies a number of features that may characterise the organisation of Neolithic societies in Anatolia and north Mesopotamia.

3.1. Close biological ties among co-burials in early sedentary communities

First, data from the three PPN/Aceramic sites suggest that co-burials within buildings in these early sedentary societies were frequently close biological families. As mentioned earlier, we do not know whether these burials represented individuals using the buildings during their lifetime. Testing this could be theoretically possible by studying inter-building dietary differences among contemporaneous burials (e.g., Knüsel et al. 2021), or by using other markers of shared space use, or using sedimentary DNA. However, comprehensive work in this direction is lacking and the question remains largely unanswered. For now, we can only speculate about whether the co-burials represented

»households«. Assuming this to be the case, our observation would suggest an early adoption of a biological family-based organisation in sedentary societies, in the PPN/Aceramic period, before full-scale food production had started. This would be consistent with the notion of investment in a built environment being facilitated by biological family-based organisation (Flannery 2002; Kuijt et al. 2011).

3.2. Change in co-burial and/or organisation traditions over time

The second and rather unexpected finding is the apparent shift in co-burial traditions between the PPN/Aceramic and PN Ceramic sites studied. The difference becomes conspicuous when the data are summarised as the proportion of individuals buried in the same building with identified relatives (Fig. 5). Compared to the three PPN/Aceramic sites, the frequency of close relatives identified among co-buried individuals is distinctly lower in the two PN/Ceramic sites. Notably, the latter are settlements with full agriculture and animal husbandry, and with private storage within buildings (reviewed in Düring 2011).

A possible confounding factor here is age: the available aDNA data in co-burial clusters in the two PN/Ceramic sites only represented subadults, whereas the PPN/Aceramic data included both adults and subadults. In Çatalhöyük, the fact that we only studied subadults was due to significantly higher aDNA preservation in subadult burials compared to adult burials in this site – a phenomenon speculated to be related to the age-dependent treatment of corpses in this site (Yaka et al. 2021a). Because we did not have access to pre-screening data from Barcın, we do not know whether the same issue applies there. Irrespective of the cause, that the PN/Ceramic period is only represented by subadults raises the question of whether the difference between PPN and PN sites in co-burial genetic kinship patterns could in fact reflect different burial treatments between age groups. Two observations suggest otherwise. One is based on the analysis of dental traits by M. A. Pilloud and C. S. Larsen (2011), which found limited or no clustering within buildings and which largely comprised adults (c. 150 adult remains). Another is based on the mtDNA analysis of 10 adult Çatalhöyük burials within three buildings that found no pair of maternal relatives (Chylenski et al. 2019). Hence, it appears that the observed difference between PPN and PN sites cannot be explained simply by differences in sample age composition.

Why subfloor co-burials of the PN period appear frequently to comprise unrelated individuals remains a major question. An explanation has been put forward by I. Hodder (2022), suggesting that the co-burial of unrelated individuals in Çatalhöyük could reflect traditions that evolved to consolidate community ties across biological families, possibly as a response to forces that disrupted those communal ties, influenced by the development of private storage and the potential for increasing inequality. These traditions could involve buildings inhabited by biological families burying the dead of other families (Kuijt 2002), of widespread child

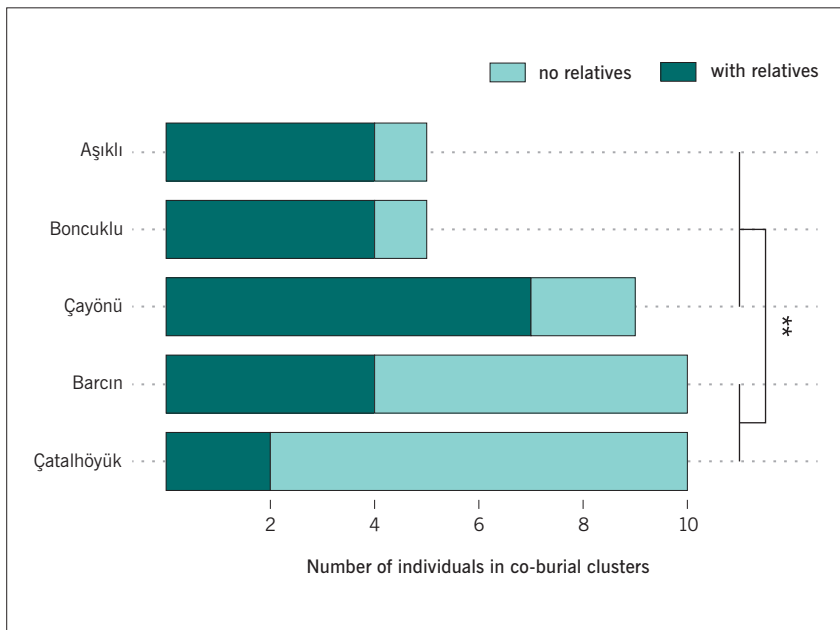


Fig. 5 Kinship frequencies among co-burial clusters in five Neolithic sites. The figure represents a summary of the data in Fig. 4, with each individual being classified as having been identified with co-buried relatives, or with no co-buried relatives identified. The difference between the three PPN and two PN sites was tested using the Fisher's exact test ($p = 0.004$), shown as two asterisks (**) on the figure.

Abb. 5 Häufigkeit von Verwandtschaftsbeziehungen innerhalb von Mehrfachbestattungsgruppen an fünf neolithischen Fundstellen. Die Abbildung stellt eine Zusammenfassung der Daten in Abb. 4 dar, wobei jedes Individuum mit oder ohne mitbestatteten Verwandten identifiziert wurde. Der Unterschied zwischen den drei vorkeramischen und den zwei keramischen Fundstellen wurde mit dem exakten Test von Fisher ($p = 0.004$) untersucht, in der Abbildung durch zwei Sternchen (**) gekennzeichnet.

fostering/adoption as documented in the ethnographic record⁴, or of buildings being used by fluid social groups.

3.3. A model for changing gender relationships and social organisation through Neolithisation

The third observation arising from the data is the absence of evidence for female exogamy (patrilocal) in the PPN/Aceramic data. In Boncuklu and Aşıklı we have adult women buried with their possible siblings. In Çayönü, we have two adult females estimated to be 2nd degree relatives, and an adult female with an estimated great nephew. The sample size is small but the pattern is suggestive. Assuming it will be supported by future data, we can imagine three scenarios to explain this: either female exogamy was not widely practised; or a high frequency of adult females stayed with their families without having children; or female exogamy was practised, but upon death, adult women were moved back and interred with their biological family, a tradition reported in ethnographic research (Ensor et al. 2017). In either case, the available picture from these three PPN/Aceramic sites is in contrast to Neolithic Europe, which presents a clear picture of female exogamy, where adult female burials within a cemetery are found only to be related to their offspring (reviewed in Bentley 2022).

Hence, the data suggest, albeit highly tentatively, the following model: the earliest sedentary societies of the PPN/Aceramic period had adopted biological-family-based organisation without a patrilocal bias. With intensifying agricultural and food production practices, at least some societies in

PN/Ceramic Anatolia responded by adopting new traditions that attempted to maintain fluidity and communal ties and compensate for the elevated stresses caused by increasing autonomy, wealth accumulation and inequality among households. How long these traditions may have continued is unclear. However, Neolithic societies in Europe of the following millennia had already become organised along highly patrilocal and patrilineal lines. Biased post-marital residence towards a single gender may have evolved to minimise property inheritance conflicts (an issue that does not concern mobile foragers). In this model, the reason why most societies adopted patrilocal (instead of matrilineal) traditions could be related to different gender roles in inter-group aggressive encounters (Ember 2011). Equally, the social and economic requirements of agricultural life may also have supported male polygamy, which could boost offspring numbers and hence labour force per household.

Further research and evidence will be needed to test this model fully. In addition, it will be important to study the same process in other societies that independently underwent the transitions to food production and sedentism.

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⁴ E.g., Schildkrout 1973; Silk 1987; Alber 2003; Berman 2014.

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