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THE NEOLITHIC DEMOGRAPHIC TRANSITION, POPULATION PRESSURE AND CULTURAL CHANGE.

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Summary

Using paleoanthropological data from about 100 cemeteries in the Northern Hemisphere (Europe, North Africa, and North America), the signature of a previously unknown demographic shift has been detected, associated with the transition from a hunter-gatherer to an agricultural economy. This shift is characterized by a dramatic and abrupt increase in the birth rate and, beyond, of the individual female fertility and the metapopulation growth rate, over a period of less than a millennium, following the onset of the transition to agriculture. This demographic process has been termed the Neolithic Demographic Transition (NDT).

The methodological innovation that has made identification of the NDT possible is the use of a *relative chronology*, fixed to the local onset of the Neolithic, instead of the absolute (historical) chronology. Using archaeological data (about 700 enclosures in Europe and 31 cross-cultural remains of early village societies), this presentation outlines some of the cultural consequences of the NDT, and also reexamines, on an empirical basis, the question of whether population pressure was the cause or the effect of the cultural change. The data show that the demographic response of the population was simultaneous with the cultural shift.

Introduction

A period of shifts and reversals in a civilization can be understood as the relatively rapid emergence or disappearance of a geographical area exercising ideological, economic and military influence or supra-regional domination over a relatively long duration. The causes of such shifts are complex, historical and conjunctural. Among the main causes of cultural shifts, the size of the population and its demographic dynamics certainly appear to have played a role. But in attempting to measure a link between population and economic – and cultural – variation, the results of historical time series are ambiguous (see, for example Schofield 2000).

To measure the impact of demography on a civilization shift, i.e. on a macrocultural change, rather than trying to build up a topology of the causes of these changes in general, I will be looking upstream, chronologically speaking, from known historical civilizations, to focus on a specific point, which is the shift from hunter-gatherer to farming societies.

There are two chronologies in human history: a long chronology, starting 1.8 millions years ago with *Homo ergaster*, the first departure from Africa and the beginning of global colonisation by early humans, and a short chronology, beginning 180,000-200,000 years ago and concerning anatomically modern humans, i.e. members of our species. This short chronology, which is still proceeding, has seen the global colonisation of our planet by humans. Humans have been hunter-gatherers for 95% of the time to date, as against only 5% when they have been producers. Needless to say, the shift from hunter-gatherer to producer societies has been the major qualitative change in human history, and the source of all preindustrial societies up to the dawn of the 20th century. These preindustrial societies have provided all the "civilizational" content of written history. The question then arises as to whether, in this major shift, it is possible to detect the influence of population. If so, did demographic pressure come before or after the cultural change? Was it one of the causes or one of the effects of the cultural change?

Detection of the Neolithic Demographic Transition on a Worldwide Scale

The question of the causal link between demography and cultural change has been a recurrent topic of discussion in archaeology for forty years (see, in particular: Service 1968, Boserup 1965, Binford 1968, Cohen 1977, Flannery 1969, Cowgill 1975, Henry 1991, and Rosenberg 1990, 1998). But the problems involved in gathering quasi-experimental archaeological data have left the question with no consensual answer. The situation is changing thanks to two methodological innovations in paleodemography: the use of: 1) a non-conventional demographic indicator in cemeteries, representing the birth rate; and 2) a non-standard chronological frame that makes it possible to gather information which is dispersed over time and space and to highlight otherwise undetectable demographic patterns underlying the archaeological data.

The Paleodemographic Indicator, Absolute Chronology and Relative Chronology

The demographic indicator is represented by the proportion of immature skeletons aged five to 19 years in a cemetery. With a demographic model for a stable population, counter-intuitive variation in this indicator represents, to within a constant, the variation of the birth and growth rates of the living population generating the cemetery and not of mortality (see Sattenspiel and Harpending, 1983; Johansson and Horowitz, 1986; McCaa, 2001, Bocquet-Appel 2002).

Because it does not allow comparisons of associations between cultural and demographic events occurring at different dates, the usual absolute (historical) chronology has been abandoned. Absolute chronology masks temporally distant statistical regularities that need to be compared in attempting to detect the signature of a global population process, and in particular of causal processes that occur according to a local time scale, but are historically scattered.

This is the case, for example, of the contemporary demographic transition, which began at the end of the 18th century, in continental zones distant from each other (New England in North America and Normandy in France) and spread from region to region, at different times and speeds, until the 1970s in South East Asia [Bocquet-Appel et al 1998, 2002]. How can the single image of this transition, representing a transcultural demographic process, be linked with data like those mentioned above, representing a demographic process highly dispersed over space and time?

As indicated above, the absolute chronology is thus replaced by a relative chronology, which is conceived simply as a duration that elapsed locally from the start of a major cultural shift (in this paper, the introduction of the agricultural system) up to the date of the demographic indicator, or the dates of other relevant cultural changes such as, for example, the appearance of public spaces [Bocquet-Appel and Dubouloz 2003, Bocquet-Appel and Dubouloz 2004], of a social hierarchy, of a defined size of village units, etc.

The time elapse since the local beginning of a major cultural shift, symbolized by dt , can have a positive value ($dt > 0$) if a minor event has succeeded a major event, such as the date of a Late Neolithic cemetery relative to the introduction of the Neolithic, or a negative value dt ($dt < 0$) if, on the contrary, the minor event has preceded the major one, such as the date of a Mesolithic cemetery relative to the start of the Neolithic. The change to a relative chronology makes it possible to gather infor-

mation which is dispersed over space and time and to position it within a common temporal frame. The relative chronology has been repeatedly discussed elsewhere [Bocquet-Appel y Paz de Miguel Ibanez 2002, Bocquet-Appel 2002, Bocquet-Appel and Dubouloz 2004, Bocquet-Appel 2005].

Detection of the Signal of the Neolithic Demographic Transition (NDT)

Figures 1 and 2 show the variations in the proportion of immature skeletons in two continental samples of hunter-gatherer and horticulturist-farmer cemeteries, in Europe and North-Africa (Mesolithic-Neolithic) and in North America (Formative-Woodland). In both figures, towards $dt = 0$, i.e. just at the onset of the local introduction of an agricultural production system, an abrupt change can be discerned in the proportion of immature skeletons, which increases from 18 to 30% over a duration of approximately $dt = 600-700$ years. This abrupt rise, which is interpreted as the signature of an explosion in the birth rate and thus in individual female fertility, has been named the Neolithic Demographic Transition (abbreviated to NDT) [Bocquet-Appel 2002].

At its peak ($dt = 600-700$ years), this change corresponds to an estimated birth rate exceeding 50 per thousand and to a growth rate of about 1.3%, but with a high confidence interval for the latter [Bocquet-Appel and Naji 2006]. The similarity between the two NDT signatures can be compared in Figure 3. Between $dt = 3000$ and $dt = 1500$ (their common duration in the frame), the two transition profiles coincide to a remarkable extent, suggesting that they represent regional expressions of the same global process, starting around the 14th millennium cal BP in the Levant and continuing until the last hunter-gatherer societies in the 20th century AD in Australia [Bocquet-Appel and Deham 2006].

The assumed cause of the NDT is an unprecedented increase in individual female fertility, via a succession of effects on intermediate demographic variables. These effects range from the sedentarization of local hunter-gatherer populations to the impact of sedentarization on a reduction in the frequency of breast-feeding, resulting ultimately in a shorter duration of the reproductive cycle and in its corollary, an increase in fertility. The NDT scenario is discussed in detail elsewhere [Bocquet-Appel and Naji 2006].

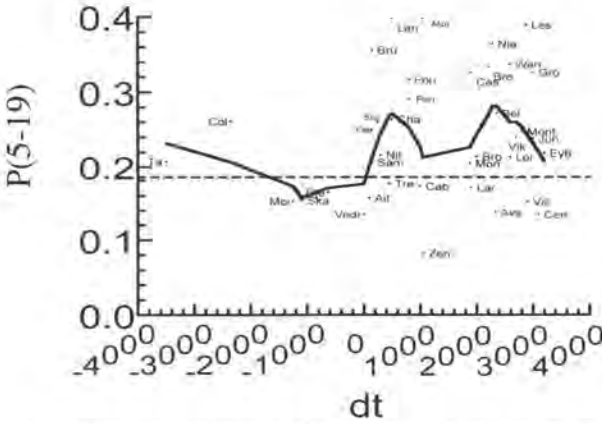


Figure 1. Profile of variation in the proportion of immature skeletons in cemeteries (vertical axis, labelled P (5-19)) relative to local emergence of the Neolithic (horizontal axis, dt) (36 European and African cemeteries) [Bocquet-Appel 2002].

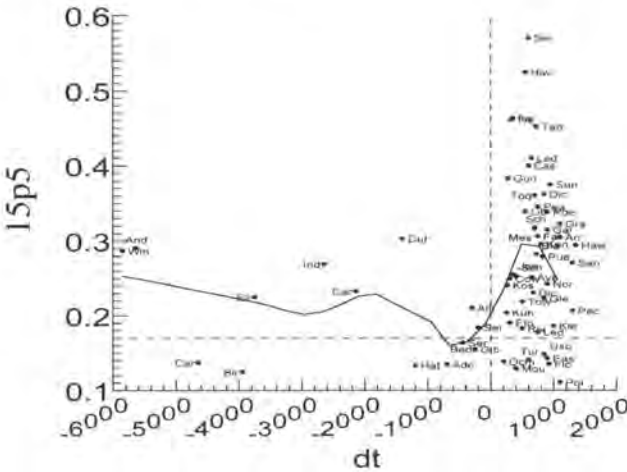


Figure 2. Profile of variation in the proportion of immature skeletons in cemeteries (vertical axis, labelled 15p5) relative to local emergence of the Neolithic (horizontal axis, dt) (60 North American cemeteries) [Bocquet-Appel and Naji 2006].

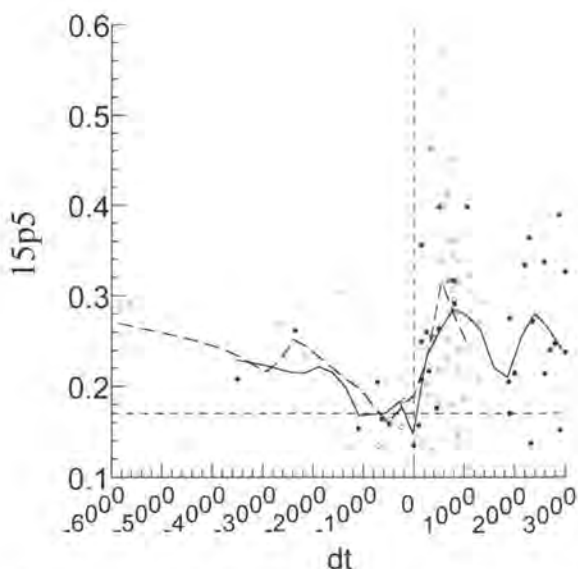


Figure 3. Signatures of the two Neolithic demographic transitions, in Europe/North Africa and North America, relative to local emergence of the Neolithic [Bocquet-Appel and Naji 2006].

Some Cultural Consequences of the Neolithic Demographic Transition (NDT).

I now present three cultural consequences of the impact of the NDT detected in the archaeological data, and their interpretations. These concern the appearance of i) supra-domestic spaces represented by enclosures and Neolithic enclosure systems, ii) “large” villages [Bandy 2006], and iii) the time taken for some large villages to be differentiated as supra-local chiefdoms [Bandy 2006].

The Neolithic enclosures make up a rather loose descriptive category. It embraces vast enclosures with pits and palisades whose construction and lifetime spanned a greater or lesser amount of time, simple enclosures with little investment of energy, highly structured monuments corresponding to formal models, and village palisades or true citadels [Andersen 1997; Darvill and Thomas 2001]. Interpretations thus range from fortifications to cattle enclosures, from cemeteries to ceremonial or cultural centers, from central plazas to markets and dwellings.

But there is a particular dimension that needs to be given to the interpretation of Neolithic enclosures: this resides in their probable structural link with the processes governing the organization of the social sphere of the prehistoric communities concerned, which bear witness to a form of demographic pressure [see Bocquet-Appel and Dubouloz 2003]. Figure 4 shows the distribution, in relative chronology, of the enclosures and Neolithic enclosure systems in 686 sites centred in the Danube area in North-Eastern Europe. It can be seen that these reached their maximum density at around $dt = 750$ years. This duration is close to the tempo of the peak birth rate as estimated from paleoanthropological data from European and North African cemeteries (see Figure 3). The pattern observed in the distribution of the enclosures is interpreted as a population response to the NDT in the social sphere, with a supra-domestic value (Bocquet-Appel and Dubouloz 2003, 2004).

Figure 5 shows the distribution of villages considered as sufficiently "large" (> 300 inhabitants and covering 3 ha) relative to the onset of the local agricultural system in 31 archaeological sequences worldwide (Bandy 2006). The bimodal distribution of the villages is interpreted by Bandy as follows: The first mode, at $dt=500$ years, indicates the time when large villages appeared following the introduction of agriculture, up to a maximum duration of 1500 years, with 9/10th of the large villages appearing during the first millennium. This fits in well with the estimated average duration of the NDT. The appearance of large villages is regarded as an indication of the end of the fusion of population units at the beginning of agriculture [Bandy 2006]. Subsequently, during the NDT, rapid population growth would have been an unprecedented difficulty facing populations and the social organization of their villages.

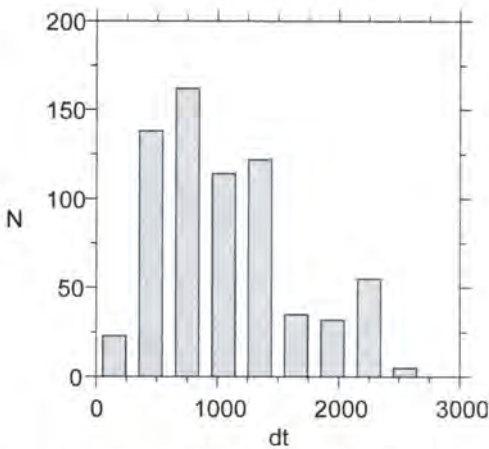


Figure 4. Number of Neolithic enclosures and enclosure systems (N=686), relative to the introduction of the Neolithic locally [Bocquet-Appel and Dubouloz 2003, 2004].

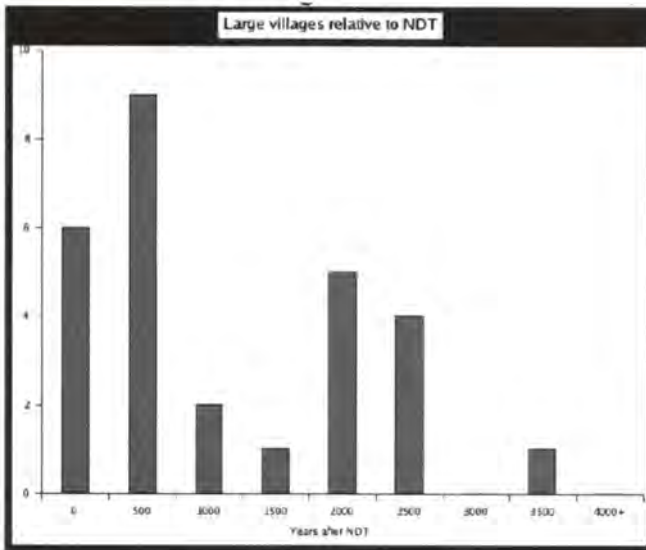


Figure 5. Distribution of large villages (> 300 inhabitants and covering 3 ha), relative to the introduction of the Neolithic locally (31 archaeological sequences worldwide) [from M. Bandy 2006].

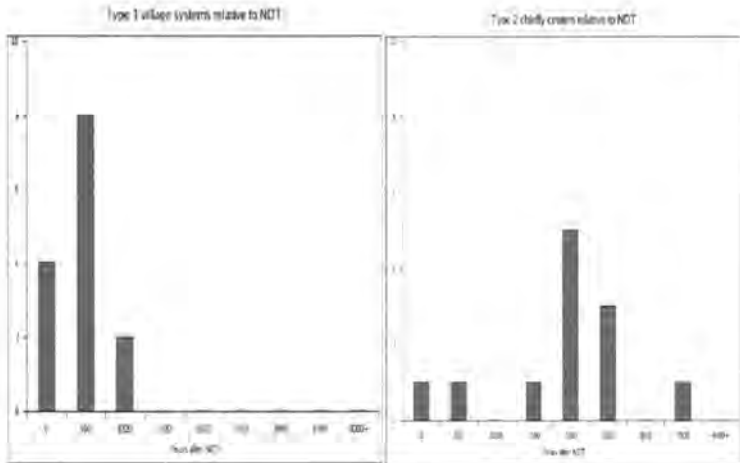


Figure 6. *Distribution of the preceding data, subdivided into simple large villages (on the left) and supra-local chiefdoms (on the right) [from M. Bandy 2006].*

The increase in community sizes would have induced increasing levels of intra-village conflicts, implying the development of institutions at a higher level of social integration to resolve conflicts between individuals and groups than in the smaller village units (Bandy 2006). The second mode around $dt = 2000$ (Figure 5) is interpreted as the appearance of small political capitals or centres of chiefdoms, as a response to rising levels of conflict. Figure 6 shows both distributions, that of large villages and that of chiefdoms (Bandy 2006). Although this interpretation of the archaeological patterns appearing during the NDT will not be further discussed here for reasons of space, their importance regarding the resulting dynamics and cultural evolution can nevertheless be perceived.

Before answering the initial question, as to whether population was the cause or the effect of the major cultural shift from hunter-gatherers to producers, we need to return once more to the meaning of the dt variable. First of all, it represents the relative chronology. However, the dt variable has another and more fundamental meaning than that of a simple chronology. When the new Neolithic production system was introduced into the population, the value of dt was zero. Therefore dt is a unit of time relative to the economic change. Thus, over and above the

understanding of dt in terms of relative chronology, dt is in fact a measurement of the pace of the economic shift. A graph such as that in Figure 3 is therefore a representation of the shift, both demographic (immature proportion) and economic (relative to the position $dt = 0$) in two sub-continental geographical areas, within a common chronological frame.

It is the position of the two shifts relative to each other that makes it possible to provide an empirical answer to the recurrent question of the causes of the cultural change in the context of the shift to agriculture (Boserup 1965, Service 1968, Cohen 1977; for a summary, see Graber 1997). Since $dt = 0$ indicates the start of the economic shift, then, according to whether the beginning of the signal of the demographic shift precedes ($dt < 0$), coincides with, or succeeds the start of the economic shift ($dt = 0$) represented on the horizontal axis, it is possible to determine if the growth of the population is the cause or the effect of this shift.

Looking at Figure 3, it can be seen that the demographic reaction neither precedes nor succeeds the economic change, but strictly coincides with it. The common variable underlying the fertility explosion and the establishment of the farming system is sedentarism (and its impact on suckling frequency). This is probably the reason why the two patterns, the fertility explosion and the start of the farming system, are superimposed. But the establishment of the farming system is not the cause of sedentarism. The scenarios for the emergence of sedentarism vary from region to region: it may precede the farming system as in the NE and SW of North America [Bandy and al 2007; Kholer et al. 2007] or occur simultaneously as with the PPNA in the Levant [Guerrero and al 2007].

This leads us to conclude that population was at once the cause and the effect of this shift in civilization. The cause, because by exerting pressure on the carrying capacity of the hunter-gatherer production system, population also increased the probability of a system shift; and the consequence, because as soon as the new economic system was introduced, the population tended to grow towards the new carrying capacity of the horticulturist-farmer system, as attested by the fertility explosion. This seems to agree with the predictions of Malthus-Boserup's demographic model [Wood 1998, Lee 1987].

The considerable increase in population, in regional pockets on a worldwide scale between 11,000-3,500 years BP, generated previously unknown forms of socio-economic and political organization, such as village units, which appear in 35 archaeological levels on a worldwide

scale, 300 years on average after the onset of the NDT, or chiefdoms, which appear nearly 2000 years after [Bandy 2006]. The NDT was caused by the conjunction of forager sedentarization and the adoption, in certain regions, of a farming economy, which made it possible for considerable potential demographic growth to be supported economically.

But the NDT, because of the unprecedented demographic growth it generated, induced incalculably more complex social, political, economic and ideological relationships compared to the relatively simple community-based forager societies, which had remained practically unchanged for perhaps tens of thousands of years. The NDT formed the basis of the world of preindustrial populations, which is currently disappearing with the contemporary demographic transition.

Conclusion

Among the major causes of shifts and reversals in civilizations, population size and demographic dynamics are commonly thought to have played a role. However, historical time series produce results that are ambiguous. Archaeological data, which concentrate on major cultural shifts in history covering several millennia, show that the demographic response of the population was simultaneous with the cultural shift.

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