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The demographic change generated by the Mesolithic - Neolithic mutation in Europe is mainly identified by the slight increase of archaeological data. The speed and importance of this change however are not specifically evaluated, was it fast, slow, or average? Is there a notable increase in human numbers related to this deep transformation of our way of life, in other words, is there a demographic transition? Do we need to consider instead a slow growth without any kind of demographic transition? From a database of European Mesolithic-Neolithic cemeteries, representing a space-time sample of a non conventional demographic marker, the signal of a Neolithic demographic transition (NDT) was detected (Bocquet-Appel 2002; Bocquet-Appel y Paz de Miguel Ibanez 2002). This demographic marker is defined by the proportion of immature skeletons, 5 to 19 years of age, in cemeteries. Within a growing population, the proportion of immature (dead or alive) is high. Within a declining population, this proportion is low which correspond respectively to age pyramids with a large or thin base. The NDT signal is characterized by a relatively abrupt increase of the immature skeletons proportion. From the Mesolithic to the Neolithic, the proportion of immature skeletons increases by 20% to 30% over a 500 years period. In addition, another independent archaeological marker, signaling a demographic growth, revealed a similar signal than the paleoanthropological data (Bocquet-Appel et Dubouloz 2003). This marker is characterized by the chronological frequency variation of 700 enclosures and other enclosed structures. The detection of the NDT signal in Europe allowed for a prediction regarding its worldwide impact: if the NDT occurred in Europe, the transition must have then occurred in all the independent agriculture invention centers in the world. The signal of this transition must therefore be noticeable in the regional cemetery data of the corresponding region (Bocquet-Appel and Dubouloz 2004).

In this paper, the prediction of a world wide transition, noticeable in the skeletal data, is tested for the first time outside Europe through 62 North American cemeteries (Map 1 and Table 1). We will use in the remaining part of this paper, the name Neolithic Demographic Transition (NDT), even though “Neolithic” strictly refers to an archaeological period of the Old World, in order to facilitate the detection of this transition, which matches the economic forager-farmer change.

The data are represented by a non conventional demographic marker, the proportion P of immature skeletons (5 to 19 years of age) relative to the overall skeletal population of the cemetery, without child under 5 years of age, d(5+), which are known to be underrepresented. In other words ${}_{15}P_5$ = d(5-19) / d(5+) (Bocquet-Appel y Paz de Miguel Ibanez 2002)[i].. The archaeological and anthropological criteria used to select the cemeteries and the calculation of the ${}_{15}P_5$ are : (1) the possibility, with a reasonable amount of manipulation, of redistributing the skeletons from unstandardized age-groups into demographic age-classes, (2) cultural homogeneity (cemeteries in which several periods were mixed were rejected or split into homogenous periods), (3) the existence of absolute or relative dates for the materials, (4) the apparently “natural death” of the individuals (cemeteries suspected to be the result of mass violent death were excluded), and (5) post-contact cemeteries were included only when the demographic transition took place prior to 1492. (6) the proportion of individuals excavated must be representative of the living population, in other words, based on the evaluation of the archaeologist at the time of the excavation, at least 50% of the cemeteries must have been excavated. The geographical distribution of these cemeteries is shown in figure 1. Of the cemeteries initially retained, 24 were Mesolithic, 38 Neolithic. This yielded a sample of 62 cemeteries (Table 1). Whenever possible the (calibrated) dates of the cemeteries were those of the original publications (Table 1). When sites chronologies did not exist, the average dates of the cultures (or horizons) of these cemeteries or regional syntheses were used instead (Buikstra 1984, Buikstra and Koningsberg 1986 ; Cassidy 1984 ;Cohen 1989; Cowan and Watson 1992; Crawford, et al 1997 ; Diehl 1996 ; Goodman 1984; Hart 1990; Hutchinson 1998; Larsen 1984; Larsen et al. 1992; Lynott 1986; Mac Neish 1992; Palkovitch 1994; Patteson 1986; Piperno and Pearsall 1998; Rose et al 1984; Smith 1978, 1989; Trigger 1981; Wolf 1977). The demographic interpretation of ${}_{15}P_5$ is based on a sample of 45 pre-industrial mortality tables. Various demographic parameters called paleodemographic estimators were calculated from these tables by regression analysis on simulated stable populations, (Bocquet-Appel 2002; Bocquet-Appel and Masset 1996; Bocquet and Masset 1977). Among these estimators, the crude birth rate (*b*) and the increase rate (*r*), have a correlation with the demographic indicators of respectively R^2=0.963 and 0.875.

The demographic change will be set in the economic change frame. The space-time distribution of the data clouds the detection of the uniqueness of the demographic transition phenomenon, which goes beyond the absolute chronology and which develops following its own pace. The main reason is that the distribution adds up various forager-farmer transitional processes which spread on the map at different moments region to region. Instead of an absolute chronology, the frame has been changed and the data set in a relative chronology (Bocquet-Appel 2002).Under the hypothesis that the demographic Neolithic transition has developed a demographical process of its own, independent from the geographical location and the absolute date of the sampled sites (cemeteries), as is the present demographic transition, we can then remove geography form the space-time distribution, in order to simply keep the time distribution in relation to the local starting date of the process. This starting date is here called: the economical change front. A common profile to all data is thus obtained, without the influence of geography or absolute chronology. The chronological distance of a cemetery from the economical change front, both situated on X, is the time interval *dt* separating the date of the front, $t_0(X)$, from the date of the cemetery, t(X), or, $dt\ (X) = t_0\ (X) - t(X) = dt$. When *dt* is negative, the site is chronologically located before the economical change front, in other words, in the forager's period. We should emphasize that since *dt* =0 represents the introduction of horticulture-agriculture in the population, then the variation of the indicator ${}_{15}P_5$ on the *dt* axis represents the demographic variation directly linked to the chronology of the production system change. In fact the change of frame allows us to directly position the demographic change relatively to the economic change. We can then answer the question: what was the magnitude and speed of the demographic feedback to the Neolithic economic change? Was the feedback before or after the introduction of the agrarian system?

Figure 2 shows the observed profile of ${}_{15}P_5$ with the chronological distance to the *dt* change in 93 european and north American cemeteries (Figure 2: European[ii] in plain line N=38 ; North american in dotted line N=55) [iii] . These profiles indicate the underlying trend of the ${}_{15}P_5$ within the relative chronological frame dt. The profiles are estimated by loess fitting procedure (proportion parameter alpha = 0,3)[iv]. This correction is similar to a mobile average (Bocquet-Appel 2002). The hypothesis of the lack of change between the ${}_{15}P_5$ of the hunter-gatherer group sites (dt<0) versus the horticultor-farmers (dt ≥0), in other words of a flat profile, is tested with a Kruskal-Wallis one way analysis of variance (Mann-Whitney U statistic = 181.0, χ=7.95 with 1 df, P= 0.005)[v] (Asatryan and Safaryan 1986). The hypothesis of flat profiles is rejected and thus the alternate hypothesis of a change is selected. The horizontal dotted line of figure 2, represents the expected value of ${}_{15}P_5$, under the hypothesis of a stationary[vi] r =0, increase rate. We will only describe the segment of common (relative) chronology for both groups in Figure 2, from dt=–3500 to dt=1000. Outside these boundaries, profile variations are describable respectively either in the light of specific demographic history of the American prehistoric history, or in term of a statistical sample deficit in European data around dt=1000-2000. In either case it does not concern the detection of the NDT signal. At dt=-3500 (Figure 2), the initial forager proportion of ${}_{15}P_5$ is relatively high, around 24%. Then, both ${}_{15}P_5$ profiles decrease continuously. They then drag the estimated bottom value of a stable population (17%, ***b***=35±6 out of a thousand with a confidence interval IC95%), around dt=–1000 - –800, where a kind of dip is forming, lasting for about one millennia. On both profiles from the economic change front up to the first maximum of each curve, the pace of both transition (the length during which the abrupt change of ${}_{15}P_5$ on dt occurs) lasts for about 500-700 years, where the smoothed values for ${}_{15}P_5$ immature proportion increase from 15-18% to 29%. In other words a 75% increase (***b***=56±6 out of a thousand and ***r***=0.0167±0.0107). During the economic transition, both European and North American demographic profiles are very similar in terms of pace and magnitude, regardless of an average chronological gap of about 3,500 years and an intercontinental geographical distance. We have indeed the same world wide NDT signal.

To identify more clearly the chronology of the demographic change, we clustered the European and American cemeteries from the relatively common chronology of dt= -3,500 to dt= 1,000[vii]. By doing so, we hypothesize that the continental samples belong to the same population event and we thus limit the influence of their specific history on the pattern we want to demonstrate. It also allows for a NDT signal with a wider empirical base of 64 cemeteries (15 foragers and 49 horticultor-farmers). The hypothesis of a flat profile is rejected by the Kruskal-Wallis one-way analysis of variance[viii].). In order to precisely estimate the beginning of the NDT signal on dt, we can adjust the proportion parameter value by selecting α=0.2 and 0.3, in the Loess procedure. In other words, we try to identify a profile corresponding to a smaller information range around the estimated value of ${}_{15}P_5$. The drawback of this method is the profile flexibility due to locale variations. The profile becomes sensitive to the sampling effect of individual cemeteries.

Both estimations of the NDT signal are represented on Figure 3. The estimations are very similar. In both profile estimations (Figure 3a and 3b), on the large 4,500 years scale in relative chronology dt, there is a remarkable coincidence between the economic change and the demographic change.
Figure 3 can be interpreted as follow: on the dt<0 section of the hunter-gatherer production system, the ${}_{15}P_5$ value at dt= -3,500 is roughly equal to 24%. This rather high value does not match a stable population, but a growing one. ${}_{15}P_5$ then continuously decreases and drags the estimated bottom value (17%) of the population replacement at stable equilibrium. ${}_{15}P_5$ then reaches a low value (${}_{15}P_5 \cong$15-16%) around dt=-800 years, matching a slightly decreasing demographic population. ${}_{15}P_5$ finally stabilizes around the stable equilibrium value. Following the preceding period indicating a growth (decreasing), this period can be interpreted as a stagnation of the metapopulation which reaches its maximum carrying capacity level for the hunter-gatherer production system. The period ends by the introduction of horticulture-agriculture at dt=0. The metapopulation prompt reaction to the new system by what we have to call a birth rate explosion could be the sign of the old forager fertility regulation system being disrupted. It could also illustrate the increase of the carrying capacity of the new system. Here we concur with the Malthus and Boserup model scenario (Wood 1998, Lee

1987) in which the population is alternatively the cause and the consequence of the economic change effect.

What are the variable(s) proxy for the economic change responsible for the unprecedented increase in both magnitude and geographical spread of the crude birth rate? Fertility increases when the birth interval decreases through earlier weaning age and vice versa. What could have lower the weaning age within the Neolithic toolkit? There is an existing hypothesis, probably first formulated by Malthus (1978: 13) and then by other researchers, namely: nomadism versus sedentism (Carr-Saunders 1922). The fertility increase could have been caused by a byproduct of the Neolithic toolkit illustrated by sedentism. In documented nomadic societies, women carry the children up to 3-4 years old (ref). Tied to their mother, children are able to practice suckling, which is known to delay the return of menstruation, as well as near exclusive breast feeding (Rosner A, Schulman SK 1990). This is known as lactation amenorrhea (Rivera 1996). The longer period of amenorrhea lactation for hunter-gatherers, correlated with a late weaning age, is the result of their mobility. With a long term decrease in mobility toward sedentism during the NDT, the process in favor of suckling with its consequences changed course, generating an early return of the reproductive cycle and an increase in fertility for mothers. In this hypothesis, the high fertility increase was the mechanical consequence of the disappearance of gatherers mobility.

The prediction that if a NDT occurred in Europe, then it should have occurred in all the agriculture invention centers on the planet, and its signal should have then be detectable in the corresponding regional cemeteries, is corroborated by North American cemeteries.

This result reinforces the idea that this transition was historically at the origin of the pre-industrial population regime for agrarian population (Bocquet-Appel and Dubouloz 2004) with high fertility and mortality, otherwise known as high demographic regime (McCaa 2002). This system is ending with the achievement of the "nth" demographic transition, currently occurring, in human history.

[i] The demographic notation of $_{15}P_5$ is the proportion of 5 years of age skeletons, at 5 years plus 15 years, in other words, 5 to 19 years of age skeletons

[ii] Paleoanthropological data of three Portuguese sites labeled Cabeço da Arruda, Moita do Sebastiào and Casa da Moura, and radiometric data for the first two, were updated in order to include the new inventory of Jackes and Meiklejohn (2004). The influence of the update on the observed profile is trivial.

[iii] Cemeteries with N(5+)≥ 50

[iv] We can demonstrate that by simulating cemeteries of various densities on dt, the variation of the alpha value of 0.3 to 0.4 does not change significantly the estimated profile. This estimated profile is thus able to detect a change in the archaeological data (Bocquet-Appel 2002; Bocquet-Appel and Paz de Miguel Ibánez 2002).

[v] (Mann-Whitney U statistic = 181.0, χ=7.95 with 1 df, P= 0.005)

[vi] Obtained through inverse regression of r=f($_{15}p_5$).

[vii] In order to match north American data with European criteria already previously analyzed (cf Bocquet-Appel 2002), only North American cemeteries with N(5+)≥ 50 were included.

[viii] Mann-Whitney U statistic = 185.00, χ= 8.36 with 1 df, P= 0.004)