THE DEMOGRAPHY OF PREHISTORIC CEMETERIES

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ДЕМОГРАФИЯ ДРЕВНИХ МОГИЛЬНИКОВ

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The first part of this paper discusses demographic theory. The most serious obstacle to reconstructions based on skeletal series appears to be their incompleteness (burials outside regular cemeteries) while the question of non-stationarity may be of secondary importance. The conditions for applying Halley's method to the construction of life tables are therefore of prime interest. Attention is paid to the theory of "apparent" life tables deformed by non-zero growth rate. The demographic theory and supposed (or inferred) initial conditions enable the formulation of models that can be tested against archaeological and anthropological data (type of populations, their sex and age structure, population size, number of graves to be expected, mobility in time and space, etc.). The main reason for population growth in prehistory was the formation of a non-equilibrium state in social relations. In consequence of this, population growth cannot be viewed as an autonomous factor causing economic and social change or historical events. The second part of the paper applies this theory to several examples from Central Europe (Linear Pottery in East Germany, Corded Ware at Vikletice, La-Tène cemeteries in Bohemia, and Early Medieval series from Moravia). Full text of the paper has been published by the Archaeological Institute in Prague in the Czech language (Demografie pravěkých pohřebišť, Praha 1983).

I. Introduction to prehistoric demography

1. Introduction

Demography is a social science despite the fact that it began to manipulate with numbers much earlier than the other branches of the study of man. Palaeodemography depends to a great degree on physical anthropology and, in fact, is often practised by anthropologists. This, however, does not exclude it from the sphere of prehistory. Both sociological and historical reconstructions based on archaeological remains cannot do without a fairly detailed comprehension of prehistoric mortality, fertility, population reproduction and growth, the size of families and communities, population density estimates, relative number of children, adults and old people, etc. Any study of population mobility should also start from demographic considerations.

2. Demographic problems

The three principal problems discussed by demography are (1) the mortality patterns of human populations (usually expressed by life table functions), (2) their patterns of reproduction and (3) their changes in time and space. The formulation of models is of great importance as they enable prehistorians to link the demographic theory based on living populations with their own records. The models may be tested against archeological data and in some cases may help bridge their incompleteness.

3. Demography of prehistoric cemeteries

Prehistoric cemeteries contain much information relevant to demography. Archaeology alone cannot extract it without physical anthropology which determines the age of the deceased and quite often the sex (the latter can frequently be recognized by archaeologists with sufficient reliability). Demographic theory applicable to prehistoric cemeteries is accessible in a number of handbooks some having already been adapted for use by archaeologists; their understanding does not presuppose more than basic mathematics (e. g. *Acsádi - Nemeskéri 1970*; *Weiss 1973*; *Spiegelman 1955*; *Henry 1976*). Prehistoric data, however, are not identical with those for which demographic methods have been devised: the series are small (which encourages the use of statistics) and their effective study depends on several conditions (stationarity, completeness, no migrations) that may not be met automatically.

4. Life tables

Certain conditions being fulfilled, life tables of prehistoric populations can be constructed on the basis of archaeological and anthropological records by means of the so-called Halley method. The tables may be either complete (year by year) or abridged, the values being calculated for one, four, five, or ten year age groups. Detailed instructions are given for the calculation of both the complete (Eqs. [1] to [8]) and the abridged tables (Eqs. [9] to [14]); in both the cases the only input is the number of dead (D_x) as observed in prehistoric cemeteries. The life tables contain several functions which are interpreted as follows: D_x is the absolute number of deaths in age group x; d_x is the relative number of deaths; l_x is the probability that a person survives to age x (or the relative number of survivors to age x); q_x is the probability that a person surviving to age x would die before reaching age $x + 1$; L_x is the average number of years to be lived by a person during the time interval x; e_x is the average number of years remaining to an individual who survived to the beginning of time interval x (so-called life expectancy); c_x is the percentage of persons of age x in the living population (in the life tables it is assumed that the population has a zero growth rate). Many examples of life tables can be found in Appendix 3 to this paper.

5. Conditions for the use of Halley's method

Life tables cannot be constructed on the basis of the death record alone unless certain conditions are met. This is often acknowledged by those engaged in palaeodemographic research but rarely observed in actual application.

One of the conditions is that the prehistoric population to be studied is closed to migrations. This may rarely be the case with prehistoric peoples as there could have been frequent short distance shifts within "tribe" territory. Such moves were necessary to level off the instability of either families or local communities subject to various random factors causing their decrease in size or even extinction (natural catastrophes, enemy raids, sterility etc.). The reason for moves may also have been periodical devastation of the natural resources. If the migrating contingent has the same age structure as the whole population, Halley's method can still be used; in many instances, however, inferences as to the number of inhabitants will be invalid.

Another condition is that the population studied is complete, i. e. that no dead persons were buried outside the regular cemetery. It has been known for some time that most children up to the age of 2 or 3 years are missing from prehistoric cemeteries. Interments in settlement sites (in abandoned pits, etc.) common during the Aeneolithic and Bronze Age periods in Central Europe prove that few skeletal series represent complete populations even in respect of adult persons. The incompleteness of this type, however, can often be recognized by causing differential D_x values for the two sexes. The best way to account for missing children is to use some model life table of a live complete population. The probability of a 5 year old child dying before its 15th birthday

($_{10}q_5$) is calculated first and the number of children in the first 5 years of life is then related to it by means of Weiss' model life tables. In practice this can be done by means of Eqs. [15] to [17] and Table 1. Such estimates seem to be rather on the conservative side. *Henneberg (1977)* has proposed another procedure for the reconstruction of the number of „missing children"; his method, however, presupposes the knowledge of C (completed fertility), an unknown population parameter.

The third condition for using Halley's method is stationarity, i. e. the supposition that the population had a zero growth rate. The age structure of a growing community may be quite different from that of a stationary population whether measured by the d_x or the c_x function. The most sensitive indicator seems to be the greatly increased number of children. It is impossible to calculate life tables from skeletal data if the growth rate differs from zero. Fortunately, growth rates higher than approximately 1% seem to be rare and, if present at all, restricted to short periods of time. Thus, they do not seem to affect cemeteries used for several centuries. If the skeletal record is combined from different sites of a closed region, the possible influence of short term or local variation in the growth rate can also be removed. Life tables based on non-stationary data have been termed apparent and will be discussed later in this paper.

6. Reproduction of prehistoric populations

A population is called stationary if it neither increases nor decreases in size, i. e. its yearly natural growth rate r equals zero. If r is different from zero but constant, the population is called stable. The crude (yearly) death rate d, the crude (yearly) birth rate b, and growth rate r are linked by Eq. [20]. The stationary life table being given, the birth rate of a stable population with $r \neq 0$ can be calculated by means of Eqs. [21] or [22] and its age structure by means of Eq. [23]. The fertility of prehistoric groups cannot be derived from the data but its shape may be assumed to approximate the following table based on research by *K. M. Weiss (1970)*.

x	f'_x
15—19	0.092
20—24	0.248
25—29	0.249
30—34	0.201
35—39	0.140
40—44	0.058
45—49	0.012
	1.000

The numbers in the table (f'_x) can be converted into the usual fertility rates (f_x) by means of Eq. [24] where C denotes completed fertility (the number of children born to a woman who reached the end of her reproductive period). The net reproduction rate R_0 can be calculated according to Eq. [26] (it counts the number of daughters born to a woman at average child-bearing age) and used for the estimate of the growth rate r if the length of one generation or the average age of mothers (a) is known (cf. Eqs. [29] and [30]). A possible alternative is logistic growth (cf. Eq. [31]); it is an unstable model where P_{max} is the maximum population determined by the carrying capacity of the region. The number of persons, both living (P) and dead (D) corresponding to a cemetery or a living community can be calculated by means of Eq. [32] where t is the time of its use in years. If the condition of stationarity is not met, Eq. [33] holds. The number of children born to a woman is given by Eq. [35] or [37a] depending on whether the population is stationary (C_0) or stable (C_r). The average number of persons belonging to one nuclear family can be approximated by the average number of individuals per one woman in reproductive age. This estimate can be calculated by means of Eqs. [41] or [49] (i. e. P^*_0 or P^*_r; e' equals either e_{15} or 30 if $e_{15} > 30$). Another way of estimating the family size is given by Eq. [42] (c_{15-49} is expressed in percentages). The probability of widowhood or widowerhood can be calculated by means of Eq. [44], the probability of orphanhood by means of Eq. [45].

II. Demographic models

Demographic models are sets of propositions that (1) fulfil the demographic theory, (2) meet a set of initial conditions relating them to concrete human populations and (3) follow logically from the demographic theory and the initial conditions.

7. Model life tables

Model life tables are calculated on the basis of living populations; either the tables issued by the U. N. or those derived by *K. M. Weiss* (*1973*) are widely used. They are useful in many instances but quite often they disagree with skeletal data most probably because the ageing of skeletons by anthropologists is not exact enough (underrated for adults). It is true, however, that adult mortality in living populations with high overall mortality may also contain errors. An example of how a progressive error in anthropological ageing may affect concrete life table value based on skeletal remains is shown in Table 2.

8. Apparent and true life tables

This paragraph investigates the influence of non-stationarity of prehistoric series on the values of life table functions. The problem was first developed theoretically and the results applied to model life tables (Tables 3 to 4). It can be shown that the crude birth rate ($b = 1/e_0$) and the age structure of the living population (c_x) as calculated from the apparent life tables correspond to the true values as calculated from the stationary life table and growth rate r (on condition that the stable population is absolutely open, i. e. all superfluous people emigrate without changing the age structure and the size of the original population). If the stable population with $r = k$ is closed, its apparent life table corresponds exactly to the apparent life table of an open stable population with $r = 2k$. Unless the growth rate of the stable population is very small, the apparent population parameters (i. e. those derived from the apparent tables) are worse, usually much worse, than the true values. This becomes the basis on which stationarity can sometimes be recognized.

9. Stationary populations

Let us assume that there are several samples (skeletal series) taken from the same prehistoric population. Then, the sample life table exhibiting the „best" demographic parameters will be stationary, as any of the apparent life tables lead to worse parameters. A stationary population at that must have a growth potential, i. e. the rise of r to approximately 2% should not lead to consequences that are improbable or even impossible (e. g. a crude birth rate exceeding certain values). If the stationary series of graves is subdivided chronologically into equal parts, each of them should contain the same number of graves or other characteristic artifacts (on condition that the population is closed). This cannot result in proof of stationarity but may disprove it at least in some instances.

10. Population stationary „on the average"

Strict stationarity is improbable not only because it is hardly possible to keep the natural increase in sufficiently narrow limits but also because it would not allow for the restitution of losses caused by random factors. Most real populations would therefore have slightly positive growth rates their stationarity being achieved in the long run and over large territories. Such a situation is hardly distinguishable archaeologically from strict stationarity, especially if the small samples from prehistoric cemeteries are taken into account.

11. Closed stable populations

Because the size of any stable population grows exponentially it cannot remain closed for a longer period. Given r = 0.02, the original population grows to ten times its original size in 100 years. It can hardly be supposed that any region could support such an increase of inhabitants without drastic changes in the subsistance pattern. It follows that a closed population could not inhabit the same settlement area for more than 100 years if the growth rate were 2%, and for more than 200 years if the growth rate equalled 1%. (The actual uninterrupted occupation of a region by a closed population was probably much shorter.) The cemetery of a closed population should produce an apparent life table with a greatly increased number of children and highly suppressed number of adults; all the population parameters (e. g. e_{15} or l_{15}) would be incredibly poor. The number of late graves from the cemetery would be several times higher than the number of early graves.

12. Open stable population

If a stable population maintains its original size (i. e. the natural increase emigrates periodically according to the scheme in Table 5), the only point in which its cemetery differs from a stationary case is the age structure. The apparent life tables will show an unproportionally high number of children and most demographical parameters will be fairly poor; this need not be striking unless the growth rate is sufficiently high. It can be shown that it is whole families which emigrate; otherwise an unstable situation would develop with a long lasting deformation of the age pyramid. The emigration of young males, e. g., could not be perpetuated without destroying the very basis of prehistoric communities.

13. Model of a prehistoric cemetery

Let us assume a settlement site with an observed number of house ruins (R) and let it be possible to estimate the mean life of a house (z). Population parameters P_r^* (family size), d (crude death rate) and l_x (the relative number of survivors up to age x when the regular interment of children begins) can also be derived. Then, if the houses were inhabited by one family each, the number of graves (D^+) belonging to the settlement site can be calculated as $D^+ = RzP_r^* dl_x$. It has been shown empirically that for most prehistoric populations of Central Europe the number of graves produced by one family in one hundred years is 9 or 10 (Eq. [47], Tables 6 and 7); groups of graves covering one family may sometimes be identified on this basis. The index of masculinity can be calculated from Eq. [48]. It should be 1000 if the two sexes were balanced in the living society, otherwise the deficiency in one of the sexes has to be explained (random variation in the parameters used, however, must be taken into account). The apparent age structure can also be inferred if the real life tables and the value of r are estimated with some confidence.

14. Possibility of growth in prehistoric populations

It can be shown by the study of living primitive populations that methods of keeping their size within acceptable limits were known and used (*Sussman 1972, Hassan 1973 etc.*; cf. also *Binford 1972*, 434). This must have also been the case in prehistory as an unlimited growth based on uncontrolled fertility rates would have led, despite a high mortality level, to the rapid overpopulation of the Earth in several centuries. The most effective practices enabling growth control may have been prolonged breastfeeding, postpartum taboo, reduced coital frequency, coitus interruptus, delay of marriages, abortions, and possibly infanticide. The removal of such practices would lead to a rapid growth if needed (as in the case of colonization or expansion). Thus, population mobility seems to be connected with an increased birth rate, not a decline in mortality, which cannot be proved since the Neolithic period.

15. Mobility of prehistoric populations

The following units of social mobility are to be assumed for Central European prehistory: (a) Individuals following their husbands or wives; unimportant demographically. (b) Travelling individuals or small groups (trade, acquisition or raw materials, festivals and rituals, wars etc.); unimportant demographically. (c) Individual families. Their moves over great distances cannot be assumed because families depended heavily on the help of their relatives. They could have moved short distances, however, especially in the framework of internal colonization or recolonization of „tribal" territories. (d) Communities or their parts. Again, they could have moved within the framework of internal colonization, or external colonization, usually over short distances. (e) Tribes or their parts. Forming autonomous wholes within which almost all the necessary social and economic relations could be maintained, they were the smallest units capable of medium or long distance migration. (f) Groups of warriors, possibly accompanied by their families. Such units may have moved frequently at the end of prehistory as demonstrated by written records. Their formation and action, however, depends on a developed network of social relations that cannot be assumed for periods preceding the Iron Age of Central Europe.

The following types of mobility can be supposed as typical for the prehistoric period since the Neolithic: (1) Migration resulting from overpopulation. This is the most frequently assumed type of migration and, at the same time, the most improbable. It presupposes the inability of populations to control their reproduction. It should be detectable by archaeologically observed overpopulation in the regions from whence the migration starts, but this does not seem to be substantiated by the archaeological record in concrete instances. (2) Internal colonization. Probably the most frequent type of mobility extremely difficult to prove by archaeology alone. It consists of short distance shifts of families or communities to replace random losses of a neighbouring population or to fill gaps in the settlement network. This form of migration does not require any sharp rise in the growth rate of the populations involved. (3) Expansion. A possible form of migration of tribes or their parts over medium and long distances. It does not presuppose any marked growth before the expansion: rapid growth, however, should follow as the newly gained territory was depopulated and it was necessary to restore the usual network of social and economic relations as soon as possible. (4) Colonization. This is a form of migration to areas with much lower population density characterized by a steadily moving colonization wave. Behind the front of the wave one can assume a demographically active zone with a high growth rate producing the colonists. This zone would move along with the wave. Denoting the territory colonized after t years at T_t and the possible yearly decrease in population density as h we get Eq. [49] which determines the advance of the colonization. If the whole increase emigrates and h is zero, Eq. [50] holds and the advance is slow. (5) Invasion. This is the movement of parts of a population (mostly of an armed upper class, possibly consisting of more or less complete families) which replaces the local upper class in newly occupied territory. This type of migration presupposes developed social relation with a relatively autonomous leading group separable from the lower layers of the society. It implies large scale mixing of people and their ability to adopt, at least partially, a basically alien culture. (6) Infiltration. This peculiar form of prehistoric migrations, which seems to have been a frequent case, has been discussed in some detail in a parallel paper (*Neustupný 1982*).

16. The causes of population growth

The naive view of population growth, shared by many prehistorians, is that it is a natural consequence of the sexual life of man. We have tried to show, however, that even prehistoric peoples were able to control their reproduction and usually did not overpopulate. Each individual needed a certain network of relatives on whom he depended for help and cooperation, i. e. he needed a certain density of social relations. If this network was impaired or partially destroyed in some way, i. e. the density of social relations decreased (e. g. the neighbouring community died out, or a part of a tribe expanded to an alien milieu so that contact with the old homeland became difficult, or the network became asymmetrical because the community settled at some place in the colonization front), the most natural reaction was to restitute it by means of natural growth. This explanation of population growth implies that it cannot be considered as an autonomous factor explaining changes in the economy, society, or history. On the contrary, it is a phenomenon that may occur as a consequence of economic and social development or a historical event.

III. Examples

17. Linear Pottery culture

The Middle Neolithic Linear Pottery culture of Eastern Germany is also known, in addition to numerous settlement sites, from two almost completely uncovered cemeteries and a set of more or less isolated graves worked by an anthropologist (*Bach 1978*). In the absence of archaeological

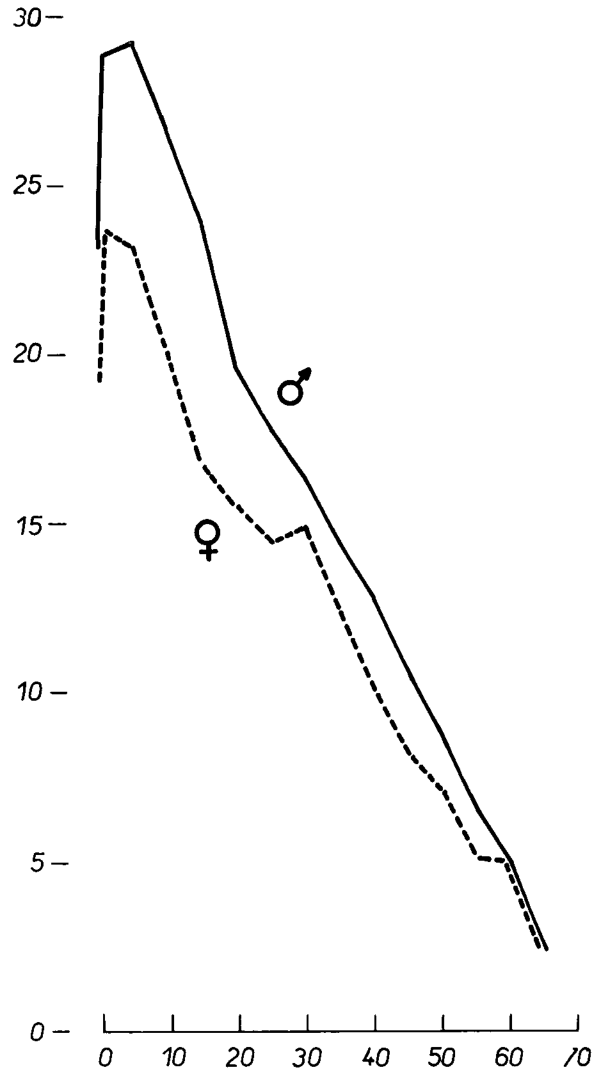

Fig. 1. Life expectancy function (e_x) of the Linear Pottery population in East Germany.

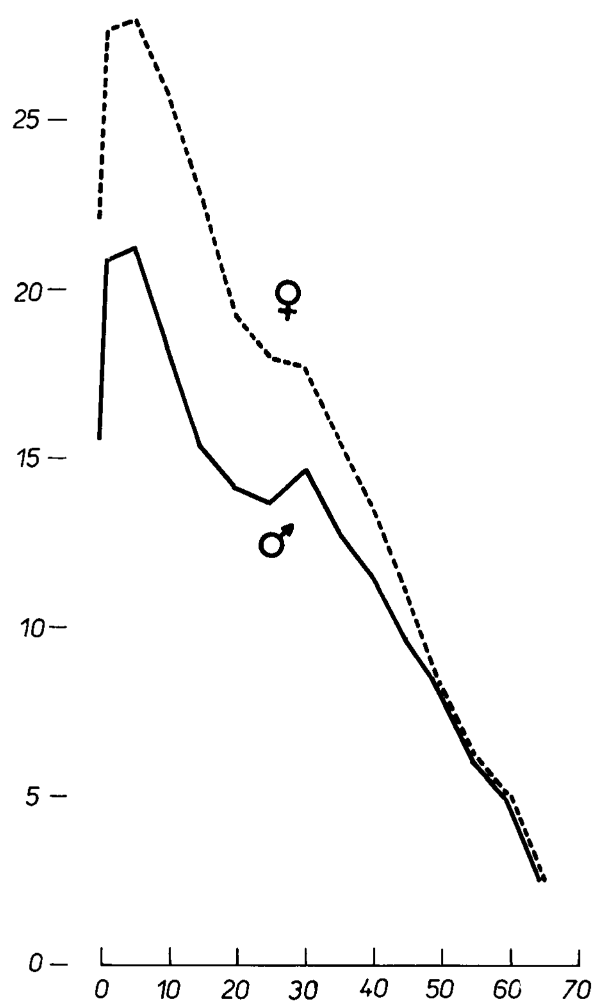

Fig. 2. Life expectancy function (e_x) of the Vikletice population.

criteria, both the sex and age have been determined anthropologically. There is a difference between the number of male and female graves but it is not statistically significant. The distribution of both the sexes, however, differs if five year groupings are compared: the number of female burials over 30 years is significantly greater than the number of male interments in the same category. With the exception of children in the first two or three years of life, there is no evidence of incompleteness. The life tables (8 to 10) show parameters acceptable as the reflection of a stationary population, but the supposition of an error in the anthropological ageing and/or a slight positive rate of natural increase (up to 1%) would bring them nearer to expected values (cf. Table 12). The crude death rate for women especially (0.052) seems to be too low. The index of masculinity is surprisingly close to 1000 but there must have been a deficiency of women in the reproductive age. This is one of the consequences of the high specific mortality of young adult women (cf. Fig. 1). Another result of this phenomenon is the unusually big family size. The negligible number of old people over 50 years excludes the possibility that the Linear pottery society was based on big families uniting three generations. The probability that a woman became a widow before reaching the age of 30 is almost one half, and more than one half of the children became orphans before reaching the age of 15. All these numbers would change somewhat for the better if either an ageing error or a positive natural increase were admitted, but the difference would not be great.

The shape of the male life expectancy function (e_x) seems to reflect a „natural“ mortality with no unusual causes of death (cf. Fig. 1). It is, however, different with the same function for woman where there is a subsidiary maximum at the age of 30. Judging from the situation in living primitive populations, the percentage of females dying between the age of 15 and 50 should be greater by some 3% to 10% than that of males, due to deaths resulting from childbirth (cf. *Henry 1976*, 156; *Acsádi - Nemeskéri 1970*, 253). In the Neolithic series the difference between men and women in the reproductive age is approximately 7% which falls within the expected range. The high death rate of woman thus seems to be „natural“ and need not be explained by any other cause.

The demographic parameters derived above have been used to estimate the number of graves to be expected in the case of Bylany 1, a closed part of the famous neolithic site. The number of houses (R) can be surmised at approximately 500 on the basis of extensive excavations (*Pavlů 1977*). For the mean life of a house (z) there are varying estimates, just as for the number of inhabitants of one house (P; cf. Table 13). If d is set to 0.048 and l_3 to 0.69 (cf. Table 12), the result is a wide spectrum of estimates of the total number of graves (cf. Table 13). An analysis of more or less fully

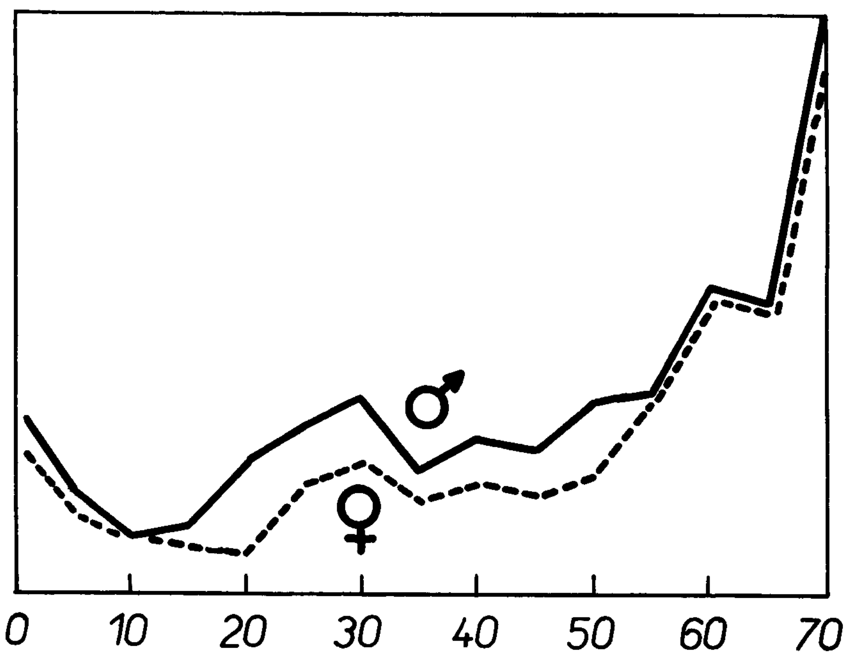

Fig. 3. Function q_x of the Vikletice population.

excavated cemeteries of the Linear Pottery culture in Central Europe shows that they are rather small — 40 to 70 graves in one typological phase. This suggests that no more than several hundred graves can be expected at Bylany, which cannot be brought into accord with the calculated numbers otherwise than by accepting both the very small size of a family (inhabiting one house) and the very short mean life of the house. Current estimates for the total population of a neolithic village (50 to 200 persons) are certainly to high; the probable upper limit being 25 individuals.[1]

18. Vikletice (Corded Ware culture in Bohemia)

The cemetery at Vikletice has been almost completely excavated (*Buchvaldek - Koutecký 1970*). The sex of the dead was determined archaeologically (men lying on their right side, women on the left side, both the sexes facing South), the age of the deceased by anthropological methods (*Chochol 1970*). The record used is incomplete in the sense that children up to 2 to 3 years of age were not buried regularly. Otherwise there is no evidence of incompleteness, the differences between the number of male and female burials being statistically insignificant. The number of male skeletons aged over 40 is, however, significantly lower than the number of corresponding female remains, caused by differing specific mortality of the two sexes. The index of masculinity is in the range of from 600 to 700 with a pronounced deficit of living males especially in the reproductive period (Fig. 4). Selective infanticide cannot be supposed. A comparison of the life expectancy of the Vikle-

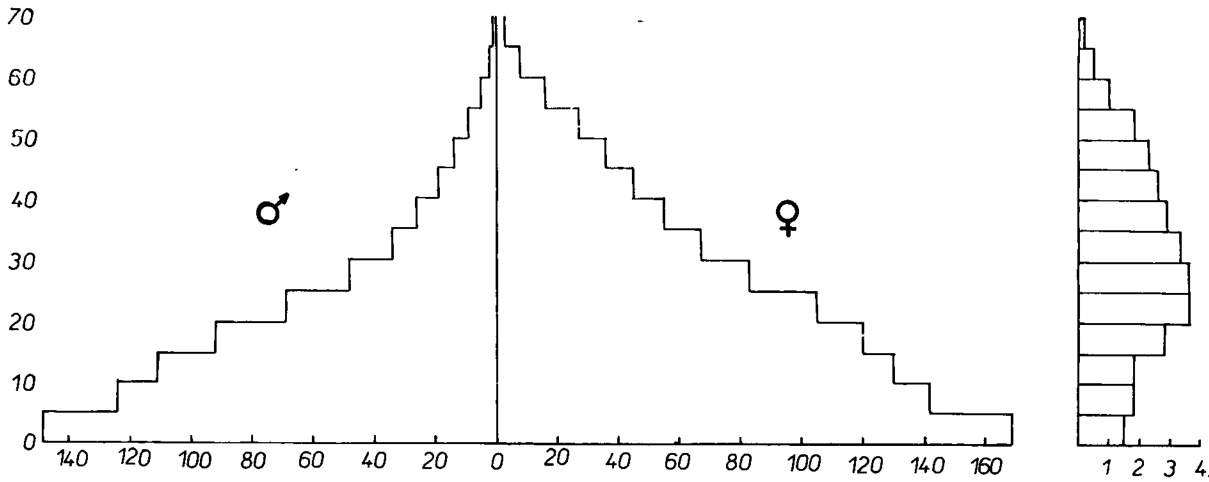

Fig. 4. Vikletice. Age pyramid (left) and the difference between the numbers of females and males (right).

tice population with that of aeneolithic Tiszapolgár (Fig. 5) shows that the function has approximately the same shape for persons over 30 years; the Tiszapolgár curve, however, is shifted by some 3 years upwards. This is most probably due to the rather simple method of anthropological ageing applied at Vikletice as compared with the intricate methods used by Acsádi and Nemeskéri for Tiszapolgár. It seems likely that the Tiszapolgár life table (Table 18) can be accepted as a model for the „natural" stationary mortality pattern. No manipulation with the Vikletice life table can bring them into full accordance with Tiszapolgár for ages up to 30 years; this is due to the high specific mortality of both young males and females. This fact can be explained neither by non-stationarity nor by incompleteness; it seems to reflect a high mortality of young adult women in consequence of their maternity function and a high mortality of young adult males, perhaps as a consequence of fights. The real crude death rate was probably somewhat lower than that implied

1. The number of graves as calculated above depends neither on estimates of the absolute duration of the site nor on the hypothesis of continuous settling of the site area.

by Tables 14 to 17 but it hardly reached that of Tiszapolgár. It is surprising that both the mortality of females in the middle and later phases at Vikletice and at Tiszapolgár does not reflect the expected high mortality of mothers. If it is real (and it seems to be so at least for the latter series), the explanation should probably be sought in specific forms of fertility control.

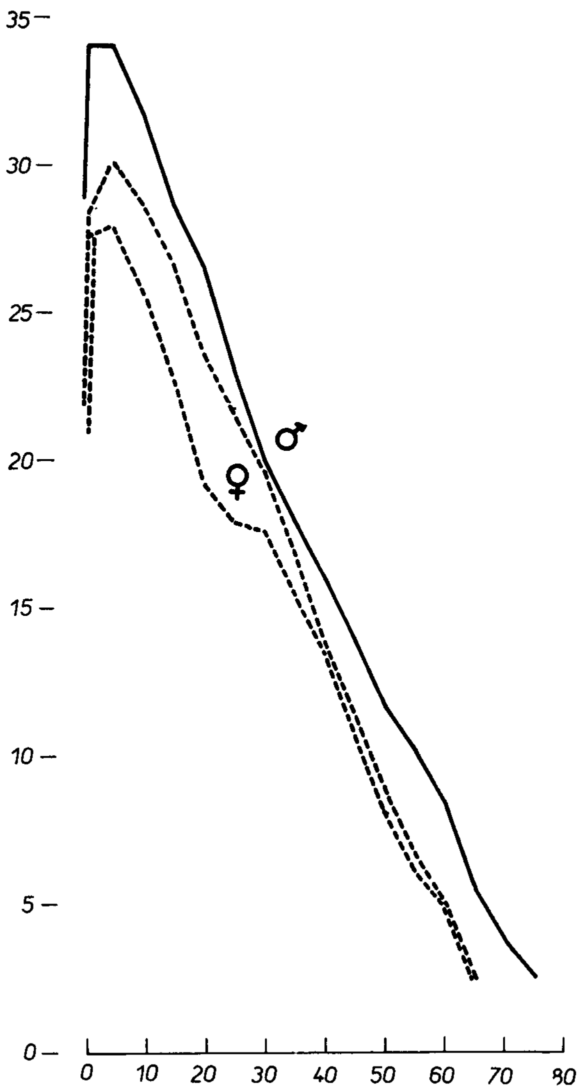

Fig. 5. Life expectancy (e_x) of various Aeneolithic populations. From up to down: Tiszapolgár; Vikletice, females of the middle to final phases; Vikletice, all females.

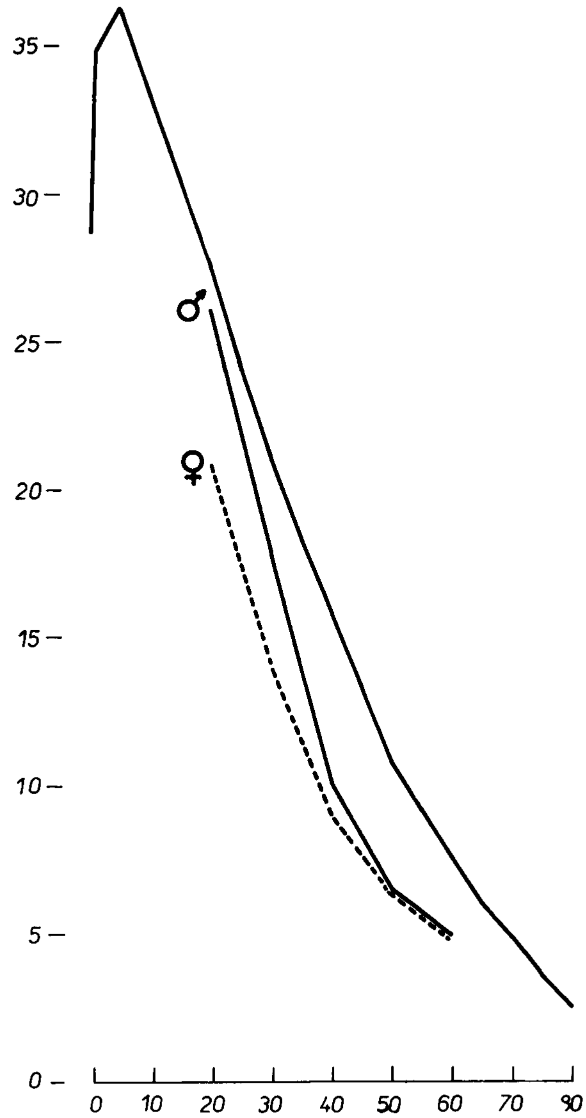

Fig. 6. Life expectancy (e_x) of various late populations. From up to down: Hungary, 10th to 12th century AD; Mikulčice females; Mikulčice males.

The graves at Vikletice disclose clearcut aggregation into nine spatial groups. These groups, if considered outside the chronological pattern, do not make much sense. However, if arranged into a relative sequence by means of computer-aided seriation, and if this sequence is broken into phases of about 100 years, it means that most of the grave groups contain approximately 10 graves in one phase (Table 20). In view of the numbers in Tables 6 an 7 it seems likely that the grave groups cover remains of one family each; individual families may have lasted for one, two, or three centuries at most. The groups containing far less than 10 graves in one phase should then be interpreted as reflections of families that failed to reproduce themselves for more than one to three generations. This explanation can serve as a basis for counting the number of families inhabiting the Vikletice settlement area in each phase: they were 4 to 5, which suggests 14 to 18 persons (or 25 persons at the most). The generally low numbers of graves in the middle phase presumably indicate that it was of relatively shorter duration. The number of families may have been reduced in the final phase when the only well documented „family“ used grave group V.

19. La-Tène cemeteries in Bohemia

Our starting point in this case was *Waldhauser's* paper (*1979*) collecting graves from various sites all over Bohemia, some of the skeletons being determined by anthropologists of questionable professional competence. Waldhauser's archaeolcgical judgement as to the sex has been followed where possible; for the age we accepted the view of physical anthropologists. There seems to be a sharp difference between the mortality of men and women, but it cannot be proved statistically. The low number of child graves is suggesting but, here again, statistical tests are unconvincing. The tables constructed for the adult part of the population (Tables 22 and 23) exhibit a mortality pattern which seems to reflect unusually high errors in the ageing methods. Neither incompleteness nor non-stationarity can be assumed but the many unexplained phenomena warn against deducing too much from this rather small series of graves.

20. Mikulčice (medieval series from Moravia)

Four skeletal series have been elaborated by *M. Stloukal* and *L. Vyhnánek* (*1976*), both anthropologically and demographically. The very high masculinity index already suggests that many females are missing from the series as large scale infanticide can hardly be assumed in the conditions of Christianity in a centre of the Great Moravian Empire (9th century AD). Many children are also missing. If life tables are calculated by Halley's method (Table 24), then there is a disagreement with the (presumably) stationary and complete model life table for the 10th to 12th century AD in Hungary, as calculated by Acsádi and Nemeskéri (Table 25). This is a poor basis for the reconstruction of demographic parameters. The Mikulčice series presents problems that arise in a complicated early medieval society (the four cemeteries are situated within a fort and there is a large number of other contemporaneous cemeteries both inside and outside it).

21. Conclusions

Both the formulation of demographic models and their application to several prehistoric cemeteries in Central Europe demonstrate a useful approach to the quantitative study of early agricultural populations. There are still many problems to be solved but the basic lines of research, initiated on a large scale by *Acsádi* and *Nemeskéri* (*1970*), seem to be sufficiently clear. Halley's method for the construction of life tables appears to be a sound basis despite the fact that a number of presuppositions has to be made. Fortunately, at least some of them appear justified in view of the long periods covered by prehistoric cemeteries. Minor shifts of the results, however, are to be expected with the perfection of physical anthropology (the ageing of skeletons, the determination of the sex) but these should not change the overall picture of prehistoric demography achieved so far.

There seems to be little demographic progress in Central Europe within the peasant phase prior to the emergence of state organization. The „natural“ birth and death rates were nearer to 0.04 than to 0.05 on the average, reaching 0.035 under optimum conditions; the actual rates, however, may have been higher if unnatural causes death were in operation. In consequence of this, typical life expectancy of a newborn was from 23 to 28 years. Some two-thirds of persons lived to the beginning of the adult age (15 years). About one half of the population was in the reproductive span (15—50) but less than one tenth over 50. An average woman gave birth to 3.5 to 4 children, and an average family numbered 3.2 to 4.1 persons if stationarity was to be achieved. The length of a generation was approximately 27 years. The peasant families, however, were unstable: there were many widows and widowers, and a high percentage of children were orphans.

Most farming communities of Central Europe were small (composed of several families each) for the greater part of prehistory. They used to keep themselves in the stationary state but, occasionally, were able to propagate effectively by increasing their growth rate up to approximately 0.02 (i. e. 2%). This was a precondition for various forms of population mobility. The growth of populations, however, cannot be conceived as an autonomous natural factor causing historical or cultural change.

Appendix 1: Symbols

Symbols widely used in demographic publications are preceded by an asterisk

*	a_x	Average age of mothers in age group x (e.g. for $x = 15-19$ years $a_x = 17{\cdot}5$).
*	$\bar{a}$	Average age of mothers. Cf. Eq. [28].
*	b	Annual birth rate (crude: the number of births in a year divided by the average population for the year). Cf. Eqs. [21], [22] and [38].
*	B	Number of births in a population over one year.
*	c_x	Proportion of persons of age x in the living population. Cf. Eqs. [8], [14] and [23].
	C	Completed fertility (average number of children born to the woman who reached the end of her reproductive period). Cf. Eqs. [25a] and [25b].
	C_0	Completed fertility in a stationary population. Cf. Eq. [34].
	C_r	Completed fertility in a stable population. Cf. Eq. [36].
	C_0^*	Number of children actually born to an average woman in a stationary population. Cf. Eq. [35].
	C_r^*	Number of children actually born to an average woman in a stable population. Cf. Eq. [37a].
*	d	Annual death rate (crude: the number of deaths in a year divided by the average population for the year). Cf. Eq. [20].
*	d_x	Proportion of persons dying at age x (or in the interval given by x). Cf. Eqs. [1] and [9].
*	D	Total number of deaths in a population over certain period. Cf. Eqs. [15], [32d] and [33].
*	D_x	Number of persons dying at age x over certain period; number of skeletons aged x in a cemetery.
	D^+	Number of persons buried over certain period. Cf. Eqs. [18] and [46].
	e	Base of natural logarithms (2·71828).
*	e_0	Expectation of life (life expectancy) at birth. Cf. Eqs. [7b] and [13b].
*	e_x	Life expectancy at age x. Cf. Eqs. [7a] and [13b].
	e'	Mean length of the reproductive period of females in a population. Cf. Eq. 39.
*	f_x	Fertility of females in one year of a five year period (the number of children born to a five year cohort of women in one year divided by the average number of women in that cohort).
	f_x'	Relative fertility given by Eq. [24].
	F	In upper indexes: females.
	h	Decrease in population density during migration.
	I^M	Index of masculinity. Cf. Eq. [48a].
	k	Constant number.
*	l_x	Relative number of persons surviving to age x; throughout this paper it is assumed that $l_0 = 1{\cdot}0$. Cf. Eqs. [2] and [10].
*	ln	Natural logarithms (base 2·71828).

*	log	Decadic logarithms (base 10).
*	L_x	Average number of years lived by a person at age x. Cf. Eqs. [5] and [12].
*	n^Lx	Average number of years lived by a person in the time interval of n years beginning with year x. Cf. Eqs. [6], [12a] and [12c].
*	m	Proportion of female births (typically $m = 0{\cdot}49$).
	M	In upper indexes: males.
	n_i	Length (in years) of time interval i, used in the abridged life tables.
*	p_x	Probability that a person who lived at the beginning of time interval x survives to the beginning of interval $x + 1$. Cf. Eqs. [4] and [5].
*	P	Population size over certain period. Cf. Ef. [32b].
*	P_0	Initial size of a stable population. Cf. Eq. [33b].
*	P_t	Size of a stable population after t years. Cf. Eqs. [29], [30] and [31].
*	P_{max}	Maximum admissible size of a population (so-called carrying capacity).
	P_0^*	Estimate of average family size (stationary population). Cf. Eq. [41].
	P_r^*	Estimate of average family size (stable population). Cf. Eq. [40].
	P^{**}	Estimate of average family size. Cf. Eq. [42].
*	q_x	Probability that a person who lived at the beginning of time interval x dies before reaching the beginning of $x + 1$. Cf. Eqs. [3a] and [3b].
*	n^qx	Probability that a person who lived at the beginning of year x dies during the next n years (Eq. [3c] and [11]); probability of widowhood and orphanhood (Eqs. [44] and [45]).
*	r	Annual rate of natural increase (crude: the difference between the number of births and deaths in a year divided by the average population in that year). Cf. Eq. [20].
	R	Number of houses found in a settlement site.
*	R_0	Net reproduction rate (average number of daughters born to a woman at the average age of mothers $\bar{a}$). Cf. Eq. [26].
	s	Number of divisions (age groups) in abridged life tables.
*	t	Time (in years).
*	T	Length of generation. Cf. Eq. [43].
*	T_x	Technical variable used in the calculation of life tables. Cf. Eq. [13].
	T_0	The original territory of a migrating population.
	T_t	Territory occupied by a migrating population after t years. Cf. Eqs. [49] and [50].
*	x	In indexes: age of persons in years or in terms of a time interval.
	z	Mean life of a house.
*	ω	The highest age of any person in a population.

Appendix 2: Demographic Equations

The Equations are ordered according to their occurrence in the paper.

Eq. [1] $d_x = D_x / \sum_{i=0}^{\omega} D_i$

Eq. [2a] $l_0 = 1{\cdot}0$

Eq. [2b] $l_{x+1} = l_x - d_x$

Eq. [3a] $q_x = d_x / l_x$

Eq. [3b] $q_x = (l_x - l_{x+1}) / l_x$

Eq. [3c] $n^qx = (l_x - l_{x+n}) / l_x$

Eq. [4a] $p_x = 1 - q_x = (l_x - d_x) / l_x = l_{x+1} / l_x$

Eq. [4b] $p_0 p_1 p_2 \ldots p_x = l_x$

Eq. [5] $L_x = (l_x + l_{x+1}) / 2 = l_x - d_x / 2$

Eq. [6]	$_nL_x = \sum_{i=x}^{x+n-1} L_i$	
Eq. [7a]	$e_x = 0{\cdot}5 + (\sum_{i=x+1}^{\omega} l_i)/l_x = (\sum_{i=x}^{\omega} L_i)/l_x$	
Eq. [7b]	$e_0 = 0{\cdot}5 + \sum_{i=1}^{\omega} l_i = \sum_{i=0}^{\omega} L_i$	
Eq. [8]	$c_x = L_x/e_0$	
Eq. [9]	$d_i = D_i/\sum_{j=1}^{s} D_j$	(in abridged life tables)
Eq. [10]	$l_i = l_{i-1} - d_{i-1}$	(in abridged life tables)
Eq. [11]	$q_i = d_i/l_i$	(in abridged life tables)
Eq. [12a]	$L_i = n_i(l_i - d_i/2) = n_i(l_i + l_{i+1})/2$	(in abridged life tables)
Eq. [12b]	$L_0 = 0{\cdot}65\, l_1 + 0{\cdot}35$	(in abridged life tables)
Eq. [12c]	$_4L_1 = 1{\cdot}361\, l_1 + 2{\cdot}639\, l_5$	(in abridged life tables)
Eq. [13]	$T_x = \sum_{i=x}^{s} L_i$	(in abridged life tables)
Eq. [13a]	$e_0 = T_0 = \sum_{i=1}^{s} L_i$	(in abridged life tables)
Eq. [13b]	$e_x = T_x/l_x = (\sum_{i=x}^{s} L_i)/l_x$	(in abridged life tables)
Eq. [14]	$c_x = L_x/e_0$	(in abridged life tables)
Eq. [15]	$D = \sum_{0}^{\omega} D_x = (\sum_{5}^{\omega} D_x)/l_5$	
Eq. [16]	$D_0 = d_0 \sum_{0}^{\omega} D_x = d_0 D = (d_0/l_5) \sum_{5}^{\omega} D_x$	
Eq. [17]	$D_{1-4} = d_{1-4} D = (d_{1-4}/l_5) \sum_{5}^{\omega} D_x$	
Eq. [18]	$D^{+} = D l_x$	
Eq. [19]	not used	
Eq. [20]	$r = b - d$	
Eq. [21]	$b = 1/\sum_{0}^{\omega} e^{-rx} L_x$	
Eq. [22]	$b = 1/\int_0^{\omega} e^{-rx} l_x dx$	
Eq. [23a]	$c_x = b e^{-rx} l_x$	(continuous time)
Eq. [23b]	$c_x = b e^{-rx} L_x$	(discrete time)
Eq. [24]	$f_x = f'_x C/5$	
Eq. [25a]	$C = \sum_{x=0}^{\omega} f_x$	(one-year increment)
Eq. [25b]	$C = 5\sum_{i=1}^{s} f_i$	(five-year increment)
Eq. [26]	$R_0 = m \sum f_x\, {}_5L_x$	
Eq. [27a]	$\log(1 + r) \approx \log R_0/\bar{a}$	
Eq. [27b]	$r \approx \ln R_0/\bar{a}$	
Eq. [28]	$\bar{a} = (\sum a_x f_x\, {}_5L_x)/(\sum f_x\, {}_5L_x) = (\sum a_x f'_x\, {}_5L_x)/(\sum f'_x\, {}_5L_x)$	
Eq. [29]	$P_t = P_0(1 + r)^t$	(discrete time)
Eq. [30]	$P_t = P_0 e^{rt}$	(continuous time)
Eq. [31]	$P_t = P_{\max}/(1 + \mathrm{k}\, P_{\max} e^{-rt})$	
Eq. [32]	$Pd = D/t$	(stationary population)
Eq. [32b]	$P = D/dt = De_0/t$	(stationary population)
Eq. [32c]	$t = e_0 D/P$	(stationary population)
Eq. [33a]	$D = P_0 d(e^{rt} - 1)/r$	(stable population)
Eq. [33b]	$P_0 = Dr/d(e^{rt} - 1)$	(stable population)

Eq. [34] $C_0 = 10/\sum f'_x\, {}_5L_x$
Eq. [35] $C^*_0 = 2/l_{15}$
Eq. [36] $C_r = 10R_0/\sum f'_x\, {}_5L_x \approx 10e^{r\bar{a}}/\sum f'_x\, {}_5L_x$
Eq. [37a] $C^*_r = 2R_0/l_{15} \approx 2e^{r\bar{a}}/l_{15}$
Eq. [37b] $r \approx (\ln (C^*_r l_{15}/2))/\bar{a}$
Eq. [38] $b \doteq B/P$
Eq. [39] $e' = \begin{cases} e_{15} & \text{if } e_{15} < 30 \\ 30 & \text{if } e_{15} \geqq 30 \end{cases}$
Eq. [40] $P^*_r = C^*_r/(be') \approx 2e^{r\bar{a}}/(be'l_{15})$
Eq. [41] $P^*_0 = 2e_0/(e'l_{15}) = e_0C^*_0/e'$
Eq. [42] $P^{**} = 200/c_{15-49}$ (c_{15-49} in percentages)
Eq. [43] $T = (\ln R_0)/r$
Eq. [44] $n^q x = (l_x - l_{x+n})/l_x$ (probability that a husband or wife aged x years dies in the following n years)
Eq. [45] $n^q x = (l_x - l_{x+n})/l_x$ (probability that a child born to a person of age x becomes orphan at age n)
Eq. [46] $D^+ = P^*_r\, \mathrm{d}R\, zl_x$ (number of graves produced by one community; x is the age at which regular burials begin)
Eq. [47] $D^{**}_t = kt$ (number of graves produced by one family in t years; k typically equals 0·1 or 0·09)
Eq. [48a] $I^M = 1000D^Md^F/(D^Fd^M)$
Eq. [48b] $D^M/D^F = (I^Md^M)/(1000d^F)$
Eq. [49] $T_t = T_0rt/(1 + h)^t = T_0rte^{-ht}$
Eq. [50] $T_t = T_0rt$ ($h = 0$)

Appendix 3: Tables

Tab. 1. Model table for the reconstruction of "missing" children based on the mortality of children aged 5 to 14 (${}_{10}q_5$) Cf. Equations [15], [16] and [17]. Derived from *Weiss 1973.*

${}_{10}q_5$	l_5	d_0	d_{1-4}
0·2857	0·420	0·400	0·180
0·2553	0·470	0·367	0·163
0·2381	0·525	0·333	0·142
0·2105	0·570	0·300	0·130
0·1883	0·616	0·267	0·117
0·1667	0·660	0·233	0·107
0·1477	0·704	0·200	0·096
0·1287	0·746	0·167	0·087
0·1128	0·789	0·133	0·078

Tab. 2. The influence of ageing error (for ages over 15 years) on the life expectancy function (e_x). (1) values of Table 10, (2) the same supposing an ageing error.

x	(1) e_x	(2) e_x
0	20·78	23·03
1— 4	25·72	28·62
5— 9	25·51	28·87
10—14	22·66	26·33
15—19	19·51	23·51
20—24	17·24	21·53
25—29	15·86	20·04
30—34	15·21	19·12
35—39	13·08	17·13
40—44	11·16	15·67
45—49	9·18	13·58
50—54	7·78	11·77
55—59	5·76	9·69
60—64	5·00	8·20
65—69	2·50	6·00
70—74		4·88
75—79		2·50

Tab. 3. Apparent life table of the closed stable population derived from Weiss' model table MT : 25—60 ($r = 0.02$).

x	d_x	$d_x e^{-2r\bar{x}}$	d_x	l_x	L_x	e_x	c_x
0	0·200	0·1960	0·3876	1·0000	0·7481	10·76	6·95
1— 4	0·096	0·0851	0·1683	0·6124	2·0054	16·35	18·63
5— 9	0·064	0·0474	0 0937	0·4441	1·9862	18·03	18·45
10—14	0·040	0·0243	0·0481	0·3504	1·6318	17·19	15·16
15—19	0·089	0·0442	0 0874	0·3023	1·2930	14·53	12·01
20—24	0·077	0·0313	0·0619	0·2149	0·9198	14·42	8·55
25—29	0 068	0·0226	0·0447	0·1530	0·6533	14·24	6·07
30—34	0 058	0·0158	0·0312	0·1038	0·4635	14·08	4·31
35—39	0·051	0·0114	0·0225	0·0771	0·3293	13·77	3·06
40—44	0·043	0·00786	0·0155	0·0546	0·2343	13·41	2·18
45—49	0·037	0·00553	0·0109	0·0391	0·1682	12·74	1·56
50—54	0 031	0·00380	0·0075	0·0282	0·1222	11·70	1·14
55—59	0 031	0·00311	0 0062	0·0207	0·0880	10·03	0·82
60—64	0 033	0·00271	0·0054	0·0145	0·0590	8·26	0·55
65—69	0 030	0·00202	0·0040	0·0091	0·0355	6·67	0·33
70—74	0 024	0·00132	0·0026	0·0051	0·0190	4·94	0·18
75—79	0·028	0·00126	0·0025	0·0025	0·0062	2·48	0·06
		0·50571	1·0000		10·7628		100·01

Tab. 4. Apparent life table of the (absolutely) open stable population derived from Weiss' model table MT : 25—60 ($r = 0.02$)

x	d_x	$d_x e^{-r\bar{x}}$	d_x	l_x	L_x	e_x	c_x
0	0·200	0·1980	0·2990	1·0000	0·8056	16·36	0·0493
1— 4	0·096	0·0904	0·1365	0·7010	2·4438	22·18	0·1494
5— 9	0·064	0·0551	0·0832	0·5645	2·6145	23·22	0·1598
10—14	0·040	0·0312	0·0471	0·4813	2·2888	21·80	0·1399
15—19	0·089	0·0627	0·0947	0·4342	1·9342	18·90	0·1182
20—24	0·077	0·0491	0·0741	0·3395	1·5122	18·47	0·0924
25—29	0·068	0·0392	0 0592	0·2654	1·1790	17·93	0·0721
30—34	0·058	0·0303	0·0458	0·2062	0·9165	17·36	0·0560
35—39	0·051	0·0241	0·0364	0·1604	0·7110	16·60	0 0435
40—44	0·043	0·0184	0·0278	0·1240	0·5505	15·74	0·0337
45—49	0·037	0·0143	0·0216	0·0962	0·4270	14·56	0·0261
50—54	0·031	0·0108	0·0163	0·0746	0·3322	13·06	0·0203
55—59	0·031	0·0098	0·0148	0·0583	0·2545	11·01	0·0156
60—64	0·033	0·00945	0·0143	0·0435	0·1818	8·90	0·0111
65—69	0·030	0·00778	0·0117	0·0292	0·1168	7·04	0·0071
70—74	0·024	0·00563	0·0085	0·0175	0·0662	5·07	0·0040
75—79	0·028	0·00594	0·0090	0·0090	0·0225	2·50	0·0014
		0·6622	1·0000		16·3571		0·9999

Tab. 5. Time changes of an open stable population with natural growth rate r.

time	population: resident	population: emigrating				discrete time	continuous time
0	P					$P(1+r)^0$	Pe^{r0}
1	P				Pr	$P(1+r)$	Pe^{r}
2	P			Pr	$Pr(1+r)$	$P(1+r)^2$	Pe^{2r}
3	P		Pr	$Pr(1+r)$	$Pr(1+r)^2$	$P(1+r)^3$	Pe^{3r}
4	P	Pr	$Pr(1+r)$	$Pr(1+r)\,2$	$Pr(1+r)^3$	$P(1+r)^4$	Pe^{4r}
.							
.							
.							
t	P	$Pr + \ldots + Pr(1+r)^{t-3} + Pr(1+r)^{t-2} +$ $+ Pr(1+r)^{t-1}$				$P(1+r)^t$	Pe^{tr}

	discrete time	continuous time
Number of resident persons	P	P
Number of emigrating persons (after t years)	$M = tPr$	$M = tP(e^r - 1)$
Number of descendents of emigrating persons (after t years)	$O = Pr \sum_{i=0}^{t} (1+r)^i$	$O = P(e^{rt} - 1)$
Total number of descendents of the original population (after t years)	$P_t = P(1+r)^t$	$P_t = Pe^{rt}$

Tab. 6. The number of dead (D) and buried (D^+) persons produced by one family of Weiss' model life table MT : 25—60 (children up to 2 years not buried).

	stationary population		stable population (absolutely)		open		closed	
P_r^*	3·36		3·55		3·85		3·55	
D_r^*	0·13		0·14		0·15			
r	0·00		0·01		0·02		0·01	
b	0·04		0·05		0·06		0·05	
t	D	D^+	D	D^+	D	D^+	D	D^+
25	3·33	2·44	3·49	2·25	3·82	2·32	3·30	1·65
50	6·67	4·89	6·98	4·55	7·64	4·65	7·55	3·78
75	10·00	7·34	10·46	6·81	11·46	6·97	13·00	6·50
100	13·33	9·78	13·95	9·09	15·28	9·29	20·00	9·99
125	16·67	12·23	17·44	11·36	19·10	11·61	28·97	14·48
150	20·00	14·67	20·93	13·63	22·92	13·94	40·51	20·24
175	23·33	17·11	24·42	15·90	26·73	16·25	55·32	27·64
200	26·66	19·56	27·90	18·17	30·55	18·58	74·34	37·14

Tab. 7. The number of dead and buried persons produced by one Vikletice and Tiszapolgár family (children up to 2 years not buried).

	Vikletice, population according to Table 15 (females)		Table 16 (females, late phase)		Table 14 (males)		Tiszapolgár Table 18 (both sexes)	
P_0^*	3·55		3·38		4·41		3·18	
D_0^*	0·16		0·16		0·29		0·11	
b	0·046		0·048		0·065		0·035	
t	D	D^+	D	D^+	D	D^+	D	D^+
25	4·08	2·74	4·06	2·47	7·17	4·30	2·78	2·09
50	8·16	5·47	8·11	4·95	14·33	8·60	5·56	4·17
75	12·25	8·21	12·17	7·42	21·50	12·90	8·35	6·26
100	16·33	10·94	16·22	9·90	28·67	17·20	11·13	8·35

Tab. 8. Linear Pottery culture in East Germany: males (values for x < 15 reconstructed).

x	D_x	d_x	l_x	L_x	e_x	c_x(%)
0	26·8646	0·2252	1·0000	0·8536	23·24	3·67
1— 4	12·4541	0·1044	0·7748	2·8237	28·89	12·15
5— 9	6·8420	0·0574	0·6704	3·2085	29·18	13·81
10—14	6·1340	0·0514	0·6130	2·9365	26·67	12·64
15—19	2·5450	0·0213	0·5616	2·7548	23·89	11·86
20—24	10·0450	0·0842	0·5403	2·4910	19·73	10·72
25—29	10·0460	0·0842	0·4561	2·0700	17·91	8·91
30—34	8·0460	0·0674	0·3719	1·6910	16·40	7·28
35—39	8·0450	0·0674	0·3045	1·3540	14·48	5·83
40—44	6·0460	0·0507	0·2371	1·0588	12·88	4·56
45—49	6·0450	0·0507	0·1864	0·8052	10·70	3·46
50—54	5·0460	0·0423	0·1357	0·5728	8·77	2·46
55—59	5·0450	0·0423	0·0934	0·3612	6·61	1·55
60—64	3·0460	0·0255	0·0511	0·1918	5·01	0·83
65—69	3·0450	0·0255	0·0256	0·0640	2·50	0·27
Σ	119·2922	1·0000		23·2369		

Tab. 9. Linear Pottery culture in East Germany: females (values for x < 15 reconstructed).

x	D_x	d_x	l_x	L_x	e_x	c_x(%)
0	30·0728	0·2252	1·0000	0·8536	19·21	4·44
1— 4	13·9414	0·1044	0·7748	2·8237	23·69	14·70
5— 9	7·6580	0·0573	0·6704	3·2088	23·16	16·71
10—14	6·8660	0·0514	0·6131	2·9370	20·10	15·29
15—19	15·9090	0·1191	0·5617	2·5108	16·71	13·07
20—24	13·9090	0·1042	0·4426	1·9525	15·53	10·17
25—29	13·9090	0·1042	0·3384	1·4315	14·54	7·45
30—34	5·4090	0·0405	0·2342	1·0698	14·90	5·57
35—39	5·4090	0·0405	0·1937	0·8672	12·49	4·52
40—44	5·9090	0·0442	0·1532	0·6555	10·13	3·41
45—49	5·9090	0·0442	0·1090	0·4345	8·22	2·26
50—54	3·4090	0·0255	0·0648	0·2602	7·13	1·35
55—59	3·4090	0·0255	0·0393	0·1328	5·13	0·69
60—64	0·9090	0·0068	0·0138	0·0518	5·00	0·27
65—69	0·9090	0·0068	0·0069	0·0172	2·49	0·09
	133·5382			19·2069		

Tab. 10. Linear Pottery culture in East Germany: both sexes (children up to 5 years reconstructed).

x	D_x	d_x	l_x	L_x	e_x	c_x(%)
0	56·9382	0·2252	1·0000	0·8536	20·78	4·11
1— 4	26·3959	0·1044	0·7748	2·8237	25·72	13·59
5— 9	14·5000	0·0573	0·6704	3·2088	25·51	15·44
10—14	13·0000	0·0514	0·6131	2·9370	22·66	14·13
15—19	19·6370	0·0777	0·5617	2·6142	19·51	12·58
20—24	24·1370	0·0955	0·4840	2·1812	17·24	10·50
25—29	24·1370	0·0955	0·3885	1·7038	15·86	8·20
30—34	13·6370	0·0539	0·2930	1·3302	15·21	6·40
35—39	13·6370	0·0539	0·2391	1·0608	13·08	5·11
40—44	12·1360	0·0480	0·1852	0·8060	11·16	3·88
45—49	12·1360	0·0480	0·1372	0·5660	9·18	2·72
50—54	8·1360	0·0322	0·0892	0·3655	7·78	1·76
55—59	8·1360	0·0322	0·0570	0·2045	5·76	0·98
60—64	3·1360	0·0124	0·0248	0·0930	5·00	0·45
65—69	3·1360	0·0124	0·0124	0·0310	2·50	0·15
Σ	252·8351			20·7793		

Tab. 11. Linear Pottery culture in East Germany. Calculation of the mean age of mothers ($\bar{a}$) and the completed fertility (C_0). Based on Table 9.

x	L_x	f'_x	f'_xL_x	a_x	$a_xf'_xL_x$
15—19	2·5108	0·092	0·2310	17·5	4·0424
20—24	1·9525	0·248	0·4842	22·5	10·8949
25—29	1·4315	0·249	0·3564	27·5	9·8022
30—34	1·0698	0·201	0·2150	32·5	6·9885
35—39	0·8672	0·140	0·1214	37·5	4·5528
40—44	0·6555	0·058	0·0380	42·5	1·6158
45—49	0·4345	0·012	0·0052	47·5	0·2477
Σ			1·4512		38·1443

$\bar{a}$ = 26·28
C_0 = 6·89

Tab. 12. Demographic parameters of the Linear Pottery population in East Germany (on the condition of stationarity and reliability of Tables 8 to 10).

	males	females	males and females
b	0·043	0·052	0·048
e_0	23·24	19·21	20·78
e_{15}	23·89	16·71	19·51
l_{15}	0·56	0·56	0·56
${}_{10}q_5$	0·16	0·16	0·16
C_0		6·89	
C_0^*		3·56	
P_0^*		4·11	
P_0^{**}			4·05
D_0^*	0·15	0·21	0·18
$\bar{a}$		26·28	
c_{0-14}	42·30	51·14	47·27
c_{15-49}	52·62	46·45	49·39
$c_{50-\omega}$	5·11	2·40	3·34

Tab. 13. Various hypotheses of the mean life of a house and the number of its inhabitants, and their consequences for the Linear Pottery site of Bylany 1.

Hypothesis	Parameters for 1 house		Consequences for Bylany 1 (500 houses)	
	mean life (z)	number of inhabitants (P)	number of dead (D)	number of graves (D^+; $l_3 = 0·69$)
A (Soudský - Pavlů)	14·5	17·5	6090	4202
B (Modderman)	22·5	8	4320	2981
C (Kuper - Lüning)	25	5·5	3300	2277
D (Neustupný)	7	4·11	690	476

Tab. 14. Vikletice males (sex determined archaeologically, children up to 5 years reconstructed).

x	D_x	D_x	d_x	q_x	l_x	L_x	e_x	c_x
0	1·250	20·1170	0·2969	0·2969	1·0000	0·8070	15·46	5·22
1— 4	6·832	8·7257	0·1288	0·1832	0·7031	2·4725	20·85	15·99
5— 9	3·750	3·7500	0·0553	0·0963	0·5743	2·7332	21·22	17·67
10—14	4·167	4·1670	0·0615	0·1185	0·5190	2·4412	18·21	15·79
15—19	6·999	6·9990	0·1033	0·2258	0·4575	2·0292	15·32	13·12
20—24	6·875	6·8750	0·1015	0·2866	0·3542	1·5172	14·06	9·81
25—29	5·875	5·8750	0·0867	0·3431	0·2527	1·0468	13·71	6·77
30—34	2·375	2·3750	0·0350	0·2108	0·1660	0·7456	14·56	4·80
35—39	2·375	2·3750	0·0350	0·2672	0·1310	0·5675	12·79	3·67
40—44	1·626	1·6260	0·0240	0·2500	0·0960	0·4200	11·54	2·72
45—49	1·626	1·6260	0·0240	0·3333	0·0720	0·3000	9·55	1·94
50—54	1·125	1·1250	0·0166	0·3458	0·0480	0·1985	8·07	1·28
55—59	1·125	1·1250	0·0166	0·5287	0·0314	0·1155	6·02	0·75
60—64	0·500	0·5000	0·0074	0·5000	0·0148	0·0555	4·97	0·36
65—69	0·500	0·5000	0·0074	1·0000	0·0074	0·0180	2·43	0·12
	47·000	67·7617				15·4646		

Tab. 15. Vikletice females (sex determined archaeologically, children up to 5 years reconstructed).

x	D_x	D_x	d_x	q_x	l_x	L_x	e_x	c_x
0	0·417	17·9258	0·2352	0·2352	1·0000	0·8471	21·98	3·85
1— 4	5·502	8·2054	0·1077	0·1408	0·7648	2·7750	27·63	12·63
5— 9	4·920	4·9200	0·0646	0·0983	0·6571	3·1240	27·93	14·21
10—14	3·500	3·5000	0·0459	0·0775	0·5925	2·8478	25·71	12·96
15—19	3·000	3·0000	0·0394	0·0721	0·5466	2·6345	22·65	11·99
20—24	7·209	7·2090	0·0956	0·1865	0·5072	2·2995	19·22	10·46
25—29	7·209	7·2090	0·0946	0·2293	0·4126	1·8265	18·05	8·31
30—34	3·874	3·8740	0·0508	0·1597	0·3180	1·4630	17·68	6·66
35—39	3·874	3·8740	0·0508	0·1901	0·2672	1·2090	15·57	5·50
40—44	2·874	2·8740	0·0377	0·1742	0·2164	0·9878	13·63	4·49
45—49	2·874	2·8740	0·0377	0·2110	0·1787	0·7992	10·98	3·64
50—54	3·624	3·6240	0·0476	0·3376	0·1410	0·5860	8·25	2·67
55—59	3·624	3·6240	0·0475	0·5086	0·0934	0·3482	6·18	1·58
60—64	1·750	1·7500	0·0230	0·5011	0·0459	0·1720	4·99	0·78
65—69	1·749	1·7490	0·0230	1·0000	0·0229	0·0572	2·50	0·26

Tab. 16. Vikletice. Calculation of the mean age of mothers $\bar{a}$ and the completed fertility C_0 (assumption: stationarity of Table 15).

x	L_x	f_x'	$f_x'L_x$	a_x	$a_x f_x L_x$
15—19	2·6345	0·092	0·2424	17·5	4·2415
20—24	2·2995	0·248	0·5703	22·5	12·8312
25—29	1·8265	0·249	0·4548	27·5	12·5070
30—34	1·4630	0·201	0·2941	32·5	9·5570
35—39	1·2090	0·140	0·1693	37·5	6·3472
40—44	0·9878	0·058	0·0573	42·5	2·4349
45—49	0·7992	0·012	0·0096	47·5	0·4555
Σ			1·7978		48·3743

$\bar{a}$ = 26·91
C_0 = 5·56

Tab. 17. Vikletice females, middle, late and final phases (sex determined archaeologically, children up to 5 years reconstructed).

x	D_x	d_x	l_x	L_x	e_x	c_x
0	16·0647	0·2886	1·0000	0·8124	20·95	3·88
1— 4	6·9859	0·1255	0·7114	2·5144	28·31	12·00
5— 9	3·7490	0·0673	0·5859	2·7612	30·08	13·18
10—14	2·8667	0·0515	0·5186	2·4642	28·66	11·76
15—19	2·0010	0·0359	0·4671	2·2458	26·55	10·72
20—24	3·0000	0·0539	0·4312	2·0212	23·55	9·65
25—29	3·0000	0 0539	0·3773	1·7518	21·55	8·36
30—34	2·0000	0·0359	0·3234	1·5272	19·73	7·29
35—39	2·0000	0·0359	0·2875	1·3475	16·88	6·43
40—44	2·5000	0·0449	0·2515	1·1455	13·94	5·47
45—49	2·5000	0·0449	0·2067	0·9212	11·42	4·40
50—54	2·7500	0·0494	0·1618	0·6855	8·90	3·27
55—59	2·7500	0·0494	0·1124	0·4385	6·71	2·09
60—64	1·7500	0·0314	0·0630	0·2365	5·01	1·13
65—69	1·7500	0·0314	0·0316	0·0790	2·5	0·38
	55·6673	0·9998		20·9519		100·01

Tab. 18. Tiszapolgár-Basatanya, aeneolithic cemetery, both sexes (age and sex determined anthropologically, children up to 5 years reconstructed). *Cf. Acsádi - Nemeskéri 1970,* 276—277.

x	D_x	d_x	l_x	L_x	e_x	c_x
0	36·078	0·1764	1·0000	0·8853	28·89	3·06
1— 4	18·325	0·0896	0·8236	3·0579	34·00	10·59
5— 9	12·007	0·0587	0·7340	3·5232	33·98	12·20
10—14	8·125	0·0397	0·6753	3·2772	31·72	11·35
15—19	13·125	0·0642	0·6356	3·0175	28·55	10·45
20—24	7·610	0·0372	0·5714	2·7640	26·47	9·57
25—29	9·164	0·0448	0·5342	2·5590	23·14	8·86
30—34	13·921	0·0680	0·4894	2·2770	20·03	7·88
35—39	14·765	0·0722	0·4214	1·9265	17·86	6·67
40—44	12·625	0·0617	0·3492	1·5918	16·04	5·51
45—49	11·388	0·0557	0·2875	1·2982	13·94	4·50
50—54	13·046	0·0638	0·2319	0·9995	11·69	3·46
55—59	10·082	0·0493	0·1680	0·7168	10·18	2·48
60—64	6·318	0·0309	0·1187	0·5162	8·37	1·79
65—69	9·384	0·0459	0·0878	0·3242	5·44	1·12
70—74	6·559	0·0321	0·0419	0·1292	3·67	0·45
75—79	2·013	0·0098	0·0098	0·0245	2·50	0·08
	204·535	1·0000		28·888		100·02

Tab. 19. Demographic parameters of aeneolithic populations: (1) Vikletice males, (2) Vikletice females, (3) Vikletice females, middle to final phases, (4) Tiszapolgár, (5) the same as column 1, reconstructed values, (6) the same as column 2, reconstructed values.

	(1)	(2)	(3)	(4)	(5)	(6)
b	0·0647	0·0455	0·0477	0·0346	0·0542	0·0400
e_0	15·46	21·98	20·95	28·89	18·45	24·97
e_{15}	15·32	22·65	26·55	28·55	18·31	25·64
l_3	0·60	0·67	0·61	0·75	0·60	0·67
l_{15}	0·46	0·55	0·47	0·64	0·46	0·55
$_{10}q_5$	0·20	0·17	0·20	0·13	0·20	0·17
C_0		5·56	5·82	4·10		
C_0^*		3·66	4·28	3·15		3·66
P_0^*		3·55	3·38	3·18		3·55
P_0^{**}		3·92	3·82	3·74		
D_0^*	(0·29)	0·16	0·16	0·11		0·16
$\bar{a}$		26·91	27·54	27·69		
c_{0-14}	54·67	43·65	40·82	37·20		
c_{15-49}	42·83	51·05	52·32	53·44		
$c_{50-\omega}$	2·51	5·29	6·87	9·38		

Tab. 20. Distribution of the Vikletice graves according to grave groups and chronological phases.

	III	IV	V	VI	VII	VIII	IX	III to IX
Early	6	21	—	1	—	15	2	45
Middle	—	7	1	—	5	5	2	20
Late	—	14	11	4	8	13	—	50
Final	—	—	11	4	—	—	—	15
Undetermined	—	12	1	3	7	9	—	32
Sum	6	54	24	12	20	42	4	162

Tab. 21. Distribution of the Vikletice families according to grave groups (I to IX) and relative chronological phases.

Grave group	Phase			
	Early	Middle	Late	Final
I	1 family?	1 family?	isolated grave?	isolated grave?
II	1 family?	isolated grave?	isolated grave?	isolated grave?
III	1 family	—	—	—
IV	1 family 2 families?	1 family	1 family	—
V	—	isolated grave?	1 family	1 family
VI	isolated grave	—	1 family?	1 family?
VII	—	1 family	1 family	—
VIII	1 family	1 family	1 family	—
IX	isolated graves	isolated graves	—	—
Number of families	3—6	4—5	4—7	1—4

Tab. 22. La-Tène cemeteries in Bohemia: adult males.

x	D_x	d_x	l_x	L_x	e_x	q_x
15—19	4·9545	0·0840	1·0000	4·7900	26·02	0·0840
20—24	4·4546	0·0755	0·9160	4·3912	23·17	0·0824
25—29	2·9545	0·0501	0·8405	4·0772	20·03	0·0596
30—34	6·4546	0·1094	0·7904	3·6785	16·14	0·1384
35—39	7·4545	0·1263	0·6810	3·0892	13·33	0·1855
40—44	8·9546	0·1518	0·5547	2·3940	10·80	0·2737
45—49	7·4545	0·1263	0·4029	1·6988	8·93	0·3135
50—54	6·7046	0·1136	0·2766	1·0990	6·86	0·4107
55—59	6·2045	0·1052	0·1630	0·5520	4·90	0·6454
60—64	2·2046	0·0374	0·0578	0·1955	4·26	0·6471
65—69	1·2045	0·0204	0·0204	0·0510	2·50	1·0000
Σ	59·0000			26·0164		

Tab. 23. La-Tène cemeteries in Bohemia: adult females.

x	D_x	d_x	l_x	L_x	e_x	q_x
15—19	2·3636	0·0503	1·0000	4·8742	24·36	0·0503
20—24	4·3636	0·0928	0·9497	4·5165	20·52	0·0977
25—29	6·3637	0·1354	0·8569	3·9460	17·47	0·1580
30—34	8·8637	0·1886	0·7215	3·1360	15·28	0·2614
35—39	6·8636	0·1460	0·5329	2·2995	14·81	0·2740
40—44	1·0303	0·0219	0·3869	1·8798	14·45	0·0566
45—49	1·5303	0·0326	0·3650	1·7435	10·17	0·0893
50—54	7·2803	0·1549	0·3324	1·2748	5·92	0·4660
55—59	6·7803	0·1443	0·1775	0·5268	3·90	0·8130
60—64	0·7803	0·0166	0·0332	0·1245	5·00	0·5000
65—69	0·7803	0·0166	0·0166	0·0415	2·50	1·0000
Σ	47·0000			24·3631		

Tab. 24. Mikulčice, both sexes ("missing" children reconstructed).

x	D_x	d_x	l_x	L_x	e_x	c_x
0	372·2389	0·2789	1·0000	0·8187	21·29	3·84
1— 4	162·4291	0·1217	0·7211	2·5632	28·39	12·04
5— 9	116·0	0·0869	0·5994	2·7798	29·88	13·06
10—14	41·0	0·0307	0·5125	2·4858	29·52	11·67
15—19	62·0	0·0464	0·4818	2·2930	26·24	10·77
20—24	35·0	0·0262	0·4354	2·1115	23·77	9·92
25—29	35·0	0·0262	0·4092	1·9805	20·14	9·30
30—34	58·5	0·0438	0·3830	1·8055	16·34	8·48
35—39	58·5	0·0438	0·3392	1·5865	13·13	7·44
40—44	116·5	0·0873	0·2954	1·2588	9·71	5·91
45—49	116·5	0·0873	0·2081	0·8222	7·73	3·86
50—54	68·5	0·0513	0·1208	0·4758	6·51	2·23
55—59	68·5	0·0513	0·0695	0·2192	4·47	1·03
60—64	12·0	0·0090	0·0182	0·0685	5·03	0·32
65—69	12·0	0·0090	0·0092	0·0230	2·5	0·11
	1334·668			21·2920		99·98

Tab. 25. Hungary, 10th to 12th century AD, model life table (cf. *Acsádi- Nemeskéri 1970,* Table 130).

x	d_x	l_x	L_x	e_x	c_x
0	0·2000	1·0000	0·8700	28·72	3·03
1— 4	0·1080	0·8000	2·9150	34·81	10·15
5— 9	0·0465	0·6920	3·3438	36·03	11·64
10—14	0·0395	0·6455	0·1288	33·44	10·90
15—19	0·0420	0·6060	2·9250	30·46	10·19
20—24	0·0345	0·5640	2·7339	27·54	9·52
25—29	0·0430	0·5295	2·5400	24·17	8·84
30—34	0·0540	0·4865	2·2975	21·09	8·00
35—39	0·0585	0·4325	2·0162	18·41	7·02
40—44	0·0580	0·3740	1·7250	15·90	6·01
45—49	0·0575	0·3160	1·4362	13·35	5·00
50—54	0·0760	0·2585	1·1025	10·81	3·84
55—59	0·0610	0·1825	0·7600	9·21	2·65
60—64	0·0490	0·1215	0·4850	7·58	1·69
65—69	0·0380	0·0725	0·2675	6·02	0·93
70—74	0·0210	0·0345	0·1200	4·89	0·42
75—79	0·0105	0·0135	0·0412	3·61	0·14
80—84	0·0030	0·0030	0·0075	2·50	0 03
Σ	1·0000		28·7150		100·00

SOUHRN

Demografie jakožto společenská věda se zabývá kvantitativní stránkou reprodukce lidské společnosti. Správné představy o demografii ovlivňují prakticky všechny sociologické i historické problémy prehistorie. Demografie pravěku je principiálně řešitelná studiem pohřebišť (pohlaví pohřbených může být často určeno archeologicky, někdy antropologicky; fyzické stáří pouze antropologicky).

Základním pramenem poznání demografie pravěkých populací jsou jejich úmrtnostní tabulky konstruované tzv. Halleyovou metodou. Jejich použití spočívá na předpokladech kompletnosti, uzavřenosti vůči migracím a stacionarity. Předpokladem je dále správné stanovení věku zemřelých (zejména u starších dospělých osob). Pokud tyto předpoklady (zvláště stacionarita) nejsou splněny, dostáváme aplikací Halleyovy metody pouze zdánlivé úmrtnostní tabulky. Pro posouzení reprodukce populací musíme ovšem kromě úmrtnosti znát ještě fertilitu. Důležitou metodou je modelování pravěkých populací, při němž se rozsáhle užívá poznatků o živých společnostech. Zvláštní problematiku v rámci demografie představuje mobilita (tzv. migrace jsou jen jednou její součástí).

Demografické metody jsme se pokusili aplikovat na řadu kosterních sérií středoevropského pravěku počínaje neolitem. V demografických parametrech tohoto období se nezdá být zjistitelný progresívní vývoj. Přirozená úmrtnost byla od neolitu do doby hradištní přibližně stejná; roční hrubá míra úmrtnosti byla spíše 0,04 než 0,05 a v optimálních podmínkách se blížila číslu 0,035. Patnácti let se dožilo asi 2/3 jedinců, ve společnostech s vysokou celkovou úmrtností snad jen 45—55%. Asi polovina obyvatelstva byla v produktivním věku (15—50 let); ve stáří nad 50 let žilo méně než 10% osob. Dětí bylo málo (pravěké populace se udržovaly přibližně ve stacionárním stavu) a tomu také odpovídala malá velikost základních rodin (3—4 osoby). Zvýšení přirozeného přírůstku na 2% bylo vždy možné a mohlo se stát základem migrací.

Hlavní příčinou růstu populací (pokud k němu vůbec došlo) bylo snížení hustoty společenských vztahů. Početní růst pravěkých populací nemůžeme proto považovat za autonomní faktor, který by sám o sobě mohl vysvětlit ekonomické nebo společenské změny či historické události.

РЕЗЮМЕ

Демография — общественная наука о количественной стороне репродукции человеческого общества. Верное представление о демографии влияет практически на все социологические исторические проблемы общества. Демография древнего мира может быть принципиально решена с помощью изучения могильников (пол похороненных часто

может быть определен археолосическим, иногда антропологическим методом; возраст — только антропологическим методом).

Основным источником познания демографии древнего населения являются таблицы смертности, сконструированные так назыв. методом Халлея. Их применение опирается на условиях комплектности, стационарности и исключения миграций. Следующим условием является верное определеление возраста умерших (прежде всего старших взрослых особ). Если же эти условия (особенно стационарность) не выполняются, при применении метода Халлея получается только лишь видимость таблиц смертности. Для суждения о репродукции населения следует, однако кроме смертности, знать также и рождаемость. Важным методом является такое моделирование древнего населения, при котором широко используются сведения о живых обществах. Особенной проблематикой в рамках демографии представляется передвижение (так назыв. миграции являются лишь одной из его составных частей).

Мы попытались применить демографические методы на ряд костяковых серий среднеевропейского первобытного периода, начиная с неолита. В демографических параметрах всего этого периода, кажется, невозможно определить никакой прогресс. Естественная смертность со времени неолита до городищенского периода была приблизительно одинакова; ежегодная смертность примерно была скорее 0,04, чем 0,05, а в оптимальных условиях приближалась к числу 0,035. До пятнадцати лет дожило примерно 2/3 особ, в обществах с высокой общей смертностью, возможно, только 45—55%. Примерно половина населения находилась в продуктивном возрасте (15—50 лет); людей, старших 50 лет, жило менее 10%. Детей было мало (древнее население находилось приблизительно в стационарном состоянии), этому отвечает также невеликость основных семей (3—4 человека). Повышение естественного прироста на 2% было возможно всегда, оно могло стать основой миграции.

Главной причиной роста населения (если он вообще имел место) было снижение густоты общественных отношений. Поэтому численный рост древнего населения нельзя расценивать как автономный фактор, могущий сам по себе объяснить экономические или общественные изменения или исторические события.

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References

Acsádi, Gy. - Nemeskéri, J. 1970: History of Human Life Span and Mortality. Budapest.

Bach, A. 1978: Neolithische Populationen (Weimarer Monographien zur Ur- und Frühgeschichte Nr. 1). Weimar.

Binford, L. R. 1972: An Archaeological Perspective. New York and London.

Buchvaldek, M. - Koutecký, D. 1970: Vikletice. Ein schnurkeramisches Gräberfeld - Vikletice - pohřebiště kultury se šňůrovou keramikou. Praehistorica III. Praha.

— *1972:* Die Interpretation des schnurkeramischen Gräberfeldes von Vikletice — Interpretace pohřebiště se šňůrovou keramikou ve Vikleticích, PA LXIII, 142—179.

Chochol, J. 1970: Die anthropologische Analyse der auf dem schnurkeramischen Gräberfeld von Vikletice geborgenen Menschenreste, in: *Buchvaldek - Koutecký 1970*, 257—283.

— *1979:* Kosterné nálezy ze sídlištních jam knovízské kultury v severozápadních Čechách — Skeltettfunde aus Siedlungsgruben der Knovízer Kultur in Nordwestböhmen, PA LXX, 21—41.

Halley, E. 1693: An Estimate of the Degrees of the Mortality of Mankind, in: *D. Smith* and *N. Keyfitz*, Mathematical Demography, 21—26. Berlin-Heidelberg-New York.

Hassan, F. A. 1973: On Mechanism of Population Growth during the Neolithic, CA 14, 535—540.

Henneberg, M. 1977: Proportion of dying children in paleodemographical studies, PrzA 43, 105—114.

Henry, L. 1976: Population-analysis and models. London.

Neustupný, E. 1978: Mathematics at Jenišův Újezd, in: Das keltische Gräberfeld bei Jenišův Újezd in Böhmen, Bd. II, 38—67. Teplice.

— *1982:* Prehistoric migrations by infiltration, AR XXXIV, 278—293.

Pavlů, I. 1977: K metodice analýzy sídlišť s lineární keramikou — To the methods of Linear Pottery settlement analysis, PA LXVIII, 5—55.

Spiegelman, M. 1955: Introduction to Demography. Chicago.

Stloukal, M. - Vyhnánek, L. 1976: Slované z velkomoravských Mikulčic — Slavjane iz velikomoravskich Mikulčic — Slawen aus dem großmährischen Mikulčice. Praha.

Sussman, R. W. 1972: Child Transport, Family Size and Increase in Human Population during the Neolithic, CA 13, 258—259.

Waldhauser, J. 1979: Konfrontation der anthropologischen und archäologischen Ermittlung von Männer-, Frauen- und Kindergräbern auf keltischen Nekropolen in Böhmen, Anthropologie XVII/1, 55—62.

Weiss, K. M. 1973: Demographic Models for Anthropology (Memoirs of the Society for American Archaeology No. 27).