

Warriors die young: increased mortality in early adulthood of Scythians from Glinoe, Moldova, 4th–2nd c. BC

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Abstract

Scythians were nomadic groups, playing a dominant role on the Eurasian steppes in the Early Iron Age according to many archaeological and historical sources. In this paper, we aim at assessing demographic features and dynamics of a Scythian population from the Black Sea region. We hypothesise that they differed from other societies not only in terms of culture, but also demography: their fertility was lower, and life expectancy higher than in other contemporaneous populations. We examined 220 skeletons from Glinoe (Moldova), dated to the 4th–2nd c. BC, to assess fertility and biological status from life table parameters and basic indicators of the reproductive potential. The main difference between Scythians and other Early Iron Age societies seems to be a higher probability of dying in early adulthood, which could partly result from their engagement in warfare. Scythian fertility was rather low: a finding in line with studies of modern nomads.

Keywords: nomadic populations, Black Sea region, Early Iron Age, fertility, life tables, Bayesian methods

1 **Introduction**

2 Scythians, Iranian-speaking Indo-Europeans, are the earliest nomadic societies about whom
3 solid written accounts are available. In archaeological and historical records their emergence
4 dates back to the seventh century BC. It appears that Scythians had migrated from the Asian
5 steppes, and settled down in the area north of the Black Sea, displacing other nomads, the
6 Cimmerians (Morillo et al. 2008). Notably, the term “Scythian” refers to a chronological and
7 ethno-cultural phenomenon that was common across the Eurasian steppes in the Early Iron
8 Age rather than to any specific populations.

9 At its peak, the territory inhabited by Scythians extended between the Danube River
10 in the west, and the Yenisei River in the east (Parzinger 2007, 2010). Many researchers claim
11 that the core territory of tribes designated as “Scythian” by the written sources of Antiquity,
12 including Herodotus, were the steppes of the northern Black Sea region (North Pontic
13 region), between the lower Danube and Don rivers (Skoryj 2003; Meyer 2016), shown in
14 Figure 1.

15 [Figure 1 here]

16 In the ancient history Scythian communities were viewed as some of the most vivid
17 nomadic groups at that time. Scythians were not only breeders of cattle, horse and sheep, but
18 also warriors, being among the earliest peoples to master the art of horseback riding, and
19 among the best horse-riders of that time. Historical sources have shown them as
20 unconquerable warriors who occupied vast areas of central and western Asia and south-
21 eastern Europe (Piotrowicz 1939; Sulimirski 1954; Phillips 1972; Wendelken 2000;
22 Chochorowski 2004, 2007). The nomadic style of life, fierce inter-tribal relations, highly
23 stratified social structure, and animal-style ornaments were characteristic of the Scythian
24 culture (Kubczak 1978; Parzinger 2007, 2010; Meyer 2016). Scythians, like most nomadic
25 societies, were rather loosely organized in a clan-based structure (Khazanov 1978), but

1 appear to have cooperated in the times of great need such as, for example, during the Persian
2 invasion in 512 BC (Morillo et al. 2008).

3 The literature suggests that the main driving forces of the Scythian expansion across
4 the Eurasian steppes were cultural factors, including their advanced technology, such as using
5 the short reflexive arc while riding, and high social and military organization, with very
6 strong social stratification (see Phillips 1972; Rolle 1989; Melyukova 1995; Olkhovsky 1995;
7 Petrenko 1995; Kardin 2003; Kim 2012; Meyer 2016). However, it can be hypothesised that
8 in order to achieve such a significant advantage over other human groups, Scythians had to
9 differ from them also in terms of their demographic structure (especially through lower
10 mortality and thus longer life expectancy). In the past, domination was closely related to
11 undertaking military actions, and this in turn strongly influenced – and was influenced by –
12 the demographic structure of populations (see Kumar 2012).

13 The impact of warfare on populations is quite well recognized, with substantial and
14 long-lasting effects of armed conflict on demography, although the casual links between
15 demography and war are far from being well understood (Brunborg et al. 2006; Kumar 2012).
16 Some demographic variables, such as life expectancy, adult and infant mortality rates, were
17 found to be useful predictors of political violence leading to warfare (Goldstone 2002). The
18 relationship between demography and war reflects the relative capacity of a given population
19 to defend themselves or to threaten other societies. Thus, population increase and decrease
20 have always been regarded as critical to security (de Bliokh 1977; Mearsheimer 2001).

21 Although research on Scythian burial sites in the region of Pontic steppes has been
22 carried out for over 200 years, there is hardly any information on the biology and
23 demography of those peoples. The vast majority of studies of Scythians have been conducted
24 by archaeologists and historians. They included, among others, analyses of Scythian
25 weapons, burial practices or trade contacts (e.g. Melyoukova 1964; Monakhov 1999; Sinika

2007). Information about Scythian customs, rituals and daily life are provided by written sources, including the early accounts of Herodotus and Hippocrates, and by images present on the items of material culture excavated from the Scythian barrows (e.g. drawings on the vessels from the Kul-Oba kurgan).

In contrast, only a few anthropological articles on the biology of Scythians have been published so far. They include mainly short reports (e.g., Wentz and de Grummond 2007) or studies of basic anthropological characteristics of particular individuals (see Konduktorova 1974; Livinova 1999). This is probably due to the small number of Scythian skeletal remains available for research and/or their poor preservation. So far, anthropological studies were predominantly conducted on Siberian-Scythians from the Altai (Ricaud et al. 2004; Jordan et al. 2009), rather than the Scythians from the Black Sea region.

Paleodemographic studies, based on the age distribution of the deceased, allow for assessing biological characteristics of past populations at the time of their existence. The population parameters being reconstructed include the population size and the level of reproductive success. Under some theoretical and empirical assumptions, these variables describe the biological status of a population and, enable a reconstruction of population dynamics, and thereby changes in the biological status over time. Moreover, knowledge of demographic changes contributes to our understanding of the ecological status of a human group, based on its adaptation to environmental conditions, and also on its cultural status, defined by technological equipment and societal organization (Henneberg 1976; Ward and Weiss 1976; Piontek and Henneberg 1981; Mensforth 1990). Thus, paleodemographic data on the population structure, dynamics, fertility, and mortality patterns can provide significant insight into past human lifestyles and population processes (Chamberlain 2009).

The unsatisfactory state of research on the biology of past populations of nomadic warriors in general, and Scythians in particular, makes further studies exceptionally useful.

Hence, the aim of this study is to contribute to the current state of knowledge by assessing the state and biological dynamics of a Scythian population from the Glinoe site in Moldova. We have tested a hypothesis that Scythians, due to their position and lifestyle, were characterized by relatively low fertility, low mortality and higher life expectancy compared with neighbouring populations from the similar period. Besides, it should be also emphasized that the examined sample is not only a unique osteological series, but also one of the largest collections of the Scythian skeletal remains in Europe. For the first time it was possible to conduct a research on biodemography of Scythians on such a large sample to fill the gap in knowledge about this unique human society.

Material and methods

Material

The osteological material used in this study comes from the Glinoe site, dated from the end of the 4th to the end of the 2nd c. BC (Telnov et al. 2012, 2016). The research was conducted on 220 individuals: 48 subadults and 172 adults (Table 1). The majority of human skeletons, both of adults and children, were incomplete and rather poorly preserved. It could be a consequence of the type of soil in which human skeletal remains were deposited, which was highly acidic *chernozem*, known to have a negative impact on bone preservation (see Watson 1967; Ursu et al. 2014). Moreover, many of the elite Scythian burial sites had been robbed and partly destroyed before the excavations took place (Gerling 2015). In Glinoe, fragments of bones of the skull (cranial vault), shafts of long bones, teeth, vertebrae, as well as fragments of the pelvis (pubic bones) were mostly preserved. The osteological material was preserved enough to determine age-at-death in the majority of individuals, what is essential for biodemographic research. For some individuals, however, we could assess only the lower limit of the age category, e.g. over 20 years.

[Table 1 here]

1 To evaluate fertility and population dynamics of the Scythians from Glinoe, only the
2 individuals with determined age-at-death were taken into account. This narrowed the sample
3 to 197 individuals: 47 subadults and 150 adults. By contrast, the analysis of the probability of
4 survival was performed for the whole population, since this method includes also those
5 individuals with known lower limit of their age range, even though the upper limit may be
6 undeterminable due to the poor state of preservation of the osteological material.

7 *The cemetery*

8 The cemetery, from which the examined sample originates, is located on the left bank
9 of the lower Dniester river, in the Glinoe village, south-eastern Moldova (46°66'84"N,
10 29°80'15"E) . To the present day, only the northern part of the Glinoe burial ground has been
11 preserved, approximately 1.5 km long and 0.35 km wide. In the southern part of the cemetery
12 there are currently residential buildings, and therefore the majority of this area is not
13 available for archaeological research (Telnov et al. 2012, 2016).

14 The burial ground of Glinoe consists of 113 barrows (Telnov et al. 2012, 2016). The
15 chronology of this cemetery was determined on the basis of grave goods found during the
16 archaeological excavations (mainly amphorae and epigraphic data, as well as ceramics and
17 lamps). The functioning of the cemetery can be divided into three chronological periods: the
18 early stage (from the end of the 4th c. BC to the first half of the 3rd c. BC), the middle stage
19 (the second half of the 3rd c. BC to the first quarter of the 2nd c. BC), and the late stage (the
20 second and the third quarters of the 2nd c. BC).

21 The analysis of archaeological material excavated from the Glinoe site, such as
22 weapons, objects of everyday use, jewellery, toiletries, items of worship, and other cult
23 objects, allowed to associate these funerary complexes with the Scythian civilisation (Telnov
24 et al. 2012, 2016). In particular, the animal motifs depicting birds, horses and panthers on
25 these artefacts were typical of the Scythian culture.

Burials and grave offerings

Burial mounds at the Glinoe site varied in terms of their size and the funerary equipment depending on the social status of the buried people. Magnificent burial mounds of distinctive design were built for Scythian nobles, with the equipment emphasizing their privileged position, while the ‘commoners’ were buried in much smaller graves, with scarce tomb inventory, or rarely without any. Most of the barrows excavated at Glinoe contained single graves, less frequent were double graves, and multiple graves occurred sporadically. Burial chambers were located 1–6 m below the ground level. The heads of the deceased were predominantly orientated in the northern direction (82.5%), less frequently to the south (10.0%), and extremely rarely to the east (1.5%) or west (6.0%) (Telnov et al. 2012, 2016).

Almost all the Scythians from the Glinoe site were entombed in the supine position – on the back – and only in three cases the remains were positioned differently. The vast majority of the individuals were buried on a mat made of animal skins or grass, rarely of reeds; occasionally, wooden planks or the bark of trees were used for this purpose. More than 20 individuals had a “pillow” made of grass under their heads; in rare instances were these “pillows” made of felt and clay, or in a form of stone plates (Telnov et al. 2012, 2016).

In the barrows at the Glinoe cemetery different categories of funerary equipment were found: weapons, tools, household items (awls, spindles, needles, lamps), dishes (bowls, jugs, amphorae), harnesses for horses (bridles, clasp), jewellery (bracelets, earrings), garments (buckles, beads, pieces of footwear and headgear), hygiene objects (mirrors), religious and cult objects (incenses and amulets). Only a few burials did not contain any funerary equipment. In most of the graves elements of the Scythian weapons were found: mostly arrowheads, and comparatively rarely, in fewer than 15 graves, axes and spears (Sinika et al. 2014; Telnov and Sinika 2014a, 2014b; Sinika and Telnov 2015a, 2015b; Telnov et al. 2012; 2016).

Archaeological research revealed evidence for the occurrence of human groups settled very close to the Scythian population under study, in the contemporary villages of Chiobruchi and Krasnoe (Sinika et al. 2012). However, the closest neighbors of the Scythians from Glinoe and also their trading partners were Getian tribes, and the inhabitants of the Greek colony of Tiras, located on the Black Sea coast (Samoylova 1988).

Methods

Life table biometric functions

Age-at-death of particular individuals was determined through standard methods applied in physical anthropology (Buikstra and Ubelaker 1994; Scheuer and Black 2000, 2004; Baker et al. 2005; Schaefer et al. 2009; White and Folkens 2005). Age of subadults was assessed on the basis of dental development according to standards proposed by Moorrees et al. (1963a, 1963b) and tabulated by Smith (1991) and Lewis (1999), as well as bone measurements (mainly long bone shafts) and epiphyseal closure using data gathered by Scheuer and Black (2000, 2004), and Schaefer et al. (2009). Age of adults was estimated from pubic symphyseal surface (Todd 1921) and the auricular surface of the ilium (Lovejoy et al. 1985), degree of tooth wear (Lovejoy 1985), as well as cranial suture closure (Meindl and Lovejoy 1985), with the last-mentioned age indicator used when other criteria were not available.

Due to the fact that sex assessment based on morphological features was possible only in a few cases, this variable was not included in this study. However, it should be emphasized that nomadic cultures (hunter-gatherers and pastoralists) featured far less rigid divisions of labour between their male and female members than did the sedentary societies (Streatfield 2016). Moreover, Scythian women were involved in warfare alongside men, as evidenced by both historical sources (Rolle 2006:175; Morillo et al. 2008:105; Mayor 2014:12; Payen 2015) and archaeological data (see Guliaev 2003; Rolle 1989:88, 2006:175, 2011:120). In contrast to Chinggiz Khan's Mongol women, who fulfilled only complementary functions

1 and did not play any central role in military affairs (De Nikola 2010), Scythian women have
2 ridden alongside their men into battle, shooting at their enemy from horseback (Guliaev
3 2003; Fialko 2011; Mayor 2014:83; Worrall, 2014; Streatfield 2016:10). In some prehistoric
4 populations inhabiting Eurasian steppes armed females were buried in as many as 37 percent
5 of the graves (see Mayor 2014:63). For this reason, in the population under study mortality
6 resulting from military actions was probably not as strongly sex-dependent as in other human
7 groups (non-warriors), and hence sex of the individuals who died in armed conflicts most
8 likely did not significantly influence the age-at-death distributions in our sample.

9 The analysis of mortality was performed by using life tables, constructed on the basis
10 of the total number of the deceased by age, assuming a stationary population, and applying
11 classical Halley's method. A detailed methodology for calculating the life table functions for
12 the stationary population model was described by Acsádi and Neméskei (1970). This model
13 assumes a balance between mortality and fertility and thus zero population growth
14 (Chamberlain 2009). The stationary population model for life tables is usually used to
15 describe mortality in a short period of time.

16 With regard to longer periods of time, the assumption of a balance between fertility
17 and mortality does not hold, since no real population is characterized by constant levels of
18 fertility and mortality in the long term (Acsádi and Neméskei 1970; Chamberlain 2009).
19 Therefore, a somewhat more realistic model is the one assuming a stable population, with
20 non-zero growth rate, r . For the stable population model the distribution of the deceased by
21 age x (D_x) was reconstructed by re-building the order of the deceased according to the
22 following formula (Chamberlain 2009; see also Pressat 1961; Holzer 1980):

$$D_x' = D_x (1+r)^x,$$

where D_x' means the number of deaths at age x in a stable population, D_x – the number of deaths at age x in a stationary population, and r – the annual population growth rate.

For the stationary population model we applied two different values of natural growth: one estimated for the examined sample, and one typical for contemporary population with a similar adaptive strategy to Scythians. The first one was estimated on the basis of regression function parameters (after Bocquet-Appel 2002:43) using the share of population between 5 and 20 years of age, $P(5-19) = 0.269$. By applying the estimators of the regression parameters proposed by Bocquet-Appel (2002:64), the r value was computed as 0.0131.

When undertaking the calculations above, one important correction needed to be made. In archaeological samples there is often inadequate representation of deceased subadults, and thus their number does not reflect the actual death rate at this stage of ontogeny, in particular for infants and children aged 1–7 (Konigsberg and Frankenberg 1994; Chamberlain 2009). To avoid errors resulting from the underestimation of the percentage of children who died before age 15, the missing number of children was therefore estimated by using the following equation (Henneberg 1977):

$$d_{0-15} = 1 - \frac{2R_0}{R_{pot} \times U_c}$$

where d_{0-15} is a fraction of deceased children before reaching age 15, U_c is an average number of children born over the reproductive period by women in the population, R_{pot} denotes the potential gross reproductive rate (see below), and R_0 is the net reproductive rate (for the stationary population model $R_0 = 1$). The estimate of $P(5-19) = 0.269$ discussed above is therefore based on the corrected number of children.

The second, alternative value for r was arbitrarily adopted from the literature. There are no demographic data for a group of exactly the same lifestyle as the Scythians (nomadic warriors). Hence, for the purpose of this work natural growth rate for a contemporary

nomadic hunter-gatherer population, the Dobe !Kung tribes, was assumed as $r = 0.002$. The Dobe !Kung, inhabiting Namibia and Botswana, have been selected as being the closest to the Scythians in terms of their ecological strategy, that is unspecialized foraging in arid areas of low productivity (Howell 1979 after Chamberlain 2009; Schutkowski 2006).

Measures of the opportunity for natural selection

The biological status of the Glinoe Scythians was estimated using the measures of the opportunity for natural selection by differential mortality. The potential opportunity for natural selection was assessed by using the following three measures of the reproductive status of a population:

- (1) The Crow index (I_m), which is the ratio of the number of children who failed to survive to the reproductive age (P_d) to the number of children who have reached this age (P_s):

$I_m = P_d / P_s$ (Crow 1958). In the life-table notation, I_m can be re-expressed as:

$$I_m = \frac{d_{0-15}}{l_{15-20}},$$

where d_{0-15} is the fraction of children who died before reaching age 15, and l_{15-20} is the fraction of individuals who reached the onset of the reproductive period.

- (2) The Biological State Index (I_{bs}), determining what fraction of a given generation has a chance to fully participate in the reproduction of the next generation, under a given mortality level in the population (Henneberg and Piontek 1975):

$$I_{bs} = 1 - \sum_{x=0}^{\omega} d_x s_x,$$

where d_x is a fraction of the individuals deceased at the age x , ω is the age of the oldest individual in the group, and s_x is the probability of not completing childbearing for women at age x . The s_x thus captures female deaths before the end of the reproductive

period, and is calculated for women under 50 years. In this study we used s_x values estimated by Henneberg (1975).

- (3) The Potential Reproductive Rate (R_{pot}), which is a similar measure, constrained to mortality of individuals at reproductive age (Henneberg 1975).

$$R_{pot} = 1 - \sum_{x=15}^{\omega} d_x s_x$$

The I_{bs} and R_{pot} values fall within the $[0, 1]$ range. For different age categories the following values were assumed after Henneberg (1975): for 15–20 years, $s_x = 0.95$; for 20–35 years, $s_x = 0.55$; and for 35–55 years, $s_x = 0.07$.

Bayesian models for estimating age

In recent years, bespoke Bayesian statistical methods, developed for estimating age in prehistoric populations, have gained prominence in paleodemography. Notable approaches look at how a measurement of physical features (stages) of the skeletons map onto the age groups for adults (Caussinus and Courgeau 2010; Séguy et al. 2013). In this study, as the age of individuals was determined by using a range of different methods for adults and for children, sometimes used in parallel, an abridged approach was used.

To estimate the age for the Glinoe Scythian population, we propose a multinomial model, which is a simplified version of the approach of Caussinus and Courgeau (2010). We model the distribution of the overall number of deaths, $N = 220$, over the following seven age categories: 0–5, 5–10, 10–15, 15–20, 20–35, 35–50, and 50+, with p_1, \dots, p_7 denoting the probabilities that the age of death for a particular individual belongs to the corresponding group. For the parameters $\mathbf{p} = [p_1 \dots p_7]'$, a Dirichlet distribution was assumed *a priori*, with hyperparameters $\mathbf{a} = [a_1 \dots a_7]'$ referring to ‘pseudo-counts’ – in this case, we assumed that $a_1 + \dots + a_7 = N$, to give the data and the priors similar weight (see e.g. Crooks et al. 2005).

1 In this study, we carried out the analysis *conditional* on the measurement results; in other
2 words, we assumed that the age identification was correct. Additionally, we assumed that the
3 counts for broad age categories, for example adults 20+ were distributed amongst the well-
4 defined groups in proportion to their size. We have tested this assumption by running a model
5 with the counts for broad age groups excluded, and the differences proved to be negligible.

6 The assumptions *a priori* reflect our beliefs about the distribution of deaths before the
7 data from excavations are taken into account. In our case, the model has been estimated under
8 four different specifications of the Dirichlet prior distributions for \mathbf{p} . Firstly, a ‘vague’ prior
9 (P1) was assumed, with $a_1 \dots a_7$ proportional to the width of the successive age classes (5, 5,
10 5, 5, 15, 15, and ca. 10 years). This is a uniform (flat) distribution, aggregated for broader age
11 classes, where skeletons have equal probabilities of being classified into any individual five-
12 year age group. The distribution is referred to as ‘vague’, as it reflects a lack of information *a*
13 *priori* about the age at death for individual remains.

14 Secondly, we have estimated three more informative prior distributions based on the
15 values of q_{0-5} and q_{35-50} for the Glinoe Scythians, by using the indirect methods of
16 estimations described and implemented in a spreadsheet by Timæus and Moultrie (2013). To
17 cover a range of possible shapes of the distribution of deaths by age characteristic of high-
18 mortality populations, we used the Princeton South female standards, smoothed by using
19 either the splicing method (P2), the modified logit model (P3), or the log-quadratic model
20 (P4). The estimated numbers of deaths were then used to calculate the values of $a_1 \dots a_7$ for
21 the distributions (P1) – (P4), by rescaling them so that they add up to $N = 220$.

22 For the last, open-ended age interval (50+) we have assumed that the number of years
23 lived by people in this group is a random variable following a gamma distribution, $\Gamma(19, 1.9)$,
24 with mean of 10 years and 95-per cent probability of being between 6 and 15 years.

Kaplan-Meier method

The survival probability of individuals from different age classes was also estimated by using survival analysis. In general, survival analysis relates to statistical procedures in which a response variable is the time at which a given event occurs. The procedures are based on the probability of surviving between two points in time (Selvin 1998; Liczbińska 2015). The survival function, $S(x)$, gives the probability that a given person survives up to age x .

A commonly-used nonparametric method of survival analysis, which does not require grouping of the time of events into intervals of equal length, is the Kaplan-Meier estimator.

The method is based on a series of points for which the data are available: $x_0 < x_1 < \dots < x_N$, and estimates $S(x)$ for $x_j < x \leq x_{j+1}$ as a ratio of the number of survivors up to age x divided by the number of survivors up to x_j . The method is particularly useful in the case of censored data, when values of measurements or observations are only partially known, as in our study for individuals for whom only the lower age limits are known, e.g. over 20 years.

Additionally, we assumed here that deaths for particular age groups were occurring at mid-points of particular age intervals, which for broad groups, such as 20–35 or 35–50 years, is a very strong and simplifying assumption.

The Kaplan-Meier estimator can be used to compare the survival times of two groups of individuals coming from different social strata. In our case, this could not be done by using a traditional method applying the e_0 parameter of life table, as it was not possible to assess the social status of the majority of Scythian children based on the characteristics of their graves.

Computations

The Kaplan-Meier estimation was performed by using the STATISTICA package (StatSoft, Inc. 2011; STATISTICA version 10, www.statsoft.com), and the Bayesian analysis was done in OpenBUGS, version 3.2.2 (www.openbugs.net). In the case of Bayesian models,

all estimates are based on a sample of 100,000 iterations of the numerical Markov chain Monte Carlo algorithm, after discarding the initial 10,000 as the ‘burn-in’. The OpenBUGS code is available from the corresponding author upon request.

Fertility measures assessed from mortality data

The second component of the biological dynamics assessed within this study was fertility. The parameters of female fertility were estimated based on mortality tables and the natural increase (Weiss 1973; Henneberg and Steyn 1994). The following measures were calculated:

- (1) Mean family size (M), defined as an average number of children born to a woman from a given population, and calculated by using the formula: $M = 2 e^{rT} / l_{15}$, where r is the natural growth rate, T is the mean duration of a generation (in years), and l_{15} is a life-table parameter indicating the proportion of individuals surviving to 15 years of age.
- (2) Mean birth interval (A), defined as the period between successive births expressed in months: $A = 12 e_f / M$. The term e_f is the number of years lived by an adult during the reproductive period, and calculated by using the formula: $e_f = (T_{15} - T_{50}) / l_{15}$ based on standard life-table quantities. M is defined as above.
- (3) Total fertility rate (TFR), defined as the average number of children born to a woman during her whole reproductive period, i.e. between 15 and 50 years of age, approximated as follows: $TFR = 30 M / e_f$; e_f and M defined as above.
- (4) Average age-specific fertility rate (f_x), or the ratio of the number of live births to all women aged x calculated from the length of intergenetic intervals according to the formula: $f_x = 12 / A$, with A defined as above.

Calculations were made according to the formulae constructed by Henneberg and Steyn (1994), modified by the authors to account for different age categories used in this study.

Socio-economic status

The social status of adults was assessed based on archaeological evidence, such as grave offerings, tomb construction and ritual treatment (see Ivantchik 2011). Each individual was categorized into the one out of two social classes: nobles and commoners. Their graves differ mainly in size and construction: the amount of clay excavated during the building of the catacombs for nobles was greater than 20 cubic meters (Figure 2). For both groups the same burial inventory was found in graves – hand-made vessels, weaponry, horse harnesses, toiletries – but gold adornments, pottery, ceramic vessels and amphorae were found only for individuals with higher social status (Figure 3).

[Figure 2]

[Figure 3]

Results

Mortality indicators

As mentioned before, the reconstruction of the biological status of the Scythians was based on data on age at death of 197 individuals whose skeletal remains were recovered from the burial ground in Glinoe. Two models were assumed: the stationary population model ($r = 0$) and the stable population model ($r = 0.002$ and $r = 0.013$). The first stage of the study was to determine the distribution of deaths by age categories in the stationary population (Table 2). Under this model the value of life expectancy at birth (e_0) was estimated as 28.9 years, and that of a 20-year-old adult (e_{20}) – 15.5 years.

This e_0 value is high, but in fact it does not reflect the actual state of the population since it results from the low fraction of individuals dying before the onset of the reproductive age ($d_{0-15} = 19.8\%$). Underestimation of the number of individuals who died in the youngest age categories is also confirmed by the value of l_{0-15} , which indicates that the vast majority of

individuals (80%) survived to the beginning of the reproductive period: very unlikely, given the historical era under study.

[Table 2 here]

The values of life expectancy at birth, e_0 , were subsequently calculated for the stable population model with positive population growth (Table 2). As was expected, the shares of deaths in the younger age categories decreased, and so did the probability of death, leading to a slight increase in life expectancy for each age category. However, the differences in e_0 and e_{20} between the stationary and stable population model are rather small.

Based on these results alone it is not possible to draw reliable conclusions on the demography of the Scythians due to a very low number of subadults in the population. Hence, in the next step, as mentioned in the Methods section, the number of children who died in the age category 0–15 years was estimated according to the model proposed by Henneberg (1977). The method assumes that a woman during her whole reproductive cycle could give birth to 6 children. After correcting the number of individuals, the share of deceased children increased from 19.8% (d_{0-15}) to 53.1% (d^*_{0-15}). Next, the life-table biometric functions were calculated for the stationary and stable population models, taking into account the corrected number of children (Table 3).

[Table 3 here]

Accounting for the number of missing children resulted in a significant decrease of the e_0 estimates, from 29.9 to 19.4 years (assuming $r = 0$), from 29.4 to 19.9 years (for $r = 0.002$), and from 31.8 to 23.06 years (for $r = 0.013$). As was expected, life expectancy of adults, e_{20} , did not change in either model (Figure 4). In addition, after correcting the numbers of children, the probability of death (q_{0-20}) increased, as did the percentage of deceased juveniles (d_{0-20}), while the fraction of adults ($d_{20-\omega}$) declined (Figures 5 and 6).

[Figure 4 here]

1 [Figure 5 here]

2 [Figure 6 here]

3 The measures of the opportunity for natural selection through differential mortality in
4 the population from Glinoe are presented in Table 4. Thus, amongst the Glinoe Scythians
5 approximately 70% of individuals had a chance to survive to the beginning of the
6 reproductive period, as indicated by R_{pot} , but only slightly more than 50% could fully
7 participate in reproduction, as shown by the I_{bs} value. For both models, the values of these
8 two measures are very similar (Table 4).

9 [Table 4 here]

10 The application of the Kaplan-Meier method confirms that, without correction of the
11 number of children, the probability of survival to the age of 15 in this population exceeded
12 80%. In contrast, about 30% of individuals reached the end of the reproductive period (Figure
13 7). The nobles were characterized by a slightly higher survival probability during the period
14 from birth to the 20–35 years age group, as compared with those belonging to the commoners
15 (the highest differences were observed among people in the age groups 15–20 and 20–35
16 years). However, these differences are not statistically significant (Gehan's Generalized
17 Wilcoxon test; $p = 0.6211$). After the age group 20–35, the differences in the survival
18 probability of individuals belonging to different social strata begin to blur (Figure 8).

19 [Figure 7 here]

20 [Figure 8 here]

21 *Uncertainty and sensitivity: Bayesian model results*

22 The Bayesian models introduced above allowed for assessing the uncertainty in the resulting
23 estimates of age, conditional on assuming correct measurements. The analysis also enabled
24 evaluating the sensitivity of the outcomes to the various prior distributions.

As in the deterministic calculations presented before, the undercount of the number of children was corrected, based on the calculations shown in Tables 3 and 4. The increase of d_{0-15} from 19.8% to 53.1% implies that, for the initial value of $N = 220$, the number of deaths in the youngest age classes needs to be inflated ca. five-fold, from 40 to 200. Hence, it was assumed that the multiplicative correction for the numbers of deaths for these age groups is normally distributed with mean of five years and a standard deviation of one year, $N(5, 1)$, so that with 95-per cent probability, the original numbers of deaths need to be inflated between three- and seven-fold.

The results are reported in Figures 9a and 9b in terms of estimates life expectancies at ages 0, 5, 10, 15, 20, 35 and 50. For the estimated probability distributions, the mean values are shown together with 95-per cent probability intervals, for all four priors (P1) – (P4), both with and without the correction for the undercount of the number of children.

[Figure 9a here]

[Figure 9b here]

The mean results under a vague prior (P1) broadly agree with the deterministic calculations reported in Tables 3 and 4, and are similar to those obtained under the log-quadratic prior (P4), especially after applying the correction for children. On the other hand, the results proved sensitive to the choice of the priors: the more informative priors, (P2) and (P3), produce much higher values especially for e_5 and e_{10} , reflecting the relative lack of knowledge about infant and childhood mortality for the reasons discussed before.

An additional modelling exercise has been carried out separately for 176 of the skeletons, for which an approximate period of burial could be established. Given the small numbers of skeletons from the earliest and the latest phases of the exploitation of the cemetery, the errors of estimation were very high. As a result, the patterns of e_x for different

phases were not significantly different from one another. In order to examine the possible differences in life expectancy among Scythians between different historical periods, additional osteological material, for example from neighbouring sites, should be ideally incorporated into the analysis to boost the samples.

Fertility measures

The values of the fertility measures are presented in Table 5. Generally, the Glinoe Scythian population seems to be one with a rather low reproductive potential. The age-specific fertility rates f were low, and the intergenetic intervals A long. The average number of children per woman with a completed reproduction cycle was around 3.49. After the introduction of the natural increase rate into the life table, fertility figures were still at low levels: age-specific fertility rates f hardly changed, and the intergenetic intervals A shortened by 1 or 5 months, depending on the assumption on r . The number of children per woman with a completed reproduction cycle reached almost four (Table 5).

[Table 5 here]

Discussion

Life expectancy (e_x), which captures the central tendency of longevity in an examined sample (Daugherty and Kammeyer 1995), not only summarizes the mortality experience of the entire population, but it is also a useful measure for comparing different life table models (Chamberlain 2009). In the Glinoe Scythian population, the deterministic estimates of the life expectancy at birth (e_0) without correcting for the undercount of children were between 28.9 and 31.8 years, depending on the assumed growth rate r , while e_{20} ranged between 15.5 and 16.9, respectively. However, due to a very low percentage of subadults aged under 15 years (19.8%), the e_0 values are unreliable. Realistically, total subadult mortality is expected to range between 30 and 50 percent (or even 70%) for archaeological populations (Weiss 1973,

see also Lewis 2007). Thus, it seems very unlikely that only less than 20% of children from the sample studied died before the age 15. Importantly, the population under study comes from the Early Iron Age, when the medical care only slightly – if at all – could have limited mortality of children, the most vulnerable section of a population.

The literature has widely reported insufficient number of subadults in skeletal samples (Henneberg 1977; Lovejoy et al. 1977; Piontek 1977; Mensforth 1990; Meindl and Russell 1998). This is, among others, due to the fact that child remains are much more fragile than that of adults, and therefore are easier to degrade than the mature skeletons (Lewis 2007). In the case of our sample poor preservation of bony remains could have also resulted from contemporary plundering of the Scythian graves in Glinoe for gold, and from highly acidic soil in which these individuals were buried (see Watson 1967; Ursu et al. 2014). After correction of the missing number of children the value of d_{0-15} increased 2.7-fold: from 19.8% to 53.1%, reaching similar levels to those obtained in other studies, and fitting very well the range of variability of this parameter for the Iron period (between 45% and 58%; Budnik and Henneberg 2009). The correction of the missing number of children also resulted in a decrease of the e_0 parameter by nearly 10 years: from 28.9 years to 19.4 years ($r = 0$). In contrast, this correction did not substantially affect the value of e_{20} since it is not susceptible to the influence of the underestimated number of children.

The use of Bayesian methods has additionally enabled assessing the errors and sensitivity in the estimates of life expectancy, as presented before. There are several important implications of the findings from the Bayesian analysis. Firstly, the errors of the estimates are relatively high, even without taking measurement uncertainty into account. Secondly, the estimates are very sensitive to the choice of prior distributions and to additional assumptions, such as those on the undercount of children or the value of e_{50} . This is not surprising, given the low numbers of skeleton in many age classes (Table 1). On the other

hand, the main advantage of Bayesian methods is that they provide an assessment of the uncertainty of the estimates, as demonstrated in Figures 9a and 9b.

In terms of e_0 and e_{20} , the Scythian population was also compared with populations from earlier and from the same historical periods, and with those from similar geographical areas (Europe) (Table 6). Importantly, these are not societies that could have been even hypothetically conquered by Scythians (e.g., Assyria, Media or Urartu; Petrenko 1995:18). Unfortunately, there is no opportunity to compare the data on the demographic structure of Scythian groups and the populations dominated by them, because no demographic data are available for any conquered populations. One clear limitation of such comparative studies is related to making comparisons between the populations which differ in lifestyle, subsistence economy (populations defeated by Scythians were mainly farmers), biology, and so on. Also, certain a priori assumptions, which are unavoidable in plaeodemography (e.g. value of the s_x parameter), make the analysis of the results and drawing definitive conclusions difficult.

As it can be seen, without correcting for the undercount of children, the population of Glinoe has been characterized by relatively high values of e_0 . Similar values were obtained for the populations from a similar period, for example for S'Illot des Porros (Spain) (Alesan et al. 1999), and slightly lower values for the Scythians from Mamai-gora (Ukraine) (Litvinova 2004), but it has to be noted that in these studies, the undercount of the number of children was not corrected. Interestingly, for the Scythians from Glinoe and those from Mamai-gora the relatively low values of life expectancy of adults (e_{20}) were reported. As argued before, this could have resulted to some extent from the lifestyle of Scythians.

Scythians appear in the history as nomadic warriors who conquered large areas, especially in central and western Asia, as a result of many wars (Piotrowicz 1939; Phillips 1972; Kubczak 1978; Petrenko 1995:18; Wendelken 2000). Thus, the relatively low value of e_{20} could have resulted partly from the excess deaths among adults because of their

1 participation in military operations. This interpretation is supported by an increase of
2 probability of death after age 20 (see Tables 6 and 7) as well as a decrease in survival
3 probability after this age (see Figure 9). Amongst the Glinoe Scythians, young adults had a
4 relatively high risk of death, as recorded for different life table models (see Tables 2 and 3).
5 [Table 6 here]

6 Furthermore, it seems unlikely that poor health was the main cause of death of adults in
7 the population under study, which was confirmed by the analysis of skeletal indicators of
8 health status. In the examined sample the following frequencies of stress markers were found:
9 linear enamel hypoplasia – 31.0%, cribra orbitalia – 28.2%, porotic hyperostosis – 2.7%, and
10 Harris lines – 29.4% (Łukasik 2015). Low values of stress markers' prevalence, as compared
11 with other populations from the same period, can be seen as evidence a relatively good health
12 in the group under study (e.g. Goodman et al. 1980; Lanphear 1990).

13 However, an alternative interpretation of the skeletal lesions, based on the idea of
14 osteological paradox (Wood et al. 1992; Arcini 1999), cannot be excluded. According to
15 Wood et al. (1992), stress markers might have occurred in relatively healthy individuals, who
16 were able to survive long enough for bone or tooth changes to form, which usually takes
17 weeks or months. According to DeWitte and Stojanowski (2015), to avoid the osteological
18 paradox, multiple markers of stress should be used, because they provide information about
19 different periods of life of individuals and suggest the presence of slightly different stress
20 factors (Salvadei et al. 2001). Moreover, these authors highlight that the relationship between
21 the demographic structure and the presence of stress markers also should be considered, and
22 that both adults and children should be analysed. Furthermore, only a close interdisciplinary
23 cooperation and a thorough archaeological context can provide a reliable interpretation of the
24 results. Such approach was applied in the research of the Scythian population under study.

1 It should be emphasized that stress markers are very general measures of health,
2 reflecting the occurrence of only certain diseases, since not all disorders leave changes on
3 bones, like e.g. smallpox or measles (Lewis and Roberts 1997; Steckel and Rose 2003; Ortner
4 2003). However, it can be assumed that had the studied group experienced such diseases,
5 then the whole population should have been affected (individuals in all age categories), not
6 just young adults, who are by definition the strongest in the group, being immunologically
7 resistant (see Elgert 2009:65).

8 Hence, if Scythians were characterised by relatively good health, the increased
9 mortality of adults could be a consequence of their lifestyle, marked by conflicts and warfare.
10 In the case of past human populations conducting numerous wars (like Scythians) a relatively
11 high frequency of skeletal evidence of violence, such as injuries or trauma, can be expected
12 (see Walker 1989; Owens 2007; Mayor 2014; Martin and Harrod 2015). However, it was
13 impossible to perform such kind of research in our sample, because the skeletal material was
14 not preserved well enough.

15 The measures of the opportunity for natural selection in the group under study do not
16 differ significantly from the data obtained for selected human populations from a similar
17 period (Piontek 1979; Budnik and Henneberg 2009) (Table 7). For the Glinoe Scythians the
18 value of Crow's index I_m is slightly over 0.20, confirming low mortality among children. The
19 I_{bs} and R_{pot} indices show that 50% of the whole population studied, and 70% of adults, had a
20 chance to fully participate in reproduction.

21 The measures of fertility indicate rather low reproductive potential of Scythians: they
22 are distinguished by a relatively small number of children per woman with completed
23 reproductive cycle, and long intervals between successive births. In the Glinoe sample, low
24 fertility and hence long birth-spacing intervals, resulting in low population growth rates, are
25 most probably consequences of their way of life: nomadism and high mobility. Low fertility

1 is highly adaptive and therefore is the norm for mobile groups (see Whitley and Dorn 1993),
2 leading to a better food supply for the mother and concomitantly the child, which in the long
3 run means a higher survival rate of the offspring (Schutkowski 2006:212).

4 The reproductive strategy discussed above is typical of contemporary nomadic
5 populations. It has been well known and well documented in the literature that nomadic
6 pastoral populations have lower natural population growth rates than sedentary farming
7 societies (e.g. Henin 1968, 1969; Swift 1977; Roth 1986, 1994; Bentley et al. 1993; Randall
8 2008). This phenomenon is seen in such pastoral populations as the Tuareg and Maures
9 (Randall 1984) or for the Sudanese Baggara population (Henin 1968, 1969). Lower fertility
10 in free-living nomadic groups has been also reported by Steckel and Rose (2003), in which
11 the gross reproduction rate value was around 2.5, in contrast to 3–4 for sedentary groups. For
12 the south Sinai Bedouins the mean number of living children per family was around five
13 (Leonard and Crawford 2008).

14 Finally, it is also worth emphasizing that in polygamous societies an average woman
15 bears fewer children (on average four) than in monogamous ones (around five) (Leonard and
16 Crawford 2008). According to the Herodotus descriptions (Minns 2011), not only the
17 Scythians were the populations of pastoral character, but they had polygamous relationships.
18 This could also influence their low reproductive potential. Additionally, low fertility level is
19 an adaptive strategy for warrior populations, as described by Gould (2015) for a modern
20 African pastoral society, the Kipsigis. Traditionally, the Kipsigis remained unmarried until
21 their mid-twenties and had long birth intervals, but in the 20th century their fertility rose
22 sharply, after they have ceased their warfare activities.

23 The most interesting finding of our research is the relatively high risk of death in
24 young adulthood, plausibly a result of warfare. However, it raises a question how Scythians
25 managed to dominate over other groups on the Eurasian steppes if there were characterized at

1 the same time by high adult mortality and low fertility, and how they maintained their
2 fighting strength.

3 One possible explanation could be the recruitment of local people into the Scythian
4 army, especially in the regions where they have direct contact with e.g. Thracians or
5 Meotians (see Melyoukova 1979). Such a strategy was common among other past human
6 societies with a successful military track record, like the Roman Empire (Delbruck 1990) or
7 the Macedonian Empires (Ashley 1998). Moreover, the same phenomenon was also found for
8 the British, during their rule in India, who had a lower fertility rate than the local populations
9 (see Marshall 2001:283–84; Roy 2013). This hypothesis could be also supported by Meyer’s
10 (2016:1) recent interpretation of the “Scythian Empire”, whereby “the power of nomadic
11 tribes in the region was based on the armed administration of an extensive exchange network
12 that integrated the services and resources of different local communities.”

13 Unfortunately, there are no written sources which could confirm this hypothesis, but
14 Scythian funeral inventory suggests that such an explanation is at least reasonable, because a
15 series of Scythian burials with one bladed swords of the Thracian type can be interpreted
16 either as a Thracian influence on Scythian weaponry (see Melyukova 1979; Redina 2005;
17 Sinika 2007), or – possibly – as an indication of recruiting Thracians into the Scythian
18 armies. Hence, the recruitment of local people into the Scythian army cannot be excluded, at
19 least as a hypothesis, until more definitive archeological and historical material can be found.
20 In particular, since it was not unconceivable that the Scythians could recruit local people into
21 their army to maintain fighting strength despite high adult mortality and low fertility, it would
22 be worthy to examine if individuals ascribed in this study to commoners could have been
23 outsiders recruited by the Scythians. For this reason, future anthropological studies on
24 Scythians could carry on the analysis of biodistance markers of individuals from lower social
25 status using ancient DNA or dental non-metric traits.

Conclusions

In terms of biodemographic features the Scythian population from Glinoe did not differ significantly from other human groups from the Early Iron Age, with the exception of higher probability of dying in early adulthood, as indicated by various estimates of the life table parameter q_{20} . These results suggest that the demographic structure could depend to some extent on their lifestyle, including conflicts and wars, significantly contributing to high mortality of young adults, despite their relatively good health. Fertility in this group, reconstructed on the basis of life table parameters and the estimated population growth, was low, which is typical of nomad populations.

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Figure captions

Figure 1. Map of the Scythian core territory (grey) and area of their presumable influences (dotted line) with the location of Glinoe. Cartographic data: openstreetmap.org, ©

OpenStreetMap contributors, Open Database License (ODbL)/Creative Commons CC-BY-SA 2.0.

Figure 2. Scythian barrows containing individuals of different social status: a) nobles, b) commoners

Figure 3. Barrow 103 burial 1, Glinoe site, Moldova; 1a – handmade cup with iron knife and animal bones ; 1b – handmade bowl with 2 spindle whorls (inside and nearby); 2a – bronze bracelet; 2b – glass beads, 3a – silver earring; 3b – bronze mirror with iron handle, 4a – glass beads; 4b – glass beads

Figure 4. Life expectancy e_x in the Scythian skeletal sample (r – value of population growth, [corr] – correction of number of children)

Figure 5. Probability of death (q_x) in the Scythian skeletal sample (r – value of population growth, [corr] – correction of number of children)

Figure 6. Distribution of the deceased (d_x) in the Scythian skeletal sample (r – value of population growth, [corr] – correction of number of children)

Figure 7. Survival probability in age categories

Figure 8. Survival probability by social status

Figures 9a and 9b. Life expectancy estimates obtained by using Bayesian models under different assumptions a priori: Mean values (solid lines) and 95-per cent intervals (dashed)

Table 1. Population size by the number and percentage of the deceased in age categories

Age category	<i>N</i>	%
Subadults		
Infans I (0–7 years)	26	11.8
Infans II (7–15 years)	13	5.9
Juvenis (15–20 years)	8	3.6
unknown (under 20 years)	1	0.5
Adults		
Young adult (20–35 years)	84	38.1
Middle adult (35–50 years)	54	24.5
Old adult (50+ years)	12	5.5
unknown (over 20 years)	22	10.0
Total	220	100.0

Table 2. Life-table biometric functions for Scythian skeletal remains from Glinoe (without correction of number of children)

Age	Stationary population model				Stable population model ($r=0.002$)				Stable population model ($r = 0.013$)			
	d_x	l_x	q_x	e_x	d_x	l_x	q_x	e_x	d_x	l_x	q_x	e_x
0–7	13.2	100.0	0.1	28.9	12.5	100.0	0.1	29.4	9.3	100.0	0.1.	31.8
7–15	6.6	86.8	0.1	25.8	6.4	87.5	0.1	26.1	5.1	90.7	0.1	27.7
15–20	4.1	80.2	0.1	19.6	4.0	81.1	0.0	19.8	3.4	85.6	0.1	21.1
20–35	42.6	76.1	0.6	15.5	42.5	77.1	0.6	15.7	41.1	82.1	0.5	16.9
35–50	27.4	33.5	0.8	10.7	28.2	34.6	0.8	10.8	32.1	41.1	0.8	11.3
50– ω	6.1	6.1	1.0	10.0	6.5	6.5	1.0	10.0	9.0	9.0	1.0	10.0

r - the natural growth rate

Table 3. Life-table biometric functions for Scythian skeletal remains from Glinoe (with correction of number of children)

Age	Stationary population model				Stable population model ($r = 0.002$)				Stable population model ($r = 0.013$)			
	d_x	l_x	q_x	e_x	d_x	l_x	q_x	e_x	d_x	l_x	q_x	e_x
0–7	35.4	100.0	0.4	19.4	34.3	100.0	0.3	19.9	28.1	100.0	0.3	23.1
7–15	17.7	64.6	0.3	21.1	17.4	65.7	0.3	21.5	15.5	71.9	0.2	23.7
15–20	2.4	46.9	0.1	19.6	2.4	48.3	0.0	19.8	2.3	56.4	0.1	21.1
20–35	24.9	44.5	0.6	15.5	25.3	46.0	0.6	15.7	27.2	54.1	0.5	16.9
35–50	16.0	19.6	0.8	10.7	16.8	20.6	0.8	10.8	21.2	27.1	0.8	11.3
50– ω	3.6	3.6	1.0	10.0	3.9	3.9	1.0	10.0	5.9	5.9	1.0	10.0

r - the natural growth rate

Table 4. Measures of opportunity for natural selection through differential mortality

Population model	I_m	R_{pot}	I_{bs}
Stationary; $r = 0.000$	0.25	0.71	0.51
Stable; $r = 0.002$	0.21	0.71	0.52
Stable; $r = 0.013$	0.17	0.72	0.57
I_m - Crow index, R_{pot} - Potential Reproductive Rate, I_{bs} - Biological State Index			

Table 5. Fertility figures for the Scythian population from Glinoe

Population model	f	A (months)	M	TFR
Stationary; $r = 0.000$	0.15	82.56	2.49	3.49
Stable; $r = 0.002$	0.15	81.62	2.53	3.54
Stable; $r = 0.013$	0.16	76.55	2.73	3.81

f - average age-specific fertility rate, A - mean birth interval, M - mean family size, TFR - total fertility rate

Table 6. Life expectancies at birth, e_0 , and in early adulthood, e_{20} (in years) from Early Iron Age populations (stationary population model, without correction of the number of children)

Site and dating	e_0	e_{20}	Data source
Glinoe, Moldova (4th-2nd c. BC)	28.9	15.5	Authors' calculations
Pontecagnano, Compania, Italy (7th-6th c. BC)	15.3	–	Lombardi Pardini et al. 1984
Classic period (Athens & Corinth), Italy (6th-3rd c. BC)	24.7	–	Angel 1969
Pantanello, Greek colony (7th-2nd c. BC)	21.2	20.6	Henneberg and Henneberg 2000
Mamai-gora, Ukraine (3rd-2nd c. BC)	26.9	15.8	Litvinova 2004
S'Illot des Porros, Spain (4th c. BC-2nd c. AD)	28.5	17.5	Alesan et al. 1999

Table 7. Measures of opportunity for natural selection in skeletal samples from Early Iron Age (stationary population model)

Site	N	d_{0-15}	R_{pot}	I_{bs}	Data source
Glinoe (Moldova)	197	0.19	0.71	0.51	Authors' calculation
Sultana (Romania)	118	0.30	0.75	0.44	Piontek 1979
Trzebule (Poland)	56	0.36	0.67	0.40	Piontek 1979
Zamęczno (Poland)	36	0.20	0.70	0.42	Piontek 1979
Przeczyce (Poland)	606	0.36	0.63	0.38	Piontek 1979
Częstochowa-Raków (Poland)	56	0.22	0.64	0.39	Piontek 1979
Kozia Góra (Poland)	75	0.33	0.72	0.43	Piontek 1979
Baczyna (Poland)	66	0.18	0.71	0.43	Piontek 1979
Ziemięcice (Poland)	40	0.20	0.69	0.41	Piontek 1979
Czech Republic/Slovakia	227	0.17	0.67	0.50	Piontek 1979