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Pagan-Christian Change in Northeastern Hungary in the 10^{th}–13^{th} centuries AD – A Palaeodemographic Aspect

István János[1], László Szathmáry[2] and Lajos Hüse[3]

[1] Institute of Environmental Science, College of Nyíregyháza, Nyíregyháza, Hungary
[2] University of Debrecen, Department of Evolutionary Zoology and Human Biology, Debrecen, Hungary
[3] University of Debrecen, Faculty of Health Science, Department of Social Science, Nyíregyhaza, Hungary

A B S T R A C T

In the present paper the authors compared skeletal populations (2421 individuals) excavated from four cemeteries, namely Hajdúdorog-Gyúlás (10^{th} century AD), Hajdúdorog- Temetöhegy (11^{th} century AD), Hajdúdorog-Katidülö (12^{th}–13^{th} century AD) and Hajdúdorog-Szállásföld (12^{th}–13^{th} century AD) from a micro-region of Northern Hajdúság (located in the northern part of the Great Hungarian Plain in Hungary in the Carpathian Basin) based on demographic data. The cemeteries were dated to the age of the Hungarian conquest and the Arpadian age and provided representative data for anthropological research. Previous studies based on craniological and archaeological investigations have already suggested that there was discontinuity in the population history between the 10^{th} and the 11^{th} centuries AD and continuity between the 11^{th} and 12^{th} centuries AD in this region. This hypothesis could be partially supported by demographic investigations because conclusive evidence was found that there must have been a change in the population at the turn of the 10^{th} and 11^{th} centuries AD, and there was certain continuity between the 11^{th} and 12–13^{th} centuries AD. The authors suppose that there were two crises in the examined period: the first crisis set in at the transition from the pagan era (10^{th} century AD) to the Christian era (from the beginning of the 11^{th} century AD, with population resettlements within the Carpathian Basin), the second might have been more moderate and meant burying the dead of the populations lacking a church in the churchyards of villages which had a church. At that time one graveyard around a church may have been used by several village populations.

***Key words**: palaeodemography, pagan, Christian, 10^{th}–13^{th} centuries AD, skeletal populations, Hungary*

Introduction

Palaeodemographic reconstruction of past populations is one of the most important subjects in the field of biological anthropology. However, there are some problems of research especially due to lack of data about sex, age at death, cause of death and infant underrepresentation. Consequently, the reconstruction and the relationships determined between the skeletal remains and the ancient biological populations based on demographic data may not always be reliable[1–3]. The representativeness of the cemeteries is a very important condition and the number of skeletons to be examined for a suitable palaeodemographic reconstruction should be high[4]. For decades, palaeodemography has been a widely used practice in the field of physical anthropology to understand the life quality and mortality features of past populations[5–12].

Despite all the problems arising under research, the demographic structure of a skeletal population can shed light on alterations caused by factors determining cultural, historical and adaptive changes in ancient populations[13]. It is known that the change in the way of life of a given population can be reflected in the demographic parameters[14,15].

Fortunately, we managed to have a momentous osteological database from a micro-region of Northern Hajdúság (located in the northern part of the Great Hungarian Plain in Hungary in the Carpathian Basin), from where

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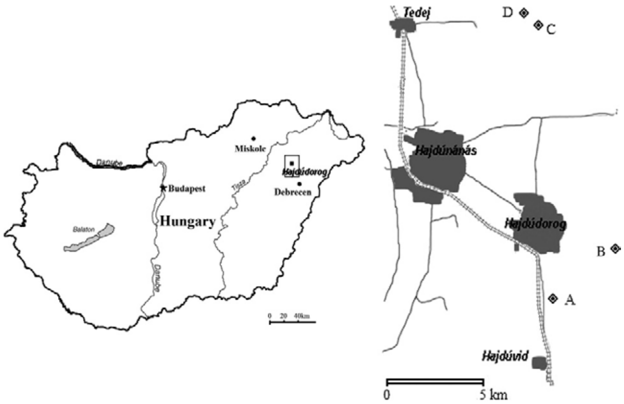

Fig. 1. Location of the excavated sites described in the study. A – Katidûlõ site, B – Gyúlás site, C – Temetõhegy site, D – Szállásföld site.

skeletons of four fully excavated cemeteries were available[16]. The skeletal finds were excavated at sites around the town of Hajdúdorog from 1977 to 2005 (Figure 1).

Hajdúdorog-Gyúlás cemetery (10th century AD) located 3 km east of the town of Hajdúdorog is fully excavated, without any loss of graves. Hajdúdorog-Temetöhegy cemetery (11 km north of the town) was started in the 940s AD (though only few graves could be dated to this earliest period) and the population might have increased in the 11th century AD, as the high number of graves in that period indicated it. There is evidence that this cemetery was even used at the beginning of the 12th century AD. The loss of graves could be estimated 30%, the majority of the skeletons (more than 90%) could be dated to the 11th century AD. Hajdúdorog-Szállásföld (12th–13th century AD), a fully excavated graveyard around a church with more than 1200 graves, is located in the neighbourhood, only 500 m northwest of Hajdúdorog--Temetöhegy site. It was used from approximately 1141 AD to 1235 AD. Another cemetery in the same period (Hajdúdorog-Katidülö), located about 2 km south of the town of Hajdúdorog could only be examined up to 80–90% because a few graves were pillaged by harriers. This graveyard was also used from about 1141 AD to 1235 AD. The preservation state and decomposition level of skeletal remains are similar on the average in each cemetery. These are due to the following reasons: 1) the excavation area is relatively small with similar soil conditions (loess soil in each site), 2) the excavated sites lie near each other (the distances between them are only 1–20 km) (Figure 1), 3) the grave depth has not varied considerably over the four centuries, it ranges between 60 cm and 160 cm beneath the present ground surface. According to archaeological and historical evidence, the region might have been depopulated after the Mongolian invasion (1241 AD)[16].

Previous studies on these series were based on mainly craniological and skeletal investigations; many of them already suggested that there was discontinuity in the population history between the 10th and the 11th centuries AD and continuity between the 11th and 12th centuries AD (with close relationship between Temetöhegy and Szállásföld sites) in this region[17,18]. Earlier, only Hajdúdorog-Temetöhegy was examined from a palaeodemographic and palaeopathologic point of view[19,20].

The examinations of other cemeteries dated to the 10th century AD and 11th century AD, pointed out that the population structure seemed to be significantly transformed at the turn of the two centuries in the Carpathian Basin. It might have been connected with the establishment of the Hungarian Kingdom and the set in of the Christian era after pagan times. It definitely must have been a sharp historical turn for the Hungarian conquerors' population consisting of various Finno-Ugric and Turkic ethnic groups, who started to migrate from the Eastern European steppes into the Carpathian Basin in Central-Europe in 895 AD. Most papers dealing with this subject-matter initially relied on demographic data and took anatomical and human ecological evidence into consideration only afterwards, so putting forth the hypothesis mentioned above[21–24].

Some of these previous studies managed to reconstruct two types of population development structures: according to the first, which is called »Ibrány type«, there was discontinuity in the population history between the 10th and the 11th centuries AD, while the second, which is named »Püspökladány type« development, refers to a continuous transition in the population history through the two centuries[19–22].

Considering the above-mentioned thoughts, we were inquisitive about what kind of relationships might have existed, from a palaeodemographic point of view, among these four ancient populations, which either followed each other chronologically or lived in the same age in this region. To sum up, skeletal remains were used to examine whether historical, religious changes and changes in the way of life were reflected in the demographic parameters of these ancient populations.

Materials and Methods

Skeletal findings belonging to 2421 individuals excavated from the above-mentioned sites with high representativeness constituted the basis of our examination (Table 1).

The morphological sex determination of the individuals was carried out by using the recommendation suggested by Éry et al.[25]

For the sub-adult individuals, the age determination based on dental development, degree of epiphyseal union, ossification of bones and diaphysis length of long bones was performed following the classic instructions proposed by Schour and Massler, Johnston and Stloukal and Hanáková[26–28]. For the adult skeletons, we applied the combined methods of Acsádi and Nemeskéri, Nemeskéri et al. and Sjøvold[5,29,30]. Since sexual dimorphism is not always evident in immature skeletons, we decided to determine the minimum limit of the adult class at 23 years of age and the upper limit at 80 years of age. Conse-

TABLE 1
THE AGGREGATE DATA OF THE FOUR TESTED CEMETERIES

Name of site	Archaeological Period	Code	Sub-adults	Males	Females	Total
Hajdúdorog-Gyúlás	10^{th} century AD	Hdg	28	16	12	56
Hajdúdorog-Temetöhegy	11^{th} century AD	Hdt	240	166	206	612
Hajdúdorog-Katidülö	12^{th}–13^{th} century AD	Hdk	250	220	209	679
Hajdúdorog-Szállásföld	12^{th}–13^{th} century AD	Hds	483	285	306	1074
Total			1001	687	733	2421

quently, in a few cases when we could give an individual an age interval which overlapped between the sub-adult and adult age groups we made a correction (e.g. when the age at death of an individual was determined 19–26 years, we corrected it to 23–26) in order to avoid the appearance of values of statistically fragmented individuals between the sub-adult and adult age groups in the mortality rates of life tables (Tables 2, 3, 4 and 5). Henceforward, we refer to the individuals less than 23 years of age as sub-adults and the individuals from 23 to 80 years of age as adults.

Taking account of the previous viewpoints, the following parameters were considered here: sex ratio, mortality rate (d_x) and life expectancy (e_x) separately for the two sexes and the total populations, using the life tables created by DEMOGRAF software[19]. Additionally, we analysed the individuals' aggregate mortality rate in childhood (infans I–II stadiums, d_{0-14}) and the characteristics of the mortality median (l_x=50, age at death where the 50% of the given population deceased). The life tables were created by following the palaeodemographic aspects used widespread[5] and we analysed the mortality data yearly (less than 1 years, 1 years, 2 years etc.) in order to get an appropriately precise review about the populations' life history. Apart from the case of 0-year-old infants, we could not determine the age at death to a given year (only age intervals could be given), thus for the sake of statistical correctness, the mortality data consist of fragmented individuals in the tables. According to Alesan et al.[11] the ideal conditions for palaeodemographic analysis are: 1) only one population, community, or group used the cemetery from which the skeletal remains were excavated, and this population did not concurrently use other cemeteries. 2) all individuals from that community were buried in the cemetery. 3) the archaeological excavation was complete, and anthropological recovery was exhaustive and not differential and 4) entrances by birth balanced exits by death, and there were no differences between these events in terms of age or sex. These conditions are given fast fully, but some uncertainty are involved due to the loss of graves in Temetöhegy and Katidülö sites, the possible use of Szállásföld graveyard by several populations as well as the relative low number of the individuals in the case of Gyúlás site. Nevertheless, it can be worthy of note that a cemetery with 56 individuals may be regarded as a representative sample in the 10^{th} century AD in Northern and Eastern Hungary since the average grave number ranges around 30–40 in the pagan period probably due to the semi-nomadic way of life[31]. Here, we assumed that these skeletal populations were representative of the past living populations and presumed that they are stationary. No corrections were made for the natural increases.

χ^2 tests were done to compare the sex ratios of the populations and to confront the infantile mortality rates with the expected (model) rates[32]. Kolmogorov-Smirnov test was applied so that we could estimate relationships between the four ancient populations based on life expectancy and mortality rates of adults (above 23, two sexes pooled, males and females)[33]. This method is a general non-parametric test which is able to compare two empirical functions of two samples. All statistical tests were done by using SPSS for Windows software.

Results

We managed to determine and analyse 2421 individuals in the four archaeological sites. Approximately half of the examined individuals (41.3%) belonged to the sub-adult group. Within this group, the mortality rate in childhood (infans I–II. stadiums, d_{0-14}) was 44.7% in Gyúlás, 30.3% in Temetöhegy, 32.3% in Katidülö and 34.9% in Szállásföld (Table 4). Basically, it could be concluded that these percentages were except for Gyúlás population (χ^2 at 5% level), (χ^2=0.425, p=0.514, df=1 for Gyúlás; χ^2=84.796, p<0.001 df=1 for Temetöhegy; χ^2= 76.201, p<0.001, df=1 for Katidülö; χ^2=85.247, p< 0.001, df=1 for Szállásföld, regarding the East, 5^{th} level model life table, where d_{0-14}=48.8%; and χ^2=0.013, p= 0.909, df=1 for Gyúlás; χ^2=55.6083, p<0.001, df=1 for Temetöhegy; χ^2=47.343, p<0.001, df=1 for Katidülö; χ^2=47.620, p<0.001, df=1 for Szállásföld, regarding the West, 5^{th} level model life table, where d_{0-14}=45.4%) were significantly lower than the values of the models proposed by Coale and Demény[32] used as a rule for the age of the Hungarian conquest and the Arpadian age. However, models, as it follows from their features, do not represent the historical demographic status of the concrete populations precisely, therefore we did not make corrections for the infantile skeletons in the life tables.

It is well known that the burial customs have also changed between the pagan (until 10^{th} century AD) and Christian era (from the 11^{th} century AD) in the Carpathian Basin, which manifested in the grave furnishing. In the pagan times, the graves of 0–8-year-old children

TABLE 2
DISTRIBUTION OF THE LIFE EXPECTANCY IN THE FOUR EXAMINED POPULATION SAMPLES –TOTAL POPULATIONS

x	e_x			
	Hdg	Hdt	Hdk	Hds
0	29.35	32.12	33.70	34.32
1	28.35	31.59	33.33	33.84
2	27.35	31.17	33.48	33.66
3	27.87	31.01	33.83	34.24
4	28.22	31.15	34.77	34.84
5	28.57	31.42	34.60	34.76
6	29.99	31.63	34.63	34.77
7	31.01	31.16	34.46	34.76
8	32.82	30.87	34.30	34.91
9	32.69	30.44	33.87	34.53
10	31.98	30.44	33.77	34.46
11	32.17	29.89	33.22	34.47
12	32.41	29.59	32.70	34.01
13	32.21	29.14	32.06	33.77
14	32.03	28.65	31.92	33.74
15	32.39	28.20	31.84	34.05
16	32.45	27.94	31.22	34.14
17	33.13	27.59	30.73	34.13
18	32.71	27.07	30.14	34.78
19	31.71	26.59	29.32	34.46
20	30.71	25.92	28.48	33.55
21	29.71	25.20	27.70	33.13
22	28.71	24.43	26.81	32.43
23	27.71	23.63	25.90	31.72
24	27.00	22.89	25.73	31.18
25	26.28	22.13	25.18	30.63
26	25.56	21.47	24.67	30.09
27	24.84	20.77	24.02	29.27
28	24.10	20.12	23.27	28.33
29	23.37	19.49	22.64	27.38
30	22.62	18.85	21.97	26.42
31	22.09	18.22	21.36	25.55
32	21.55	17.70	20.75	24.68
33	21.10	17.36	20.18	23.83
34	20.65	16.97	19.55	22.97
35	20.21	16.59	18.96	22.12
36	19.90	16.23	18.41	21.26
37	19.60	15.89	17.87	20.41
38	19.32	15.48	17.39	19.56
39	19.05	14.98	16.90	18.72
40	18.81	14.48	16.38	17.89
41	18.71	14.08	15.95	17.13
42	18.41	13.61	15.47	16.39
43	17.87	13.22	15.00	15.63
44	17.32	12.88	14.51	14.88
45	16.77	12.51	14.02	14.13
46	16.22	12.20	13.50	13.38
47	15.66	11.85	12.97	12.62
48	15.10	11.48	12.38	11.85
49	14.54	11.00	11.85	11.13
50	13.97	10.53	11.27	10.48
51	13.45	10.07	10.76	9.88
52	12.84	9.50	10.27	9.38
53	12.42	9.06	9.86	9.01
54	12.02	8.61	9.47	8.71
55	11.62	8.24	9.19	8.50
56	11.24	7.91	8.92	8.35
57	10.86	7.62	8.65	8.23
58	10.51	7.33	8.35	8.11
59	10.17	6.95	8.03	7.84
60	9.86	6.58	7.65	7.58
61	9.58	6.12	7.16	7.16
62	9.08	5.51	6.54	6.61
63	8.32	4.90	5.93	6.07
64	7.73	4.40	5.39	5.56
65	7.13	3.99	4.90	5.09
66	6.51	3.55	4.47	4.67
67	6.00	3.22	4.06	4.28
68	5.48	2.92	3.70	3.92
69	4.96	2.76	3.41	3.63
70	4.54	2.62	3.22	3.39
71	4.13	2.75	3.21	3.31
72	3.70	2.76	2.85	2.97
73	3.29	2.65	2.51	2.62
74	2.92	2.82	2.20	2.30
75	2.63	2.70	2.03	2.12
76	2.50	2.40	2.34	2.47
77	2.00	1.90	2.00	2.00
78	1.50	1.41	1.50	1.50
79	1.00	0.93	1.00	1.00
80	0.50	0.51	0.50	0.50

x – age (years); e_x – life expectancy of the individuals at the x age

are characterised by poor grave goods or even deficiency of goods, while richly furnished graves (with several types of arms, personal articles and animals) are typical of elder juvenile and adult individuals. Contrarily, in the Christian period, the grave goods are limited to only few personal articles (mostly coins and crucifixes) in every age group but the graves of children are richer than those of adults. According to the thoughts mentioned above, the appreciation of children was much lower in the pagan era than in the Christian period. Thus, in pagan cemeteries, lower rate of children would be expected due to the inadequate grave nursing in the excavation sites[19,31]. In the present case, however, the differentiations in burial modes was not reflected in the frequency

TABLE 3
DISTRIBUTION OF THE LIFE EXPECTANCY IN THE FOUR EXAMINED POPULATION SAMPLES – MALES AND FEMALES

x	e_x – M				x	e_x – F			
	Hdg	Hdt	Hdk	Hds		Hdg	Hdt	Hdk	Hds
23	26.59	25.94	27.59	33.38	23	29.21	22.08	24.13	30.20
24	25.86	25.10	27.30	32.62	24	28.52	21.28	24.05	29.84
25	25.13	24.28	26.69	31.86	25	27.82	20.49	23.56	29.49
26	24.39	23.48	26.15	31.10	26	27.13	19.86	23.08	29.15
27	23.65	22.68	25.53	30.27	27	26.42	19.21	22.39	28.33
28	22.90	21.89	24.79	29.33	28	25.72	18.66	21.64	27.39
29	22.14	21.11	24.14	28.39	29	25.01	18.11	21.01	26.45
30	21.38	20.34	23.42	27.43	30	24.29	17.56	20.39	25.49
31	20.87	19.58	22.67	26.53	31	23.71	17.03	19.91	24.63
32	20.36	18.93	21.91	25.65	32	23.13	16.61	19.45	23.77
33	20.00	18.40	21.16	24.79	33	22.54	16.42	19.06	22.92
34	19.64	17.85	20.36	23.92	34	21.95	16.15	18.61	22.07
35	19.30	17.32	19.59	23.06	35	21.36	15.90	18.21	21.22
36	18.97	16.83	18.90	22.20	36	21.08	15.65	17.80	20.37
37	18.65	16.36	18.23	21.33	37	20.81	15.43	17.44	19.52
38	18.34	15.85	17.58	20.47	38	20.55	15.10	17.16	18.70
39	18.05	15.31	16.97	19.59	39	20.32	14.64	16.81	17.88
40	17.78	14.78	16.37	18.75	40	20.10	14.17	16.39	17.06
41	17.65	14.36	15.91	17.99	41	20.04	13.81	16.02	16.31
42	17.37	13.93	15.38	17.25	42	19.72	13.29	15.58	15.55
43	16.91	13.57	14.90	16.50	43	19.05	12.86	15.13	14.78
44	16.45	13.32	14.42	15.74	44	18.37	12.43	14.62	14.04
45	16.00	12.99	13.96	14.98	45	17.69	12.02	14.11	13.29
46	15.55	12.73	13.44	14.22	46	16.99	11.67	13.57	12.54
47	15.11	12.42	12.93	13.44	47	16.30	11.29	13.03	11.80
48	14.66	12.00	12.37	12.64	48	15.59	10.95	12.40	11.06
49	14.23	11.51	11.86	11.90	49	14.88	10.48	11.84	10.35
50	13.80	10.97	11.30	11.22	50	14.15	10.08	11.23	9.73
51	13.47	10.47	10.78	10.59	51	13.42	9.64	10.73	9.15
52	12.98	9.89	10.33	10.02	52	12.68	9.10	10.20	8.71
53	12.50	9.40	9.94	9.56	53	12.34	8.70	9.77	8.42
54	12.02	8.95	9.54	9.16	54	12.01	8.24	9.37	8.22
55	11.55	8.60	9.24	8.87	55	11.70	7.85	9.13	8.09
56	11.07	8.29	8.95	8.62	56	11.41	7.50	8.87	8.03
57	10.60	8.00	8.67	8.46	57	11.16	7.21	8.64	7.96
58	10.13	7.71	8.36	8.31	58	10.94	6.92	8.35	7.86
59	9.66	7.35	8.01	8.08	59	10.76	6.51	8.06	7.57
60	9.20	6.97	7.62	7.78	60	10.64	6.16	7.69	7.33
61	8.74	6.48	7.16	7.30	61	10.60	5.71	7.15	6.99
62	8.02	5.79	6.59	6.70	62	10.42	5.17	6.49	6.48
63	7.28	5.13	5.99	6.14	63	9.63	4.62	5.85	5.98
64	6.81	4.56	5.49	5.62	64	8.82	4.19	5.28	5.48
65	6.35	4.05	5.03	5.13	65	8.00	3.90	4.74	5.03
66	5.89	3.56	4.62	4.72	66	7.17	3.53	4.29	4.61
67	5.45	3.17	4.21	4.32	67	6.56	3.28	3.87	4.22
68	5.01	2.82	3.86	3.96	68	5.94	3.06	3.50	3.87
69	4.60	2.58	3.56	3.66	69	5.30	3.02	3.22	3.59
70	4.20	2.34	3.35	3.41	70	4.83	3.03	3.04	3.35
71	3.85	2.36	3.31	3.33	71	4.37	3.30	3.06	3.28
72	3.42	2.32	2.93	3.00	72	3.93	3.33	2.73	2.94
73	3.03	2.17	2.58	2.67	73	3.50	3.20	2.39	2.55
74	2.68	2.26	2.26	2.35	74	3.10	3.39	2.10	2.22
75	2.45	2.40	2.09	2.19	75	2.75	2.90	1.93	2.03
76	2.50	2.36	2.42	2.50	76	2.50	2.40	2.22	2.43
77	2.00	1.87	2.00	2.00	77	2.00	1.90	2.00	2.00
78	1.50	1.38	1.50	1.50	78	1.50	1.41	1.50	1.50
79	1.00	0.90	1.00	1.00	79	1.00	0.93	1.00	1.00
80	0.50	0.50	0.50	0.50	80	0.50	0.51	0.50	0.50

x – age (years), e_x – life expectancy of the individuals at the x age, M – Males, F – Females of children because 10th century Gyulás represented the highest level (about 45%) of child mortality reflecting model life table rates. But actually, other factors (such as fertility) might have a greater influence on the relative frequency of children in burial sites than mortality, which could follow from population differences[34]. Additionally, there is no conclusive evidence for such a high child mortality rate suggested by model life tables (about 46–49%) in medieval cemeteries.

The decided difference in the parameter of d_{0-14} (14.3%) between the 10th century AD (Gyúlás site) and 11th century AD (Temetöhegy site) seemed to be obvious (χ^2=5.587, p=0.018, df=1). This could be explained by the human adaptation changes (alteration in the way of life from semi nomadic to settled mode of living) and by the transformation in the social structure after the Hungarians became Christian in the central region of the Carpathian Basin[23,35]. Here, mention must also be made that the relative low number of individuals in the case of Gyulás site increases the random effects in the statistics and it must be taken into account in the evaluation. Reasonably, the same parameter is relatively low between the 11th century and the 12th–13th centuries (Table 4): the difference is 0.98% between Temetöhegy and Katidülö sites (χ^2=0.435, p=0.509, df=1), while between Temetöhegy and Szállásföld sites it is 4.79% (χ^2=3.393, p=0.065, df=1).

The adult population of the four cemeteries consisted of 687 males and 733 females, who represented the 48.4% and the 51.6% of the adults, respectively. This pattern approached the hypothetical rate 50/50% (χ^2=1.490, p= 0.222, df=1). Thus, we can state that the two sexes are represented nearly equally in the sites of Hajdúdorog. Considering the sexes in the four cemeteries separately, these also showed similar ratios which did not differed significantly from the expected rate (except in the case of Temetöhegy site, see below): 57.1% males to 42.9% females (χ^2=0.571, p=0.450, df=1) for the Gyúlás population, 44.6% males to 55.4% females (χ^2=4.301, p=0.040, df=1) for the Temetöhegy population, 48.7% males to 51.3% females (χ^2=0.282, p=0.595, df=1) for the Katidülö population and 48.2% males to 51.8% females (χ^2= 0.746, p=0.388, df=1) for the Szállásföld population (Table 1). Consequently, the sex characteristics of the populations could be considered realistic, in spite of the presence of fragmentary skeletons.

The mortality median (l_x=50) indicated continuous growth in the subsequent periods, which were about 23 years in the 10th century AD Hajdúdorog-Gyúlás (Hdg), 33 years in the 11th century AD Hajdúdorog-Temetöhegy (Hdt), 35 and 36 years in the 12th–13th century AD Hajdúdorog-Katidülö (Hdk) and Hajdúdorog-Szállásföld (Hds).

A similar trend, which showed 29.3 years for Hdg, 32.1 years for Hdt, 33.7 years for Hdk and 34.3 years for Hds, appeared in life expectancy (e_x0) at birth, which was presumably owing to some growth in the living standard from the 10th century AD to the 13th century AD as well as calculable feeding connected with the spread of a settled way of life. These e_x0 values also approximated the model rates (Figure 2, Table 2). It is obvious, however, that in the case of Gyulás site the low values of l_x=50 and e_x0 at least partly derived from the significantly higher ratio of the sub-adult group as compared with the other three cemeteries.

Nevertheless, life expectancy (e_x) gave a different image by the growth of the age at death. If we consider the age groups ten yearly (10, 20, 30... 80), the data of the total populations showed that the life condition of Gyúlás population was relatively high above the 10 year age group (Figure 2, Table 2). This can be compared to the previous assumption that the low rate of perinatal burying in the 10th and former centuries AD may be explained as follows: 1) the shallow grave depth[36,37] and 2) palaeosociological evidence[22]. The life expectancy values of

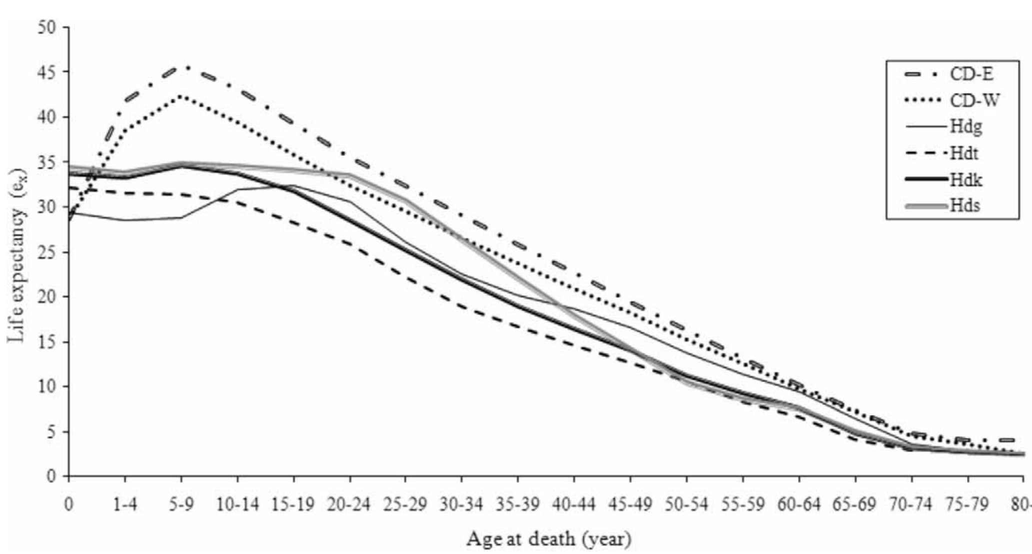

Fig. 2. Life expectancy curves of the four analysed population – Total populations. CD-E – Coale and Demény East 5th level model, CD-W – Coale and Demény West 5th level model.

TABLE 4
DISTRIBUTION OF THE MORTALITY RATES IN THE FOUR EXAMINED POPULATION SAMPLES – TOTAL POPULATIONS

x	d_x				x	d_x			
	Hdg	Hdt	Hdk	Hds		Hdg	Hdt	Hdk	Hds
0	0.00	1.47	1.84	1.49	41	1.21	1.41	1.37	0.72
1	0.00	1.80	3.33	2.37	42	0.77	1.59	1.40	0.71
2	5.36	2.57	3.74	4.38	43	0.77	1.71	1.35	0.78
3	4.46	3.38	5.00	4.15	44	0.77	1.59	1.36	0.77
4	4.17	3.62	2.05	2.29	45	0.77	1.70	1.26	0.80
5	6.85	3.30	2.45	2.44	46	0.77	1.57	1.26	0.81
6	5.06	1.39	1.94	2.33	47	0.77	1.45	1.10	0.82
7	6.25	1.87	1.92	2.61	48	0.77	1.20	1.27	1.02
8	1.79	1.50	1.28	1.38	49	0.77	1.23	1.14	1.33
9	0.60	2.55	2.02	2.03	50	0.86	1.22	1.34	1.55
10	2.38	1.13	0.99	2.14	51	0.71	1.00	1.42	1.97
11	2.38	1.76	1.06	1.14	52	1.07	1.27	1.61	2.43
12	1.49	1.36	0.81	1.59	53	1.07	1.25	1.62	2.62
13	1.49	1.26	1.89	1.97	54	1.07	1.40	1.88	2.77
14	2.38	1.38	1.99	2.57	55	1.07	1.44	1.78	2.76
15	1.79	1.80	0.81	2.05	56	1.07	1.45	1.72	2.65
16	2.68	1.58	1.08	1.80	57	1.07	1.37	1.55	2.39
17	0.89	1.16	0.88	2.86	58	1.07	1.14	1.45	1.87
18	0.00	1.24	0.40	1.14	59	1.07	1.13	1.26	1.75
19	0.00	0.79	0.35	0.14	60	1.07	0.93	1.02	1.34
20	0.00	0.71	0.50	1.00	61	0.72	0.68	0.79	1.01
21	0.00	0.56	0.26	0.50	62	0.36	0.71	0.81	1.07
22	0.00	0.53	0.23	0.50	63	0.64	0.93	1.01	1.14
23	0.52	0.68	1.98	0.80	64	0.64	1.07	1.10	1.22
24	0.52	0.64	1.08	0.80	65	0.64	0.99	1.23	1.33
25	0.52	0.94	1.18	0.80	66	0.82	1.10	1.21	1.32
26	0.52	0.82	0.84	0.32	67	0.82	1.04	1.26	1.32
27	0.52	1.01	0.61	0.11	68	0.82	1.03	1.27	1.33
28	0.52	1.05	0.90	0.11	69	0.97	0.82	1.23	1.25
29	0.52	1.03	0.83	0.08	70	0.97	0.75	1.19	1.26
30	0.95	1.10	1.00	0.25	71	0.88	0.44	0.63	0.75
31	0.95	1.44	1.01	0.28	72	0.88	0.27	0.58	0.66
32	1.13	1.95	1.13	0.30	73	0.88	0.25	0.53	0.61
33	1.13	1.76	0.96	0.32	74	0.88	0.12	0.51	0.60
34	1.13	1.78	1.10	0.33	75	0.88	0.08	0.48	0.59
35	1.39	1.80	1.18	0.33	76	0.43	0.04	0.15	0.15
36	1.39	1.83	1.26	0.35	77	0.43	0.04	0.10	0.14
37	1.39	1.59	1.39	0.38	78	0.43	0.04	0.10	0.14
38	1.39	1.36	1.36	0.40	79	0.43	0.04	0.10	0.14
39	1.39	1.36	1.29	0.46	80	0.43	0.04	0.10	0.14
40	1.60	1.62	1.54	0.67					

x – age (years), d_x – percentage of individuals dying at the x age

Gyúlás were only exceeded by Szállásföld rates in four age groups (Figure 2, Table 2,). Life expectancy (e_x) seems to have been rising from the 11^{th} century AD to the 13^{th} century AD, and it can be concluded that the population of Gyúlás did not follow this trend. The average difference was the highest between the data of Gyúlás and Temetöhegy sites (2.76), which may be indicative of the assumed population historical discontinuity at the turn of the 10^{th} century AD and 11^{th} century AD. On the other hand, the least difference (1.79) could be detected between Katidülö and Szállásföld sites (both dated to the 12^{th} –13^{th} centuries AD), which is surprising because distant relationship could be demonstrated between these two cemeteries, based on anatomical data[17,18]. However,

TABLE 5
DISTRIBUTION OF THE MORTALITY RATES IN THE FOUR EXAMINED POPULATION SAMPLES – MALES AND FEMALES

x	d_x – M				x	d_x – F			
	Hdg	Hdt	Hdk	Hds		Hdg	Hdt	Hdk	Hds
23	1.03	0.62	2.56	0.74	23	1.07	0.91	3.74	2.12
24	1.03	0.72	1.39	0.74	24	1.07	0.99	2.03	2.12
25	1.03	0.82	1.66	0.74	25	1.07	1.77	2.08	2.12
26	1.03	0.82	1.40	0.54	26	1.07	1.69	1.26	0.60
27	1.03	0.92	0.95	0.19	27	1.07	2.17	0.99	0.19
28	1.03	0.98	1.29	0.19	28	1.07	2.25	1.58	0.19
29	1.03	1.02	1.06	0.13	29	1.07	2.22	1.58	0.14
30	2.13	1.13	0.99	0.37	30	1.61	2.31	2.21	0.51
31	2.13	1.69	0.93	0.44	31	1.61	2.87	2.29	0.55
32	2.75	2.25	1.02	0.51	32	1.61	3.92	2.59	0.58
33	2.75	2.15	0.82	0.51	33	1.61	3.44	2.26	0.63
34	2.75	2.27	0.99	0.57	34	1.61	3.41	2.52	0.63
35	2.75	2.47	1.37	0.57	35	2.80	3.31	2.41	0.63
36	2.75	2.57	1.46	0.59	36	2.80	3.31	2.56	0.68
37	2.75	2.39	1.57	0.59	37	2.80	2.77	2.85	0.79
38	2.75	2.23	1.82	0.59	38	2.80	2.20	2.52	0.86
39	2.75	2.29	1.88	0.73	39	2.80	2.17	2.22	0.92
40	3.21	2.78	2.49	1.19	40	3.20	2.55	2.38	1.24
41	2.52	2.75	2.24	1.31	41	2.28	1.94	2.09	1.28
42	1.89	3.04	2.41	1.31	42	1.09	2.23	2.02	1.27
43	1.89	3.44	2.46	1.34	43	1.09	2.26	1.81	1.47
44	1.89	2.99	2.48	1.32	44	1.09	2.29	1.82	1.47
45	1.89	3.18	2.26	1.37	45	1.09	2.45	1.72	1.52
46	1.89	2.89	2.28	1.32	46	1.09	2.32	1.70	1.59
47	1.89	2.39	2.03	1.25	47	1.09	2.36	1.42	1.72
48	1.89	2.05	2.34	1.68	48	1.09	1.88	1.66	2.00
49	1.89	1.89	2.06	2.17	49	1.09	2.11	1.53	2.65
50	2.19	2.04	2.28	2.56	50	1.09	1.96	1.96	3.05
51	1.67	1.71	2.64	3.08	51	1.09	1.57	1.85	4.02
52	1.67	2.11	2.82	3.81	52	2.75	2.05	2.26	4.98
53	1.67	2.28	2.77	4.18	53	2.75	1.84	2.33	5.29
54	1.67	2.62	3.12	4.78	54	2.75	2.00	2.81	5.27
55	1.67	2.68	3.02	4.82	55	2.75	2.10	2.60	5.20
56	1.67	2.61	2.88	5.03	56	2.75	2.16	2.55	4.59
57	1.67	2.49	2.67	4.71	57	2.75	2.04	2.24	4.00
58	1.67	2.13	2.44	3.94	58	2.75	1.64	2.12	2.89
59	1.67	1.99	2.17	3.40	59	2.75	1.72	1.80	2.95
60	1.67	1.63	1.91	2.44	60	2.75	1.43	1.29	2.41
61	0.86	1.02	1.51	1.94	61	2.22	1.19	0.98	1.76
62	0.86	1.16	1.46	2.13	62	0.55	1.16	1.11	1.77
63	1.82	1.56	1.81	2.35	63	0.55	1.49	1.36	1.81
64	1.82	1.78	1.99	2.53	64	0.55	1.72	1.47	1.92
65	1.82	1.88	2.12	2.84	65	0.55	1.42	1.77	2.01
66	1.82	2.18	2.03	2.80	66	1.38	1.50	1.81	2.03
67	1.82	2.14	2.10	2.82	67	1.38	1.34	1.88	2.02
68	1.82	2.14	2.10	2.82	68	1.38	1.30	1.92	2.05
69	1.82	1.78	2.04	2.68	69	2.08	0.98	1.87	1.88
70	1.82	1.72	1.99	2.72	70	2.08	0.82	1.77	1.88
71	1.53	1.05	1.07	1.64	71	2.08	0.44	0.92	1.11
72	1.53	0.65	1.02	1.46	72	2.08	0.28	0.80	0.94
73	1.53	0.55	0.93	1.32	73	2.08	0.28	0.73	0.91
74	1.53	0.33	0.93	1.29	74	2.08	0.21	0.66	0.91
75	1.53	0.17	0.89	1.26	75	2.08	0.21	0.62	0.91
76	0.57	0.18	0.25	0.32	76	1.24	0.21	0.21	0.23
77	0.57	0.18	0.21	0.32	77	1.24	0.21	0.12	0.19
78	0.57	0.18	0.21	0.32	78	1.24	0.21	0.12	0.19
79	0.57	0.18	0.21	0.32	79	1.24	0.21	0.12	0.19
80	0.57	0.18	0.21	0.32	80	1.24	0.21	0.12	0.19

x – age (years), d_x – percentage of individuals dying at the x age, M – Males, F – Females these detected separations were not significant and restricted to the sub-adult age group. By applying the Kolomogorov-Smirnov test for paired comparison, significant difference was only shown ($p<0.05$) in one case of pairs: between Gyúlás and Temetöhegy sites in females. In all other cases (other pairs in females, all pairs in males and total populations), the test was not significant. Thus, on the basis of the adult e_x values (two sexes pooled, males and females) considerable distinctions could not be observed among the four sites (populations). The above mentioned slight average (but not significant) differences originated mostly from the variation of the sub-adult mortality and need to be treated cautiously. However, the tendencies, which suggest some distinction between the 10th and latter centuries AD, are worthy to be considered (Figure 2, Tables 2, 3 and 6).

The mortality rate data (d_x) showed that Gyúlás population significantly differed from the three other populations as regards both the two sexes examined separately and the total values (Figures 3, 4 and 5). Table 4 indicates high death percentage of the 2–7 year age groups for Gyúlás population. Similarly high death rate

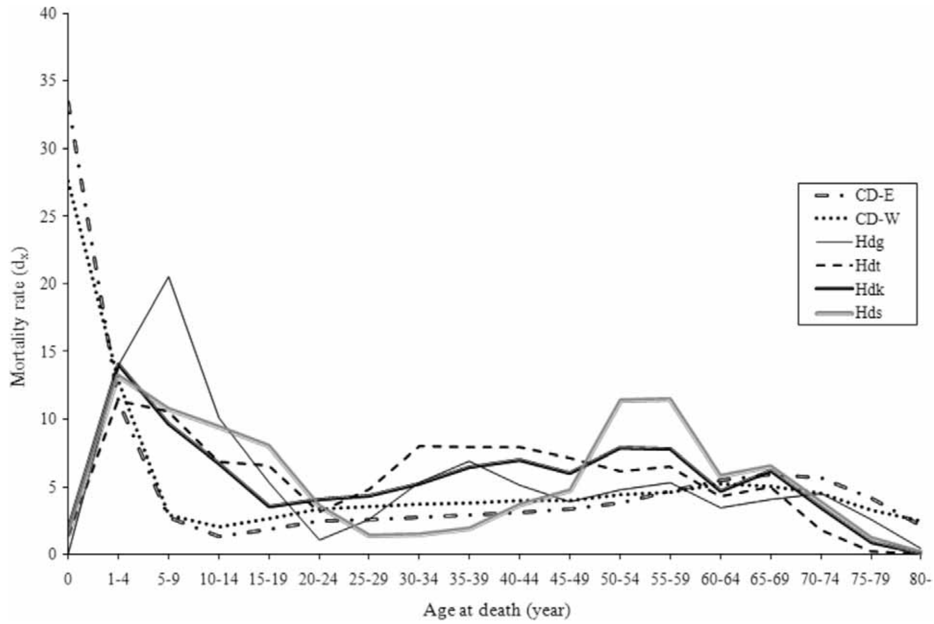

Fig. 3. The mortality curves of the four examined populations – Total populations. CD-E – Coale and Demény East 5th level model, CD-W – Coale and Demény West 5th level model.

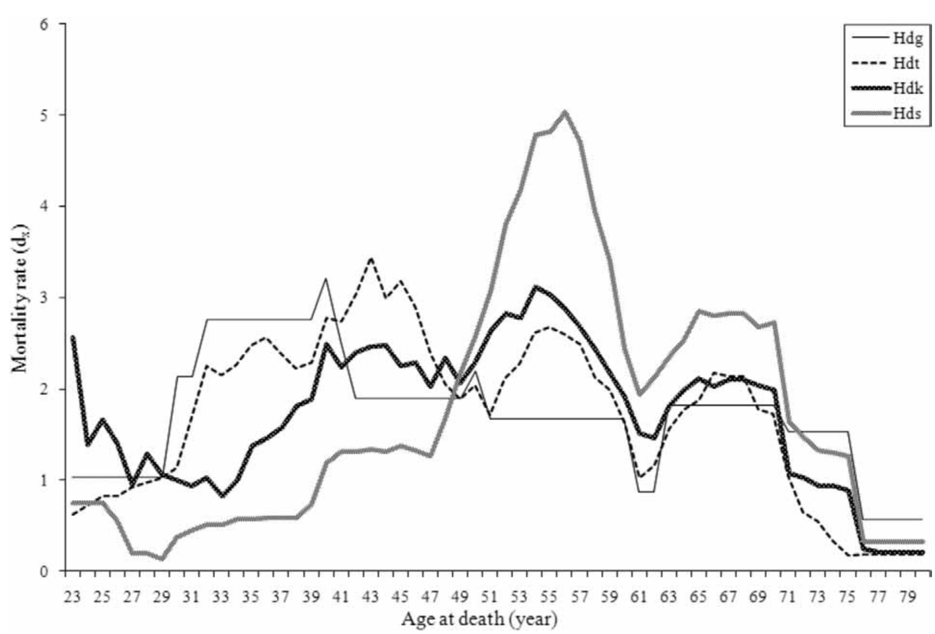

Fig. 4. The mortality curves of the four examined populations – Males.

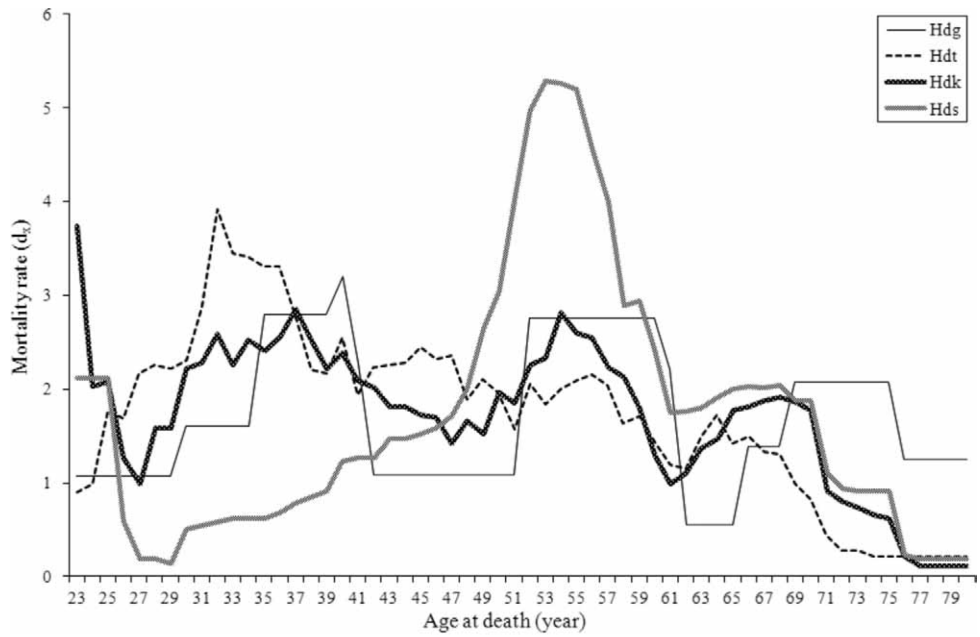

Fig. 5. The mortality curves of the four examined populations – Females.

was indicated for the 50–57 year group of Szállásföld population (considering the two sexes together). For Temetöhegy population the highest peak was observed for the 32–37 years with the females (Table 5, Figure 5), which was followed by the top of the males' peak at an about 5 year older age group (Table 5, Figure 4). Despite the sex differences, we could conclude that the top peak values of the two sexes were near each other within a given cemetery population. The data indicated conspicuous regularity (top peaks in 45–60 and in 60–70 years) in the mortality rate both in the 11th century AD and in the 12th –13th century AD and, while Gyúlas' population represented high child mortality and lower adult mortality (Figures 3, 4 and 5).

TABLE 6
RESULTS OF THE KOLMOGOROV – SMIRNOV TEST FOR PAIRWISE COMPARISON OF POPULATIONS (SIGNIFICANT DIFFERENCES ARE SIGNED IN BOLD, P<0.05)

Sites, Samples	Males+Females		Males		Females	
	D	p	D	p	D	p
Hdg vs Hdt	0.362	0.001	0.276	0.024	0.19	0.248
Hdg vs Hdk	0.466	<0.001	0.276	0.024	0.224	0.109
Hdg vs Hds	0.293	0.014	0.345	0.002	0.328	0.004
Hdt vs Hdk	0.121	0.792	0.121	0.792	0.086	0.982
Hdt vs Hds	0.328	0.004	0.241	0.068	0.190	0.248
Hdk vs Hds	0.379	<0.001	0.293	0.014	0.224	0.109

K-S test for d_x (23–x)

Sites, Samples	Males+Females		Males		Females	
	D	p	D	p	D	p
Hdg vs Hdt	0.206	0.146	0.137	0.606	**0.276**	**0.019**
Hdg vs Hdk	0.137	0.606	0.103	0.899	0.189	0.222
Hdg vs Hds	0.172	0.324	0.138	0.607	0.241	0.056
Hdt vs Hdk	0.103	0.899	0.086	0.977	0.137	0.606
Hdt vs Hds	0.189	0.222	0.155	0.454	0.189	0.222
Hdk vs Hds	0.137	0.606	0.120	0.765	0.155	0.454

K-S test for e_x (23–x)

TABLE 7
SURVIVOR PATTERN OF THE POPULATIONS FROM THE GREAT HUNGARIAN PLAIN BETWEEN THE 1^{ST} AND 11^{TH} CENTURIES AD, ON THE BASIS OF CRANIOLOGICAL RESULTS. THE RATES OF CRANIOLOGICAL COMPONENTS, WHICH ARE TYPICAL OF A GIVEN PERIOD AND THE IMMIGRANT COMPONENT (IN BOLD FACE ON THE RIGHT), ARE GIVEN IN PERCENTAGE[36]

Craniological component (%)							Archaeological period
8	17	16	9	3	11	**36** ◄	Early Arpadian age11th century AD
15	17	10	8	7	**43** ◄		Age of the Hungarian conquest 895–1000 AD
13	11	15	25	**36** ◄			Late Avar period 670–895 AD
10	10	10	**70** ◄				Early Avar period 568–670 AD
16	17	**67** ◄					German period 5th–6th century AD
18	**82** ◄						Period of the transition 4th–5th century AD
100 ◄							Sarmatian period 1st–4th century AD

Using Kolmogorov-Smirnov test for paired comparison we found significant differences among the mortality rates (d_x) of the adults (age of 23–80 years, two sexes pooled) of four populations, only populations of Temetöhegy and Katidülö do not differ significantly from each other ($p<0.05$), (Table 4, 6). Similar trend can also be observed in the case of males (except that Temetöhegy and Szállásföld do not differ significantly from each other in this case) but not in females where the tests did not show significant differences (Table 5, 6). In most cases of pairs, Gyúlás 10th century population diverged from the other three ones. The continuity presumed based on anatomical data between the 11th century AD Temetöhegy and the 12th–13th century AD Szállásföld populations could be justified in males and females but in the case of the total populations (the two sexes pooled, age of 23–80 years), it could not be observed statistically. Furthermore, it is interesting to see one part of the d_x data: we divided both adult males and females ten yearly (30, 40, 50...80) and calculated d_x values for them. According to these contracted data, surprisingly more favourable d_x values in age groups 30–50 were found in Hajdúdorog-Szállásföld site than in Hajdúdorog-Katidülö and in Hajdúdorog-Temetöhegy sites. It was typical of both males and females. These aggregate d_x values (30–50) are the followings: males — Hdg – 9.34(30), 36.68(40), 36.51(50), Hdt – 7.03(30), 30.12(40), 56.78(50), Hdk–11.30(30), 25.65(40), 48.49(50), Hds–3.64(30), 9.93(40), 25.56(50), females — Hdg – 9.10(30), 32.74(40), 44.83(50), Hdt – 14.31(30), 44.26(40), 66.06(50), Hdk – 15.47(30), 40.07(40), 57.80 (50), Hds – 7.99(30), 15.50(40), 33.52(50). There is about a twofold average difference in the $d_{x\ 30–50}$ between Temetöhegy and Szállásföld sites with both males and females, but at the age 40, the difference goes up to about threefold. A similar trend can also be observed between Szállásföld and Katidülö sites. This more favourable mortality of Szállásföld in age groups 30–50 as compared with the Temetöhegy site (theoretically continuous with Szállásföld's population) and the contemporary Katidülö site may be explained by the growing living standard and heightened level of fertility, which might not be typical of either the two other populations (knowing that the region was intensively inhabited until the Mongolian invasion in 1241 AD[16]). Here, the presumption that Szállásföld graveyard was used by several village populations, which was suggested by the very high number of graves, might serve as a possible reason. Accordingly, the different origin, the selection factors (physical and social environment) and the adaptation process might have influenced the development or formation of these populations. However, when we interpret these results, it is important to mention that two crises might also have played a key role in the population development in this region: the first passed off at the turn of the 10th and 11th century AD and involved the above mentioned pagan- -Christian change, while the second juncture was more moderate, and meant that populations lacking a church had to bury into a churchyard of a village with a church according to Christian customs from the 11th century AD. In our opinion, the first crisis could be pointed out here (in the case of Gyúlás and other three populations), which is in accordance with the data known from literature[19–22]. The second and more moderate crises cannot be discovered easily by using demographic methods only.

Discussion and Conclusions

Based on our demographic examinations of 2421 individuals from four cemeteries (10th–13th century AD), we could also conclude that there must have been some sort of transformation in the population history between the 10th century AD and the 11th century AD in the micro-region of Northern Hajdúság. In addition, the example of Gyúlás shows that 10th century antecedents may not have influenced the population structure of later periods

(12^{th}–13^{th} centuries AD) significantly. Behind this there might have been a human adaptation momentum, with resettlements enforced at the turn of the 10^{th} century AD and 11^{th} century AD within the Carpathian Basin, which must have had a significant effect on human population ecology in this area. The similarity detected in the case of Katidülö and Temetöhegy might have been in connection with the way of life and exogenous circumstances, which were typical of that age. As regards the adaptation, it is quite probable that changes in the demographic status may have been accelerated by the given historical turns rather than the anatomical features. Previous studies (see introduction chapter) have already suggested that the population from Gyúlás (dated to the age of the Hungarian conquest) did not develop in a continuous way, and its anatomical characteristics did not appear later in the examined period. Consequently, it seemed reasonable to use the term žIbrány type' to characterise this region. Taking all the parameters (d_{0-14}, l_x=50, e_x, d_x) into consideration, it could be found that this population dating to the 10^{th} century AD differed significantly from the other three populations from the 11^{th} century AD and 12^{th} –13^{th} century AD. The hypothesis that Temetöhegy population (11^{th} century AD) went on to bury into the Szállásföld graveyard (12^{th}–13^{th} century AD), as it was assumed by previous studies, could be justified by our results based on mortality rates (d_x). It could be noticed either in males or in females but not in the two sexes pooled together. The remote resemblance between the two populations (Hdk and Hds) living in the same age (12^{th} –13^{th} century AD) can probably be traced back to the way of life that was typical of the given age.

These conclusions mentioned above are in accordance with a previous study[38] which also suggests some sort of historical turn in the population history of the Great Hungarian Plain between the 10^{th} and 11^{th} centuries AD (Table 7). On the basis of the examination of the survival of craniological features belonging to 4026 individuals from different archaeological periods (dating from the 1^{st} to the 11^{th} century AD), they assume that the local Sarmatians and Gepids with the Avar populations together might have played an important role in the population dynamics till the 10^{th} century AD. Though the Hungarian conquerors' component (the new, immigrant component of this period) was relatively high (43%) in the 10^{th} century, this population indicated only 11% in the 11^{th} century AD. It is likely enough that the resettlements of these populations might have mostly been regulated by the environmental circumstances (vegetation zones, precipitation and relief) which were regular followed by the trend of anatomical characteristics from the 7^{th} century AD until the 10^{th} century AD in the central region of the Carpathian Basin[35]. However from the beginning of the 11^{th} century, the craniological features denoted that the populations of the Great Hungarian Plain may have been composed of quite heterogeneous components. Consequently, the anatomical characteristics of the 11^{th} century AD population of the Great Hungarian Plain cannot be determined by the Hungarian conquerors' craniological features or these features cannot be separated unequivocally. So in the background of the heterogeneity of the 11^{th}–13^{th} century Christianized population in the Hungarian Kingdom, certain political intentions may be assumed. It is less known to what extent the gene flow between groups, the migration, or the local survival of the populations played a role in the different periods. Assuming that these factors might have affected the subsequent periods in a similar degree, these tendencies can be taken into consideration.

In our opinion, two crises may have taken place in the periods examined in the present study (from the 10^{th} to the 13^{th} centuries AD): the first might have been induced by the course of events during which the early pagan Hungarians including various ethnic groups were converted to Christianity in the 11^{th} century AD and the Hungarian Kingdom was established with extensive resettlements within the Carpathian Basin. The second crisis might have been more moderate, which meant burying the dead of the populations lacking a church in the churchyards of villages which had a church. That is, it can be assumed that several villages may have shared a church and a graveyard. Thus, in many cases, it is difficult to reconstruct the original structure of several ancient populations excavated from a cemetery used jointly and we can only analyse their individual skeletal remains. We are of the opinion that the population history of an extensive area can be interpreted through the addition of such micro-regional investigations, as the general effects which might have influenced the population structure can be analysed in details.

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I. Janos

Institute of Environmental Science, College of Nyíregyháza, Sóstói u. 31/B 4400 Nyíregyháza, Hungary
e-mail: janosi2@zeus.nyf.hu

PAGANSKO-KRŠĆANSKA PROMJENA U SJEVEROISTOČNOJ MAĐARSKOJ U 10.–13. ST. – PALAEODEMOGRAFSKI ASPEKT

S A Ž E T A K

U ovom radu autori uspoređuju skeletne ostatke (2421 jedinki) iskopane iz četiri groblja, Hajdúdorog-Gyúlás (10. stoljeće), Hajdúdorog-Temetöhegy (11. stoljeće), Hajdúdorog-Katidülö (12.–13 st.) i Hajdúdorog-Szállásföld (12.–13. st.) iz mikro-regije sjeverne Hajdúság (koja se nalazi u sjevernom dijelu Velike mađarske nizine u Karpatskoj kotlini) na temelju demografskih podataka. Groblja datiraju do vremena mađarskog osvajanja i Arpadskog doba i pružaju reprezentativne podatke za antropološka istraživanja. Prethodne studije se temelje na kraniološkim i arheološkim istraživanjima koja su pokazala kako postoji diskontinuitet u povijesti populacije u navedenoj regiji između 10. i 11. stoljeća poslije Krista i kontinuiteta između 11. i 12. stoljeća poslije Krista. Ova hipoteza se djelomično podupire demografskim istraživanjima o promjeni u stanovništvu na prijelazu iz 10. i 11. stoljeća poslije Krista, dok je postojao izvjestan kontinuitet između 11. i 12. do 13. stoljeća poslije Krista. Autori pretpostavljaju kako su postojale dvije krize u promatranom razdoblju. Prva kriza se pojavila na prijelazu iz paganskog doba (10. stoljeće) u kršćansku eru (od početka 11. stoljeća nakon Krista kod populacije koja je naselila Karpatsku kotlinu), dok je drugi mogao biti umjereniji i odnosio se na pokapanju mrtvih kod populacije bez crkve u groblja naselja koja su imala crkvu. U to je vrijeme jedno groblje oko crkve moglo biti korišteno od strane nekoliko seoskih populacija.