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SUGGESTIONS FOR IMPROVING THE OBJECTIVITY OF PALAEODEMOGRAPHIC DATA, AS EXEMPLIFIED IN THE ANALYSIS OF EARLY BRONZE AGE CEMETERIES OF THE LOWER TRAISEN VALLEY

Part I

ABSTRACT: The demographic features of four recently uncovered Early Bronze Age cemeteries in the region of the lower Traisental (Franzhausen I: 757 individuals; Gemeinlebarn F: 258 individuals; Pottenbrunn-Ratzersdorf: 79 individuals; the partially excavated site of Franzhausen II: 134 individuals; a total of 1,228 individuals) were analyzed.
We tested to what extent the criteria of experience and perception used for aging and sexing the skeletons were subjective. This led to a specific probability calculation. The two mortality tables calculated from differently prepared raw data (one set using conventional methods, the other using probability calculations) show marked differences.
In our opinion, populations should only be compared after a probability calculation has shown the magnitude of the uncertainties in the demographic parameters.

KEY WORDS: Palaeodemography — Probability calculations — Early Bronze Age.

INTRODUCTION

During large scale excavations which have been performed by the *Abteilung für Bodendenkmalpflege des Österreichischen Bundesdenkmalamtes* since 1981, about 80 new sites were uncovered and 2,500 graves dated between the Middle Neolithic and the Early La Tène were recovered (Neugebauer 1987, Neugebauer and Gattringer 1988, Neugebauer-Maresch and Neugebauer 1988).

The four Bronze Age necropolises of Franzhausen I, Franzhausen II, Pottenbrunn-Ratzersdorf and Gemeinlebarn F yield the major part of the material.

These cemeteries belong to the Early Bronze Age: they exhibit both subtle chronological differences as well as variations in density of occupancy (*Table 1*). The currently most copious field Franzhausen I contains 714 graves and represents, due to its relatively long period of use of 300 years, three phases (stages Gemeinlebarn I, II, III): most of the burials are associated with the stage Gemeinlebarn II, as is the small cemetery Pottenbrunn-Ratzersdorf, containing 81 graves.

On the other hand, the 258 graves in Gemeinlebarn F and the 134 graves from the currently incompletely recovered cemetery Franzhausen II are characterized by a predominance of the upper layer of the Early

Table 1. Numbers and dates of the four Bronze Age cemeteries in the Lower Traisen Valley. (= only partially recovered; GEM I-III = stages Gemeinlebarn I-III)*

CEMETERY	Early Bronze Age - Unterwölbling		
Franzhausen I (N = 757)	GEM I	GEM II	GEM III
Pottenbrun (N = 79)	–	GEM II	–
Gemeinlebarn F (N = 258)	–	–	GEM III
Franzhausen II (N* = 134)	–	–	GEM III

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Bronze Age (Gemeinlebarn III). These cemeteries must be chronologically younger by 100 years.

The preliminary results of our computations may indicate that this chronological differentiation may have a non-negligible influence on the analysis of population dynamics as well as on the interpretation of the demographic results.

In this article we pursue two objectives: first, we suggest corrections that enable a more objective estimation of sex and age of the individual and calculate the consequences for the important variables of mortality tables; second, we use these consequences to compare the demographies of the Traisental ensembles.

At present, we do not have a workable alternative to the model of a stationary population: we therefore calculate the mortality tables using this model, i. e. birth rate = death rate (Feichtinger 1973, Acsádi and Nemeskéri 1970).

We believe that the prerequisites used for methodical analyses and comparisons of the Traisental ensembles are favourable because: 1) all grave fields encompassed by the analysis were recovered in an identical manner, e. g. by the same excavator; 2) the material exhibits the same – non-ideal – state of preservation, as a result of the specific conditions in the riverine lowlands; 3) almost identical methods of sexing and aging were used – implying the same reference populations.

MATERIAL AND METHOD

For this analysis a total of 1,228 individuals (Franzhausen I: 757, Franzhausen II: 134, Gemeinlebarn: 258, Pottenbrunn-Ratzersdorf: 79) from 4 Bronze Age cemeteries were available.

I. Methods of estimation of sex and age at death

A preliminary estimation of the age at death was determined in the usual manner: for subadults, tooth eruption and calcification (Ubelaker 1978), the length of long bones (Stloukal and Hanáková 1979) and epiphyseal union (Ferembach, Schwidetzky and Stloukal 1979) were used; for adults the „complex method" was used (Nemeskéri, Harsányi and Acsádi 1960) – closure of the ectocranial sutures (modified tables after Rösing 1977), molar wear (Brothwell 1972), and degenerative changes of the vertebral column (Stloukal, Vyhnánek and Rösing 1970) and articulate joints (Stloukal and Vyhnánek 1975).

The estimation of sex follows the list published by Acsádi and Nemeskéri (1970) (a total of 30 characteristics, including the robustness of the long bones).

II. Mathematical estimation of age at death and the consequences for the mortality tables

Experience has shown that the age intervals obtained using the various criteria are often disjoint (see *Table 2*). Various attempts at avoiding this dilemma are in use: either one enlarges the interval so that all estimated intervals are subsets or one defines an interval bracketed by the average of lower limits and the average of upper limits.* In many cases, one relies on the problematic justification of having chosen some „reasonable" interval.

Such criteria of reasonability, based as they are on perception and experience, are difficult to assess. Since we do use the age intervals and presently do not dispute their reliability, yet want to eliminate the reasonability criterion, we have developed the following mathematical approach.

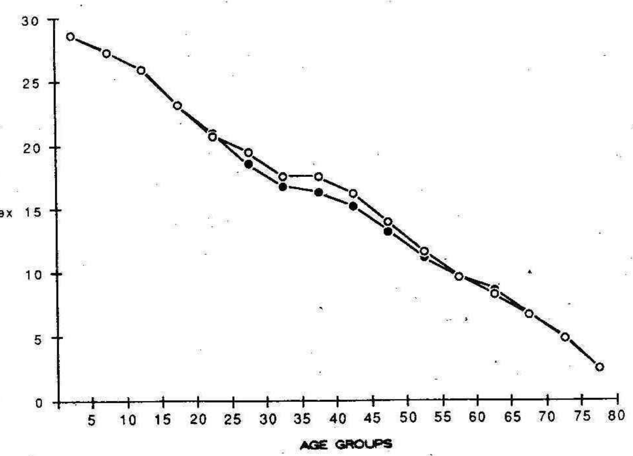
Every age interval, determined by the appropriate criteria, is assigned a probability. In the refined model, we assume all probabilities to be equal (this is equivalent to assuming all age criteria are equally reliable). If, let us say, three criteria were usable, then the probability is 1/3 for each interval. *Table 2* shows 4 cases that clarify the model. In the third case, the usual age estimate would have been 40 – 60 years. In our view, the probability is not constant: in particular, it is greater in the region of overlap. The mortality tables are now calculated with such probability functions for each individual. A comparison of the results of conventional demography shows a marked difference in the intermediate age groups – these age groups have more disjoint age intervals. In *Table 3* and *Graph 1*, we have exemplified life expectancy:

$$e_x = \frac{1}{l_x}\int_x^{\infty} l(t)dt$$

$$l(t) = \frac{1}{L_0}\cdot L(t)$$

l_x = percentage of survivors at time x
$l(t)$ = percentage of survivors at time t
L_0 = population at time t = 0
$L(t)$ = population at time t

in the cemetery Gemeinlebarn F.



Graph 1. Life expectancy ex; total population of Gemeinlebarn F – comparison of methodology: o = conventional, ● = refined probability model.

* We are indebted to F. – W. Rösing, Ulm for clarifications of these methods.

Table 2. Clarification and comparison of the methods: "coventional" = the currently used estimation of age at death interval; "refined model" = age at death probability function, assuming all intervals are equally reliably estimated.

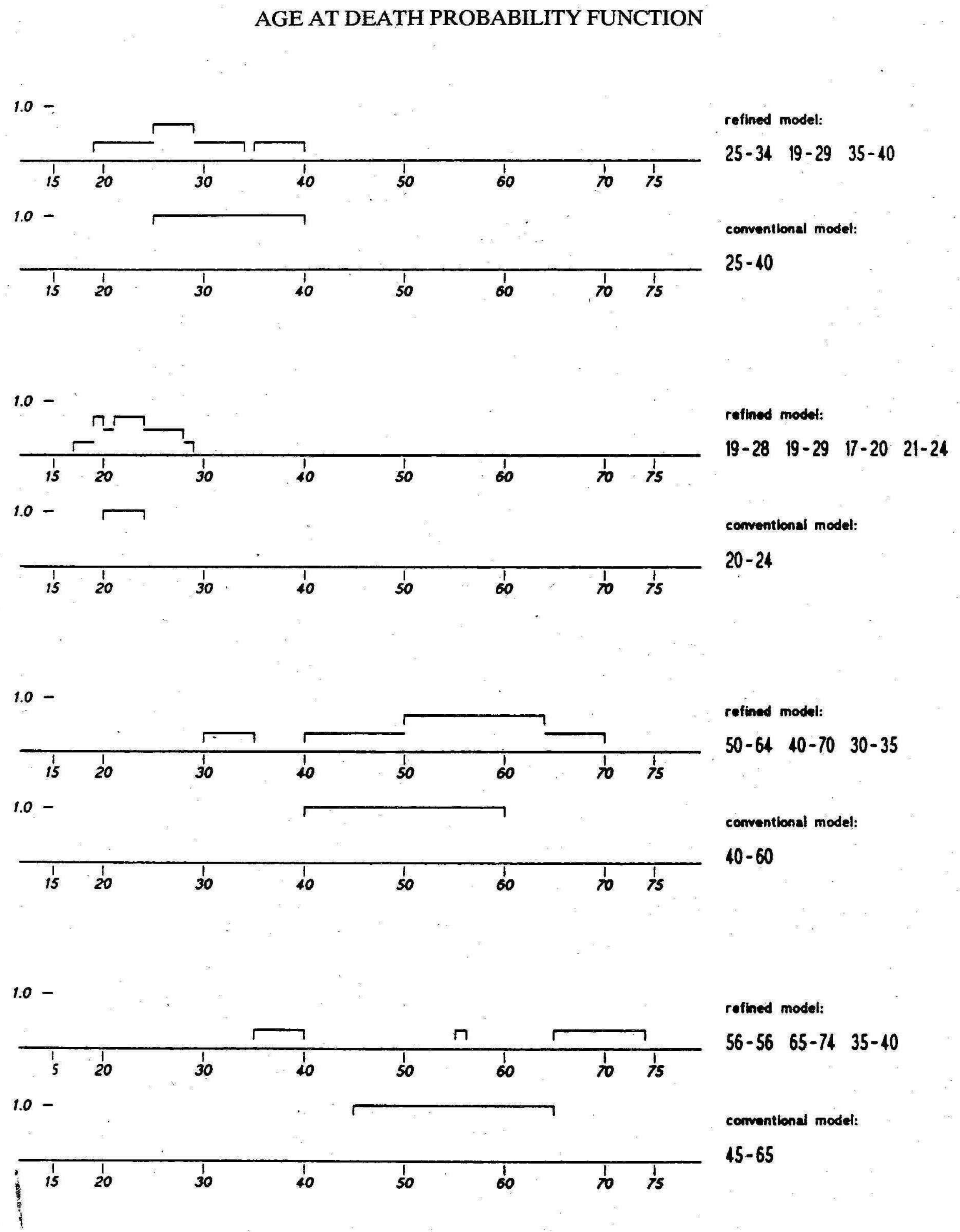


Table 3. Gemeinlebarn F – comparison of methodology: probability of dying q_x and life expectancy e_x (in years). (CONV = conventional model, PROB = refined probability model.)

Age Groups	Probability of dying qx		Life expectancy ex	
	CONV	PROB	CONV	PROB
0–5	0.13	0.13	28.6	28.6
5–10	0.13	0.13	27.4	27.3
10–15	0.08	0.08	26.0	25.9
15–20	0.12	0.11	23.1	23.1
20–25	0.13	0.17	20.9	20.7
25–30	0.17	0.16	18.5	19.4
30–35	0.24	0.25	16.8	17.6
35–40	0.22	0.20	16.3	17.5
40–45	0.19	0.17	15.2	16.2
45–50	0.21	0.19	13.2	13.9
50–55	0.30	0.25	11.1	11.6
55–60	0.36	0.39	9.6	9.6
60–65	0.34	0.37	8.6	8.2
65–70	0.44	0.44	6.7	6.7
70–75	0.50	0.51	5.0	4.9
75–80	1.00	1.00	2.5	2.5

In the subadult age range, there are almost no differences between the two methods, because in this age range, more consistent age estimators can be applied. (The uniformity in the 60+ age group is due to the paucity of individuals in this age group and also the extent of the range.)

A comparable difference between the two methods will be manifest in the calculated probability of dying in the age interval Δx

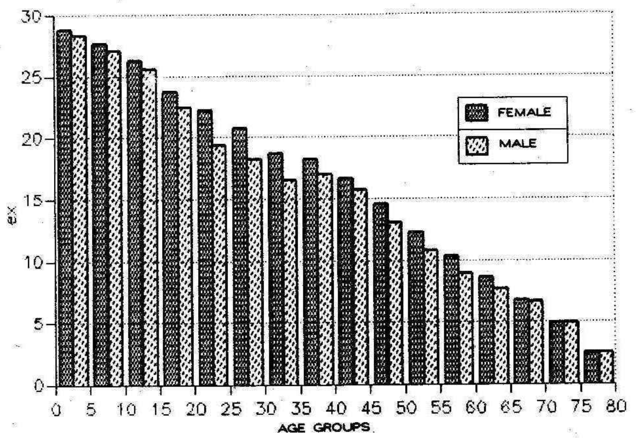
$$q(x)=\frac{l_x}{d_x} \quad \text{with } \Delta x=\text{const}$$

l_x = percentage of survivors at time x
d_x = number of deaths at time x
Δx = age interval

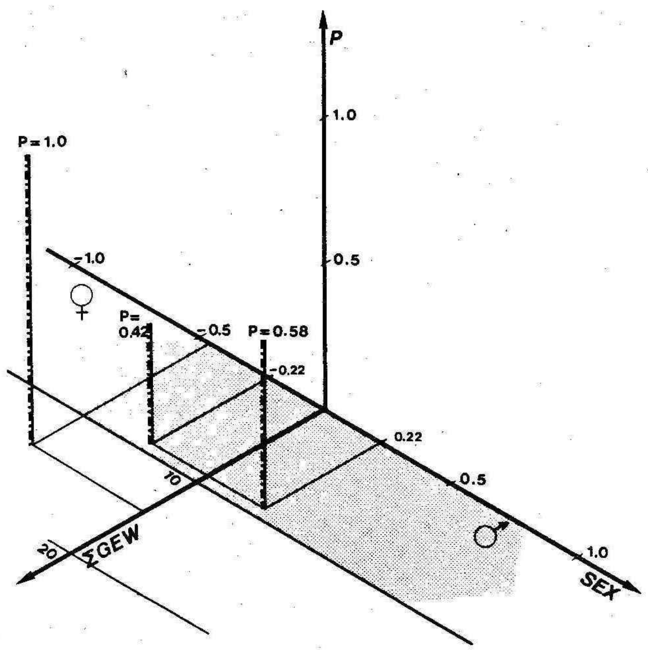
The importance of making such model calculations before interpreting subsequent comparisons is all the more striking when comparing the life expectancy for the different sexes: the sex difference for the population of Gemeinlebarn (*Graph 2*) is only slightly higher than the difference for life expectancy using conventional and the refined model calculations. Similar results are exhibited in the three other ensembles Franzhausen II, Franzhausen I, and Pottenbrunn-Ratzersdorf.

III. Non-subjective sex estimation

In the present article, sex was estimated using an array of 30 criteria, each with a markedness ranging from hyperfeminine (−2) to hypermasculine (+2). Each of these criteria has a weight; different criteria do not necessarily lead to the same sex estimate. We



Graph 2. Gemeinlebarn F: differences according to sex for life expectancy ex (all age intervals with equal probability, anthropologically determined sex only, sexually uncertain individuals with 0.5 probability contained in each group).

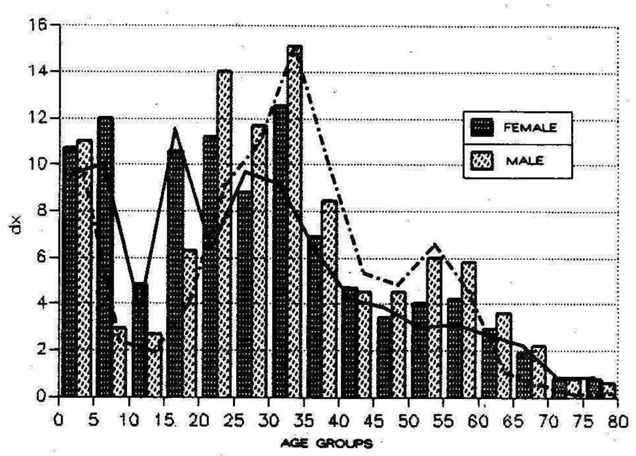


Graph 3. Calculation of sex probability (SEX = sex number from +2 to −2; ΣGEW = sum of weights of the criteria used for sex determination of an individual; P = probability).

calculate, from the weighted average, a sex number, with positive numbers denoting masculinity.

A sizable fraction of the population has an uncertain sex diagnosis. In order to include these in the calculations of mortality tables, we also introduce probability functions.

In *Graph 3*, we show the range where it is not possible to attribute a certain sex with a probability (= reliability) of 1.0. Based on our experience with these grave fields, we limit the uncertainty at a weighting of 10. An individual with a sex number 0.46 and a sum of weights 14 can be considered feminine with a probability



Graph 4. Gemeinlebarn F: graph of d_x values of the individuals that died within an age group (bars: using the more objective age and sex data; lines: using the conventionally determined data: -- = female, -.- = male).

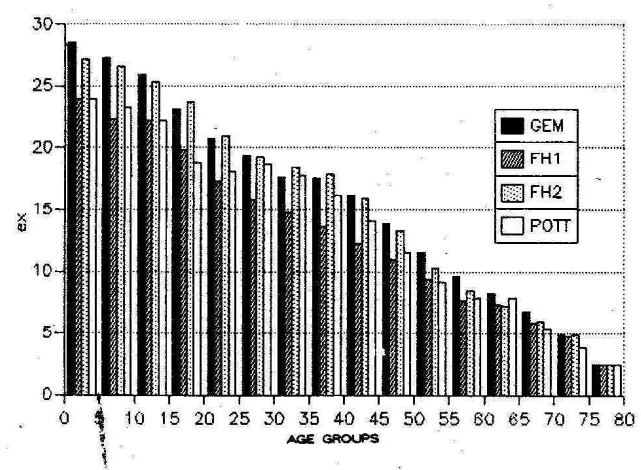
of 1.0. An individual with a sum of weights 9 and a sex number 0.22 is, using the formula (see next page)

$$P=\left(1+\frac{\sum GEW_i}{59}\right)\cdot 0.5$$

male with a probability of 0.58 and female with a complementary probability of 0.42.

Using such probability functions, the results differ conspicuously from those obtained conventionally. We show such differences for d_x (percentage of deaths in an age interval Δx) for the cemetery Gemeinlebarn F (*Graph 4*).

We believe that the commonly practised comparison of populations is not permissible without an exact enumeration of the methods used – these certainly are major sources of discrepancy – and a clear analysis of data processing. Without such error and variance calculations, a comparison that intends to characterize populations is counterproductive.



Graph 5. Population comparison of life expectancy e_x (total populations with mathematical estimation of age at death; GEM = Gemeinlebarn F; FH1 = Franzhausen I; FH2 = Franzhausen II; POTT = Pottenbrunn-Ratzersdorf).

Table 4. Mortality tables: calculated for the total population with the use of probability models.

Age Groups	Dx	dx	lx	qx	Lx	Tx	ex
Gemeinlebarn F							
0–5	32.54	12.6	1.000	0.126	4.69	28.57	28.57
5–10	28.54	11.1	0.874	0.127	4.09	23.88	27.33
10–15	16.49	6.4	0.763	0.084	3.66	19.79	25.93
15–20	20.77	8.0	0.699	0.115	3.30	16.13	23.07
20–25	26.67	10.3	0.619	1.167	2.84	12.84	20.74
25–30	21.27	8.2	0.515	0.160	2.37	10.00	19.40
30–35	27.40	10.6	0.433	0.245	1.90	7.63	17.62
35–40	16.42	6.4	0.327	0.195	1.48	5.73	17.53
40–45	11.18	4.3	0.263	0.165	1.21	4.26	16.17
45–50	10.91	4.2	0.220	0.192	0.99	3.05	13.86
50–55	11.57	4.5	0.178	0.252	0.78	2.05	11.56
55–60	11.52	4.5	0.133	0.336	0.55	1.28	9.62
60–65	8.84	3.3	0.088	0.373	0.36	0.73	8.23
65–70	6.30	2.4	0.055	0.442	0.22	0.37	6.65
70–75	4.09	1.6	0.031	0.514	0.12	0.15	4.93
75–80	3.87	1.5	0.015	1.000	0.04	0.04	2.50
Franzhausen I							
0–5	104.12	13.8	1.000	0.138	4.66	23.93	23.93
5–10	127.12	16.8	0.862	0.195	3.89	19.27	22.35
10–15	62.26	8.2	0.695	0.118	3.27	15.38	22.15
15–20	59.32	7.8	0.621	0.128	2.87	12.12	19.79
20–25	76.96	10.2	0.534	0.190	2.42	9.25	17.32
25–30	74.82	9.9	0.432	0.229	1.91	6.83	15.81
30–35	59.95	7.9	0.333	0.238	1.47	4.92	14.75
35–40	47.45	6.3	0.254	0.247	1.11	3.45	13.57
40–45	40.99	5.4	0.192	0.283	0.82	2.34	12.19
45–50	29.72	3.9	0.137	0.286	0.59	1.51	11.01
50–55	23.29	3.1	0.098	0.314	0.41	0.93	9.42
55–60	24.51	3.2	0.067	0.480	0.26	0.51	7.58
60–65	11.25	1.5	0.035	0.425	0.14	0.26	7.28
65–70	8.30	1.1	0.020	0.544	0.07	0.12	5.80
70–75	3.81	0.5	0.009	0.549	0.03	0.04	4.75
75–80	3.13	0.4	0.004	1.001	0.01	0.01	2.50
Franzhausen II							
0–5	19.88	14.8	1.000	0.148	4.63	27.24	27.24
5–10	15.38	11.5	0.852	0.135	3.97	22.61	26.55
10–15	12.73	9.5	0.737	0.129	3.45	18.64	25.30
15–20	8.61	6.4	0.642	0.100	3.05	15.20	23.67
20–25	11.31	8.4	0.578	0.146	2.68	12.15	21.02
25–30	13.62	10.2	0.493	0.206	2.21	9.47	19.19
30–35	11.30	8.4	0.392	0.215	1.75	7.26	18.53
35–40	6.65	5.0	0.307	0.161	1.41	5.51	17.92
40–45	5.22	3.9	0.258	0.151	1.19	4.10	15.89
45–50	4.62	3.5	0.219	0.158	1.01	2.91	13.28
50–55	7.10	5.3	0.184	0.288	0.79	1.90	10.30
55–60	6.82	5.1	0.131	0.387	0.53	1.11	8.44
60–65	4.71	3.5	0.080	0.437	0.31	0.58	7.20
65–70	3.31	2.5	0.045	0.545	0.17	0.27	5.85
70–75	1.45	1.1	0.021	0.527	0.08	0.10	4.87
75–80	1.31	1.0	0.010	1.000	0.02	0.02	2.50
Pottenbrunn-Ratzersdorf							
0–5	13.20	16.70	1.000	0.614	4.58	23.96	23.96
5–10	10.36	13.10	0.833	0.157	3.84	19.38	23.26
10–15	4.32	5.50	0.702	0.078	3.37	15.54	22.15
15–20	10.63	13.50	0.647	0.208	2.90	12.17	18.80
20–25	10.73	13.60	0.513	0.265	2.22	9.27	18.08
25–30	5.91	7.50	0.377	0.198	1.70	7.05	18.70
30–35	4.43	5.60	0.302	0.186	1.37	5.35	17.71
35–40	2.44	4.40	0.246	0.177	1.12	3.98	16.18
40–45	2.75	3.50	0.202	0.172	0.93	2.86	14.12
45–50	3.05	3.90	0.168	0.230	0.74	1.93	11.54
50–55	3.61	4.60	0.129	0.354	0.53	1.19	9.24
55–60	3.16	4.00	0.083	0.480	0.32	0.66	7.93
60–65	1.08	1.40	0.043	0.315	0.18	0.34	7.93
65–70	1.26	1.60	0.030	0.538	0.11	0.16	5.43
70–75	0.79	1.00	0.014	0.731	0.04	0.05	3.85
75–80	0.29	0.40	0.004	1.000	0.01	0.01	2.50

Table 5. Mortality tables: calculated for females (F) and males (M) with the use of probability models.

Age Groups	D_x		d_x		l_x		q_x		e_x	
	F	M	F	M	F	M	F	M	F	M
Gemeinlebarn F										
0 – 5	9.75	9.50	10.70	11.00	1.000	1.000	0.107	0.110	27.53	31.66
5 – 10	10.92	2.50	12.00	2.90	0.893	0.890	0.134	0.032	25.52	30.24
10 – 15	4.41	2.35	4.80	2.70	0.774	0.862	0.062	0.031	24.08	26.17
15 – 20	9.69	5.44	10.60	6.30	0.725	0:834	0.146	0.075	20.51	21.94
20 – 25	10.20	12.16	11.20	14.00	0.619	0.772	0.180	0.182	18.60	18.52
25 – 30	8.04	10.10	8.80	11.70	0.508	0.631	0.173	0.185	17.14	17.09
30 – 35	11.45	13.06	12.50	15.10	0.420	0.515	0.299	0.293	15.21	15.39
35 – 40	6.29	7.24	6.90	8.40	0.294	0.364	0:234	0.229	15.63	15.71
40 – 45	4.30	3.94	4.70	4.50	0.225	0.281	0.209	0.162	14.65	14.65
45 – 50	3.07	3.90	3.40	4.50	0.178	0.235	0.189	0.191	12.86	12.00
50 – 55	3.64	5.24	4.00	6.00	0.145	0.190	0.276	0.318	10.27	9.24
55 – 60	3.82	5.01	4.20	5.80	0.105	0.130	0.399	0.445	8.23	7.38
60 – 65	2.64	3.16	2.90	3.60	0.063	0.072	0.459	0.506	7.04	6.30
65 – 70	1.70	1.91	1.90	2.20	0.034	0.036	0.548	0.619	5.89	5.18
75 – 75	0.70	0.70	0.80	0.80	0.015	0.014	0.500	0.594	5.00	4.53
75 – 80	0.70	0.48	0.80	0.60	0.008	0.006	1.000	1.000	2.50	2.50
Franzhausen I										
0 – 5	21.00	26.67	6.70	10.10	1.000	1.000	0.067	0.101	25.58	26.90
5 – 10	36.67	34.21	11.60	13.00	0.933	0.899	0.125	0.145	23.30	24.65
10 – 15	29.42	13.41	9.30	5.10	0.817	0.769	0.114	0.066	21.27	23.39
15 – 20	29.72	24.42	9.40	9.30	0.723	0.718	0.131	0.129	18.69	19.88
20 – 25	40.19	29.44	12.80	11.20	0.629	0.625	0:203	0.179	16.12	17.46
25 – 30	39.76	30.38	12.60	11.50	0.501	0.513	0.252	0.225	14.59	15.72
30 – 35	32.68	22.55	10.40	8.60	0.375	0.398	0.277	0.215	13.66	14.55
35 – 40	22.47	20.80	7.10	7.90	0.271	0.312	0.263	0.253	12.94	12.88
40 – 45	18.47	18.63	5.90	7.10	0.200	0.233	0.294	0.304	11.67	11.37
45 – 50	13.00	13.33	4.10	5.10	0.141	0.162	0.293	0.312	10.49	10.24
50 – 55	10.77	9.13	3.40	3.50	0.100	0.112	0.343	0.311	8.80	8.47
55 – 60	10.52	10.60	3.30	4.00	0.066	0.077	0.510	0.523	7.09	6.56
60 – 65	4.53	4.95	1.40	1.90	0.032	0.037	0.449	0.512	6.87	6.00
65 – 70	3.27	3.26	1.00	1.20	0.018	0.018	0.587	0.690	5.43	4.66
75 – 75	1.34	0.89	0.40	0.30	0.007	0.006	0.582	0.604	4.59	4.48
75 – 80	0.96	0.58	0.30	0.20	0.003	0.002	1.001	1.001	2.50	2.50
Franzhausen II										
0 – 5	2.50	5.00	6.00	9.70	1.000	1.000	0.060	0.097	30.24	30.03
5 – 10	3.00	5.50	7.20	10.70	0.940	0.903	0.077	0.118	27.21	27.99
10 – 15	4.30	2.01	10.40	3.90	0.868	0.796	0.119	0.049	24.27	26.41
15 – 20	3.13	4.34	7.50	8.40	0.764	0.757	0.099	0.111	22.22	22.64
20 – 25	5.23	4.34	12.60	8.40	0.689	0.673	0.183	0.125	19.38	20.16
25 – 30	5.52	6.76	13.30	13.10	0.563	0.588	0.236	0.223	18.16	17.70
30 – 35	4.50	5.68	10.80	11.00	0.430	0.457	0.252	0.241	18.00	17.06
35 – 40	1.78	3.28	4.30	6.40	0.321	0.347	0.133	0.184	18.23	16.70
40 – 45	1.48	2.15	3.60	4.20	0.278	0.283	0.128	0.148	15.65	14.90
45 – 50	1.14	2.40	2.70	4.70	0.243	0.241	0.113	0.193	12.59	12.05
50 – 55	2.72	3.30	6.50	6.40	0.215	0.195	0.304	0.329	8.87	9.33
55 – 60	2.79	2.94	6.70	5.70	0.150	0.131	0.448	0.438	6.66	7.68
60 – 65	2.05	1.70	4.90	3.30	0.083	0.073	0.597	0.450	5.02	6.72
65 – 70	1.15	1.29	2.80	2.50	0.033	0.040	0.832	0.620	3.76	5.17
70 – 75	0.12	0.47	0.30	0.90	0.006	0.015	0.500	0.594	5.00	4.53
75 – 80	0.12	0.32	0.30	0.60	0.003	0.006	1.001	1.000	2.50	2.50
Pottenbrunn-Ratzersdorf										
0 – 5	2.75	2.83	9.30	10.30	1.000	1.000	0.093	0.103	26.99	26.97
5 – 10	3.25	2.17	11.00	7.90	0.907	0.897	0.122	0.088	24.51	24.77
10 – 15	1.15	0.18	3.90	0.70	0.796	0.819	0.049	0.008	22.57	21.91
15 – 20	4.76	4.21	16.20	15.30	0.757	0.812	0.214	0.188	18.60	17.07
20 – 25	4.74	5.56	16.10	20.20	0.595	0.659	0.270	0.306	17.98	15.44
25 – 30	2.65	2.83	9.00	10.30	0.434	0.457	0.207	0.224	18.71	16.15
30 – 35	2.37	1.75	8.00	6.30	0.344	0.355	0.233	0.178	17.94	15.11
35 – 40	1.57	1.57	5.30	5.70	0.264	0.291	0.202	0.196	17.64	12.85
40 – 45	0.69	1.53	2.30	5.50	0.211	0.234	0.110	0.236	16.48	10.37
45 – 50	1.10	1.40	3.70	5.10	0.187	0.179	0.200	0.284	13.22	7.80
50 – 55	1.22	1.85	4.10	6.70	0.150	0.128	0.275	0.524	10.90	4.91
55 – 60	0.96	1.66	3.30	6.00	0.109	0.061	0.299	0.989	9.09	2.55
60 – 65	0.77	0.02	2.60	0.10	0.076	0.001	0.343	1.003	6.90	2.45
65 – 70	0.97	0.00	3.30	0.00	0.050	0.000	0.660		4.20	0.00
70 – 75	0.50	0.00	1.70	0.00	0.017	0.000	1.000		2.50	0.00
75 – 80	0.00	0.00	0.00	0.00	0.000	0.000			0.00	0.00

COMPARISONS AND PERSPECTIVES

We list a few examples of the many particular results found among the Bronze Age populations of the Traisen Valley:

The comparison of the most important parameter of a mortality table, the life expectancy e_a (*Table 4* and *Graph 5*), shows that the predominantly (chronologically) older populations Franzhausen I and Pottenbrunn (values for e_a of 23.9 and 24.0 years, respectively) are to be contrasted with the younger populations Franzhausen II and Gemeinlebarn F (where the values are 27.2 and 28.6 years).

A similar trend can be perceived for the sexually differentiated cases (*Table 5*) for males and – less marked – for females. (In the sexually differentiated cases calculations were done with the probability functions; if no anthropological data were available, archaeological data, viz. orientations, side of deposition and/or grave artefacts were used. The other sexually unidentifiable individuals were not used in the calculations.)

It is possible that these results are correlated with the chronological age of the grave fields and that they reflect a change in the quality of living – e. g. improved environmental conditions. Supplementary investigations involving types and frequencies of illnesses in these populations are being carried out, as well as those directed at the problem of the infant deficit, which has not been addressed in any of the 4 cemeteries.

We are furthermore investigating the effect that the choosing of fixed age intervals has on the parameters of the mortality tables and we are also attempting at generalizing the formalism that calculates the probability functions for sex estimations.

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