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Anthropological research into a family tomb from Vetlá cemetery (Bohemia, 19th–20th centuries), with a focus on the morphological similarity of biologically related individuals.

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Abstract: In common osteological practice, there are few opportunities to verify the relationship between morphological similarity and the biological relatedness of individuals. This contribution expands knowledge in this area based on research into a family tomb from Vetlá (Bohemia, 19th–20th centuries), where 131 non-metric cranial traits were monitored in 7 skulls and the degree of similarity between individuals was calculated using a similarity coefficient. Trait frequencies were evaluated within the family and compared to a reference sample. Due to the small number of individuals statistical methods were not applied, and the authors focused on graphical representation of the results. It was confirmed that a positive relationship between the degree of similarity of individuals and their degree of relatedness is visible. At the same time, in the group of biologically related individuals a greater similarity and a lower degree of its variability was apparent than in unrelated individuals. The average frequency of all the evaluated traits together also appears to be higher in the family sample than in the reference sample. In addition, several individual traits were found to support the documented kinship of individuals, not only on the skulls but also on the scapula.

Keywords: non-metric traits, skull, kinship analysis, similarity coefficient, genealogical documented sample.

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Introduction

Given the rarity of genealogically documented osteological samples worldwide (Gavrus-Ion et al. 2017), each additional family grave or tomb that can be studied represents a unique opportunity to expand our knowledge of the influence of biological relationships on the morphological features of the human skeleton and dentition. Studies to date have shown that there is a positive relationship between the degree of biodistance and the degree of similarity of individuals, and that there is conspicuous agreement in closely related individuals in the occurrence of specific traits (e.g. Case et al. 2017, Cvrček et al. 2018, 2020). This relationship can be used especially in the effort to detect individuals with biological affinity in anonymous (pre)historical burial grounds (e.g. Pietrusewsky & Douglas 1992, Case 2003, Ricaut et al. 2010), or in the identification of family members of historically known personalities whose identity has been lost over time (Horáčková & Vargová 1997, Thurzo & Beňuš 2003).

The degree of similarity between individuals can be assessed using different approaches, from teeth through frontal sinuses to anatomical variants and developmental anomalies of the whole skeleton, etc. (Stojanowski & Schillaci 2006). Non-metric dental traits seem to be the most ideal (e.g. Paul & Stojanowski 2015, 2017; Irish et al. 2020), but are subject to a number of limitations, such as abrasion, intravital and postmortem losses, caries, or fillings (Alt & Vach 1998). The analysis of non-metric osteological traits is a suitable alternative (Johnson & Lovell 1994, Prowse & Lovell 1996); cranial traits are most often used due to several factors, such as the higher number of traits and, as a rule, their better preservation compared to the postcranial parts of the skeleton (Spence 1996, Cvrček et al. 2018), and the fact that in the secondary placement of the remains, the assignment of postcranial bones to the skull may not always be entirely certain (Slavec 2004).

However, the number of studies on this topic using a documented sample remains low. Some authors are even skeptical about the reflection of biological relatedness in the occurrence of non-metric traits, because although they are qualitative traits, they do not show simple monogenic inheritance, but manifest themselves as quantitative traits, i.e. polygenically conditioned with the possible participation of the external environment (Tyrrell 2000, Brown 2015). In the Spring of 2017, the authors were asked to help with the retrieval of skeletal remains during the reconstruction of a 19th–20th century family tomb in Vetlá (part of Vrbice village, Litoměřice District, Bohemia) which belonged to one of the most important local landowner families. This was an opportunity for them to be researched, and above all to answer these questions: 1) Does the degree of morphological similarity among the individuals correspond to their documented relationships? 2) Is it possible to find specific traits that support their biological relationships?

Material and methods

Material

Based on a genealogical search including death records (State Regional Archives in Litoměřice, Prague City Archive), and documents and portraits from the private family archive of the vault's owners, it was possible to identify the remains of 8 individuals with known family relationships from among the remains stored in the tomb (Figs. 1, 2); 7 of these were adults (3 males and 4 females, 33–86 years old), and one was a 10-year-old boy. The last 3 burials (Nos. 5, 7, 8) were in coffins (2 metal and 1 wooden); the remains of the other individuals were laid in one corner of the tomb in the form of a reduction of older burials, but for individuals Nos. 1 and 2 only the skulls could be individually identified with certainty. Due to the diametrically different preservation of the material (adults vs. the juvenile, complete skeletons vs. distinctly incomplete skeletons, or skulls alone), only the skulls were selected to evaluate the degree of similarity of the individuals in this study. The skull of individual No. 1, however, eventually had to be excluded from the evaluation due to very significant post-mortem damage (the maxilla, base and occipital parts of the skull were missing), meaning that only the skulls of 6 adults and 1 juvenile were evaluated (Nos. 2–8). Despite the fact that individual No. 8 was not an adult and the ontogenetic development of his skeleton was not complete, he was left in the evaluated sample because 1) his family affiliation and relationships to the adults are unquestionable; 2) the occurrence of most of the evaluated traits is documented prenatally or in childhood (e.g. Hauser & De Stefano 1989, Mann et al. 2016), albeit that there are statistically significant differences between non-adults and adults in the occurrence of some (Česnys 1985); and 3) his documented chronological age reached the

Fig. 1. Vetlá cemetery, a view inside the family tomb during its opening before exhumation. Photo: J. Štěpán.

upper limit of the interval 0–10 years, within which it is not appropriate to evaluate cranial traits for comparison purposes (Česnys 1985).

Next, the 140 skulls of the Pachner skeletal collection (Department of Anthropology and Human Genetics, Faculty of Science, Charles University, Prague) were used to determine reference data. This sample consists of the skeletal remains of people from second half of the 19th and the first third of the 20th centuries (Cvrček et al. 2018), and it was chosen for its chronological and geographical similarity to the genealogically documented sample, and the almost certain unrelatedness of individuals according to written records (information on the bones, vital records from Prague City Archive).

Methods

To determine the degree of similarity of individuals, 131 cranial non-metric traits were evaluated (Movsesjan et al. 1975, Hauser & De Stefano, 1989), of which 28 were unilateral and 103 bilateral (see Supplementary file, Tab. S1). The degree of similarity between individuals was calculated using a similarity coefficient (SC) (Cvrček et al. 2018). The relationship between the resulting similarity coefficient of biologically related pairs and the degree of their relationships was graphically ex-

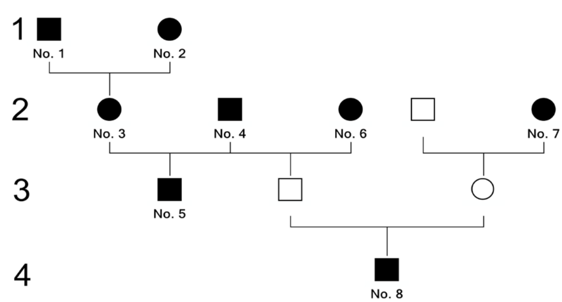

Fig. 2. Family tree of the genealogically documented sample (generations Nos. 1–4). All individuals in the sample have a number, and individuals included in this study (Nos. 1–8) are shown in black.

	2	3	4	5	6	7	8
2	–	40	45	33	30	36	31
3		–	28	28	26	31	30
4			–	38	28	42	31
5				–	29	44	26
6					–	20	33
7						–	28
8							–

Table 1. Similarity coefficient (SC) values for individuals Nos. 2-8 by cranial non-metric traits.

pressed by using the logarithm of their coefficient of relationship (r), which was estimated using a tabular method (Falconer & Mackay 1996) based on the method of VanRaden (1992). However, the low number of individuals explains why statistical processing was not performed in this study (Cvrček et al. 2021).

For all of the evaluated cranial non-metric traits together, the difference in their occurrence between the genealogically documented sample and the reference samples was expressed. At the same time, specific traits which support documented relationships were monitored; their selection was conditioned by a population frequency of less than 10 % (Gemmerich-Pfister 1999, Cvrček et al. 2018), either incidence on individual or incidence on side, and their occurrence in at least two biologically related individuals (Cvrček et al. 2018).

Results

The greatest degree of similarity between biologically related individuals based on cranial non-metric traits exists between mother No. 2 and daughter No. 3, and father No. 4 and son No. 5 (r = 0.5) (Tab. 1). The similarity between boy No. 8 and his grandparents Nos. 4 and 6 (r = 0.25) is greater than the similarity between boy No. 8 and his half-uncle No. 5 (r = 0.125). On the other hand, there is greater similarity between male No. 5 and his grandmother No. 2, between which there is a greater biological distance (r = 0.25), than between male No. 5 and his mother No. 3, whose biological distance, on the other hand, is smaller (r = 0.5). Overall, the degree of similarity of biologically related individuals corresponds to their biological distance (Fig. 3).

If the degree of similarity between biologically related and unrelated individuals within a family is compared (Fig. 4), then biologically related pairs (N = 8) graphically show less variability and a higher median than biologically unrelated pairs (N = 13).

On the other hand, there are only three traits with a population frequency of less than 10 % between close relatives that support their known relationship (see

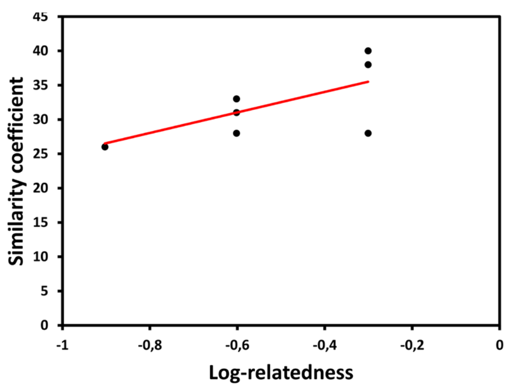

Fig. 3. Relationship between the similarity coefficient (SC) of biologically related individuals Nos. 2–8 (y-axis) and the log-relatedness of individuals (x-axis). The red line represents the regression line. Note: log-relatedness disregards unrelated individuals.

Supplementary, Tab. S1): *foramen zygomaticofaciale partitum* (grandmother No. 6 and grandson No. 8), and *foramen spinosum incompletum* and *ponticulus jugularis internus incompletus* (mother No. 2 and daughter No. 3). However, another five traits were recorded the reference frequency of which is higher than 10 %, but which also occur between close relatives: *ossiculum epiptericum* (mother No. 3 and son No. 5), *sulcus frontalis* (father No. 4 and son No. 5), *incisura frontalis absens* (grandmother No. 6 and grandson No. 8), *foramen palatinum minus accessorium absens* (father No. 4 and son No. 5), *foramen hypoglossale cum spina* (male No. 5 and half-nephew No. 8). Last but not least, the occurrence was noted of two population-rare traits, which, although unique, are similar in their character: female No. 2 has *ossiculum lambdae* and her daughter No. 3 has *ossiculum suturae saggitalis*. Overall, however, a higher average frequency of evaluated cranial non-metric traits is graphically visible in the genealogically documented sample compared to the reference Pachner collection, both on the individual and on the side (Fig. 5).

In addition to the similarities in cranial non-metric traits, the overall examination of the skeletal remains of the family also evinced a striking agreement in the morphology of the suprascapular notch between father No. 4 and son No. 5. The typical sharply formed notch is missing on both sides; conversely, it is wide open and flows smoothly in the superior border of the scapula. This is the so-called type V of the suprascapular notch (Polguj et al., 2011; Fig. 6). The frequency of this anatomical variant in Central European recent populations ranges from about 4.5 to 12.9 % (Polguj et al. 2013, Al-Redouan et al. 2021).

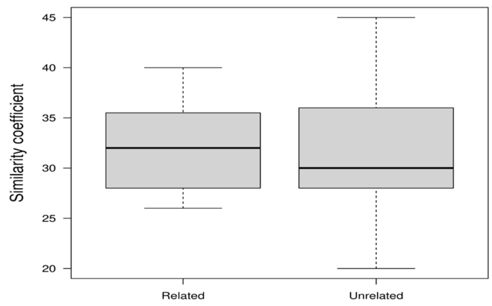

Fig. 4. Variability in the degree of similarity between biologically related (N = 8 pairs) and unrelated (N = 13 pairs) individuals based on the similarity coefficient.

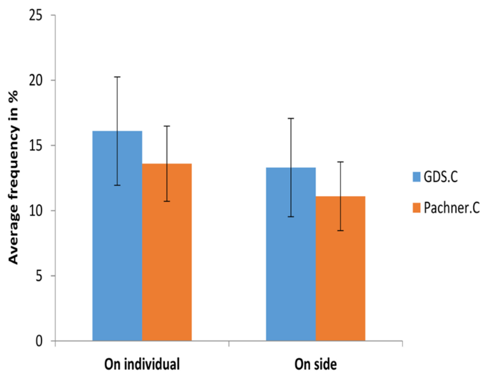

Fig. 5. Average frequency of all evaluated cranial non-metric traits (n = 131) in the genealogically documented sample with comparison of their incidence in the reference Pachner collection both on the individual and on the side. GDS.C = genealogically documented sample: cranial traits, Pachner. C = Pachner colletion: cranial traits.

Discussion

This research, in line with previous studies (e.g. Spence 1996, Velemínský & Dobisíková 2005, Case et al. 2017, Cvrček et al. 2018) confirmed that there is a positive relationship between the degree of similarity and the degree of relatedness of individuals. Thus, the smaller the biodistance, the greater the similarity. However, even in this family there was a case where there was a greater similarity between the grandparent and the grandchild than between the parent and the child, as previously shown in other samples (Spence 1996, Drozdová 2006, Cvrček et al. 2018).

Fig. 6. Agreement between father No. 4 (left) and son No. 5 (right) in the morphology of suprascapular notch: type V (arrows).

The small number of individuals and the biological relationships between them were probably reflected in the low number of population-rare cranial traits with a frequency below 10%. However, the graphically apparent increase in the average frequency of all evaluated cranial traits in the family sample compared to the reference sample suggests that even for commonly occurring traits with a population frequency above 10%, their frequency increased due to genetic factors (Hauser & De Stefano 1989, Carson 2006). Therefore, when assessing the degree of similarity between individuals, it is appropriate to also take into account those traits the limit of which either exceeds or meets the 10% population occurrence threshold, but which in comparison to the reference sample are not (statistically) significant. Even these traits can serve as a good indicator of biological affinity (Case et al. 2017, Cvrček et al. 2018), although it is important to consider them in context or on the basis of comparisons with reference data. At the same time, however, it cannot be ruled out that the increase in the average frequency of evaluated traits found is conditioned by the small number of individuals.

The presence of *ossiculum lambdae* in female No. 2 and at the same time *ossiculum suturae saggitalis* in her daughter No. 3 supports the assumption that traits can be found among close relatives which, although at first sight different, are essentially the same (Thurzo & Beňuš 2003). In this case, they are intrasutural ossicles which arise in ontogenesis as a result of the creation of an additional ossification center within the suture during its formation (Hauser & De Stefano 1989); predisposition to their creation can be hereditary (e.g. Molleson 1987, Molleson et al. 1993, Vlček 1997).

Likewise, the postcranial finding of identical suprascapular notch formation between father No. 4 and son No. 5 supports the findings of some previous studies where the authors have observed that the scapula may bear a number of traits, the frequencies of which are not high, that also can serve as a suitable indicator of biological affinity between individuals (Angel et al. 1987, Vlček 1995, Yammine 2013, Cvrček et al. 2018).

Each piece of such research is accompanied by an effort to process the results as objectively as possible using statistical approaches (e.g. Ullrich 1969, Wiltschke-Schrotta 1988, Heinrich & Teschler-Nicola 1991, Alt & Vach 1995, 1998). Unfortunately, this is not always possible (Cvrček & Velemínský 2020). Most genealogically documented samples include only a few individuals, usually no more than ten (e.g. Molleson et al. 1993, Spence 1996, Horáčková & Vargová 1997, Vlček 2000, Thurzo & Beňuš 2003, Velemínský & Dobisíková 2005, Drozdová 2001, Cvrček & Velemínský 2020). In addition, biological relationships need not exist between all the individuals in a sample due to the presence of biologically unrelated individuals, which is also this case. Other limits for evaluating the similarity of individuals within a sample may be the poor preservation of their remains or their too young age, when the skeleton is not yet as fully developed as in adults (Spence 1996). In such circumstances, graphical and descriptive outputs therefore represent a possible alternative to mathematical calculations and statistical tests, the power of which would be low (Ellis 2010). Although this approach may be considered subjective (Asherson 1963), it has been shown that it can be used at least in parallel with statistical evaluation (e.g. Cvrček et al. 2018) – at least because mathematical expressions of similarity can determine the same degree of similarity in individuals with otherwise marked morphological differences, and together with statistical approaches, do not allow the capture of these individual deviations or, conversely, the capture of individual similarities (Szilvássy et al. 1987, Cvrček et al. 2020). However, the character of the relationship between the degree of relatedness and the degree of similarity of individuals, as well as the difference between the degree of similarity of related and unrelated individuals or between the frequency of traits in the family and the reference sample, can also be stated on the basis of scopical and graphical assessment, regardless of statistical conclusions (e.g. Vlček 1997, 2000; Carson 2006, Drozdová 2006, Cvrček et al. 2021). Such an approach is particularly important for cases where a statistical evaluation does not give a significant result despite graphically obvious relationships or differences, which can happen particularly with numerically small samples.

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Supplementum

	Trait	Family sample						Reference sample					
		Incidence on individual			Incidence on side			Incidence on individual			Incidence on side		
		N	Inc.	%	N	Inc.	%	N	Inc.	%	N	Inc.	%
1	*Sutura metopica*	7	0	0	-	-	-	140	9	6.4	-	-	-
2	*Sutura metopica partialis*	7	0	0	-	-	-	140	0	0	-	-	-
3	*Sutura supranasalis absens*	7	4	57.1	-	-	-	140	29	20.7	-	-	-
4	*Fissura metopica*	6	0	0	-	-	-	140	2	1.4	-	-	-
5	*Ossiculum metopicum*	6	0	0	-	-	-	140	0	0	-	-	-
6	*Lophus frontalis*	6	0	0	-	-	-	140	16	11.4	-	-	-
7	*Sutura parametopica*	7	0	0	14	0	0	140	0	0	280	0	0
8	*Ossiculum suturae coronalis*	6	0	0	13	0	0	128	2	1.6	258	2	0.8
9	*Ossiculum internasale*	6	0	0	-	-	-	138	8	5.8	-	-	-
10	*Ossiculum praefrontale*	6	0	0	13	0	0	140	2	1.4	280	3	1.1
11	*Os zygomaticum partitum*	6	0	0	13	0	0	140	0	0	280	0	0
12	*Fissura zygomatica transverza*	6	0	0	13	0	0	140	5	3.6	280	6	2.1
13	*Sutura infraorbitalis*	6	5	83.3	12	9	75.0	140	70	50	280	108	38.6
14	*Sutura incisiva*	7	1	14.3	14	2	14.3	139	1	0.7	278	2	0.7
15	*Sutura incisiva partialis*	7	5	71.4	14	10	71.4	139	35	25.2	278	64	23.0
16	*Ossiculum medianum palatinum anterior*	7	0	0	-	-	-	138	0	0	-	-	-
17	*Ossiculum medianum palatinum posterior*	5	0	0	-	-	-	138	0	0	-	-	-
18	*Ossiculum epiptericum*	7	3	42.9	14	4	28.6	126	23	18.3	260	33	12.7
19	*Stenokrotaphia*	7	0	0	14	0	0	131	1	0.8	267	2	0.7
20	*Sutura frontotemporalis*	7	0	0	14	0	0	128	1	0.8	265	1	0.4
21	*Processus frontalis squamae temporalis completus*	7	0	0	14	0	0	133	8	6.0	272	10	3.7

22	*Processus frontalis squamae temporalis incompletus*	7	0	0	14	0	0	127	8	6.3	262	11	4.2
23	*Processus temporalis squamae frontalis completus*	7	0	0	14	0	0	119	0	0	248	0	0
24	*Processus temporalis squamae frontalis incompletus*	7	0	0	14	0	0	115	1	0.9	244	1	0.4
25	*Processus parietalis ossis sphenoidalis*	7	2	28.6	14	4	28.6	131	19	12.8	269	32	11.9
26	*Ossiculum bregmaticum*	6	0	0	-	-	-	124	1	0.8	-	-	-
27	*Ossiculum suturae sagittalis*	5	1	20	-	-	-	112	4	3.6	-	-	-
28	*Ossiculum incisurae parietalis*	7	1	14.3	14	1	7.1	132	24	18.2	268	30	11.2
29	*Os parietale partitum*	7	0	0	14	0	0	140	0	0	280	0	0
30	*Ossiculum suturae squamosae*	7	0	0	14	0	0	128	3	2.3	266	4	1.5
31	*Squama temporalis partita*	7	0	0	14	0	0	138	0	0	278	0	0
32	*Sutura squamomastoidea*	5	1	20	11	1	9.1	139	56	40.3	279	89	31.9
33	*Processus mastoideus bipartitus*	6	0	0	12	0	0	137	4	2.9	277	4	1.4
34	*Ossiculum lambdae*	7	1	14.3	-	-	-	127	12	9.4	-	-	-
35	*Ossiculum suturae lamboidaea*	7	3	42.9	14	5	35.7	117	51	43.6	239	79	33.1
36	*Os Incae completum*	7	0	0	-	-	-	140	0	0	-	-	-
37	*Os Incae bipartitum*	7	0	0	-	-	-	140	0	0	-	-	-
38	*Os Incae tripartitum*	7	0	0	-	-	-	140	0	0	-	-	-
39	*Os Incae multipartitum*	7	0	0	-	-	-	140	0	0	-	-	-
40	*Os Incae incompletum*	7	0	0	-	-	-	140	3	2.1	-	-	-
41	*Processus interparietalis*	7	0	0	-	-	-	139	6	4.3	-	-	-
42	*Sutura mendosa*	7	1	14.3	14	2	14.3	139	22	15.8	279	36	12.9
43	*Ossiculum asterii*	7	1	14.3	14	1	7.1	132	23	17.4	270	31	11.5
44	*Ossiculum suturae occipitomastoidae*	6	0	0	12	0	0	114	7	6.1	241	7	2.9
45	*Sulcus frontalis*	6	3	50	13	5	38.5	140	45	32.1	280	71	25.4
46	*Incisura trochlearis*	7	2	28.6	14	2	14.6	140	21	15.0	280	23	8.2
47	*Foramen trochleare*	7	1	14.3	14	1	7.1	140	3	2.1	280	3	1.1

48	*Incisura frontalis absens*	7	5	71.4	14	8	57.1	140	54	38.6	280	70	25.0
49	*Foramen frontale*	7	6	85.7	14	10	71.4	140	47	33.6	280	67	23.9
50	*Incisura supraorbitalis*	7	0	0	14	0	0	140	2	1.4	280	2	0.7
51	*Foramen supraorbitale*	7	1	14.3	14	2	14.3	140	22	15.7	280	26	9.3
52	*Foramen nasale absens*	6	2	33.3	12	2	16.7	137	25	18.2	274	30	10.9
53	*Foramen zygomaticofaciale absens*	6	2	33.3	13	2	15.4	140	35	25.0	280	52	18.6
54	*Foramen zygomaticofaciale partitum*	6	3	50	13	3	23.1	140	14	10	280	15	5.4
55	*Foramen ethmoidale anterius absens*	5	0	0	12	0	0	133	0	0	269	0	0
56	*Foramen ethmoidale posterius absens*	5	0	0	11	0	0	136	2	1.5	273	2	0.7
57	*Canalis opticus partitus*	6	0	0	12	0	0	115	10	8.7	248	15	6.0
58	*Foramen infraorbitale absens*	6	0	0	12	0	0	140	0	0	280	0	0
59	*Foramen infraorbitale partitum*	6	1	16.7	12	1	8.3	140	6	4.3	280	6	2.1
60	*Foramen infraorbitale accessorium*	6	1	16.7	12	2	16.7	140	27	19.3	280	30	10.7
61	*Foramen palatinum minus absens*	5	0	0	11	0	0	139	1	0.7	278	1	0.4
62	*Foramen palatinum minus accessorium absens*	5	2	40	11	2	18.2	137	33	24.1	276	51	18.5
63	*Ponticulus palatinus*	7	0	0	14	0	0	136	8	5.9	273	8	2.9
64	*Ponticulus palatinus incompletus*	7	1	14.3	14	1	7.1	136	27	19.9	273	37	13.6
65	*Foramen parietale absens*	7	5	71.4	14	8	57.1	140	85	60.7	280	127	45.4
66	*Foramen parietale inferior*	7	0	0	14	0	0	140	0	0	280	0	0
67	*Foramen squamosum superius*	7	0	0	14	0	0	133	1	0.8	271	1	0.4
68	*Processus parietalis squamae temporalis*	7	0	0	14	0	0	134	2	1.5	273	3	1.1
69	*Foramen mastoideum absens*	6	2	33.3	13	2	15.4	140	32	22.9	280	38	13.6

70	*Foramen mastoideum intrasuturam*	6	3	50	13	5	38.5	118	79	66.9	257	124	48.2
71	*Foramen mastoideum extrasuturam temporale*	6	5	83.3	13	7	53.8	118	71	60.2	259	103	39.8
72	*Foramen mastoideum extrasuturam occipitale*	6	0	0	13	1	7.7	119	14	11.8	256	18	7.0
73	*Foramen mastoideum accessorium*	6	3	50	12	5	41.7	140	32	22.9	280	36	12.9
74	*Foramen tympanicum*	6	0	0	12	0	0	135	20	14.8	271	31	11.4
75	*Foramen marginale*	6	0	0	12	0	0	139	7	5.0	274	10	3.6
76	*Foramen occipitale*	7	2	28.6	-	-	-	140	19	13.6	-	-	-
77	*Foramen condylaris absens*	6	4	66.7	12	4	33.3	140	46	32.9	280	57	20.4
78	*Canalis condylaris absens*	6	4	66.7	12	4	33.3	139	55	39.6	279	74	26.5
79	*Canalis condylaris intermedius*	4	1	25.0	10	3	30	133	53	39.8	270	72	26.7
80	*Canalis condylaris intermedius incompletus*	5	0	0	11	0	0	132	40	30.3	270	48	17.8
81	*Foramen hypoglossale partitum*	3	6	50	12	3	25.0	138	49	35.5	276	61	22.1
82	*Foramen hypoglossale partitum cum spina*	6	2	33.3	12	2	16.7	138	37	26.8	276	47	17.0
83	*Canalis basilaris medianus*	6	0	0	-	-	-	140	2	1.4	-	-	-
84	*Canalis craniopharyngeus*	6	0	0	-	-	-	138	8	5.8	-	-	-
85	*Foramen spinosum incompletum*	6	2	33.3	12	2	16.7	136	14	10.3	275	20	7.3
86	*Foramen spinosum incompletum partialis*	6	5	83.3	12	5	41.7	136	52	38.2	275	74	26.9
87	*Foramen ovale partitum*	6	0	0	12	0	0	137	1	0.7	276	1	0.4
88	*Foramen ovale incompletum*	6	1	16.7	12	1	8.3	134	5	3.7	272	8	2.9
89	*Foramen ovale et spinosum confluens*	6	0	0	12	0	0	138	7	5.1	277	9	3.2

90	*Foramen Vesalii*	6	4	66.7	12	5	41.7	138	86	62.3	277	132	47.7
91	*Ponticulus jugularis externus*	5	0	0	11	0	0	138	18	13.0	277	18	6.5
92	*Ponticulus jugularis externus incompletus*	5	1	20	11	1	9.1	137	33	24.1	276	41	14.9
93	*Ponticulus jugularis internus*	5	0	0	11	0	0	138	1	0.7	277	1	0.4
94	*Ponticulus jugularis internus incompletus*	5	2	40	11	2	18.2	138	6	4.3	277	7	2.5
95	*Ponticulus pterygospinosus*	5	1	20	11	2	18.2	140	4	2.9	274	4	1.5
96	*Ponticulus pterygospinosus incompletus*	5	0	0	11	0	0	128	13	10.2	259	18	7.0
97	*Ponticulus pterygoalaris*	5	0	0	11	0	0	140	4	2.9	280	5	1.8
98	*Ponticulus pterygoalaris incompletus*	5	0	0	11	0	0	134	9	6.7	266	11	4.1
99	*Processus clinoideus medius*	6	1	16.7	12	1	8.3	130	88	67.7	267	146	54.7
100	*Ponticulus carotico-clinoideus*	6	0	0	12	0	0	130	23	17.7	264	36	13.6
101	*Ponticulus carotico-clinoideus incompletus*	4	0	0	9	0	0	102	23	22.5	226	27	11.9
102	*Ponticulus interclinoideus*	4	0	0	10	0	0	94	7	7.4	209	10	4.8
103	*Ponticulus interclinoideus incompletus*	3	0	0	6	0	0	20	2	10	49	4	8.2
104	*Taenia interclinoidea*	6	0	0	12	0	0	126	6	4.8	258	8	3.1
105	*Foramen mentale absens*	5	0	0	10	0	0	52	0	0	104	0	0
106	*Foramen mentale partitum*	5	0	0	10	0	0	52	0	0	104	0	0
107	*Foramen mentale accessorium*	5	0	0	10	0	0	52	2	3.8	104	2	1.9
108	*Ponticulus mylohyoideus*	5	0	0	10	0	0	54	3	5.6	108	5	4.6
109	*Ponticulus mylohyoideus incompletus*	5	0	0	10	0	0	54	10	18.5	108	11	10.2
110	*Facies condylaris bipartita*	5	1	20	11	2	18.2	132	13	9.9	268	15	5.6
111	*Assimilatio atlantis*	6	0	0	-	-	-	140	0	0	-	-	-
112	*Depressio biparietalis circumscripta*	7	0	0	14	0	0	140	3	2.1	280	6	2.1

113	*Depressio interparietalis*	7	0	0	-	-	-	140	23	16.4	-	-	-
114	*Spina trochlearis*	7	1	14.3	14	2	14.3	138	22	15.9	279	31	11.1
115	*Tuberculum marginale absens*	6	3	50	13	4	30.8	140	67	47.9	280	101	36.1
116	*Tuberculum zygomaxillare*	6	2	33.3	13	3	23.1	140	23	16.4	280	34	12.1
117	*Torus palatinus*	7	2	11.8	-	-	-	138	66	47.8	-	-	-
118	*Torus maxillaris*	7	1	14.3	14	2	14.3	134	3	2.2	268	4	1.5
119	*Spina suprameatica*	6	0	0	12	0	0	138	60	43.5	278	102	36.7
120	*Depressio suprameatica*	6	5	83.3	12	9	75.0	135	34	25.2	278	64	23.0
121	*Torus acusticus*	6	0	0	12	0	0	139	1	0.7	275	2	0.7
122	*Tuberculum pharyngeum absens*	6	0	0	-	-	-	139	8	5.8	-	-	-
123	*Condylus tertius*	6	0	0	-	-	-	140	1	0.7	-	-	-
124	*Tuberculum praecondylare*	6	0	0	12	0	0	139	6	4.3	264	8	3.0
125	*Processus paracondylaris*	5	0	0	10	0	0	130	4	3.1	265	7	2.6
126	*Processus retromastoideus*	6	0	0	12	0	0	140	0	0	280	0	0
127	*Linea nuchae suprema*	7	4	57.1	14	8	57.1	140	81	57.9	280	159	56.8
128	*Torus occipitalis*	7	0	0	-	-	-	140	7	5.0	-	-	-
129	*Processus styloideus elongatus*	4	1	25.0	8	2	25.0	28	1	3.6	85	3	3.5
130	*Torus mandibularis*	5	0	0	10	0	0	52	0	0	104	0	0
131	*Fossa pharyngea*	6	2	33.3	-	-	-	138	22	15.9	-	-	-

Table S1: Evaluated non-metric cranial traits (Nos. 1–131) and their frequencies in the genealogically documented assemblage in comparison with the reference frequencies from the Pachner collection (Cvrček et al. 2018).