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Non-metric dental analysis of a Bronze Age population from the Armenian Plateau

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Abstract: The aim of this study is to assess the biological distance between populations from the Armenian highland, Georgia, Eastern Europe, Central Asia and Siberia on the basis of the frequency of non-metric dental traits. It is well known that these traits are characterized by high inter-population differentiation, low sexual dimorphism, and their recording is affected by relatively small intra and inter-observer error. These traits are successfully used in the description and explanation of ethno-genetic processes. Comparative analysis was performed on 30 populations, and the frequency of non-metric dental traits in all populations was determined by principal component analysis. Based on our bio-distance results, we suggest there was a degree of genetic proximity among inland populations of the Armenian Plateau and Transcaucasian area at the beginning of the Bronze Age. The Armenian Plateau and Georgian samples and all those from Kalmykia (Pit Grave culture), the Ukraine (Tripolye culture), the Urals (Sintashtinskaya, Timber Grave cultures), the Volga region (Pit Grave, Balanovo, Fatianovo, Potapovsky cultures) and Central Asia (Gonur-Depe) exhibited close affinities. This conclusion is consistent with that reported by other bio-distance studies examining non-metric cranial traits and Armenian Plateau samples.

Key words: Armenian Plateau, Georgia, biological anthropology, archaeology, non-metric dental traits

Introduction

The study of historical and modern human dentition in dental anthropology is a well-established sub-discipline of Physical Anthropology. It is defined by Hillson (1996: 1) as "a study of people (and their close relatives) from the evidence provided by teeth". Such research can yield information on a variety of topics including growth, development and a healthy diet as well as occupational activity and biological affinities. This information is useful in studies of both individuals and populations. Non-metric dentition trait analysis can infer biological relationships between populations and track evolutionary variation arising from changing settlement patterns. Dental morphology provides insights into phenotypic group differences and suggests differences in genotypic affiliation (Varela and Cocilovo 2000). Non-metric dental traits are part-

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ly controlled by genetics, and they are relatively free of gender and age bias (Scott and Turner 1997). Analysis of biological relationships using non-metric dental traits is extremely helpful even in combined samples, when standardized procedures are followed (Ullinger et al. 2005).

The highly inherited non-metric morphological crown and roots traits in human dentition vary within and between populations. The term "non-metric" implies structural variations of individual crown and root forms visually scored in two ways: (1) by the "presence-or-absence" characteristics of furrow patterns, accessory ridges and supernumerary cusps and roots, and (2) by differences in form, such as curvature and angles (Hillson 1996; Scott and Tumer 1997; Zubov 1973, 1979). Numerous studies have demonstrated that morphological dental forms respond to the following: (1) micro-evolutionary forces of genetic admixture (as in Turner 1969; Pinto-Cisternas et. al. 1995 and Khudaverdyan 2011b), (2) mutation (in Morris et al. 1978), (3) genetic drift (Turner 1969; Postnikova 1974; Scott and Dahiberg 1982; Segeda 1993; Khudaverdyan 2009; Vargiu et al. 2009 and Zubova 2008, 2010), and (4) selection (in Dahlberg 1963 and Scott and Turner 1988). These factors highlight the high degree of genetic control.

Investigations have provided information on local-scale non-metric variation in the following populations (1) Asian and Pacific (Hanihara 1965, 1966; Hanihara and Minamidate 1965; Sasaki and Kanasawa 1998; Kitagawa 2000), (2) African (Grine 1986, 1990; Lease 2003), (3) Indian (Lukacs and Walimbe 1984; Lukacs and Hemphill 1991), (4) Central Asian (Khodjaiov 1977; Rikushina et al. 2003), (5) European (Jørgensen 1956; Kaczmarek and Pyżuk 1985; Kaczmarek 1991, 1992; Segeda 1993; Cucina et al. 1999; Gravere 1999; Lease 2003; Coppa et al. 2007; Vargiu et al. 2009; Zubova 2010), (6) The near East (Smith 1978; Smith et al. 1987; Moskona et al. 1998), Siberia (Postnikova 1974; Tur 2009; Zubova 2008), (7) Australian (Townsend and Brown 1981; Townsend et al. 1986, 1990) and (8) North American (Sciulli 1998, Tocheri 2002; Ullinger 2003; Lease 2003; Lease and Sciulli 2005; Edgar and Lease 2007).

Surprisingly, past and present Transcaucasian populations have received little attention (Kashibadze 1990, 2006 and Khudaverdyan 2009), and reconstruction of biological relationships among ancient human groups from teeth remains an important research problem for Transcaucasian bio-archaeologists. The aim of this work is to compare non-metric dental variation in ancient Transcaucasian inhabitants with Bronze Age samples from Eastern Europe, the European-Russian steppe, Central Asia and Siberia, and thus clarify the origins and interactions between Transcaucasians and neighbouring Eurasians. Our results will test Gamkrelidze and Ivanov's (1984) and Gray and Atkinson's (2003) hypothesis concerning the ancestral home of Indo-European areas of the Armenian Plateau and adjoining territories.

The Zubova method (1968, 1973 and 1974) is the most widely employed system in the Russian school of anthropology and this is the recommended standard for scoring non-metric dental traits. These traits are characterised by high inter-population differentiation, and the analysis of their occurrence enables researchers to obtain data on genetic relationships between populations with different ethnic composition. Odontological traits are used successfully to describe and explain both evolutionary and micro-evolutionary processes. Similar type studies are commonly used to determine specific research questions such as the synchronic biological relatedness of segments of a particular society (Johnson and Lovell 1994) or diachronic changes in trait expressions in a particular region (Lukacs and Hemphill 1991; Cucina et al. 1999; Gravere 1999 and Coppa et al. 2007). Teeth are normally well preserved in archaeological material and they are often the only source for investigation of human remains.

Archaeological context

In early history, the Caucasus was a crossroads linking the Eastern and Western worlds. From IV millennium BC to I millennium BC, copper, bronze and iron tools and trinkets were commonly produced in this region and traded in neighboring lands where those metals were less abundant (Trifonov 1991; Nechitailo 1991 and Pystovalov 2002). Invention of wheeled vehicles and "kibetka-houses" on wheels allowed cattlemen-farmers in the Near East to move and survive with ease on the open steppes. Their movement across Eurasia in early times did not constitute a military invasion. The wide expanse of the Eurasian steppes offered favourable conditions for human life and the spread of information and technology promoted wide cultural integration throughout this area during the Bronze Age (Merpert 1988; Chernykh 1988).

Craniological data enabled identification of alien Mediterranean characteristics influencing various ethnic Eurasian samples, and they revealed a migratory stream from the Caucasus and Near East (Solodovnikov 2006; Khokhlov and Mimokhod 2008; Dubova 2010; Khudaverdyan 2011a). These samples exhibited close affinities with the Armenian Plateau Kura-Araxes culture sample and also with Tripolye culture samples from the Ukraine and Moldova (Alekseeva and Krus 1999 and Khudaverdyan 2011a). Hence, it is possible to outline cultural and ethnic communications in antiquity and also the known role of the Armenian Plateau as intermediary between the ancient distribution area of Tripolye cultures and Eastern countries (Passek 1949; Martiroyan and Mnacakanyan 1973 and Lang 2005).

The Kura-Araxes Armenian Plateau and Georgian samples and the Catacomb culture samples from Kalmykia, Ukraine and Dnieper have very close affinities. Gamkrelidze and Ivanov (1984) developed a hypothesis concerning this area. They considered the Armenian uplands and adjacent territories as the ancestral home of Indo-Europeans whence part of the tribes migrated to the Northern Black Sea Coast through the Caucasus, and a second part travelled through Central Asia and the Volga region. They then hypothesised that the tribal part which transported the important Aryan tribes' Catacomb ceremony was the first tribal part who migrated to the Black Sea steppes through the Caucasus, and perhaps also by sea. Berzin and Grantovsky (1962) and Klejn (1984) suggested that Indo-Aryans originated from the Catacomb culture, and Khlopin (1983) also connected this culture with the Indo-Aryans because the catacomb burial ritual observed at Sumbar cemetery had its roots in Southwestern Turkmenistan in the early IV millennium BC. In contrast, Fisenko (1966) considered that the Catacomb people were Proto-Hittites, and while Kuzmina (1998) supported this view, Anthony (2007) reported that the Catacomb ritual originators were Greek ancestors.

The Armenian Plateau sample, the Albashevo, Fatianovo and Balanovo cultures and the Timber Grave samples from the Volga region all exhibit close affinities (Khudaverdyan 2011a). The presence of Mediterranean characteristics in the following cultures was also noted by Trofimova (1949); (1) the Fatianovo culture, (as in Shevchenko 1984, 1986) (2) the Timber Grave cultures of the forest-steppe Volga region (Khokhlov 2000) and (3) the culture in the Southern Urals Mountains (Yusupov 1989).

Craniological research of the Eluninskaya and Andronovo cultures indicate a morphological association of these Siberian samples with populations from the Caucasia, the Near East and Central Asia (Solodovnikov 2006; Khudaverdyan 2011a). The different rates of genetic drift and external gene flow may have contributed to the morphological differentiation and diversification in the different Eastern European and Siberian populations.

The aim of this study is to establish new non-metric dental data for the ancient Transcaucasians, and to compare it with results from similar studies in Eastern European, Central Asian and Siberian populations. This will further the understanding of dental development and also the genetic relationships between these populations.

Materials and Methods

This inter-group analysis included a total of 30 series (Fig. 1, Table 1) from Transcaucasian, Eastern European, Central Asian and Siberian territories (Postnikova 1974; Khodjaiov 1977; Rud 1978; Kashibadze 1990, 2006, Gravere 1999; Rikushina et al. 2003; Zubova 2008, 2010; Tur 2009; Khudaverdyan 2009; and Kitov 2011).

Between 4000 and 3000 BC, the Early Bronze Age farming and cattle-breeding Landjik tribe comprised the Kuro-Arexes population of the Armenian Plateau, while the Late Bronze sample centred on the Black Fortress Armenian Plateau site. The combination of remains from these two sites for statistical analysis is justified by the following: (1) the individual 10 to 13 samples were inadequate for subsequent bio-distance analysis, (2) there was little distance between these sites which shared the common Shirak Plain cemetery and (3) analysis of all non-metric traits in this study revealed no significant differences between the remains from these two sites (Khudaverdyan 2009). However, remains from the Lchashen site on the Armenian Plateau were treated independently because there were sufficient crania in the Sevan burial pool (Kashibadze 2006). The Bronze Age sample contained (1) remains from the four Armenian sites of Lchashen, Shirakavan, Keti and Karchakhpyur with the two latter sites dated 1st century BC – 3rd century AD (Classical Age: c. 1^{st} BC – 3^{rd} AD, Kashibadze 1990) and (2) the Georgian Digomi and Mckheti samples which were analysed together because of their small numbers (Kashibadze 2006).

The following 10 non-metric dental traits were recorded for comparative analysis, using the binary system of "presence" or "absence": (1) diastema of the upper central incisors I^1–I^1 and double shovelling; (2) crowding of the upper lateral incisor I^2; (3) reduced hypocone of the upper second molar, forms

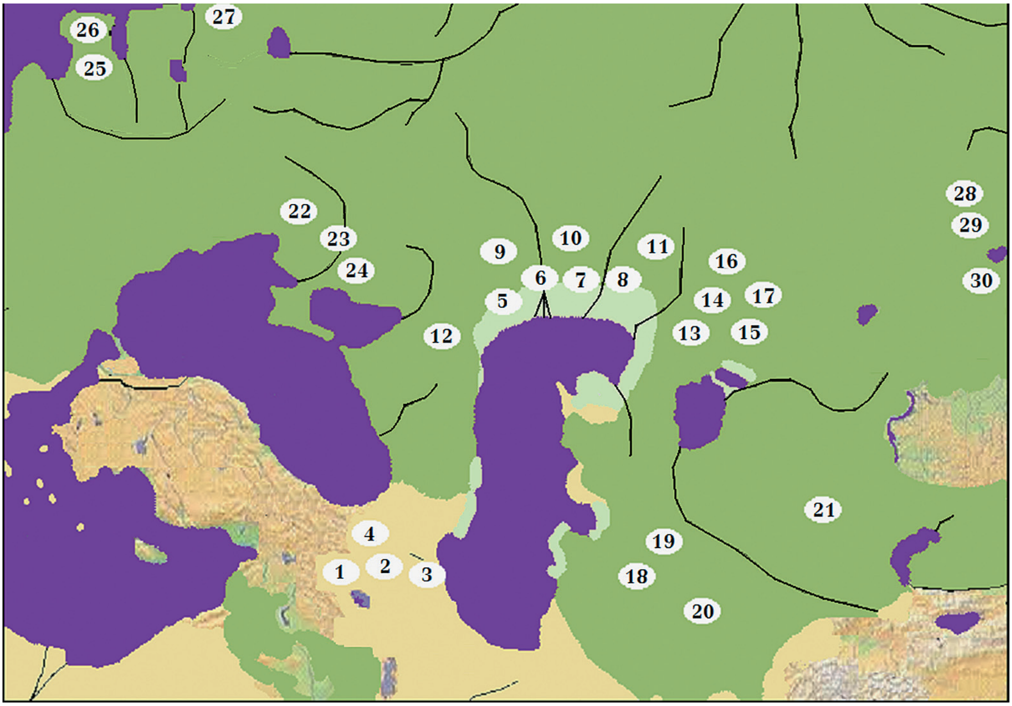

Fig. 1. Map of 30 samples used in the present study: 1–3 Armenian Plateau, 4 Georgia, 5–11 Volga region, 12 Kalmykia, 13–17 Ural, 18–20 Turkmenia, 21 Uzbekistan, 22–24 Ukraine, 25 Karelia, 26–27 Latvia, 28 Siberia, 29 Altai, 30 Siberia

3+ and 3, and reduced maxillary second permanent molar. Here, Dahlberg's degree of cusp reduction was employed; (4) Carabelli cusp on the upper first molar M^1; (5) four-cusped forms on the lower first molar M_1; (6) form +5 on the lower first molar $M_{1;}$ (7) four-cusped crown form of the lower second molar M_2; (8) deflected metaconid wrinkle on the lower first molar M_1 (9) the variant 2med II position of the second furrow of the M_1 metaconid, and (10) the distal crest on the lower first molar M_1 trigonid (Zubov 1968, 1973, 1974).

These were selected because traits (1) should not reveal inter-correlations in frequency of occurrence; (2) should have high inter-group variability; (3) can not change their degree of formation variant with an individual's age; 4) it should be easy to find comparative data for different populations.

This data was then subjected to multiple correspondence analysis (MCA) and agglomerative clustering techniques, the unweighted pair-group method/arithmetic average algorithm (UPGMA), which measures similarity as the average distance between all cases in one cluster to all cases in another. Here, the average distance between all cases in the resulting cluster is as small as possible and the distance between two clusters is taken as the average between all possible pairs of cases in the cluster. Statistical software packages of Kozintseva and Kozintseva, and Stat Soft STATISTICA 6.0 were used for this analysis.

Table 1. Transcaucasian, Eastern European, Central Asian and Siberian craniological samples

	Region Sample name	Absolute dates Chronological unit	Author
1	Armenian Plateau Landjik, Black Fortress	c. 4000–2000 BC	Khudaverdyan 2009
2	Armenian Plateau Lchashen, Shirakavan, Keti, Karchakhpyur	c. 3000–2000 BC c. 1 BC–AD 3	Kashibadze 1990, 2006
3	Armenian Plateau Lchashen	c. 3000–2000 BC	Kashibadze 2006
4	Georgia Digomi, Mckheti	c. 3000–2000 BC	Kashibadze 1990
5	Volga region Total group	c. 2000–1500 BC Fatianovo culture	Gravere 1999
6	Volga region Total group	c. 2000 BC Balanovo culture	Gravere 1999
7	Volga region Krivaya Luka	c. 4000–3000 BC Pit Grave culture	Zubova 2010
8	Volga region Taktalachuks	c. 3000–2000 BC	Rud 1978
9	Volga region Total group	c. 3000 BC Potapovsky culture	Kitov 2011
10	Volga region Total group	c. 18–15 BC Pokrovkaya culture	Kitov 2011
11	Volga region Total group	c. 17–16 BC Petrovskaya culture	Kitov 2011
12	Kalmykia Total group	c. 4000–3000 BC Pit Grave culture	Zubova 2010
13	Ural Total group	c. 17–16–13 BC Alakul culture	Kitov 2011
14	Ural Total group	c. 1800–1100BC Timber Grave culture	Kitov 2011
15	Ural Total group	Timber Grave and Alakul cultures	Kitov 2011
16	Ural Total group I	c. 16–12 BC Sintashtinskaya culture	Kitov 2011
17	Ural Total group II	c. 16–12 BC Sintashtinskaya culture	Kitov 2011
18	Turkmenia Total group	Painted Ceramics culture	Gravere 1999
19	Turkmenia Gonur-Depe	c. 3000–2000 BC	Rikushina et al. 2003
20	Turkmenia Altyn-Depe	c. 3000–2000 BC	Rikushina et al. 2003
21	Uzbekistan Sapalli-tepe	c. 3000–2000 BC	Khodjaiov 1977
22	Ukraine Total group	c. 5000–3000 BC Dnieper-Donets culture	Gravere 1999
23	Ukraine Total group	c. 4000–3000 BC Cucuteni-Trypillian culture	Gravere 1999

Table 1. cont.

	Region Sample name	Absolute dates Chronological unit	Author
24	Ukraine Total group	c. 4000–3000 BC Pit Grave culture	Gravere 1999
25	Karelia Oleniostrov	c. 5000–3000 BC	Gravere 1999
26	Latvia Total group	c. 5000–3000 BC	Gravere 1999
27	Latvia Kiwytkalnsk	c. 3000–2000 BC	Gravere 1999
28	Siberia Forret-steppe Barabinskaya	c. 1700–1200 BC Andronovo culture	Zubova 2008
29	Altai Total group	c. 1700–1200 BC Andronovo culture	Tur 2009
30	Siberia Total group	c. 10–8 BC Tagarskaya culture	Postnikova 1974

Results

Comparative analysis

Table 2 lists data on the frequency of occurrence of odontological traits in 11 populations on the Armenian Plateau in Eastern Europe/Central Asia, listed in Table 1 as population Nos 1, 5, 6, 7, 12, 18, 20, 21, 25, 26 and 27. The analysis included a group where we fixed non-metric traits. The comparative analysis results emphasise the importance of the Armenian Plateau's position on the anthropological map of Eastern Europe, Central Asia and Siberia.

Placement of the sample coordinate axis was determined by the value of dimension 1 with 34.7% and dimension 2 which had 25.3% of inertia. The singular values of the first three dimension coordinates are given in Table 3, where (1) the positive weight of dimension 1 gave the maxima of the four-cusp lower first molars (0.853), the I^1–I^1 diastema (0.782) and double shovelling (0.794); (2) the positive weight of dimension 2 provided the maxima for the +5 form on M_1 (0.827), the Carabelli cusp on M^1 (0.650) and the four-cusp lower second molars (0.592) and (3) the third coordinates accounted for 20.0% of the intergroup, and the positive weight signified the hypocone reduction on M^2 (0.742).

The graph of the first two dimensions in Fig. 2 demonstrates how geographic and ethnic trends are vizualized. The first dimension shows populations of the Armenian Plateau (Landjik and Black Fortress), the Volga region (Krivaya Luka: Pit Grave culture), Turkmenia (Painted Ceramics culture) and Kalmykia (Pit Grave culture). These are depicted on the positive-coordinate axis and are clearly separated from the other groups, while Altyn-Depe and Sapallitepe tend to cluster together. Meanwhile, groups from the Volga region (Fatianovo culture), Karelia (Oleni ostrov) and Latvia (Kiwytkalnsk and group c. 5000–3000 BC) cluster on the negative-coordinate axis.

The distance between the samples was checked in the cluster tree on Fig. 3, where the following affinities are noted: (1) samples from Kalmykia (Pit Grave

Table 2. Percentage occurence of non-metric dental traits in comparative samples

Sample	I^1–I^1 diastema	I^2 crowding	Hypocone reduction on M^23+ and 3	Carabelli cusp on M^1	Four-cusped M_1	Form +5 on M_1	Four-cusped M_2	Deflecting wrinkle of metaconid	2 med II on M_1	Distal trigonid crest
1	23.7	62.5	37.5	31.3	14.3	26.8	64.7	42.5	29.2	42.5
2	2.4	1.2	34.2	43.4	16.7			16.7	41.7	16.7
3	3.6	1.8	32.7	38.7	23.3		72.4	16.7	40.0	10.0
4	4.9	1.7	10.3	47.1	9.7			18.5	14.8	8.9
5	2.0	2.0	22.5	18.6	8.8	8.8	86.1	2.9	33.3	0
6	4.0	4.0	28.5	50.0	10.7	53.6	90.5	9.1	28.6	4.5
7	25.0		12.5	16.7	18.2	0	72.7	0		0
8		25.2	35.7	27.2	8.3	50.0	70.0	20.0		11.1
9			50.0	29.1	13.0		86.7	26.7	21.4	12.5
10			52.0	10.9	14.0		76.9	16.7	17.4	3.2
11			43.8	4.3	27.3		82.4	26.7	6.7	0
12	12.5		42.3	5.6	10.5	6.7	89.5	25.0		0
13			47.1	8.0	7.4		68.5	14.3	11.1	3.9
14			12.5	21.7	4.2		88.2	12.5	10.0	8.3
15			35.6	18.8	10.9		82.5	18.5	23.1	0
16			22.2	16.0	17.4		28.6	17.6	5.6	0
17			41.2	15.8	25.0		61.1	41.7	10.0	0
18	3.0	13.6	26.1	28.5	5.7	31.4	92.5	4.2	19.2	
19			33.3	38.3	18.8	75.4	83.1	11.5		0
20	15.4		27.3	40.0	18.1	80.7	97.3	23.1		6.3
21	17.2	0	16.7	13.6	33.3	63.0	97.7			15.1
22	4.2	0	16.1	35.2	0		75	7.1	13.3	3.8
23	0	16.7	16.7	50.0	21.4		62.5	9.1	30	0
24	0	15.4	12.5	29.5	6.1		92.9	9.4	24.1	1.1
25	6.7	0	26.2	30.8	3.5	21.4	55.5	15.4	30.8	10.9
26	3.3	3.3	14.1	30.3	2.4	23.8	66.0	11.1	27.0	0
27	9.9	11.3	22.0	38.3	10.2	20.4	83.1	11.4	22.2	14.7
28			27.8	4.8	38.9		89.5	5.6		0
29		0	52.2	68.7	23.8		96.4	10.3	17.2	11.1
30		11.1	41.2	32.1	10.0	90.0	88.3	28.6		3.6

culture) and the Volga region (Krivaya Luka – Pit Grave culture) are once again identified as most closely allied with the Landjik and Black Fortress samples from the Armenian Plateau, (2) Kiwytkalnsk samples have affinity with the Turkmenia sample (Painted Ceramics culture), (3) the Latvian sample from. 5000–3000 BC and the Balanovo Bronze Age culture-from the Volga region exhibit very close

Table 3. The MCA singular values of seven non-metric dental traits in three dimensions for 11 samples*

Non-metric dental trait	Dimension 1	Dimension 2	Dimension 3
I^1–I^1 diastema	0.782	–0.455	–0.042
Double shovelling	0.698	–0.301	0.560
Forms 3+ and 3 hypocone reduction on M^2	0.279	–0.113	0.742
Carabelli cusp on M^1	–0.227	0.650	0.455
Four-cusped M_1	0.853	0.079	–0.447
Form +5 on $\mathbf{M}_1$	0.440	0.827	0.190
Four-cusped M_2	0.529	0.592	–0.310
Percentages of inertia explained	34.7	25.3	20.0

*Samples are listed in Table 1: 1. Armenian Plateau, Landjik, Black Fortress; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 7. Volga region, Krivaya Luka, Pit Grave culture; 12. Kalmykia, Pit Grave culture; 18. Turkmenia, Painted Ceramics culture; 20. Turkmenia, Altyn-Depe; 21.Uzbekistan, Sapallitepe; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk.

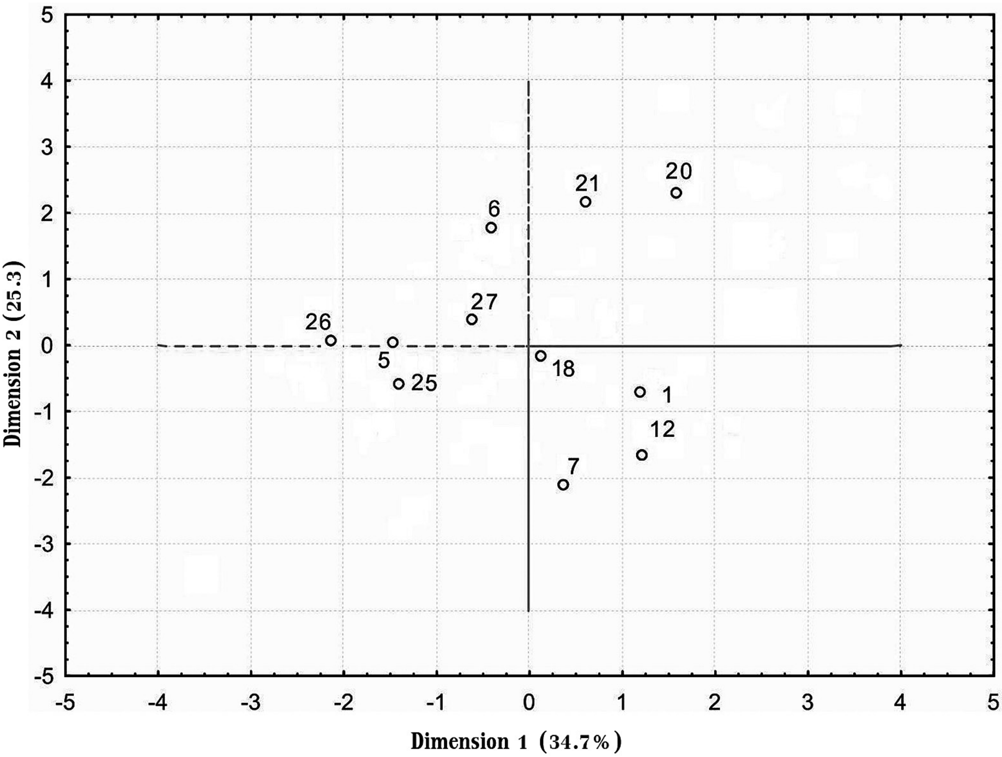

Fig. 2. Multiple Correspondence Analysis; 2D plot of column coordinates: dimension 1 × 2
1. Armenian Plateau, Landjik, Black Fortress; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 7. Volga region, Krivaya Luka, Pit Grave culture; 12. Kalmykia, Pit Grave culture; 18. Turkmenia, Painted Ceramics culture; 20. Turkmenia, Altyn-Depe; 21.Uzbekistan, Sapallitepe; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk.

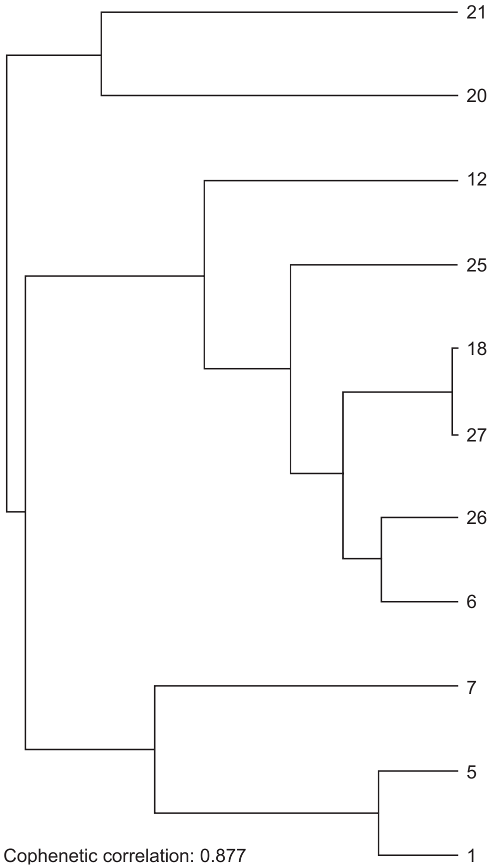

Fig. 3. Cluster tree
1. Armenian Plateau, Landjik, Black Fortress; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 7. Volga region, Krivaya Luka, Pit Grave culture; 12. Kalmykia, Pit Grave culture; 18. Turkmenia, Painted Ceramics culture; 20. Turkmenia, Altyn-Depe; 21.Uzbekistan, Sapallitepe; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk.

affinities, while (4) the Central Asian Altyn-Depe and Sapallitepe samples have the closest affinities of all.

Table 2 presents the frequency of occurrence of non-metric dental traits in 20 Transcaucasian, Eastern European, Center Asian and Siberian populations listed in Table 1 as: Nos 1–2, 4–6, 8–10, 13–14, 18–20, 22–27, 29. Analysis included new groups from the Ukraine, the Volga, the Urals and Siberia, and the new non-metric traits of deflected metaconid wrinkle, 2med (II) and distal trigonid crest.

The first two coordinate values are given in Table 4 and placement of the samples' coordinate axis was determined by values of dimension 1 with 32.8% and dimension 2 with 22.4% of inertia, respectively. The character of attribute connection in these coordinates show that the large first coordinate axis values correspond to groups with deflected metaconid wrinkle (0.767), distal trigonid crest (0.747), four-cusp lower first molars (0.710) and hypocone reduction on M^2 (0.646). The second coordinate axis are maximum for the four-cusp lower second molars (0.749) and the Carabelli cusp on the upper first molar (0.621). The third coordinate axis accounts for 16.6% of the intergroup, and the weight gives a 2med (II).

The graph of the first two dimensions in Fig. 4 denotes the following populations close to the axes' intersection; (1) the Georgian Digomi and Mckheti; (2) the Latvian Kiwytkalnsk and the Volga region Potapovsky and Pokrovkaya cultures; (3) the Armenia Plateau sample of Lchashen, Shirakavan, Keti and Karchakhpyur serves as a link between the Volga region Taktalachuks, and the Ukrainian Cucuteni-Trypillian and Pit Grave cultures which share affinities. Meanwhile, the remaining Alakul and Timber Grave cultures from the Urals and the Turkmenian Painted Ceramics culture cluster close to the centre. The more discriminant distal trigonid crest, and the four-cusp lower first molar dental traits are on the positive coordinates of the first axis: with the Armenian Pla-

Table 4. The MCA singular values of seven non-metric dental traits in three dimensions for 20 samples*

Non-metric dental trait	Dimension 1	Dimension 2	Dimension 3
Forms 3+ and 3 hypocone reduction on M^2	0.646	0.147	–0.284
Carabelli cusp on M^1	0.269	0.621	0.483
Four-cusped M_1	0.710	0.558	0.037
Four-cusped M_2	–0.079	0.749	–0.444
Deflecting wrinkle of metaconid	0.767	–0.446	–0.185
2med (II)	0.388	–0.118	0.755
Distal trigonid crest	0.747	–0.282	–0.214
Percentages of inertia explained	32.800	22.500	16.600

*Samples are listed in Table 1: 1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4.Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 18. Turkmenia, Painted Ceramics culture; 19. Turkmenia, Gonur-Depe; 20.Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 29. Altai, Andronovo culture.

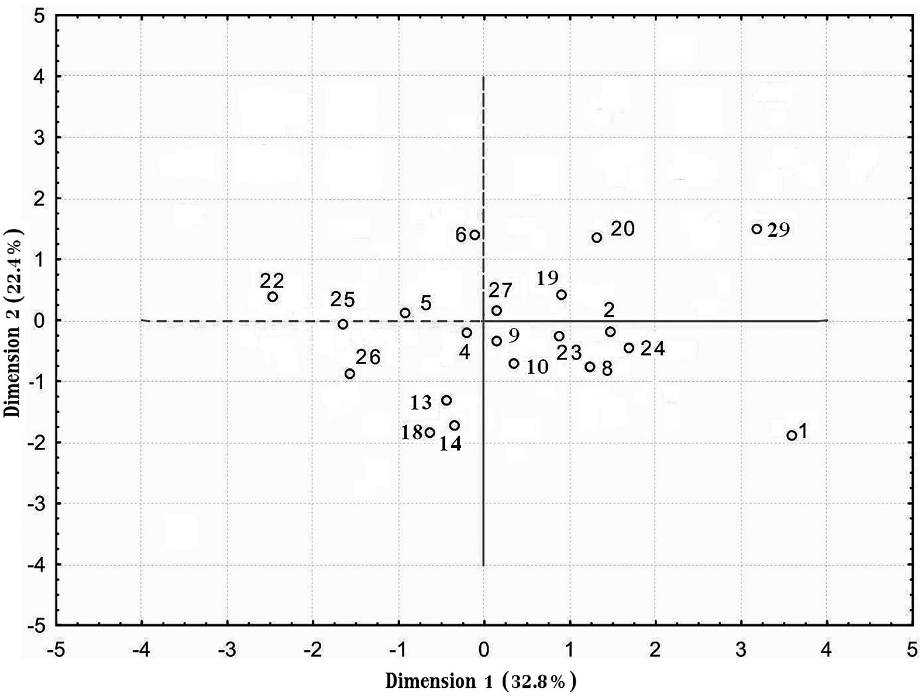

Fig. 4. Multiple Correspondence Analysis; 2D plot of column coordinates: dimension 1 × 2
1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4.Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 18. Turkmenia, Painted Ceramics culture; 19. Turkmenia, Gonur-Depe; 20.Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 29. Altai, Andronovo culture.

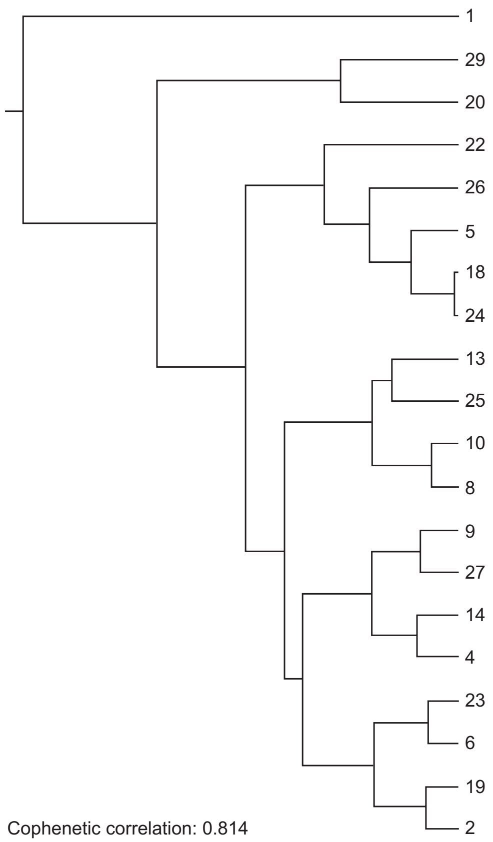

Fig. 5. Cluster tree
1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4.Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovo culture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 18. Turkmenia, Painted Ceramics culture; 19. Turkmenia, Gonur-Depe; 20.Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 29. Altai, Andronovo culture.

teau group, the Altai Andronovo culture and the Turkmenian Altyn-Depe samples exhibiting higher frequencies of these traits.

The distance between the samples is checked in the cluster tree in Fig. 5. Results there show: (1) the Armenian Plateau Lchashen, Shirakavan, Keti and Karchakhpyur groups and the Turkmenian Gonur-Depe samples exhibit closest affinities to the Ukanian Cucuteni-Trypillian tribe cultures and the Balanovo from the Volga region; (2) the Digomi and Mckheti Georgian sample shares closest affinity with the Timber Grave Ural culture: (3) the Volga Potapovsky culture is the steppe population with closest affinity to the Latvian Kiwytkalnsk group; (4) the Altyn-Depe Turkmenian sample is closest in identity to the Altai Andronovo culture and (5) the Turkmenian Painted Ceramics culture and the Ukrainian Pit Grave culture also share affinity.

The frequency of occurrence of 5 non-metric dental traits in 26 Transcaucasian, Eastern European, Central Asian and Siberian populations is analysed in Table 2. This compares Tables 1's reduced non-metric traits numbered 11, 15–17, 28 and 30 and the included new groups. The first two coordinate values are also presented in Table 5 with placement of the 26 sample coordinate axis determined by the first dimension value of 38.8% of inertia and dimension 2 with 22.2%. The following results were determined: (1) the first dimension has the greatest values for hypocone reduction in the second maxillary permanent molar at 0.82, the four-cusp lower first molars at 0.756 and deflected metaconid wrinkle at 0.681: (2) the second dimension has maximum for the four-cusp lower second molars at 0.920 and (3) the third dimension has 17.2% of the intergroup. Finally, the positive weight gives a Carabelli cusp on the upper first molar.

The graph resulting from the first two axes is highlighted in Fig. 6. This shows

Table 5. The MCA singular values of five non-metric dental traits in three dimensions for 26 samples*

Non-metric dental trait	Dimension 1	Dimension 2	Dimension 3
Forms 3+ and 3 hypocone reduction on M^2	0.821	0.192	0.168
Carabelli cusp on M^1	–0.482	–0.254	0.833
Four-cusped M_1	0.756	0.041	0.307
Four-cusped M_2	–0.038	0.920	0.206
Deflecting wrinkle of metaconid	0.681	–0.406	0.058
Percentages of inertia explained	38.900	22.300	17.200

*Samples are listed in Table 1: 1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4. Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovoculture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 11. Volga region, Petrovskaya culture; 12. Kalmykia, Pit Grave culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 15. Ural, Timber Grave and Alakul cultures; 16. Ural total group I, Sintashtinskaya culture; 17. Uraltotal group II, Sintashtinskaya culture; 19. Turkmenia, Gonur-Depe; 20. Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 28. Forest-steppe Barabinskaya, Andronovo culture; 29. Altai, Andronovo culture; 30. Siberia,Tagarskaya culture.

the proximity of the following groups and reveals that they gathered towards the axes' intersection; the Potapovsky culture, the Taktalachuks from the Volga, the Ural Timber Grave and Alakul cultures, the Turkmenian Gonur-Depe, the Latvian Kiwytkalnsk, the Armenian Plateau Lchashen, Shirakavan, Keti, Karchakhpyur and the Siberian Tagarskaya culture. The first axis shows that the Landjik and Black Fortress Armenian plateau populations, the Ukrainian Pit Grave culturecand the Volga Balanovo culture are close to each on the positive-coordinate axis. Here, the most discriminant dental traits are the disto-lingual cusp hypocone reduction of the second maxillary permanent molar, the four-cusp lower first molars and deflected metaconid wrinkle. These traits show higher frequencies in the Urals (Total group II: Sintashtinskaya Culture), the Volga region (Petrovskaya culture) and Armenian Plateau (Landjik and Black Fortress) groups; and slightly lower frequencies in the Turkmenia (Gonur-Depe and Altyn-Depe), Altai (Andronovo culture), Armenian Plateau (Lchashen, Shirakavan, Keti and Karchakhpyur) and the Volga region (Potapovsky culture and Taktalachuks) samples. The Ural populations (Total group II: Sintashtinskaya culture), Ukraine (Dnieper-Donetz Culture) and Volga region (Petrovskaya culture) are located further from the axes' intersection. Meanwhile, the Ukrainian (Cucuteni-Trypillian culture), Georgian (Digomi and Mckheti), and Karelia (Oleni ostrov) samples are located near the negative-coordinate axes' intersection, while the Volga region Fatianovo culture and Ural Timber Grave culture recorded very close affinity.

The cluster tree in Figure 7 checks the distance between the samples. Here; (1) the Landjik and Black Fortress Armenian Plateau group share some dental morphological affinities with the Ural total group II: Sintashtinskaya cultures; (2) the Forest-steppe Barabinskaya Andronovo culture has affinity with the Volga Pokrovkaya and Petrovskaya cultures,the Kalmykia Pit Grave culture and the Ural Alakul cultureand (3) The Digomi and Mckheti Georgian samples, the Ukranian Cucuteni-Trypillian cultureand

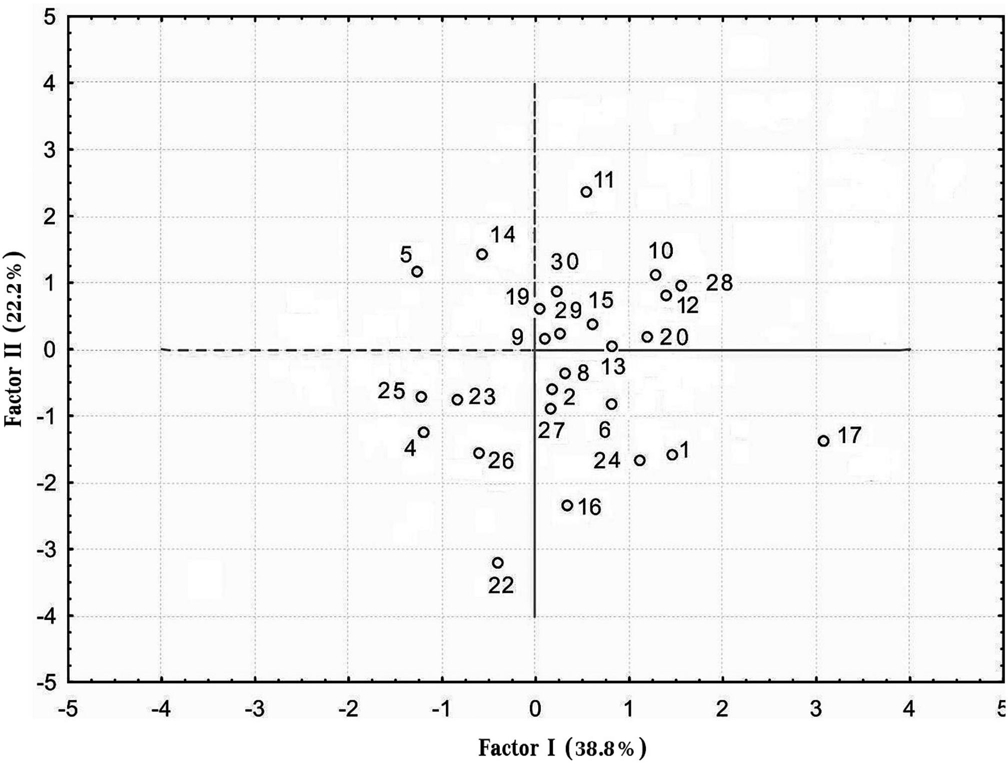

Fig. 6. Multiple Correspondence Analysis; 2D plot of column coordinates: dimension 1 x 2.
1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4. Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovoculture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 11. Volga region, Petrovskaya culture; 12. Kalmykia, Pit Grave culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 15. Ural, Timber Grave and Alakul cultures; 16. Ural total group I, Sintashtinskaya culture; 17. Uraltotal group II, Sintashtinskaya culture; 19. Turkmenia, Gonur-Depe; 20. Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 28. Forest-steppe Barabinskaya, Andronovo culture; 29. Altai, Andronovo culture; 30. Siberia,Tagarskaya culture.

the Armenian Plateau Lchashen, Shirakavan, Keti and Karchakhpyur samples displayed very close affinity.

Discussion and Conclusion

Factor correspondence and cluster analysis revealed non-metric odontologic analogies for a complex of traits in populations from Transcaucasia, Eastern Europe, Central Asia and Siberia. The Armenian Plateau sample (Landjik, Black Fortress) and samples from the Volga region (Krivaya Luka – Pit Grave culture and the Balanovo culture), Kalmykia (Pit Grave culture), and Ukraine (Pit Grave culture) exhibit very close affinities. The odontological data also revealed close affinities between the Armenian Plateau Lchashen, Shirakavan, Keti, and Karchakhpyur sample, the Ukrainian Tripolye cultureand the Volga Taktalachuks and

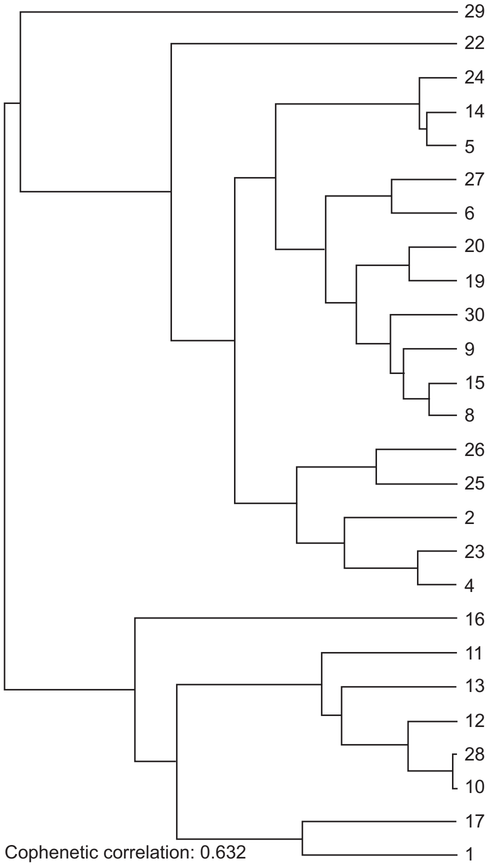

Fig. 7. Cluster tree
1. Armenian Plateau, Landjik, Black Fortress; 2. Armenian Plateau: Lchashen, Shirakavan, Keti, Karchakhpyur; 4. Georgia, Digomi, Mckheti; 5. Volga region, Fatianovo culture; 6. Volga region, Balanovoculture; 8. Volga region, Taktalachuks; 9. Volga region, Potapovsky culture; 10. Volga region, Pokrovkaya culture; 11. Volga region, Petrovskaya culture; 12. Kalmykia, Pit Grave culture; 13. Ural, Alakul culture; 14. Ural, Timber Grave culture; 15. Ural, Timber Grave and Alakul cultures; 16. Ural total group I, Sintashtinskaya culture; 17. Ural-total group II, Sintashtinskaya culture; 19. Turkmenia, Gonur-Depe; 20. Turkmenia, Altyn-Depe; 22. Ukraine, Dnieper-Donets culture; 23. Ukraine, Cucuteni-Trypillian culture; 24. Ukraine, Pit Grave culture; 25. Karelia, Oleniostrov; 26. Latvia c. 5000–3000 BC; 27. Latvia, Kiwytkalnsk; 28. Forest-steppe Barabinskaya, Andronovo culture; 29. Altai, Andronovo culture; 30. Siberia,Tagarskaya culture.

Balanovo culture. Craniological analysis showed Moldovian and Ukrainian Tripolye culture samples are unique in exhibiting much closer affinities to the Armenian Plateau samples (Khudaverdyan 2011a).

The Georgia (Digomi, Mckheti) group has close affinity with those of the Latvian (Kiwytkalnsk) and Volga region (Potapovsky and Pokrovkaya cultures) samples. The Altyn-Depe Turkmenian sample's closest affinity is to the Altai Andronovo culture, while the closest affinity of all was between the Painted Ceramics Turkmenian culture, the Latvian Kiwytkalnsk and the Ukrainian Pit Grave culture.

These analyses provided abundant evidence supporting population migration from the Armenian Plateau and Transcaucasia. This is consistent with recent genetic studies supporting the Near Eastern contribution to the European gene pool; where the great majority of European Y chromosomes originated from Neolithic expansion (Richards et al. 2000; Chikhi et al. 2002 and Balaresque et al. 2010). This then suggested that the dispersal of Indo-European languages was accompanied by migration and gene flow from the Armenian Plateau and Transcaucasian homeland to the various historical seats of Indo-European languages.

The origin and development of ancient cultures is clearly connected with general laws of social and economic development and environmental influence. The physical environment has played a significant role in all stages of mankind's development, and it has paramount importance in expanding or constraining a society's cultural and economic progress. In conjunction with the expansion of cattle-breeding and the emergence of ancient metallurgy, the Eurasian steppe developed from first dividing ethnic groups to uniting them in a larger community. The steppe's wide expanse provided favourable conditions for human life, and the spread of information and technology promoted wide Bronze Age cultural integration throughout this area (Sarianidi 2010). This has resulted in the contemporary ethnic diversity of this region with its great variety of anthropological types. Reference to morphological features of ancient populations in Eastern Europe, Central Asia and Siberia has appeared in previous works (Khudaverdyan 2009, 2011a; Khokhlov & Mimokhod 2008; Solodovnikov 2006 and Dubova 2010). This revealed the participation of Near Eastern, Armenian Plateau and Caucasian indigenous populations in formation of the anthropological character of certain tribes and their movements. It has also inflamed the desire to further track the roots of the earliest cultural foundations.

Odontological morphological traits markedly differentiate the comparative populations from Transcaucasia, Eastern Europe, Central Asia and Siberia emanating from different ethnic and cultural complexes. Thus, they provide an appropriate method for studying the biological differentiation of foundation populations. Herein, samples from the Armenian Plateau and Georgia possessed closest affinity to populations from Kalmykia (Pit Grave culture), the Ukraine (Tripolye culture), the Urals (Sintashtinskaya, Timber Grave cultures), the Volga region (Pit Grave, Balanovo, Fatianovo, Potapovsky cultures) and from Central Asia (Gonur-Depe). These conclusions are consistent with reports from other bio-distance studies examining non-metric cranial features and Armenian Plateau samples. Based on our biodistance results, we suggest that there was a degree of genetic drift among inland populations at the beginning of the Bronze Age, Although this assertion requires further exploration, it is clear that the techniques employed in this study were most appropriate in uncovering existent significant differences between the populations. In conclusion, the biodistances determined in non-metric dental traits reported herein indicate that no significant prehistoric gene flow occurred in the Armenian Plateau.

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Conflict of interests

The author declares that there is no conflict of interests.

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References

Abdushelishvili MG. 1982. Anthropology of the population of Caucasus in the Bronze Age. Tbilisi, National Academy of Science of Georgia.

Abdushelishvili MG. 2003. Anthropology of the Ancient and Modern people of Caucasus. In: TI Alekseeva, editor. Anthropology horizons. Moscow: Scientic World. 248–65.

Alekseeva TI, Krus S. 1999. The Ancient population of Eastern Europe. In: TI Alekseeva, editor. The Eastern Slavs. Anthropology and Ethnic History. Moscow: Scientic World. 254–79.

Anthony DW. 2007. The horse, the wheel and language: How Bronze-Age riders from the Eurasian steppes shaped the modern world. Princeton and Oxford: Princeton University Press.

Balaresque P, Bowden GR, Adams SM, Leung Ho-Yee, King TE, Rosser ZH, et al. 2010. A Predominantly Neolithic Origin for European Paternal Lineages. PLoS Biology 8(1): e1000285. doi:10.1371/journal.pbio.1000285.

Berzin E, Grantovsky E. 1962. Kinsman of Indians on Black Sea shores. Soviet Land XV (10):26–27.

Chernykh EN. 1988. Circumpontic Province and ancient Indo-Europeans. In: NY Merpert and EN Chernykh, editors. Ancient East an ethnocultural contact, Moscow: Science. 37–57.

Chicki L, Nichols RA, Barbujani G, Beaumont MA. 2002. Y genetic data support the Neolithic Demic Diffusion Model. Proc Natl Acad Sci 99:11008–13.

Coppa A, Cucina A, Lucci M, Mancinelli D, Vargiu R. 2007. The origins and spread of agriculture in Italy: a dental nonmetric analysis. Am J Phys Anthropol 133: 918–30.

Cucina A, Lucci M, Vargiu R, Coppa A. 1999. Dental evidence of biological affinity and life conditions of prehistoric Trentino (Italy) samples from the Neolithic to the Early Bronze Age. Int J Osteoarch 6:404–16.

Dahlberg AA. 1963. Dental evolution and culture. Hum Biol 35: 237–49.

Dubova NA. 2010. Process of ethnogenesis on the Eurasian space (anthropological consequences of migrations and trade in Bronze Age). In: SA Arytyunov, AP Bujilova, et al., editors. “Esse Homo”: his biological and social history. Materials of the International Conference, devoted to the 80 birth anniversary Academician RAS Valery P. Alekseev (Fourth Alexeev’s reading), Moscow: Scientic World. 7–79.

Edgar H, Lease L. 2007. Correlations between deciduous and permanent mandibular molars in a European-American sample. Am J Phys Anthropol 133:726–34.

Fisenko VA. 1966. On the origins and chronology of the Catacomb-grave culture. Saratov: Saratov University Press.

Gamkrelidze TV, Ivanov VV. 1984. Indo-European language and Indo-Europeans. Tbilisi: Tbilisi University Press

Gray RD, Atkinson QD. 2003. Language-tree divergence times support the Anatolian theory of Indo-European origins. Nature 426 (6965):435–39.

Grine FE. 1986. Anthropological aspects of the deciduous teeth of South African blacks. In: RJ Singer, et al., editors. Variation, culture and evolution in African populations. Johannesburg: Witwatersrand University Press. 47–83.

Grine FE. 1990. Deciduous dental features of Kalahari San: comparisons of non-metrical traits. In: GH Sperber, editor. From the apes to angels. New York. 153–69.

Gravere RU. 1999. Odontological aspect in ethnogenesis and ethnic history of Eastern Slavic peoples. In: TI Alekseeva, editor. The Eastern Slavs. Anthropology and Ethnic History. Moscow: Scientic World. 205–19.

Hanihara K. 1965. Some crown characters of the deciduous incisors and canines in Japanese-American hybrids. J Anth Soc Nippon 72:135–45.

Hanihara K. 1966. Mongoloid dental complex in the deciduous dentition. J Anth Soc Nippon 74:61–71.

Hanihara K, Minamidate T. 1965. Tuberculum accesorium mediale internum in the human deciduous lower second molars. J Anth Soc Nippon 73:9–18.

Hillson SW. 1996. Dental Anthropology. Cambridge: Cambridge University Press.

Johnson AL, Lovell NC. 1994. Biological differentiation at Predynastic Naqada, Egypt:

an analysis of dental morphological traits. Am J Phys Anthropol 93:427–33.
Jørgensen K. 1956. The deciduous dentition: a descriptive and comparative anatomical study. Acta Odont Scand 14:1–202.
Kaczmarek M. 1991. Reflection on scoring non-metric dental traits. Variability and Evolution 1:76–94.
Kaczmarek M. 1992. Dental morphological variation of the Polish people and their Eastern neighbours. In: P Smith, E Tchernov, editors. Structure, Function and Evolution of Teeth. Freund Publishing House Ltd. 413–423
Kaczmarek M, Pyżuk M. 1985. Analiza odontologiczna wczesnośredniowiecznej populacji z Czerska. In: J Piontek, A Malinowski, editors. Teoria i empiria w Polskiej Szkole Antropologicznej. Wydawnictwo Naukowe UAM, Poznań, seria antropologia, 11.261–77.
Kashibadze VF. 1990. Odontology of Armenians. Biological Journal of Armenia 4 (43):285–295.
Kashibadze VF. 2006. Odontological data for an anthropological history of the Caucasus. Ethnographic Reviews 5:117–33.
Kitagawa Y. 2000. Nonmetric morphological characters of deciduous teeth in Japan: diachronic evidence of past 4000 years. Int J Osteoarch 10:242–53.
Kitov EP. 2011. Anthropology of the population of Southern Urals Mountains of Bronze Age. Ph D dissertation. Moscow.
Khodjaiov TK. 1977. Anthropological structure of the population of Bronze Age from Sapallitepe. Tashkent: Fan.
Khohlov AA. 2000. Craniological materials Timber Grave Culture of the south of the Average Volga region. In: SG Efimova, editor. The people of Russia: from the past to the present, Moscow. 217–42.
Khokhlov AA, Mimokhod RA. 2008. Craniology of the population of steppe Ciscaucasia and the Volga region in post Catacomb time. Anthropology bulletin 16:44–70.
Khlopin IN. 1983. Southwest Turkmenia during of Late Bronze Age (on materials of Sumbar burial). Leningrad: Science.
Khudaverdyan AYu. 2009. The bronze population of Armenian highland. Ethnogenesis and ethnic history. Yerevan: Van Aryan.
Khudaverdyan AYu. 2011a. Migrations in the Eurasian steppes in the light of paleoanthropological data. The Mankind Quarterly LI (4):387–63.
Khudaverdyan AYu. 2011b. Secular dental changes in the populations of the Armenian highland: evolutionary and ecological aspects. Archeology, Ethnography & Anthropology of Eurasia 1(45):139–46.
Klejn LS. 1984. The coming of Aryans: who and whence? Bulletin of the Deccan College Research Institute 43: 57–72.
Kuzmina EE. 1998. Cultural connections of the Tarim Basin people and pastoralists of the Asian steppes in the Bronze Age. In: VH Mair, editor. The Bronze Age and Early Iron Age peoples of Eastern Central Asia, vol. I. The Institute for the Study of Man in collaboration of the University of Pennsylvania Museum Publications. 63–93.
Lang J. 2005. Armenians. The people creator. Riddles of ancient civilizations. Moscow.
Lease L. 2003. Ancestral determination of African-Americans and European-Americans deciduous dentition using metric and non-metric analysis. Ph.D. dissertation. Columbus, Ohio: Ohio State University.
Lease L, Sciulli P. 2005. Brief communication: discrimination between European-American and African-American children based on deciduous metrics and morphology. Am J Phys Anthropol 126:56–60.
Lukacs J, Hemphill B. 1991. The dental anthropology of prehistoric Baluchistan: a morphometric approach to the peopling of South Asia. In: Kelley, CS Larsen, editors. Advances in dental anthropology, M. New York, 77–119.
Lukacs JR, Walimbe SR. 1984. Deciduous dental morphology and the biological affinities of a Chalcolithic skeletal series from Western India. Am J Phys Anthropol 65: 23–30.
Martiroyan AA, Mnacakanyan AO. 1973. Prierevansky treasure of ancient Bronze.

Short messages of Institute of archeology Academy of Sciances USSR 134:122–27.

Merpert NY. 1988. About an ethnocultural situation 4000–3000 BC in Circumpontic zone. In: NY Merpert, EN Chernykh, editors. Ancient East an ethnocultural contact, Moscow: Science. 7–36.

Morris DH, Gladstone HS, Dahlberg AA. 1978. Uto-Aztecan premolar: the anthropology of a dental trait. In: PM Butler, KA Joysey, editors. Environment, Evolution, and Function of Teeth. New York. 69–79.

Moskona D, Vainder M., Hershkovitz I., Kobyliansky E. 1998. Dentition peculiarities in human isolates – South Sinai Beduin tribes. In: J Mayhall and T Heikkinen, editors. Dental morphology 1998: 11th International symposium on dental morphology. Oulu, Finland. 74–84.

Nechitailo AL. 1991. Communications of the population of steppe Ukraine and the North Caucasus during a Bronze Age. Kiev.

Passek TS. 1949. Periodization Tripol settlements. Kiev.

Pinto-Cisternas J, Moggi-Cecchi J, Pacciani E. 1995. A morphological variant of the permanent upper lateral incisor in two Tuscan samples from different periods. In: J Cecchi-Moggi, editor. Aspects of dental biology: Paleonthology, anthropology and evolution. Florence International Institute for the Study of Man. 333–39.

Postnikova NM. 1974. Odontologic characteristic craniological series Minusinskaya Basin. In: AA Zubov, editor. Rasogenetic processes in ethnic history, Moscow. 243–50.

Pystovalov S. 2002. Development of cattle breeding economy in Northern Black Sea Coast during of a Neolith and Bronze Age. In: EV Iarovoi, et al., editors. Most ancient of a generality of farmers and cattlemen of Northern Black Sea Coast (IV millennium BC – IV centuries AD), Tiraspol. 101-04.

Richards M, Macaulay V, Hickey E, Vega E, Sykes B, Guida V, et l. 2000. Tracing European founder lineages in the Near Eastern mtDNA pool. Am J Hum Genet 67:1251–276.

Rikushina GV, Dubova NA, Suvorova NA. 2003. Odontologic characteristic of the ancient population of Turkmenistan (on materials of burial Bronze Age from Gonur-Depe). In: GA Aksyanova, editor. Science the person and a society: results, problems, prospects. Moscow. 130–40.

Rud NM. 1978. Odontologic the characteristic of the population from Taktalachuks. In: EP Kazakov, editor. Monument of the Bulgarian time in east areas Tatarii. Moscow. 120–28.

Sarianidi VI. 2010. Long before Zarathustra (archaeological evidence in Bactria and Margiana). Moscow.

Sasaki K, Kanazawa E. 1998. Morphological traits on dentino-enamel juction of lower deciduous molar series. In: J Mayhall and T Heikkinen, editors. Dental morphology 1998: 11th international symposium on dental morphology. Oulu, Finland, University of Oulu. 167–78.

Sciulli PW. 1998. Evolution of the dentition prehistoric Ohio Valley Native Americans: II. Morphology of the deciduous dentition. Am J Phys Anthropol 106:189–205.

Scott GR, Dahiberg AA. 1982. Microdifferentiation in tooth crown morphology among indians of the American Southwest. In: B Kurten, editor. Teeth: Form. Function and Evolution. New York. 259–91.

Scott GR, Turner CG. 1988. Dental Anthropology. Annual Review of Anthropology 17: 99–126

Scott RG, Turner CG. 1997. The anthropology of modern human teeth: dental morphology and its variation in recent human populations. Cambridge: Cambridge University Press.

Segeda SP. 1993. Odontological data for the Chernyakov culture population. Dental Anthropology Newsletter **7**(2):5–7.

Shevchenko AB. 1984. Paleoanthropology data to a question on a population origin Srubnaja a cultural-historical generality. In: II Gokhman, editor. Problems of anthropology of the ancient and modern population of Eurasia. Leningrad: Science. 55–73.

Shevchenko AB. 1986. Anthropology of the population of South Russian steppes during a Bronze Age. In: II Gokhman, editor. Anthropology of the modern and ancient population of the European part of the USSR. Leningrad: Science. 121–215.

Smith P. 1978. Evolutionary changes in the deciduous dentition of Near Eastern populations. J Hum Evol 7:401-08.

Smith PE, Koyoumdisky-Kaye Kalderon W, Stern D. 1987. Directionality of dental trait frequency between human second deciduous and first permanent molars. Arch Oral Biol 32:5–9.

Solodovnikov KN. 2006. The population of mountain and forest-steppe of Altai of the Bronze Age according to paleoanthropology. PhD dissertation. Barnaul.

Trifonov WA. 1991. Steppe near Kuban during an epoch of eneolithic-average bronze (periodization). Ancient cultures near Kuban (on materials of archaeological works in zones of land improvement of Krasnodar territory). Leningrad: Science.

Trofimova TA. 1949. To a question on anthropological ties during an Fatianovo Culture. Soviet ethnography 3:37–73.

Tocheri M. 2002. The effect of sexual dimorphism, asymmetry and inter-trait association on the distribution of thirteen deciduous dental nonmetric traits in a sample of Pima Indians. Dental Anthropology 15:1–9.

Townsend GC, Brown T. 1981. The Carabelli trait in Australian aboriginal dentition. Arch Oral Biol 26:809–14.

Townsend GC, Yamada H, Smith P. 1986. The metaconule in Australian aboriginals: an accessory tubercle on maxillary molar teeth. Hum Biol 58:851–62.

Townsend GC, Yamada H, Smith P. 1990. Expression of the entoconulid (sixth cusp) on mandibular molar teeth of an Australian aboriginal population. Am J Phys Anthropol 82:267–74.

Turner CG. 1969. Directionality in the canine field model. J Dent Res 48:1310.

Tur SS. 2009. Odontologic characteristic of population Andronovo culture from Altai. News of the Ural State University 4:228–36.

Ullinger J. 2003. A comparison of morphological traits in deciduous and permanent dentition. Am J Phys Anthropol 36: 212.

Ullinger JR, Sheridan SG, Hawkey DE, Turner CG, Cooley R. 2005. Bioarchaeological analysis of cultural transition in the southern Levant using dental nonmetric traits. Am J Phys Anthropol 128: 466–76.

Yusupov RM. 1989. Population anthropology Srubnaja cultures Southern Uralja. Materials of Bronze and Early Iron Age from Southern Uralja and the Bottom Volga region. Ufa.

Varela HH, Cocilovo JA. 2000. Structure of the Prehistoric population of San Pedro de Atacama. Curr Anthropol 41:125–32.

Vargiu R, Cucina A, Coppa A. 2009. Italian populations during the Copper Age: Assessment of biological affinities through morphological dental traits. Hum Biol 81:479–93.

Zoubov AA. 1968. Odontology: methods in anthropological research. Moscow: Science.

Zubov AA. 1973. Ethnic odontology. Moscow: Science.

Zubov AA. 1974. Odontoglyphics. In: A.A. Zubov, editor. Racialgenetic processes in ethnic history. Moscow: Science. 11–42.

Zubov AA. 1979. Conclusion. In: AA Zubov, NI Khaldeeva, editors. Ethnic odontology of the USSR. Moscow: Science. 229–54.

Zubova AV. 2008. Anthropological structure of the population of Western Siberia during epoch of the developed and Late Bronze. PhD dissertation. Novosibirsk.

Zubova AV. 2010. The population of a Pit Grave cultural-historical generality in light odontologic data. Bulletin of archeology, anthropology and ethnography 2(13):85–95.