Eur J Anat, 16 (2): 134-149 (2012)

ORIGINAL ARTICLE

Nonmetric cranial variation in human skeletal remains from the Armenian Highland: microevolutionary relations and an intergroup analysis

Anahit Y. Khudaverdyan

Institute of Archaeology and Ethnography, National Academy of Science, Yerevan, Republic of Armenia

SUMMARY

Nonmetric traits are frequently analyzed in the field of anthropology to measure genetic relatedness, or biodistance within or between populations. These studies are performed under the assumption that nonmetric traits are inherited genetically. Historically, interpretations of both biological and cultural change within the Armenian Highlands, have cited large-scale population movements. Biological estimates of these changes have traditionally relied upon biodistance estimates, using odontologic, craniofacial measures of both deformed and nondeformed skulls. In order to evaluate whether large-scale prehistoric and historic migrations occurred in the Armenian Highlands, we examine the biodistance results from nonmetric cranial traits for 19 mortuary samples that represented all time periods on the Armenian Highlands. None of the distances between each pair of mortuary samples examined in this study was significant. These results suggest biological continuity in the populations of Armenia. The biodistance results also suggest endogamy within inland populations. The broader implications of these results are also discussed.

Key words: Armenian Highlands – Biological anthropology – Archaeology – Osteology – Nonmetric traits – Biodistance

INTRODUCTION

In the last 80 years (from Berry and Berry, 1967; Movsesyan et al., 1975; Česnys, 1986, 1988; Kozintsev, 1988, to the recent papers by Prowse and Lovell, 1996; Christensen, 1997; Ishida and Dodo, 1997; Sutter and Mertz, 2004), a large body of literature has been dedicated to the assessment of the biological significance and importance of nonmetric traits of the skull (also named "discontinuous", "epigenetic", "discrete"). The importance that both the environment (Piontek, 1979, 1988; Hauser and Bergman, 1984; Bergman and Hauser, 1985; Bergman, 1993; Rubini et al., 1997) and heredity have in their expression has been evaluated. Regarding the potential use of such traits in studies of human populations, it is assumed that the phenotype (observable characteristics) of an individual will provide direct information about his or her genotype (genetic constitution). With regard to the important contributions regarding heredity

Submitted: February 03, 2012
Accepted: April 26, 2012

Corresponding author:
Dr. Anahit Khudaverdyan. Institute of Archaeology and Ethnography, National Academy of Science, Yerevan 0025, Charents st.15, Republic of Armenia.
Phone: +(374) 077133-254 / +(374) 565-884. E-mail: ankhudaverdyan@gmail.com; akhudaverdyan@mail.ru

(Torgersen, 1951a, 1951b; Berry, 1975; Reinhard and Rösing, 1985; Rubini, 1997), we would particularly underline the report by Sjövold (1984). Nonmetric traits of the skeleton are therefore often used to assess genetic relatedness within (Cheverud and Buikstra, 1981; Kohn, 1991) and between (Movsesyan, 2005; Česnys and Tutkuvienė, 2007; Matsumura, 2007; Saunders and Rainey, 2008) past populations. Understanding these relationships in past populations (especially those without written histories) can provide information about migration patterns, residence patterns, population structures, and human origins and evolution (Hanihara et al., 2003; Hlusko, 2004; Mclellan and Finnegan, 1990; Lane and Sublett, 1972; Turan-Ozdemir and Sendemir, 2006).

The term "biodistance" is commonly used to describe genetic relatedness. Saunders and Rainey (2008) describe biodistance as a measure of the amount of divergence; less divergence is equal to a closer genetic relationship (Saunders and Rainey, 2008; Sherwood et al., 2008). Christensen (1998) used biodistance analyses to trace the spread of the Zapotecan language family throughout Oaxaca, Mexico. By analyzing both nonmetric traits and linguistic data, he determined that people migrating from a central area were able to establish themselves in other areas of Oaxaca. These groups became distinct from the parent population in both genetics and in language dialects. Alt et al. (1997) studied the nonmetric traits of individuals in a triple burial in Dolce Vestonice. The data collected by this research team led them to conclude that the three were part of the same family. There are also various researchers who discuss the numerous factors that confound the heritability of nonmetric traits (Williams et al., 2005). Some factors that have been found to have a noticeable effect on the expression of these traits are geography, habitat, sexual dimorphism (differences in physical appearance between individuals of different sexes in the same species), age, nutrition, disease, size, and intertrait correlations (Berry, 1975; Cheverud et al., 1979).

The main purpose of this research project is to gain some insight into the expression of nonmetric traits on human skulls from the Armenian Highlands (from the Bronze Age to the beginning of the 20th century). The study of the heritability of some discontinuous traits based on a skeletal collection of individuals from various areas of the Armenian Highlands with known family relationships, has provided a new stimulus in the scientific debate.

Prehistory and history of the Armenian Highlands

The Armenian Highlands (also known as the Armenian Uplands, the Armenian Plateau, or simply Armenia) is the central and highest of three land-locked plateaus that together form the northern sector of the Middle East (Hewsen, 1997). The present Armenian Republic (Fig. 1) is located in the South Caucasus on the eastern end of the Armenian Plateau. In early history, the Armenian highlands were a crossroads linking East and West (Martirosyan, 1964). Recent genetic studies confirmed that this avenue served not only for commerce and cultural diffusion, but also for the exchange of genes (Balaresque et al., 2010). From 4th millennium BC to 1st millennium BC, tools and trinkets of copper, bronze and iron were commonly produced in this region and traded in neighboring lands where those metals were less abundant (Krupnov, 1966; Trifonov, 1991; Nechitailo, 1991; Pystovalov 2002, etc.).

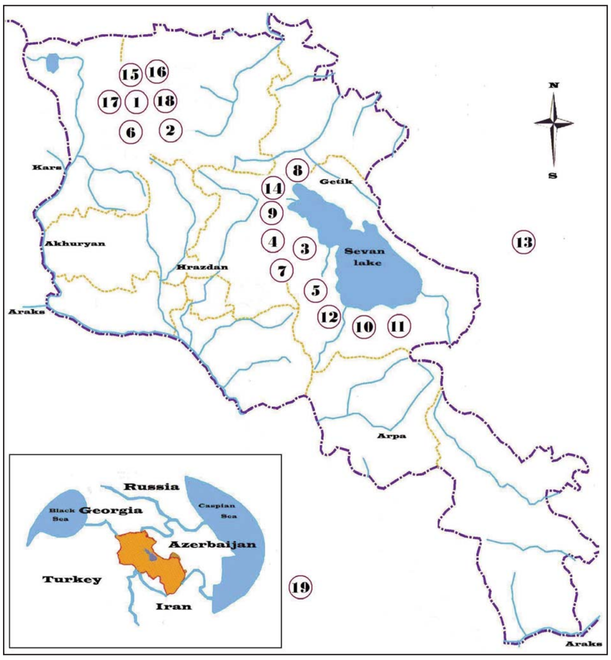

Fig. 1. Map showing the origins of the 19 Armenian Highland samples used in the present study: 1. Landjik, 2. Black Fortress, 3. Nerkin Getashen I, 4. Nerkin Getashen II, 5. Nerkin Getashen III, 6. Artik, 7. Karmir, 8. Sarukhan, 9. Arcvakar, 10. Karashamb, 11. Akunk, 12. Lchashen, 13. Shushi, 14. Karchakhpyur, 15. Shirakavan, 16. Beniamin, 17. Vardbakh, 18. Black Fortress I, 19. Crania Àrmenica

The invention in the Near East of wheeled vehicles and "kibetka-houses" on wheels allowed cattle drovers-farmers to move and survive with ease on the open steppes. Their movement across Eurasia in early times was not a military invasion, but a slow expansion caused by a decline in the child mortality rate and a resulting increase in population growth. The wide expanse of the Eurasian steppes, offering favorable conditions for human life and the spread of information and technology, facilitated a process of wide cultural integration in the Bronze Age throughout this area.

Craniological data have allowed identification of alien Mediterranean characteristics influencing several ethnic Eurasian groups and revealed evidence of a migratory stream from the Armenian Highland and the Caucasus (Khudaverdyan, 2011a). The Armenian Highland samples (Kura-Araxes Culture) and the Catacomb culture samples from Kalmykia, Ukraine, Dnieper, exhibit very close affinities to one another. If we follow a hypothesis put forward and developed by Gamkrelidze and Ivanov (1984) considering the ancestral home of Indo-European areas of the Armenian Highlands and adjoining territories, whence other tribes entered the Northern Black coast both through the Caucasus and through Central Asia and the Volga region (carriers of a Catacomb culture ceremony), it is necessary to assign that movement to Aryan tribes, which were one of the first to reach the Black Sea coast steppes through the Caucasus (or possibly by sea?). Khlopin (1983) connects the Catacomb culture with the Indo-Aryans, because catacomb burial rituals had roots in Southwestern Turkmenistan since the early IV millennium BC (Sumbar cemetery). Fisenko (1966) suggest that the Catacomb people were Proto-Hittites. Kuzmina (1998) is also a supporter of the Fisenko's hypothesis. Anthony (2007) assumed the Catacomb people to be ancestors of the Greeks, while Berzin and Grantovsky (1962), and Klejn (1980, 1984) determined that the Indo-Aryans originated from the Catacomb culture.

The Armenian Highland samples (Kura-Araxes culture) serve as a phenetic link between the Dnestr region and the Ukraine samples (Tripolye Culture), which feature the closest affinities to each other. Hence, it is possible to outline the cultural and ethnic communications in antiquity and the known role of the Armenian Highlands (Kura-Araxes culture) as the intermediary between the ancient area of distribution of Tripolye cultures and the Eastern countries (Passek, 1949; Martiroyan and Mnacakanyan, 1973; Lang, 2005).

The Armenian Highland samples and the Albashevo, Fatianovo, Balanovo Cultures and Timber Grave samples from the Volga region exhibit very close affinities to one another (Khudaverdyan, 2011b). The presence of the Mediterranean components was also remarked by Trofimova (1949) in carriers of the Fatianovo culture, Shevchenko (1984, 1986) and Khokhlov (2000) in carriers of the Timber Grave cultures of the forest-steppe Volga region, and also by Yusupov (1989) in the Southern Ural Mountains.

The craniological and odontological research indicates some morphological association of the Siberian samples (Eluninskaya and Andronovo Cultures) with populations from Caucasia and Turkmenistan (Solodovnikov, 2006; Zubova, 2008; Tur, 2009; Khudaverdyan, 2011a). The different rates of genetic drift and external gene flow may have contributed to the morphological differentiation and diversification amongst the different Eurasian populations. The initial starting area (or one of the intermediate areas), as indicated by the anthropological data, would seem to be the Armenian highlands, and the Caucasus as a whole.

In the Ancient (Classical) time (1^{st} century BC - 3^{rd} century AD) in the Armenian Highland and Caucasus there was interaction of different ethno-cultural units – Iranian-speaking nomadic (Scythians, Sarmatians, Sauromatians, Saka) (Herodotus IV; Strabo XI) and local. The advancement of the Scythians, Sarmatians and Saka in the territory of Armenian Highland and Transcaucasia was accompanied by not only an interaction of various cultural elements, but also a mixture of them. Detailed analysis of the anthropological materials from the Armenian Highland allows us to explain not only the complicated anthropological compound of the population but also to discover the reason for the anthropological and ethnic non-homogeneity in the populations of the Classical Age. Intragroup analysis revealed two groups within the population (Khudaverdyan, 2000, 2012). The dolichocephaly type in both cases is presented. The male skulls of the first group have been diagnosed as classical European group. The second is the same European type, but the horizontal profile of the face (group II) in them is a little weakened. The female skull group has the same analogical image as the males. It is necessary to state that carriers of this complex remind one of the Scythians from the territory of the Dnestr region, Steppes of Black Sea Coast, Ukraine, the Sarmatians from the Volga region and the Saka from the territory of Turkmenistan (Khudaverdyan, 2012). The invasions of the various tribes led, in stages, to a mixture of outsiders among the native Armenians, and the dilution of their ranks on the plateau. The artificial modification of skulls (such as bregmatic, ring deformations of a head, were known in the classical population of the Beniamin, Shirakavan and Karmrakar, Vardbakh) and teeth in ancient Armenia may be related to the emerging social complexity and the need to differentiate among people, creating a niche for such highly visual bodily markers (Khudaverdyan, 2011c).

Materials and Methods

Eleven samples from 19 Armenian Highland sites were examined in this study (Fig. 1, Table 1). In the Early Bronze period (4000-3000 BC) farmer and cattle-breeder Landjik represent the Kuro-Arexes population of the Shirak Plateau (Khudaverdyan, 2009).

The Late Bronze period samples are represented by remains of three Armenian highlands sites. The combination of the remains from these four sites is justified for three reasons. First, the small sample sizes for certain sites (Landjik, Black Fortress) were inadequate (from 10 to 15 individuals) for subsequent biodistance analysis. Second, the Landjik, Black Fortress, and Artik sites represent a cemetery from Shirak Plain. Indeed, the geographic distance among sites is short. Finally, analysis of all the nonmetric cranial traits examined in this study revealed that no significant differences were present among the remains from the four sites, and hence the data from these sites were combined for subsequent statistical analyses. An adequate number of remains were available

Table 1. Armenian Highland craniological samples.

	Sample name	Date	Researchers
1	Landjik	c. 4000-3000 BC	Khudaverdyan, 2009
2	Black Fortress	c. XIV-XII BC	Khudaverdyan, 2009
3	Nerkin Getashen I	c. XV BC	Movsesyan,1990
4	Artik	c. XV/XIV-XI BC	Movsesyan,1990
5	Total group: Landjik, Black Fortress, Nerkin Getashen I, Artik	I period	
6	Sarukhan	c. XI-IX/ VIII BC	Movsesyan,1990
7	Nerkin Getashen II	c. XIII-XII BC	Movsesyan,1990
8	Nerkin Getashen III	c. IX-VIII BC	Movsesyan,1990
9	Arcvakar	c. XI-IX/ VIII BC	Movsesyan,1990
10	Akunk	c. XI-IX/ VIII BC	Movsesyan,1990
11	Karashamb	c. XI-IX/ VIII BC	Movsesyan,1990
12	Karmir	c. XI-IX/ VIII BC	Movsesyan,1990
13	Lchashen	c. 3000 - 2000 BC	Movsesyan,1990
14	Shushi	c. 3000- 2000BC	Movsesyan,1990
15	Total group: Sarukhan, Nerkin Getashen II and III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen, Shushi	II period	
16	Shirak Plateau (total group): Landjik, Black Fortress, Artik	I period	
17	Sevan region (total group): Sarukhan, Nerkin Getashen II and III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen	II period	
18	Karchakhpyur-Shirakavan	c. 1 BC – AD 3	Movsesyan,1990
19	Beniamin, Vardbakh, Black Fortress I	c. 1 BC – AD 3	Khudaverdyan, 2000, 2005
20	Total group: Karchakhpyur-Shirakavan, Beniamin, Vardbakh, Black Fortress I	c. 1 BC – AD 3	
21	Bingel Dag	20 century	Bunak, 1927; Movsesyan, Kochar, 2001

from the Artik site (Movsesyan, 1990), and were therefore analyzed as a single sample. Nine Late-Period (XI-IX/VIII BC) samples were analyzed in this investigation (Movsesyan, 1990). The different site designations for Nerkin Getashen I, Nerkin Getashen II, and Nerkin Getashen III represent different time periods, rather than spatially discrete cemeteries. The sites (Sarukhan, Nerkin Getashen II, Nerkin Getashen III, Arcvakar, Akunk, Karashamb, Karmir, Lchashen) (Movsesyan, 1990) included in Period II are located in the Sevan region. The remains from the Akunk and Lchashen sites (Movsesyan, 1990) were treated as independent samples, because a sufficient number of crania from these spatially discrete cemeteries was available for study. The Classical period (1st century BC – 3rd century AD) samples examined in this study include the remains from Karchakhpyur, Shirakavan (Movsesyan, 1990), Beniamin, Vardbakh, and Black Fortress I (Khudaverdyan, 2009). After the Armenian genocide in 1915, Bunak has gathered a large collection (Museum of Anthropology, Moscow) of human skulls (i.e. the victims a genocide). The modern population include remains from these people (Bingel Dag: Armenians from Musha) (Bunak, 1927).

For this study, 24 non-metric (i.e., epigenetic) cranial and mandibular traits were used to assess the biological affinities (Table 2) among the 19 prehistoric and historic Armenian Highland mortuary samples examined here (Table 1). All traits examined in this study were successfully used in other biodistance studies, and their scoring procedures and descriptions are well-known in the literature (Berry and Berry, 1967; Movsesyan, 1975, 1990; Kozintsev, 1980, 1988; Česnys and Tutkuvienė, 2007). Non-metric cranial traits have successfully been used to evaluate the evolutionary relations and biological affinities among numerous archaeological samples (e.g., Blom, 1998; Ishida and Dodo, 1997). Non-metric cranial traits have the advantage of being scoreable from highly frag-

Table 2. A complete list of nonmetric traits analyzed and the methods used to score them.

Trait	Scoring Method
Sutura metopica	absent, complete
Foramen supraorbitale	presence/absence
Foramen infraorbitale accessorium	two distinct foramina, more than two distinct foramina
Foramen parietale	present (on parietal), present (sutural). Absent
Os bregmaticum	presence/absence
Os epiptericum	presence/absence
Os apicis lambdae	presence/absence
Os asterii	presence/absence
Ossa suturae coronalis	presence/absence
Ossicula suturae squamosae	presence/absence
Ossa suturae sagittalis	presence/absence
Ossa suturae lambdoïdeae	presence/absence
Canalis condylaris intermedius	patent, not patent
Canalis hypoglossi bipartite	complete (within canal)
Foramen mastoideum absent	absent, 1, 2, more than 2
Foramen mastoideum exsutural	absent, 1, 2, more than 2
Foramen spinosum bipertitum	partial formation
Foramina alatine minoranus	absent, 1, 2, more than 2 (the lesser palatine foramina lie on both sides of the posterior border of the hard palate, immediately posterior to the greater palatine foramen)
Foramina mentale accessorium	absent, 1, 2, more than 2
Cribra orbitale	presence/absence
Os zygomaticum bipartitum	presence/absence
Tuberculum praecondylare	presence/absence (immediately anterior and medial to the occipital condyle)
Torus palatinus	presence/absence

mented skeletal materials. Although some studies have reported that some non-metric cranial traits are influenced by cranial deformation (Konigsberg et al., 1993; Ossenberg, 1970), other studies have indicated that most non-metric cranial trait expressions are largely free of influence from artificial cranial deformation (Griffin, 1995; Khudaverdyan, 2000).

Data are subjected to the component and cluster analysis. The clustering procedures produce branching-tree diagrams to illustrate similarities/differences among cases in complex data matrices, by forming clusters that minimize intracluster variation while maximizing intercluster variation. Inspection of the 24 non-metric cranial traits and frequencies retained for biodistance analysis indicate that some of the trait expressions demonstrate a geo-temporal trend.

Table 3. Number of affected and observed crania, and their dichotomized trait frequencies by mortuary sample for 24 nonmetric cranial traits used in biodistance analysis*.

Traits	Bronze	Age	Bronze	Iron Age	Artik		Akunk		Lchashen		Classica	Age	Classical	Age	Classical	Age	Modern	Armenians
	I	period	II	period	I	period	II	period	II	period	Beniamin	et all	Shirak	avan	Total	group	Bingel	Dag
	A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	A/	O	R	
1 *Sutura metopica*	21.2/	54	12.3/	259	19.47/	36	4.35/	28	13.49/	126	17.8/	58	6.67/	30	12.3/	88	225	
2 *Foramen supraorbital*	54.5/	54	45.1/	222	36.11/	36	27.27/	22	44.00/	125	44.95/	82	40.7/	27	42.9/	108	38	
3 *Cribra orbitale*	48.4/	59	16.4/	235	11.11/	36	9.09/	22	8.00/	125	27.3/	76	8.33/	24	17.9/	100	105	
4 *Foramen infraorbitale acces.*	19.8/	65	9.71/	245	11.11/	36	4.76/	21	8.80/	125	38.2/	50	5.0/	20	21.6/	70	97	
5 *Os zygomaticum bip.*	13.92/	67	11.3/	251	2.78/	36	1.19/	21	6.50/	123	39.6/	52	5.56/	18	22.6/	70	46	
6 *Os bregmaticum*	2.8/	60	1.9/	259	2.78/	36	1.08/	23	0.22/	125	1.93/	52	0.83/	30	1.38/	82	10	
7 *Ossa suturae coronalis*	15.99/	67	10.4/	229	2.78/	36	4.35/	23	3.22/	125	10.1/	113	3.45/	29	6.8/	142	25	
8 *Os epipterìcum*	35.9/	67	23.4/	220	17.14/	35	4.76/	21	20.00/	120	20.2/	57	21.74/	23	21.0/	80	163	
9 *Ossicula suturae squamosae*	18.7/	66	6.2/	228	2.78/	36	4.35/	23	3.34/	120	18.5/	89	0.92/	27	9.8/	116	15	
10 *Os asterii*	18.9/	65	7.8/	239	8.33/	36	1.08/	23	6.50/	123	10.9/	46	3.44/	29	7.2/	75	132	
11 *Foramen parietale*	56.4/	58	53.97/	236	47.22/	36	34.78/	23	43.65/	126	54.5/	80	46.42/	29	50.5/	109	387	
12 *Os apicis lambdae*	15.6/	66	12.7/	234	2.78/	36	8.69/	23	4.84/	124	10.0/	50	10.71/	28	10.4/	78	62	
13 *Ossa suturae sagittalis*	19.1/	65	3.97/	250	0.69/	36	1.08/	23	0.81/	124	5.4/	92	0.83/	29	3.2/	101	-	
14 *Ossa suturae lambdoïdeae*	48.8/	68	40.6/	253	22.22/	36	47.82/	23	25.60/	125	58.7/	101	28.58/	28	43.7/	129	341	
15 *Foramen mastoideum absent*	57.6/	65	42.98/	255	37.14/	36	21.40/	23	34.92/	126	65.8/	73	28.57/	28	47.2/	92	294	
16 *Foramen mastoideum exsutural*	29.6/	64	23.7/	252	17.14/	35	30.43/	23	34.92/	126	33.6/	87	28.57/	28	31.1/	115	248	
17 *Canalis condylaris intermed.*	62.3/	60	61.4/	228	53.33/	30	44.44/	18	63.93/	122	61.5/	45	46.66/	15	54.1/	60	697	
18 *Canalis hypoglossi bipartite*	25.5/	60	27.6/	227	23.33/	30	33.33/	18	22.13/	122	37.5/	24	46.66/	15	42.1/	39	333	
19 *Tuberculum praecondylare*	21.1/	60	8.9/	250	3.33/	30	5.55/	18	5.73/	122	27.3/	22	6.67/	15	16.99/	37	85	
20 *Foramen spinosum bipertitum*	30.5/	64	9.3/	227	11.42/	35	4.54/	22	8.06/	122	40.0/	25	25.92/	17	32.96/	42	62	
21 *Torus palatinus*	39.6/	62	22.7/	233	15.15/	33	16.67/	18	14.63/	124	40.9/	89	1.47/	17	21.2/	106	198	
22 *Foramina palatina minoranus*	52.9/	63	43.8/	230	40.24/	33	50.0/	14	38.84/	121	49.1/	60	52.94/	17	51.1/	77	-	
23 *Sulcus mylohyoideus*	18.4/	30	24.7/	116	-		-		19.35/	62	-		-		-		-	
24 *Foramina mentale accessor*	21.6/	29	9.2/	56	-		-		-		22.0/	55			22.0/	55	-	

* O: number of crania actually observed; A: number of crania showing trait (affected); R – radians.

In total, the comparative analysis included 15 craniological series from the territory of Eurasia (2 samples /Fatianovo and Balanovo Cultures/ from the Volga region (Chesnis, 1986), 2 samples /Sapallitepe, Gonur Depe/ from Central Asia (Khodjaiov, 1977; Nevchaloda and Kufterin, 2008), 4 samples /Afanasevo, Andronovo, Karasukskaya and Tagarskaya Cultures/ from Siberia (Kozintsev, 1980), 4 samples /Chernyakhov Culture/ from Ukraine (Chesnis and Konduktorova,1982), 2 samples /Budeshti, Malaeshti/ from the Dnestr region (Chesnis and Konduktorova,1982), 1 sample /Latgali/ from Latvia (Chesnis, 1986)). Kozintseva and Kozintseva's statistical package (Peter the Great Museum of Anthropology and Ethnography, St. Petersburg) was used.

Results and Discussion

The remaining 24 traits, their frequencies, and the number of individuals observed for each trait for the 9 Armenian Highland samples are provided in Table 3 (only Bingel Dag sample – in radians). More specifically, the presence of a sutura metopica, sagittal, squamosae ossicles, multiple infraorbital foramina, foramen spinosum, bridging of the mylohyoid groove, tuberculum praecondylare and palatine torus show a chronological trend between two samples (periods I and II: from the Bronze Age to the Iron Age). For the multiple infraorbital foramina, and os zygomaticum, the classical sample (Beniamin-Vardbakh-Black Fortress I) generally has a higher frequency of expression for these traits. For the palatine torus, the Artik, Akunk, Lchashen, and Karchakhpyur-Shirakavan samples have the lowest frequencies of expression, while the Beniamin-Vardbakh-Black Fortress I and all Bronze Age (period I) samples are characterized by relatively higher levels of expression. Coronal ossicles show a slighter temporal trend in Classical period samples than those of the Bronze period, characterized by higher frequencies of expression.

Analysis 1. Brothwell (1959) first applied an array of ten non-metrical characteristics to the study of multivariate distances among populations. The number of traits was further increased after Berry and Berry's paper (1967) was published. Those traits have frequently been employed not only to compare populations by the multivariate distances method, but also to study processes affecting the genetic variations in the population structure and to determine kinship among individuals, etc. The purpose of such an analysis is to gain some insight into the expression of non-metric traits on the 11 human samples from the Bronze Age to the beginning of the 20th century from the Armenian Highlands (N 4, 5, 10, 13, 15-21). The values of the first three factors are given in table 4. The differentiation that can be traced in the Armenian Highland populations is shown in Fig. 2.

Table 4. Elements of three initial components for 11 groups.

Trait	I	II	III
Sutura metopica (frontalis)	**0.976**	0.017	0.066
Foramen supraorbitale	**-0.711**	**0.642**	0.227
Foramen infraorbitale accessorium	0.486	**0.693**	**-0.500**
Os zygomaticum bipartitum	0.014	**0.932**	-0.253
Ossa suturae coronalis	-0.233	**0.882**	0.280
Os epiptericum	**0.823**	0.326	0.399
Os asterii	**0.882**	0.427	0.064
Foramen parietale	**0.938**	-0.090	0.007
Canalis condylaris intermedius	**0.975**	-0.003	0.114
Canalis hypoglossi bipartite	**0.897**	-0.290	-0.106
Values	58.403	29.200	6.361

As expected, the first axis accounts for the majority (58.5%) of the intergroup discrimination. Taking into account the character of connection of attributes in these coordinates, it is possible to tell that the large values till I coordinate axes correspond to groups with the sutura metopica (0.976), canalis condylaris intermedius (0.975), foramen parietale (0.938), canalis hypoglossi bipartite (0.897), os asterii (0.882) and os epiptericum (0.823). The negative weight gives a foramen supraorbitale (-0.711). The second factor (29.2%) is the maximum for os zygomaticum bipartitum (0.932), ossa suturae coronalis (0.882), foramens infraorbitale accessorium (0.693) and supraorbitale (0.642). The third factor accounts for 6.4% of the intergroup variance. The negative weight gives a foramen infraorbitale accessorium (-0.500).

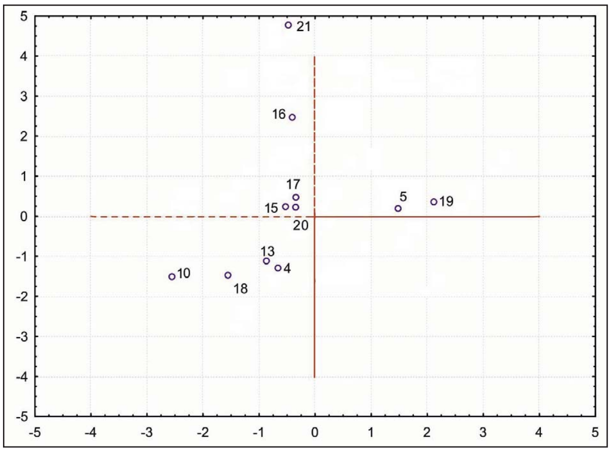

Fig. 2. Factor analysis: 4 – Artik, 5 – Armenian Highland /I period: Bronze Age/, 10 – Akunk, 13 – Lchashen, 15 – Armenian Highland /II period: Bronze and Early Iron Ages/, 16 – Shirak Plateau /I period/, 17 – Sevan region /II period/, 18 – Karchakhpyur-Shirakavan, 19 – Beniamin, Vardbakh, Black Fortress I, 20 – Armenian Highland /Classical Age/, 21 – Bingel Dag.

Figure 2, The graph obtained using the first two axes, shows how the groups from the Armenian Highland (II period and Classical Age) and the Sevan region (period II) are close to one another. Groups from the Karchakhpyur-Shirakavan, Shirak Plateau (Bronze Age: I period), Akunk and Bingel Dag are well distinguished from the groups from Armenian Highland. The graph shows how the groups from the Armenian Highland (Bronze Age (period 1) and Classical Age: Beniamin, Vardbakh, Black Fortress I) close to one another. The Artik and Lchashen samples also exhibit close affinities to one another.

Next, we applied cluster analysis (Fig. 3, table 5). In this diagram, the Lchashen, Akunk and Akunk samples are relatively close to the Karchakhpyur-Shirakavan sample. Importantly, Ancient sample (Karchakhpyur-Shirakavan) is closely related to the previous samples (Bronze and Iron Ages). The most isolate Bingel Dag sample is shown in Figure 3. The prehistoric series, including the Shirak Plateau (I period), the Sevan region (II period) and the groups from periods I and II (Bronze and Early Iron Ages) are nearer the Ancient samples (total group and Beniamin-Vardbakh-Black Fortress I), as mentioned above.

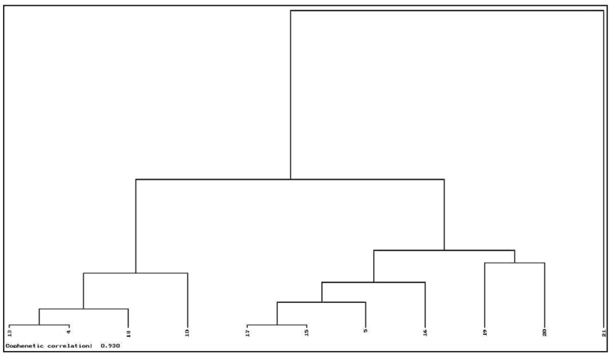

Fig. 3. Cluster tree: 4 – Artik, 5 – Armenian Highland /I period: Bronze Age/, 10 – Akunk, 13 – Lchashen, 15 – Armenian Highland /II period: Bronze and Early Iron Ages/, 16 – Shirak Plateau /I period/, 17 – Sevan region /II period/, 18 – Karchakhpyur-Shirakavan, 19 – Beniamin, Vardbakh, Black Fortress I, 20 – Armenian Highland /Classical Age/, 21 – Bingel Dag.

Analysis (2) of 11 series (N 4, 5, 10, 13, 15-21). The values for the first three factors are given in table 6. The characters are of different nature: sutural bones and varieties of openings, even cribra orbitalia, a pathological manifestation. It is known that pathological

Table 5. Matrix of distance, values for eleven Armenian Highland mortuary samples examined in this study.

Sample name	Lchashen	Akunk	Artik	Shirak Plain	Sevan region	Beniamin, Vardbakh, Black Fortress I	Karchakhpyur-Shirakavan	Armenian Highland /I period/	Armenian Highland /II period/	Armenian Highland /Classical Age/	Bingel Dag
Akunk	2.24										
Artik	0.54	2.08									
Shirak Plateau /I period/	3.68	5.62	4.03								
Sevan region /II period/	2.05	4.19	2.46	1.92							
Beniamin, Vardbakh, Black Fortress I	3.97	5.62	4.04	2.30	3.14						
Karchakhpyur-Shirakavan	0.89	1.49	1.02	4.37	2.76	4.72					
Armenian Highland /I period/	2.91	5.07	3.25	1.24	1.00	2.64	3.69				
Armenian Highland /II period/	1.71	3.85	2.07	2.04	0.54	2.85	2.48	1.23			
Armenian Highland /Classical Age/	1.94	3.60	2.03	2.51	1.95	2.07	2.65	2.21	1.43		
Bingel Dag	7.85	9.40	7.64	8.32	7.65	7.68	8.53	7.39	7.58	7.73	-

changes in bones manifested in the root of the orbit (i.e. cribra orbitalia) are frequently the result of acquired or congenital anaemia(thalassemia), caused by deficiency of Mg, Cl, Fe and folic acid in nutrition, or by helminthiases and malaria. With all the above in mind, one may assume that thalassemia is a reliable indicator of the socio-economic standard as regards the state of health of the population (including the level of hygiene, nutrition and others). Brothwell (1981) referred to them as "environmental indicators". Fornaciari et al. (1981) found them to be an appropriate test of the nutrition standard of a population and even of social stratification. Here this trait is called "the misery factor", because it informs about both the malady and the unfavorable environment bringing about this sickness (Bergman, 1987). In this work it was taken for granted that individuals in which no cribra orbitalia were found, lived in "on average better conditions" (as regards nutrition, hygiene and the state of health), in contrast to those with cribra orbitalia living in "on average worse conditions", following the assumed criteria. In contrast to grave equipment, cribra orbitalia provide a biological, organism-dependent source of information about living conditions. In the Bronze Age (period I) and Modern era, higher frequencies of expression are found for cribra orbitale. Cribra orbitale impedes the connection of both parts of the facies condylaris into one, and produces such bony protuberances as the tuberculum praecondylare and the torus palatines. Clinical and osteological research suggests that malnutrition or non-specific systemic stress is strongly correlated with the incidence of vertebral anomalies (Bergman, 1993; See et al., 2008; Khudaverdyan, 2011d). See et al. (2008) documented numerous vertebral anomalies in the offspring of vitamin A-deficient rats, including cleft neural arches, occipital vertebrae, vertebral blocks etc. In addition, over 80% of the offspring exhibited basioccipital malformation of some variety (See et al., 2008). In their analyses of non-metric traits in human crania, Bergman (1993) and Khudaverdyan (2011d) have also found a statistically significant association between cribra orbitalia and the precondylar tubercle, which they attributed to a common morbid factor. However, many researchers in the analysis include criba orbitalia as an epigenetic variation (Chesnis and Konduktorova, 1982; Hauser and De Stefano, 1989; Movsesyan, 1990; Zupanic, 2004; Česnys and Tutkuvienė, 2007; Khudaverdyan, 2009).

Factor I (46.4%) has tuberculum praecondylare (0.971) and cribra orbitale (0.911) as their strongest values. High values also correspond to the os apicis lambdae (0.725), ossicula suturae squamosae (0.702) and lambdoïdeae (0.686), with the foramen mastoideum absent (0.691) (Table 6). The positive weight (factor II, 32.2%) is given for maximum foramens mastoideum exsutural (0.947), mastoideum absent (0.636), ossa suturae lambdoïdeae (0.660) in contrast to the negative weight for os bregmaticum (-0.761), ossicula suturae squamosae (-0.618). The third component accounts for 9.9% of the intergroup variance. The negative weight gives a foramen spinosum bipertitum (-0.752).

Table 6. Elements of three initial components for 11 groups.

Trait	I	II	III
Cribra orbitale	**0.911**	-0.179	0.169
Os bregmaticum	0.276	**-0.761**	0.460
Ossicula suturae squamosae	**0.702**	**-0.618**	-0.054
Os apicis lambdae	**0.725**	-0.227	0.163
Ossa suturae lambdoïdeae	**0.686**	**0.660**	0.144
Foramen mastoideum absent	**0.691**	**0.636**	0.102
Foramen mastoideum exsutural	0.306	**0.947**	-0.034
Tuberculum praecondylare	**0.971**	-0.040	-0.137
Foramen spinosum bipertitum	0.515	-0.334	**-0.752**
Values	46.398	32.173	9.841

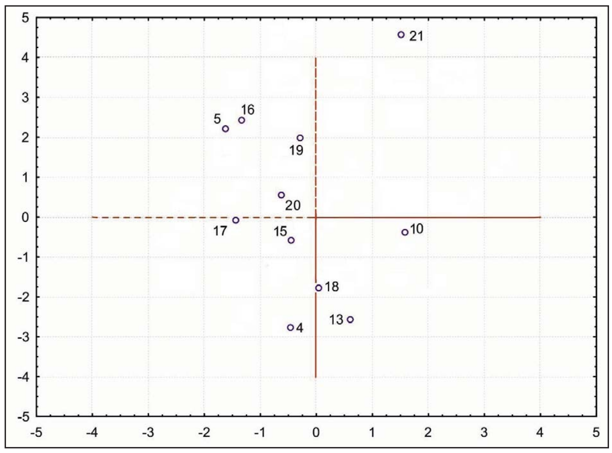

Fig. 4. Factor analysis: 4 – Artik, 5 – Armenian Highland /I period: Bronze Age/, 10 – Akunk, 13 – Lchashen, 15 – Armenian Highland /II period: Bronze and Early Iron Ages/, 16 – Shirak Plateau /I period/, 17 – Sevan region /II period/, 18 – Karchakhpyur-Shirakavan, 19 – Beniamin, Vardbakh, Black Fortress I, 20 – Armenian Highland /Classical Age/, 21 – Bingel Dag.

Figure 4: The graph obtained using the first two axes shows how the groups from Armenian Highland (I period and Beniamin-Vardbakh-Black Fortress I) and Shirak Plateau /I period/ are close to one another. The most isolate Bingel Dag and Akunk samples. The Karchakhpyur-Shirakavan and Akunk samples exhibit close affinities to one another.

When considering the dendrogram (Fig. 5, table 7), we should note the significant similarity of the ancient group of the Karchakhpyur-Shirakavan to the samples from Bronze and Early Iron Ages (Lchashen, Akunk, Artik). The Shirak plateau sample (I period) and the samples from Classical period (Beniamin-Vardbakh-Black Fortress I) and Bronze Ages exhibit close affinities to one another. Here again, the Classical samples are closely related to the previous samples (Bronze Age). Again the most isolate Bingel Dag sample. According to the results presented here, it is possible to discern temporal trends among the Armenian Highland samples in this study. The results indicate a slight chronological trend, where populations from the Bronze to Ancient periods are more similar to one another, while the modern population appears to be more distant . Other biodistance studies using nonmetric data arrived at results similar to those reported here (Movsesyan, 1990; Movsesyan and Kochar, 2001; Khudaverdyan, 2009).

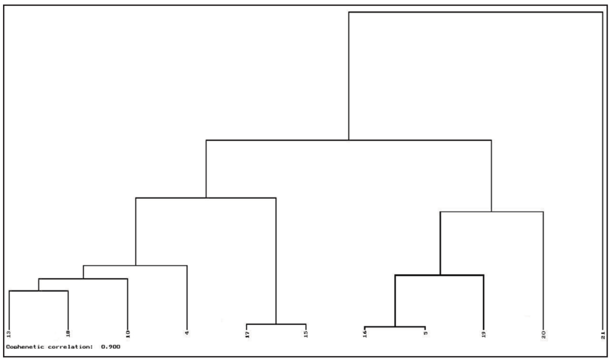

Fig. 5. Cluster tree: 4 – Artik, 5 – Armenian Highland /I period: Bronze Age/, 10 – Akunk, 13 – Lchashen, 15 – Armenian Highland /II period: Bronze and Early Iron Ages/, 16 – Shirak Plateau /I period/, 17 – Sevan region /II period/, 18 – Karchakhpyur-Shirakavan, 19 – Beniamin, Vardbakh, Black Fortress I, 20 – Armenian Highland /Classical Age/, 21 – Bingel Dag.

The next step in the analysis is to compare non-metric variation among the ancient inhabitants of the Armenian Highland with samples from the Eurasia, in order to help clarify the origins and interactions between the inhabitants of the Armenian Highland and neighboring Eurasia. An analysis of more than 14 groups of the Bronze and Iron Ages is undertaken here. The anthropological cover of Eurasia was generated during exclusively difficult historical events (Abdushelishvili, 1982, 2003; Khudaverdyan, 2011a, b). The advancement of the Mediterraneans in the territory of Eastern European was accompanied by not only an interaction of various cultural elements, but also by a mixture – a distribution sometimes at considerable distances from their centre of formation. On the basis of the

Table 7. Matrix of distance, values for eleven Armenian Highlands mortuary samples examined in this study.

Sample name	Lchashen	Akunk	Artik	Shirak Plain	Sevan region	Beniamin, Vardbakh, Black Fortress I	Karchakhpyur-Shirakavan	Armenian Highland /I period/	Armenian Highland /II period/	Armenian Highland /Classical Age/	Bingel Dag
Akunk	1.48										
Artik	1.85	1.41									
Shirak Plateau /I period/	5.75	4.80	5.52								
Sevan region /II period/	3.78	2.43	2.98	2.94							
Beniamin, Vardbakh, Black Fortress I	4.77	4.04	4.93	1.38	2.86						
Karchakhpyur-Shirakavan	1.12	1.17	1.57	4.76	2.89	3.87					
Armenian Highland /I period/	5.50	4.47	5.21	0.48	2.53	1.41	4.53				
Armenian Highland /II period/	3.29	1.98	2.68	3.07	0.53	2.74	2.42	2.68			
Armenian Highland /Classical Age/	3.96	3.78	4.33	2.97	3.49	1.99	3.06	3.06	3.22		
Bingel Dag	5.88	5.65	7.04	6.13	6.12	5.13	5.96	5.96	5.78	5.97	-

received information, cluster analysis has shown the epigenetic condensations of groups from Eurasia and factors of relatives or, conversely, distinctions between them.

Analysis 3. Placement of the 14 samples (Armenian Highland /I period: Bronze Age and II period: Bronze and Early Iron Ages/, Shirak Plateau /I period/, Sevan region /II period/, Artik, Akunk, Lchashen (Movsesyan, 1990; Khudaverdyan, 2009), Volga region /Fatianovo and Balanovo Cultures/ (Chesnis, 1986), Central Asia /Sapallitepe, Gonur Depe/ (Khodjaiov, 1977; Nevchaloda and Kufterin, 2008), Siberia /Afanasevo, Andronovo, Karasukskaya and Tagarskaya Cultures/ (Kozintsev, 1980)) determined by the values of factors I (35.2%) and II (28.3%) (Table 8). The positive weight (factor I) given for maximum foramen mastoideum (0.892) and parietale (0.799), ossa suturae lambdoïdeae (0.877), os apicis lambdae (0.788) and canalis condylaris intermedius (0. 794). Factor II has, as their strongest values, ossa suturae coronalis (0.896), sagittalis (847), sutura metopica (0.749), os asterii (0.708) and torus palatines (0.608). Factor III accounts for the 17.99% of the intergroup discrimination. Factor III has its strongest positive value a foramen supraorbitale (0.741) and negative weight a canalis hypoglossi bipartite (-0.850).

Table 8. Elements of three initial components for 14 groups.

Trait	I	II	III
Sutura metopica	-0.465	**0.749**	-0.210
Foramen supraorbitale	-0.297	0.444	**0.741**
Ossa suturae coronalis	-0.316	**0.896**	0.044
Os asterii	0.100	**0.708**	0.245
Foramen parietale	**0.799**	0.039	0.376
Os apicis lambdae	**0.788**	0.202	0.069
Ossa suturae sagittalis	0.262	**0.847**	0.371
Ossa suturae lambdoïdeae	**0.877**	-0.081	0.148
Foramen mastoideum absent	**0.892**	-0.031	0.208
Canalis condylaris intermedius	**0.794**	0.023	-0.358
Canalis hypoglossi bipartite	0.097	0.429	**-0.850**
Torus palatinus	0.524	**0.608**	-0.552
Values	35.194	28.205	17.989

Inspection of the 12 nonmetric cranial traits, frequencies retained for biodistance analysis indicates that some of the trait expressions demonstrate a geographic or ethnic trend (Fig. 6). More specifically, the populations from the Volga regions and Siberia show an ethnic trend between samples (a positive field). The Armenian Highlands samples and the Mediterranean samples from Central Asia exhibit close affinities to one another (a negative field).

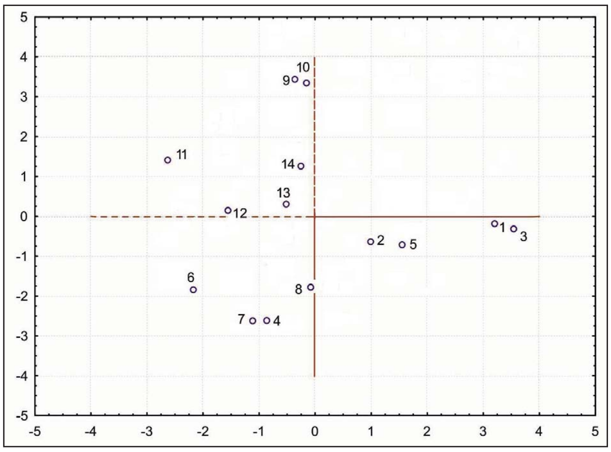

Fig. 6. Factor analysis: 1 – Armenian Highlands / period I: Bronze Age/, 2 – Armenian Highland / period II: Bronze and Early Iron Ages/, 3 – Shirak Plateau / period I /, 4 – Armenian Highland /Artik/, 5 – Sevan region / period II /, 6 – Armenian Highland /Akunk/, 7 – Armenian Highland /Lchashen/, 8 – Central Asia /Sapallitepe, Gonur Depe/, 9 – Volga region /Fatianovo Culture/, 10 – Volga region /Balanovo Culture/, 11 – Siberia /Andronovo Culture/, 12 – Siberia /Afanasevo Culture/, 13 – Siberia /Karakolskaya Culture/, 14 – Siberia /Tagarskaya Culture/.

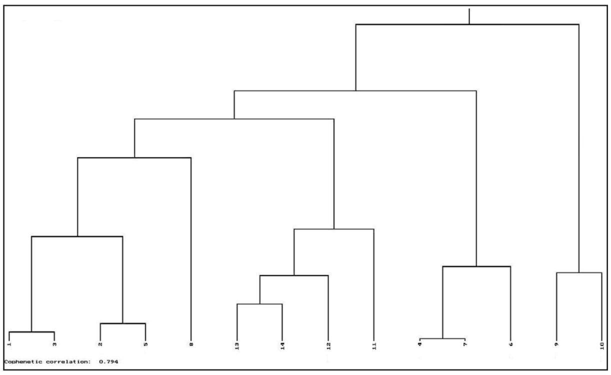

Fig. 7. Cluster tree: 1 – Armenian Highland / period I: Bronze Age/, 2 – Armenian Highland period /II: Bronze and Early Iron Ages/, 3 – Shirak Plateau / period I /, 4 – Armenian Highland /Artik/, 5 – Sevan region / period II /, 6 – Armenian Highland /Akunk/, 7 – Armenian Highland /Lchashen/, 8 – Central Asia /Sapallitepe, Gonur Depe/, 9 – Volga region /Fatianovo Culture/, 10 – Volga region /Balanovo Culture/, 11 – Siberia /Andronovo Culture/, 12 – Siberia /Afanasevo Culture/, 13 – Siberia /Karakolskaya Culture/, 14 – Siberia /Tagarskaya Culture/

The diagonal matrix of distance is provided in Table 9. The dendrogram gives a visual idea of the relationship between the various groups (Fig. 7). Cluster analysis provides a different representation of the distance matrix, because it is an unrooted tree whose branches have different lengths. Long branch lengths

Table 9. Matrix of distance, values for fourteen Eurasia mortuary samples examined in this study.

Sample name	Armenia /I period/	Armenia /II period/	Shirak Plateau	Artik	Sevan region	Akunk	Lchashen	Sapallitepe, Gonur Depe	Fatianovo Culture	Balanovo Culture	Andronovo Culture	Afanasevo Culture	Karakolskaya Culture	Tagarskaya Culture
Armenian Highland /II period: Bronze and Early Iron Ages/	2.38													
Shirak Plateau /I period/	0.57	2.71												
Artik	5.27	3.06	5.49											
Sevan region /II period/	1.71	0.72	2.04	3.59										
Akunk	6.26	3.92	6.48	1.71	4.59									
Lchashen	5.18	2.90	5.44	0.46	3.48	1.68								
Central Asia /Sapallitepe, Gonur Depe/	4.06	2.74	4.52	3.39	2.90	4.63	3.11							
Volga region /Fatianovo Culture/	5.98	5.13	6.15	6.66	5.48	5.98	6.43	7.15						
Volga region /Balanovo Culture/	5.29	4.62	5.57	6.55	4.92	6.16	6.26	6.28	1.59					
Siberia /AndronovoCulture/	6.33	5.01	6.86	5.91	5.43	5.87	5.46	4.37	5.65	4.45				
Siberia /Afanasevo Culture/	4.93	3.32	5.45	4.16	3.77	4.47	3.71	2.59	5.53	4.52	1.92			
Siberia /Karasukskaya Culture/	3.87	2.35	4.38	3.94	2.76	4.36	3.54	2.49	4.88	3.88	2.68	1.14		
Siberia /Tagarskaya Culture/	3.69	2.58	4.18	4.65	2.91	4.90	4.29	3.41	4.08	2.94	2.84	1.95	1.05	-

may be interpreted as an indicator of a large degree of morphological separation, while short branch lengths are indicative of a small degree of morphological separation between samples. The Artik sample features close affinity with those of the Lchashen and Akunk samples. The Armenian Highland samples from Periods I and II (Bronze and Iron Ages), the Shirak Plateau and the Sevan region serve as an epigenetic link between Central Asia (Sapallitepe, Gonur Depe) samples, which feature the closest affinities to one another. Within the dendrogram are samples from the Armenian Highlands featuring the closest affinities to one another. These four prehistoric skeletal series of different periods from Siberia are also similar to other series in the same region. Within the dendrogram are samples from the Volga region featuring the closest affinities to one another (Fatianovo and Balanovo Cultures). Thus, the cluster analysis of the 12 nonmetric cranial traits of the samples in the Bronze and Iron Ages from Eurasia indicates that in some of the traits, expressions demonstrate an ethnic trend.

Analysis (4) of 10 series: Armenian Highlands /Beniamin-Vardbakh-Black Fortress I, Karchakhpyur-Shirakavan/ (Movsesyan, 1990; Khudaverdyan, 2000, 2005), Ukraine /Chernyakhov Culture: Dzuravka, Chernykhov-Romashki-Derevynnoe-Teleshovka, Gavrilovka-Voloshskoe, Koblevo-Ranjevoe-Viktorovka/ (Chesnis and Konduktorova, 1982), the Dnestr region /Budeshti, Malaeshti/ (Chesnis and Konduktorova, 1982), Latvia /Latgali/ (Chesnis, 1986). Global processes led to cultural and genetic transformations within the Armenian Highlands and Transcaucasia. In the present study we investigated the potential effects of gene flow among the population samples of the Armenian Highland. The results of craniological analysis give a typical picture of infiltration, from the 8th century BC up to the 3rd century AD, alien to the ethnic groups of the Transcaucasia. This scenario is consistent with supporting archaeological and historical studies (Piotrovskii, 1959; Krupnov, 1960; Strabo, 1964; Ter-Martirosov, 1999). According to archeologists, the Scythian presence in the Caucasus had been permanent (Vinogradov and Dudarev, 1983; Petrenko, 1983; Il'inskaya and Terenozhkin, 1983). Here we have undertaken a nonmetric traits analysis of more than 10 groups from the territory of the Armenian Highlands and Eastern Europe. The emplacement of the coordinate axis of the samples is determined by the values of factors I (38.8% of the total variability) and II (28.3% of the total variability) (table 10). Factor I has as their strongest values canalis condylaris intermedius (0.863), foramen parietale (0.826), os asterii (0.659) and ossa suturae lambdoïdeae (0.658). The highest negative value corresponds to the foramen supraorbitale (-0.802). The highest positive weights (factor II, 28.3%) are given for foramen infraorbitale accessorium (0.859) and ossa suturae lambdoïdeae

(0.630). The third component accounts for 14.7% of the intergroup variance/variability. The highest negative weight gives a canalis hypoglossi bipartite (-0.916).

Table 10. Elements of three principal components for 10 groups.

Trait	I	II	III
Sutura metopica	-0.047	0.871	-0.143
Foramen supraorbitale	**-0.802**	0.497	-0.024
Foramen infraorbitale accessorium	0.397	**0.859**	0.159
Os asterii	**0.659**	-0.033	-0.456
Foramen parietale	**0.826**	0.006	0.012
Ossa suturae lambdoïdeae	**0.658**	**0.630**	0.061
Canalis condylaris intermedius	**0.863**	-0.343	0.266
Canalis hypoglossi bipartite	-0.074	0.042	**0.916**
Values	38.788	28.276	14.611

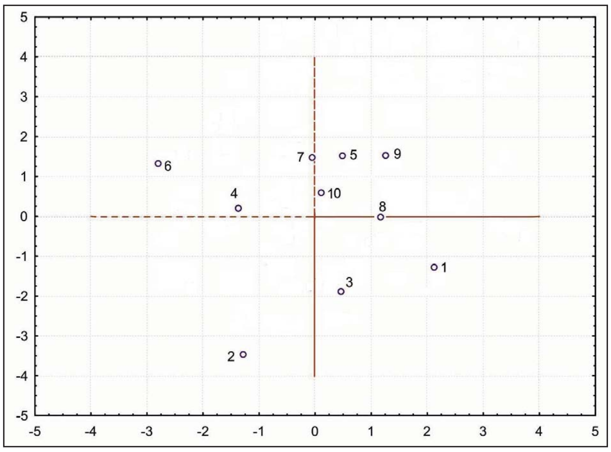

Fig. 8. Factor analysis: Armenian Highland /Beniamin-Vardbakh-Black Fortress I/, 2 – Armenian Highland /Karchakhpyur-Shirakavan/, 3 – Armenian Highland /Classical Age/, 4 - Ukraine /Dzuravka/, 5 – Ukraine /Chernykhov, Romashki, Derevynnoe, Teleshovka/, 6 – Ukraine /Gavrilovka, Voloshskoe/, 7 – Ukraine /Koblevo, Ranjevoe, Viktorovka/, 8 – the Dnestr region /Budeshti/, 9 – the Dnestr region /Malaeshti/, 10 – Latvia /Latgali/

The populations from Ukraine, the Dnestr region (Chernyakhov Culture) and Latvia (Latgali) show close affinities with one another. The Armenian Highland samples also exhibit close affinities with one another. Groups Karchakhpyur-Shirakavan are well distinguished from the groups from the Armenian Highland.

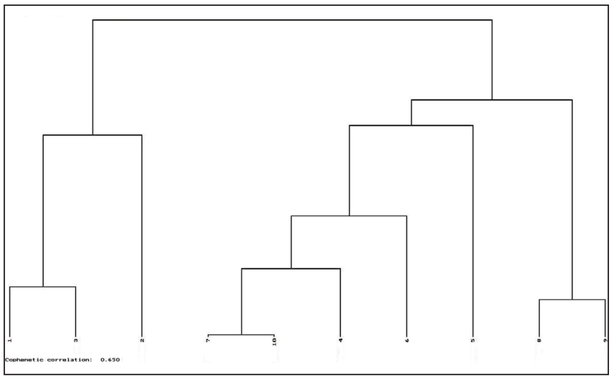

Fig. 9. Cluster tree: 1 – Armenian Highland /Beniamin-Vardbakh-Black Fortress I/, 2 – Armenian Highland /Karchakhpyur-Shirakavan/, 3 – Armenian Highland /Classical Age/, 4 - Ukraine /Dzuravka/, 5 – Ukraine /Chernykhov, Romashki, Derevynnoe, Teleshovka/, 6 – Ukraine /Gavrilovka, Voloshskoe/, 7 – Ukraine /Koblevo, Ranjevoe, Viktorovka/, 8 – Dnestr region /Budeshti/, 9 – Dnestr region /Malaeshti/, 10 – Latvia /Latgali/

The diagonal matrix is provided in Table 11. The dendrogram gives a visual idea of the relationship between the various groups (Fig. 5). Interestingly, the total sample from Beniamin-Vardbakh-Black Fortress I are the most similar to the Karchakhpyur-Shirakavan sample. When compared to other samples examined by this study (Dnestr region, Ukraine /Chernyakhov Culture/, Latvia) samples from Armenian Highland are the least similar. Given the small biological distances between the Ancient period samples from the Armenian Highland, the biological distances are most likely due to genetic drift and non-significant gene flow.

Conclusion

The biodistance results reported in this study indicate that differences among prehistoric samples from the Armenian Highland are nonsignificant. Instead, when relying on nonsignificant biodistance results, it is suggested that an ancestral-descendant relationship existed among Armenian Highland populations from the Bronze Age through the Classical period. While it is recognized (craniometric studies and dental traits) that significantly different immigrant populations in the Classical period may have been present in the prehistoric Armenian Highland, they were not detected among the samples analyzed by this study. These conclusions are consistent with those reported by other biodistance studies that examined non-metric cranial analyses for Armenian Highland samples. Further,

Table 11. Matrix of distance, values for ten Eurasia mortuary samples examined in this study.

Sample name	Beniamin-Vardbakh -Black Fortress I	Karchakhpyur-Shirakavan	Armenian Highland /Classical Age/	Dzuravka	Chernykhov, Romashki, Derevynnoe, Teleshovka	Gavrilovka, Voloshskoe	Koblevo, Ranjevoe, Viktorovka	Budeshti	Malaeshti	Latgali
Karchakhpyur-Shirakavan	4.21									
Armenian Highland /Classical Age/	1.82	2.45								
Dzuravka	3.78	3.75	3.03							
Chernykhov, Romashki, Derevynnoe, Teleshovka	3.42	5.96	4.15	2.94						
Gavrilovka, Voloshskoe	5.68	5.06	4.85	2.04	4.23					
Koblevo, Ranjevoe, Viktorovka	3.83	5.27	3.77	2.32	2.73	2.87				
Budeshti	3.10	4.62	2.91	3.58	4.24	4.57	2.37			
Malaeshti	3.49	5.75	3.85	3.50	3.21	4.28	1.45	1.69		
Latgali	2.83	4.57	2.88	1.68	1.88	3.14	1.34	2.64	2.09	-

based on the biodistance results presented here, we suggest that at the beginning of the Bronze period there appears to have been a degree of genetic flow among inland populations. The biodistances reported here suggest that there was a decrease in isolation (i.e., increased gene flow) among the Classical populations during 1st century BC – 3rd century AD. This assertion requires further exploration. In spite of this possibility, it is clear that the techniques employed in this study would have made it more likely to find significant differences among the samples, if any existed. In conclusion, the biodistances from the non-metric cranial traits reported here indicate that no significant prehistoric gene flow occurred in the Armenian Highlands.

References

Abdushelishvili MG (1982) *Anthropology of the population of Caucasus in the Bronze Age*. Tbilisi.

Abdushelishvili MG (2003) Anthropology of the Ancient and Modern people of Caucasus. In: Alekseeva TI (ed). *Anthropology horizons*. Moscow.

Alt KW, Pichler S, Vach W, Klíma B, Vlcek E, Sedlmeire J (1997) Twenty-five thousand-year-old triple burial from Dolni Vestonice: An ice-age family? *Am J Phys Anthropol*, 102: 123-131.

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

Balaresque P, Bowden GR, Adams SM, Leung H-Y, King TE, Rosser ZH, Goodwin J, Moisan J-P, Richard C, Millward A, Demaine GB, Wilson IJ, Tyler-Smith C, Previderè C, Jobling MA (2010) A Predominantly Neolithic origin for European paternal lineages. *PLoS Biology* 8(1), e1000285. doi:10.1371/journal.pbio.1000285

Bergman P (1987) Cribra orbitalia und ausgewählte Discreta der Schädel aus dem Reihengräberfeld von Milicz, Niederschlesien (12. – 14. Jh.) unter Berücksichtigung der Grabausstattung. *Acta Musei Nationalis Pragae,* 43: 103-108.

Bergman P, Hauser G (1985) Multi-dimensional complexes of skull traits. *Anthropol Anz,* 43: 165-171.

Bergman P (1993) The occurrence of selected non-metrical traits of the skull in relation to cribra orbitalia and grave equipment. *Variability and Evolution,* 2: 63-75.

Berzin E, Grantovsky E (1962) Kinsman of Indians on Black Sea shores. *Soviet Land,* (publ. by the Soviet Embassy in India) XV (10): 26-27.

Berry AC, Berry RJ (1967) Epigenetic variation in the human cranium. *J Anat*, 101: 361-379.

Berry AC (1975) Factors affecting the incidence of non-metrical skeletal variants. *J Anat*, 120: 519-535.

Blom DE (1998) *Tiwanaku regional interaction and social identity: a bioarchaeological approach*. Ph.D. Thesis. University of Chicago, Chicago.

Brothwell DR (1959) The use of non-metrical characters in the skull in differentiating populations. Ber. 6. *Tag Dtsch Ges Anthropol Kel,* 103: 103-109.

Brothwell DR (1981) *Digging up bones. The excavation, treatment and study of human skeletal remains.* Oxford University Press.

Bunak VV (1927) *Crania Armenica*. Moscow.

Česnys G (1986) Discrete signs of a skull at people Fatianovo and Balanovo Cultures. *Anthropology questions*, 76: 117-127.

Česnys G (1988) The variability of discrete cranial traits in the East Baltic area and adjacent territories. *Homo*, 38: 75-97.

Česnys G, Tutkuvienė J (2007) Topographical approach to kinship assessment within population according to discrete cranial traits: the 5th-6th cc. Plinkaigalis cemetery. *Acta medica Lituanica*, 14: 7-16.

Chesnis GYA, Konduktorova TS (1982) Non-metrical traits of the skulls of Chernyakhov Culture. *Anthropology questions*, 70: 62-76.

Cheverud JM, Buikstra JE (1981) A comparison of genetic and phenotypic correlations. *Am J Phys Anthropol,* 42: 958-968.

Cheverud JM, Buikstra JE, Twichell E (1979) Relationships between non-metric skeletal traits and cranial size and shape. *Am J Phys Anthropol,* 50: 191-198.

Christensen AF (1997) Cranial non-metric variation in North and Central Mexico. *Anthropol Anz*, 55: 15-32.

Christensen AF (1998) Colonization and microevolution in formative Oaxaca, Mexico. *World Archaeology*, 30: 262-285.

Fisenko VA (1966) *On the origins and chronology of the Catacomb-grave culture*. Sratov University, Saratov.

Fornaciari G, Mallegni F, Bertini D, Nuti V (1981) Cribra orbitalia and elemental bone iron in the punics of Carthage. *Ossa,* 8: 63-77.

Gamkrelidze TV, Ivanov VV (1984) *Indo-European language and Indo-Europeans*. Tbilisi University, Tbilisi.

Griffin M (1995) *Artificial cranial deformation and nonmetric cranial variation revisited: evidence from a southeastern U.S. coastal population sample*. Paper presented at the 2nd Annual Meeting of the Midwest Bioarchaeology and Forensic Anthropology Association. Dekalb. September 30.

Hanihara T, Ishida H, Dodo Y (2003) Characterization of biological diversity through analysis of discrete cranial traits. *Am J Phys Anthropol,* 121: 241-251.

Hauser G, Bergman P (1984) Some biological and methodological problems of asymmetrical development, illustrated with reference to sutural bones. *Anthropol Anz,* 42: 101-116.

Hauser G, De Stefano GF (1989) Epigenetic variant of the human skull. Nägele & Obermiller, Stuttgart.

Herodotus (1972) History in Nine Books. Translation and Notes by G.A. Stratanovsky. Leningrad.

Hewsen RH (1997) The geography of Armenia. In: Hovannisian RG (ed). *The Armenian people from ancient to modern times*. Vol. 1. St. Martin's Press, New York.

Hlusko LJ (2004) Integrating the genotype and phenotype in hominid paleontology. *Nat Acad Sci USA*, 101: 2653-2657.

Il'Inskaya VA, Terenozhkin AI (1983) *Scythia 7th-4th centuries BC.* Kiev.

Ishida H, Dodo Y (1997) Cranial variation in prehistoric human skeletal remains from the Marianas. *Am J Phys Anthropol,* 104: 399-410.

Khodjaiov TK (1977) *Anthropological structure of the population of Bronze Age from Sapallitepe*. Fan, Tashkent.

Khohlov AA (2000) Craniological materials Srubnaya cultures of the south of the Average Volga region. In: Efimova S (ed). *The people of Russia: from the past to the present*. Moscow.

Khudaverdyan AY (2000) *The population of the Armenian uplands during Antiquity, based on data from the Beniamin cemetery.* Tigran Mec, Yerevan.

Khudaverdyan AY (2005) Population Vardbakh of ancient age according to data to anthropology: cranioscopy, odontology, paleodemograhy, paleoecology. The VI Congress of the Ethnographers and Anthropologists of Russia, St. Petersburg.

Khudaverdyan AY (2009) *The bronze population of Armenian highland. Ethnogenesis and ethnic history*. Van Aryan.Yerevan.

Khudaverdyan A (2011a) Migrations in the Eurasian steppes in the light of paleoanthropological data. *The Mankind Quarterly,* LI (4): 387-463.

Khudaverdyan AY (2011b) *Ancient communities of the Caucasus - in the worlds' dialogs (an anthropological etude).* Lap Lambert Academic Publishing AG & Co. KG. Germany.

Khudaverdyan A (2011c) Artificial modification of skulls and teeth from ancient burials in Armenia. *Anthropos,* 106: 602-609.

Khudaverdyan AY (2011d) Unusual occipital condyles and craniovertebral anomalies of the skulls burials Late Antiquity period (1st century BC - 3rd century AD) from Armenia. *Eur J Anat,* 15: 162-175.

Khudaverdyan A (2012) Bioarchaeological analysis of populations Armenian Highlands and Transcaucasia in Ancient time. *The Mankind Quarterly,* 53: 388-413.

Khlopin IN (1983) *Southwest Turkmenia during an epoch of Late Bronze (on materials of Sumbar burial)*. Science, Leningrad.

Klejn LS (1980) Where did the Aryans come into India from? *The bulletin of the Leningrad University,* 20: 35-39.

Klejn LS (1984) The coming of Aryans: who and whence? Bulletin of the Deccan College. *Research Institute,* 43: 57-72.

Kohn LAP (1991) The role of genetics in craniofacial morphology and growth. *Ann Review Anthropol,* 20: 261-278.

Konigsberg LW, Kohn LAP, Cheverud JM (1993) Cranial deformation and nonmetric trait variation. *Am J Phys Anthropol,* 90: 35-48.

Kozintsev AG (1980) Discrete signs on skulls of Bronze Age from Southern Siberia. *Museum of Anthropology and Ethnography,* XXXVI: 75-99.

Kozintsev A (1988) *Ethnic Cranioscopy*. Nauka, Leningrad.

Krupnov EI (1960) *Ancient History of the Northern Caucasus.* Science, Moscow.

Krupnov EI (1966) Caucasus in the most ancient history of our country. *History questions,* 5: 27-40.

Kuzmina EE (1998) Cultural connections of the Tarim Basin people and pastoralists of the Asian steppes in the Bronze Age. In: Mair VH (ed). *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.

Lang J (2005) *Armenians. The people creator.* Riddles of ancient civilisations. Moscow.

Lane RA, Sublett AJ (1972) Osteology of social organization: Residence pattern. *American Antiquity,* 37: 186-201.

Martirosyan AA (1964) *Armenia during of Bronze Age and Early Iron.* National Academy of Science of Armenia, Yerevan.

Martirosyan AA, Mnacakanyan AO (1973) Prierevansky treasure of ancient bronze. *Short messages of Institute of Archeology Academy of Sciences USSR,* 134: 122-127.

Matsumura H (2007) Non-metric dental trait variation among local sites and regional groups of the neolithic jomon period, Japan. *Anthropological Science*, 115: 25-33.

Mclellan LJ, Finnegan M (1990) Geographic-variation, asymmetry, and sexual dimorphism of nonmetric characters in the deer mouse (peromyscus-maniculatus). *Journal of Mammalogy,* 71: 524-533.

Movsesyan AA (1990) To the paleoanthropology of the Bronze Age in Armenia. *Biolog J Armen,* 4: 277-283.

Movsesyan AA (2005) *Phenetic analysis of paleoanthropology*. Moscow.

Movsesyan AA, Kochar NR (2001) Ancient populations of Armenia and their role in contemporary Armenian type formation. *The Anthropology Bulletin*, 7: 95-116.

MOVSESYAN AA, MAMONOVA NN, RICHKOV YG (1975) The program and method of research of anomalies of a skull. *Anthropology questions*, 51: 127-150.

NECHITAILO AL (1991) *Communications of the population of steppe Ukraine and the North Caucasus during a Bronze Age*. Kiev.

NEVCHALODA AI, KUFTERIN VV (2008) To the characteristic of diseases of inhabitants Gonur Depe. In: Dubova NA (ed). *Works of Margian archaeological expedition* 2, Moscow.

OSSENBERG NS (1970) The influence of artificial cranial deformation on discontinuous morphological traits. *Am J Phys Anthropol,* 33: 357-372.

PASSEK TS (1949) *Periodization Tripol settlements*. Kiev.

PETRENKO VG (1983) *Scythian Culture in the Northern Caucasus*. Archaeological Collection of Articles of the State Hermitage, 23. Leningrad.

PIONTEK J (1979) Natural selection and microevolutionary variability of non-metric traits in medieval populations of Poland. *Studies in Phys Anthropol*, 5: 95-110.

PIONTEK J (1988) Natural selection and non-metric traits in skeletal populations. *J Hum Evol*, 3: 321-327.

PIOTROVSKY BB (1959) *Vansky kingdom (Urartu).* East literature, Moscow.

PROWSE TL, LOVELL NC (1996) Concordance of cranial and dental morphological traits and evidence for endogamy in ancient Egypt. *Am J Phys Anthropol,* 101: 237-246.

PYSTOVALOV S (2002) Development of cattle breeding economy in Northern Black Sea Coast during an epoch of a neolith-late of bronze. In: Iarovoi EV (d). *Most ancient of a generality of farmers and cattlemen of Northern Black Sea Coast (IV millennium BC - IV centuries CE).* Tiraspol.

REINHARD R, RÖSING FW (1985) *Ein Literaturüberblick über Definitionen diskreter merkmale anatomischer Varianten am Schädel des Menschen*. Selbstverlag, Ulm.

RUBINI M (1997) Biological homogeneity and familial segregation in the Iron age population of Alfedena (Abruzzo, Italy), based on cranial discrete traits analysis. *Int J Osteoarchaeol,* 6: 454-462.

SAUNDERS SR, RAINEY DL (2008) Nonmetric trait varation in the skeleton: abnormalities, anomalies and atavisms. In: Katzenberg MA, Saunders SR (eds). *Biological anthropology of the human skeleton* (2nd ed.). John Wiley and Sons, Inc., New Jersey, pp 533-560.

SEE AW, KAISER ME, WHITE JC, CLAGETT-DAME M (2008) A nutritional model of late embryonic vitamin A deficiency produces defects in organogenesis at a high penetrance and reveals new roles for the vitamin in skeletal development. *Developmental Biology,* 316: 171-190.

SHERWOOD RJ, DUREN DL, DEMERATH EW, CZERWINSKI SA, SIERVOGEL RM, TOWNE B (2008) Quantitative genetics of modern human cranial variation. *J Hum Evol*, 54(6): 909-914.

SHEVCHENKO AB (1984) Paleoanthropology data to a question on a population origin Srubnaja a cultural-historical generality. In: Gokhman I (ed). *Problems of anthropology of the ancient and modern population of Eurasia*. Leningrad.

SHEVCHENKO AB (1986) Anthropology of the population of South Russian steppes during a bronze epoch. In: Gokhman I (ed). *Anthropology of the modern and ancient population of the European part of the USSR*. Leningrad.

SJØVOLD T (1984) A report on the heritability of some cranial measurements and non-metric traits. In: Van Vark GN, Howells WW (eds). *Multivariate statistical methods in physical anthropology*. D. Reidel Publishing Company.

SOLODOVNIKOV KN (2006) The population of mountain and forest-steppe of Altai of the Bronze Age according to paleoanthropology. Ph.D. dissertation. Barnaul.

STRABO (1964) The *Geography* XI, IV. Translation and Notes by G Stratanowski. Science, Moscow.

SUTTER RC, MERTZ L (2004) Nonmetric cranial trait variation and prehistoric biocultural change in the Azapa Valley, Chile. *Am J Phys Anthropol,* 123: 130-145.

TER-MARTIROSOV F (1999) Shirak during an epoch of classical antiquity. In: Hairapetya S (d). *Shirak's historical and cultural heritage*. Vol. 9. Gyumri.

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). Science, Leningrad.

TROFIMOVA TA (1949) To a question on anthropological ties during an Fatianovo Cultures. *Soviet ethnography,* 3: 37-73.

TORGERSEN J (1951a) The developmental genetics and evolutionary meaning of the metopic suture. *Am J Phys Anthropol,* 9, 193-210.

TORGERSEN J (1951b) Hereditary factors in the sutural pattern of the skull. *Acta Radiologica,* 36: 374-382.

TURAN-OZDEMIR S, SENDEMIR E (2006) Incidence of mylohyoid bridging in 13th century byzantine mandibles. *Anat Sci Intl*, 81: 126-129.

TUR SS (2009) Odontologic characteristic of population Andronovo culture from Altai. *News of the Ural State University* 4: 228-236.

VINOGRADOV VB, DUDAREV SL (1983) *Chronology of Some Monuments and Complexes at the Beginning of the 1st Millennium BC from Karachaevo-Cherkesia and Pyatigor'e*. Problems of Archaeology and Ethnography of Karachaevo-Cherkesia. Issue 2. Cherkessk.

WILLIAMS FL, BELCHER RL, ARMELAGOS GJ (2005) Forensic misclassification of ancient nubian crania: Implications for assumptions about human variation. *Curr Anthropol*, 46: 340-346.

ZUBOVA AV (2008) *Anthropological structure of the population of Western Siberia during epoch of the developed and late Bronze*. Ph.D. dissertation. Novosibirsk.

ZUPANIC Z (2004) New method of identifying family related skulls. Springer-Verlag, Wien.

YUSUPOV RM (1989) *Population anthropology Srubnaja cultures Southern Uralja*. Materials on a Bronze and Early Iron Age Southern Uralja and the Bottom Volga region, Ufa.