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Deciduous Human Teeth from the Upper Paleolithic Site of Yudinovo, Western Russia

Population affinities of the Timonovka-Yudinovo Upper Paleolithic people are reconstructed on the basis of three isolated deciduous teeth (a lower lateral incisor, and lower and upper second molars, likely representing three individuals) found in 1987–1996, from Yudinovo in the Middle Desna basin (15–12 ka BP). On the basis of measurements and descriptive traits and computed microtomography, the teeth were compared with those from other Upper Paleolithic sites in northern Eurasia. The principal component analyses of metric and nonmetric traits revealed similar patterns. To minimize random variation, the results of both analyses were integrated. The results indicate affinity with the Pavlov people of Central Europe. The diagnostic trait combination includes weak expression of the Carabelli cusp on the upper second molar, accessory sixth cusp on the lower second molar, large vestibulo-lingual diameter of both molars, and moderate mesio-distal diameter of the lower second molar. These results support the view that the Timonovka-Yudinovo tradition is related to the eastern Gravette one.

Keywords: *Upper Paleolithic, Timonovka-Yudinovo culture, Yudinovo, Pavlov, dental measurements, nonmetric dental traits, deciduous teeth, micro-CT analysis, Gravette.*

Introduction

The Upper Paleolithic site of Yudinovo is located in the Middle Desna basin, at the southwestern periphery of Yudinovo village (Pogarsky District of the Bryansk Region). The site lies on the right bank of the Sudost River, and is restricted to the higher level of the first above-flood terrace of this (Velichko, Gribchenko, Kurenkova, 1996: 35). The site was discovered in 1934 by K.M. Polikarpovich. In 1947, he had started an excavation, which was continued in 1961, and led by V.D. Budko from 1962 to 1967. In 1980, after a long break, the excavation was resumed by the Bryansk Paleolithic expedition of the Leningrad Branch of the Institute of Archaeology of the USSR Academy of Sciences. From 1980 to 1985 and from 1987 to 1990, the excavations were led by Z.A. Abramova, and from 1995 to 1997 and from 2000 to 2003 by G.V. Grigorieva. From 2004 on, the site has been excavated by the Desna Paleolithic expedition of the Museum of Anthropology and Ethnography (MAE) of the Russian Academy of Sciences (RAS) led by G.A. Khlopachev.

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Yudinovo is a multilayered site: its lower layer, with houses made of mammoth bones, belongs to the period from 15 to 13.5 ka BP, while the upper layer is dated to 12.5–12.0 ka BP. The structure and paleogeographic features of the lower cultural layer point towards a long duration for the functioning of the site, and the cyclic character of its habitation. Yudinovo belongs to the Timonovka-Yudinovo variant of the Middle Dnieper archaeological culture, first described by L.V. Grekhova (1970, 1971). Typical features of the lithic industry of this culture are: scarcity of tool shapes; prevalence of burins and end-scrapers; leading role of retouched side-burins in the group of burins; shortened forms of end-scrapers; presence of blunt-edged points; low number of perforating tools; absence of geometrized tools; rarity of bifacial and ventral processing of blanks; and low number of combination or double tools (Grekhova, 1971: 15, 21).

The genesis of the Timonovka-Yudinovo traditions of the Desna basin remains a hotly debated topic. Some researchers consider them as Epigravettian, and relate them to local Gravettian traditions of a Central European origin (Desbrosse, Kozlowski, 1988: 100). Some elements of the primary processing of a tusk are similar between the Timonovka-Yudinovo sites and the Eastern Gravettian site Khotylevo-2 from the same region (Khlopachev, 2006: 215, 237). Other scholars tend to find the roots of those traditions among the Magdalenian of Central Europe (Otte, 1981: 141; Grigorieva, 1999: 26; 2002; Belyaeva, 2002). In order to assess this problem objectively, an analysis of biodistances based on anthropological data is required. But such an analysis has long been impossible, since all sites found to date are settlements, and thus there were no anthropological data available from them. The site of Yudinovo was an exception: in 1987, 1990, and 1996, three deciduous human teeth were found there.

The teeth from Yudinovo have not yet been studied by anthropologists because only permanent teeth have traditionally been used for inter-population comparisons. During the last several decades, a number of studies have shown that the distal upper and lower deciduous molars (m^2 and m_2, respectively) are not less informative than their permanent counterparts, since they are the key teeth in the row of the deciduous and permanent molars (Farmer, Townsend, 1993; Bockmann, Hughes, Townsend, 2010). The permanent molars, which are commonly considered the teeth of "second generation", in fact belong to the row of primary teeth, because they do not have predecessors. Both deciduous and permanent molars are formed on the basis of the same dental lamina and, taking into account the high degree of their morphological similarity, the second deciduous and first permanent molars can be considered meristic elements in the row of the molars (Bailey, Benazzi, Hublin, 2014: 105; Bailey et al., 2016). But the second deciduous molars start their formation earlier, and their crowns are formed faster than those of the first permanent molars. Thus, the morphology of m^2 and m_2 is under a stricter genetic control and is less influenced by environment than that of the permanent molars (Sofaer, 1973). In the light of these data, the deciduous teeth from Yudinovo appear as an exceptionally important source of information regarding the population history and origin, not only of the population of Middle Desna basin, but of northern Eurasia in general. The main purpose of this study is to analyze comprehensively the morphology of the teeth from Yudinovo, in order to shed light on the biological relatedness of the Timonovka-Yudinovo population.

General description of the specimens

The lower right first incisor Yudinovo 1 (Fig. 1, *1*) was found in 1987. It belonged to a 5–7 year old child, and was lost naturally. The tooth is well-preserved, with no signs of post-mortem damage. A little less than a half of

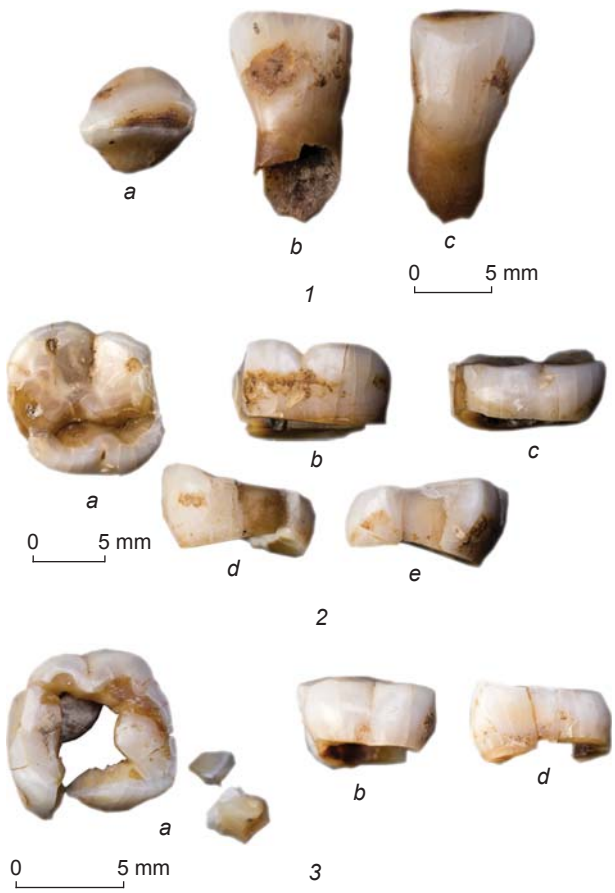

Fig. 1. Dental remains from Yudinovo.
1 – lower right first incisor (Yudinovo 1); *2* – lower left second molar (Yudinovo 2); *3* – upper left second molar (Yudinovo 3).
a – occlusal norm; *b* – lingual norm, *c* – vestibular norm, *d* – mesial norm, *e* – distal norm.

the crown is worn out, and a wide stripe of naked dentine can be observed at the cutting edge. The root is mainly resorbed (the maximal length of the remaining part is just 4.7 mm). Deposits of dental calculus are observed on the lingual and interdental surfaces.

The lower left second molar Yudinovo 2 (Fig. 1, *2*) was found in 1990. It belonged to a 10-12 year old subadult individual. The enamel of the occlusal surface is heavily worn. There are wide areas of open dentine in the protoconid, hypoconid, and hypoconulid, and dentine points in the metaconid and entoconid. Moderate calculus is found on the lingual surface of the crown and in the interdental space.

The upper left second molar Yudinovo 3, belonging to a 10–11 year old child, was found in 1996. It is separated into six fragments (Fig. 1, *3*), two pairs of which can be attached to one another. Pre-mortem damage and pathological changes are absent, except a very weak calculus.

All three teeth belonged to different individuals. This is evident from the mismatch between contact points of the occlusal surfaces of the crowns of the upper and lower molars, as well as from the different intensity of calculus in the incisor as compared to the molars.

Study protocol and analytical methods

The specimens were investigated using both dental metrics and nonmetric traits. The measurement protocol included mesio-distal and buccolingual diameters of the crown and neck of each tooth. The group of nonmetric traits was composed of a conventional set of markers used in Russian and world dental anthropology (Zubov, 1968, 1974, 2006; Turner, Nichol, Scott, 1991), as well as archaic and Neanderthal complex markers (Zubova, 2013; Khaldeeva, Kharlamova, Zubov, 2010; Bailey, 2002; Bailey, Skinner, Hublin, 2011). A detailed description of the grade scales for all variables can be found elsewhere (Zubova, Chikisheva, Shunkov, 2017: 122–125; Zubova, Stepanov, Kuzmin, 2016: Tab. 1, p. 136–138).

The upper molar was examined only visually, owing to its poor preservation. The incisor and lower molar were scanned with a computed X-ray microtomograph Skyscan-1172, which made a thorough description of the morphology of the teeth possible despite the attrition of the external enamel. The scanning protocol was set as follows: tube voltage 100 kV, current strength 100 μA (no filter), rotation step 0.25°, averaging over three frames, at the resolution of 3.45 μm/pixel. The raw data were reconstructed using NRecon (Bruker-microCT) software. For each specimen, a 3D model was rendered in CTAn (Bruker-microCT), allowing visual separation of dentine and enamel. The models were visualized using CTVox (Bruker-microCT) software.

Principal component analysis (PCA) was the main statistical method employed for both metric and nonmetric traits. Input variables in the PCA were the buccolingual diameter of the m^2, and the mesio-distal and buccolingual diameters of the m_2. Six variables from the entire set of nonmetric markers were employed in the statistical analysis, since these variables are common between this study and publications of most comparative samples: hypocone reduction (minimal grade of presence 4–) and metacone reduction (minimal grade 2); Carabelli cusp (grades 2–5) at the m^2; sixth accessory cusp; tami; protostylid (grades 2–5) at the m_2. The grades of presence of the traits were converted in a binary form (presence of a trait – 1, absence – 2). The sample mean was substituted for missing values. Coordinates of specimens along first two principal components of both analyses (i.e. analyses of metric and nonmetric traits) were used as raw variables for calculating integrated principal components (IPC). These latter describe most of the metric and nonmetric variation in the sample (for description of this technique see (Kozintsev, Gromov, Moiseyev, 2003: 152)). All calculations were carried out using Statistica for Windows, version 7.0.

The question regarding the possibility of direct comparison of the morphology of the deciduous and permanent teeth, and the use of their traits in the same analysis, is being discussed (see, e.g., (Brabant, 1967; Edgar, Lease, 2007)). Therefore, the specimens from Yudinovo were compared only to deciduous teeth from other locations. The reference sample included: Caldeirão 2, 11 (Voisin et al., 2012; Trinkaus, Bailey, Zilhão, 2001); Cisterna 3 (Trinkaus et al., 2011); Dolní Věstonice 36 (Trinkaus et al., 2000; Early Modern…, 2006: 200–210); Pavlov 6/2, 7, 8, 9, 10, 12 (Sládek et al., 2000: 130–131, 137–140; Early Modern…, 2006: 211–234); Sungir 3 (Zubov, 2000); Kostenki 14 (layer IV, 6/1), Kostenki 15, Kostenki 18, Ust-Kyakhta (unpublished data of A.A. Zubova); Malta 1, 2 (Zubov, Gokhman, 2003; Shpakova, 2001); Listvenka (Shpakova, 1997, 2001); Khaiyrgas (Zubova, Stepanov, Kuzmin, 2016), Strashnaya 1 (Zubova, Krivoshapkin, Shalagina, 2017).

Morphological description of the specimens

Yudinovo 1. The crown (Fig. 1) is of subtriangular shape, with the edge strongly inclined in a distal direction. The root is almost round in section, and moderately flattened mesio-distally at the neck. The lingual cusp is not developed; accessory ridges on the external layer of enamel of the lingual surface are absent. After the enamel was virtually removed and the relief of the dentine surface had been reconstructed, two finger-shaped ridges spreading from the lower third of the crown to the cutting edge were observed (Fig. 2).

The dimensions of the crown and the neck (see *Table*) are close to the means of these variables in modern populations (Zubov, Khaldeeva, 1993: Suppl., tab. 1). Considering the Upper Paleolithic European specimens, Yudinovo 1 can be compared to the lower first incisor of Dolní Věstonice 36: the dimensions of its neck and its vestibulo-lingual diameter are smaller than those of Yudinovo 1. Among Siberian dental remains from Malta and Listvenka, specimens exhibiting either larger or smaller vestibulo-lingual diameters can be found.

Yudinovo 2. Visual examination of the tooth revealed that the crown was of oval shape (see Fig. 1) and included at least five cusps, arranged in two rows. Large contact facets are present at both mesial and distal sides of the crown. The length of the distal facet is 5.8 mm, but the length of the mesial facet could not be measured, as the enamel of the mesial side was damaged post-mortem. C7, protostylid, or cingular derivatives were not observed.

When the layer of worn enamel was virtually removed on the CT reconstruction (Fig. 3), a Y-type of contact between cusps of the crown, a vestibular position of the hypoconulid, and the presence of an accessory sixth cusp became visible. A rudimentary element of C7 was detected in entoconid; but the degree of development of this structure does not permit scoring this trait as present. The distal trigonid crest and deflecting wrinkle of the

Fig. 2. 3D-reconstruction of enamel-dentine junction of the Yudinovo 1 incisor. Lingual side.

Dimensions of the deciduous teeth from Yudinovo and comparative samples (mm)

Specimen	m^2		m_2		i_1		
	MD cor	BL cor	MD cor	BL cor	BL cor	MD col	BL col
Yudinovo 1	–	–	–	–	4.2	3.2	3.8
Yudinovo 2	–	–	9.6	9	–	–	–
Yudinovo 3	–	10.2	–	–	–	–	–
Kostenki 14	–	–	11	9.5	–	–	–
Kostenki 15	9.6	9.8	10.72	8.7	–	–	–
Kostenki 18	8.9	10	9.55	8.75	–	–	–
Sungir 3	8.8	9.9	9.2	9.1	–	–	–
Caldeirão 2	–	–	10.5	9.5	–	–	–
Caldeirão 11	–	–	11.1	9.6	–	–	–
Cisterna 3	–	–	11.1	9.7	–	–	–
Dolní Věstonice 36	10.2	10.9	10.9	8.6	3.9	2.8	3.5
Pavlov 6/2	8.2	10.2	–	–	–	–	–
Pavlov 7	–	–	9.4	9.1	–	–	–
Pavlov 8	–	–	9.7	9	–	–	–
Pavlov 9	–	–	9.3	9.5	–	–	–
Pavlov 10	–	–	9.5	–	–	–	–
Malta 1	8.2	9.2	9.7	8.4	4.6	–	–
Malta 2	9.7	10.1	10.8	8.7	4	–	–
Listvenka	–	–	10.8	9.2	4.1	–	–
Ust-Kyakhta 3	…	9.5	–	–	–	–	–
Strashnaya 1	–	–	11.6	10.1	–	–	–

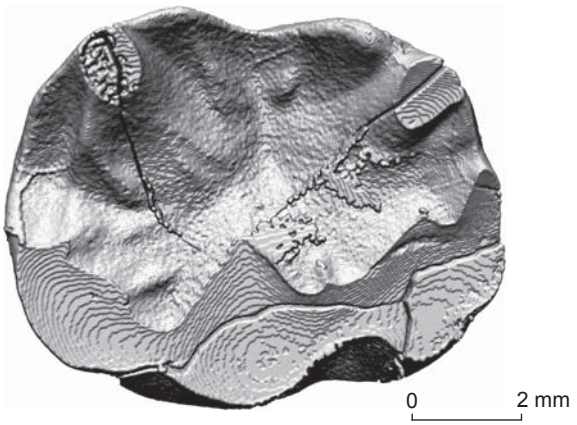

Fig. 3. 3D-reconstruction of enamel-dentine junction of the Yudinovo 2 molar. Left – mesial side; right – distal side.

metaconid are absent. An anterior fovea, delimited by the mesial segments of the protoconid and metaconid, was observed in the mesial part of the crown.

The odontoglyphic pattern was also reconstructed using the microtomography data. It includes the intertubercular fissures I–VI; grooves of the second order 1 and 2med, 1 and 2end, and 1 and 2prd; grooves of the third order 3med, 3prd, and 2'end. The odontoglyphic pattern of the hypoconid and hypoconulid could not be reconstructed, owing to their severe attrition. The presence of the 4end groove at the entoconid can be supposed, but its presence or absence cannot be demonstrated convincingly because of the post-mortem damage of the crown, which precludes a complete virtual removal of the enamel layer. Of diagnostically important odontoglyphic combinations, the 2med (fc) variant and type 2 of superposition of the first grooves' points of contact of the metaconid and protoconid can be observed. Both traits are neutral in terms of assigning the specimen to the Western or Eastern dental patterns.

Yudinovo 3. The crown (see Fig. 1) is of subrectangular shape, with a large hypocone and a moderately reduced metacone. The distal accessory ridge and posterior fovea are absent. A little groove (grade 1) was observed in the area where the Carabelli cusp is usually found, but no other structure indicative of the presence of this trait is present. No cingular derivatives were observed on the vestibular surface. The presence or absence of other traits cannot be determined, owing to post-mortem damage.

Results of comparative analysis

The comparison of the teeth from Yudinovo with other samples from northern Eurasia has shown that such features as the weak development of the Carabelli cusp at the m^2 and the presence of the sixth accessory cusp at the m_2 limit the range of morphologically similar finds to the specimens from Pavlov in Central Europe. Yudinovo 3 is most similar to the Pavlov 6 and Pavlov 12 specimens, in which the Carabelli cusp is absent and the distal cusps of the crown are equally reduced. Yudinovo 2 exhibits a similarity in most traits to the Pavlov 7 and Pavlov 8 specimens, which most likely belonged to the same individual as Pavlov 6. The most convincing indicator of its affinity is the presence of the sixth cusp, which is rarely found among the Upper Paleolithic European dental specimens and is traditionally considered an "Eastern" marker. It is much more often found in Siberian samples, and was observed at Malta (the younger child), Strashnaya, and Khaiyrgas. But the lower molars of those Siberian individuals are not similar to the specimens from Yudinovo, if many dental traits are taken into account.

As upper and lower molars are not always both represented in the Upper Paleolithic specimens employed in the comparative analysis, only 7 reference samples were employed in the PCA: Kostenki 15, Kostenki 18, Malta 1, Malta 2, Sungir 3, Dolní Věstonice 36, and Pavlov 6 and 8 (features of the upper and lower molars were combined as if they belonged to the same individual). The results of the analysis confirm the similarity between the Yudinovo and Pavlov molars. They plot closely at the positive ends of PC 1 and 2 of the nonmetric traits PCA (Fig. 4, *1*). The PC1 experiences statistically significant loadings from the Carabelli cusp (–0.77), tami (–0.84), and protostylid (–0.8). The PC2 differentiates the specimens on the basis of the degree of the metacone reduction (0.75) and the presence/absence of the sixth accessory cusp of the m_2 (0.898).

According to the results of the PCA based on dental metrics, the Yudinovo teeth remain similar to the specimens from Pavlov (Fig. 4, *2*) despite an apparent 90° rotation of the plot as compared to the previous analysis. Another difference is a more clearly pronounced separation of Dolní Věstonice 36 from the dental remains from the Kostenki-Borschevo archaeological region. The PC2 ordinates the specimens according to the vestibulo-lingual diameter of the m^2 (0.93). Loadings on the PC1 demonstrate different directions of variation of the mesio-distal vs. vestibulo-lingual dimensions of the m_2. Both variables produce high loadings, but of different sign (0.94 and –0.76, respectively). Such a discrepancy in the variation of the sagittal and transverse dimensions of permanent teeth can, in some cases, be explained by sexual dimorphism (Zubova, Moiseyev, Khartanovich, 2017). But for deciduous teeth it is not possible to assess the degree to which sexual dimorphism affects the results, since the sex of most specimens cannot be determined by their morphology. It is unlikely that the influence of sexual dimorphism on the PCA results for the Yudinovo teeth was very strong, because both metric and nonmetric traits exhibit similar patterns of variation. Importantly, the raw variables are not significantly correlated.

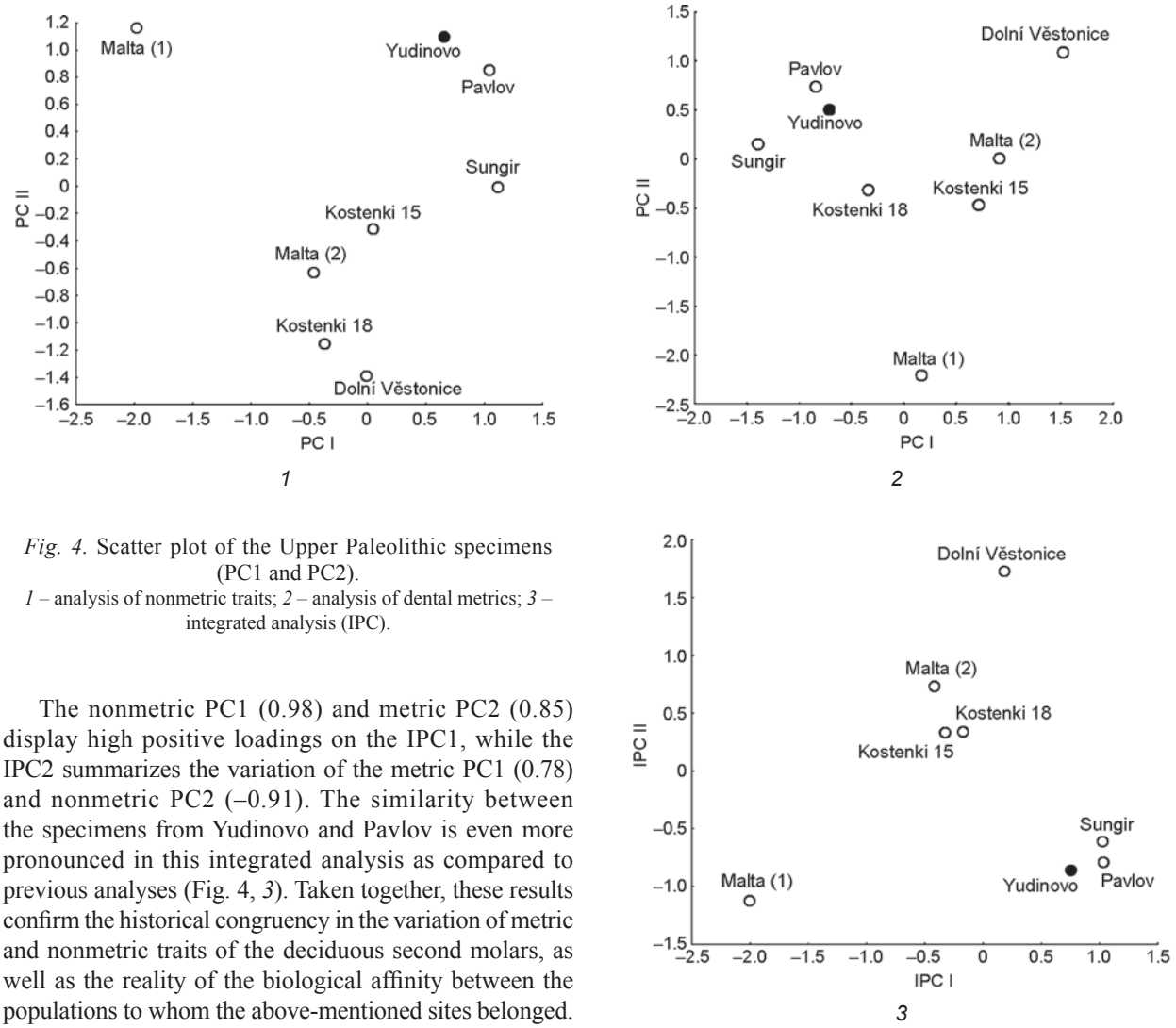

Fig. 4. Scatter plot of the Upper Paleolithic specimens (PC1 and PC2).
1 – analysis of nonmetric traits; *2* – analysis of dental metrics; *3* – integrated analysis (IPC).

The nonmetric PC1 (0.98) and metric PC2 (0.85) display high positive loadings on the IPC1, while the IPC2 summarizes the variation of the metric PC1 (0.78) and nonmetric PC2 (–0.91). The similarity between the specimens from Yudinovo and Pavlov is even more pronounced in this integrated analysis as compared to previous analyses (Fig. 4, *3*). Taken together, these results confirm the historical congruency in the variation of metric and nonmetric traits of the deciduous second molars, as well as the reality of the biological affinity between the populations to whom the above-mentioned sites belonged.

Conclusions

The results of the current study lead to two important conclusions. First, the existing data on the dental morphology of the Yudinovo inhabitants confirm the views according to which the genesis of the Timonovka-Yudinovo traditions is more related to the eastern variant of the Gravette culture rather than to the Magdalenian culture of Central Europe. Only a few Magdalenian representatives were employed in this study: Cisterna 3 and the relatively early materials from the Solutrean-Magdalenian layer of Caldeirão, which could not be included in the statistical analysis. Nevertheless, the differences in metric traits between them and the Gravettian specimens from Pavlov and Dolní Věstonice are fairly evident (see *Table*) and fit very well into the paleogenetic results showing a genetic differentiation between the populations of the two archaeological cultures (Fu et al., 2016).

Second, the results of this study demonstrate that information on distal deciduous molars gives a very good perspective on the biological relationships between Paleolithic populations. This not only due to their "key" position in the molar row, but also to historic congruency in the variation of metric and nonmetric traits of isolated teeth, which is accompanied by the absence of a strict biological association between the sizes of the crowns and their morphological complexity.

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