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Quaternary International

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## Straight from the horse's mouth: High-resolution proxies for the study of horse diet and its relation to the seasonal occupation patterns at Divnogor'ye 9 (Middle Don, Central Russia)

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### ARTICLE INFO

#### Article history:

Received 14 July 2017

Received in revised form

13 December 2017

Accepted 6 January 2018

Available online xxx

#### Keywords:

Microwear

Mesowear

Palaeobiology

Non-destructive sampling

Seasonality

Ungulate

Equidae

Pleistocene

Upper palaeolithic

Hunting

Mass kill

### ABSTRACT

In this study, we present the results of tooth mesowear and microwear analyses on fossil horses recovered in two Late Pleistocene archaeological layers at Divnogor'ye 9 (Middle Don, Central Russia). Tooth wear refers to two high-resolution proxies for reconstructing dietary habits in ungulates which give access to different periods in life history of the animals sampled. Mesowear is a proxy averaging diet over months, while microwear reflects the diet of the last days before death. The first objective of this study is to integrate and compare the results from mesowear and microwear to investigate the dietary habits of the studied fossil horses (*Equus ferus*), to reconstruct their habitat(s), and compare with stable isotope and indirect proxies. The second objective is to participate to disentangle the various hypotheses of site formation and the nature of accumulation of the horse remains.

The horse populations around Divnogor'ye 9 likely lived in habitats where both grass and browse were available, but our analysis indicates that they were selectively and exclusively feeding on grass. Furthermore, we used tooth microwear pattern as a high-resolution proxy for estimating the duration of mortality events and their seasonality. The application of a well standardized approach to interpret the microwear data permitted us to classify the two assemblages as seasonal events. The results support the hypothesis that the two accumulations of the horse remains represent seasonal, repeated occupations of the site by Late Glacial hunters in the same season for hunting and mass killing of horses. This study highlights the advantage of using non-destructive sampling methods in a multidisciplinary approach when investigating ungulate diets and patterns of fossil accumulations in archaeological sites.

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### 1. Introduction

The integrated use of high-resolution techniques on archaeological faunal material has increased in the recent years to reconstruct ancient human subsistence strategies (Rendu, 2007; Julien

et al., 2012, 2015; Sánchez-Hernández et al., 2014, 2016; Balasse et al., 2017; Tornero et al., in press). The recent advances in the application of these techniques to archaeological sites are providing relevant data about hominid behavior and ecology. Among those, the study of mortality events of large game at prehistoric sites is key for understanding seasonal resource procurement by hominins (e.g. Farizy et al., 1994; Speth, 1997, 2010; Fenner, 2009; Julien, 2007, 2009; Hoffecker et al., 2010; Carlson and Bement, 2013; Rendu et al., 2012; Lubinski, 2013; Julien et al., 2015; Rivals et al., 2015a; Rodríguez-Hidalgo et al., 2016).

In this study, we use an integrated approach, combining two

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methods of tooth wear analysis, mesowear and microwear and compare our results with other direct (stable isotope) and indirect proxies (pollen, faunal analyses, lithic remains, etc.). Tooth mesowear analyzes the shape of wear facet to evaluate the abrasiveness of the diet in ungulates. Mesowear is a (palaeo)ecological proxy which reflects the diet of the last weeks or months before the death of an animal and thus indicates dietary preferences on an ecological scale (Fortelius and Solounias, 2000). Tooth microwear patterns, microscopic features produced by food items on the teeth, reflect the diet of the last days of life of an animal (Grine, 1986; Solounias and Semprebon, 2002). Consequently, microwear is a high-resolution proxy for estimating the diet at the time of death, and can be used for assessing the duration of accumulation events in archaeological sites and their seasonality. This approach allows researchers to differentiate assemblages which accumulated in a seasonal or shorter event, events longer than a season, and separated events occurring in different seasons (Rivals et al., 2015a, 2015b). Therefore, the integration of dental wear offers new doors to investigating seasonal patterns of ungulate accumulations in archaeological sites using non-destructive sampling.

For this approach, we analyzed two sets of samples from two horse bone beds of the well-preserved Late Paleolithic site of Divnogor'ye 9 (Middle Don, Central Russia). Despite the more than ten-year history of the site research, there are several debated views regarding the formation of the bone accumulations and the nature of human activity at the site. According to Bessudnov and Bessudnov (2010) and Bessudnov et al. (2012, 2013), Divnogor'ye 9 is considered as a place for periodic mass killing and primary butchering of wild horses. On the other hand, Lavrushin et al. (2010, 2011) proposed that most of the bones' horizons are of natural origin in Divnogor'ye 9 and were formed due to repeated mudflows that caused the death of horses. Kuznetsova et al. (submitted)

suggested that the horses died of starvation at the end of winter or early spring, and that they died at the top of the ravine and then were redeposited by temporary flows to the entrance of the ravine.

In this context, this study has two objectives: (1) to investigate the diet of the horse at two temporal scales: ecological i.e. annual average (through mesowear), and at the time of death (through microwear), and (2) to inform about the duration and seasonality of accumulation(s) of the horse assemblages in layers 5 and 6 of Divnogor'ye 9 using the variability of the microwear signal to provide new evidence to explain the formation of the site.

## 2. Divnogor'ye 9

Divnogor'ye 9 (also spelled Divnogorie 9) is an open air archaeological site on the bank of the Tikhaya Sosna River, a tributary of the Don River, at the southern margin of the Central Russian Upland in the Voronezh Region (50° 57' N, 39° 18' E) (Fig. 1). More precisely, the site is located in a gully of a chalk plateau, without permanent water, which formed during the Last Glacial period. The 16 m deep excavation exposed the entire stratigraphic profile down to the valley bottom, which is characterized by lacustrine sediments in the lower part of the profile overlain by paleosols and slope deposits (Lavrushin et al., 2010, 2011; Bessudnov et al., 2013; Sycheva et al., 2016).

Divnogor'ye 9 is comprised of seven layers, all yielding faunal remains. The layers where the samples come from were accumulated during the Raunis interstadial (14.5–13.4 ka uncal BP). Likely deposited in a relatively short period, they have been dated of  $14,430 \pm 160$  (AA-90655, Layer 6) and  $13,900 \pm 140$  BP (AA-90654, Layer 5) (Lavrushin et al., 2011) (Fig. 2). The pollen record of the lacustrine sediment indicates that grasses and dwarf shrubs including *Artemisia* and *Chenopodiaceae* were common while pine

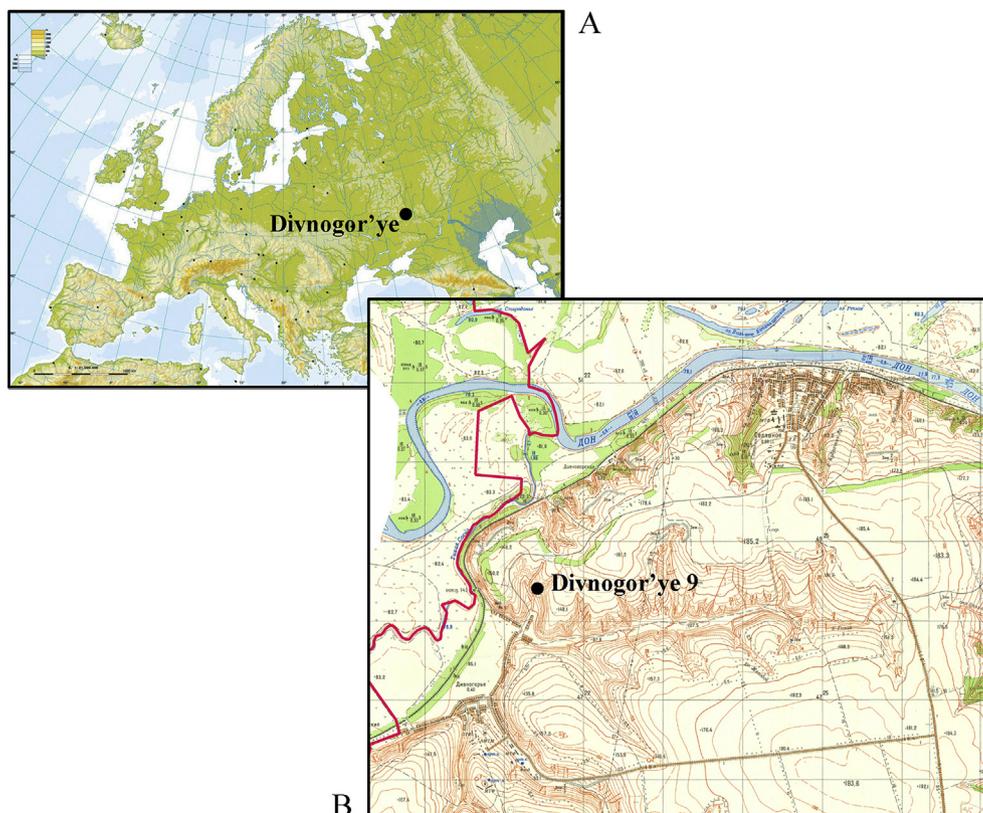


Fig. 1. A. General map of the location of Divnogor'ye 9. B. Topographic map of the location of the site.

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