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GENERAL BIOLOGY

Molar Microwear of Narrow-Headed Vole (*Microtus gregalis* Pall., 1779) Depending on the Feed Abrasiveness

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Abstract—In the narrow-headed vole, enamel microwear of the first mandibular molar (of the protoconid and entoconid anterior enamel wall) was studied under the laboratory conditions and at the fixed feed composition. The classic parameters and the area of the enamel prism lesion were taken into account. The enamel lesion patterns caused by the tooth–tooth and tooth–food interactions have been determined. Differences were found between the voles kept on feed with different abrasive properties, as well as between the lingual and buccal conids of the first mandibular molar. In the *Microtus* species, the ratio of micro-lesions (pits and scratches) did not depend on the abrasive properties of the feed consumed. The extent of preservation of the enamel contour anterior edge depended on the feed composition and could be used as an indicator for indirect evaluation of the *Microtus* species diet.

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Studying of microwear of the molar chewing surface provides important information on the diet of the contemporary and fossil mammals [1, 2]. On the basis of the chewing surface microwear, successful paleoreconstructions of the environmental conditions [1, 3, 4] and feed composition have been made for both large [1, 4] and small [3, 5] mammals. High information value of the chewing surface microwear has been also demonstrated for various groups of rodents [1, 2, 5–7]. Nevertheless, in the voles of the genus *Microtus*, the relationships between these parameters and diet remain poorly studied. Since *Microtus* species, in particular, the narrow-headed vole, are mass species of the late Quaternary, and they are widely used for biota analysis [8, 9], studying of the enamel microwear in this group may greatly enhance the paleoreconstruction potential.

In this study, we aimed at experimentally evaluating of the molar enamel microwear of the narrow-skulled vole as dependent on the abrasive properties of feed consumed under laboratory conditions.

The object of the study was narrow-headed voles from the laboratory colony of the Institute of Plant and Animal Ecology, Ural Division, Russian Academy of Sciences. The voles were divided into two groups, the diet of which differed in the feed abrasive properties. The first group (n = 22) consumed “soft food” composed of the components with low abrasive properties: peeled dandelion leaves, carrot cleaned off soil, apples without core. The second group (n = 22) consumed “hard food” with high abrasive properties: the monocotyledonous plant leaves, hay, and carrot not cleaned of soil. All voles were kept on the same feed composition for at least a month.

Microwear was examined on the anterior enamel wall of the entoconid (Ed) and protoconid (Prd) of the first mandibular molar (m1) using micrographs made at a magnification of 700× using a TESCAN VEGA3 electron scanning microscope. The number of microwear variables (pits and scratches) and their linear parameters (length and width) were determined using the Microwear 4.02 semiautomatic software (Ungar Peter, 1994–2002, United States). Apart from these micro-lesions, which are traditionally used to characterize enamel microwear [6, 7], we evaluated the area of lesion on the anterior wall of enamel prism, as a ratio of total area of chips to total area of the enamel prism anterior wall (Fig. 1).

Note that lesions smaller than 25 μm^2 that belong to pits were not taken into account, as well as the large enamel wall lesions exceeding 1/3 of the total area of the prism anterior wall, because they belong to another type of enamel wear, mesowear.

The microwear distinctions on Prd and Ed of the first mandibular molar and their dependence on the feed abrasive properties were estimated using Student’s t test and ANOVA by means of the Statistica 8.0 software (StatSoft, 1984–2007, United States).

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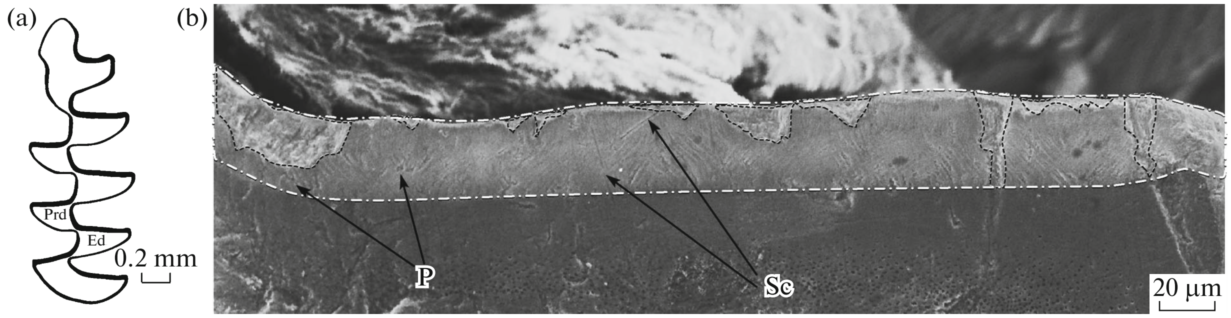

Fig. 1. (a) A scheme of the m1 chewing surface in *M. gregalis*; (b) the anterior enamel wall of entoconid with pit (P) and scratch (Sc) designations and a scheme of the chip area assessment (dotted line, the area of enamel lesion; dash-and-dot line, the total area).

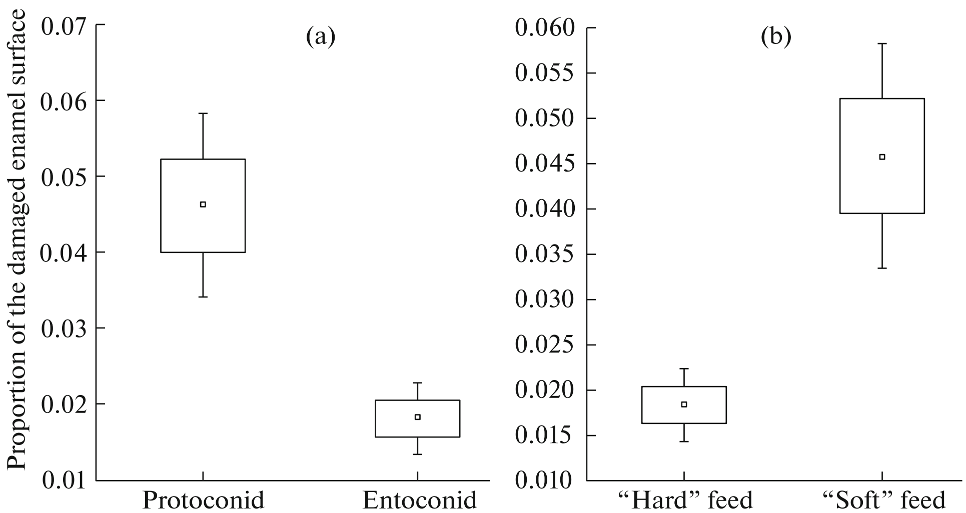

Fig. 2. (a) Mean values and confidence interval of the damaged surface proportion on the anterior enamel wall of the proto- and entoconid and (b) in voles that were kept on feeds with different abrasive properties.

Analysis of the main microwear variables (pits and scratches) revealed no significant differences between voles kept on the "soft" or "hard" feeding ($F(3.81) = 1.24$, $p = 0.29$). However, within a single molar, Ed and Prd differed significantly in the number of microlesions ($F(3.81) = 3.49$, $p = 0.003$). On Prd, there were less pits though their linear dimensions were increased ($F(14.72) = 21.174$, $p \ll 0.001$). In the *Microtus* species, enamel deterioration has some specific features because the direction and size of microlesions depend on peculiar orientation of the enamel texture elements. Hence, calculation of small pits and scratches was obstructed, but the remaining irregular elements seem to appear at random and were greatly variable in different groups.

Analysis of the micro-chip area on the enamel wall showed that, in voles kept on the "soft" feed, the area of lesions was significantly larger than in voles kept on the "hard" feed ($t = -4.13$, $p \ll 0.001$) (Fig. 2). The outer enamel layer (radial enamel) was affected to a greater extent, while only single chips penetrated the enamel contour to affect the inner enamel layer (lamellar enamel).

Within a single molar (Fig. 2), a significantly larger lesion area was on Prd ($t = 4.24$, $p \ll 0.001$) (Fig. 2). In the groups kept on different feeds, there were significant differences between the mean indices of the enamel wall lesion on Ed and Prd ($t = 4.14$, $p \ll 0.001$ and $t = 2.62$, $p = 0.01$ on the "soft" and "hard" feeds, respectively). In *Microtus* species, various microlesions on the buccal and lingual molar conids were found earlier [10] and they seem to result from the peculiar occlusion features [11].

Formation of the molar cutting edge depends on two factors: interaction of the upper and lower chewing surfaces of teeth and the tooth-food interactions [12, 13]. Formation of the chewing surface microlesions depends on the same factors. In voles consuming soft feed, interaction of the chewing surfaces of the upper and lower teeth has the greatest effect on microwear formation [14]. The largest area of the enamel wall lesion was observed in the voles kept on the "soft" feed. In voles that consume hard feed, interaction of teeth with food was of greater importance [14]. Enamel microwear depends on the presence of small abrasive (e.g., cereal phytoliths) and hard particles contained in food (e.g., sand particles). In voles kept on the "hard" feed, the tooth enamel preservation was better. These data are in accordance with the results of mesowear experimental analysis reported earlier [15]. In voles kept on the "soft" feed and predominantly having the tooth wear type against each other, enamel lesion was also stronger than in voles kept of the "hard" feed and predominantly having tooth wear type against food.

In the *Microtus* species, with their specific features of the molar chewing surface, the total area of lesions of the enamel contour anterior edge, which demonstrates the extent of enamel preservation during tooth–tooth and tooth–food interactions, proved to be a more informative parameter for indirect evaluation of diet than quantitative estimation and linear parameters of the microwear variables. This index can be successfully used for indirect assessment of the *Microtus* species diet.

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