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Incisor and mandible anomalies in the Harting's vole *Microtus hartingi* (Mammalia: Arvicolinae) in Europe

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ABSTRACT. We observed incisor and mandibular anomalies in two populations of Harting's vole from Strandzha foothills and the Eastern Rhodopes. In the laboratory colony of voles originating from the Rhodope foothills, over six years, incisor pathology persisted at a constant rate of 15%. In the colony of voles from Strandzha foothills, maintained at the University of Latvia (Riga) and Zoological Institute (Saint Petersburg) from 1988 to 2000, not a single case of incisor overgrowth was observed. However, *M. h. strandzensis*, caught in the same biotopes in early 2000's, were examined for abnormal growth of the maxillary incisors and mandibular deformation. The new data on changes in the ecology of Harting's vole over the last three decades are presented.

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KEY WORDS: *Microtus hartingi*, incisor overgrowth, mandible deformation, habitat fragmentation.

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Аномалии резцов и нижней челюсти у полевки Хартинга *Microtus hartingi* (Mammalia: Arvicolinae) в Европе

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РЕЗЮМЕ. В двух популяциях полевки Хартинга из предгорий Странджа и Восточных Родоп мы обнаружили проявление аномалий резцов и нижней челюсти. В лабораторной колонии, сформированной из особей родопской популяции, патология резцов сохранялась в течение 6 лет на уровне 15%. В колонии полевок из Странджа, существовавшей в Латвийском университете (Рига) и в Зоологическом институте (Санкт-Петербург) с 1988 по 2000 г., не было отмечено ни одного случая нарушения роста резцов. Однако в начале 21 века в тех же биотопах были отловлены *M. h. strandzensis*, у которых также появилась аномалия роста верхних резцов и деформация нижней челюсти. Приводятся новые данные об изменениях в экологии полевок Хартинга за последние три десятилетия.

КЛЮЧЕВЫЕ СЛОВА: *Microtus hartingi*, чрезмерный рост резцов, деформация нижней челюсти, фрагментация среды обитания.

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Harting's vole (*Microtus hartingi* Barret-Hamilton, 1903) belongs to the subgenus *Sumeriomys* Argyropulo, 1933, genus *Microtus* Schrank, 1798 (Arvicolinae) and to the "guentheri" group, representatives of which are mosaically distributed across the Balkan Peninsula (Serbia, Macedonia, Bulgaria, and Greece), Asia Minor and the rest of West Asia (Turkey, Iran, Lebanon, Syria, Israel, Jordan), as well as North Africa (Libya) (Kryštufek & Shenbrot, 2022). Harting's vole first entered southeastern Europe from Anatolia in the Middle Pleistocene via a land corridor (McHugh et al., 2008). The corridor was finally submerged by a significant rise in sea level at 7–5.3 Ka (Kerey *et al.*, 2004).

The Bulgarian subspecies *M. hartingi strandzensis* was first described by Markov (1960) in Gramatikovo (the south-eastern part of the Balkan Peninsula, Stran-

dzha Mountain). In 1988, F. Golenishchev captured voles (Bulgaria, 42.5°N, 27.65°E) in lucerne fields to form a colony at the Zoological Institute of the Russian Academy of Sciences (Saint Petersburg, Russia) and in the Ethology Laboratory at the University of Latvia. The latter laboratory colony reproduced successfully for 12 years. Not a single case of incisor overgrowth was recorded during this period (data from T. Zorenko).

In 2004 V. Mitkovska and a team from University of Plovdiv caught the very first *M. h. strandzensis* vole (42.05°N, 27.65°E), which exhibited the overgrowth and deformation of the upper incisors, as well as structural aberrations of the mandible. Similar anomaly occurred in their F1 in the laboratory (10 specimens in the museum collection). Later, in 2012, T. Zorenko captured at the same spot two males of this subspecies with overgrown upper incisors. Figure 1 shows severe pathological deformation of the upper incisors (Fig. 1B) and mandible deformation (Fig. 1D) compared to normal incisors (Fig. 1A) and mandible (Fig. 1B) in *M. h. strandzensis*. In the foothills of Strandzha, voles inhabit humid biotopes, avoiding habitats such as agricultural areas, dry meadows with sparse vegetation, and grazing grounds (Markov & Dimitrov, 2010). In 2012, we observed that habitats preferred by voles started to overgrow with forest vegetation, which could apparently affect voles in these areas (Fig. 2) and reduce their population numbers, as suggested by the data of Markov and Dimitrov (2010). Thus, the number of animals in all studied areas ranged from 0.54 to 2.08 individuals per 100 trap-days.

Another locality in Bulgaria from which we received material is the Eastern Rhodopes. Two males and three females of *M. hartingi* were caught and karyotyped at the beginning of the 21th century for the first time (Chassovnikarova *et al.*, 2008). T. Zorenko and N. Atanasov examined the Eastern Rhodope Mountains and discovered an isolated population of *M. hartingi*, with a range represented by small patches (Fig. 3), distant from each other (41.38°N, 26.08°E). In April 2014, vole presence was recorded on two patches only. One of them was Meden Buk, where only a single adult pair was found. The second patch, 25 km from Meden Buk had three colonies, but no animals were caught during three days of trapping. At the end of May 2016, the number of voles was 13.3 individuals per 100 trap-days in this patch. Young voles were captured on the third patch located 2 km away from the second one; the number of voles was 6.7 individuals per 100 trap-days. By May 2024, the first and second vole habitats were transformed by cultivation: the Meden Buk patch became the almond tree plantation, and the second patch became a crop culture plantation.

At the end of May 2024, three new patches were discovered in the same region: Mandritsa village spot (41.38°N, 26.12°E); and two sites 3 km and 8 km away. The method of trap-lines (Sherman traps and mouse traps) was used in order to establish the relative numbers of the Harting's voles. The number of voles on these spots was 6.25, 8.33 and 4.4 individuals per 100 traps-days accordingly. The obtained data shows that although the number of voles in the eastern Rhodope Mountains was not high during our study, it was still higher than in the foothills of Strandzha.

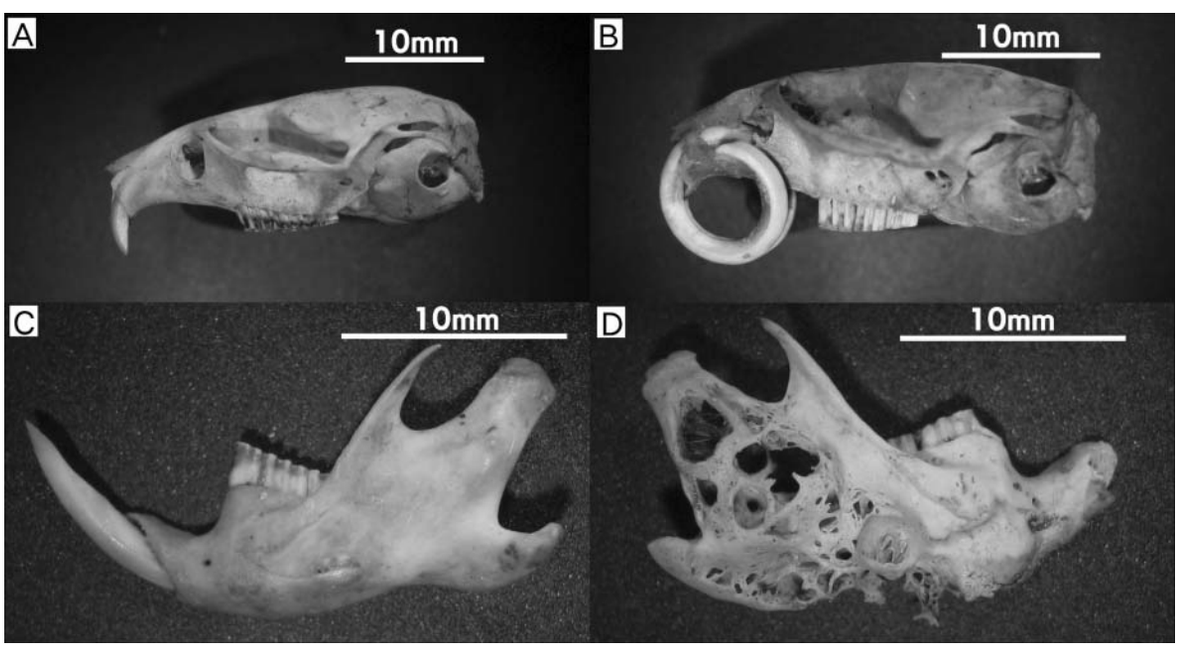

Fig. 1. Growth of upper incisors: (A) normal and (B) pathological; and deformation of mandible: (C) normal and (D) pathological in *M. h. strandzensis* from Strandzha Mountain.

Fig. 2. Overgrowth of Harting's vole habitats with trees and shrubs in the foothills of Strandzha. Photograph by V. Mitkovska.

In 2016, ten voles were captured in the Rhodopes; the lengthening of the upper and shortening of the lower incisors (5.4 and 5.1 mm compared to the normal 4.8 and 7.4 mm, respectively; the frontal length of incisors on the skull was manually measured using calipers) was observed in two males. Such alterations are the first sign of the onset of anomaly. In 30 days after capture, the incisors of one male had grown significantly, so he could not feed anymore and died soon. In the second male, incisor overgrowth appeared only after six months. During this period, a male with two females produced four litters. A similar pathology of the incisors was observed in 3 of his 19 offspring. The laboratory colony formed from captured animals was maintained for 6 years. In each generation (F1–F6), on average, 16% (14–19.2%) of animals exhibited the incisor pathology, while the mandible deformation was relatively rare. Upper incisors overgrowth (Fig. 4B) and mandible deformation (Fig. 4D) in the laboratory colony of Rhodopean voles are shown in comparison with normal upper incisors (Fig. 4A) and mandible (Fig. 4C). The overgrowth of the upper incisors and molar teeth and deformation of the mandible in small rodents, including voles, was found both in natural populations and in laboratory colonies (Harvey *et al*., 2009; Imbschweiler *et al.*, 2011; Jheon *et al*., 2015; Imai *et al*., 2018; Jentzsch *et al*., 2020). These authors suggested various reasons for the occurrence of bone pathology of the mandible and incisor overgrowth, such as an inappropriate diet, osteomyelitis as a result of infection, disorders of phosphorus-calcium metabolism and a genetic background. The emergence of mandible deformation and heterochrony of incisor growth may be the result of the fixation of harmful alleles in local populations (Whitlock, 2003).

In our case, both in the foothills of Strandzha and the Eastern Rhodopes, there is a reduction in habitat for the Harting's vole, fragmentation of the range, which could lead to chronic stress and to inbreeding due to lack of territories. We assume that the Strandzha population was exposed to environmental stress for the last three decades and first exhibited the pathology shortly after being exposed to it, while the Eastern Rhodopean population has been living under similar stress for thousands of years and nowadays has a stable rate of the similar anomaly. According to our hypothesis, impaired growth of incisors and mandible deformation may result from chronic physical or social stress caused

Fig. 3. Biotope of *M. hartingi* in the eastern Rhodope Mountain discovered in 2014 and 2016. Photograph by G. Dobryansky.

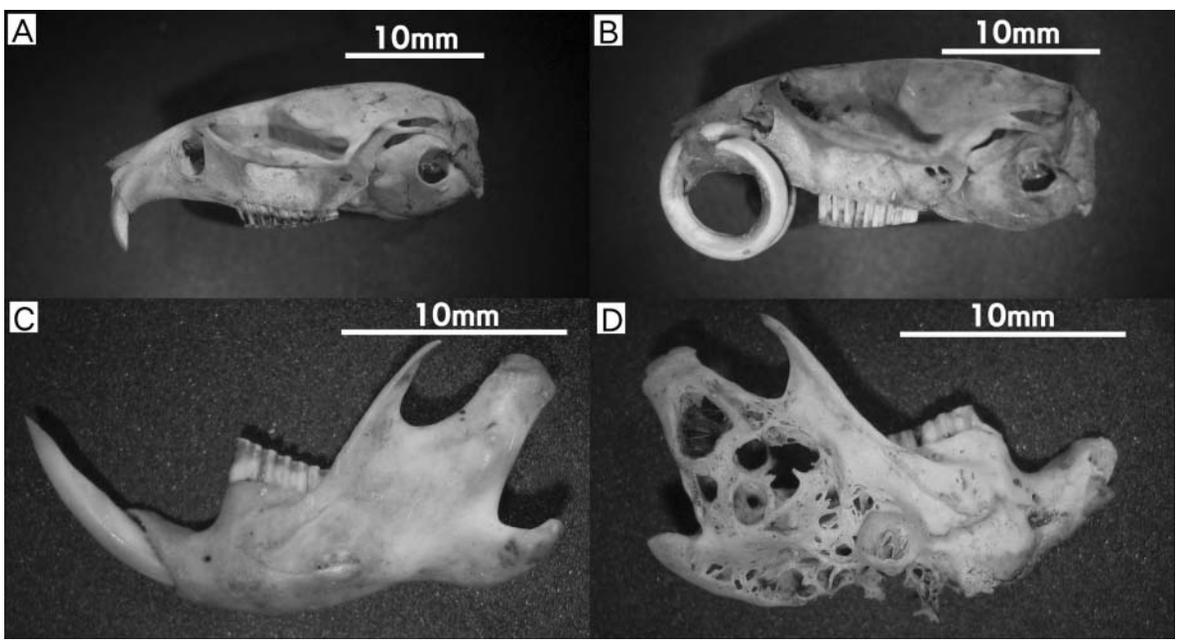

Fig. 4. Growth of incisors: (A) normal and (B) pathological; and deformation of mandible (C) normal and (D) pathological, in *M. hartingi* (F1) from the Rhodopean population.

by disturbance of biotopes, lack of migration routes and settlement sites. The stress and inbreeding might theoretically produce a cumulative effect on mandible morphology in both populations of voles.

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