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WINTER DENUDATION OF MOLEHILLS IN MOUNTAINOUS AREAS

DENUDACJA KOPCÓW KRECICH W TERENACH GÓRSKICH W OKRESIE ZIMOWYM

During its burrowing activities the mole forms numerous molehills on the surface of fields, pastures and meadows. In undulating tracts of land these molehills undergo degradation as the result of denudation and surface erosion processes. Zoogenic denudation processes are particularly active in mountainous areas owing to the climatic and topographic conditions stimulating them there namely, rapid thawing of snow, considerable water flow, sharp slope gradient, existence of slippery areas of various kinds facilitating transport of rock material down slopes. In the Karkonosze mountain area zoogenic denudation caused by the mole activity varied from 1—3 tons of rock material/1 ha of pasture annually.

I. INTRODUCTION

The burrowing activities of the mole, *Talpa europaea* Linnaeus 1758, are reflected on the surface of the ground as molehills, consisting of soil thrown up from burrows and underground chambers, creating the characteristic spot-like microsculpture of the area. Molehills differ in size, most frequently 30—40 cm in diameter and 15—20 cm high (Grulich, 1959; Jońca, 1964; Rusakov, 1970; Sklarov, 1953; Skoczeń, 1958). From the geomorphological point of view the mole's burrowing activities, which it undertakes in search of food (Grulich, 1959; Godfrey, 1955; Skoczeń, 1958), contributes to intensification of denudation and erosion of rock material (Jońca, 1970), which is loosened and thrown up above the ground surface. Molehills located on slopes are subject to particularly intensive erosion. The role of the mole in contributing to erosion in mountain fields and pastures and in undulating tracts of land is far greater than in flat areas.

The degradation process of superficial zoogenic forms, including molehills, is termed zoogenic denudation, hence their transport over slopes by water and wind is defined as zoogenic erosion. The intensity of molehill degradation depends on many physiographic factors (Grulich, 1959), in particular on slope gradient, amount and character of surface water flow, soil type vegetation cover, and season.

The number of molehills varies within fairly wide limits: from less than twenty (Turček, 1965) to several thousand (Voronov, 1950; Grulich, 1959; Rusakov, 1970) per hectare, the total volume being 10 m^3 (Turček, 1965; Sklarov, 1953) to 150 m^3 (Jońca, 1964) per hectare, during periods of mass occurrence of moles. Studies published to date contain little information on the extent of molehill erosion, usually reported as estimated data based on short-term observations. The author's observations on zoogenic erosion in the Sudety Mountains led to interesting, but incomplete conclusions in this connection. A special type of molehill degradation was observed from 1967—71 in the basin of Jelenia Góra area and on the northern slopes of the Karkonosze Mountains (Sudety Mountains, Silesia).

II. DESCRIPTION OF STUDY AREA AND METHODS

Measurements of molehills and observations on their destruction history were made in Karpacz on the pasture slopes of the Karkonosze Mountains where they border the bottom of the basin of Jelenia Góra, over an area of 3.5 ha. A small birch copse is situated almost in the centre of the area, which is shaped like an isosceles triangle with the apex directed downhill. Its surface is topographically varied. The east, pastured, part of the area slopes NW and W at an angle of 7—16°, the south part (meadow) slopes N at an angle from 5—8°, and the small somewhat marshy valley of the Wilczy Potok stream slopes 1—3° northwards.

The area lies 620—650 m above sea level, and is covered by a thin layer (12—25 cm) of brown podzolized soil, formed of forest soil, with a considerable admixture of skeletal parts, particularly in the pasture part of the area, which gradually changes to podzolized turf soil in those parts bordering the stream. The substratum is Karkonosze granite.

The part of the Karkonosze Mountains studied lying in the shadow of the Śnieżka massif, is often subject to warm southerly winds of the föhn type cause intensive evaporation and thawing of the snow cover, which may consequently be reduced by as much as fifteen centimetres/day. Numerous molehills then appear through the snow, often in the from of columns, towers or mushrooms. These forms were examined from the aspect of their destruction by thawing, denudation and washing away by water flowing down the slope. Measurements were made of their heigh and diameter, their shape, course, rapidity of degradation, method of transport from their sites, and eroded rock content. These studies were made on molehills of differrent shape and structure on selected parts of the area. Forms of different dimensions occurring in different parts of the area with varying slope gradient distance from the bed of the stream forming the local denudation base were chosen. The weight of rock material contained in molehills was determined. For this purpose the material contained in forms of similar size and shape to those examined in detail was weighed, and expressed as the weight of fresh material. Hillocks and other superficial formations due to the activities of small forest rodents in the central part of the study area were excluded from these considerations.

III. MORPHOLOGY OF MOLEHILL FORMS AND THEIR DEGRADATION

The number of molehills exposed was fairly large in early winter (November and December) and relatively small towards the end of the winter period. The number of molehills varies very considerably in different years, with an average of 1 molehill occuring per 2 m^2.

In 1967, 1970, and 1971 about 70% of the molehills resembled mushrooms or towers (Fig. 1). In 1968 and 1969 there were few forms of this type. Fungiform hills had a stalk from 5—8 cm in height and 9—15 cm in diameter, and the measurements of their »pileus« or »cap« was 25—30 cm wide, 30—60 cm long (depending on the gradient of the slope) and 15—22 cm thick. The cap was always unevenly shaped, the longer part of the »umbrella« — shaped cap being on the further side of the slope, and often from 15—20 cm long. Molehills shaped like mushrooms or towers were frozen, the expelled soil and rock fragments held together by ground ice. In addition the mushroom cap was usually supported from the bottom by frozen snow or ice (Fig. 2).

Fungiform molehills appearing above the snow as the result of a thaw in winter, or the effect of a föhn wind, crumbled and collapsed; small particles of earth were carried down the slope, usually by force of gravity, and less often by melt or rain water flowing down the slope. An accumulation of waste carried from molehills by surface water or wind action could be seen in patches of snow on the lower part of the slope. The role of wind in transport of soil particles from molehills can usually be seen most clearly when strong icy winds blow, but no quantitative studies of this were made during 1967—1971. The considerable degree of moisture in molehills is a factor reducing the loss of soil particles by warm föhn winds.

Most thawing and degradation of molehilis was caused by the warming action of sun, particularly in February, and consequently this process could be observed more clearly on fine sunny days. Because of sun exposure, some molehills on the south and south-west sides, disintegrated and were carried downhill more quickly. After a certain time the cap rim of fungiform hills degraded on the N, NW and NE sides also, and towards the end of this destructive process forms were observed to take shape as towers or columns 20—30 cm high and 10—18 cm in diameter. Within a short time these also crumbled, underwent denudation, and eroded. Thermal degradation and gravitational-erosive shifting processes can remove 30—70% of molehill mass from a slope within 2—3 days of thaw or prevalence of föhn wind. As the result of several recurrences of this process during the winter, 70—80% of rock material forming molehills is subject to denudation. In addition to the shapes of molehills described above the dense, compacted, unmown grass covering the slope and forming a smooth, slippery surface facilitates degradation and shifting of waste forming the molehills to a considerable degree (Fig. 3).

In February 1967, 6—6.5 tons of rock material were removed from an area of 2 ha. The average weight of the denuded molehill was 4.2 kg.

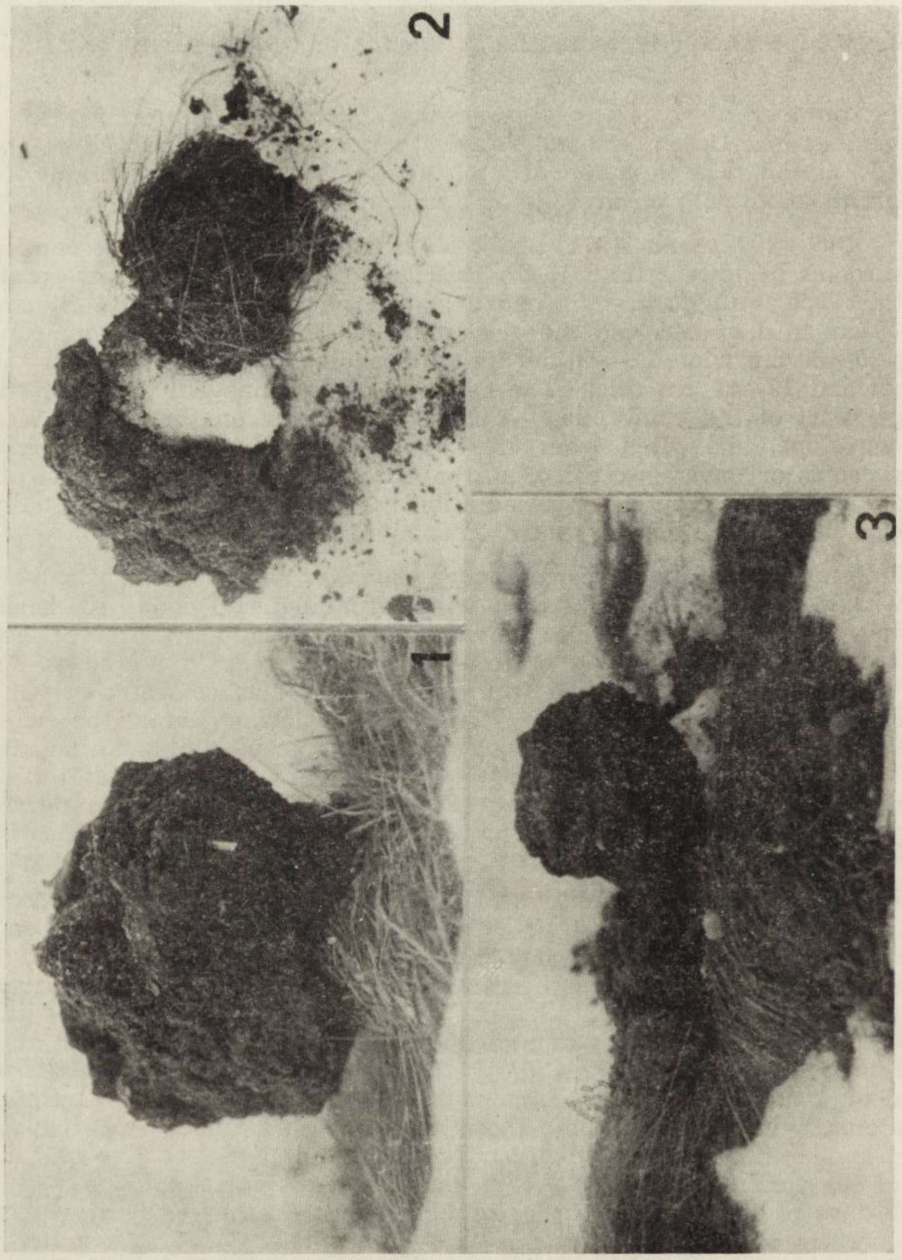

Fig. 1. Fungiform molehill exposed when snow thawed in 1971. It was formed on a layer of snow on gentle slope (7° slope towards NW), with a relatively thick stalk and small spherical cap. Height 24 cm, diameter of cap 17 cm.

Fig. 2. Molehill with grass and limp of snow inside showing that it was formed in late autumn or early winter, when ground had not yet frozen and a layer of fresh snow was lying on the area.

Fig. 3. Molehill degraded on south side, and supported on shady side by frozen snow.

Density of distribution of molehills varied from 1 per 1 m^2 to 1 per 7 m^2. In 1970 during a period of only 2.5 days (16th—18th January), as the snow melted, about 2.5 ha was exposed, on which the weight of denuded material was assessed as 2.5—3.0 tons. In 1971 intensive thawing of snow towards the end of the second 10-day period in January caused denudation of about 7.0 tons of waste from an area of 3.2 ha. These observations show that during the winter a considerable amount of waste shifts from the slopes of mountain pastures as the result of thermal degradation of molehills. Molehills in the form of mushrooms, towers and columns are far more rapidly and easily denuded than normal molehills, that is, those shaped like mounds.

The question arises as to the genesis of the mushroom-shaped molehills, which are not, however, mentioned by Grulich (1959). The frequently moisture content and considerable height of the molehills at first suggests that these may be particular forms of hydrolaccoliths. The facts, however, that their cap is connected through the »stalk« with the ground by means of a round canal 5—6 cm in diameter, unfilled with ice, and the considerable number of these forms occurring on fairly steep, dry slopes, led to the following conslusions:

In the Karkonosze Mountains, as in other mountains, snow falls at the beginning of winter before the ground freezes. At that time (Grulich, 1959; Formozov, 1966) moles are still burrowing in the soft ground and eject soil from their burrows on to the snow cover. In the study area, if the snow cover is slightly frozen on the surface, then waste slips a little down the slope, forming a mushroom of rock waste resting on a thin stalk. If a low temperature is maintained for a longer time, leading to gradual freezing of the soil, the molehill also freezes and is next covered by falling snow. It is not exposed until a temporary thaw occurs, or the spring thaw, but remains in a form similar to a mushroom. It is then more subject to degradation and denudation, as it has a lesser area of contact with the ground than the normal mound-shaped molehill. The height of the mushroom-shaped molehill, and in consequence also its susceptibility to denudation, increases when the mole ejects waste matter on to a thick layer of compact, sloping grass sprinkled with snow. Such cases frequently occur on mountain pastures.

It must be emphasized that the value of denudation of rock material from molehills, mean of 2 tons per 1 ha in the Karkonosze Mountains may be far higher under conditions favouring this process. This value refers only to denudation in winter. Zoogenic denudation caused by the mole's activities over a whole year is several times greater (Voronov, 1950; Jońca, 1964; 1970; Turček, 1965). Those molehills rendered more resistant to weathering degradation by vegetation, as often encountered in flat meadows (less often on slopes with a fairly steep gradient), contribute to the specific microsculpture of an area and are usually formed during the moles spring activity period (Grulich, 1969).

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REFERENCES

Godfrey G. K., 1955: A field study of the activity of the Mole, *Talpa europaea*. Ecology, *36*, 10: 678—685. Grulich I., 1959: Význam ryci činnosti krtka obecného (*Talpa europaea*) v CSR. Prace Brn. Zakl. CSAV, *31*, 3: 157—212. Formozov A. N., 1966: Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. Occasional Publ. Boreal Inst. Univ. of Alberta, Edmonton, no. *1*: 1—176. Jońca E., 1964: Wpływ gryzoni i kretów na erozję gleb na Pogórzu Wałbrzyskim (Sudety Środkowe). Czasop. geograf., *35*, 1: 61—72. Jońca E., 1970: O roli zwierząt w kształtowaniu rzeźby powierzchni ziemi. Czasop. geograf., *41*, 3: 229—337. Rusakov O. S., 1970: O nekotoryh osobennostiah rojuščej dejatelnosti krota. [In: »Sredoobrazujuščaja dejatelnost životnyh«]. MOIP — Inst. Geogr., AN SSSR: 78—79. Moskva. Sklarov G. A., 1953: K voprosu o dejatelnosti krotov v počvah dernovo-podzolistoj zony. Počvovedenie, *32*, 8: 51—57. Skoczeń S., 1958: Tunnel digging by the Mole *Talpa europaea*. Acta theriol., *2*, 11: 235—247. Turček F. J, 1965: The role of animals in baring and soil erosion on karst-land. Acta zool. Acad. Sci. Hungar., *11*, 1—2: 203—215. Voronov A. G., 1950: Vlijanie životnyh na počvy i rastitelnost stepnoj zony. [In: »Životnyj mir SSSR«]. Zool. Inst. AN SSSR: 527—538. Moskva.

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TO THE HISTORY OF THE DISTRIBUTION, INTRODUCTION AND CROSS-BREEDING OF THE TYRRHENIS MOUFLON IN EUROPE AND OVERSEA [1]

HISTORIA ROZMIESZCZENIA, ZASIEDLANIA I KRZYŻOWANIA MUFLONA

The European or Tyrrhenis mouflon, *Ovis ammon musimon* Schreber, 1782, is one of the 39 kinds of the native sheep, *Ovis ammon* L., 1758, spread over the northern hemisphere of the Old and New World. While their numbers in their original habitat steadily decreased since the early's of our century as a result of the poachers and commercial overhunting (the present numbers are no more than 200 in the wild for the Corsican and 300 in a private game enclosure for the Sardinian island), many succesful introductions was made in Europe since the 18th century.

About 1731 by Prince Eugen of Savoy in the game pasture of Belvedére (nearly Vienna, Austria), the basic stock with further sources from Corsican and Sardinian wilds for the zoological park of Lainz: and about 1858 in the zoological pasture of Hluboka, at present Bohemia, CSSR. The first important introduction in the wild of Europe was made by Karoly Forgach in the mountains of Tribeč (nearly Ghymes, at present Slovakia) in 1868, which build the stock of the present Slovakian po-

[1] This publication is a short abstract of a unpublished paper with the equal title.