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Effect of the Burrowing Activities of the Common Vole and the Mole on the Soil and Vegetation of the Biocenoses of Cultivated Fields [1]

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Goszczyńska W. & Goszczyński J., 1977: Effect of the burrowing activities of the common vole and the mole on the soil and vegetation of the biocenoses of cultivated fields. Acta theriol., 22, 10: 181—190 [With 6 Tables & 4 Figs.].

The burrowing activities of small mammals (common vole, mole) in the biocenoses of cultivated fields were evaluated and it was found that the soil from burrows of small rodents is more humid than control soil. Estimates were made of the weight, volume and area occupied by soil from molehills. It was found that molehills exert a stimulating effect on the development of plants in the immediate vicinity of molehills.

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1. INTRODUCTION

Studies on the effect of the common vole (*Microtus arvalis* Pallas, 1779) and the mole (*Talpa europaea* Linnaeus, 1758) on formation of certain habitat elements were carried out from summer 1973 to the autumn of 1975 and covered the following problems: effect of the common vole on humidity relations in soil and the significance of the mole's burrowing activities in meadow habitats.

2. STUDY AREA

The studies were carried out at Turew (52°04'N, 16°48'E) in the Leszno voivodship, in meadows and fields situated in the vicinity of the Agricultural Biology Station of the Institute of Ecology, Polish Academy of Sciences. The area is a plain, with great predominance of arable land (80%). The sites preferred by voles are perennial plantations: meadows (which occupy about 11% of the whole area), lucerne and clover (jointly about 5%). Voles also occur in overwintering corns and spring plantations, although in far smaller numbers (Ryszkowski, Goszczyński & Truszkowski, 1973). Estimates of the humidity of burrows dug

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by *M. arvalis* were made in fields of alfalfa, oat stubbly field and in meadows. Studies on intensity of soil transport by moles and the effect of the ejected soil on vegetation were limited to meadow sites, although moles were also found to be present in wooded areas and shelterbelts. The meadows included in the studies are in intensive agricultural use (2—3 hay harvests per year, cattle grazing). Fertilization is usually carried out in early spring using manure and mineral fertilizers, and the meadows are also rolled and harrowed. The plant species greatly predominating in meadows is *Dactylis glomerata* L., then other species occurring most often are *Deschampsia caespitoza* L., *Lolium perenne* L., *Taraxacum officinale* Web., *Plantago maior* L., *P. media* and *P. lanceolata* L., *Potentilla argentea* L., *P. anserina* L., and *P. repens* L., and *Trifolium repens* L.

3. STUDY METHODS

3.1. Humidity of the Burrows of Small Rodents

Studies on differences in humidity between soil in the burrows of *M. arvalis* and soil of undisturbed structure were initiated in the summer of 1973. A total number of 668 samples were taken at various times of the year, 98 on alfalfa, 50 on stubblefield, and 520 on meadows. Soil was taken from the bottom of the burrow for determination of humidity. For purposes of comparison soil samples were simultaneously taken from an undisturbed profile at the same depth and at a distance of 100 cm from the burrow. Humidity was estimated by means of the drying method and presented in percentage of weight. Comparisons were made for successive dates.

3.2. The Mole's Activities in a Meadow Habitat

The amount of soil transport to the surface by moles was examined at weekly intervals on six trial plots chosen at random, each 400 m^2 in area (20×20 m), measuring each time the length, breadth and height of new mole-hills, in order to define by means of these measurements the area occupied by mole-hills and the volume of soil ejected by the moles. After making the measurements the soil from the molehills was scattered over the plot and lightly trampled, making it easier in this way to find new molehills during the next inspection. As the weight of molehills was not estimated on the plots, a series of molehills differing in volume was taken and dried at 105°C. The relation obtained: $\log Y = 1.58 + 0.59 \log X$, where: Y — weight (g), and X — volume (cm^3), was used to calculate the weight of molehills on the study plots.

Examination of the effect of molehills on vegetation was made in other parts of the meadows. Molehills were chosen at random, taking from 1—4 samples of plants near the molehill to determine their biomass, and from 1 to 4 control samples at a distance of 1 metre from the molehill. A sample consisted of plants enclosed in a circle 300 cm^2 in area. The plants within the circle were cut, then weighed to determine fresh mass, then dried at 80°C to constant weight and weighed again. In 1974 from 60 to 75 samples from the edge of the molehill and from 60 to 75 control samples were taken in each series of measurements, for an average of about 30 molehills. In 1975 from 40 to 60 samples were taken from the edge of the molehill and the same number of control samples, for 38 molehills 26 days old and 43 molehills 9 days old.

In addition the effect of the molehills on soil temperature and humidity near the molehills was estimated. A diagram of the measurements made is given in Fig. 1.

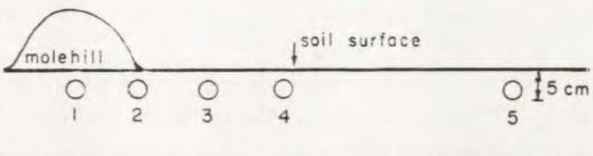

Fig. 1. Diagram of measurements of soil temperature and humidity at different distances from a molehil.

1, centre; 2, edge; 3, 10 cm from edge; 4, 20 cm from edge; 5, 1 m from edge (standard).

4. RESULTS AND DISCUSSION

4.1. Humidity of the Burrows of Small Rodents

In 1973 samples for humidity were taken from alfalfa, a meadow and a field of oat stubble, but in 1974 from the meadow only. In 1973, with rainfall of 522 mm and low soil humidity, statistically significant differences were found between the humidity of control soil and soil from burrows in the alfalfa field and oat stubbly field (Table 1). Humidity of

Table 1

Differences in soil humidity in burrows of *M. arvalis* and in undisturbed soil (depth 0—30 cm).

Date of measurement	No. of samples	Crop	Soil humidity, % in burrow	control	Differences, %	P
28.VII.1973	18	alfalfa	12.75	11.37	12.1	$0.05>P>0.02$
31.VII.1973	30	alfalfa	12.17	11.06	10.0	$0.5>P>0.2$
22.VIII.1973	50	stubble	5.20	2.70	92.5	$P<0.001$
28.VIII.1973	50	alfalfa	2.33	1.60	45.6	$P<0.001$
30.VIII.1973	30	meadow	3.03	3.39	10.6	$0.5>P>0.2$
19.IV.1974	80	meadow	15.80	15.40	2.6	$0.2>P>0.1$
20.V.1974	80	meadow	9.30	9.20	1.1	$0.5>P>0.2$
30.VII.1974	80	meadow	31.50	30.67	2.6	$0.1>P>0.05$
23.VIII.1974	80	meadow	17.25	16.90	1.8	$0.1>P>0.05$
24.X.1974	80	meadow	26.60	25.24	3.6	$0.5>P>0.2$
4.XII.1974	90	meadow	39.84	38.85	2.6	$0.5>P>0.2$

the burrows was lower in the meadow than humidity of control soil, but differences were not statistically significant.

In 1974, with very high rainfall (706 mm), greater soil humidity was found in the burrows than had been the case the previous year. Although differences in humidity were slight (in different series of measurements the soil from burrows was 1—3.6% more humid than the control soil), they were recorded throughout the whole study period during which measurements were made (Table 1). In addition it was found that the soil at the entrance to the burrow was slightly dryer than undisturbed soil. With increase of depth to 10 cm, difference in humidity between samples from the burrow and control samples continued to increase, although these differences decrease with further increasing depth and at depths over 20 cm disappear (Fig. 2).

It is possible that the interval of time since the previous rainfall may considerably effect differences in humidity between soil from burrows and standard soil. The samples taken on lucerne showed that differences in humidity in favour of burrows are: 1 day after rainfall — 1.5%; 4 days after rainfall — 1.1%; 20 days after rainfall — 0.8%.

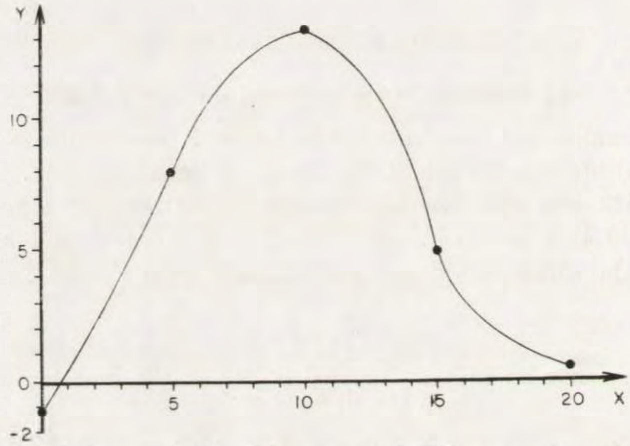

Fig. 2. Relation between depth of burrow and differences in soil humidity. X, depth (cm); Y, difference between humidity in burrow and standard sample, per cent.

It would appear that the burrows of *M. arvalis* form a water store, especially as increased soil humidity in comparison with the standard was observed even at a distance of up to 20 cm from the burrow. The average humidity obtained from the series of measurements made on 3th April 1975 for standard soil on meadows was 32.9%, and humidity of samples taken from the neighbourhood of burrows (5, 10, 15, 20 cm sideways from the burrow) — 35.2% ($0.1 > P > 0.05$). Water retention in the surface layers on soil may be considerable during periods of mass occurence of voles, when their density in some crops is as high as 2000 individuals per 1 ha (Ryszkowski *et al.* 1973), and the number of burrows can be as great as tens of thousand per 1 ha (Bashenina, 1962). It may be that losses of vegetation due to mass occurence of voles may to some degree be recompensed if such: it takes place in a dry year and the plants are able to make use of the water accumulated round the burrows.

4.2. The Mole's Activities in a Meadow Habitat

The observations carried out throughout a whole year made it possible to define the area occupied by a molehill and the volume and weight of ejected soil in successive months per 1 ha. It was found that the greatest values of these parameters were encountered during the period October-

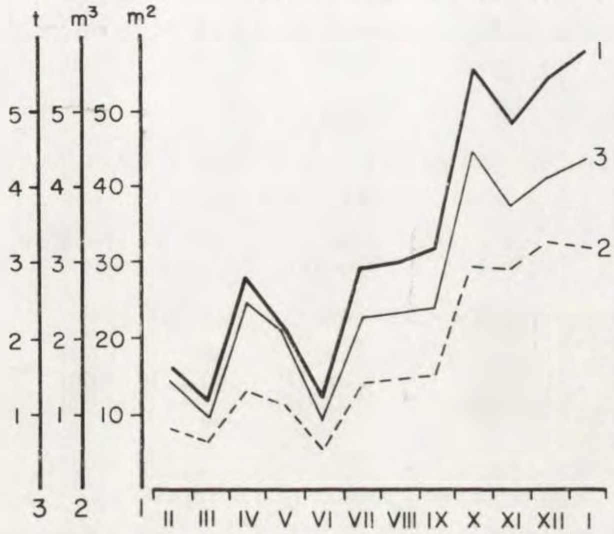

Fig. 3. Variations in area occupied by molehills and volume and weight of soil thrown up by moles per 1 ha of meadow.
1, area of molehills; 2, volume of soil from molehills; 3, weight of dry soil from molehills.

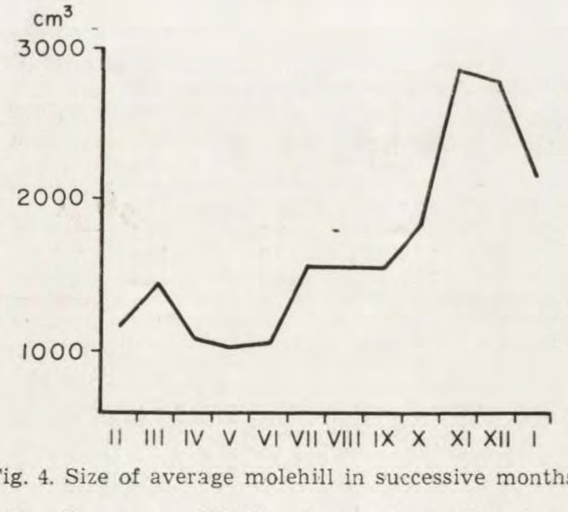

Fig. 4. Size of average molehill in successive months.

January (Fig. 3). P o p o v (1960) observed similar increase in moles activity during the winter months. At the same time, *i.e.* autumn and winter months, moles formed molehills of greater volume (Fig. 4).

During the course of a year moles throw up 21 m^3 of soil/ha of meadow, which corresponds to 32 tons/ha. The molehills formed during one year occupied 398 m^2. The results obtained for weight and volume of ejected soil are greater than those given by Abaturov (1968) for coniferous forests, and similar to the results given by Grulich (1959) for meadows in Czechoslovakia. This last author estimated the weight of ejected soil as 50 tons/ha/year, but the estimate was made of fresh soil, whereas that given in the present paper refers to the weight of dry soil. The volume of ejected earth may sometimes (in periods of mass occurence of moles) be as great as 150 m^3/ha (Jońca, 1964).

Table 2

Soil humidity in a molehill and its vicinity (depth 5 cm), Turew 1974. Number of samples given in brackets.

Date of measurement	Centre of molehill	Edge of molehill	Distance 10—15 cm from edge	Control
19.III.	12.90 (1)	12.81 (4)	17.55 (8)	15.44 (16)
22.IV.	45.90 (9)	45.50 (9)	48.68 (9)	45.82 (20)
2.V.	16.30 (17)		15.24 (68)	14.99 (68)
2.VII.	15.31 (4)	15.22 (32)	14.85 (70)	14.98 (38)
15.VIII.	15.40 (10)	15.22 (40)	15.16 (55)	16.10 (38)

Although 5 series of samples were taken for determining soil humidity, the vicinity of molehills was not found to differ significantly in respect of humidity in from any of the series from the control (Table 2). It was only in the series of March measurements that the soil from the molehill and its edge was dryer than the control ($0.05 > P > 0.02$), and soil from a distance of 15 cm from the edge more humid than the control ($0.1 > P > 0.05$). Differences in the other series were not statistically significant.

Table 3

Soil temperature (°C) at depth of 5 cm near molehill. Measurements of temperature made at hourly intervals over 24 hour period.

Date of measurements	Site of temperature measurement			
	Centre of molehill	Edge of molehill	10—15 cm from edge	1 m from edge, control
22.IV.1974	7.7	7.7	7.5	7.6
23.IV.1974	7.2	7.2	7.1	7.2
20.V.1974	17.8	13.8	13.8	14.2
15.VII.1974	20.4	18.5	18.3	18.9

Molehills exert a marked influence on the soil temperature in their vicinity (Table 3), but reduction in temperature near the molehill is a secondary effect, due to the fact that plants near a molehill are taller and limit heating of the soil. This mechanism is confirmed by the fact that differences in soil temperature near the molehill and at a standard distance become smaller after the plants are cut down. In the series of temperature measurements made during the last 10 days of May 1974, differences between the control temperature and temperature at a distance of 15 cm from the molehill was 0.24°C, but after the plants had been cut down was only 0.03°C. In the series of July measurements the differences were as follows: 0.70°C with plant cover, and 0.35°C after cutting down the plants. In both series these differences were significantly different ($P<0.001$ and $0.01>P>0.001$). Temperature in the interior of a molehill is usualy higher than the control, particularly during the late spring and summer periods, but this depends on insolation and rainfall, since in April 1974 when there were passing showers during the measurement period, temperature inside the molehill did not differ from the control temperature (Table 4).

Table 4

Plant biomass near molehill and at distance of 1 m from molehill. Area of sample was 300 cm². Approx. 30 molehills were examined in each series of measurements.

Date of estimate	No. of samples	Parameters	Fresh mass in g	Dry mass in g
20.V.1974	62	edge of molehill	64.1	-
	63	1 m from molehill	51.0	—
		difference in %	25.7	—
		significance of	2.90	
		differences t°	$0.01 > P > 0.001$	
28.V.1974	74	edge of molehill	66.3	13.24
	74	1 m from molehill	52.9	10.44
		difference in %	25.2	26.80
		significance of	2.74	3.14
		difference t°	$0.01 > P > 0.001$	$0.01 > P > 0.001$
29.VII.1974	76	edge of molehill	29.0	7.30
	76	1 m from molehill	23.6	6.25
		difference in %	22.8	16.80
		significance of	2.76	2.28
		difference t°	$0.01 > P > 0.001$	$0.02 > P > 0.01$

No significant differences were found between acidity of soil taken from molehills and that of control soil. In the first series of measurements made on soil from 50 old molehills soil pH was 7.0 (control 6.9), and in the second series taken from a different meadow soil pH for 25 newly formed molehills was 6.4 (control 6.4).

Estimates of plant biomass taken from the vicinity of a molehill and at a distance of 1 m from it (control) indicate that in the vicinity of a molehill plants develop to a greater extent. In 1974 samples were taken three times on different meadows and in all cases plant biomass near molehills was on an average 20—25% greater than the biomass of control plants (Table 4). It was also found that the size of the molehill affected the height and biomass of vegetation near molehills, but this influence depends on the time at which the molehill had been formed (Table 5). Near »old« molehills (26 days from time of their formation) vegetation was found to be more luxuriant, the larger the molehill the greater being the biomass of the plants, whereas plant biomass near »new« molehills (9 days from their formation) does not differ from control biomass (Table 5).

In places in which molehills once formed may persist for years, the burrowing activities of moles is favourable to plant succession. For

Table 5

Effect of size and age (days) of molehill on plant biomass near its edge. Samples taken from within circle 300 cm^2 in area.

Diameter of molehill (cm)	26 days			9 days		
	No. of molehills	Fresh mass, g	Dry mass, g	No. of molehills	Fresh maśs, g	Dry mass, g
25	2	85.5	15.6	2	52.5	8.3
20	6	124.2	20.5	13	72.2	13.0
25	12	120.0	20.6	12	60.7	11.8
30	6	151.8	26.7	11	73.3	13.5
35	7	159.3	30.7	5	73.0	12.5
40	4	152.7	26.3			
45	1	242.4	39.7			
Avg. molehill	38	138.4	24.4	43	67.3	12.2
Control	38	74.5	13.4	43	70.9	12.8

instance in forests molehills are first of all overgrown by moss, then vegetatively reproducing plants and tree lichen (Jakušev, 1941; Tihomirova, 1967b).

In the study area, however, molehills are destroyed every 2—3 month by rolling or other agriculture activities. Intensive grazing by cattle also contributes to rapid destruction of molehills. Under such circumstances differences in the biomass of plants near molehills and at a distance from them cannot be explained by the difference in species composition. Tihomirova (1967a) has earlier drawn attention to the fact that the species composition of plants near recently formed molehills does not differ from that of neighbouring plant cover.

Measurements of the height of grass near molehills showed that the plants growing there are significantly higher than grasses beyond the effect of the molehill (Table 6). It was also found that in the case of large molehills 30 cm in diameter grass is on an average 20% higher than grass growing near small molehills 10 cm in diameter ($0.01 > P > 0.001$ for $N = 828$).

It is extremely difficult to determine the causes of the stronger growth of plants in the immediate vicinity of molehills. It may be that physico-chemical conditions exert a stimulating effect, *e.g.* better insolation of plants near the edge of a molehill or more intensive aeration of soil. Olszewski & Skoczeń (1969) emphasized the fact that fresh molehills are well aerated. Although no differences were found in this study in soil humidity near a molehill and in control soil it would seem that the flow of rainwater over the surface of the molehill must increase

Table 6

Differences in height of grass near a molehill and 1 m from it. Number of measurements given in brackets.

Date of measurement	Height of grass in cm		Significance of differences t°
	Near molehill	1 m from molehill	
30.IV.1974	15 (110)	11 (66)	6.66 $P < 0.001$
30.IV.1974	13 (44)	11 (66)	3.07 $0.01 > P > 0.001$
30.IV.1974	15 (66)	11 (66)	6.45 $P < 0.001$
11.V.1974	23 (190)	20 (170)	3.22 $0.01 > P > 0.001$
13.V.1974	22 (281)	18 (289)	6.60 $P < 0.001$

soil humidity in its vicinity. It is probable that the wide dispersion of data makes it impossible to record this phenomenon in measurements. It is also possible that the chemical compounds (chiefly Fe, Mg, Al) carried out by moles from the deeper horizons of the soil profile exert a stimulating effect. According to Abaturov (1972) contents of these substances in the soil from molehills is greater than their concentration in horizon A_1 of the soil profile.

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WPŁYW DZIAŁALNOŚCI RYJĄCEJ NORNIKA ZWYCZAJNEGO I KRETA NA GLEBĘ I ROŚLINNOŚĆ AGROCENOZ

Streszczenie

Prowadzono oceny działalności ryjącej kretów i norników na polach i łąkach w okolicach Turwi. Stwierdzono, że gleba pochodząca z nor i korytarzy *M. arvalis* jest wilgotniejsza od gleby kontrolnej (Tabela 1). Największe różnice wilgotności między glebą z nor a glebą kontrolną znaleziono na głębokości 10 cm (Ryc. 2).

Krety na łąkach wyrzucają w ciągu roku ok. 21 m^3 gleby/ha co odpowiada ok. 32 tonom/ha (Ryc. 3). Maksimum aktywności ryjącej kretów przypada na okres jesień — zima (Ryc. 3, 4).

Produkcja roślinna w najbliższym sąsiedztwie kretowisk jest wyższa przeciętnie o 25% od produkcji roślinnej na terenach kontrolnych (Tabela 4). Na biomasę roślinności wokół kopca wpływa wiek kretowiska i jego wielkość (Tabela 5). Wyższa roślinność przy kretowiskach (Tabela 6), ogranicza nagrzewanie gleby (Tabela 3). Nie znaleziono różnic w kwasowości gleby pochodzącej z kretowisk i gleby kontrolnej.