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Tunnel digging by the mole (*Talpa europaea* Linne).

Kopanie chodników przez kreta (*Talpa europaea* Linne).

I. Introduction	235
II. Experimental material and methods	238
III. Tunnel digging	239
IV. Results	246
References	247
Streszczenie	249

I. INTRODUCTION

It may be clearly stated that a large part of what has been written on the subject of tunnel digging by moles is based on the guesswork and imagination of the authors. Hauchecorne (1927) gave as the reason for this state of affairs the fact that accurate investigation of the mole's activities in the ground is very difficult, and on this account not much is known about them. Similarly, great inaccuracy is encountered in the most recent works on the mole and in zoological textbooks on this subject.

Both in everyday language and in popular, and even in scientific literature we find the statement that the mole „roots” out its tunnels. This probably originates in the fact that the mole has a snout, which as the name indicates ought to serve as a means of „rooting”. This is the view expressed by Cuvier (1817), and of more recent authors by Adams (1903), Ogniev (1928), Brehm (1926), Schmeil (1927), Hauchecorne (1927), Matthews (1952), Abielencev et al. (1956) and others.

The view that mole „roots” with its snout is probably based on the fact that observations made of a mole which has emerged on to the surface of the ground reveal that the animal, as it runs about uneasily, does in fact press its snout into every crack and cranny it encounters. The rapidity of its movements make it difficult to perceive that the increasing pile of loose earth in the immediate vicinity of its snout has been produced by the rapid digging of its paws. The analogy with „rooting” is especially noticeable when the mole is digging a surface tunnel. The mound of fresh earth being formed, increasing in height just by the front of the animal, leads inevitably to this supposition. There is, however, on the other side of the mole’s snout, a very delicate organ of touch, and on the basis of observations so far made I must state that the mole never uses its snout to break up the earth. In my previous work (Skoczeń, 1957) I drew attention to this question, and showed that when the mole finds itself in any circumstances which might cause injury to the snout, it carefully protects this organ. For example, during a fight between two individuals, the snout is protected by both front paws, placed against the external sides of the snout. In this position the claws reach beyond the end of the snout (Fig. 10). Sometimes the mole will protect its snout from injury while fighting by lifting it as high as possible above the head of its attacking enemy (Fig. 11), or by directing the snout downwards towards its belly to afford it protection from its body. The fore part of the body is then shielded from its opponent by its outstretched paw (Fig. 12).

The second fundamental error made in discussions up to the present on this problem is the view that the mole pushes out the excavated earth on to the surface of the ground with its head, Adams (1903), Ogniev (1928), Schmeil (1927), Hauchecorne (1927), Doppelmaier et al. (1951), Formozov (1952), Matthews (1952).

On the basis of observations so far made, both under artificial breeding conditions and in their natural habitat, I was able to confirm that such treatment of this question is erroneous. The rhythm of the throwing and thrusting movements in gathering up and pushing away sawdust or earth from tunnels in the breeding pen, compared with the rhythm of the thrusting movements in ejecting earth from molehills proves that the mole under natural conditions pushes away the excavated earth with its front paws, and not with its head. The skull and entire skeleton would have to be suitably adapted to this function if the animal used its head for pushing away the earth, whereas the skull is a thin, delicate case, the frontal bones of which of ten fall in when the brain is carefully removed during preparation. The bone structure of the base of the skull is so delicate and thin that a preparation needle thrust into the brain-case shows through the bone. If the snout were used for pushing away earth, it would be liable to injury when used for pushing along the walls of the tunnel. There is no evidence of an appropriate adaptation of the spine, or in the structure of the pelvis, on which the weight of the excavated earth would rest in such a case. Pushing away of earth by the head would affect the skin, which would be considerably thicker on the head, similarly to the skin of the paws. In addition, the changes in the fur on the head would have to be more frequent, and at the end of the season, just before the moulting periods, most certainly large bald patches would be formed.

I have never so far succeeded in catching a mole which had any traces at all on its head connected with pushing away earth or with „rooting” activities (I examined several hundred moles), whereas traces are visible on the legs. When catching moles by means of cutting into the middle of a molehill with a spade, the majority of the specimens have an injured paw or humeral belt, as during the ejection movements the animal has its paw directed towards the surface of the ground (Fig. 9).

I should like here to refer to the work of *Abielencev* (1956) with regard to the digging of tunnels. I consider that the surface tunnels are a typical effect of the activity of the front paws. It is sufficient to examine the structure of the walls of the surface tunnels to see the little lumps of earth granulated by the paws. Even in areas where the soil is very soft and loose (peat deposits, cultivated soils), the surface tunnels are always the work of the front

paws. Of course the body of the animal also plays an important part in the formation of the tunnel (I shall deal with this point in greater detail later on), but this part is preceded by the activity of the front paws.

The problem of tunnel excavations by the mole is given very scant attention in literature. A broader treatment of this problem is to be found in the work of H i s a w (1923) on the American mole (*Scalopus aquaticus mahrinoïdes* Jackson). Of more recent authors only F o l i t a r e k (1935) pointed out that descriptions of tunnel digging by the mole in works so far published on the subject are not correct. According to his observations, the mole while digging turns its head towards one of its paws, while the second paw, extended forwards, digs the earth in front of it. We also encounter critical remarks on this problem in the comprehensive monograph by M a r k o w (1957) on insectivorous animals. No-one however, has so far, apart from scattered observations, carried out extensive research work on this problem.

The aim of this work is to provide a description of the technique of digging both deep and surface tunnels, raking, collecting and ejecting the earth from the tunnels, and throwing-up molehills by the mole (*Talpa europaea* L.).

II. EXPERIMENTAL MATERIAL AND METHODS

In an attempt to rear the mole under artificial conditions, laboratory observations were carried out from 1954—1957 on about 70 moles (S k o c z e ń, 1957). The animals were kept in cages 40×30 cm, with a wooden sliding bottom. The cages were placed in a dry and airy room 3×4 m, and had runs in the form of corridors constructed of pieces of wood 10×5×60 cm. The corridors were divided by a lengthways partition, making two corridors 5 cm high and 5 cm wide. Both the cages and the runs were covered by glass at the top. In addition, glass cylinders 5 cm in diameter and from 0,5 to 1 m in length were used for laboratory research purposes.

For a certain period the moles were kept in earth, then the earth was replaced by sawdust and shavings. Observations were carried out in electric light. Examination of digging and pushing out operations were carried out using both sawdust and earth. Apart from observations under artificial breeding conditions, during the experiments the moles were introduced into glass cylinders 5 cm in diameter and 0.5 m long, filled with either loose or very compactly packed earth, either dry or damp.

Investigations of the force with which the mole overcomes the resistance of the earth in ejecting it from the tunnels were carried out in tunnels formed of fibre board. Glass cylinders are not so convenient for this purpose, as the mole slips on the walls. In order to determine the strength of the

mole, a small plunger was introduced into the tunnel, which the mole then pushed out. Weights in a box were attached to the other end of the plunger.

In order to ascertain the strength of the mole's fore paws in making sideways movements (digging movements), tunnels (runs attached to the cages) with sliding sides were used, to which a spring balance was attached. Laboratory observations were supplemented by systematic field observations.

III. TUNNEL DIGGING

The mole digs two kinds of tunnel: surface tunnels, used as hunting grounds, and deep tunnels, connecting its burrow with its hunting grounds. The surface tunnels are visible from the exterior in the form of branching raised dikes. They are formed by the mole pushing out the earth simultaneously sideways and upwards, in making the sideways movements of its fore paws. Construction of these raised dike systems does not necessitate removal of the earth from the tunnels nor the formation of molehills.

When the mole digs a surface tunnel in areas overgrown by grass, e.g. pasture-land, it carries out its work in the root zone. The sound of the snapped grass roots and the simultaneous appearance in the fore part of the mound of freshly-dug earth mixed with roots and blades of grass indicates that the earth, with each stroke of the mole's paw, is pushed away in a sideways-upwards direction (Fig. 12). The activity of one paw is limited to 2—3 strokes, when the mole changes over and begins digging with the other paw. While one paw digs, the other serves as a hook maintaining the body in its forward position, and at the same time presses outwards as a result of the pressure exerted on the wall of the tunnel. Digging with alternate paws is connected not only with the avoidance of unduly tiring one paw, but also with the boring of a tunnel of suitable width.

During digging, the hind legs are kept wide apart and the claws are dug into the wall of the tunnel, thus maintaining the forwards pressure of the body. The tail is most frequently kept bent over the animal's back.

The body of the animal plays a very important part in forming the surface tunnels. As the mole squeezes itself between the lumps of loosened and wet earth, its body shapes the tunnel. A convincing demonstration of this can be obtained by observing a mole digging under natural conditions, and also by feeling the interior of a surface tunnel with the fingers. The walls of the tunnel from the interior are smooth, and the cross-section oval, corresponding to the

cylindrical shape of the body. Sometimes, as the mole passes along its system of surface tunnels, a very slight raising of the tunnel can be observed in the place where it is moving. Occasionally the mole digs with two paws simultaneously. This takes place in very soft, loose earth, cultivated or sandy soils, and often in cages in which sawdust is used as litter. I have also observed this method of digging in the case of a mole which was chasing an escaping earthworm, and also of frightened moles which attempt to dig themselves out of sight as quickly as possible.

On a basis of field and laboratory observations it may be stated that the mole, while digging surface tunnels, instead of keeping its snout sideways, uses it constantly to examine its surroundings. I have seen this during field investigations when the mole was digging its tunnel among grass roots, and its back protruded above the surface. It examined every single crack and cranny with its mobile nose.

The speed with the mole forms its surface tunnels varies considerably, and is closely dependent on the type and moisture of the ground. Where the ground is densely overgrown with grass, the surface tunnels are short and generally few in number. Where the ground, as the result of a drought, becomes hard, the mole ceases to dig this type of surface network. In areas less densely overgrown with grass, in cultivated land, where the soil is light and damp (peat deposits, stubble, ploughland, slopes of land drainage ditches) widely branching networks of surface tunnels may be found. Under these conditions the mole is capable of excavating 30 metres of surface tunnel in one night. The branches of these tunnels are extended by a definite length every day, and it is therefore almost always possible, (with the exception of periods of drought) to observe fresh sections of tunnel at the end of branches already formed.

Digging of deep tunnels takes a slightly different course than that of surface tunnels. These deep tunnels lie at varying depths (from 5 to over 50 cm below the surface). The excavated earth, in such circumstances, cannot be pressed either into the side or the ceiling of the tunnel, but must be transported to the surface.

In deep tunnels the mole digs with alternate paws, turning its head sideways at an angle, in the direction of the supporting paw (Figs. 3—5). The paw not taking part at that moment in digging operations is used as it is during the digging of surface tunnels, as

a hook, keeping the body in position at the digging face and also as a support maintaining the pressure on the digging paw. After several paring movements (up to 5), the mole changes over paws and the head is turned in the opposite direction. Sometimes during a period of drought the characteristic „paring” movements of the mole digging below the surface can be heard. During digging operations the mole reverses its position round the axis of its own body, inside the tunnel. The excavated earth is thrown back by the paw with enormous force in a sideways-ventral direction, whence the animal kicks it further away with rapid movements of its hind leg. The hind leg, during this process, moves forward, then with a strong kicking movement pushes the excavated earth backwards, away from itself. When the right fore paw is working, the right hind leg kicks away the earth, and vice versa, when the front left paw works, the left hind leg kicks away the earth. When kicking away the earth collected below its belly, the mole spreads out the toes of its hind leg and curves its claws. As I pointed out previously, the hind legs must not only maintain the mole's body in one definite place in the tunnel, but must also enable the body to keep up a constant pressure forwards. The legs are therefore widely extended and the sharp claws hooked into the wall of the tunnel. When a certain amount of earth has collected at the back of the mole in the tunnel, the animal, „somersaulting”, turns round (Figs. 6, 7), gathers up the earth and pushes it away. The mole can also turn round sideways in the tunnel. When pushing out earth from its tunnel, the mole places the surface of its paw diagonally to the line of its body (Fig. 8). The head is also turned at an angle away from the paw pushing the earth away. Occasionally when the weight is very great, the mole presses its head to the pushing paw. When engaged in this work the mole may be compared to a bull-dozer, the bulldozing plane being fixed diagonally to the line of the mole's body. Collecting and pushing away of the collected earth is done by strong thrusts, with the entire body pressing forwards. The mole makes two or three pushes, then changes over paws. This characteristic rhythm of pushing movements may be observed when the mole is ejecting the earth from molehills. After pushing out the first portion of earth the mole returns, gathers up a new portion and again ejects it. The excavated earth is ejected on to the surface by the mole in the form of the little hillocks called molehills. In order to remove the earth from the tunnel, the mole must previously have

made an opening in the surface of the ground. In order to do this, it digs out a path from the tunnel to just below the surface, then digs out a small opening. I have often seen this process during field observations. The snap of torn-up roots and moving blades of grass served to guide me to the place where the mole had dug out its opening. After a moment a little red snout appeared, investigating its surroundings. Then it disappeared, and after a moment the first portion of excavated earth appeared. The length of time between the first and second ejections depends on the distance between the digging face and the molehill and, in addition, on the hardness of the ground. Thus in the late autumn or in the winter when the mole digs deeper, and also during a period of drought, the interval between the first and second ejections is considerably longer than in other periods.

The end of the digging operations, and in consequence, of the ejection of the excavated earth may be recognised by the one or two very feeble thrusts which end the formation of the molehill. It is then obvious that the mole is removing the remainder of the earth from the tunnel, and ending for that particular time its digging operations.

Moles very often make use of old molehills to eject earth on to the surface. This occurs most frequently during a drought or when the ground is frozen on the surface. It is sometimes possible to see old, compacted molehills cracked in several places as the result of pressure from below as the freshly excavated earth was pushed out. The majority of large molehills are formed by repeated ejections of earth, although they may sometimes be the result of a single ejection. I observed this in the Jordan's Park in Cracow. One of the molehills there, about 50 cm in diameter, and 15 cm high, was formed by earth having been ejected on two separate occasions. During the second operation the mole ejected over 6 kg of earth. Another molehill 40 cm in diameter, 13 cm high (5 kg of earth) was formed on a single occasion in the place from which I had previously removed the earth. It may be accepted as a rule that where molehills are removed, new ones are almost always formed.

Examples of the work of certain moles are as follows: in the Jordan's Park in Cracow, in a damp area with sandy-clayey soil, (tunnels dug at a depth of 7—10 cm) on 12. VIII. 1957 ♀ weighing 80 g within 1—1/2 hours formed four molehills of the following diameter and weight: 40 cm 7,5 kg; 33 cm 4,0 kg; 30 cm 2,5 kg; 15 cm 1,5 kg. The mole excavates 20 cm of tunnel to 1 kg of earth in this soil.

When observing the formation of molehills, especially in wet non-sandy areas, a column of earth can sometimes be seen on the summit, from 10—15 cm in height and 5—6 cm in diameter (Figs. 13, 14). In many cases such a column passes through the entire molehill, the lower end of it often reaching the opening of the tunnel. The length of the column may therefore be as much as 40 cm. As the mole pushes out the freshly-dug earth, it pushes the entire column upwards. The upper part of the column falls in several directions, and can be seen by the side of the protruding continuation of the column (Fig. 14). The weight which the mole must contend with in pushing out a column of earth of this size is approximately 800 g (10 cm of column 5 cm in diameter, with average moisture of soil, weighs on the average 200 g). When the friction encountered throughout the entire length of the column is included, it is clear that the force exerted by the animal to overcome the resistance is incommensurably great in relation to the weight and size of the mole. In the above example the weight of the ejected earth exceeded the weight of the animal by 10—12 times as much. It should also be added that this weight is raised by the mole with one paw. During observations, a molehill weighing 6 kg was formed in about 20 minutes. For purposes of comparison I would add that these values are as follows for the American mole; the greatest weight lifted by the mole was over 3 kg. A mole weighing 120 g pressed out in the sideways movement of its paw a weight 26,4 times greater than its body weight (a human being weighing 75 kg would accordingly be able to lift 2400 kg — *Arlton*, 1936).

The above observations and calculations led me to carry out certain experiments on artificially bred moles:

Experiment I. I completely filled a glass cylinder 60 cm long, diameter 5 cm, with damp garden earth. I first rammed in two handfuls at a time, then 1 handful at a time. The length of the cylinder of earth was 48 cm. I then introduced ♀ No. 93 weighing 66 g into the cylinder. It dug through 36 cm of the earth cylinder, ejecting earth in 14 portions of the following weights (in g): 91; 85; 115; 35; 110; 15; 65; 62; 52; 32; 100; 115; 100, 75.

Experiment II. Conditions as above. ♀ No. 64 weight 80 g. Length of cylinder of earth 38 cm. Earth was ejected in the following portions (in g): 110; 84; 84; 91; 100; 108; 143; 105; 130; 75; 125.

Both females changed the direction of movement with complete freedom in a tunnel of this diameter.

Experiment III. ♂ No. 67 weight 106 g was introduced into the cylinder. In a tunnel of this diameter the mole was unable to change direction, which is essential in order to push out the excavated earth (the mole was too fat).

The mole then tried to widen the tunnel and therefore persistently scratched at the sides of the glass cylinder. I observed that the strength of the hind leg is very great (the earth is ejected from the cylinder to a distance of 0,5 m). When the mole tried to turn round in order to eject the excavated earth from the tunnel, I removed the earth by means of a scraper. The weight (in g) of each portion was as follows: 90; 70; 125; 80.

In the case of all the specimens so far examined I have found that when the piled-up earth presses on the hind quarters of the animal, the mole turns round and begins to push it away. We may obtain convincing proof of this by pressing the excavated earth with a plunger on to the body of the mole. Even when the pressure is very slight, the animal immediately „somersaults” and begins to push the earth from the tunnel.

Experiment IV. ♂ No. 154, weight 96 g was introduced into a cylinder. It began intensive digging, kicking away the earth with its hind paws from its body. As the diameter of the tunnel was too narrow for it, the mole could not turn round in order to eject the earth, and began to withdraw backwards, in this way compacting the soil behind it, and at the same time closing its air inlet. The thickness of the layer of earth blocking the tunnel was not more than 1 cm. The mole died within less than five minutes, I imagine from lack of air. On these grounds I presume that the necessary passage of air to the animal depends on its ejecting portions of earth on to the surface.

Experiment V. ♂ No. 163 weight 95 g was introduced into the cylinder. This specimen also was unable to turn round in the tunnel. It began to push out the excavated earth with the hind part of its body, kicking it out with its hind legs. Its movements were reminiscent of a dog scratching earth on to its excrement.

The moles could not manage to dig the strongly compacted and slightly-dried up earth in the cylinder, and in other artificial tunnels, and usually after several attempts gave up digging activities.

Experiment VI. ♀ No. 64 weight 80 g was introduced into the cylinder. In order to discover the force it exerted when pushing out earth, I introduced a plunger into the cylinder, on the end of which, in a box, I placed weights totalling 1700 g. Despite the great handicap which the slippery sides of the tunnel constituted, the female pushed out the plunger without difficulty.

Experiment VII. After using tunnels in the form of a cylinder, 6 cm in diameter, made of cardboard 3 mm thick, the results after calculation were obtained as follows:

♂	No. 68	weight	111 g	ejects	mass	up to	2,1 kg
♂	No. 67	„	120 g	„	„	„	2,3 „
♂	No. 75	„	110 g	„	„	„	1,7 „
♂	No. 163	„	96 g	„	„	„	1,5 „
♀	No. 93	„	61 g	„	„	„	1,1 „
♀	No. 64	„	80 g	„	„	„	1,5 „

In investigations to determine the pressure on the sides (typical digging movements) the results are as follows:

♂	No. 163	weight 125 g	pressed outwards	2,8—3 kg ¹⁾
♂	No. 75	" 117 "	" "	2,5 "
♂	No. 68	" 111 "	" "	2,1 "
♀	No. 93	" 76 "	" "	1 "

The outwards pressing movement (made under experimental conditions) took place with a rhythm characteristic of the mole. The animal makes 3—4 movements to the side, overcoming the given opposition, then there is a pause of a few seconds and a repetition of the 3—4 movements.

As will be seen from the results given above, the females, which are lighter in weight and smaller in size than the males, are on the whole weaker than the males. This is also apparent under field conditions. When more experience is obtained in catching the animals, it is possible to determine, with a large degree of probability, by the force with which the earth is ejected, whether the mole in question is a male or a female. (The males push out the earth considerably more strongly). In addition the thickness of the column of earth protruding from the molehill makes it possible to form an idea as to whether a male or a female is at work. The males often push up a column of earth of 6—7 cm, whereas the females usually do not push up more than 4 cm. An exception to the above is the period when the young moles are becoming self-sufficient.

Dieparma (1951) states in his work that A. N. Triebieliev carried out investigations on the subterranean activities of moles by means of X-rays. As a result he reached the conclusion that when the mole digs tunnels, the greater part of the excavated soil is pressed into the walls of the tunnel. Confirmation of this view is to be found, in the opinion of the author, in the hardness of the walls of the mole's tunnels and in the lack of correspondence between the amount of earth ejected and the length of the tunnel. On the basis of my own observations I may add that this does in fact take place, but only in very soft loose soils. When the mole is introduced into an artificial tunnel, filled with not too strongly compacted earth, the mole will in fact press forwards through the soil, using both sideways-pushing and digging movements. In hard soils the moles eject the whole of the excavated earth on to the surface. The number of molehills is therefore far greater in such ground than in are-

¹⁾ No. 163 increased in weight by 29 g within one month.

as where the soil is soft and loose. The hardness of the walls of the mole's tunnels is accounted for by the fact that during frequent use of the tunnel, the moles tread the earth down and wear the walls of the tunnel smooth in the same way as mice wear beaten tracks on the surface of the ground.

IV. RESULTS

On the basis of observations of moles kept under artificial living conditions, and also of field observations carried out on the tunnel-digging activities of the mole, it should be stated that the treatment of this question has not hitherto been in accordance with actual facts. The mole never uses its snout to dig tunnels. This organ is essentially an instrument of touch and smell, and under no circumstances can it serve as an instrument taking part in breaking up the soil. Whenever there is a risk of injury to the snout, the mole protects it carefully. When tunnels are being dug the snout is always turned in the direction of the paw which is not employed in digging. The term „rooting” suggesting the view cited above, is incorrect as referring to the subterranean activities of the mole.

Digging of both deep and surface tunnels is carried out using the front paws only. The surface tunnels are formed during the digging and outwards-pushing movements of the fore paws. There is no question of transport of earth here. The body of the mole plays an important part in shaping surface tunnels. Deep tunnels (at a depth of from 5 to over 50 cm below the surface of the ground) are excavated by the mole, using its fore paws for digging, and throwing the excavated earth backwards in a sideways-ventral direction. This earth, as it collects under the belly, is pushed well away by kicking movements of the hind legs. When the earth, as it collects in the rear of the animal, presses lightly on its hindquarters, the animal turns round in the tunnel, collects up the earth and begins to push it away. This is also done by the fore paws, placing first one and then the other paw diagonally to the line of the body. The earth is removed to the surface and ejected in the form of molehills. The mole never uses either its snout or its head to push out the earth from the tunnel (as has hitherto been presumed), but does this entirely with its fore paws. Use of the head to push out earth from the molehills would involve adaptation of the entire bone structure of the animal, and also of the skin and fur on the head. Digging and

ejection of earth demand great strength on the part of the mole. Laboratory investigations showed that in pushing out earth from the tunnel the mole can cope with a weight 20 times in excess of the weight of its body, and the sideways pressing movements can overcome a weight reaching up to 24 times the weight of the mole's body.

Removal of the excavated earth from the tunnel is, among others, a factor of great significance in maintaining the access of air to the animal.

Acknowledgment. — This work was partially supported by Committee of Ecology of Polish Academy of Sciences.

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REFERENCES

1. Adams, L. E. — Contribution to our knowledge of the mole (*Talpa europaea* L.). Proc. Manch. Lit. Phil. Soc. Vol. 47, 1903.
2. Adams, L. E. — Observations on a captive mole. Proc. Manch. Lit. Phil. Soc., Vol. 50, 1906.
3. Adams, L. E. — Moles and molehills. Nature. Vol. 83, 1910.
4. Arlton, A. V. — An ecological study of the mole. J. Mammal. Vol. 17, 4. 1936.
5. Abielencev, V. I., Pidopličko, I. G. and Popov, B. M. — Fauna Ukraini. Vol. 1, Ssavci, 1. AN URSSR. Kiiiv, 1956.
6. Cuvier, J. — La range animal distribuè d'après son Organisation. Vol. 1. 1817.
7. Dieparma, H. K. — Krot. Zagotizdat. Moskva, 1951.
8. Doppelmaier, G. G. et al. — Biologija liesnych zvierej i ptic. Goslezumizdat. Moskva—Leningrad, 1951.
9. Folitarek, S. — Rosprostranienije, biologija i promysiel krot (*Talpa europaea brauneri* Sat.) na Ukrainie. Biull. Mosk. Obšč. Isp. Prir. Vol. 12, 1932.
10. Formozov, A. N. — Sputnik sledopyta. Mosk. Obšč. Isp. Prir. Moskva, 1952.
11. Godet, R. — Contribution a l'etologie de la taupe (*Talpa europaea* L.). Bull. Soc. Zool. France. Vol. 76, 1951.
12. Godfrey, G. — A field study of the activity of the mole (*Talpa europaea* L.) Ecology. Vol. 36, 4. 1955.

13. Grasse, P. P. — Traite de Zoologie. Vol. 17, 2. Masson. Paris, 1955.
14. Hamilton, W. J. — Activity of Brewer's Mole (*Parascalopus breweri*). J. Mammal. Vol. 20, 3. 1939.
15. Hisow, F. L. — Observations on the Burrowing Habits of Moles (*Scalopus aquaticus mahrinoides*). J. Mammal. Vol. 4, 2. 1923.
16. Hauchecorne, J. — Studien über die wirtschaftliche Bedeutung des Maulwurfs (*Talpa europaea* L.). Ztschr. Morph. Ökol. Tiere. Bd. 9. Berlin, 1927.
17. Kawecki, Z. — Badania nad kretem (*Talpa europaea* L.) w Polsce. I. Cel i znaczenie badań na tle dotychczasowych wiadomości oraz zestawienie odnośnego polskiego piśmiennictwa. Zesz. Nauk. Wyższej Szkoły Roln. w Krakowie, 3. Zootechnika 1. Kraków, 1957.
18. Kuziakín, A. P. — Materiały po biologii krola (*Talpa europaea* L.) tulkosko listviennovo liesa. Biull. Mosk. Obšč. Isp. Prir. Vol. 44, 5. 1935.
19. Markow, G. — Nasjekomojadnitie bosajnici w Bołgarija. Bułg. Akad. Nauk, Sofia, 1957.
20. Matthews, L. H. — British Mammals. Collins. London, 1952.
21. Ogniev, S. I. — Zvieri vostočnoj Evropy i sieviernoj Azii. Vol. 1. AN SSSR. Moskva, 1928.
22. Schaerffenberg, B. — Haltung und Pflege des Maulwurfs (*Talpa europaea* L.). Der Zoolog. Garten. Bd. 11, 1939.
23. Schaerffenberg, B. — Die Nahrung des Maulwurfs (*Talpa europaea* L.). Ztschr. angew. Entomol. Bd. 27, 1. 1940.
24. Serafiński, T. — Kret na ziemiach Polski. Spr. Kom. Fizjogr. PAU. Vol. 62. Kraków, 1928.
25. Skoczeń, S. — Badania nad kretem (*Talpa europaea* L.) w Polsce. II. Próba chowu krola w warunkach sztucznych. Zesz. Nauk. Wyższej Szkoły Roln. w Krakowie, 3. Zootechnika 1, 1957.
26. Stein, G. H. W. — Materialien zur Biologie des europäischen Maulwurfs. Bonn. Zool. Beitr. Bd. 1, 1950.

EXPLANATION OF PLATES (XX—XXIV)

- Figs. 1—2. Position of mole when digging surface tunnel.
- Figs. 3—5. Position of mole when digging deep tunnel.
- Figs. 6—7. Reversal of direction by mole in the tunnel.
- Fig. 8. Position of mole as it pushes out earth from the tunnel.
- Fig. 9. Ejection of earth on to the surface to form a molehill.
- Figs. 10—12. Defensive position of mole.
- Figs. 13—14. Columns of earth protruding above molehills.

STRESZCZENIE

Na podstawie obserwacji nad kretem trzymanym w warunkach sztucznych oraz obserwacji prowadzonych w terenie nad kopaniem chodników przez kreta, stwierdzić należy, że dotychczasowe ujmowanie tego zagadnienia było niezgodne z prawdą. Kret nigdy nie posługuje się w kopaniu chodników rykiem. Organ ten jest wybitnie narządem dotyku i węchu i w żadnym wypadku nie może służyć jako narząd biorący udział w spulchnianiu gleby. Wszędzie, gdzie ryjek mógłby ulec skaleczeniu kret chroni go bardzo starannie. Przy kopaniu chodników ryjek zawsze ulega odchyleniu w kierunku łapy nie kopiącej. Termin „rycie” sugerujący wyżej przytoczony sąd jest niewłaściwy w odniesieniu do podziemnej działalności kreta.

Kopanie chodników tak powierzchniowych jak i głębokich, odbywa się tylko przy użyciu łap przednich. Chodniki powierzchniowe powstają w trakcie działalności kopiąco-rozpychającej łap przednich. Transport ziemi nie wchodzi tu w rachubę. W formowaniu chodnika powierzchniowego ważną rolę odgrywa ciało kreta. Chodniki głębokie (od 5 do ponad 50 cm poniżej powierzchni terenu), kret kopie przednimi łapami, odrzucając ziemię do tyłu w kierunku boczno-brzusznym. Nakopana ziemia spod brzucha odrzucana jest odkopującymi ruchami odnóży tylnych poza zwierzę. Gdy zbierająca się za zwierzęciem ziemia naciska lekko na tył jego ciała, kret odwraca się w chodniku zgarnia ją i zaczyna wypychać. Czyni to również przednimi łapami nastawiając to jedną to drugą łapę skośnie do linii ciała. Ziemia usuwana jest na powierzchnię i sypana w formie kretówek. Do wypychania ziemi z chodników kret nigdy nie posługuje się ani rykiem ani głową (jak dotąd przypuszczano), lecz czyni to wyłącznie przednimi odnóżami. Wypychanie ziemi z kretówek głową pociągałoby za sobą przystosowania w całym kościec zwierzęcia oraz w skórze i uwłosieniu głowy. Kopanie i wypychanie ziemi wymaga od kreta dużego nakładu siły. Badania laboratoryjne wykazały, że przy wypychaniu ziemi z chodnika kret może pokonać ciężar przewyższający 20-krotnie wagę jego ciała a w wyciskaniu w bok (ruchy kopiące), zwierzę może pokonać ciężar dochodzący do 24-krotnej wagi ciała zwierzęcia.

Usuwanie nakopanej ziemi z chodnika ma między innymi ważne znaczenie dla właściwego dopływu powietrza do chodnika.

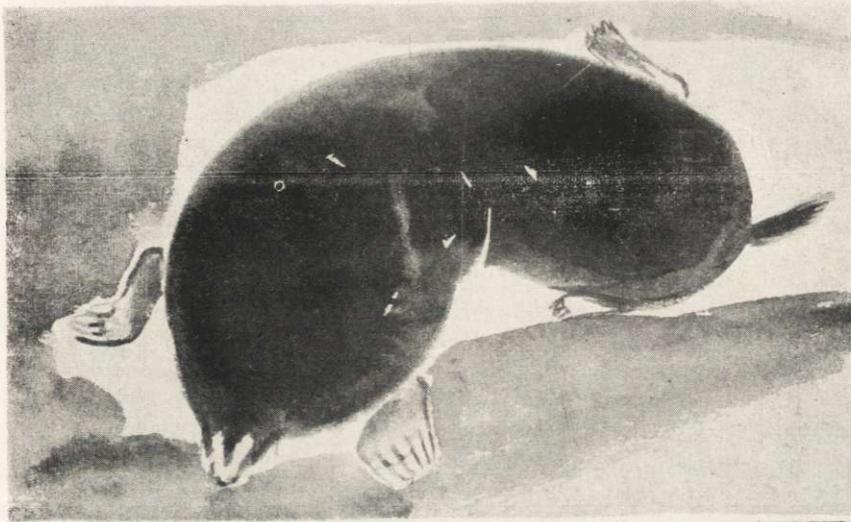


Fig. 1.

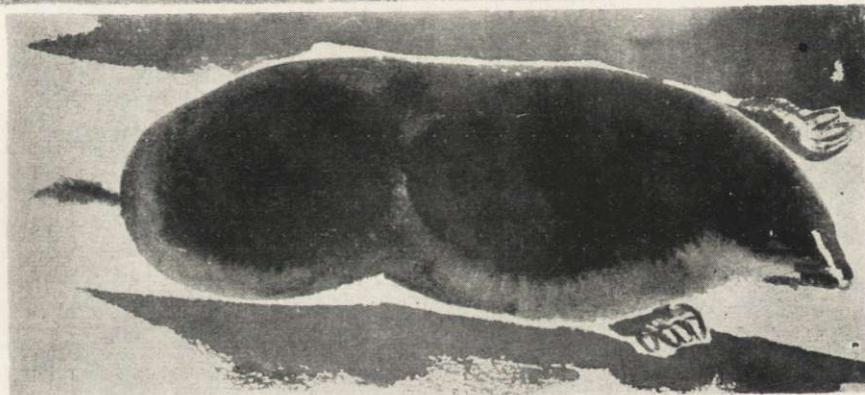


Fig. 2.

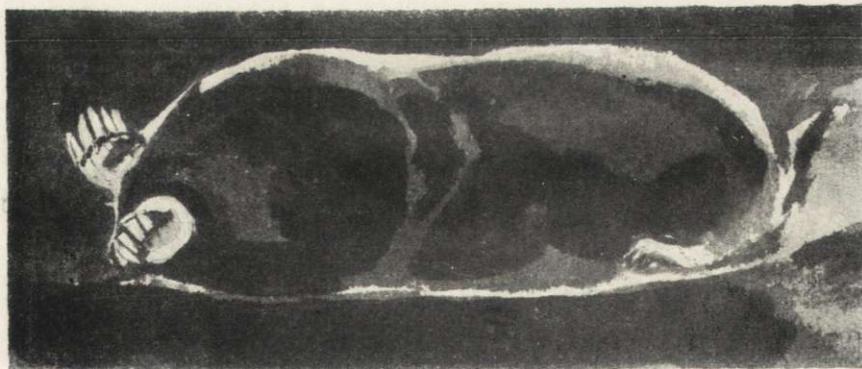


Fig. 3.

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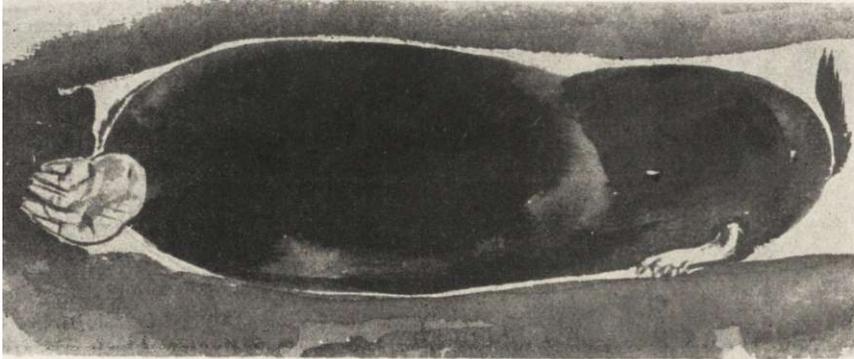


Fig. 4.

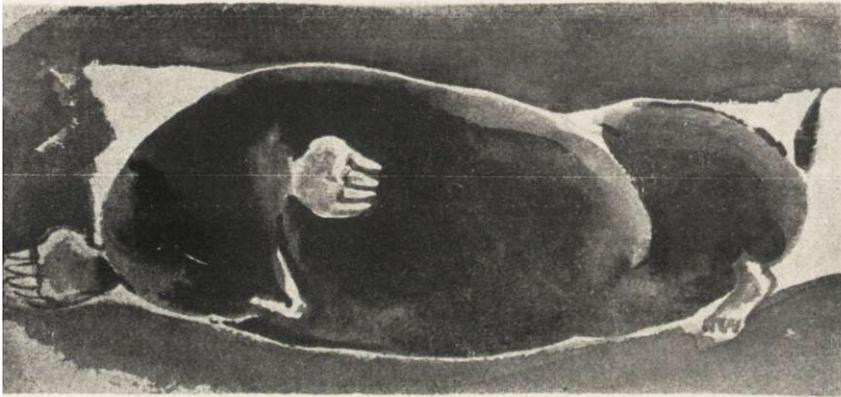


Fig. 5.

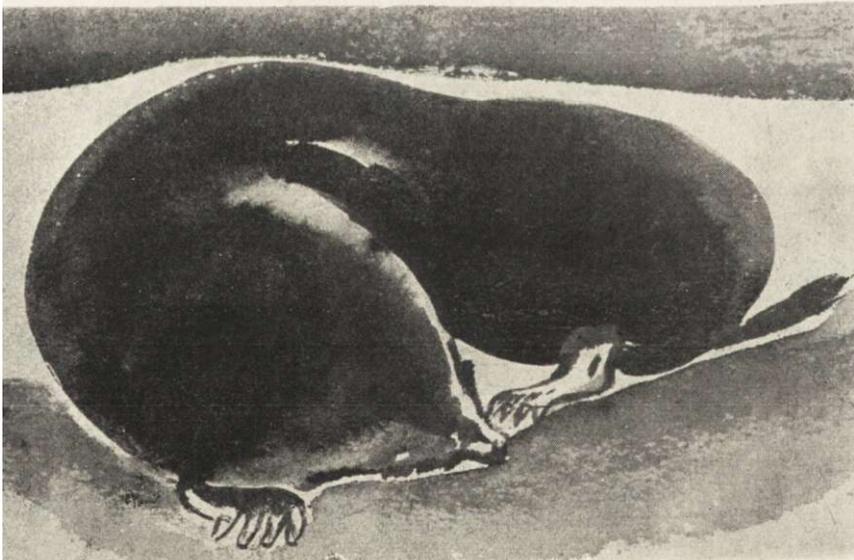


Fig. 6.

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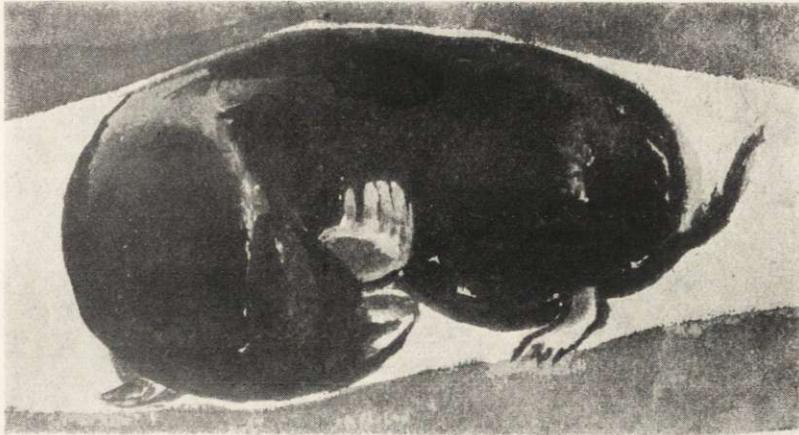


Fig. 8

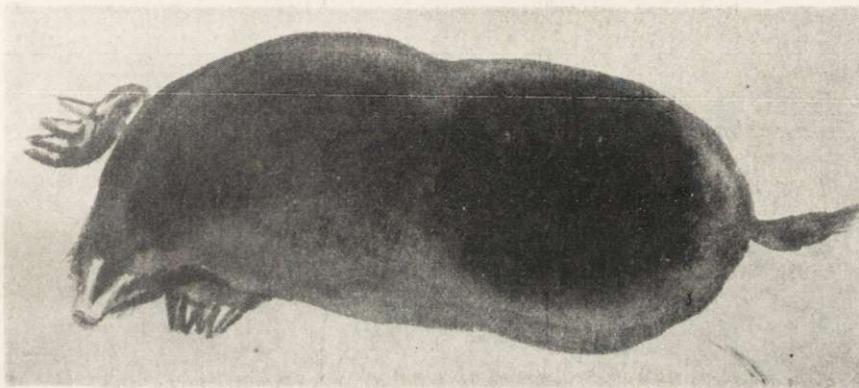


Fig. 9

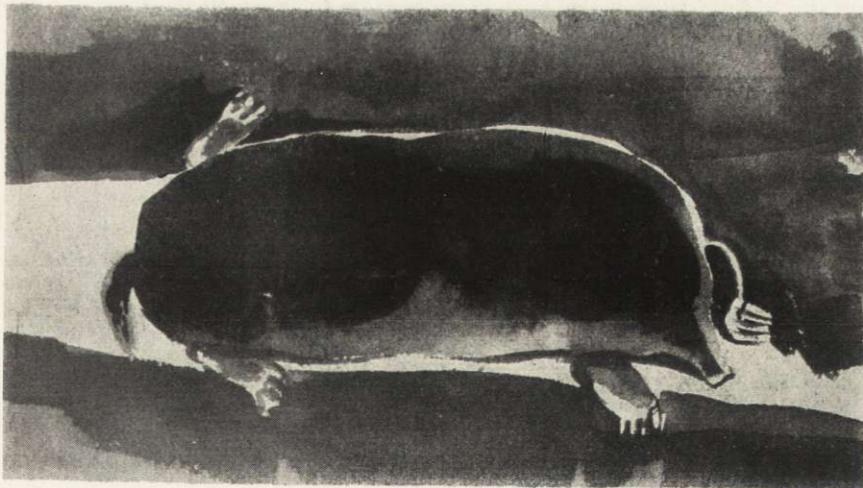


Fig. 10

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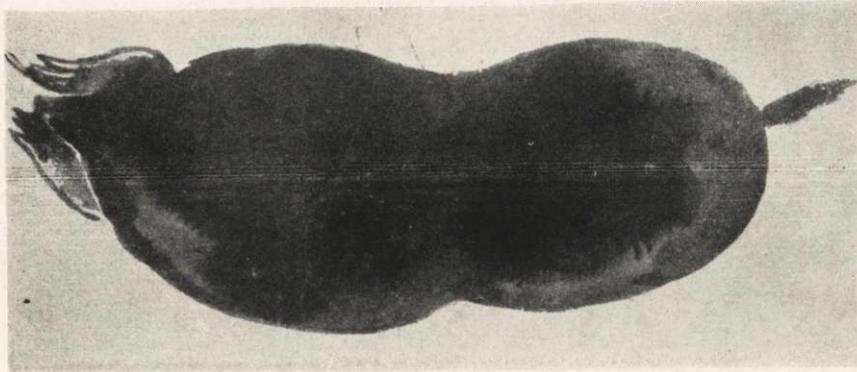


Fig. 10.

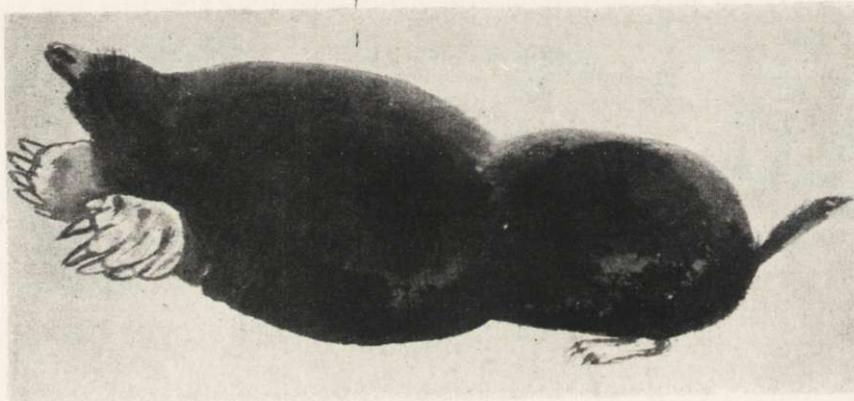


Fig. 11.

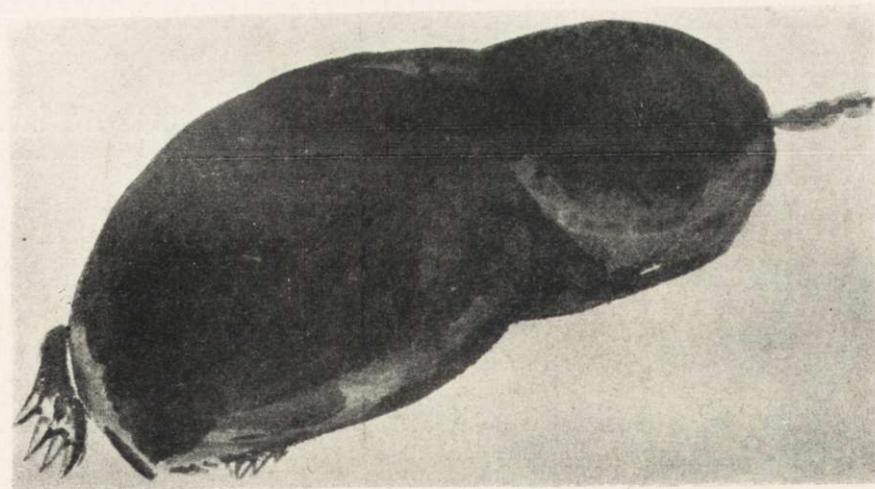


Fig. 12.

Stanisław Skoczeń

Painted by J. Świecimski



Fig. 13.

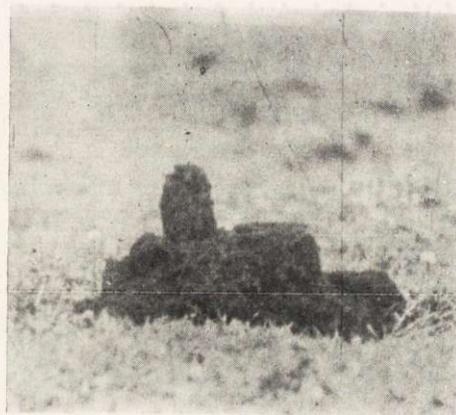


Fig. 14.

BIBLIOTEKA
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