POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGICZNY, ODDZIAŁ W KRAKOWIE

ACTA ZOOLOGICA CRACOVIENSIA

Tom V Kraków, 15 II 1960 Nr 1

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# Studia nad kretem, *Talpa europaea europaea* L. (*Insectivora*) w Tatrach Polskich

# Исследования над кротом *Talpa europaea europaea* L. (*Insectivora*) в польских Татрах

# Studies on the mole, *Talpa europaea europaea* L. (*Insectivora*) in the Polish Tatra Mts.

(With plates I—VII and 14 figures in text)

## INTRODUCTION

The present work was made to analyse the skull material originating from the Polish part of the Tatra Mts. The material was compared with the Slowak specimens determined by Hanzak & Rosicky (1949) as *Talpa europaea coeca* Savi and with the lowland population of *Talpa europaea europaea* L. from the region of Kraków. Besides the generally made skull measurements also specially conventionalised tooth measurements were made; moreover, a quantity of non-measurable morphological characters were taken into consideration, till now regularly disregarded by most authors. The systematical investigations were complemented by ecological observations.

The moles were caught in the Tatra Mts. by digging live specimens out of the surface channels or mole-hills, during periods of activity. The method of placing cylinder traps (used with success near Kraków) gave no results in the mountains; the soil conditions caused difficulties (numerous stones), and the animals were more watchful. All the traps were either filled with earth or avoided by an additional channel. The only means of catching moles, possible to use in the mountains, was a tedious watch for whole hours over the feeding-places in wait for movements of the soil. The smallest movement, a conversation, or the appearance of a herd of sheep spoilt the day's work, as the moles immediately interrupted their activity. The best results were attained in rainy days as the activity of the moles is strengthened, also on sunny days at dawn or in the early morning hours. The comparatively insignificant result of catching 22 specimens in two seasons must be ascribed to the specially difficult field conditions. Except two specimens caught accidentally into rodent traps (leg. K. Kowalski and J. Sagan) all the remaining material was acquired by the method of „waiting for a definite animal". This arduous task was performed by two scientific workers from the Department of Zoology, College of Agriculture in Kraków, Mr. St. Skoczeń and Mr. Skrzeszowski, as well as a local farmer, J. Sobczyk from Kościelisko.

I wish to express my deepest gratitude to all persons who were so kind to supply the specimens to me, that is, except the persons already named, Prof. Z. Kawecki and Prof. W. Skuratowicz; thanks to their kindness the investigations on the Tatra mole could be performed at all. I wish also to thank heartily Dr. J. Hanzak from the National Museum in Prague for making available the skull material from the Slovak Tatra Mts.

## THE ENVIRONMENT

It is not simple to ascertain the presence of the mole, as this animal not always and not everywhere shows its activity on the surface of the soil. Traces of feeding and nests which may be seen as mounds and surface channels are only a part of the whole system which is usually much larger. Moreover, the work of the mole may remain completely hidden for months and appear in a certain season, e. g. in autumn or in early spring. Places seemingly empty may unexpectedly appear inhabited. This phenomenon is well-known to mole-hunters, althought not often quoted in the literature (FOLITAREK, 1932). Because of this, when ascertaining the range of appearance of the mole, a single examination of the area may in no case be relied on; the suspected area should by inspected several times, in different seasons, and, if possible, by several independent methods. In the Tatra Mts., where the owner rights of the meadows, pastures and arable fields cause exceptional difficulties, a digging through of the ground is usually impossible. The field survey could therefore be based only on two methods, i. e. on a surface examination made in various seasons (winter excepted), and by sounding the channels with smoke-forming substances. This universally known method allows to find connecting channels between sometimes very distant feeding-grounds, without disturbing the surface. The mixture used for there investigations was composed of finely grind potassium permanganate and sulphur. Placed in paper tubes, lighted, and pushed into a channel inlet (e. g. in a molehill or in a wayside ditch) it smoulders for a long time and forms enormous amounts of heavy yellowish smoke, crawling along the channels. The smoke coming out of other molehills shows the existence of free, unobliterated connecting channels.

The mole in the Tatra Mts. is chiefly an inhabitant of the arable fields and meadows as well as higher lying pastures. It appears in forests only rarely and sporadically. The forest living places observed in the Smreczyński Forest (near Smreczyński Lake) in the environs of pasture named Hala Ornak, in Kondratowa Valley, on the sloped of Mt. Żar, and in Tomanowa Valley — were all placed not further away than 100 metres from the free space. The most scrupulous examination of forest (Regle) eastward of Kościeliska Valley showed the lack of all traces of moles, even of their feeding. On mountain pastures the moles go as far as the rocky areas. The highest living-place noted in the Western Tatra Mts. lies at an altitude of 1400 metres above see-level on the slopes of Mt. Kominiarski Wierch, and about 1600 metres near Mt. Kopa Magury. In the highest part of the Tatra Mts. the mole does not usually go outside the meadows, where some loose soil still remains between stones, and by the same earthworms or insects used as food may be found.

The upper limit of appearance of the mole oscillates with the exposition of the mountain slope. This is why e. g. the highest localities with the mole on the frontier range of the Western Tatra Mts. (near Tomanowa Pass about 1300 m., on pasture Hala Pyszna 1300 m., on Mt. Smreczyński about 1300 m.) are comparatively lower than on the other peaks surrounding Kościeliska Valley (pasture Hala Stoły 1400 metres, near Wolarnia 1400 m., on the southern slopes of Mt. Żar about 1350 m.). These differences could appear thanks to the severer climatic conditions of the northern slopes (lesser insolation). These slopes are the first to be covered by snow and the last to lose it.

In the Tatra Mts. the following factors chiefly influence the distribution and biology of the mole: 1) the degree of wetness of the ground, 2) the stoniness of the soil, 3) the snow cover, 4) the woodiness of the area. Another factor probably acts with the four already named, i. e. human dwellings and grazing by herds (manuring).

1. Degree of wetness of the ground.

The wetness of the ground is a potent factor; its effect on the biology of the mole has been observed and discussed by numerous scientists; however, this was done only for lowland environments.

In the Tatra Mts., as well as in any mountain area of Central Europe, a peculiar situation exists. In early spring, in valleys and on mountain slopes, after the snow has melted and an abundant vegetation has appeared, the meadows and alpine pastures are surrounded by broad streams coming from the neighbouring, wooded heights. Where the slope goes into a plane or forms hollows, there appear shallow, local floodings. This state lasts as long as the snow remains in the forests, because the snow is the chief source of water. About the end of May the alpine meadows and pastures are already quite dry and become saturated with water only during the rains.

The period of snow-melting and the spring floodings coincides with the period where an independent activity of the moles of the young generation begins. Traces of feeding of young individuals may be observed on flooded meadows in the form of surface channels of characteristic design (so-called „hieroglyphic" channels). These channels run across small streams and do not avoid even flooded places. Numerous mounds of earth thrown out on the slopes of wayside ditsches form the outlets of deeper channels; these outlets are placed directly above the water-table. The soil in which these channels are made is so quaggy that a man walking on it often sinks ankle-deep.

It is universally known, definitely recognized, and discussed many times by numerous authors that the mole is associated with water. There exists, however, another problem which — it seems — is not definitely solved. This is the problem of the adaptability of the mole to the disadvantegeous field conditions originated during periods of flooding. The problem may by simplified in form of the question: does the mole leave the flooded ground or does it remain on it? In a more detailed aspect there are questions on either the reasons and the „mechanics" of migration, or the means of local adaptation to the difficult flood conditions.

My observations on the feeding-places of the mole in the Tatra Mts. in the spring period (April, beginning of May) are incompatible with the data of other authors, e. g. KUZIAKIN (1935), OGNEV (1928), and also partly GODET (1951). Namely, I did not observe a migration of the mole during a flood to higher positions, as the surface channels and molehills in the flooded parts were completely fresh (not older than two or at most three hours, when observed). However, the migration of the mole in mountain areas is not a necessity as it is for the lowland moles in some conditions. I suppose that the existence of the moles in the Tatra Mts. is possible during the most difficult periods thanks to the fact that the streams from the melting snow, if not running in regular beds, run down the slopes by ways new once in a while; therefore the whole area is never completely flooded, only some part of it actually is. Moreover, some purely physical factors of the environment (soil) may act advantageously, i. e. the soil surrounding the surface channel acts as a sponge or a system of capillary vessels which does not allow water to stand inside the channel. The surface channels have walls made of loose earth and cannot hold water. Of course, in cases of complete soil flooding, e. g. in hollows, this effect must be insufficient. However, the surface channels function, i. e. are open, in normal conditions of spring watering of mountain slopes. In permanent communication channels, possessing walls beaten as well as smoothed by fur, there must be surface tention causing the wall to remain moist; however, the water does not run from it to channel inside. The same principle allows the functioning of channels dug under river bottoms, as described by Godet (1951).

The mole in the Tatra Mts. by no means leaves the surface soil layers during snow-melting periods, as some authors suppose they do in lowland conditions, e. g. Ognev (1928). The mole in the Tatra Mts. digs channels of both types, and in some cases exclusively surface channels. The reason of building shallow systems during a flood period may be explained by the shallowness of the soil in mountain areas, soil with underlying rock or by a layer of slope débris. This rock lying under the soil is also important in places where the soil is deeper, e. g. in valley bottoms on meadows or pastures at the foot of hills. The rock impedes the infiltration of water; because of this the shallow soil horizons may be even less watered than the deeper ones, lying directly on the rock.

Another problem connected with the distribution of water in an area is the question of streams as obstacles in the extension of mole colonies in this area. The proof that even large streams, e. g. the Kościeliska stream, are no obstacle for the mole to occupy an area, may be given by living-places on small grassy plots closed from one side by a vertical rock and cut off on the other side by the current of the stream. Although the mountain streams are no barrage for the mole in an absolute sense, they still are a rather serious obstacle rendering an expansion into mountains difficult.

The lack of water is one of the factors which render life impossible for moles. There are mostly no traces of feeding on open pastures, eaten off by sheep. Again, the feeding-places appear on forest borders or among larger boulders, in the shrubs of dwarf pine, where the shadow makes excessive soil drying difficult. Meadows covered by high grass are densely colonised as a rule. There is a characteristic observation to be made on arable fields growing oats. Directly after the harvest nearly all the molehills show exit holes, and after some time every activity of the moles in these areas disappears: the hills fall in, no new constructions are built. Most probably we have to do with local migrations of an area suddenly gone dry.

2. Stoniness of the soil.

The large amount of stones in the soil seems to have no effect on mole colonisation. In the region of pasture Hala Smytnia I observed permanent channels dug to a depth of about 60 centimetres in a soil so stony that the placement of cylinder traps caused grave difficulties.

Colonising an area with a stony soil, the mole digs its channels taking advantage of natural intervals between the stones and adapts in part the plan of its constructions to the local conditions. Even in such areas where the amount of loose soil is insignificant, as a. g. on pasture Hala Gąsienicowa, the mole possesses its nests and feeding areas.

The distribution of feeding-places — as far as may be seen on the surface — shows a strong effect of the soil depth on the mole colonisation. This phenomenon appears especially distinctly on pasture Hala Kondratowa. On the southern end of this pasture lie areas of grassland with very shallow soil. This part of the pasture is completely devoid of feeding-places. The feeding-places, and also the nests, so it seems, are gathered on the northern end of the pasture, in a longish deepening of the relief, where the soil is comparatively deep.

As based on numerous informations of most authors, it may be supposed that a variation in the density of colonisation of areas with unequal soil depth can be an indirect effect of differences in the quantity of food contained in the soil layer.

3. The snow cover.

The effect of the snow on the mole in Tatra Mts. was investigated only occasionally in spring and autumn. In spring, when the young generation begins independent feeding (this take place in the end of April and in the beginning of May), on alpine pastures placed higher and on forest borders, characteristic systems of so-called „hieroglyphic" channels strike the investigator's attention; these channels are mostly built in snow. I did not observe at the same time that the melting of snow should cause the recession of the moles from this area A too long-lived cover is not advantageous for the mole, although the latter is active over the winter; this effect of the snow cover is shown by differences in the altitude distribution of the mole on the northern and southern slopes of the mountains.

4. Woodiness of the area.

A coniferous forest form an environment distinctly avoided by the mole. The feeding-places of moles are never found inside woods. Colonisation of moles in a forest happens in the Tatra Mts. only in two cases, namely: either the forest is rather thin and possesses undergrowth (i. e. the ground is not uniformly covered by dead litter) or on forest borders.

However, I may assert that the mountain forest, although not advantageous as a place for colonisation by the mole, does not form a barrier for the expansion of this species. There are many glades in the Western Tatra Mts., surrounded by dense forests without undergrowth, nevertheless mole colonies appear there (e. g. pastures: Hala Stoły, Hala Przysłop Kominiarski, Hala pod Kominami etc.). I could ascertain that the mole was able to overcome a forest barier about 600 metres wide.

5. Dwellings and grazing.

It is a characteristic phenomenon, especially on alpine pastures, that the mole colonies concentrate near buildings. This is a rule, but strikes most distinctly on large pastures, where other reasons of a denser colonisation are excluded (e. g. the proximity of a forest, of water, accumulation of stones, etc.). I observed very characteristic concentrations of molehills on Kalatówki pasture near buildings and enclosures for sheep. The fact is especially striking, as the usual channels are placed at greater distances from enclosures und huts, again, in the direct neighbourhood of the latter, molehills of a distinct nest type are found. I suppose that this may by caused by a manuring of the soil, followed by a concentration of large amount of soil fauna.

## THE FOOD

The material I could collect to study the composition of the mole's food was comparatively very scarce (10 stomachs) and came from specimens caught in two living-places in the Western Tatra Mts.: pasture Hala Smytnia and the slopes of Mt. Żar (about 1200 metres altitude). The feeding-places were placed on an open grassy area in proximity of a spruce forest.

The stomachs meant for investigation were taken out of the bodies directly after killing the animal, tied together, and conserved in 75⁰/₀ alcohol.

The chief mass of food in examined specimens was composed of *Lumbricidae*. Other animal remains were found, moreover, in every stomach, but in a much lesser quantity. There were *Coleoptera* of the genus *Pterostichus* BONELLI *(Carabidae)* and *Aphodius* ILLIGER *(Scarabeidae)*, as well as *Myriapoda*, *Gastropoda* and *Acarina* not determined nearer. One specimen of a worm (order *Nematoda*) was certainly a representant of the parasital stomach fauna. No traces of vertebrate animals or larvae of *Coleoptera* were found. The food also showed a complete lack of remains of plant origin.

A comparison with the data given by other authors — even based on so scarce a material — allows to say that the composition of the food in the Tatric alpine pastures is comparatively very poor and monotonous. Especially the lack of elements so important in other regions, as larvae of *Elateridae* and *Melolonthidae*, must be explained by the scarcity of the pasture fauna.

## THE ACTIVITY

I attempted to determine the activity pattern of the mole in the field by observing the movements of the soil as seen on its surface. The movements of the soil appeared regularly three times a day: at dawn and in the early morning (more or less between 4 and 6 o'clock), about noon between 11 and 12 o'clock, and in the evening about 18 o'clock. Sometimes there happened extra short periods of activity between 13 and 14 o'clock. The time of appearance of the soil movements varied in length, but never exceeded half an hour; most often it lasted about 10 minutes. The slightest disturbance, e. g. some careless step, a conversation, or a flock of sheep going by interrupted the mole's work at once. The shyness of these animals in the Tatra Mts. was quite extraordinary, as compared to the moles in the environs of Kraków, „used" to noise.

On rainy days the activity near the surface increased; this can be explained by a migration of the earthworms to shallower layers of the soil. Changes in the configuration of the molehills observed in the morning as compared to that in the evening testify a night activity of the mole in the Tatra Mts.

## THE MORPHOLOGY

Methods of measurement.

I measured the length of the moles' body with a stiff rule, from the end of the snout to the base of the tail, by stretching the animal on its back on the rule underneath its body. I measured the length of the tail in two ways: with a rule by resting it against the base of the tail (the brush on the end of the tail was not measured), or else by a method invented by Mr. St. SKOCZEŃ, i. e. by a glass tube enclosing the tail. All the measurements of moles were made in the „cold" state, which needs stressing as a dead mole quickly contracts.

The skull measurements were made according to the general accepted conventions. The condylobasal length (Cb) was measured by a sliding rule with a nonius micrometer. The skull was caught lightly between the sliders of the instrument, so that one claw of the measure touched the intermaxillary bone directly over the incisives, and the second leaned on the posterior part of any of the two occipital condyli. Sometimes — when measuring a skull with a split basis or upper jaw — I made the measurements before boiling the skull, as it invariably fell to pieces afterwards. In these cases I took the head out of the condylic joints, denuded the rostrum of the soft parts and the periosteum, and executed the measurement of Cb as usual. In later practice, especially using large series of camparative material, I always made such measurement, as the seemingly unimpaired skulls fell to pieces when boiled, thanks to invisible cracks. The measurements made before boiling, controlled on the whole skulls, were always as accurate as those made on the boiled skulls. Of course the condition for this was a good cleaning of the bone. Thanks to the use of this method I could save many measurements, which would be lost irreparably as a large proportion of specimens caught were damaged. The width of the skull was measured by applying the sliders of the instrument to the protruding corners of the skull where the temporal and the occipital bones touch together and form a sort of crista (textfig. 1).

The measuring of teeth is somewhat more complicated. The necessity of forming some rules in this respect was made necessary by the fact, that numerous authors working on the systematics of the mole nearly always used the method of verbal definitions, often very ambiguous and — it may by guesses — based only on optical impressions. The teeth are placed in the jaw of the mole in such a way that it is possible to define the relative ratios of their heights in several different ways. These ways are difficult to identify and to compare between them in printed papers without methodological discussion, as their differences are sometimes hidden under the same expression. This is by no means a difference in writing technique only, a different numerical value or a different definitional sense correspond to each of the ways of estimation. Moreover, the descriptions of teeth are as a rule devoid of numerical expressions. A quotation from Blasius (1857) may be given as an example (p. 115): „Von den drei einspitzigen Lückenzähnen im Oberkiefer ist der zweite der niedrigste und der

Table I

*Talpa europaea europaea* L.

(measurements

| No | locality | date | collected by | sex and age | head and body | tail |
|---|---|---|---|---|---|---|
| 1 | Hala Smytnia | 20. VIII. 1956 | J. Sobczyk | ♀ juv. | 155 | — |
| 2 | Hala Smytnia | 18. VIII. 1956 | J. Sobczyk | ♀ ad. | 140 | 24 |
| 3 | Hala Smytnia | 8. VI. 1956 | J. Sobczyk | ♀ sen. | — | — |
| 4 | Hala Smytnia | 18. VIII. 1956 | J. Sobczyk | ♀ ad. | 143 | 22 |
| 5 | Hala Smytnia | 9. VI. 1956 | J. Sobczyk | ♀ sen. | 155 | — |
| 6 | Hala Smytnia | 18. VIII. 1956 | J. Sobczyk | ♂ ad. | — | 26 |
| 7 | Hala Smytnia | 16. VIII. 1956 | J. Sobczyk | ♂ juv. | 147 | 30 |
| 8 | Kominy Tyłkowe | 31. VIII. 1956 | J. Sobczyk | ♂ juv. | 137 | — |
| 9 | Żar (north side) | 22. VIII. 1956 | J. Sobczyk | ♂ juv. | 155 | 28 |
| 10 | Żar (north side) | 5. IX. 1956 | J. Sobczyk | ♂ ad. | — | — |
| 11 | Hala Smytnia | 16. VIII. 1956 | J. Sobczyk | ♂ ad. | 155 | 28 |
| 12 | Hala Smytnia | 7. VI. 1956 | S. Skoczeń | ♂ ad. | 170 | — |
| 13 | Hala Smytnia | 7. VI. 1956 | S. Skoczeń | ♂ ad. | — | — |
| 14 | Kominy Tyłkowe | 6. IX. 1956 | J. Sobczyk | ♂ ad. | 150 | 26 |
| 15 | Hala Smytnia | 20. VII. 1956 | J. Sobczyk | ♂ sen. | 160 | — |
| 16 | Hala Smytnia | VIII. 1956 | J. Sobczyk | ♂ (?) | — | 26 |
| 17 | Hala Smytnia | VIII. 1956 | J. Sobczyk | ? | — | 26 |
| 18 | Zakopane | 20. VIII. 1955 | J. Świecimski | ♂ juv. | — | — |
| 19 | Hala Gąsienicowa | 30. VIII. 1955 | K. Kowalski | ♂ ad. | 124 | — |
| 20 | Hala Ornak | 21. VIII. 1954 | K. Kowalski | ♂ | 112 | 34 |
| 21 | Hala Gąsienicowa | — | J. Sagan | ♂ (?) | — | 26 |
| 22 | Zakopane-Tatry | 22. VIII. 1955 | S. Skoczeń | ♀ | — | — |

from the Polish Tatra Mts.

in mm)

| condylo-basal length | width of the skull | width of rostrum | Width of the incisives | | | Height of premolars (right side) | | | Height of premolars (left side) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 34,2 | 15,4 | 4,2 | 0,8 | 0,6 | 0,5 | 1,1 | 1,0 | 1,1 | 1,0 | 0,9 | 1,0 |
| 31,3 | 15,6 | 4,1 | 0,7 | 0,6 | 0,6 | 1,1 | 1,0 | 1,0 | — | 0,9 | 0,9 |
| 32,2 | — | 4,1 | 0,7 | 0,7 | 0,5 | 0,9 | 0,9 | 0,8 | 0,9 | 0,8 | 0,9 |
| 31,4 | 15,0 | 4,0 | 0,7 | 0,6 | 0,6 | 1,0 | 0,9 | 0,9 | 1,0 | 0,8 | 0,8 |
| 31,8 | 15,4 | 4,4 | 0,7 | 0,6 | 0,6 | 0,9 | 0,6 | 0,6 | 0,8 | 0,7 | 0,7 |
| — | — | 4,0 | 0,7 | 0,6 | 0,5 | 0,9 | 0,7 | 0,7 | — | 0,6 | 0,6 |
| 32,2 | 15,7 | 4,2 | 0,8 | 0,6 | 0,5 | 1,1 | 1,0 | 1,1 | 1,1 | 1,0 | 1,0 |
| 33,7 | 15,7 | 4,4 | 0,8 | 0,6 | 0,6 | 1,1 | 1,0 | 1,1 | 1,1 | 1,0 | 1,0 |
| 34,0 | 15,6 | 4,3 | 0,8 | 0,6 | 0,5 | 1,0 | 0,9 | 1,0 | 1,0 | 0,9 | 1,0 |
| 33,1 | 16,2 | 4,4 | 0,7 | 0,5 | 0,3 | 0,9 | 0,8 | 0,8 | 0,9 | 0,8 | 0,8 |
| 34,0 | 15,7 | 4,1 | 0,7 | 0,6 | 0,5 | 1,0 | 0,9 | 0,9 | 1,0 | 0,8 | 0,8 |
| 34,3 | 16,5 | 4,4 | 0,8 | 0,6 | 0,5 | 1,1 | 0,8 | 0,8 | 1,1 | 0,8 | 0,8 |
| 34,1 | 15,9 | 4,6 | 0,7 | 0,6 | 0,6 | 1,2 | 0,8 | 0,8 | 1 0 | 0,8 | 0,8 |
| 33,1 | 15,7 | 4,3 | 0,8 | 0,6 | 0,5 | 1,0 | 0,9 | 0,9 | 1,0 | 0 9 | 1,0 |
| 34,2 | 15,9 | 4,7 | 0,6 | 0,5 | 0,4 | 1,0 | 1,0 | 1,0 | 1,1 | 0,7 | 0,8 |
| 33,9 | 15,5 | 4,4 | 0,7 | — | — | 1,1 | 0,7 | 0,6 | 1,0 | — | — |
| 32,6 | 15,4 | 4,2 | — | 0,6 | 0,6 | 1,1 | — | — | 1,0 | 0,8 | — |
| 33,5 | 16,2 | 4,4 | 0,8 | 0,7 | 0,5 | 1,1 | 0,9 | 1,1 | 1,1 | 0,9 | 1,0 |
| 33,9 | — | 4,6 | 0,7 | 0,6 | 0,5 | 0,9 | 1,0 | 1,0 | 1,0 | 0,8 | 0,9 |
| 31,7 | 13,7 | 4,0 | — | 0,5 | 0,5 | 1,0 | 0,7 | 0,9 | 0,9 | 0,7 | 0,8 |
| 31,4 | 16,1 | 4,0 | 0,8 | 0,6 | 0,5 | 1,0 | 0,7 | 0,8 | — | — | — |
| 31,9 | 15,5 | 4,4 | — | — | — | 1,1 | — | — | — | — | — |

dritte der dickste und kaum merklich niedriger als der erste". This assertion gives no meaning to the words „higher-lower", as the author took no permanent plane or line with respect

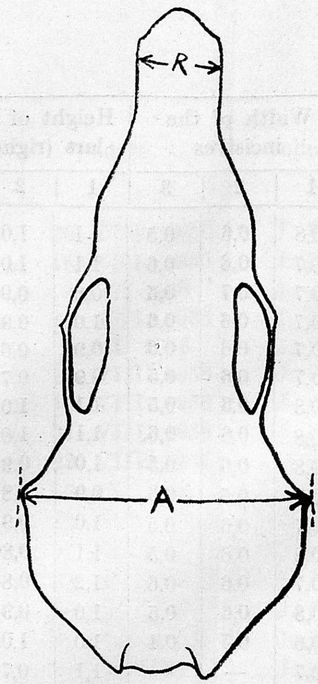


Fig. 1. Measurements on the skull of the mole: A — width of the skull, R — width of rostrum.

to which the heights of the teeth could be compared. The assumption of one common straight line would in no way facilitate the solution, as the teeth of the mole are distinctly set in different levels (Pl. I., fig. 2). Depending on the degree of curvature of the jaw especially the two hind unicuspid premolars $Pm^2$ and $Pm^3$ could be estimated as „equally" or „unequally high". In the case of an apparent inequality, an unequal level of the apices would not be the result of a difference of absolute tooth-heigh but of a different setting. The height of the teeth in the present paper is measured separately for each from the middle tubercle between the incisions on the margin of the alveole and the point of intersection of its projection on the horizontal straight line of the tooth apex (Pl. I, fig. 1). This convention is explained by a frequent wearing off of the alveoles in the anterior and posterior part to a different degree, the middle process beeing the most constant part. The tooth, while rubbed away, at the same time grows upwards. Old individuals have no tooth crowns at all and only the roots work as teeth. Nevertheless, the proportions of the teeth are conserved even then, when only the roots remain.

The technique of tooth measurements consisted in direct measuring, with a binocular provided with a scale or else by projecting the shadow of the teeth on paper with the aide of ABBE's apparatus and the measurement of the contour with an appropriate scale. I measured only the width in the incisive teeth, as only the former has systematical importance. The measurement was made on a vertical to the long axis of each tooth.

The measurement of the rostrum was made on scaled vertical projections (lateral profiles) and comprised the distance between the basis of the jaw (in the region of $Pm^1$) and the contour of the dorsal region of the rostrum, in its narrowest place.

The incisors.

The incisors, and especially their profile and comparative width proportions are often considered important for the systematics of the mole. In the moles from the Tatra Mts. the comparison of the contours of the anterior incisors (textfig. 2) shows that the commonest type of profile is the convex or the convex-broken type. The feebly arched type and the plane

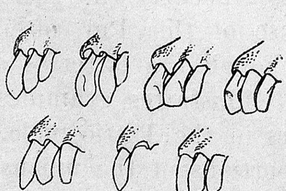

Fig. 2. Incisives of the moles: above from the Tatra Mts., below from the vicinity of Kraków.

type are found, it is true, but more rarely. The width proportions of the incisors are different. If we compare especially the lateral incisors of different specimens, we may observe that in one case thay are of the same width, in other cases $I^3$ is narrower than $I^2$. The anterior incisors may also be variously developed in width. The majority of specimens has wide anterior incisors and gradually narrower lateral incisors, but their proportions are different. The old individuals have different width proportions, because of the wearing off of the crowns and the coming out of the teeth from their alveoles.

The convex type of incisors rather well differentiates the moles from the Tatra Mts. from the lowland specimens; in the latter there is a domination of the plane type or the feebly arched type. As regards the width proportions the Tatric and lowland moles are rather similar.

The premolars.

In my work I paid attention to two characters of the premolars: the reciprocal height proportions and the morphological variability. Old specimens were also considered as the wearing off has no effect or only slight one on the form of these teeth.

In the Tatric moles the unicuspid premolars ($Pm^{1-3}$) are rather variable in height as well as in form. The variability pertains to the tooth profile on which additional tubercles can be found. They are placed on the anterior and posterior margin of the tooth edge. They may show different size and by the same influence the contour of the premolars. All the three unicuspid premolars of one individual can have similar shape, or the tooth profiles can be different. The strongest additional tubercles (especially the posterior one) are formed on $Pm^3$ and because of this $Pm^3$ often becomes somewhat similar to $Pm^4$, although the latter is already distinctly bicuspid. Textfigure 3 illustrates examples of the form of the first three premolars in the Tatric mole.

The height proportions of the unicuspid premolars in the Tatric mole form a rather uniform image: $Pm^1$ is the longest, $Pm^2$ the shortest or else equal to $Pm^3$. A very important feature characterising the Tatric moles is the mode of disposition of the first three premolars in the jaw, strictly speaking the intervals between the group $Pm^{1-3}$ and the canine on the one side and $Pm^4$ on the other. The differences occuring here are very

Fig. 3. Morphology of the premolars in the Tatric mole.

strictly related to the proportions of the whole skull, and especially with the length of the rostrum.

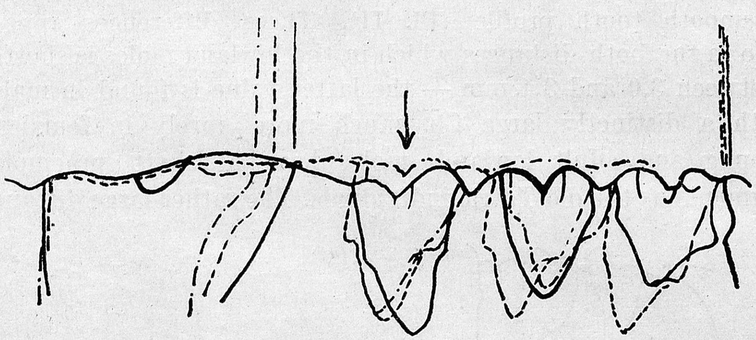

Fig. 4. The position of premolars in relation to the posterior margin of the canine in three individuals of different age of the Tatric moles.

The distance from the posterior margin of the canine to the base of the fourth premolar varies in the young and adult specimens of the Tatric moles between 3,4 and 4,0 mm. The extremes are found rarely, a distance of 3,7 mm beeing most frequent. The distance changes with the age of the individual: in old specimens it is never greater than 3,4 and usually is smaller (3,1 or even 3,0 mm). This distance is ruled by the degree of extension of the canine, changing with age, as can be seen on textfigure 4. Individual changes in the same age class are also great (textfig. 5).

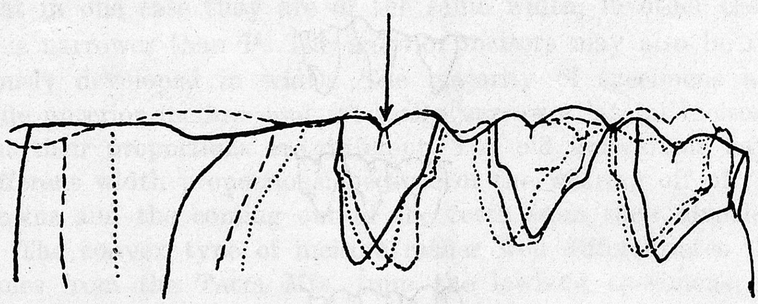

Fig. 5. Position of premolars in relation to the posterior margin of the canine in the young individuals of Tatric moles.

The premolars of the Tatric moles show rather large differences with those of the lowland moles (from Kraków). The Tatric mole has its first three premolars much more sculptured than the lowland mole; the latter nearly as a rule possesses a smooth tooth profile (Pl. II). These differences appear also in the both distances which in the lowland moles is shorter (between 3,0 and 3,4 mm — the latter value is found in males with a distinctly large Cb, much more rarely in females). Young and adult lowland moles have as short praemolar segments as the old Tatric individuals. The rather large distance

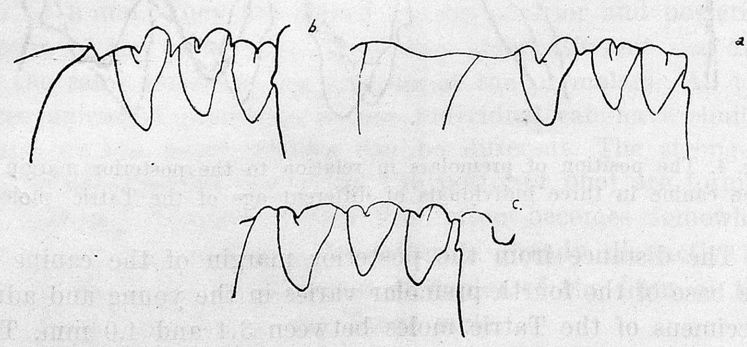


Fig. 6. Premolar position in lowland moles (region of Kraków): a. young male, Cb 34,0 mm; distance C—$Pm^4$ 3,1 mm; b. young male, Cb 34,0 mm, distance C—$Pm^4$ 2,9 mm; c. young female, Cb 35,1 mm, distance C—$Pm^4$ 3,4 mm.

between Pm³ and Pm⁴, so characteristic for the Tatric mole, is reduced in lowland moles so that the anterior margin of Pm⁴ often extends further than the posterior margin of Pm³, thereby hiding a part of the latter (in the lateral view).

The rostrum.

The rostrum is strongly variable only in its anterior part, and especially near the casing of the incisors. The inclination of the rostrum (das Rostrumabfall, STEIN, 1950), an important character for the systematics of the mole, is also variable.

A comparison of the lateral contours of the rostra in Tatric specimens shows that the morphology of the rostrum may vary, althought the angle expressing the general inclination of the rostrum in its anterior part remain the same. These changes occur independently of the height of the rostrum and of its lenght. Textfigure 7 illustrates the differences of six rostra chosen from the same height class. The drawing

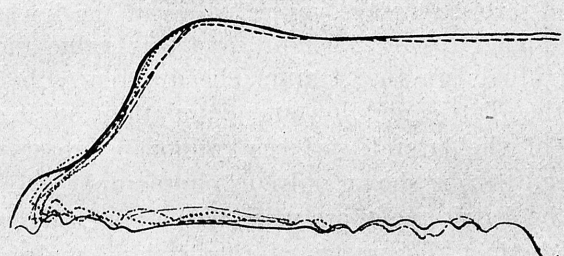

Fig. 7. Contours of six rostra of the same height class. Tatric population

shows distinctly that the dorsal profile of the rostrum is the stabilest part, and that the anterior part varies most. Changes in the form of the anterior segment of the rostrum are also illustrated by textfig. 8 on which rostra with various heights are compared. The figure shows distinctly that the some value of the angle expressing the general slope of the rostrum may mean different form of the contour of its anterior profile. The height of the rostrum in the moles from the Tatra Mts. are from 2,6 to 2,8 mm.

The characteristic features of the rostra in moles from the Tatra Mts. are seen especially distinctly if we compare them with the lowland specimens. The chief differences ar :

the proportions of the rostrum and the form of the lateral surfaces. The rostra of the Tatric moles are longer than those of the lowland individuals. However, the full length of the rostrum cannot be expressed numerically, as its limits are

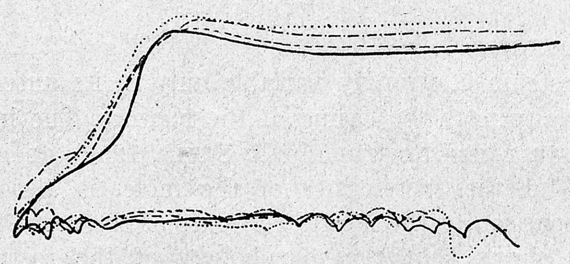

Fig. 8. Contours of four rostra of different height. Tatric population.

not sharp in the horizontal projection, so that only a visual comparison remains to be made. The rostra in the Tatric population moreover, are lower in the average than those of the lowland series. Average young males in the lowlands have somewhat higher rostra (3,0 mm), and this value increases in adult individuals up to 3,4 mm. The differences between the rostra of the Tatric and lowland populations as regards the modelling of the lateral surfaces cannot be observed in the contours and can be shown only on photographs (Pl. III). The rostra of the Tatric moles are more flat, a bone ridge above the canines is distinct. The rostra of the lowland moles are more massive, more compact and uniform. This differences make the skulls of the Tatric moles comparatively easy to recognize by their „general character“ from the lowland skulls. The width measurements made with the sliding scale does not inform on the differences as the claw of the scale catch the part which even in the slenders skulls is comparatively wide (it has then the form of the bone ridge above the canines, as described above); those measurements do not take into consideration the other features of the contour, so important for the general character of the skull.

The form and dimensions of the skull.

I based the analysis of the skull forms on the method of photographic projections. The latter consists in projecting the shadow of the skull placed horizontally on the glass of a photographic magnifying projector. The same magnification, adequately scaled, was maintained for all the skulls. This method allows to obtain nearly ideally true silhouettes, sufficiently magnified, suited for comparison. Except the projections, contour drawings were used, as based on photographic material.

In the moles from the Tatra Mts. the skulls are slim, i. e. they have comparatively narrow and not shortened rostra. The width of the rostrum on the canine level is between 4,0 and 4,7 mm (average 4,4 mm). The width of the skull in its widest place is from 15,0 to 16,5 mm (average 15,5 mm). Sexual dimorphism, very distinctly visible in lowland series, is very feebly pronounced here. Three types could be found in the series of 22 specimens of skulls from the Tatra Mts.:

1. typically male skulls,
2. typically female skulls,
3. male skulls with feebly pronounced male characters.

The male skulls are characterised by more strongly built rostra and somewhat wider jugal arches (textfig. 9). Typically female skull have narrow rostra, sometimes elongated, they are slimmer in the jugal part (textfig. 10). Cb in the Tatric population oscillates from 31,3 to 34,2 mm.

The differences between the Tatric and lowland specimens in the general outline of the skull are distinct (Pl. IV, V). Textfigure 11 illustrates on the example of two adult males from both populations that the slimness of the skull of mountain specimens consists in different proportions; the latter are different even in the lowland skulls with small widths (the quoted example gives a skull from Kraków 15,8 mm wide, a value below the average ranging 16,5 mm for the Kraków series).

The differences are much more distinct in the comparison of maximally large skulls from both populations (textfig. 12). This is the result of the lack of large forms in the Tatra Mts. The males from the lowland have stronger rostra and the jugal part; the most distinct differences may, however, be observed in the posterior part of the contour formed by the

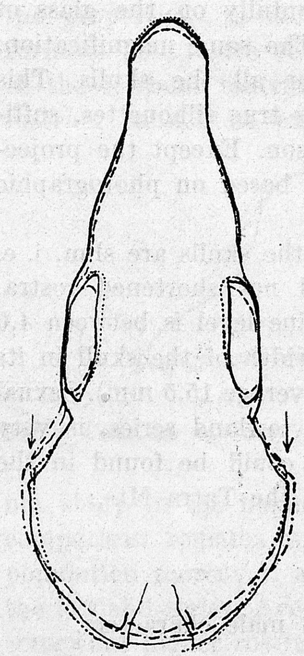

Fig. 9. Skull contours of four Tatric males (Nos. 12, 15, 17, 18).

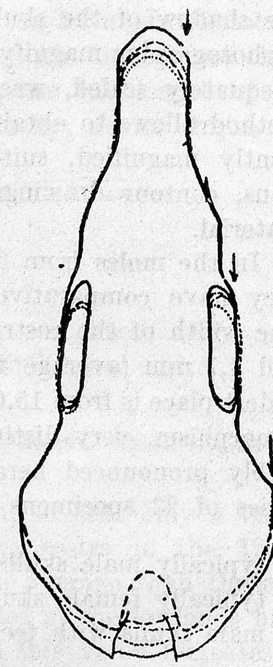

Fig. 10. Skull contours of four Tatric females (Nos. 1, 2, 4, 5).

lateral occipital bones. The skull of the Tatric moles is smooth, tuberosities and ridges are not pronounced. The lowland males have skulls strongly widened, sometimes also extended backwards. Lateral ridges are always strongly pronounced.

The differences found in the skulls of adult individuals should be explained by the inequally intense development of the skull. It seems as if the skull of the Tatric mole matured earlier, i. e. that the period of its growth were shorter and came to an end in a stage in which the lowland mole has not finished its morphological development. The differences in form of the skulls may be explained simultaneously by an inequal rate of growth of different parts of the skull. One might suppose that the skull of the Tatric mole grow slower, which would be understandable as a result of smaller amounts of food and of a shortened activity periods of the soil fauna in the mountains. And this is why the adult moles in the Tatra Mts. conserve permanently juvenile characters.

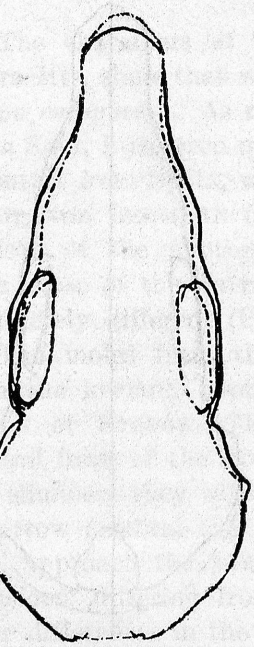

Fig. 11. Skull contours of two adult males: from Kraków (continous line) and from the Tatra Mts. (interrupted line). The Kraków specimen was chosen among the specimens with small brain-case width.

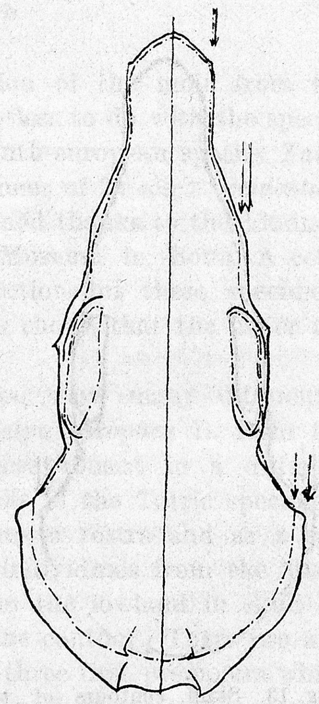

Fig. 12. Skull contours of maximally developed specimens from the Kraków (continuous line) and the Tatric (interrupted line) population.

One of the important features of the Tatric skulls appearing in comparison with the lowland mole material is also given by the angles between two parts of the contour: from the rostrum to the first inflexion (cheek inflexion) and from the posterior base of the jugal arch to the lateral corners of the brain-case. As compared to the lowland skulls, these of the Tatric moles are more „sloping“ in their contour. This feature is conserved even in these exceptional cases when the skull of the Tatric mole is larger than that of the lowland mole.

The differences of the morphology of the skull between the two mole populations were especially interesting between

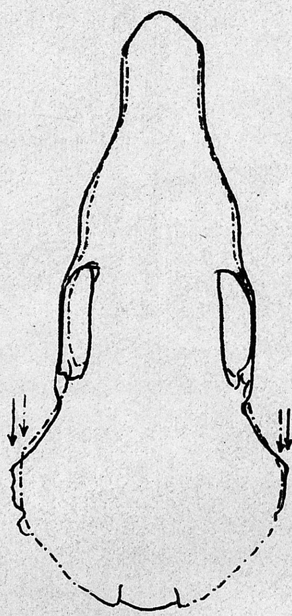

Fig. 13. Skull contours of two young females from the Kraków (continuous line) and the Tatric (interrupted line) population.

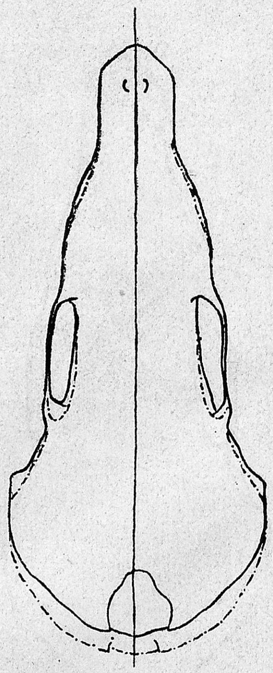

Fig. 14. Skull contours of two specimens of the same class of width: from Kraków (continuous line) and from the Tatra Mts. (interrupted line).

the specimens of similar dimensions. Thus, for example, the skulls of the June females show differences in the posterior section of the braincase. The lateral corners in the Tatric skulls lie somewhat more in front, and the part of the contour behind the jugal arches is shorter. The slight shortening of the skulls of the Tatric females is thus the effect of the shortening of the brain-case, since the lengths of the rostra are the same in both populations (textfig. 13). The skulls of the lowland moles were, although small, always of the same form as the greater ones. Especially the brain-case is specific in lowland specimens: dilated in its posterior part and concave in the anterior part of the profile (textfig. 14).

## DISCUSSION

The characters of the population of the mole from the Tatra Mts. show that we have doubtless to do with the species *Talpa europaea* L. As regards to south-european species *Talpa coeca* SAVI, I disposed only of specimens of *T. coeca occidentalis* CABRERA from Spain, which I obtained thanks to the kindness of Dr. von LEHMANN from König Museum in Bonn. A comparison of the photographic projections of these specimens with those of the Tatric population shows that the latter are completely different (Pl. VI).

The moles from the Tatra Mts. show many differences with the lowland population of *Talpa europaea* L. from the region of Kraków. These differences consist in a different general form of the skulls: the skulls of the Tatric specimens are slimmer, they often show narrower rostra and as a rule a narrow cerebral case. The adult individuals from the Tatra Mts. approach the young ones from the lowland in skull dimensions, differing from them in the contour. There are also some differences in the form of the three first premolars which in the Tatric specimens have better differentiated accessory tubercles. The section of the jaw between the canine and the fourth premolar is longer and the rostrum in lower.

In the present state of knowledge on the systematic of the mole in Poland it is impossible to decide, if the variability of character between the lowland and Tatric populations are continuous or if the Tatra Mts. have a distinct population. It is also impossible to determine the systematical relations of the Tatric moles to the moles from the Sudety and East-Carpathian Mts., as we now nothing on those populations excepting general descriptions and some measurements, and no detail morphological analyses have been made till now.

HANZAK and ROSICKY (1949) found in the alpine zone of the Slovak part of the Tatra Mts. mole specimens, which they determined as *Talpa europaea coeca* SAVI. I had the possibility to examine these specimens thanks to the kindness of Dr. J. HANZAK in the collections of the National Museum in Prag, and I had the impression that they are distinctly different from the moles I knew from the Polish Tatra Mts.

It is doubtless that in the higher parts of the Polish Tatra Mts. there exists a population of moles completely different from that in the lower mountain localities.

According to my investigations I must remark that single characters given as typic for *Talpa coeca* Savi appear in the specimens of *T. europaea* L. Thus Hanzak & Rosicky (1949) ascertain that there is a complete disjunction in the Cb values between this two forms. *T. europaea coeca* Savi is supposed to possess skulls never longer than 32,0 mm [1]. In the lowland material from Kraków there is quite a number of male and female specimens, the Cb of which is lower than 32,0 mm. The material of *Talpa europaea europaea* L. from the Polish Tatra Mts. also comprises specimens with very small skulls (e. g. No. 2, 4, 5, 7, 20, 22). This allows to ascertain that the disjunction in Cb dimensions between *Talpa europaea europaea* L. and *T. e. coeca* Savi does not exist. The table of measurements illustrates also the fact that the narrowness of the rostrum (characteristical for *T. europaea coeca* Savi) appears in the Tatric population of *T. europaea europaea* L. Similarly, blindness regarded as a characteristic feature of *T. coeca* Savi appears in one specimen of investigated Tatric population (No. 20).

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[1]) Other authors move the upper limit of Cb for *Talpa coeca* Savi as fas as 33,5 mm; Baumann, 1949; Stein, 1950).

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STRESZCZENIE

Praca jest próbą charakterystyki populacji kreta (*Talpa europaea europaea* L.) z terenu Tatr Polskich pod względem ekologicznym i systematycznym.

Kret w Tatrach zamieszkuje głównie łąki kośne i pola uprawne, oraz pastwiska w wyższych położeniach górskich dochodząc do 1600 m n. p. m. Stanowiska leśne są nieliczne i leżą w bezpośrednim sąsiedztwie otwartej przestrzeni. Osiedlanie się kreta na wysoko położonych pastwiskach uzależnione jest od szeregu czynników, w pierwszym rzędzie od miąższości gleby, a także od jej nawodnienia, kret bowiem wyraźnie unika miejsc suchych. W wielu wypadkach stwierdzono zależność gęstości osiedlenia się kreta od wypasu, względnie obecności zabudowań ludzkich, co wskazuje na działanie czynnika nawożenia gleby i zwiększenia się ilości fauny glebowej na występowanie kreta.

W analizach systematycznych opiera się autor na metodzie rzutów fotograficznych zestawianych z pomiarami. W stosunku do pomiarów zębów wprowadza on nowe konwencje, usuwające możliwość wieloznaczności danych cyfrowych.

Populacja kretów tarzańskich charakteryzuje się smukłą budową czaszki, tzn. wąskim rostrum (od 4,0 do 4,7, z przeciętną 4,4 mm) i wąską puszką mózgową (15,0—16,5 mm), co wyróżnia ją dość dobrze od populacji nizinnej (materiał porównawczy pochodził z okolicy Krakowa). Czaszki dorosłych osobników z Tatr podobne są pod względem wymiarów do czaszek młodocianych okazów nizinnych, od których są jednak wyróżnialne dzięki różnicom kształtu. Długość kondylobazalna w populacji tatrzańskiej waha się od 31,3 do 34,2 mm.

Niskie wartości długości kondylobazalnej, spotykane u wielu osobników kretów z Tatr Polskich, oraz sporadycznie poja-

wiająca się jednostronna, a nawet obustronna ślepota, nasunęły przypuszczenia o możliwości pokrewieństwa tej populacji z wykrytym na terenie Tatr Słowackich podgatunkiem *Talpa europaea coeca* SAVI. Bliższa analiza cech systematycznych u badanych osobników z Tatr Polskich, jak również zestawienie rzutów fotograficznych obrazujących kształt czaszki wykazują niezbicie, że mimo pojawiania się w obrębie tej populacji pewnych cech przypisywanych południowo-europejskiemu gatunkowi *Talpa coeca* SAVI należy ona do podgatunku *T. europaea europaea* L. Pewne cechy specyficzne tej populacji można przypisać wpływowi środowiska górskiego, które i na innych terenach europejskich doprowadza do skarlenia kreta. Należy też zaznaczyć, że okazy *Talpa europaea coeca* SAVI z Tatr Słowackich pochodzą z wysokich położeń górskich, podczas gdy badana populacja kreta zajmuje raczej niższe położenia tatrzańskie.

Ze względu na brak materiałów trudno na razie powiedzieć, czy badana populacja kretów z Tatr Polskich łączy się stopniowymi przejściami z populacją nizinną, czy też jest bardziej wyodrębniona.

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РЕЗЮМЕ

Настоящая работа является попыткой характеристики популяции крота (*Talpa europaea europaea* L.) из района польских Татр, в экологическом отношении и систематики. Крот в польских Татрах обитает главным образом в долинах лугов и пахотных полей, а также в высокогорных пастбищах доходящих до 1600 м.

Лесовые кротовины не многочисленны и встретить их можно в непосредственном соседстве открытого пространства. Поселение крота на высоко расположенных пастбищах зависим от ряда факторов, во первых от мягкости почвы, а также от её влажности, так как крот всегда избегает сухих мест.

Во многих случаях констатировано зависимость количества расселения крота в данном районе от выпаса или присутствия селений, что указывает на действие фактора унавоживания почвы и увеличения количества почвенной фауны па появление крота.

В систематических анализах автор опирается на методе фотографической проекции сопоставленной с обмерами. В отношении к обмеру зубов устанавливает новые более практические конвенции, которые устраняют возможность многозначности понимания цифровых данных.

Популяция кротов польских Татр характеризуется удлинённым строением черепа, т. е. узким рострум (от 4,0 до 4.7 со средним показателем 4,4 мм) и узкой черепной коробкой (от 15,0 до 16,5 мм), что отличает её довольно хорошо от низменной популяции (сравнительный низменный материал, автор использовал из района Кракова).

Черепа взрослых особи кротов из польских Татр в отношении размера похожи на черепа низменных молодых экземпляров, от которых однако отличаются благодаря разницам формы. Кондилобазальная длина черепа в популяции района Татр колеблется между 31,3 а 34,2. Низкие стоимости кондилобазальной длины встречаемые у многих особи кротов польских Татр, притом спорадически появляющаяся односторонияя, а даже двусторонняя слепота подсказала некоторые предноложения о возможности сродства этой популяции с обнаруженной в районе словацких Татр популяцией карликовых и слепых кротов определённых как *Talpa europaea coeca* SAVI. Однако-же более близкая анализа систематических факторов у особи из польских Татр как и сопоставление фотографическом проекции доказывает неоспоримо, что несмотря на возникновения в пределах популяции кротов из польских Татр некоторых черт свойственных южноевропейскому виду *Talpa coeca* SAVI и в связи с исключительной разницей сложения словацких экземпляров надо признать польскую популяцию как принадлежащую виду *Talpa europaea* L. Некоторые изменения в размерах черепов в отношении к масштабу переменчивости низменных экземпяров можно приписать исключительно влиянию горной среды, которая и в других районах Европы является причиной измельчания, уменьшения etc. черепа у крота.

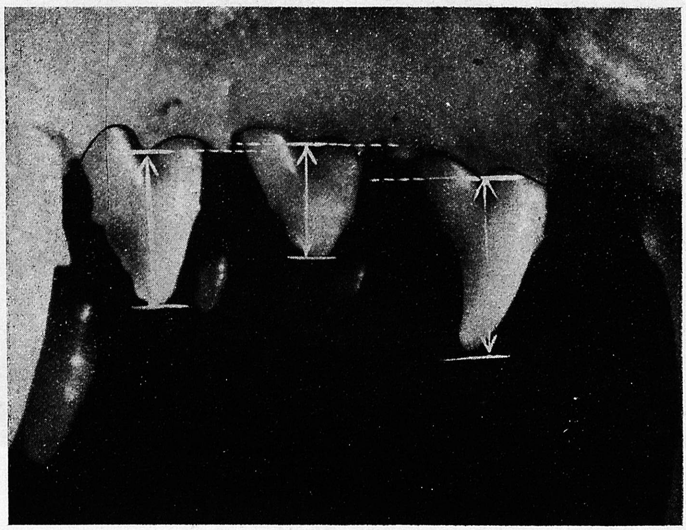
Является ли популяция кротов из польских Татр „продолжением“ низменной популяции или является более систематически выделённой трудно в нынешним состоянии наших сведений утверждать. Обнаружат это исследования в будущем.

Plate I

Fig. 1. The premolars in the upper jaw of the mole. The interrupted lines mark the levels of the alveole incision. The vertical arrows show the absolute heights of the teeth.

Fig. 2. The incisives of the Tatric mole.

Fig. 3. The incisives of a mole from the region of Kraków.



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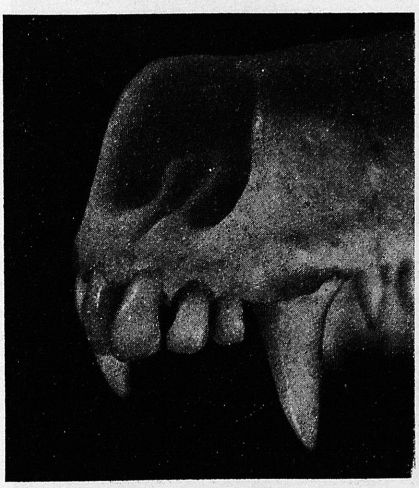

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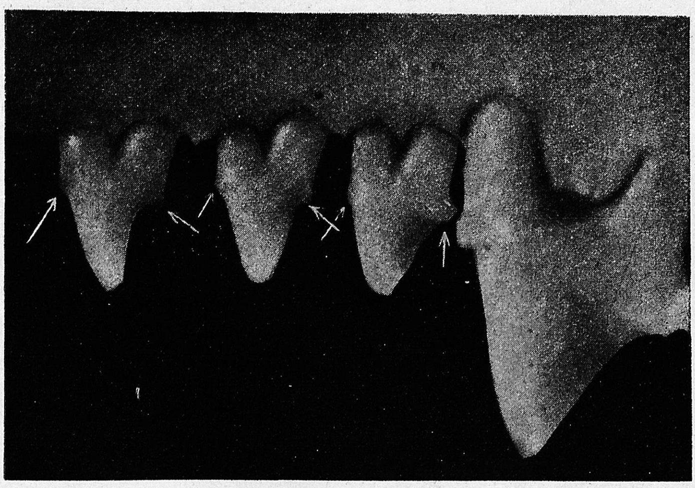
Auctor phot.
*J. Świecimski*

Plate II

Fig. 1. Typical maxillary premolars of a Tatric mole. Arrows mark accessory tubercles on the strongly developed cingulum.

Fig. 2. Maxillary premolars of a mole from the Kraków region.



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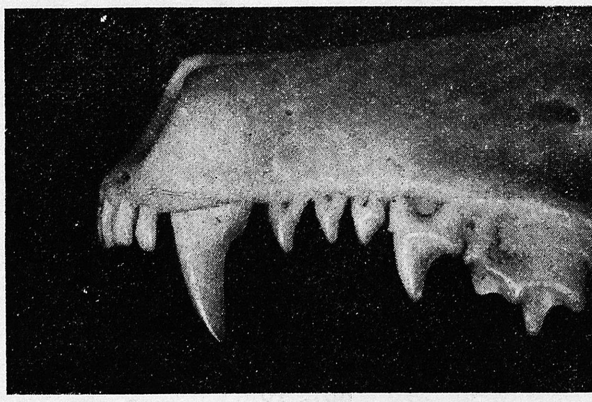
Auctor phot.
*J. Świecimski*

Plate III

**Fig. 1.** Anterior part of the mole skull from the region of Kraków.
**Fig. 2—3.** Anterior part of the mole skulls from the Tatra Mts.



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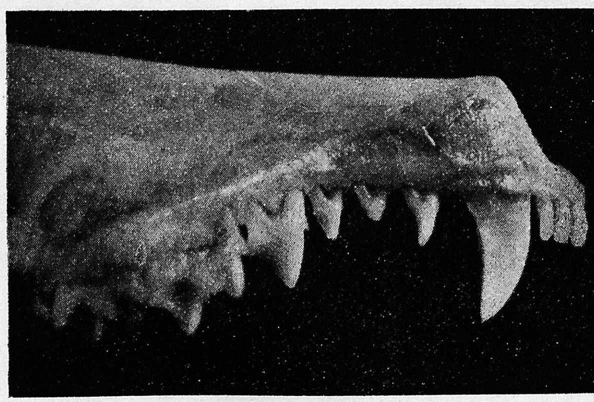

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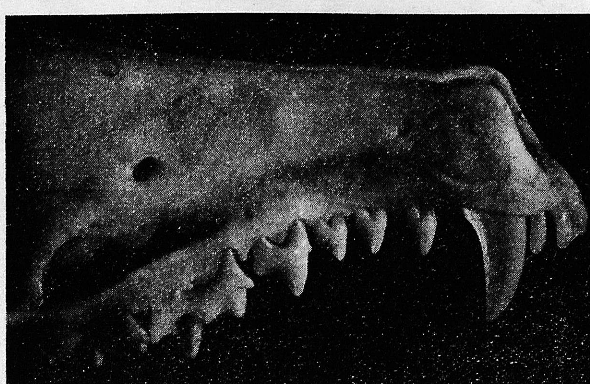


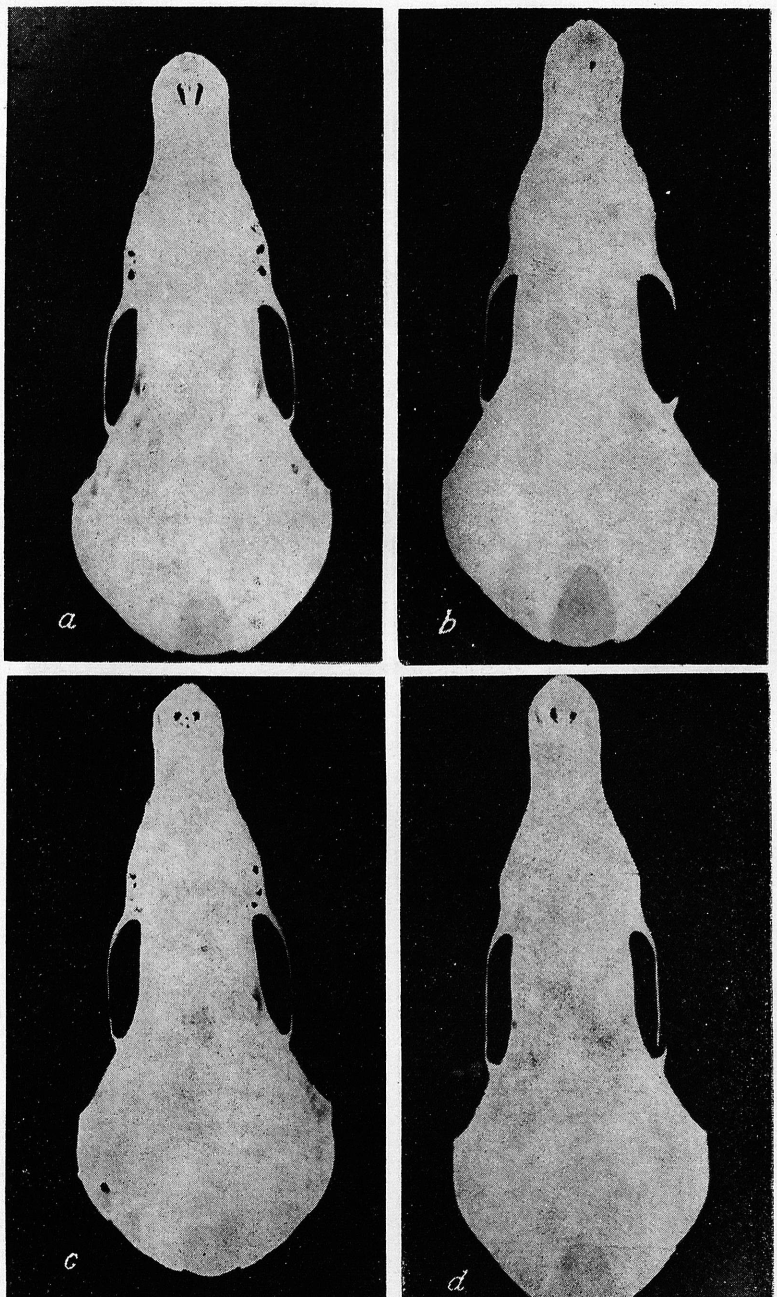
3

Phot. L. Sych

*J. Świecimski*

Plate IV

Photographic projections of the skulls of two males (a, b) and two females (c, d) of moles from the Tatra Mts.




Phot. L. Sych
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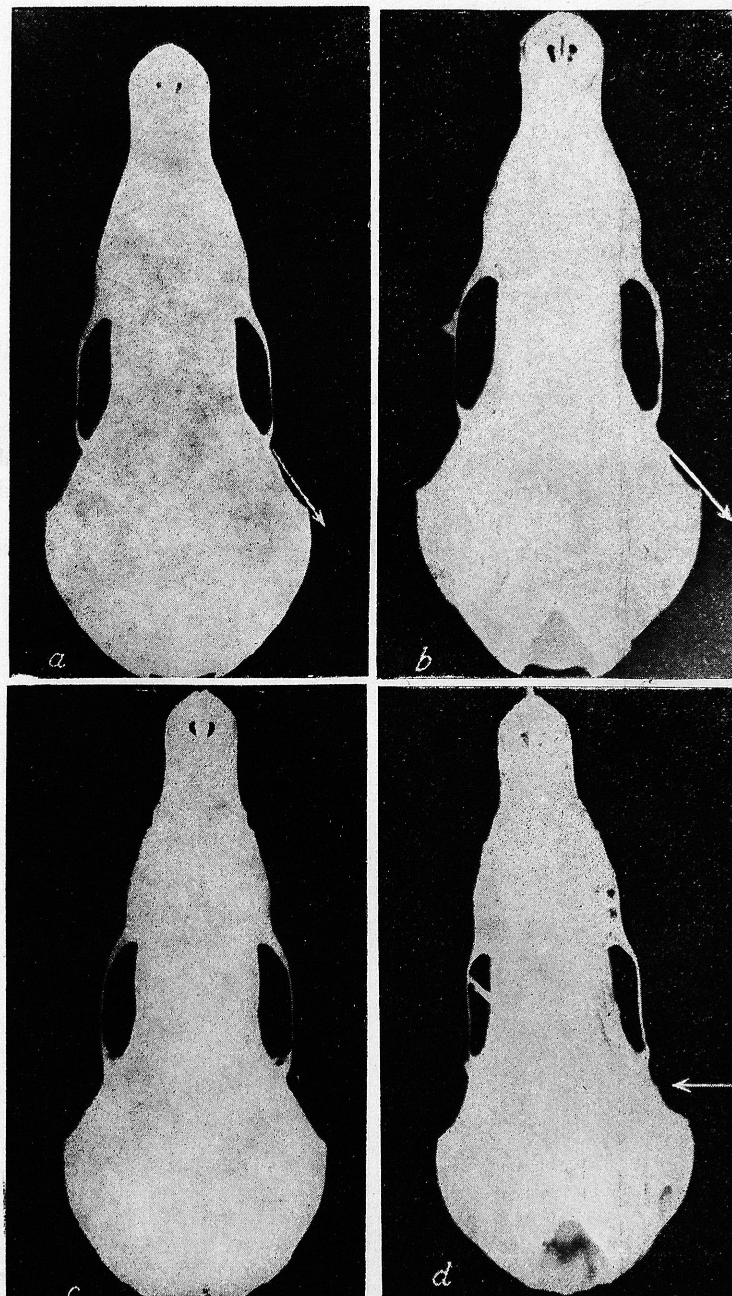
Plate V

Photographic projections of skulls of strongly developed specimens: a. from the Tatra Mts., b. from the region of Kraków.
Photographic projections of skulls of exeptionally small specimens: c. from the Tatra Mts., d. from the region of Kraków.




Phot. L. Sych
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Plate VI

Photographic projections of skulls of: a. blind male from the Tatra Mts. (Cb 31,7 mm) and b. young male from Kraków infested by skin parasites (Cb $\pm$ 31 mm).

Photographic projection of skulls of *Talpa coeca occidentalis* Cabrera from Spain. (c, d.)

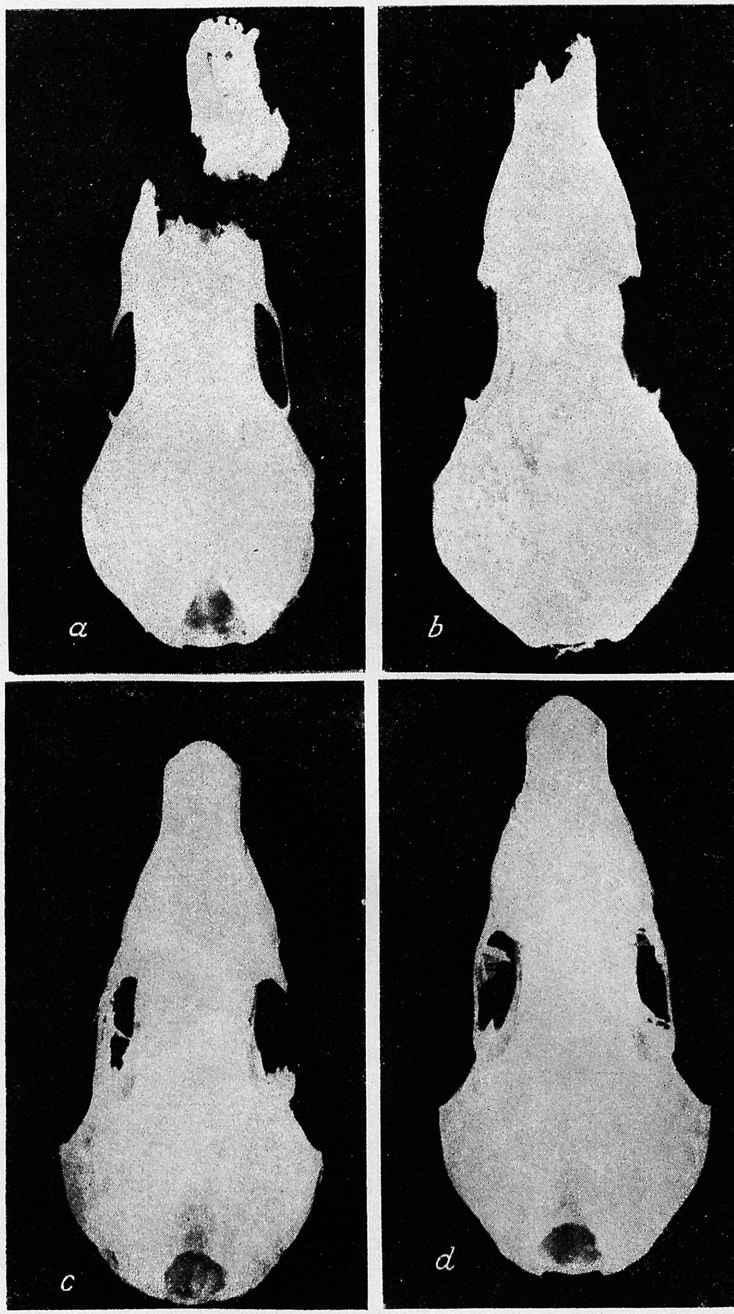


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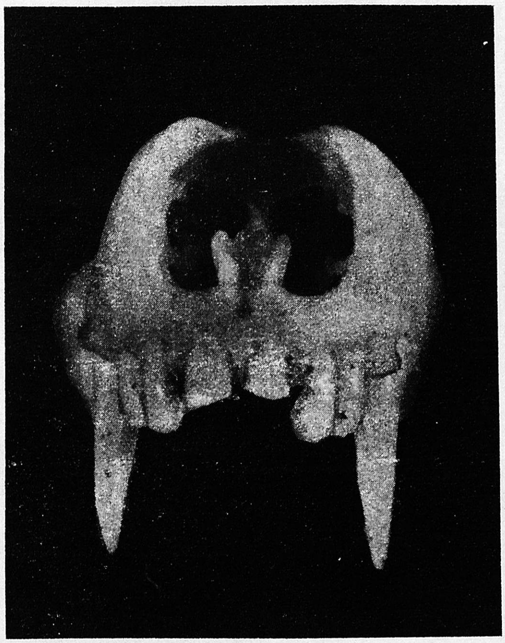
Plate VII

Anterior part of the skull of a blind, exeptionally small male from the Tatra Mts. (no 20).



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Redaktor zeszytu: doc. K. Kowalski

Państwowe Wydawnictwo Naukowe — Oddział w Krakowie 1960

Nakład 800+150 egz. — Ark. wyd. 2,25. — Ark. druk. 2¾. — Papier ilustr. kl. III 80 g 70×100
Zam. 233/59 Cena zł 12,—

Drukarnia Uniwersytetu Jagiellońskiego w Krakowie