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**Seasonal Changes of the Pelage in the Mole,
Talpa europaea Linnaeus, 1758***

[With 3 Figs. & 2 Tables]

The progress of moults in the annual cycle of the mole was investigated. Material (N = 800) was collected for the most part in one habitat in the grasslands of Kraków. Changes in hair were estimated by the planimetric measuring of pigmented areas on the skin. The spring moults of males and females resemble each other in pattern but differ in time. Unfertilized females moult at the same time as males. The moles from the Tatra Mts. finished the spring moult 10 days later than those of the Kraków region. The summer moult occurs at the same time in all moles. Adult females and young males moult more intensely. Males begin the autumn moult first, but in females the moult proceeds faster. Changes in hair were also ascertained in the winter, especially during the spells of warmer weather. The intensest pigmentation was found in moles from areas with poor edaphic conditions. There were considerable changes in the times of moults of the captive moles.

I. INTRODUCTION

The seasonal changes of the pelage in the mole *Talpa europaea* Linnaeus, 1758 have not been studied in the territory of Poland. The purposefulness of taking up such studies is connected, among other things, with the fact that since World War II moles have become an object of interest as fur-bearing animals in Poland, in spite of their being State-protected (Skoczeń, 1962).

Besides, moulting is an interesting fenological process in mammals, which was given comparatively little attention, especially as regards its dependence upon ecological conditions. Some extensive studies on the seasonal changes of the pelage in small mammals contributed to the knowledge of their evolution (Krylcov, 1962).

In the neighbouring countries, especially in Russia, the seasonal changes of hair in the mole have been investigated by Vjazlinski (1927, after Ognev, 1928), Fólitarek (1932), Baškirov & Žarkov (1934), Kuzjakin (1935), Serżanin (1938, cit. after Grigorev, 1956), Pavlinin (1949), Deparma (1951), Borodulina (1953) and Grigorev (1956).

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Teodorovič (1955) dealt with moulting in moles in Yugoslavia and Hauchecorne (1927) and Stein (1950, 1954) in Germany. No studies on this subject have been reported from other European countries. The data on the progress of moults in countries with poorly defined seasons and mild winters would be particularly instructive. Godfrey & Crowcroft (1960) mention that in England moulting moles are caught all the year round.

II. MATERIAL AND METHODS

Seasonal changes in the pelage of the mole *Talpa europaea* L. were investigated on 429 skins of adult moles and 302 skins of juveniles collected in Kraków and its environs (Table 1). In addition, 68 skins were derived from specimens caught in the Sąddecki Beskid and Tatra Mts. The material covered the years 1956—1962.

Table 1.

Numbers of skins of adult and young moles collected in grasslands of Kraków and its environs in particular months.

Age	Sex	III	IV	V	VI	VII	VIII	IX	X	XI	XII	N
Adult	♂♂	14	18	44	20	53	11	22	23	18	6	234
	♀♀	12	29	36	23	36	16	12	13	5	13	195
Young	♂♂				61	32	14	19	20	16		162
	♀♀				40	32	16	13	19	21		141

Skins were taken off and dried by the method described by Folitarek (1932), Deparma (1951) and Grigorev (1956). Changes of coat were also observed in moles kept in the laboratory.

A planimeter was used to measure areas containing pigment, which allowed a fairly close determination of the area affected by moulting in relation to the whole skin as well as the graphic presentation of the progress of the moult (Figs. 2 and 3). Where the outlines of moulting patches were bleared, the tracing point of the planimeter was led along the outermost borders of the pigmented areas on the innerside of the skin. In the case of a wavy line, the percentage of the area undergoing moulting was determined by estimation.

Three moults occur in *T. europaea*, a spring, a summer and an autumn one; there is also a fourth incomplete winter moult, described by Deparma (1951) and Grigorev (1956).

III. SPRING MOULT

1. The spring moult of females begins at the head and spreads along the mid-ventral line, covering the bases of the fore- and hindlegs and the flanks gradually. Then it passes on to the dorsal side and ends extending from the tail towards the head (Fig. 1. I, A—D). In some females the shifting patches had well-defined shapes and contours. In most of the specimens, however, the whole innerside of the skin darkened suddenly.

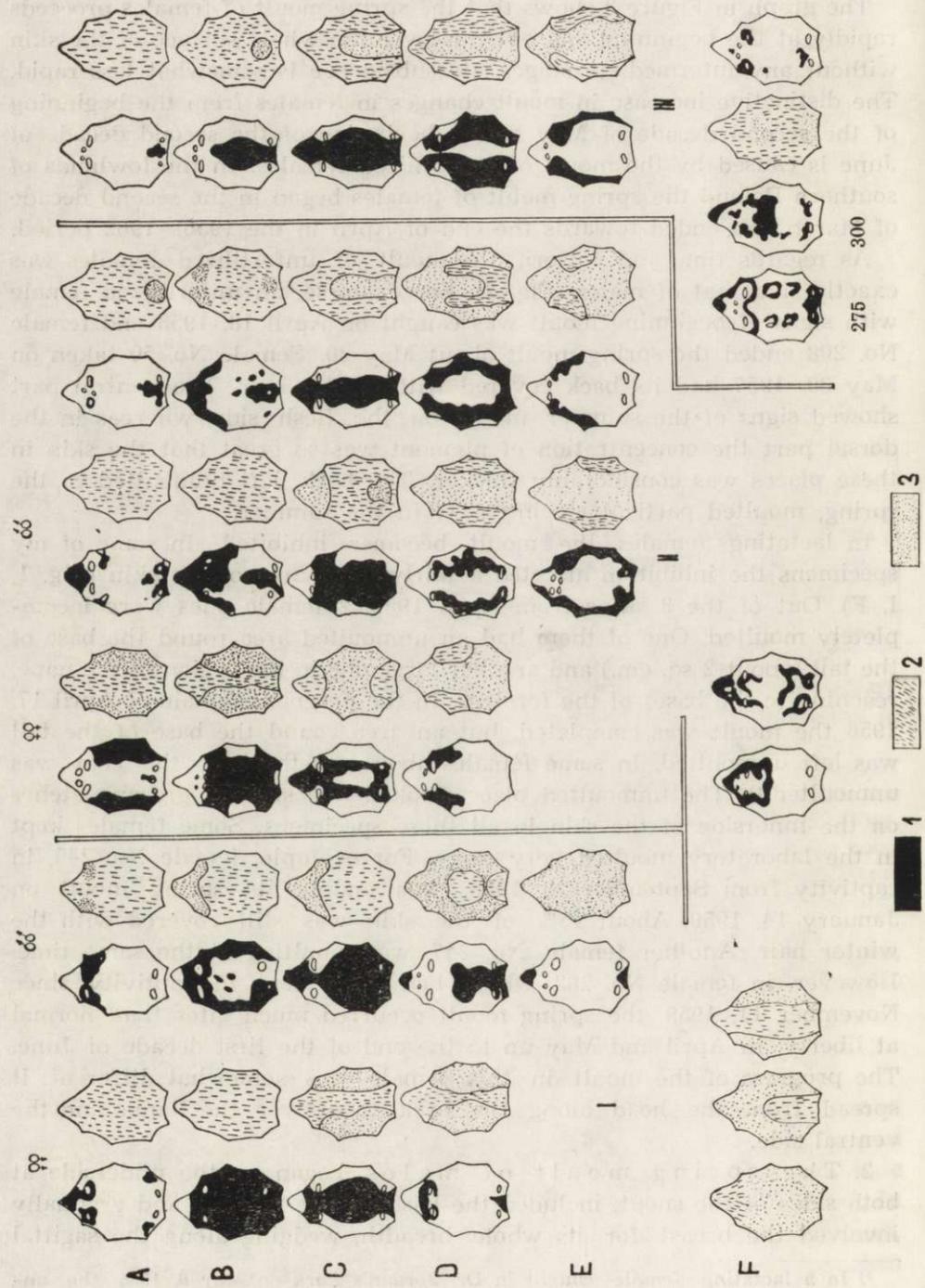
The graph in Figure 2 shows that the spring moult of females proceeds rapidly at the beginning and extends over the whole surface of the skin without any intermediate stages. Its subsidence is somewhat less rapid. The distinctive increase in moult changes in females from the beginning of the second decade of May to the beginning of the second decade of June is caused by the moult of unfertilized females. In the lowlands of southern Poland the spring moult of females began in the second decade of March and ended towards the end of April in the 1956—1962 period.

As regards time and pattern, the moult of unfertilized females was exactly like that of males (Fig. 2). For example, an unfertilized female with signs of beginning moult was caught on April 18, 1958 and female No. 208 ended the spring moult about May 20. Female No. 50 taken on May 30, 1957 had its back covered with winter hair. The ventral part showed signs of the summer moult on the flesh side, whereas in the dorsal part the concentration of pigment was so great that the skin in these places was considerably thicker. The back, left unmoulted in the spring, moulted particularly intensely in the summer.

In lactating females the moult becomes inhibited. In some of my specimens the inhibition affected a fairly large area of the skin (Fig. 1, I, F). Out of the 8 skins from April 1956, 2 female ones were incompletely moulted. One of them had an unmoulted area round the base of the tail (about 2 sq. cm.) and another large one in the region of the nape, reaching to the bases of the forelegs. In the pregnant female of April 17, 1956 the moult was completed, but an area round the base of the tail was left unmoulted. In some females about one-third of the coat was unmoulted¹⁾. The unmoulted places looked like slightly greasy patches on the innerside of the skin in all these specimens. Some females kept in the laboratory moulted very early. For example, female No. 245, in captivity from September 29, 1958, was ending its spring moult on January 14, 1959. About 15% of the skin was still covered with the winter hair. Another female, No. 247, was moulting at the same time. However, in female No. 293, which had been kept in captivity since November 11, 1959, the spring moult occurred much later than normal at liberty, in April and May up to the end of the first decade of June. The progress of the moult in this female was somewhat different: it spread from the head along the back, then over the flanks and the ventral side.

2. The spring moult of males began on the underside at both sides of the snout, included the bases of the forelegs and gradually involved the breast for its whole breadth, wedging along the sagittal

¹⁾ In a lactating female caught in Dr. Jordan's Park on May 6, 1965 the unmoulted area formed 80% of the whole skin.



line towards the middle of the belly (Fig. 1, I, A, B) to extend over its whole length. At the same time patches of pigment may appear at the bases of hindlegs and in the anal region. Having enlarged, they join the pigmented area which approaches them from the front and spread gradually over the whole ventral side and the flanks of the body. Next the flesh side of the dorsal area of the skin blackens by degrees till the whole back is occupied.

In some males the progress of the moult was rather different. Simultaneously with the appearance of pigment in the region of the forelegs the innerside of the skin blackened in the lumbar portion of the back. In this case the flanks were the last to moult. In a few specimens the moult ended in the lumbar portion of the back.

In males from the lowlands the moult started at the end of the first decade of April (Fig. 2) to reach the peak at the end of April and in the first decade of May. The gradual subsidence of the moult lasted from the second decade of May to the end of the first decade of June. The graph in Figure 2 shows that the whole weight of the moult falls in May.

In Tatra moles the spring moult appeared 10 days later than in lowland specimens. Out of the 8 males caught in Hala Smytnia (alt. 1100 m.) from 8—17 June, 5 were in the final stage of moulting (Fig. 1, I, E). In the other three males the moult was completed.

Young moles seem to moult earlier than the old ones. All of the 6 skins from the third decade of May belonging to one-year-old specimens had already gone through the moult, whereas out of the 5 skins with the moult in progress, 4 belonged to old specimens.

Some males moulted incompletely. The area left unmolted was, for the most part, the region of the base of the tail.

IV. SUMMER MOULT

The summer moult is of complimentary character. Deparma (1951) describes it as a compensatory moult, Stein (1954) uses the term "Zwischen-härung" and Godfrey & Crowcroft (1960) call it the "intermediate" moult. The extent of the summer moult depends on geographical latitude (Table 2). Siberian moles, in which the interval between the spring and autumn moults is remarkably shorter, undergo the summer moult to a much smaller extent than the moles from the middle latitudes (Deparma, 1951). This moult, especially in young animals, is often mosaic in character.

Fig. 1. Diagrams showing the progress of moults in moles in particular seasons. I — spring moult, II — summer moult, III — autumn moult, 1 — pigment, 2 — old hair, 3 — new hair.

Another course of moulting is represented by the "wavy" moult. A narrow (0.5—1 cm.) wavy strip of pigment runs across the skin and the change of hair takes place in this zone (Fig. 1, II, F). In some females the darkening of the skin on the flesh side occurred all over its surface with the exception of the bases of the forelegs or the line at the back of the neck. Then the moult followed the pattern characteristic of males. It began on the back and spread over the flanks and the ventral side.

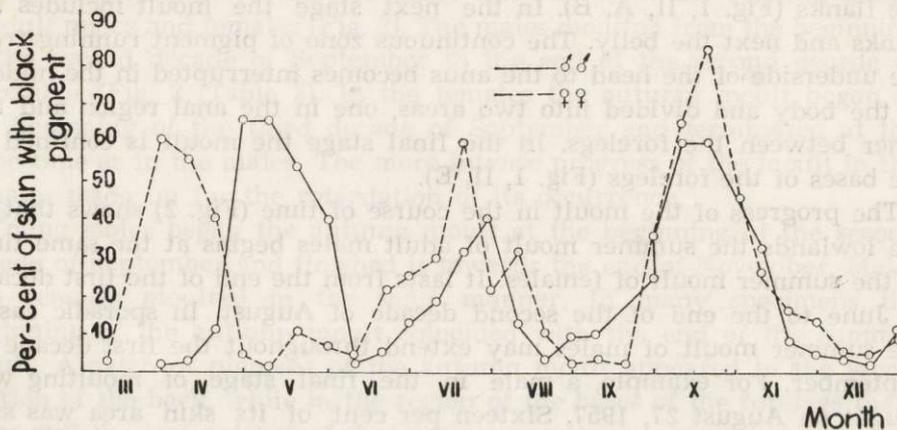


Fig. 2. Seasonal changes of hair in adult moles.

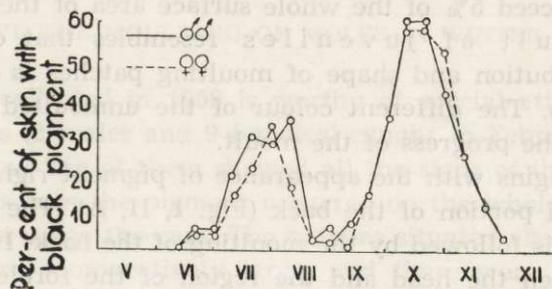


Fig. 3. Seasonal changes of hair in young moles.

The type of moult in females depends on a number of factors, above all, on fertilization, lactation and raising of the young. Figure 2 shows that the summer moult of females began towards the end of the first decade of June and lasted throughout August. As will be seen from the graph, it is prolonged and not uniform. Females moult to a considerably higher degree than the males. In some years the moult began much earlier. For example, in 1957 the first females with a fairly advanced moult were caught on May 28 and 31. In Tatra moles the summer moult ended towards the end of the first decade of September. Out of the 6 moles collected between 4 and 8 September 1959, 5 specimens (2 males

and 3 females) were in the final stage of the summer moult (Fig. 1, II, D), whereas a female caught at the foot of Mount Gubałówka was in the first stage of the autumn moult.

2. The course of the moult in adult males is somewhat simpler than that in females. The head and the sacral portion of the back are first to moult in males and are followed by the further parts of the back, the moult of which sometimes coincides with that of the flanks (Fig. 1, II, A, B). In the next stage the moult includes the flanks and next the belly. The continuous zone of pigment running from the underside of the head to the anus becomes interrupted in the middle of the body and divided into two areas, one in the anal region and the other between the forelegs. In the final stage the moult is confined to the bases of the forelegs (Fig. 1, II, E).

The progress of the moult in the course of time (Fig. 2) shows that in the lowlands the summer moult of adult males begins at the same time as the summer moult of females. It lasts from the end of the first decade of June to the end of the second decade of August. In sporadic cases, the summer moult of males may extend throughout the first decade of September. For example, a male in the final stage of moulting was caught on August 27, 1957. Sixteen per cent of its skin area was still occupied by pigment. In the first decade of September the pigmented area did not exceed 5% of the whole surface area of the skin.

3. The moult of juveniles resembles that of adults. However, the distribution and shape of moulting patches is very distinctive in young moles. The different colour of the unmoulted fur facilitates the tracing of the progress of the moult.

The moult begins with the appearance of pigment right above the tail or in the sacral portion of the back (Fig. 1, II, A). The enlarging focus of the pigment is followed by the moulting of the back. Its posterior part moults first, then the head and the region of the forelegs, followed by the breast, the flanks and finally, but even then only in a few cases, the belly (Fig. 1, II, B—E).

The moult of juveniles is marked by its mosaic pattern. The patches of pigment do not expand but subside within the limits in which they have appeared. Generally speaking, the main places that underwent moulting were the head and the posterior part of the body. The region of the base of the tail was, as a rule, left unmoulted in young moles.

Figure 3 shows that the moult of young moles begins towards the end of the first decade of June and continues throughout August. In the case

Figure 3 shows that the moult of young moles begins towards the end of the first decade of September. It will be seen from the graph that the moult of juveniles occurs at the same time as that of adult moles. In

contradistinction to the adults, however, the males of young moles moult to a somewhat greater extent than the females.

V. AUTUMN MOULT

The autumn moult is commonly considered to be one of the most uniform both in its character and in course (Table 2). Nevertheless, the materials from Kraków showed some differences in the autumn moult of adult males and females (Fig. 2). The males moulted from the beginning of the second decade of September to the end of the second decade of December (Fig. 2, Table 2). In the females the autumn moult began at the beginning of the third decade of September and terminated at the same time as in the males. The more intense progress of the moult in the females made up for the retardation of its occurrence.

Young moles began the autumn moult at the beginning of the second decade of September and finished it towards the end of November. Males and females moulted in the same manner. In many specimens the beginning of the autumn moult coincided with the end of the summer moult. A patch of pigment of the autumn moult appeared in the sacral portion of the back, while in the region of the bases of the forelegs there were still the last patches of the summer moult.

VI. THE MOULTING OF MOLES IN WINTER

The material collected in 1959 is worthy of special attention. Out of the 11 specimens (2 males and 9 females) caught in February, 6 females were in moult and one of them showed all the signs of the spring moult (No. 175). In this case the pigment occurred on the whole dorsal side of the snout, almost up to the ears. The patches situated above the bases of the forelegs were comparatively large, and there were some scattered patches of pigment between the forelegs, on the throat and in front of the clitoris (Fig. 1). The growth of the new hair could be seen in the pigmented places. Out of 6 specimens caught in February and at the beginning of March 1959, 4 (2 males and 2 females) were in moult. The winter moult may be exemplified by female No. 275 (Fig. 1, III, F), in which the moulting patches covered the snout and formed a narrow wave above the forelegs and between the ears. Some small patches occurred on the flanks and at the bases of the hindlegs and the tail. The outlines of the patches were irregular, such as can be seen in moles only in the winter.

In order to examine this phenomenon closely, 15 males and 9 females were collected in the period from the third decade of February to the

end of March 1960. Nine of the males had winter moulting patches. In some of them the patches occupied 20% of the skin surface (male No. 300, Fig. 1, III, F). Out of the 9 females, 3 from the third decade of March were in spring moult, 3 showed no signs of moulting, and 2 from March 5 had typical patches of the winter moult.

The weather in February (especially in its third decade) in the years 1958—1960 was exceptionally mild in southern Poland. On some days the temperature reached $+10^{\circ}\text{C}$. The earth was unfrozen. The occurrence of the winter moult in moles is to some extent conditioned by the supplies of food in the soil, for in areas rich in food the interiors of the winter nests were warm (within the limits of the temperature of mole body). On the other hand, in sandy areas the nests were cool ($3\text{--}5^{\circ}\text{C}$), which indicated that the moles had been exploring the territory. In one of such areas of a pasture a male with the intensest winter moult was caught (No. 300, Fig. 1, III, F).

VII. DISCUSSION

The application of the planimeter to determine the size of the moulting area in relation to the whole surface of the skin proved useful. This method made it possible to characterize the progress of seasonal changes of mole hair in the annual aspect. However, it provides no data concerning the distribution of moulting patches. Besides, it cannot be used for estimation of the wavy type of moults (which is unfrequent).

In the present material the relation between the spring moult of females and pregnancy was consistent with the data offered by Deparma (1951), Stein (1954) and Todorovič (1955). Unfertilized females moulted at the same time as the males and in conformity with their characteristic pattern. Observations seem to indicate that the fertilization is the moment when a rapid moult begins. In some mammals the moult of pregnant females undergoes an inhibition (Ognev, 1951). In Grigorev's opinion (1956), the mole is an exception in this respect, since the moult of pregnant females proceeds violently. None the less, he thinks that the progress of the moult in females is independent of the pregnancy. Out of the 22 pregnant females collected by him, 3 had the skin entirely clean, 11 were in the first stages of moulting, and 8 completed the moult.

The influence of physiological factors on the process of change of the hair in moles is evidenced by lactating females, in which the moult was inhibited during lactation, if it had not been completed before they gave birth. Grigorev (1956) found only two such females with an incom-

plete moult in his material, whereas Pavlinin (1948) writes that there occur lactating females in moult among the Ural moles.

According to Grigorev (1956), in males moulting in the spring the pigment appears first on the back and expands cranially. Then the blackened areas occur near the bases of the forelegs and on the breast. Stein's general inference (1954) concerning the uniformity of the progress of moults in the mole does not hold water in the light of the data presented. The spring moult of moles proceeds in the reverse direction to that of the remaining moults.

Stein's (1954) materials showed three peaks of moults, occurring in May, July and October. My material reveals a fourth peak (that of females' moult), which falls in April. The graph of the summer moult of young moles does not corroborate the opinion of Stein (1954) that the summer moult of young females begins earlier.

The times of moults in the adjoining countries are illustrated in Table 2. The shifting of the periods of particular moults in dependence on the specific bioclimatic conditions of given areas is striking. Some moults are prolonged, others are shortened. The data presented by Borodulina (1953) for Altai moles are characteristic of this phenomenon. The spring and summer moults overlap and the autumn moult has undergone a remarkable shortening. A comparison (Table 2) shows a regularity which consists in that the farther to the South, the more the periods of moulting are pushed apart and the intervals between them subsist. Thus it may be supposed that towards the West the moulting periods will be prolonged so as to overlap.

The winter change of hair in the mole is described by Deparma (1951) as a compensatory moult. As it occurs just before the spring moult, it is difficult to determine in some cases whether it is an early spring moult or a late winter moult. Grigorev (1956) offers instructive data on the moults of this type. In some samples taken in winter all the moles were in moult. According to Grigorev (*l.c.*), the winter moult depends on the weather conditions and activity of the moles at that time. During mild winters the moles are more active and consequently their furs undergo a heavier wear.

It will be seen from my observations of moles (caught in December) in which the autumn moult continued into the winter period and from the observations of changes in moulting during a spell of warm weather in February 1958 that both the autumn and spring moults assume all the characteristics of a winter moult owing to the deterioration of ecological conditions (drop in temperature). Captive moles, in which even after a short stay under laboratory conditions a normal moult changed into a wavy one, also seem to provide evidence of this fact.

In Stein's (1954) material, moles moulting in the winter were encountered very rarely.

Great changes in the time of moulting were observed in the moles kept in the laboratory, whereas shrews moulted in captivity at the same time as at liberty (Borowski, 1964). Borowski believes that the spring and autumn moults in shrews are governed by the length of daytime. On the other hand, the quality of the hair depends on temperature and nutrition.

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SEZONOWE ZMIANY UWŁOSIENIA U KRETA
TALPA EUROPAEA LINNAEUS, 1758

Streszczenie

Przebadano 426 skórek kretów dorosłych, 309 skórek kretów młodych z terenów zielonych Krakowa i najbliższych okolic oraz 68 skórek kretów odłowionych w Beskidzie Sądeckim i w Tatrach.

Do oceny procentu powierzchni zajętej przez linkę posłużono się planimetrem, co pozwoliło na dokładne określenie przebiegu linek w przekroju rocznym (Ryc. 2, 3).

U kretów z terenu Polski południowej występują trzy linki — wiosenna, letnia i jesienna oraz fragmentaryczna linka zimowa uzależniona od aktualnie panujących warunków klimatycznych. Linka wiosenna samców i samic ma charakter podobny (Ryc. 2). Różnią się one jedynie czasem występowania. Szczyt linki wiosennej samic przypada na kwiecień, samców na maj. Linka wiosenna samic niezapłodnionych przebiega w tym samym czasie co i linka samców. Linka letnia przebiega u wszystkich kretów w tym samym czasie. Różnice polegają na większym zaawansowaniu linki samic. Natomiast u kretów młodych samice linieją pełniej. W linie jesiennej zaznaczają się pewne różnice między dorosłymi samcami i samicami. Samce zaczynały zmianę włosa o około 10 dni wcześniej. Samice zaś liniały szybciej. U obydwu płci linka przechodziła na grudzień i pod wpływem ostrzejszych warunków klimatycznych zmieniała charakter przechodząc w linkę typowo zimową. Ta obserwacja była szczególnie w okresie zimowych ociepleń. Krety z największą linką zimową były łapane w terenach edaficznie ubogich.

U kretów trzymanyh w niewoli stwierdzono znaczne przesunięcia terminów linek. Całkowitą zmianę włosa obserwowano u dwóch samic w styczniu.

W stosunku do krajów sąsiednich, linka wiosenna i letnia kretów z terenów Krakowa i okolic rozpoczynała się wcześniej. Przerwa między tymi linkami była minimalna, ponieważ samce po zakończeniu wiosennej zmiany włosa, wchodziły niezwłocznie w okres linki letniej. Podobnie było z przejściem z linki letniej w jesienną u osobników młodych i dorosłych.