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A Study of The Structure of Hair As A Means of Mammal Identification.

Earl R. Oyer
Fort Hays Kansas State College

A Study of the Structure of Hair

as a Means of Mammal Identification

being

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by

Earl R. Oyer, B. S.,

(Fort Hays Kansas State College)

Approved:

Major Professor

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acting

Chairman Graduate Council

Acknowledgment

This thesis problem and the need of its solution was proposed by Dr. L. D. Wooster, Head of the Department of Zoology, Fort Hays Kansas State College. It has been under his careful guidance that this work was developed. Thanks are extended to him for his kind assistance and constructive criticism during the progress of the work and for his efforts in producing the photographic illustrations of original drawings used in this thesis.

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Introduction

The hair of small and medium sized mammals is often found in the stomachs, feces and pellets of predators, for example in the stomachs and feces of coyotes and in the pellets regurgitated by hawks and owls. These pellets produced by hawks and owls and the feces of mammalian predators are the undigested residue of what these animals have eaten. As is well known, hawks and owls swallow their small mammal and bird food whole. They digest all tissues except hair, feathers and bones. (Hawks even digest much of the bones.) These undigested portions are formed by the stomach into a compact pellet which is expelled through the mouth.

These waste products may be obtained from the nesting and roosting places of these birds of prey and along the trails and near the dens of such mammalian predators as the coyote.

If the hair from these sources can be identified, then much desirable information concerning the food of predators can be obtained. The purpose of this study has been to determine whether or not such identification is possible.

Does each species of mammal have a definite hair structure? Can one species be distinguished from another species by hair structure alone? To what extent are there similarities in the hair structure of closely related species? These and other questions should be answered by such a study.

The need to identify the food of the predators is largely an ecological and economic one. Should the coyote be exterminated? What hawks and owls are largely beneficial, and what largely detrimental to man's interests? These questions illustrate the problems which the study of hair can help to solve.

This study was made in Western Kansas during the years 1936 to 1938. All the hair samples were obtained from mammals which are common within a radius of 150 miles of Hays, Ellis County, Kansas.

Little study relative to hair structure for identification purposes has been made by others: Dr. L. A. Hausman[1] has studied the structure of the commercial furbearing mammals for the purpose of determining the wearing and economic values of hair; he also has made some comparative studies of human hair of the different races. It will be seen that these studies were for a different

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1. Professor of zoology, New Jersey College for Women, New Brunswick, New Jersey.

purpose and largely for a different group of mammals. Mr. Charles C. Sperry[1] has studied the hair in the stomachs of coyotes for the purpose of helping to identify their food, but not as a matter of research and he has published nothing on his findings on hair structure.

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1. Associate Biologist, Bureau of Biological Survey, Denver, Colorado.

Study of Hair

Hair samples from nineteen species of mammals taken from the territory around Hays were studied. The species included are: Pocket Gopher, Geomys busarius (Shaw); Prairie Dog, Cynomys ludovicianus (Ord); Cottontail, Sylvilagus floridanus similis Nelson; Ground Squirrel, Citellus tridecemlineatus pallidus (Allen); Brown Rat, Rattus norvegicus (Erxleben); House Mouse, Mus musculus Linnaeus; Jack Rabbit, Lepus californicus melanotis (Mearns); Western Fox Squirrel, Sciurus niger rufiventer (Geoffry); Meadow Mouse, Microtus ochrogaster (Wagner); Opossum, Didelphis virginiana virginiana Kerr; Nebraska Deer Mouse, Peromyscus maniculatus nebrascensis (Coues); Kangaroo Rat, Dipodomys ordii richardsoni (Allen); Harvest Mouse, Reithrodontomys albescens griseus (Bailey); Kansas Pocket Mouse, Perognathus hispidus paradoxus (Merriam); Grasshopper Mouse, Onychomys leucogaster articeps (Rhoads); Short-tailed Shrew, Blarina brevicauda brevicauda (Say); Little Short-tailed Shrew, Cryptotis parva (Say); Prairie Spotted Skunk, Spilogale interrupta (Rafinesque); Prairie Brown Bat, Myotis californicus ciliolabrum (Merriam).

Two types of hair can be distinguished on most mammals, the guard hair and the fur hair. The guard hair is the longer and coarser hair which protects the fur. The fur hair is much finer, usually shorter, and in most cases has enough crimp to cause it to appear wavy or otherwise variable in outline. The structure of the two types differs, the guard hair being more complex and therefore more significant for diagnosis and identification.

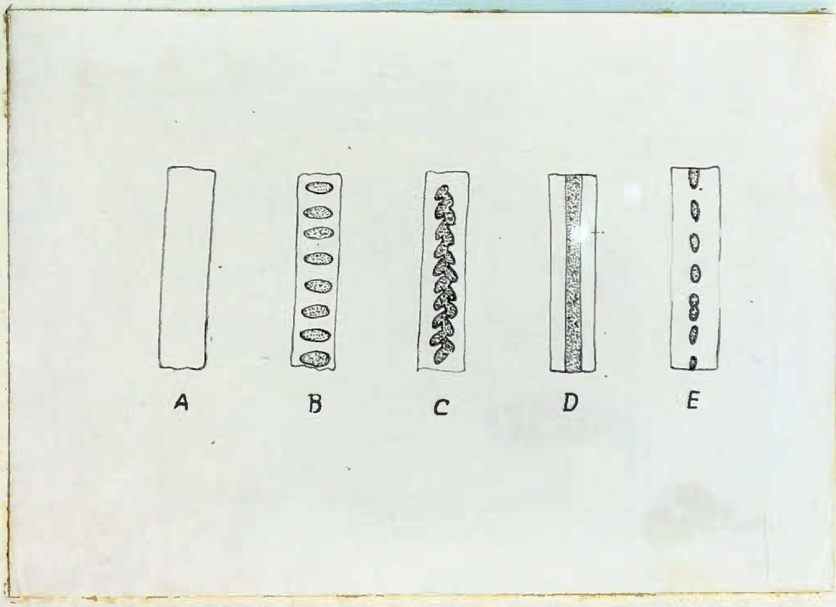

Fig. 1. Types of medullas (after Hausman).
A, medulla absent; b, medulla discontinuous;
C, medulla intermediate; D, medulla continuous; E, medulla fragmentary.

A microscopic study of a hair reveals that it is made up of a shaft composed of a medulla, a cortex and a covering of scales. The medulla is the central core which is pigmented and contains air spaces. The medulla appears dark with portions of it, in most cases, permitting light to shine through. This arrangement helps to give it a definite pattern.

Hausman[1] distinguishes five types of medullas found in hair, according to the patterns of the medulla structures. He has classified them as "absent", "discontinuous", "intermediate", "continuous", and "fragmental". (Figure 1.) The "absent" type refers to hair that has no medulla structure, as in the prairie brown bat; the "discontinuous" type has a broken medulla which is made up of a series of horizontal bars or oval-shaped elements spaced at regular intervals; the "intermediate" type forms a central core in the hair shaft with variable borders more or less notched on either side; the "continuous" medulla forms a simple continuous core extending through the center of the shaft; the "fragmental" type appears to be a continuous medulla that has been broken into fragments.

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1. Hausman, L. A., "Recent Studies of Hair Structure Relationships", Scientific Monthly, Vol. 30, p. 258-277.

The cortex is a translucent layer surrounding the medulla. In some cases it contains pigment granules.

A series of scales is found around the cortex to form an outside covering for the hair shaft. These scales overlap somewhat like shingles, the free edges of which may be seen to form a definite pattern. These overlapping scale edges point toward the tip-end of the hair. The hair shaft, which may be round or flattened, varies in its diameter, being smaller near root-end than in the mid-region. Approaching the tip-end the

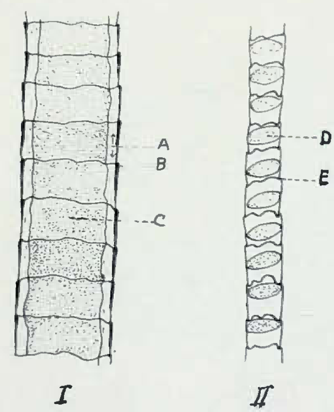

Fig. 2. Diagrammatic drawing showing general hair structure. I. Parts of guard hair; A, cortex; B, edge of scale; C, medulla. II. Parts of fur hair: D, medulla; E, scale.

shaft tapers gradually to a point. The root-end has a bulb-shaped enlargement which is translucent.

In preparation for this study, samples of hair were pulled from the dorsal region of the kinds of mammals studied. Each sample was placed in a separate envelope. These envelopes were carefully labeled with the species names and in this way the hair was retained for microscopic study. Mounts of whole hair were made on microscopic slides. Hair was first mounted in balsam and the slides were properly labeled.

These slides were first studied under the microscope for scale structure, but it was difficult to distinguish them by this examination. Various means were tried to bring out scalation patterns. In an effort to reduce the amount of pigmentation in the hair shaft, hair was placed in solutions of various acids and bases. Hair was soaked in dilute hydrochloric acid for as long as fifteen hours, but showed no noticeable change in the structure. Ammonium hydroxide applied to hair made no noticeable change. No results were obtained with the use of nitric acid. Hair placed in silver nitrate turned brown and the shaft became less translucent. The scales were not discernible.

Boiling hair in water removed the scales from the shaft. This therefore did not bring out the pattern arrangement of scales covering the shaft of the hair.

Bouin's Fluid, Eosin, Borax Carmine and Methylene Blue were used, each in turn, in an attempt to stain the hair, to determine whether they would produce a clearer view of the scales. Bouin's Fluid stained the hair shaft yellow, but the scales were not distinguishable. The other three stains colored only the root section of the hair. Thus none of these stains was of value in bringing out scale structure.

After observing under the microscope a number of dry hairs placed on a slide, it was discovered that some hairs showed better scale patterns than others. This seemingly was due partly to the angle from which the light was thrown on the hair. Upon filtering the light with red, green, blue, and amber in various combinations, the amber alone was found to be helpful in bringing out scalation. This effect was obtained by placing a piece of amber celophane over the mirror of the microscope, thus reflecting the amber light on the hair shaft. It was found that observing the entire length of the hair by moving the slide was valuable in that some variations occurred in different regions of the shaft and that scales were more readily seen on some parts than on others. For hair study the use of amber light along with placing the microscope in various positions relative to the source and amount of light proved the most valuable for discerning scalation.

For each species studied, a dry mount of hair was made by placing a small pinch of hairs on a slide, spreading them out and covering them with a 22 X 40 mm. cover glass. This larger size permitted the covering of the longer hairs. The edges of the cover glass were cemented on the slide with crystal clear cement, thus sealing the hair in an air space. This proved to be a more satisfactory method of mounting, than in balsam.

For comparative purposes of the hair structure of different individuals of a species, study was made of hair from the dorsal side of twelve Nebraska deer mice, five house mice, and two ground squirrels. A typical hair structure of each species was found. Slight variations occurred in medulla patterns, largely in pigmentation. Some of the house mice were darker in color than others; thus more pigment was found in the medullas.

Further study of variations was made in observing hair from different parts of the bodies of individuals. Hair from the dorsal and ventral sides as well as the flank of a pocket gopher showed the general structure to be the same. The medulla patterns varied slightly, but the greater variation was in the amounts of pigment. Hair from the dorsal and the ventral sides of a jack rabbit showed slight differences in the elements of the medulla patterns and the hair of the ventral side contained less pigment. Comparison of the hair samples of the dorsal and ventral sides of a prairie brown bat showed no differences in structure.

A description together with illustration* of the structure of the hair of each mammal studied follows:

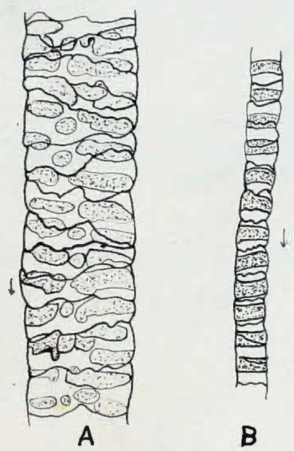

Fig. 3. A, longitudinal section of guard hair of the Pocket Gopher, showing scalation and medulla pattern; B, longitudinal section of fur hair with scale and medulla structure.

*The arrows in this and in other illustrations point toward the root-end of the hair shaft. In this and in the following drawings, except Fig. 22, the hair is magnified approximately 350 X.

Pocket Gopher, Geomys busarius (Shaw)

The root and adjoining shaft section of the guard hair are translucent to the point where the medulla begins. This translucent portion of the shaft shows wavy, transverse scale structure. Beginning where the medulla first appears and proceding toward the tip, the shaft diameter increases rather abruptly. The medulla is of the discontinuous type, varying in from two to four longitudinal rows of medulla elements, depending upon the shaft diameter.

The fur hair has a discontinuous medulla, forming transverse, dark bands at regular intervals. The scales form wavy, transverse lines at regular intervals.

Prairie Dog, Cynomys ludovicianus (Ord)

The guard hair has a continuous medulla which varies in diameter in different regions of the shaft. A prominent cortex structure is found with slight traces of pigment. The scalation is close with lines of scales considerably unparallel and irregular.

The fur hair is translucent and without medulla. A definite transverse scale pattern is distinguishable. A cross section of the guard hair shows it to be flattened considerably, but cross sectioning is of little value in determining scale and medulla pattern.

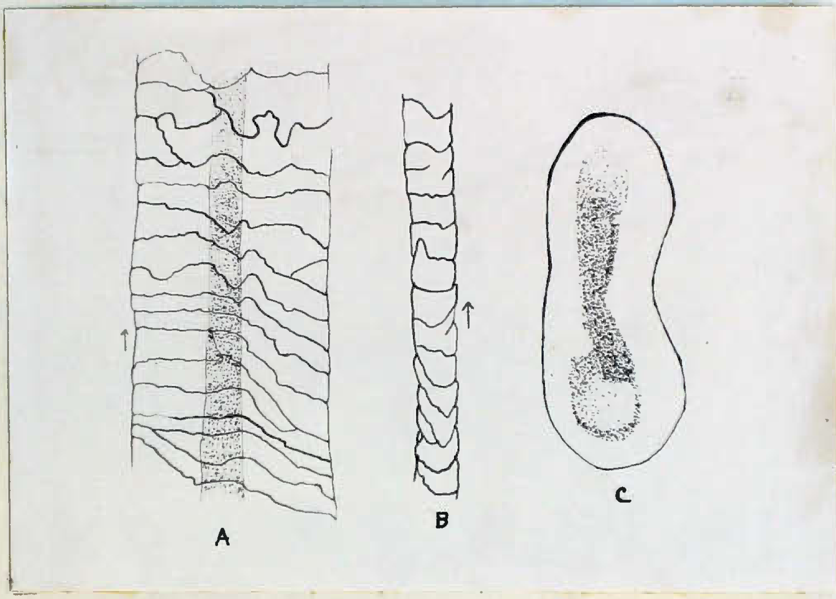

Fig. 4. A, longitudinal section of guard hair of the Prairie Dog, showing scalation and the continuous medulla; B, fur hair showing scalation; C, cross section of guard hair showing medulla.

Cottontail, <u>Sylvilagus floridanus similis</u> Nelson

The medulla of the guard hair extends full width of the shaft. The pattern varies in different regions of the shaft, a typical design being a single longitudinal row of bar-like figures on one side running parallel with two to three rows of rounded and oval-shaped designs. The scale pattern is not readily discernible in the region of heavy medullation.

The fur hair has a series of transverse bar-like patterns at regular intervals in the medulla, some of which are rounded into oval bodies. The scales vary somewhat, with a characteristic pattern having the scale lines nearly parallel and with a decided acute angle pointing toward the tip-end of the hair.

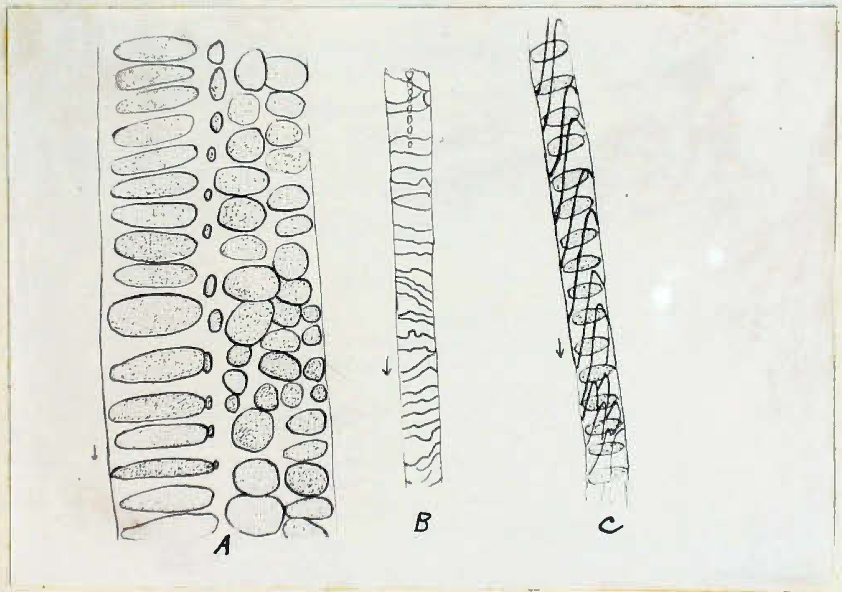

Fig. 5. A, longitudinal section of guard hair of a Cottontail rabbit, showing medulla pattern; B, section of guard hair near root-end where medulla begins; C, longitudinal section of fur hair showing both scalation and medulla pattern.

Ground Squirrel, Citellus tridecemlineatus pallidus (Allen)

The guard hairs are quite heavily pigmented so that a clear cut medulla pattern is difficult to determine. A typical pattern is of the discontinuous type with various shaped figures forming a longitudinal row. The scalation lines, where discernible, are transverse and at quite regular intervals.

The fur hair has no medulla and is quite translucent. In some sections the scales cause the shaft to appear to have an irregular border.

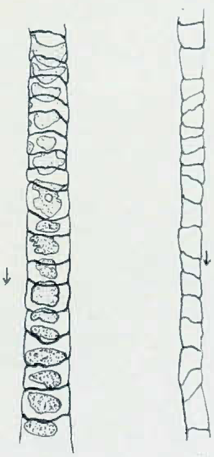

Fig. 6. Ground Squirrel hair. A, guard hair structure showing medulla and scales; B, fur hair showing scalation; no medulla is present.

Brown Rat, Rattus norvegicus (Erxleben)

Some guard hairs are quite heavily pigmented so that a definite medulla pattern is not readily seen. A characteristic medulla pattern is largely continuous with deep indentions on the sides and with translucent areas through the mid-region forming elongated figures. The guard hair scalation is indefinite.

The fur hair has a discontinuous medulla, showing at regular intervals oval-shaped bars in the central part of the shaft. The transverse scales are discernible.

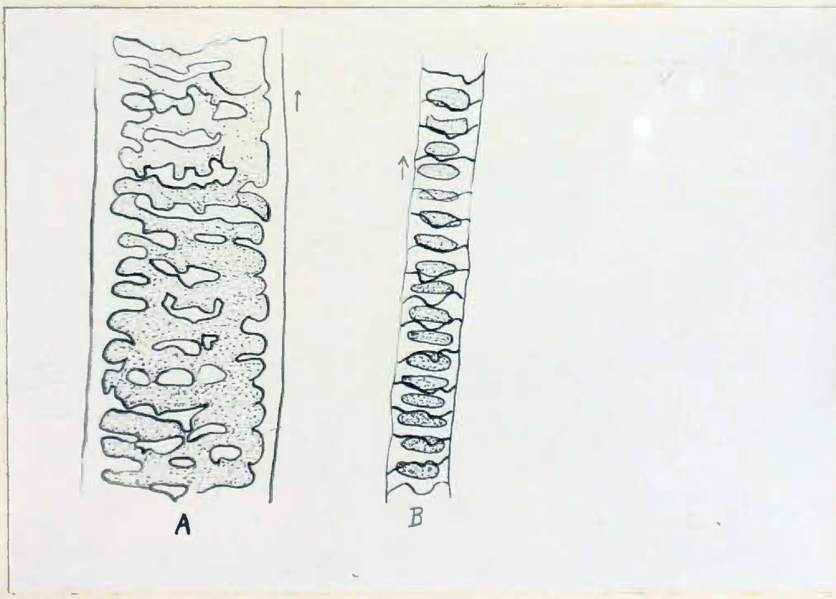

Fig. 7. Brown Rat hair. A, longitudinal section of guard hair showing medulla pattern; no definite scale structure is determined; B, fur hair showing scalation and discontinuous medulla.

House Mouse, Mus musculus Linnaeus

The guard hair has the medulla extending the full width of the diameter of the shaft in the mid-region. A typical pattern appears with three longitudinal rows of oval-shaped translucent openings. Darker colored mice show less of the translucency, but the medulla design remains the same. The scalation is quite varied.

In the fur hair structure is found the discontinuous medulla with bar-like patterns at regular intervals. The scalation lines are irregular in shape.

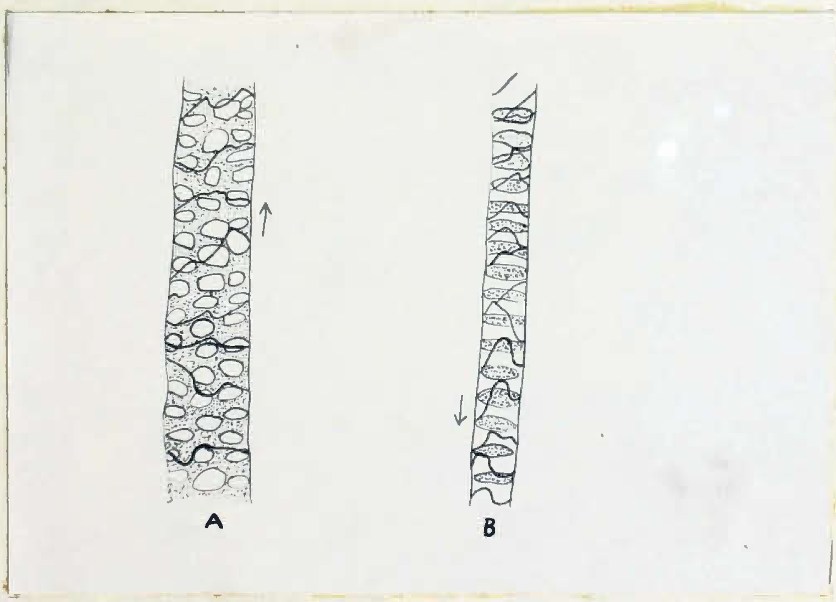

Fig. 8. House Mouse hair. A, guard hair showing scalation and medulla pattern; B, fur hair showing scalation and medulla.

Jack Rabbit, Lepus californicus melanotis (Mearns)

The guard hair is usually heavily pigmented. The medulla pattern extends the full diameter of the shaft and a characteristic pattern is a continuous structure with deep indentions on the sides with rows of irregular shaped translucent openings. Near the root-end of the guard hair is found a discontinuous medulla forming long slender bands. Here are seen diagonal scale lines at regular intervals. A cross section from the mid-region

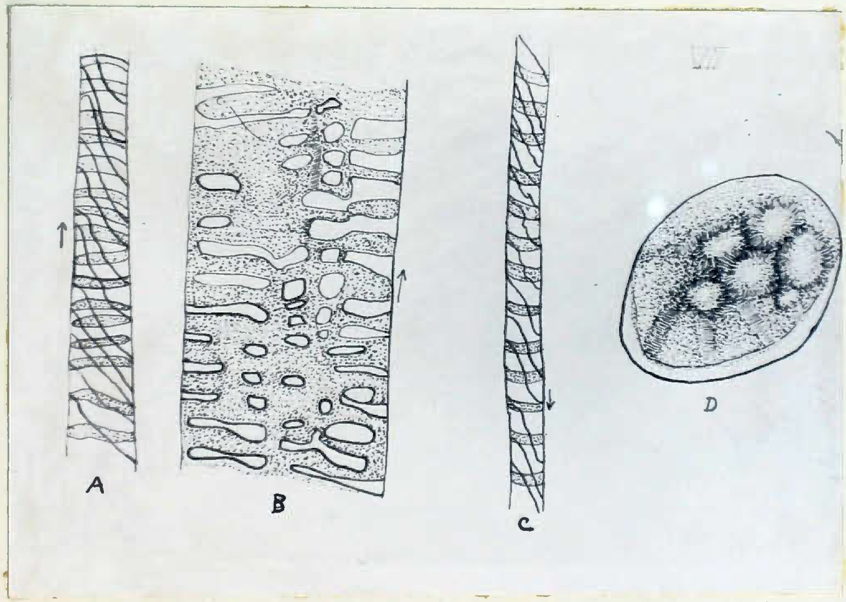

Fig. 9. Jack Rabbit hair. A, longitudinal section of guard hair near root-end showing scalation and medulla; B, longitudinal section of mid-region of guard hair; C, fur hair showing scalation and medulla; D, cross section of guard hair showing medulla.

of the shaft shows that the hair is flattened.

The fur hair shows a series of bands in a discon-tinuous medulla. The scale lines run diagonally across the shaft.

Western Fox Squirrel, Sciurus niger rufiventer (Geoffry)

The guard hairs are quite often heavily pigmented so that it is difficult to determine a definite medulla pattern. A characteristic structure in the mid-region is

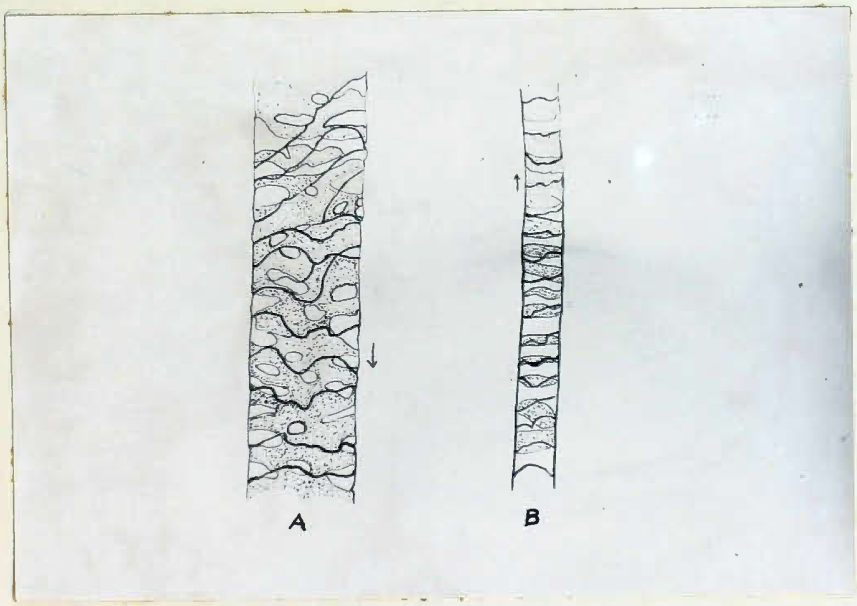

Fig. 10. Western Fox Squirrel hair. A, longitudinal section of guard hair showing scalation and medulla pattern; B, fur hair showing medulla and scalation.

the medulla extending full width of the shaft with prominent indentions on the sides and a few small translucent openings through the middle. The scalation lines are irregular and wavy and extend partly in a diagonal direction.

The fur hair has the discontinuous medulla, the pattern being irregular shaped bars reaching across the full diameter of the shaft. The scales occur at regular intervals.

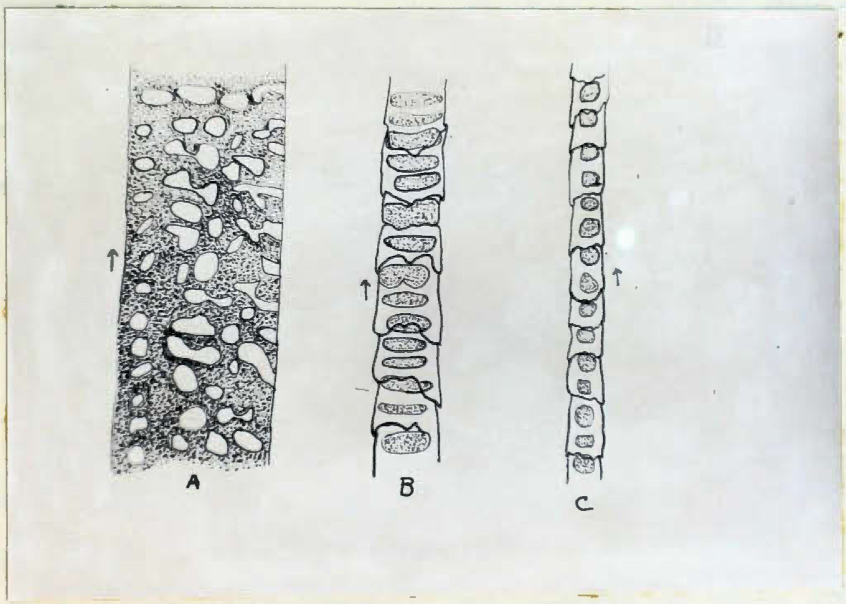

Fig. 11. Meadow mouse hair. A, longitudinal section of guard hair nearer the tip-end showing medulla pattern; B, same hair as in A, mid-section where diameter is reduced and medulla becomes discontinuous; C, mid-section of fur hair.

Meadow Mouse, Microtus ochrogaster (Wagner)

In the guard hair nearer the tip-end the medulla is continuous with various shaped translucent openings occuring in rows. In some guard hairs the diameters are greatest nearer the tip-end and then reduce considerably in the mid-region, becoming wider toward the root-end. The medulla changes from the continuous to the discontinuous bar pattern. In this region the scale edges form a notched effect on both sides of the shaft.

The fur hair has a definite scale pattern, the scale edges being somewhat dentate. The medulla is discontinuous with some patterns round-like and others forming dark bars across the shaft.

Opossum, Didelphis virginiana virginiana Kerr

The guard hair shows considerable cortex and a discontinuous medulla. The medulla pattern is quite irregular with translucent openings. The scale lines are found at regular intervals, but because of their irregularity they appear to cross in some cases.

The fur hair has no definite medulla, being largely translucent. The scalation pattern is quite definite, the scale lines running mostly diagonally at regular intervals with the notched effect of the scale edges causing the shaft to appear irregular in outline.

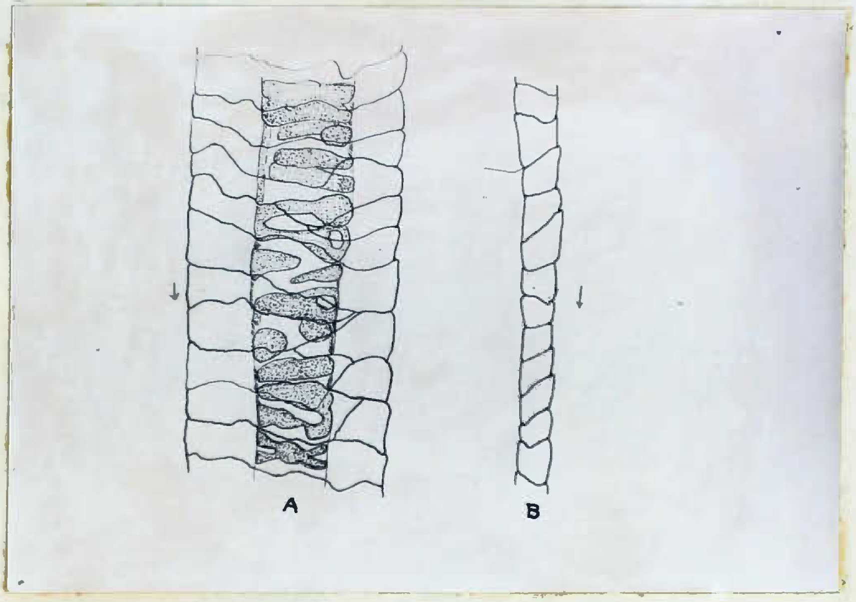

Fig. 12. Opossum hair. A, longitudinal section of guard hair showing medulla and scalation; B, fur hair with no definite medulla shown.

Nebraska Deer Mouse, Peromyscus maniculatus nebrascensis (Coues)

The guard hair has a discontinuous medulla pattern. From two to three longitudinal rows of rounded dark areas occur. A lighter streak shows across the center of each shaded area. The scalation is indefinite in the mid-region, but prominent scales are found near the root-end of the hair where the irregular transverse scale lines form prominent notches on the shaft border.

The fur hair shaft has scales forming acute angles with the points rounded. The medulla is discontinuous with disc-shaped patterns at regular intervals.

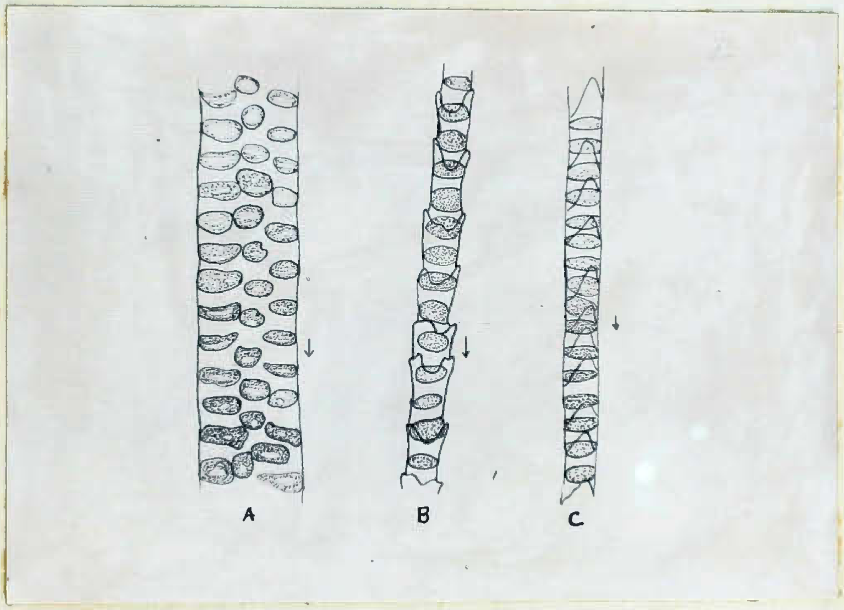

Fig. 13. Nebraska Deer Mouse hair. A, longitudinal section of guard hair at largest diameter nearest tip of shaft; B, longitudinal section of guard hair near root showing scalation and medulla; C, longitudinal section of fur hair showing scalation and medulla.

Kangaroo Rat, Dipodomys ordii richardsoni (Allen)

The section of the guard hair beginning with the root-end and reaching to the point where the medulla begins is translucent and roughly scaled. The medulla pattern is made up of from one to three longitudinal rows of elongated shaded figures which have translucent areas in the centers of the figures. The scale lines occur at regular intervals at nearly right angles to the border lines of the shaft.

Since only one type of hair is found on this animal, no distinction is made between guard hair and fur hair.

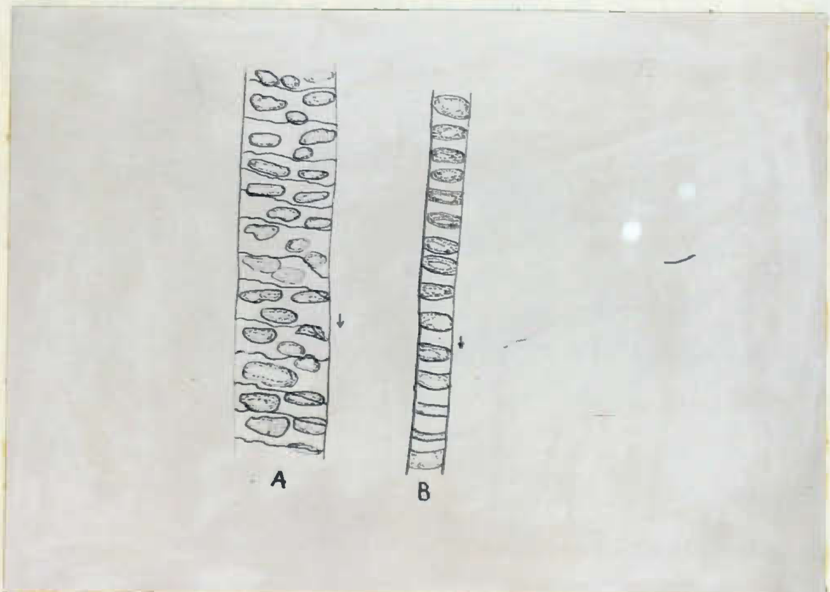

Fig. 14. Kangaroo Rat hair. A, longitudinal section of hair in region of the greatest diameter; B, the same hair as in A showing longitudinal section near tip-end. Only one type of hair is found on this mammal.

Harvest Mouse, Reithrodontomys albescens griseus (Bailey)

The guard hair near the root-end has a definite scalation pattern which gives the shaft borders a prominent notched effect. This notched border gradually diminishes as the mid-region of the shaft is approached. A characteristic guard hair has a medulla pattern of from one to three longitudinal rows of oval-shaped figures, with center portions more translucent. The scale lines dip toward the root-end.

The fur hair has a medulla pattern of oval-shaped

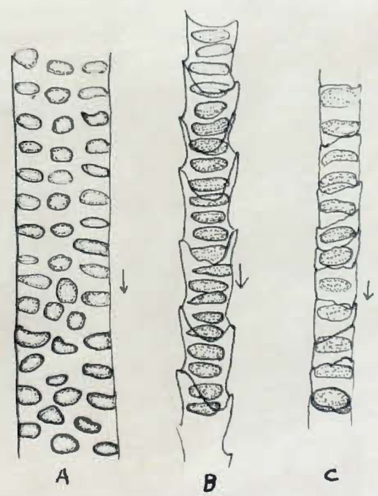

Fig. 15. Harvest Mouse hair. A, longitudinal section of guard hair in mid-region showing medulla pattern; B, the same guard hair showing scalation and medulla near the root-end; C, longitudinal section of fur hair in mid-region showing medulla and scalation.

figures, translucent in the central areas. The scale lines tend to extend diagonally across the shaft.

Kansas Pocket Mouse, Perognathus hispidus paradoxus (Merriam)

The guard hair has a much greater diameter than the guard hairs of the other species of mice included in this study. It has as its characteristic shape a shaft that tapers rapidly at the root-end, corresponding in shape to that of a sharpened lead pencil. The greater diameter is

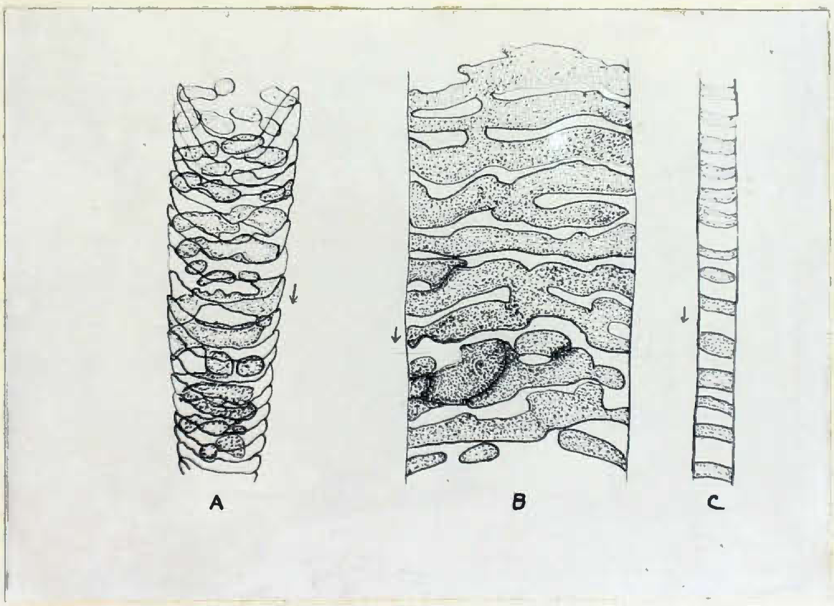

Fig. 16. Pocket Mouse hair. A, longitudinal section of guard hair close to root; B, same hair as in A in mid-region of shaft; C, fur hair showing no definite scales.

maintained throughout most of the shaft, tapering again, gradually, at the tip-end. The medulla, extending across the full diameter of the shaft, is broken with horizontal translucent incisions, some of which extend the full width of the shaft. The scalation is most prominent on the tapering section near the root. Here, close curving scale lines leave their notched effect on the borders of the shaft.

The fur hair shaft is quite smooth, and contains a discontinuous medulla of regularly spaced bars. No definite scalation is observed.

Grasshopper Mouse, Onychomys leucogaster arcticeps (Rhoads)

In the region of the greater diameter of the guard hair, no definite scale pattern is observed, but nearer the root-end the scale pattern is a curved line forming a notched effect at the shaft borders. In this region the medulla is nearly continuous along the shaft borders. Prominent irregular medulla parts project toward the center to bridge across translucent areas. Through the middle region nearer the tip-end, the medulla breaks up into three longitudinal rows of ovate translucent figures. These egg-shaped patterns are quite regular in size and in their horizontal spacing arrangement. Some are slightly shaded.

The fur hair has a broken medulla of ovate patterns and has curved scale lines that are spaced at regular intervals. The figures that make up the medulla are darker than the similarly shaped ones found in the guard hair, but each fur hair pattern unit is larger than that of the guard hair. The diameter of the hair is comparatively small.

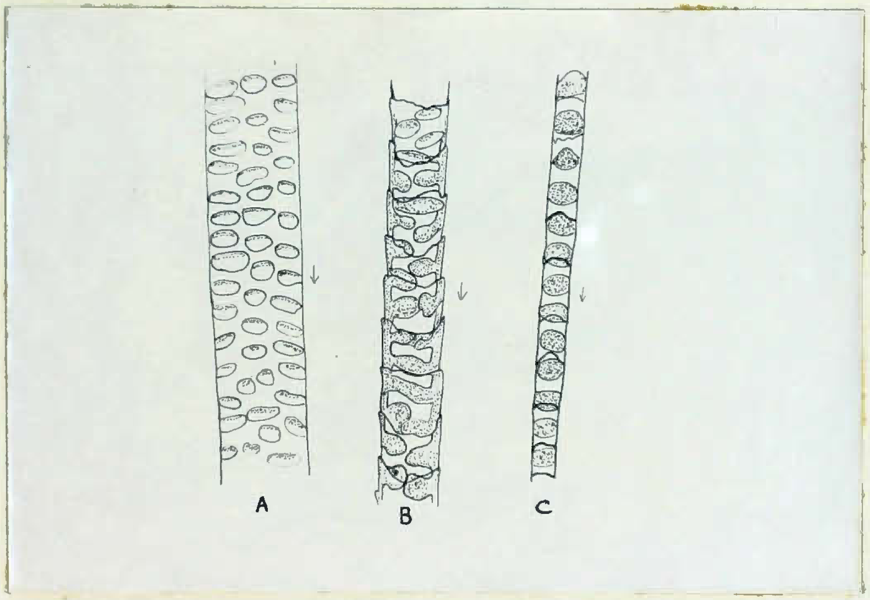

Fig. 17. Grasshopper Mouse hair. A, longitudinal section of guard hair at region of greatest diameter, close to tip, showing medulla pattern; B, same guard hair as in A, but closer to root-end, showing scalation and varied medulla; C, mid-section of fur hair showing scalation and medulla.

Short-tailed Shrew, Blarina brevicauda brevicauda (Say)

The hair structure of this species is peculiar in that the hair shaft has contrasting variations in diameters. In three to four regions along the shaft, the diameter reduces considerably at points where the shaft has a decided curve. In these curved areas the shaft appears to be flattened. In the region nearer the tip-end, where the shaft diameter is the greatest, the scalation is closely arranged at regular intervals, the horizontal

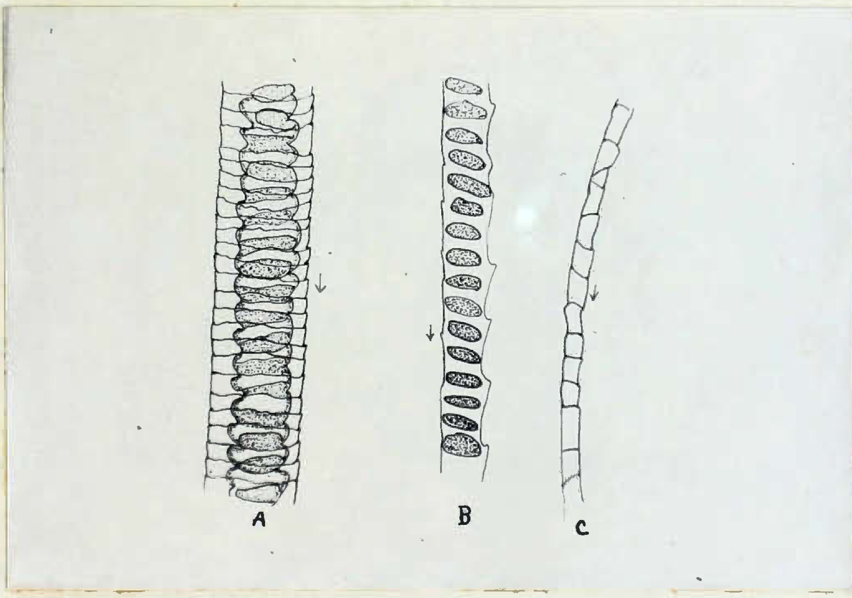

Fig. 18. Shrew (Blarina) hair. A, Longitudinal section of hair at region nearer tip, showing scalation and medulla pattern; B, Longitudinal section of same hair as in A, but in mid-section in close proximity to narrowed diameter; C, the same hair as in A and B but at narrowest diameter in bend of shaft.

scale lines running nearly parallel and forming serrated shaft borders. In close proximity to the curved areas, the scales appear to be much longer, forming a prominent notched shaft border. The medulla varies from an intermediary type to a discontinuous pattern.

Since only one kind of hair was found on a specimen of this species, no distinction is made between fur hair and guard hair.

Little Short-tailed Shrew, Cryptotis parva (Say)

As in the structure of the hairs of Blarina, the hair shaft of Cryptotis curves from two to four times at intervals where the diameter is reduced to its minimum. In the region of the greatest diameter the scale pattern is much like the pattern in Parva hair. The scalation is close, with horizontal lines, slightly wavy, running nearly parallel across the shaft. The medulla found in the region nearer the tip-end does not extend full width of the shaft. A column of rectangular-like figures is formed, with a slight showing of translucent areas between the rectangles. In other regions of the shaft, the medulla is heavily pigmented, forming a discontinuous series of horizontal bars.

Several hairs from different parts of the body of a specimen of Cryptotis were examined under the microscope for variations in structure. Since only one type of hair was found, no distinction is made between fur hair and guard hair.

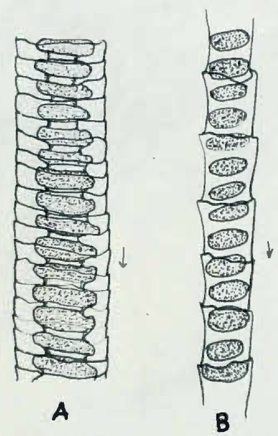

Fig. 19. Shrew (Cryptotis) hair. A, longitudinal section of hair near tip region in the greatest diameter, showing medulla pattern and scalation; B, same hair as in A, but in mid-region.

Prairie Spotted Skunk, Spilogale interrupta (Rafinesque)

The scale pattern varies on the guard hair from a very close scalation nearer the tip-end to a wider scale arrangement nearer the root-end. The medulla varies in diameter, being more continuous with translucent areas making horizontal incisions from the sides. Occasionally ovate patterns occur. More cortex is found in the section where the scales are the closest.

The fur hair has a slightly curved scale line transversing the shaft at regular intervals, varying from a horizontal to a diagonal direction. The medulla is broken or fragmented, forming a narrowed pattern in the center of the shaft. The scale edges cause the shaft to be somewhat irregular in outline. Considerable cortex structure is present in most of the fur hairs observed under the microscope.

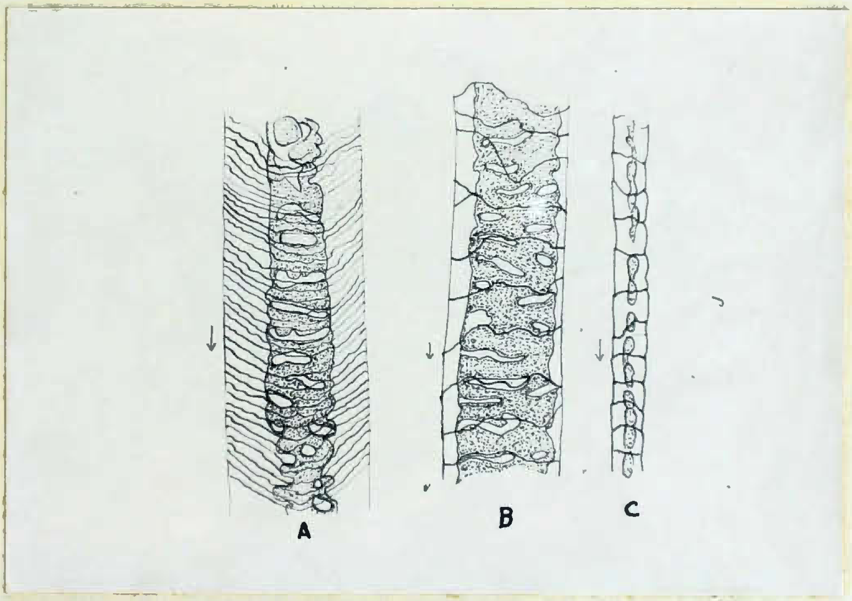

Fig. 20. Spotted Skunk hair. A, longitudinal section of guard hair in region nearer tip-end showing scalation and medulla; B, section of the same hair in region nearer the root-end; C, longitudinal section of fur hair in region nearer root-end showing scalation and medulla.

Prairie Brown Bat, Myotis californicus ciliolabrum (Merriam)

Only one kind of hair was found on specimens of this species, so no distinction is made between guard and fur hairs. A definite scale pattern is prominent on the translucent shaft, no medulla structure being present.

The scale lines extend more in a diagonal direction across the shaft, forming a serrated shaft border.

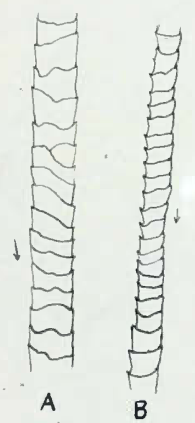

Fig. 21. A, longitudinal section of hair in mid-region showing scalation; medulla is absent; B, the same hair as in A but nearer tip-end showing scalation.

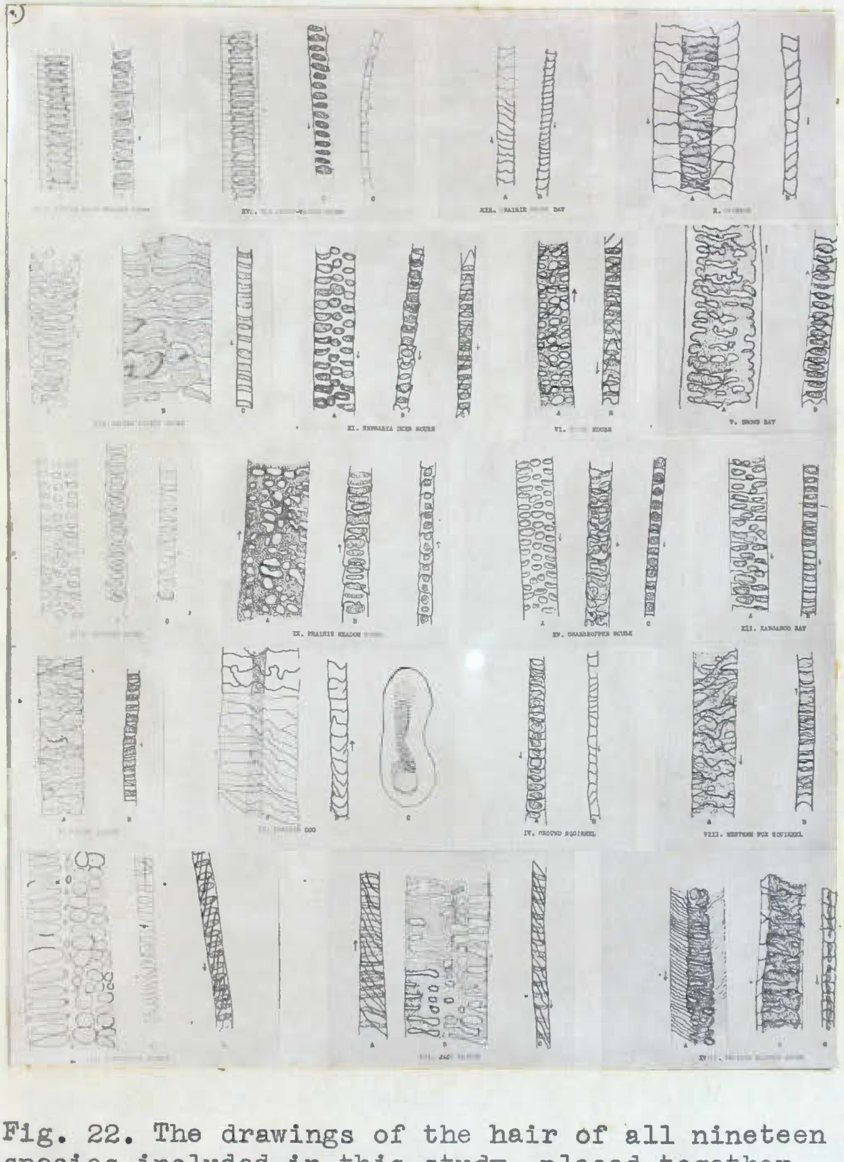

Fig. 22. The drawings of the hair of all nineteen species included in this study, placed together for ready comparison.

Conclusion

Many differences were found in the hair structure of the mammalian species studied. The differences are sufficient in most cases to identify a species. Much similarity was found in the hair structure of the harvest mouse, Nebraska deer mouse, grasshopper mouse and house mouse. Most of this similarity was found in the guard hair medulla patterns. More distinction is found in the fur hair than in the guard hair of these four species of mice. The Nebraska deer mouse fur scalation is quite distinct from the others. Close study of the fur hairs should be a means of distinguishing these species from each other.

The closest similarity was found in the hair structures of the two kinds of shrews. The scalation arrangement and the general shape of the hair shaft of both are nearly identical. Only minor differences were found in the medullas. These two species might be difficult to distinguish by hair structure alone.

The other species studied can be distinguished from each other by guard hair structure, since definite differences exist.

The most variation in medulla structure of hair from one individual animal was found in the hair of the rabbits. However the hair patterns, in spite of variations, remain distinctive.

Each species of mammal does have a definite hair pattern, but this pattern in a few cases is so closely similar to that of another species that some other means might be necessary to make a distinction.

Light control as an aid in distinguishing hair, and especially scale patterns was the most important factor in the microscopic study of hair structure.

Out of this hair study other problems have arisen. Questions such as these remain to be answered: Does any difference exist in the structure of the hair of a young mammal and that of the adult of the same species? What variations may occur in hair structure of a large number of individuals of the same species?

Summary

The study of the nineteen species of mammals was made to determine whether the structure of the hair would serve as a means of identification. Hair samples were taken from each of the nineteen species. They were examined under the microscope. By means of light control,

it was possible, in most cases, to see both the medulla structure and scalation pattern. With the use of a camera lucida, a 43 X objective and a 10 X eyepiece, microscopic drawings were made. It was found to be a practical means of identifying the common small mammals of Western Kansas from hair alone, in all cases of the animals studied except the two species of shrews, which were quite similar in appearance.

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