AN ABSTRACT OF THE THESIS OF

David L. Blew for the Master of Science Degree

in Biology presented on 14 May 1988

Title: Key to Dorsal Guard Hairs of Kansas Mammals

Abstract approved: Dwight L. Spencer

Many keys have been prepared for the identification of dorsal guard hairs, but none have been written for Kansas mammals. The objective of this project was to prepare a key to dorsal guard hairs of Kansas mammals.

Identification was based primarily on maximum hair diameter, medulla diameter, sequence of banding and cuticular scale pattern. For each genus/species in the key a description of the hair is provided along with photographs of scale patterns and medulla configurations. Six domestic species were included in the hair descriptions, but not the key, because of high variability among different breeds of domestic animals.

KEY TO
DORSAL GUARD HAIRS
OF KANSAS MAMMALS

A Thesis

Submitted to

the Division of Biological Sciences

Emporia State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

David L. Blew

May, 1988

Dwight L. Spencer

Approved for Major Department

James Tonell

Approved for Graduate Council

ACKNOWLEDGEMENTS

I would like to thank Dr. Dwight Spencer for his help and guidance, not only during this project, but throughout much of my college career. Thanks also to my other committee members, Dr. James Mayo and Dr. John Parrish. I would like to express my appreciation to Roger Ferguson who could always find equipment when I needed it.

A much deserved thanks goes to my wife Margi whose support and patience is greatly appreciated.

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INTRODUCTION

Information gathered on the food habits of certain wildlife species, whether it is knowledge of seeds eaten by birds, or prey selection by predatory animals, has greatly enhanced the ability to effectively manage wildlife populations. Determination of food habits can be difficult. Seeds that are virtually undigested can be collected from a bird's crop and although their identification is not easy, it is certainly not impossible. Methods of food habit determination are somewhat different for predatory animals. Prey selection information must be based upon examination of scat, partially digested stomach contents, or regurgitated pellets, in the case of predatory birds. Bones, feathers and hair remain relatively undigested, and they must provide the clues to prey selection. When small mammals are the primary prey, skulls and small bones may be crushed beyond identification. Hair undergoes little change during the digestive process, and although difficult to identify, as are seeds, identification is not impossible.

The need for hair identification in the fields of biology and forensic science is well known (Coman and Brunner 1971). Avian and mammalian food habit analyses can not be carried out without knowledge of hair identification. In mammal survey studies, a tuft of hair on a thorn or fence may provide the only clue to a particular mammal's presence in an area. Hair identification also has become important to law enforcement officials. Traces of hair in the bed of a truck may provide evidence needed to convict persons of game law violations.

Many keys for the identification of dorsal guard hairs have been prepared (Coman and Brunner 1971; Moore et al. 1974; Adjoran and Kolenosky 1969), however, none have been written for Kansas mammals. Although some keys include mammals found in Kansas one would have to use several keys to identify unknown hair from Kansas mammals. This would make the task more difficult. The objective of this study was to develop a simple and reliable guide to dorsal guard hairs of Kansas mammals.

METHODS AND MATERIALS

Many different methods for identifying hair have been described. Most of the techniques involve microscopic examination of hair, and those included in this study are described below.

Collection of Specimens

Hair samples were taken from mammal study skins located in the Schmidt Museum of Natural History at Emporia State University, Emporia, Kansas. Domestic mammal hair samples were obtained from a variety of sources. An attempt was made to sample hair for specimens collected from November through February. This was not always possible, particularly with hibernating species. Samples were collected by pulling a small tuft of hair from the mid-dorsal region of the study skin. The hair was washed in alcohol and viewed under a dissecting scope. Different types of guard hair, if there were more than one, were separated and placed in small envelopes for later study.

Shape of Hair Cross-section

Cross-sectioning of hair has been used by several authors (Williams 1934; Mathial 1938; Coman and Brunner 1971). Their methods are not only time consuming, but also require specialized equipment not always available to field biologists. In some cases, shape of the hair in cross-section can be determined by viewing the hair under a dissecting scope. This method was used in some cases in this study.

Hair Diameter

Five guard hairs of each type were mounted in xylene on a glass microscope slide. An ocular micrometer was used to determine maximum hair and medulla diameters at the same point on the hair. Hairs from four study skins of each genus and/or species were examined. Mean maximum hair and medulla diameters were calculated for each study skin. The standard deviation of the means was calculated. If less than four study skins were available, the range of measurements taken was recorded.

Moore and Braun (1983) described a method in which maximum diameters of the hair and the medulla were measured at the same point. A ratio of the two was calculated and 95 % confidence limits established. The ratio was then used as a diagnostic tool in their identification key. It should be noted that the Moore and Braun keys were limited to single families.

An attempt was made to incorporate a similar ratio into this Kansas mammal key. When a key contains several families, there must be a definite relationship between maximum hair diameter and medulla diameter. To test this relationship, correlation coefficients (r) were calculated for 12 of the mammals in the key. In four cases the correlation coefficients were low (Table 1). Although correlation coefficients were not calculated for all genera and species in the study, it was felt that this ratio would be difficult to incorporate in a key because of the low correlation coefficients for at least some of the mammals tested. A mammal that had a high correlation Sylvilagus, in which the medulla was nearly as wide as the hair, resulted in a

Table 1. Correlation coefficient (r) of the maximum hair diameter versus medulla diameter of four mammal genera.

Genus	r	P
Onychomys	0.68	0.005
Peromyscus	0.78	0.001
Ondatra	0.49	0.05
Didelphis	0.51	0.02

ratio of 1:1. This ratio would be of little value because of the number of mammals that have wide medullas.

Cuticular Scale Pattern

Saxinger (1925), as cited by Adjoran and Kolenosky (1960), was one of the first to describe methods for making negative impressions of fibers. His methods were soon adapted for making hair impressions to show cuticular scale patterns. Other techniques have been described for making negative impressions of hair; Schemnitz (1980) described a method for making impressions using a 3 % solution of glycerin jelly. His technique requires up to 2 hours per hair impression preparation. Because most techniques for making impressions are time consuming, a quick method was developed in this study.

The technique involved the use of fish scale impression slides, and acetone. Each hair was washed in acetone to remove dirt and oil. A few drops of acetone were placed on a fish scale impression slide and allowed to stand for about 10 seconds. Excess acetone was removed with

a glass microscope slide and the hair was placed on the fish scale impression slide and covered with a 10 cm square piece of clear plastic bag; light finger-pressure was applied to the hair for 15 to 20 seconds. The plastic was removed and the hair was lifted from the slide with forceps, thus revealing the impression.

It is difficult to label scale pattern types due to the subjectivity of pattern identification. Moore et al. (1974) described and named scale pattern types, some of which are difficult to differentiate. Thus, for this key, photos of the scale pattern type for each genus and/or species are shown, but not described.

Medulla Configuration

Medulla configuration can be a useful diagnostic tool for identifying unknown hair. Temporary slide mounts of hair were made in xylene and medulla configuration for the entire length of the hair was recorded. If the medulla could not be seen, the hair was broken to allow xylene to infiltrate the hair and clear the medulla, thus making it's structure visible. Terminology for the medulla configuration is from Moore et al. (1974) and is discussed in the RESULTS.

Hair Color

Hair color is an unreliable diagnostic tool for identification as it may vary widely within a given species. In some cases, color could be determined, but for most hair, color is given as black, white or gray. In some instances, color is simply given as dark or light.

Hair banding pattern was determined by visual inspection using a

dissecting scope. Banding arrangements are given in the key for most mammals and appear to be a reliable diagnostic character.

Length

Although hair length is of little value as a diagnostic parameter, it does serve as a reference point. Hair length not only differs from one individual to another of the same species, but on different areas of the body of the same animal, and from season to season. Hair lengths given in this guide are to be used only as a reference, and were obtained by measuring hair in the mid-dorsal region of the study skin.

Photographic Techniques

Photographs were taken with a Cannon AE-1, 35 mm, SLR camera and a photomicro unit which attached directly to an extension tube on a compound microscope. Stop down techniques were used to set the f-stop. Shutter speeds usually ranged from 0.5 to 2 seconds. Panatomic X (ASA 32) or Plus X Pan (ASA 125) were the films of choice.

RESULTS

How to Use the Key

Identification of unknown hair should be based on characteristics of several (4 to 6) similar hairs from a sample. Identification measurements should be based on the mean value for several hairs. Identification can be difficult when the sample size is small. Knowledge of hair anatomy is essential when using any hair key. Figure 1 shows typical hair anatomy, and position and configuration of a typical shield. The shield results from an increase in diameter which occurs in the upper half of most mammal hairs. Banding will usually occur in this area and medulla configuration may change at the base of the shield. The terms cortex, medulla and shield are often used in hair descriptions. Although cuticular scale patterns are pictured, they are not discussed or classified because of the subjectivity previously mentioned. Medulla configurations are shown in Figures 2 and 3 and are defined by Moore et al. (1974) as follows:

Fragmental (Figure 2,A): Sporadically interrupted by cortical material.

Uniserial Ladder (Figure 2,B): A continuous single column of discrete cells formed by transverse septa.

Multiserial Ladder (Figure 2,C): Continuous columns of rectangular cells; found only in leporid hairs.

Simple Unbroken Amorphous (Figure 2,D): A continuous tube, garden hose-like, appearing darkened without structural detail in uninfiltrated hairs, or spongy with no distinct cells in hairs that are infiltrated with mounting media where cut or broken.

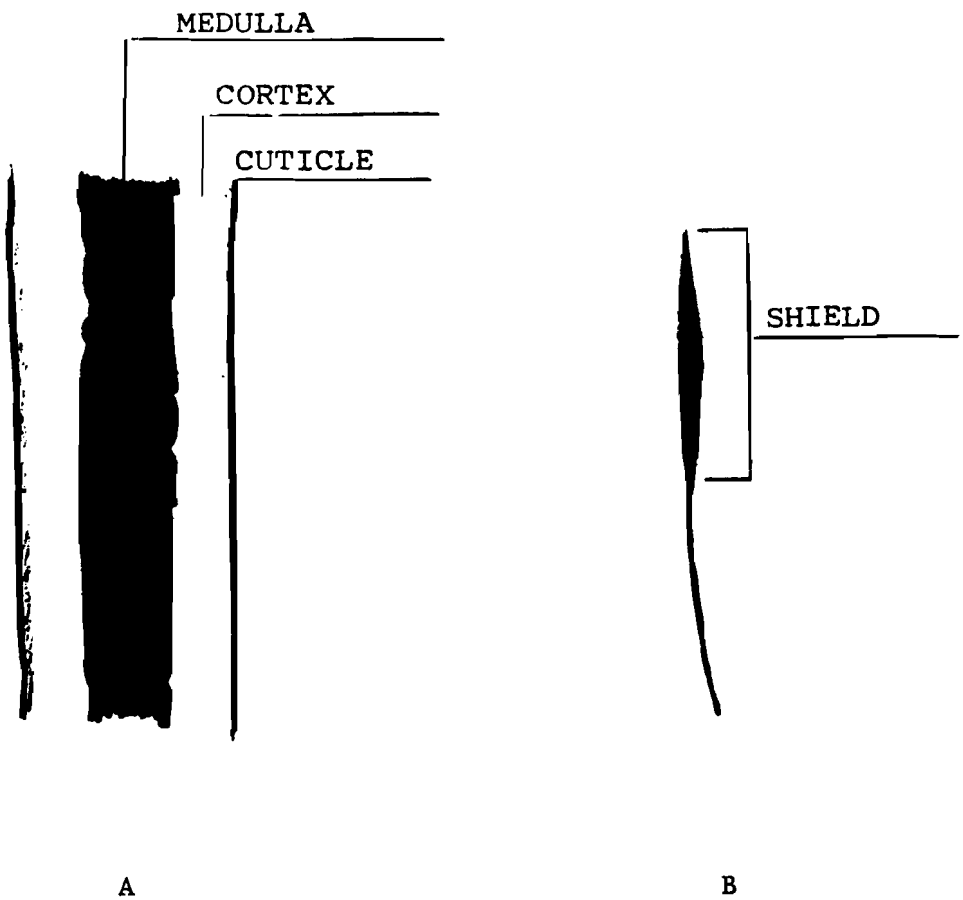


Fig. 1. Internal and external structures of mammal hair: A. cuticle, cortex and medulla, B. configuration and position of a typical shield

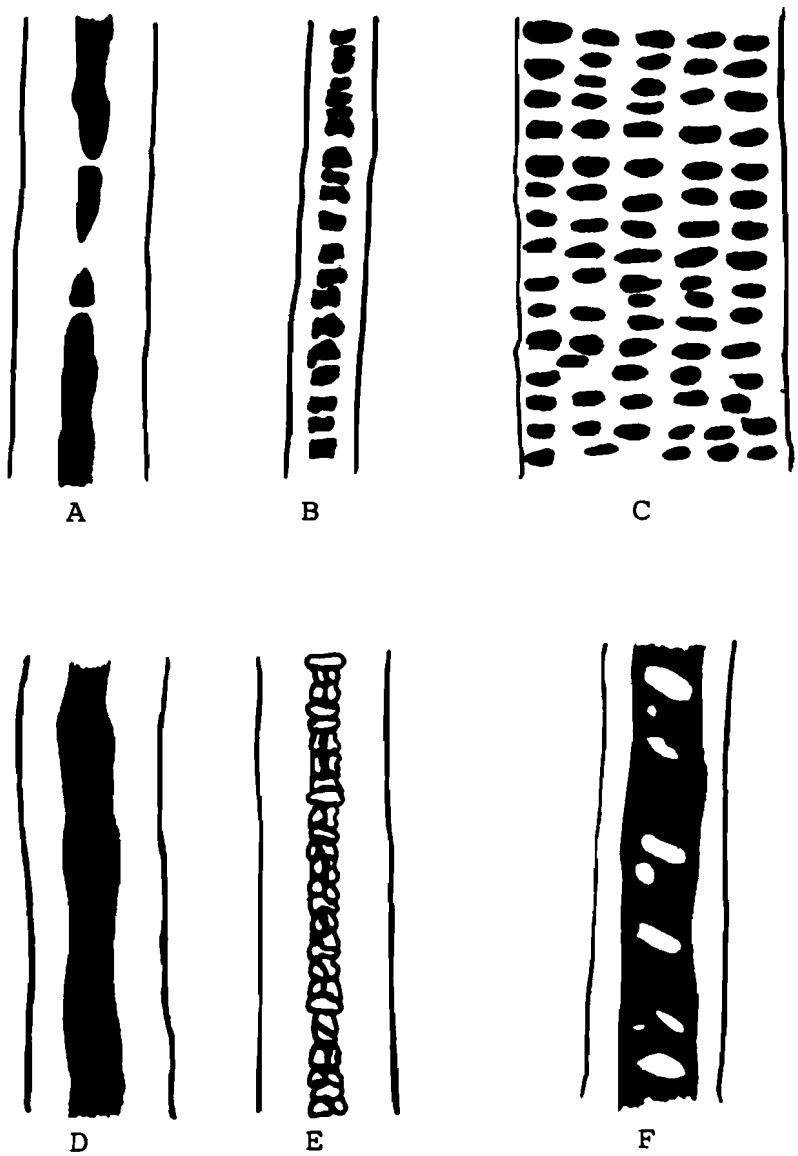


Fig. 2. Medulla configuration types: A. Fragmental, B. Uniserial ladder, C. Multiserial ladder, D. Simple unbroken amorphous, E. Unbroken cellular, F. Unbroken vacuolated

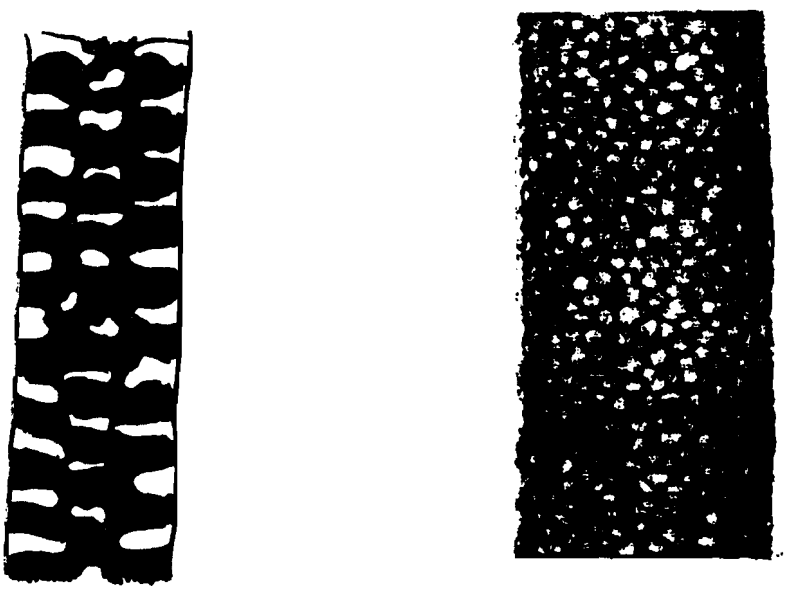
Unbroken Cellular (Figure 2,E): A continuous tube of distinct irregular cells. Infitrating with mounting media or xylene, by cutting or breaking the hair, may be necessary to bring out this detail.

Unbroken Vacuolated (Figure 2,F): A continuous tube with distinct cells, some of which appear as large, vacuoles extending entirely across a wide medulla.

Unbroken with Cortical Intrusions (Figure 3,A): A continuous tube with cortical material appearing as projections and/or islands in the medulla.

Unbroken Lattice (Figure 3,B): A continuous tube of many small, irregularly arranged, thin-walled, often polygonal cells in hairs with a narrow cortex which may appear absent.

It is not possible to identify all hair. Domestic animals show a wide variation in color, banding, length, and shape (curly or straight). Because of this variability, some domestic animals are included in the descriptions, but not in the key. The key is dichotomous and artificial, using hair characteristics which are easily determined. In some instances, the key may terminate at several genera (29b), in which case photos of scale pattern and other characteristics may be referred to in order to separate similar species or genera.



A B

Fig. 3. Medulla configuration types: A. Unbroken with cortical intrusions, B. Unbroken lattice

KEY TO DORSAL GUARD HAIRS

OF KANSAS MAMMALS

1a. Hair unbanded..2

2a. Hair white or light colored..3

3a. Hair with a well defined shield..*Didelphis*

3b. Hair without well defined shield, uniform in diameter except at extremities..4

4a. Maximum hair diameter $\leq$ 0.120 mm..*Spilogale*

4b. Maximum hair diameter > 0.120 mm..*Mephitis*

2b. Hair black or dark colored..5

5a. Maximum hair diameter $\leq$ 0.105 mm..6

6a. Maximum hair diameter < 0.070 mm..7

7a. Medulla uniserial ladder throughout or, uniserial ladder through 3/4 the hair length..8

8a. Hair with wrinkled appearance at base..9

9a. Some hairs with shield..*Blarina*, *Scalopus*

9b. Shields absent..*Cryptotis*

8b. No wrinkled appearance at base or elsewhere..*Onychomys*

7b. Medulla uniserial ladder at base and unbroken with cortical intrusions in shield or, unbroken with cortical intrusions throughout..11

11a. Hair with scale pattern shown below..

..*Mustela f.* and *n.*

11b. Scale pattern not as shown..12

12a. Medulla nearly as wide as hair, little or no cortex visible..*Microtus*

12b. Medulla not as wide as hair, cortex conspicuous..13

13a. Cortex dark, pigment visible in cortex..*Neotoma*

13b. Cortex light colored..14

14a. Upper scale margins smooth and close as in Figure 22C..*Synaptomys*

14b. Upper scale margins not as above..15

15a. Maximum hair diameter $\leq$ 0.050..*Mus*

15b. Maximum hair diameter > 0.050..*Peromyscus*

6b. Maximum hair diameter > 0.070 mm..16

16a. No internal structures visible, cortex dark, medulla margins indistinct..*Spilogale*

16b. Not as above, cortex with little or no pigment..17

17a. Shield starts near base..*Perognathus*, *Zapus*

17b. Shield starts well above base..18

18a. Hair with scale pattern shown below

..*Sigmodon*

18b. Hair not as above, may have red or gray tint..*Sciurus*

5b. Maximum diameter > 0.105 mm..19

19a. Medulla usually 80 % or more of maximum diameter..20

20a. Medulla is multiserial ladder..21

21a. Maximum diameter > 0.130 mm..Sylvilagus

21b. Maximum diameter ≤ 0.130 mm..Lepus

20b. Medulla not uniserial ladder..22

22a. Shield starts near base..Perognathus, Zapus

22b. Shield starts well above base..Spermophilus

19b. Medulla < 80 % of maximum diameter..23

23a. Medulla usually ≤ 50 % of maximum diameter or medulla absent..24

24a. Maximum diameter > 0.133 mm..Castor

24b. Maximum diameter ≤ 0.133 mm..Ondatra

23b. Medulla > 50 % of maximum diameter..25

25a. Hair with scale pattern shown

..Mustela

25b. Hair not as above..Mephitis, Procyon

1b. Hair banded..26

26a. Maximum diameter ≤ 0.075 mm..27

27a. Maximum diameter ≤ 0.040 mm..28

28a. Hair with light colored tip..Mus

28b. Hair with dark colored tip..Zapus

27b. Maximum diameter > 0.040 mm..29

29a. Shield starts near base of hair..Dipodomys

29b. Shield starts well above base..*Synaptomys*, *Geomys*, *Reithrodontomys*, *Neotoma*, *Microtus*

26b. Maximum diameter > 0.075 mm..30

30a. Hair twice banded (ie. black-white-black-white or other color combinations)..31

31a. Medulla diameter ≤ 80 % of maximum diameter..32

32a. Distal band light colored..*Felis*

32b. Distal band dark colored..*Canis*

31b. Medulla diameter > 80 % maximum diameter..*Sciurus*

30b. Hair not twice banded..33

33a. Maximum diameter > 0.150 mm..34

34a. Medulla configuration unbroken lattice..35

35a. Maximum diameter ≤ 0.300 mm..*Odocoileus*

35b. Maximum diameter > 0.300 mm..*Antilocapra*

34b. Medulla configuration not unbroken lattice..36

36a. Maximum diameter > 0.250 mm..*Erethizon*

36b. Maximum diameter ≤ 0.250 mm..*Marmota*

33b. Maximum diameter ≤ 0.150 mm..37

37a. Medulla usually > 85 % of maximum diameter..38

38a. Medulla configuration Multiserial ladder..39

39a. Maximum diameter > 0.131 mm..*Sylvilagus*

39b. Maximum diameter ≤ 0.131 mm..*Lepus*

38b. Medulla configuration not multiserial ladder..40

40a. Hair with scale pattern shown below

..Sigmodon

40b. Hair not as above..41

41a. Hair with a black tip $\leq$ 1 mm..Cynomys

41b. Hair with a black tip > 1 mm..Spermophilus

37b. Medulla diameter $\leq$ 85 % of maximum diameter..42

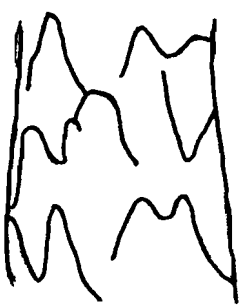
42a. Medulla uniserial ladder in base..Rattus

42b. Medulla not uniserial ladder in base..43

43a. Hair with white tip..Taxidea

43b. Hair with dark tip..44

44a. Hair with scale pattern shown below



..Urocyon

44b. Not as above..45

45a. Maximum diameter $\leq$ 0.110 mm (Vulpes velox may be larger but averages 25 mm in length, while Procyon averages 54 mm in length)..Vulpes

45b. Maximum diameter> 0.110 mm..Procyon

HAIR DESCRIPTIONS

Individual mammal descriptions, excluding domestic animals, are in taxonomic order after Cockrum (1952). Descriptions are organized in a similar order, with banding and color described first. In cases where both banded and unbanded hairs are present, each type is described separately. Some species have two different types of banded or unbanded hair and are designated as "A" or "B" to differentiate in the descriptions. Banding sequence is given from hair tip to the base. Medulla configurations are given from the hair base to the tip. Average maximum hair and medulla diameters are given with standard deviations in parenthesis. Measurements used for keying should be based on an average of several hairs.

Didelphis virginiana (Opossum) Figure 4.

Unbanded hair: Hair white; cortex nearly transparent; average length 58 mm; medulla is simple amorphous or unbroken with cortical intrusions; maximum diameter 0.1326 mm (± 0.0047 mm); medulla diameter 0.0869 mm (± 0.0011 mm).

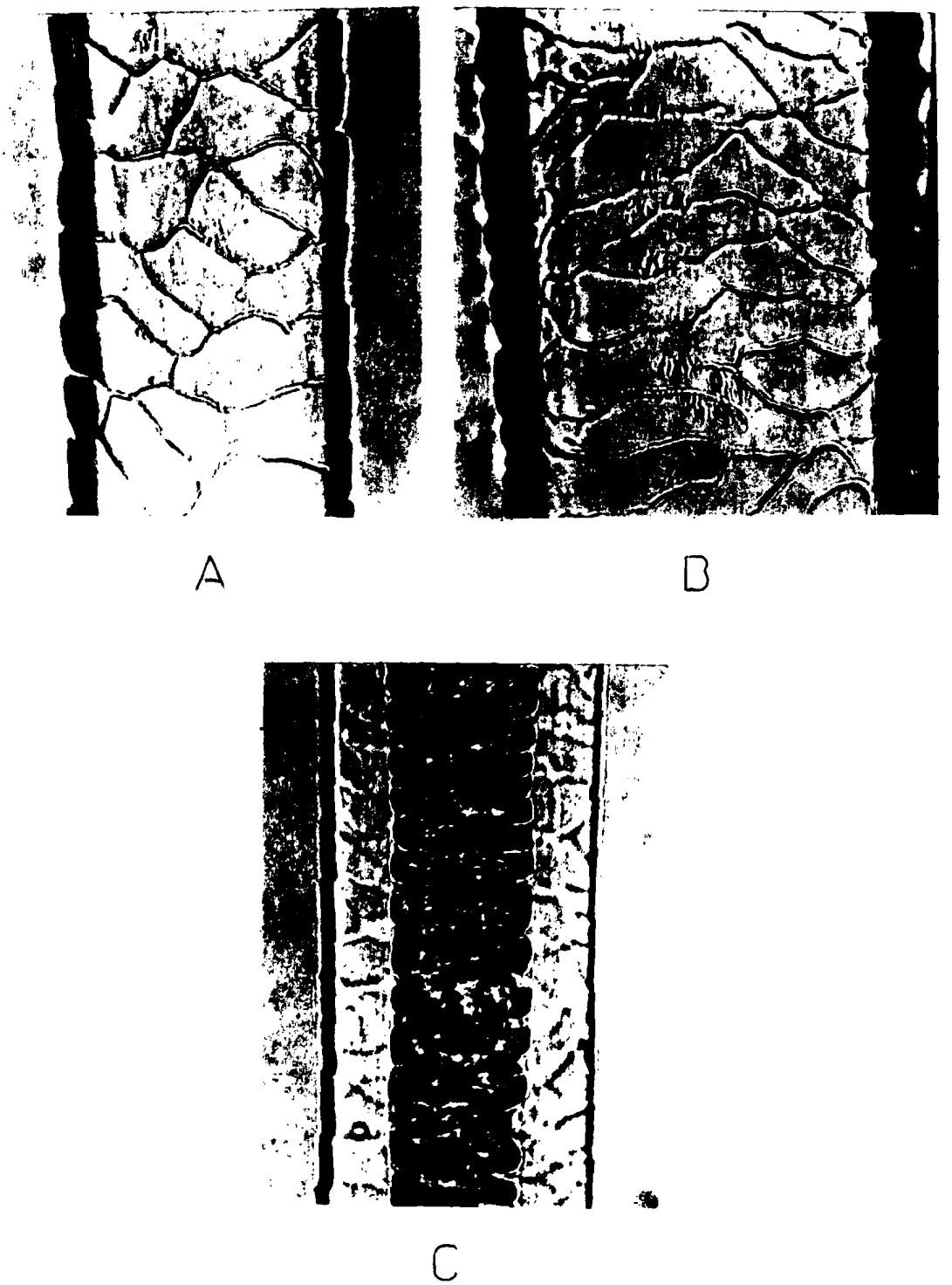


Fig. 4. Cuticular scale pattern and medulla configuration for Didelphis virginiana: A. lower shaft scale pattern, B. Upper shaft scale pattern, C. Medulla configuration.

Blarina hylophaga (Short-tailed Shrew) Figure 5

Unbanded hair: Hair light gray to black; average length 7 mm; medulla uniserial ladder throughout most of hair; some hairs with conspicuous shield others with no shield; maximum diameter 0.0375 mm (± 0.0046 mm); medulla diameter 0.0271 mm (± 0.0043 mm).

Cryptotis parva (Least Shrew) Figure 5

Unbanded hair: Hair gray; average length 5.3 mm; medulla uniserial ladder; diameter varies with some areas measuring as wide as the hair; no shields present; maximum diameter 0.0249 mm (± 0.0028); medulla diameter 0.0181 mm (± 0.0023 mm).

Scalopus aquaticus (Eastern Mole) Figure 5

Unbanded hair (A): Hair gray; average length 7 mm; medulla fragmented; not true guard hairs but shield is present; maximum diameter 0.0528 mm (± 0.0012 mm); medulla not measured due to fragmentation.

Unbanded hair (B): Hair gray; average length not measured but generally shorter than unbanded (A); medulla uniserial ladder; maximum diameter 0.0129 mm (± 0.0012 mm); medulla diameter 0.0105 mm (± 0.0019 mm).

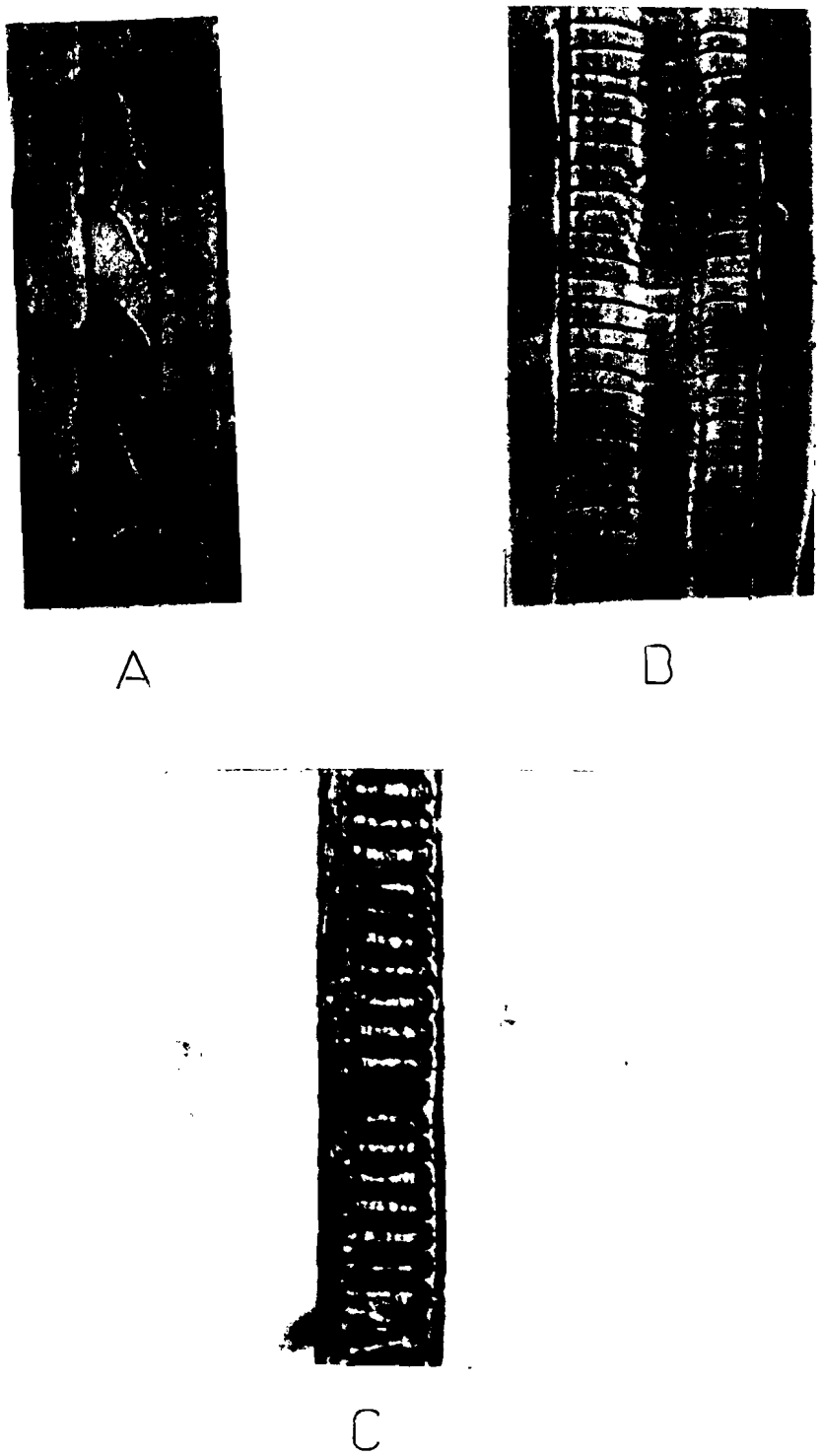


Fig. 5. Cuticular scale pattern and medulla configuration for Blarina hylophaga, Cryptotis parva, and Scalopus aquaticus: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

Sylvilagus sp. (Cottontail Rabbits) Figure 6

Banded hair: Banding sequence - black, white, black; lengths range from 25 mm to 30 mm; medulla is multiserial ladder; maximum diameter 0.1395 mm (± 0.0061 mm); medulla diameter 0.1326 mm (± 0.0067 mm); a trough, visible under a dissecting scope, extends along the hair from tip to base.

Unbanded hair: Hair black; average length 45 mm; medulla multiserial ladder; maximum and medulla diameters similar to banded; not as numerous as banded hair; may be considered as over-hairs.

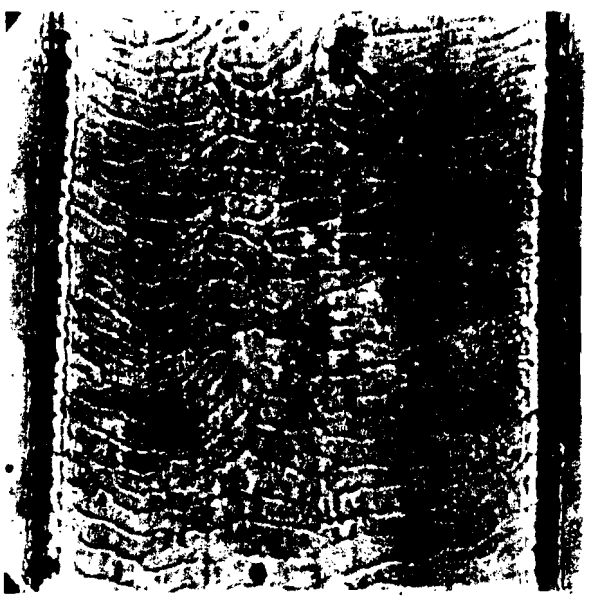
Lepus sp. (Jack Rabbits) Figure 6

Banded hair: banding sequence - black, white, black; average length 37 mm; medulla multiserial ladder; maximum diameter 0.1212 mm (± 0.0084 mm); medulla diameter 0.1171 mm (± 0.0087 mm); under a dissecting scope, a trough is visible the length of the hair.

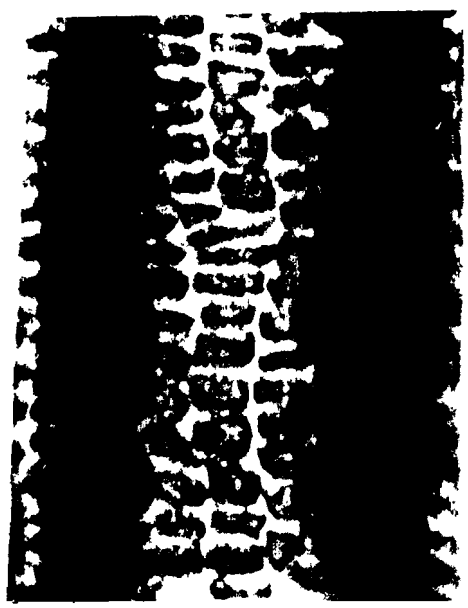
Unbanded hair: hair black or brown; length measures up to 50 mm; medulla multiserial ladder; maximum and medulla diameters similar to banded hair; both banded and unbanded are fragile and easily broken; can be distinguished from Sylvilagus by maximum diameter.

A

B



C



D

Fig. 6. Cuticular scale pattern and medulla configuration for Sylvilagus sp. and Lepus sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Marmota monax (Woodchuck) Figure 7

Banded hair: Banding sequence - black, white, black; average length 36 mm; medulla absent or fragmented in base becoming simple unbroken amorphous in the shield and fragmented in the tip; maximum diameter 0.1778 mm (± 0.0128 mm); medulla diameter 0.1423 mm (± 0.0160 mm).

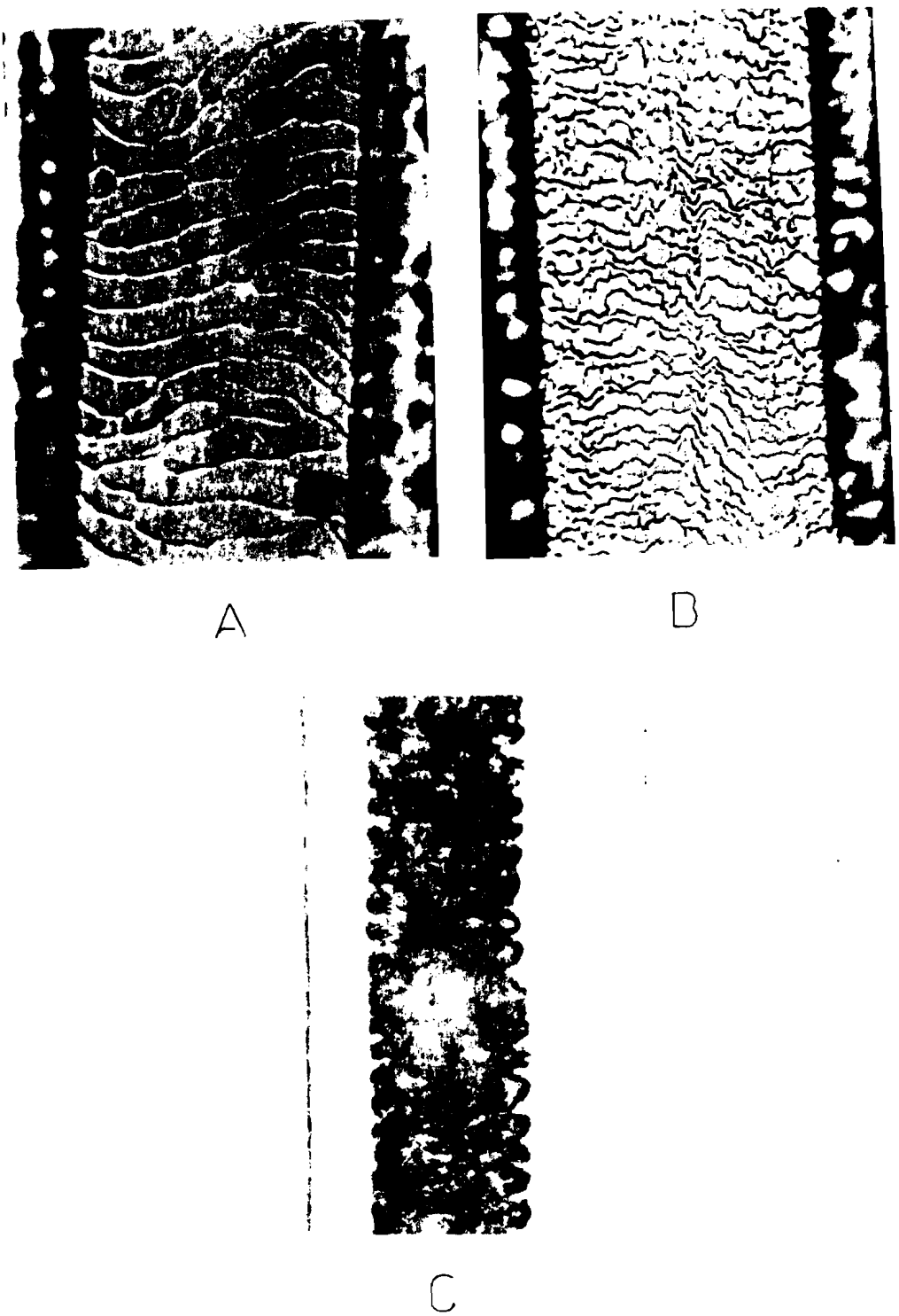


Fig. 7. Cuticular scale pattern and medulla configuration for Marmota monax: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

Cynomys ludovicianus (Blacktail Prairie Dog) Figure 8

Banded hair: Banding sequence - black, white, brown which may turn black at the base; the black tip usually less than 1 mm long; average length 12 mm; medulla unbroken with cortical intrusions; maximum diameter 0.1270 mm (± 0.0146 X mm); medulla diameter 0.1155 mm (± 0.0143 mm).

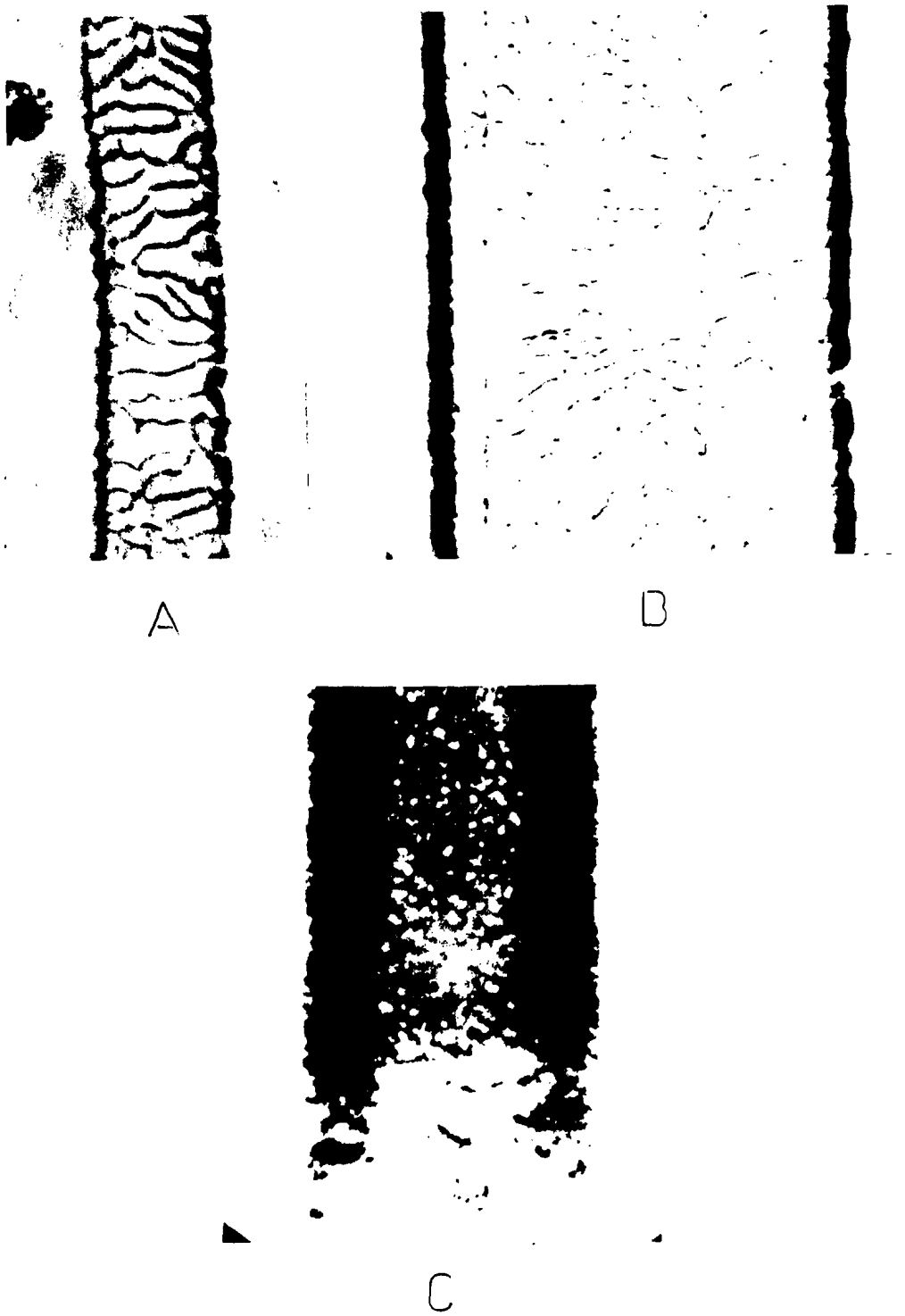


Fig. 8. Cuticular scale pattern and medulla configuration for Cynomys ludovicianus: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

Spermophilus sp. (Ground Squirrels) Figure 9

Banded hair: Banding sequence - black, white or yellow, black; average length 6 mm; medulla unbroken with cortical intrusions; maximum diameter 0.1236 mm (± 0.0053 mm); medulla diameter 0.1101 mm (± 0.0069 mm).

Unbanded hair: hair black; average length 6 mm; medulla unbroken with cortical intrusions; maximum diameter and medulla diameter are the same as banded hair; unbanded hairs may appear larger than banded and are more readily selected from a sample.

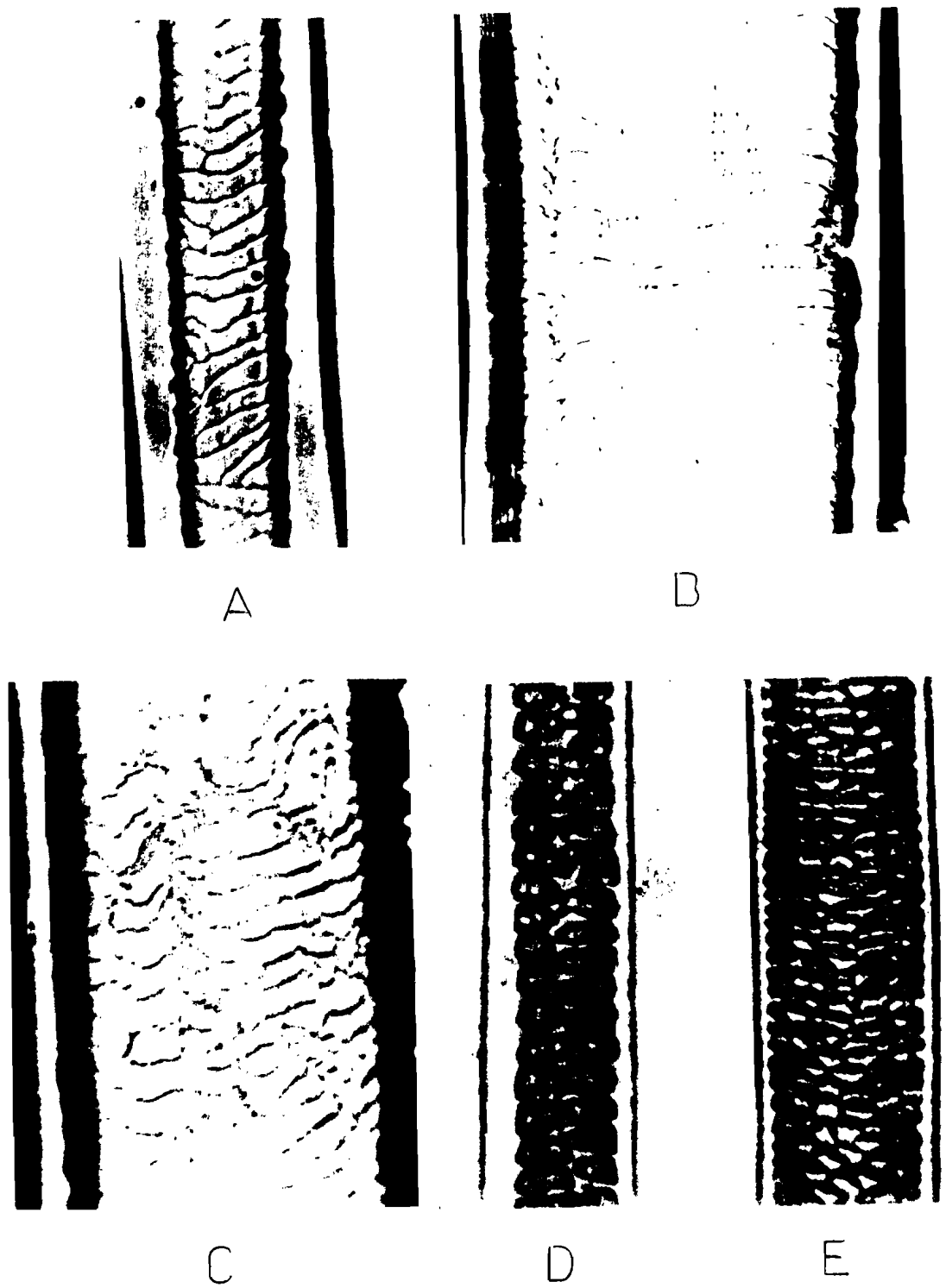


Fig. 9. Cuticular scale pattern and medulla configuration for Spermophilus sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla configuration, E. upper medulla configuration.

Sciurus Figure 10

S. niger (Fox Squirrel)

Banded hair (A): Banding sequence - black, white, black, white which turns brown near the base; the last white band may be difficult to detect as it blends well with the brown at the base of the hair; average length 19 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.1098 mm (± 0.0160 mm); medulla diameter 0.0980 mm (± 0.0131 mm).

Banded hair (B): Hair is black fading to light brown at the base; may have 1 white band in the lower end of the shield; length tends to be 3 mm to 4 mm longer than banded hair (A); medulla is uniserial ladder changing to unbroken with cortical intrusions; maximum and medulla diameters are the same as banded hair (A); when several hairs are viewed together under a dissecting scope a red color is visible.

S. carolinensis (Eastern Gray Squirrel)

Banded hair: This species has both types of banding patterns and medulla as S. niger, but the hue is gray; average length 15 mm; maximum diameter 0.1015 mm (± 0.0040 mm); medulla diameter 0.0864 mm (± 0.0029 mm); difficult to separate from S. niger unless some color is visible.

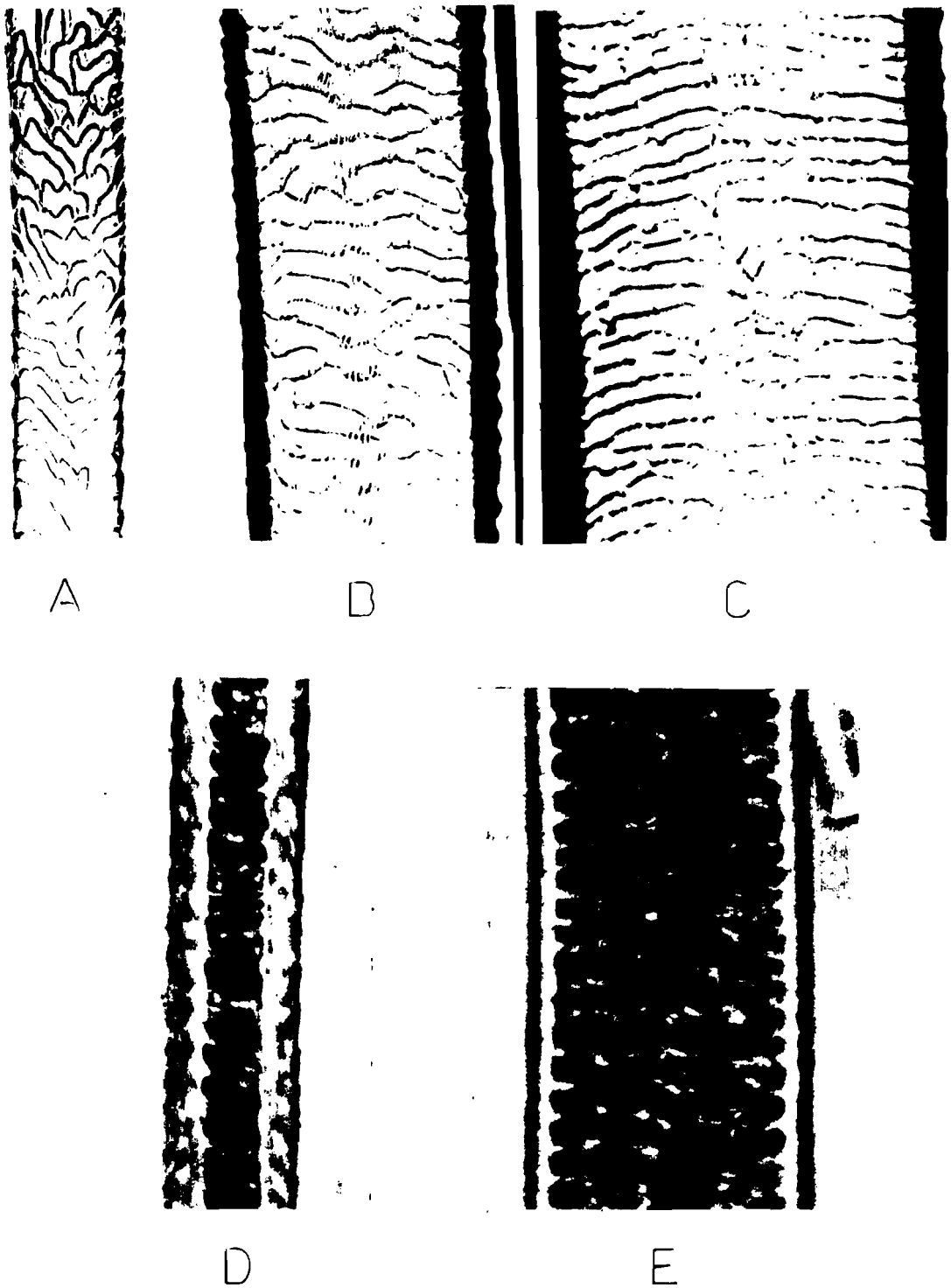


Fig. 10. Cuticular scale pattern and medulla configuration for Sciurus sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla configuration, E. upper medulla configuration.

Geomys (Pocket Gophers) Figure 11

Banded hair: Banding sequence - black, fading to white or yellow, black; average length 12 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0638 mm (± 0.0063 mm); medulla diameter not measured but is nearly as wide as hair; little or no pigment in the cortex.

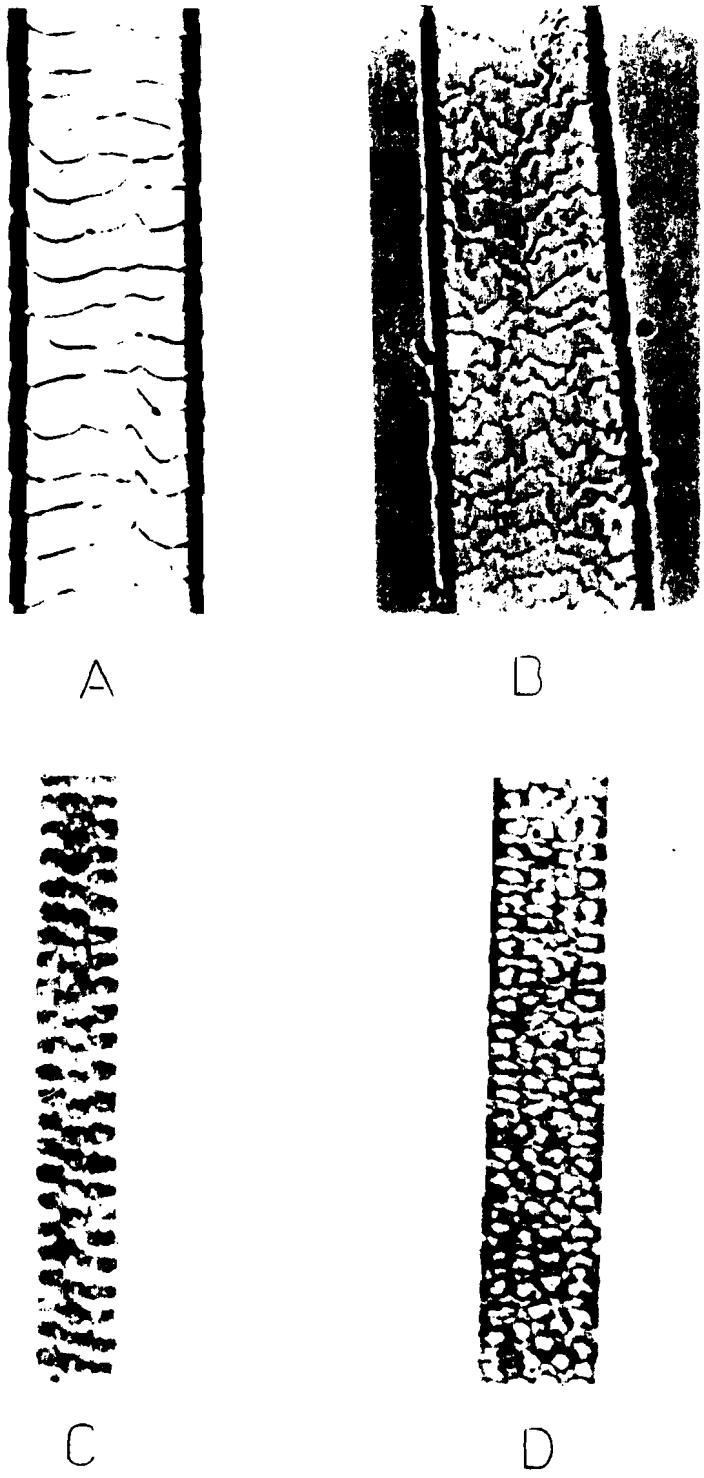


Fig. 11. Cuticular scale pattern and medulla configuration for Geomys sp.: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper shaft medulla partially cleared by mounting medium

Perognathus (Pocket Mice) Figure 12

Banded hair: Banding sequence - black, yellow, black; small hairs which are difficult to separate out in sample of hair; may appear as underhair; no measurements taken.

Unbanded hair: Hair black; average length 9 mm; medulla unbroken with cortical intrusions; shield originates near base of hair and widens abruptly; maximum diameter 0.1056 mm (± 0.0096 mm); medulla diameter 0.1035 mm (± 0.0099 mm).

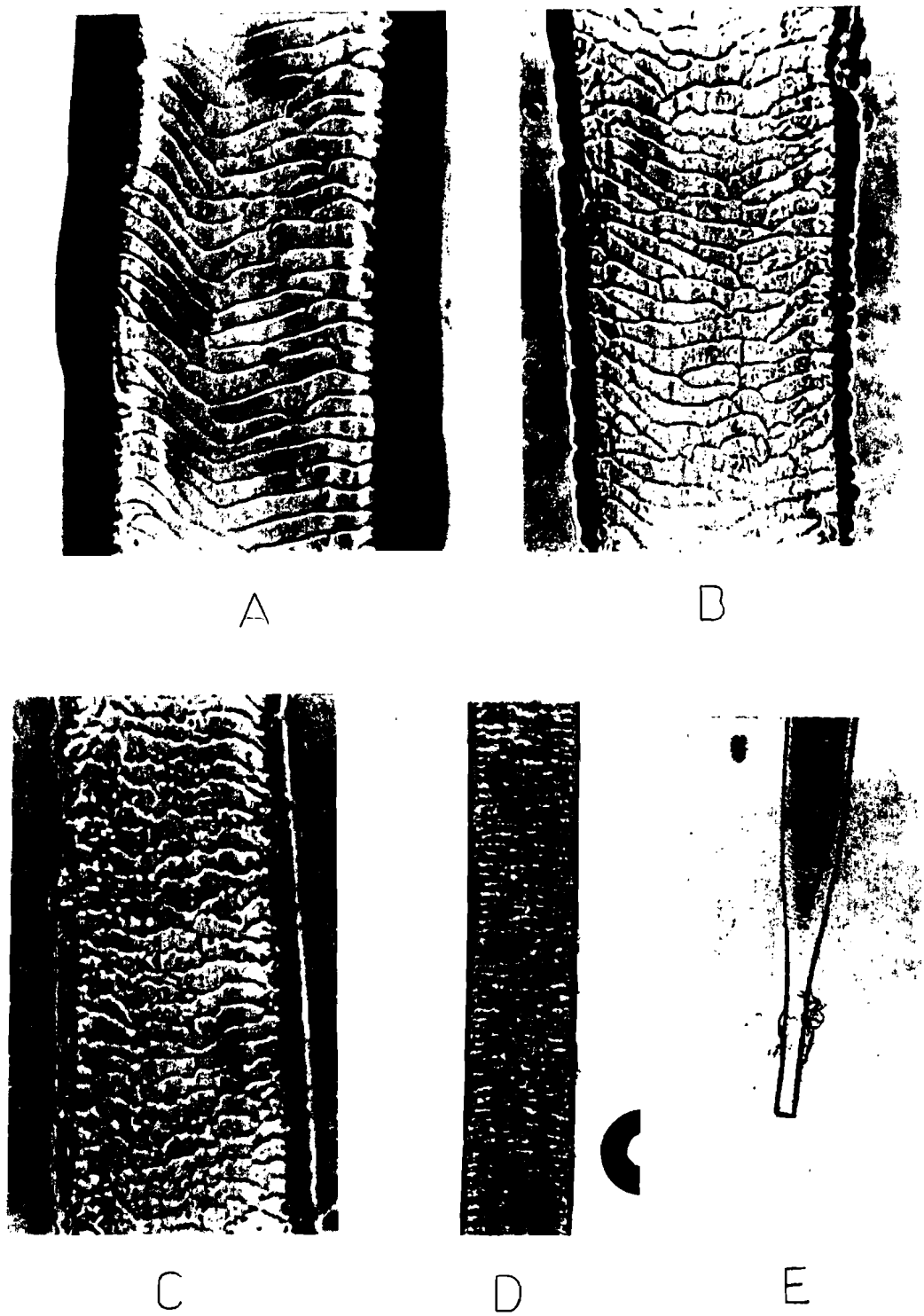


Fig. 12. Cuticular scale pattern and medulla configuration for Perognathus sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration, E. shape of hair base.

Dipodomys ordi (Ord Kangaroo Rat) Figure 13

Banded hair; Banding sequence - black, white fading to gray; average length 16 mm; medulla unbroken with cortical intrusions becoming absent in the distal end; shield orginates at the base with the maximum diameter occurring anywhere along the hair except at the tip; maximum diameter 0.0558 mm (± 0.0129 mm); medulla not measured as it is nearly as wide as the hair; these hairs are small in diameter for their length.

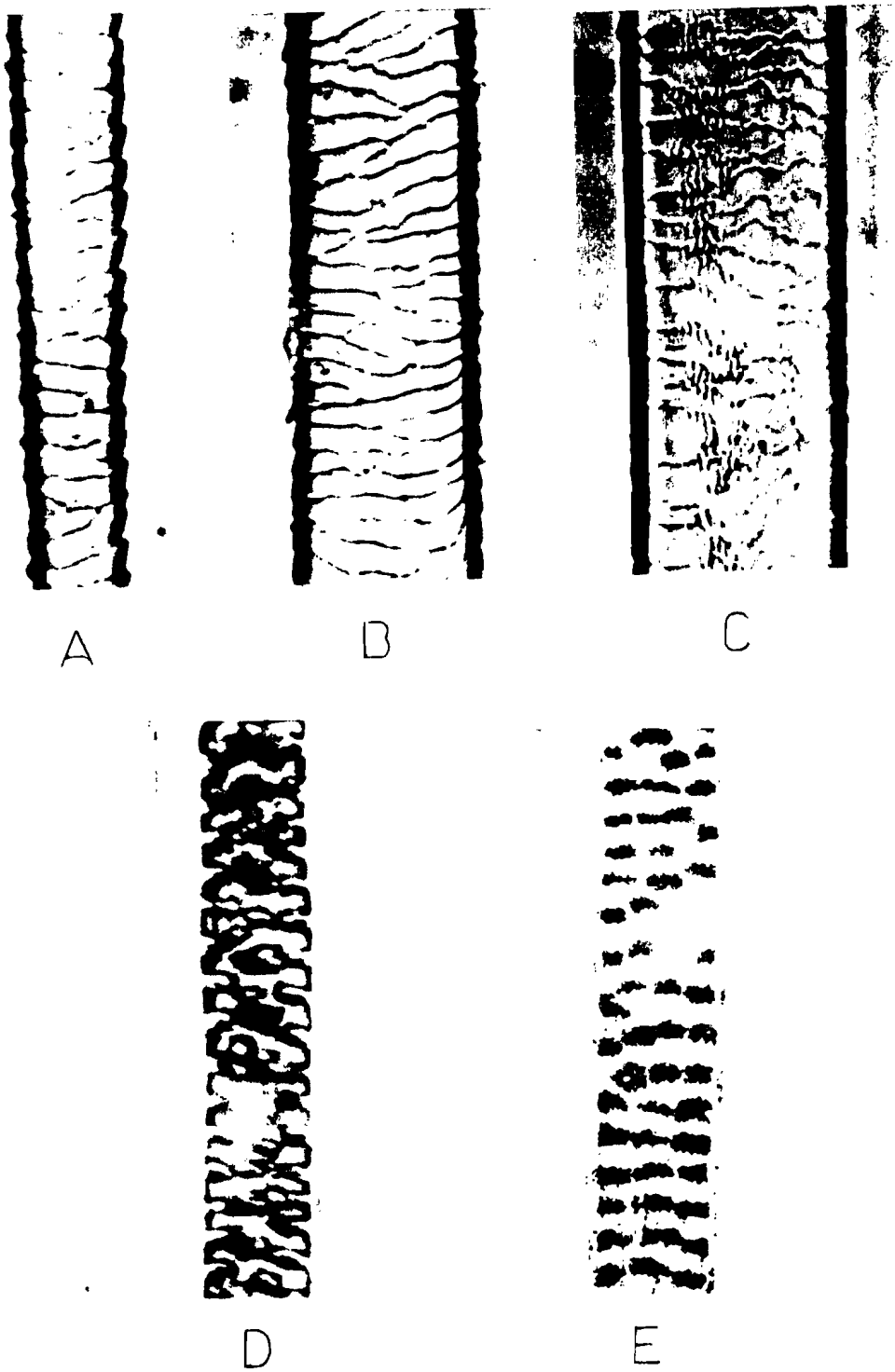


Fig. 13. Cuticular scale pattern and medulla configuration for Dipodomys ordi: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla partially cleared by mounting medium.

Castor canadensis (Beaver) Figure 14

Unbanded hair: Hair is brown or black; average length 43 mm; medulla absent, fragmented or unbroken with cortical intrusions; well defined shield; maximum diameter 0.1475 mm (± 0.0140 mm); medulla, only present in 1 specimen, ranged from 0.0275 mm to 0.0600 mm.

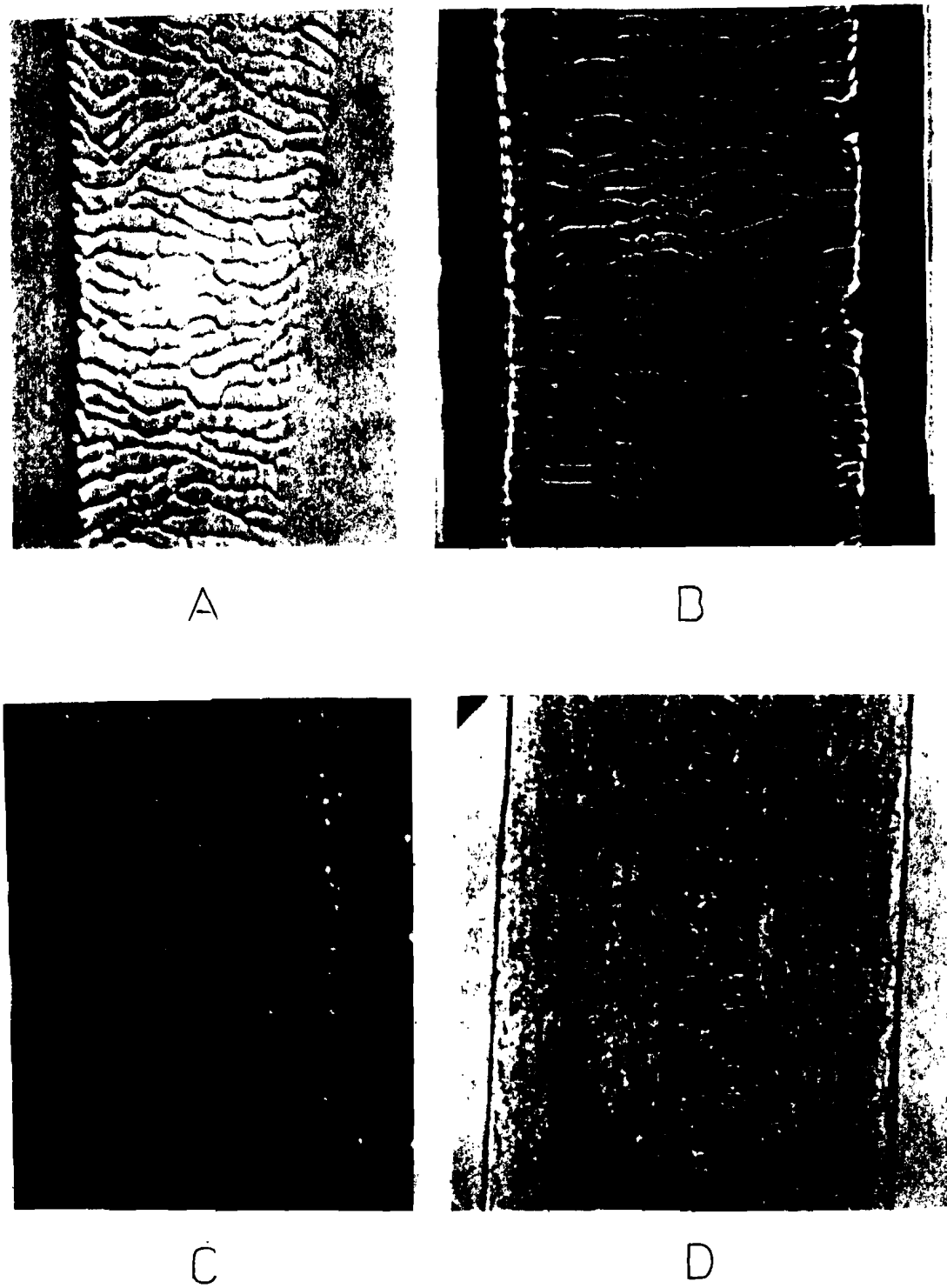


Fig. 14. Cuticular scale pattern and medulla configuration for Castor canadensis: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Reithrodontomys (Harvest Mice) Figure 15

Banded hair: Banding sequence - black, white which may turn dark toward base; average length 9 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0547 mm (± 0.0079 mm); medulla diameter 0.0477 mm (± 0.0075 mm).

Unbanded hair: Hair dark (brown to gray); average length 9 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; shield not well defined and there is a long thin tip (3 mm); maximum and medulla diameters not measured.

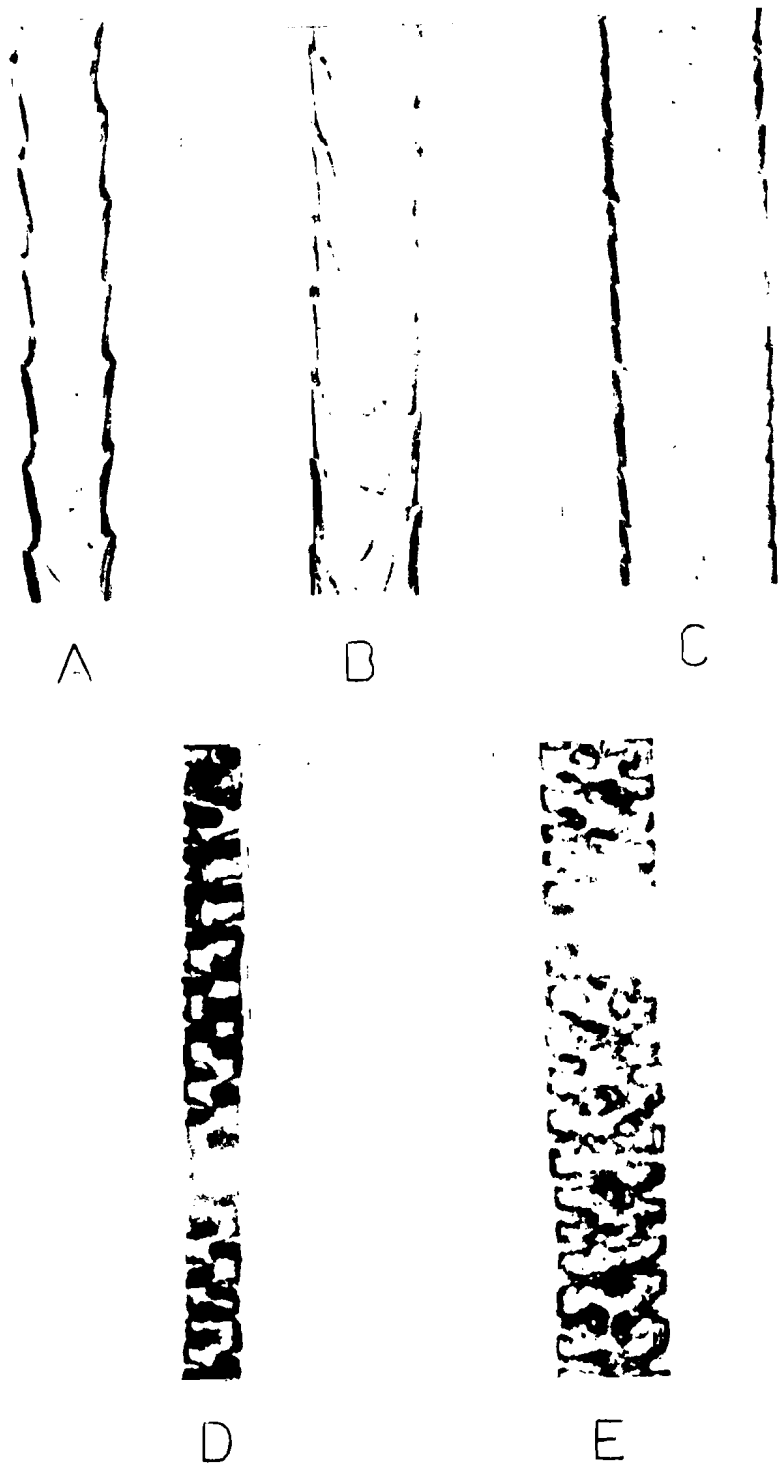


Fig. 15. Cuticular scale pattern and medulla configuration for Reithrodontomys sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla.

Peromyscus (Deer Mice) Figure 16

Unbanded hair: Hair dark (brown to gray); average length 8 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0541 mm (± 0.0046 mm); medulla diameter 0.0419 mm (± 0.0056 mm).

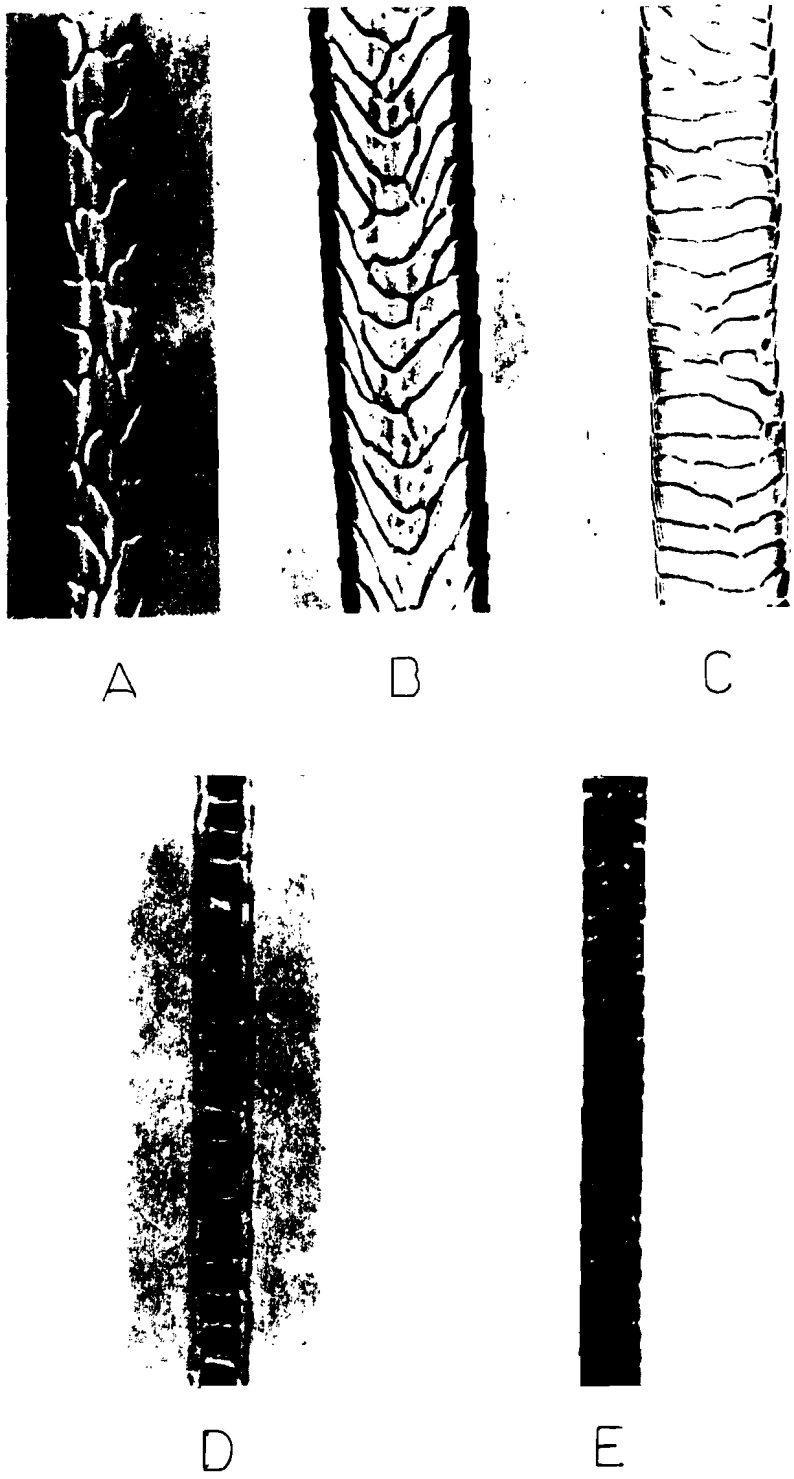


Fig. 16. Cuticular scale pattern and medulla configuration for Peromyscus sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla.

Onychomys leucogaster (Northern Grasshopper Mouse) Figure 17

Unbanded hair: Hair gray or black; average length 9 mm; medulla uniserial ladder although in some cases the upper shield may be unbroken with cortical intrusions; hair with a long, thin basal section and a short shield region; maximum diameter 0.0495 (± 0.0036 mm); medulla diameter 0.0374 mm (± 0.0039 mm).

Fig. 17. Cuticular scale pattern and medulla configuration for Onychomys leucogaster: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper medulla.

Sigmodon hispidus (Hispid Cotton Rat) Figure 18

Banded hair: Banding Sequence - black, white, black; average length 16 mm; medulla configuration unbroken with cortical intrusions; maximum diameter 0.1010 mm (± 0.0041 mm); medulla diameter 0.0899 mm (± 0.0040).

Unbanded hair: Hair dark (some with a small, white tip); average length medulla configuration and maximum and medulla diameters are the same as banded hair; both types of hair may have a trough throughout parts of the hair which is visible under a dissecting scope.

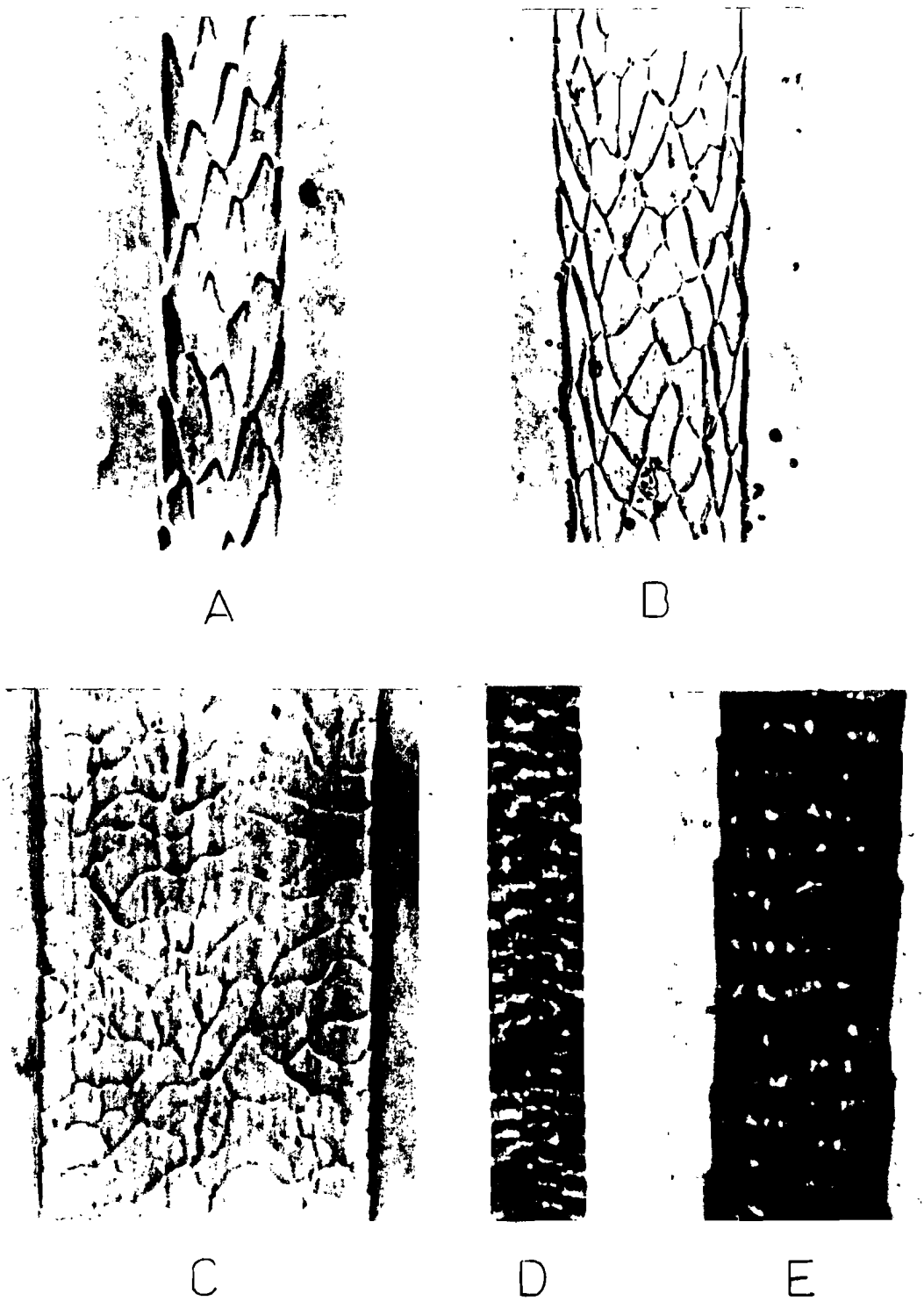


Fig. 18. Cuticular scale pattern and medulla configuration for Sigmodon hispidus: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, C. upper medulla.

Neotoma (Wood Rats) Figure 19

Banded hair: Banding sequence - black, white, black or brown; average length 15 mm; medulla unbroken with cortical intrusions; maximum diameter 0.0514 mm (± 0.0051 mm); medulla diameter 0.0489 mm (± 0.0011 mm).

Unbanded hair: Hair black or brown; average length 15 mm; medulla unbroken with cortical intrusions; maximum diameter 0.0601 mm (± 0.0015 mm); medulla diameter 0.0510 mm (± 0.0029 mm); hair has large amount of pigment in the cortex.

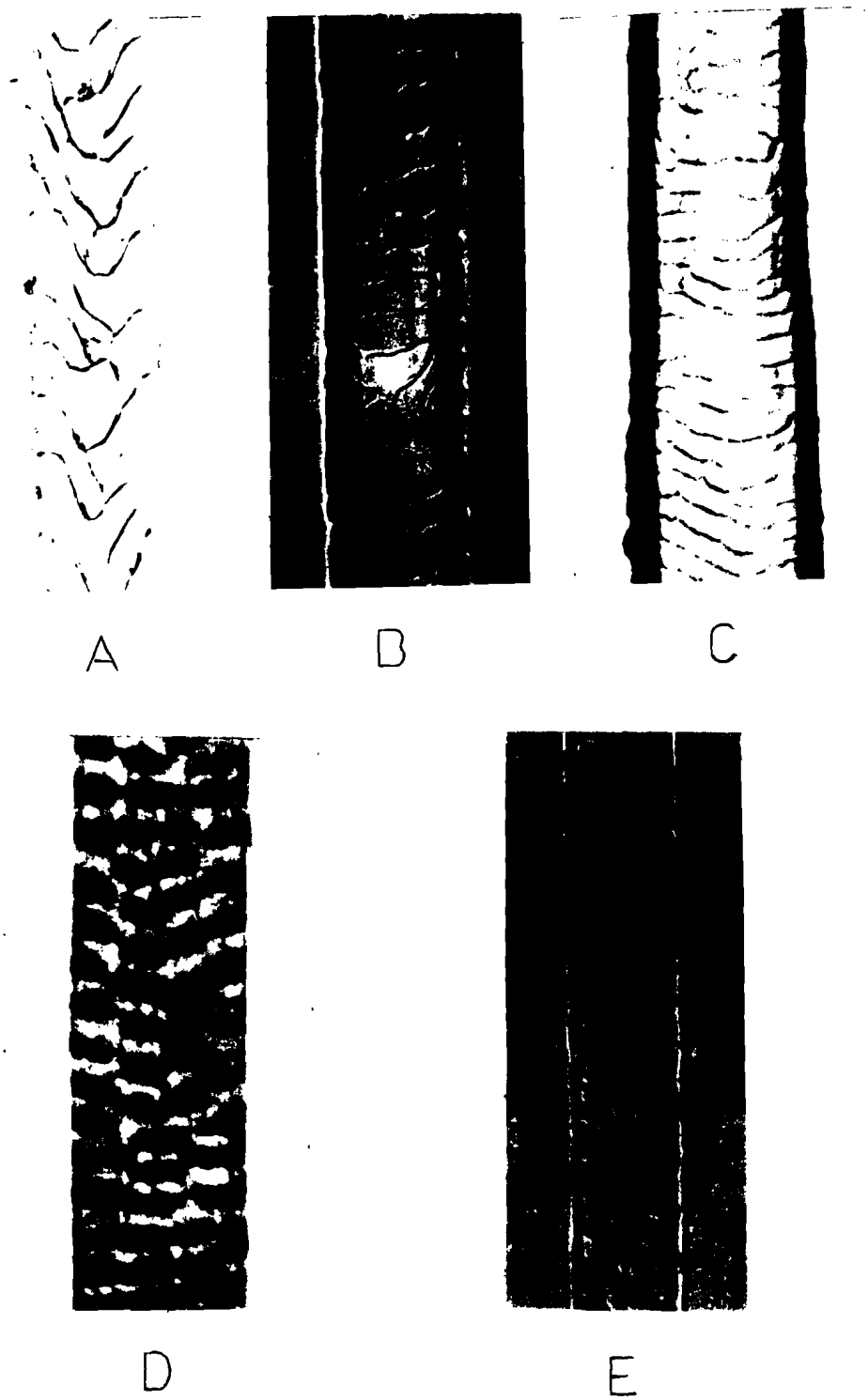


Fig. 19. Cuticular scale pattern and medulla configuration for Neotoma sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla, E. medulla cleared by mounting medium.

Microtus (Voles) Figure 20

Banded hair: Banding sequence - black, white, black or gray; average length 12 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0503 mm (± 0.0084 mm); medulla nearly as wide as hair and was not measured.

Unbanded hair: Hair dark; average length 12 mm; medulla configuration same as banded; maximum diameter 0.0619 mm (± 0.0047 mm); medulla nearly as wide as hair and was not measured.

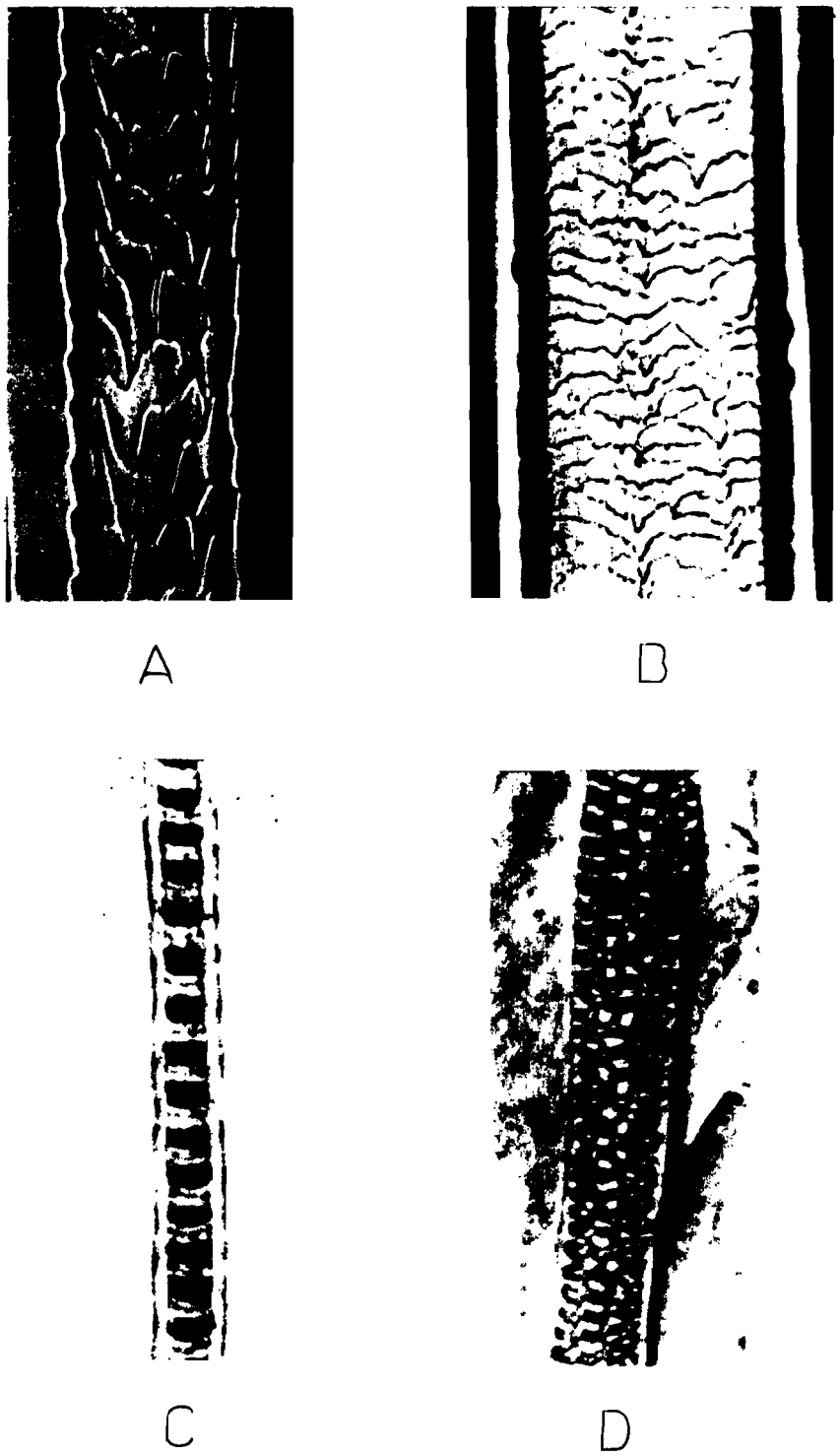


Fig. 20. Cuticular scale pattern and medulla configuration for Microtus sp.: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper medulla partially cleared by mounting medium.

Ondatra zibethicus (Muskrat) Figure 21

Unbanded hair: Hair dark brown to black; may have an orange tip; average length 31 mm; medulla unbroken with cortical intrusions; maximum diameter 0.1206 mm (± 0.0051 mm); medulla diameter 0.0533 mm (± 0.0068 mm).

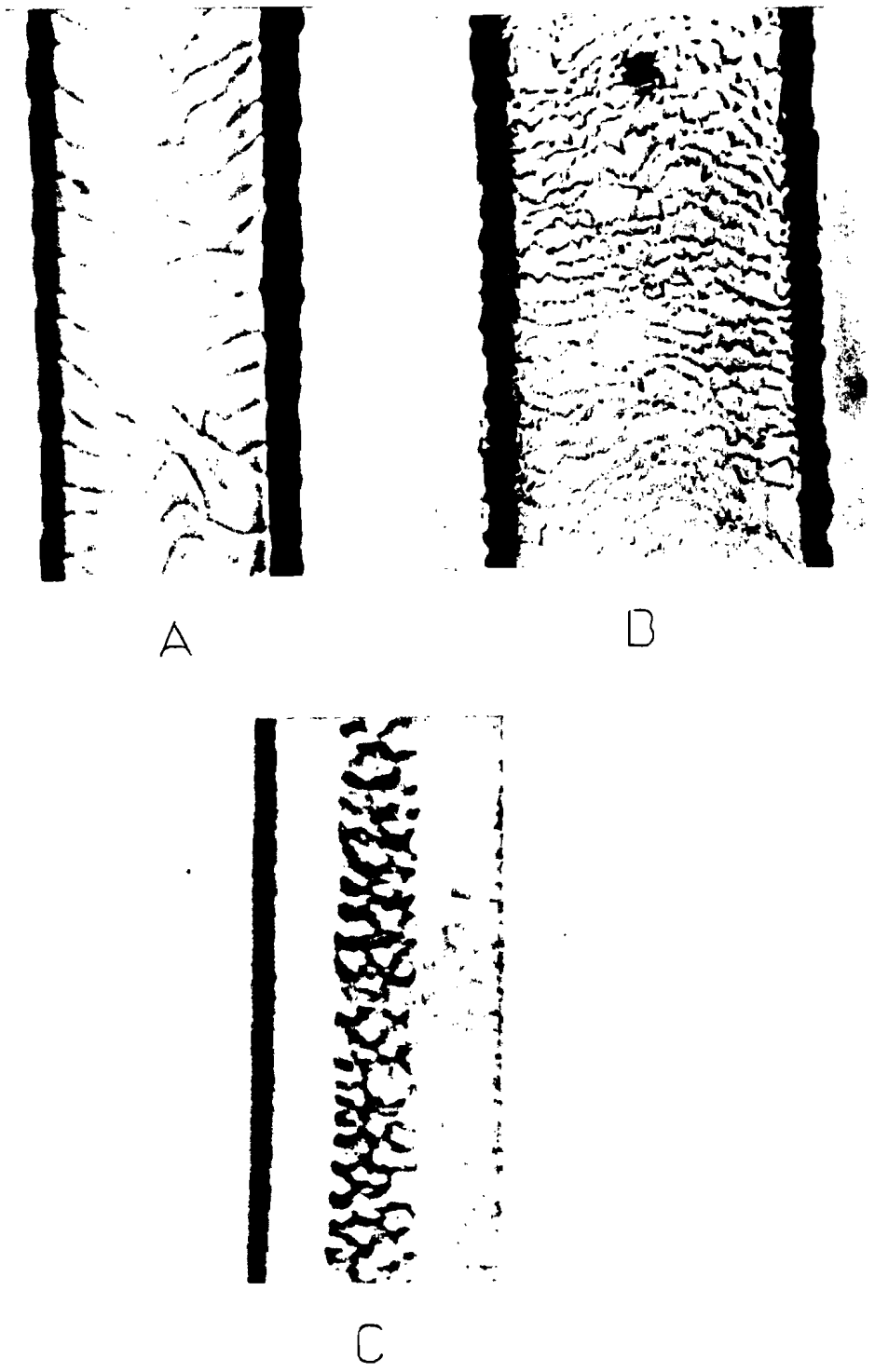


Fig. 21. Cuticular scale pattern and medulla configuration for Ondatra zibethicus: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

Synaptomys cooperi (Southern Bog Lemming) Figure 22

Banded hair: Banding sequence - black, yellow, black; average length 16 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0481 mm (± 0.0044 mm); medulla diameter 0.0415 mm (± 0.0048 mm).

Unbanded hair: Hair dark; average length and medulla configuration same as banded hair; maximum diameter 0.0609 mm (± 0.0074 mm); medulla diameter 0.0505 mm (± 0.0086 mm).

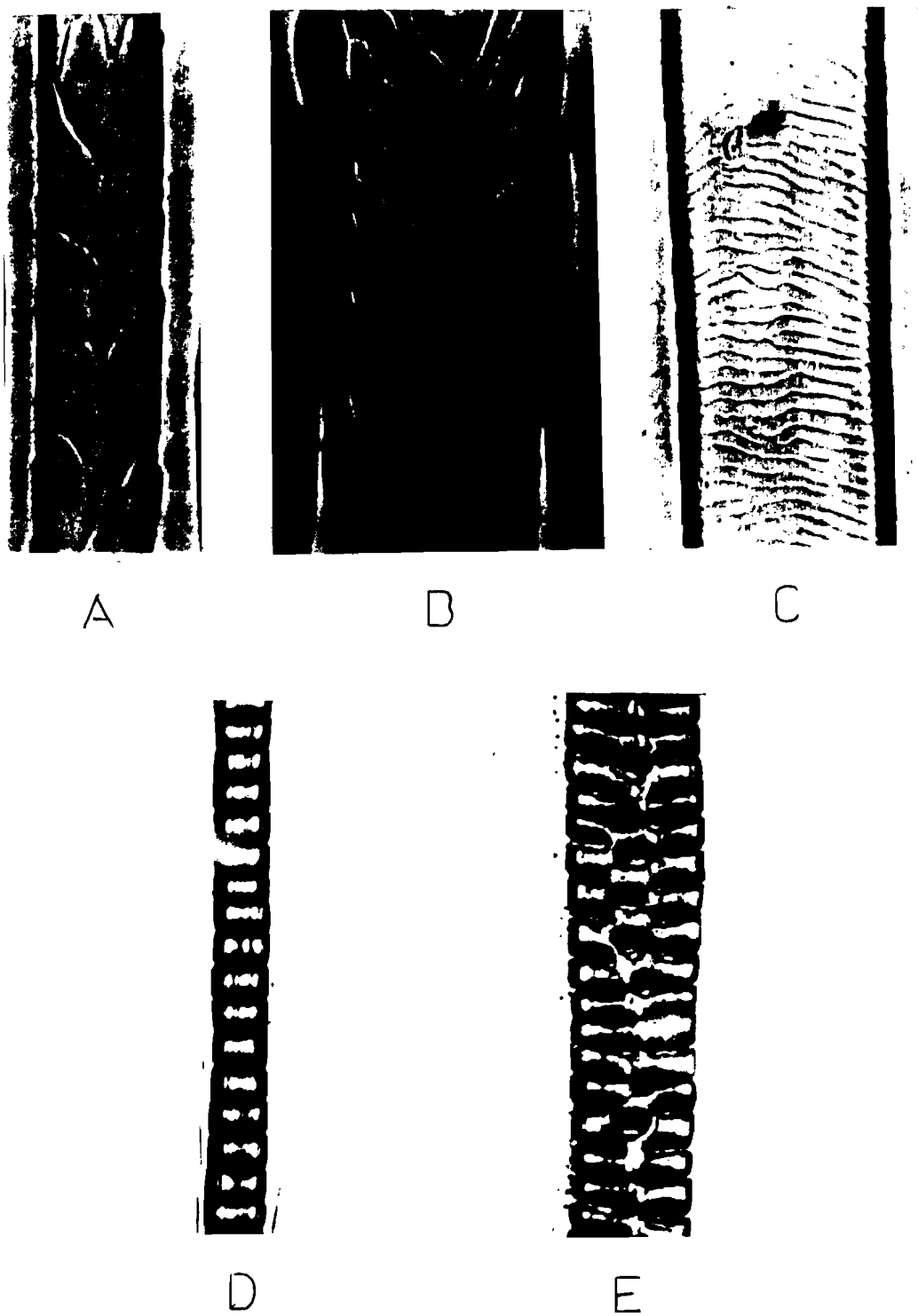


Fig. 22. Cuticular scale pattern and medulla configuration for Synaptomys cooperi: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla.

Rattus (Old World Rats) Figure 23

Banded hair: Banding sequence - black, gray or brown; average length 13 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.1297 mm (± 0.0116 mm); medulla diameter 0.1022 mm (± 0.0057 mm); shield originates near base and gradually widens up to a point 3/4 the length of the shaft and then narrows to the tip.

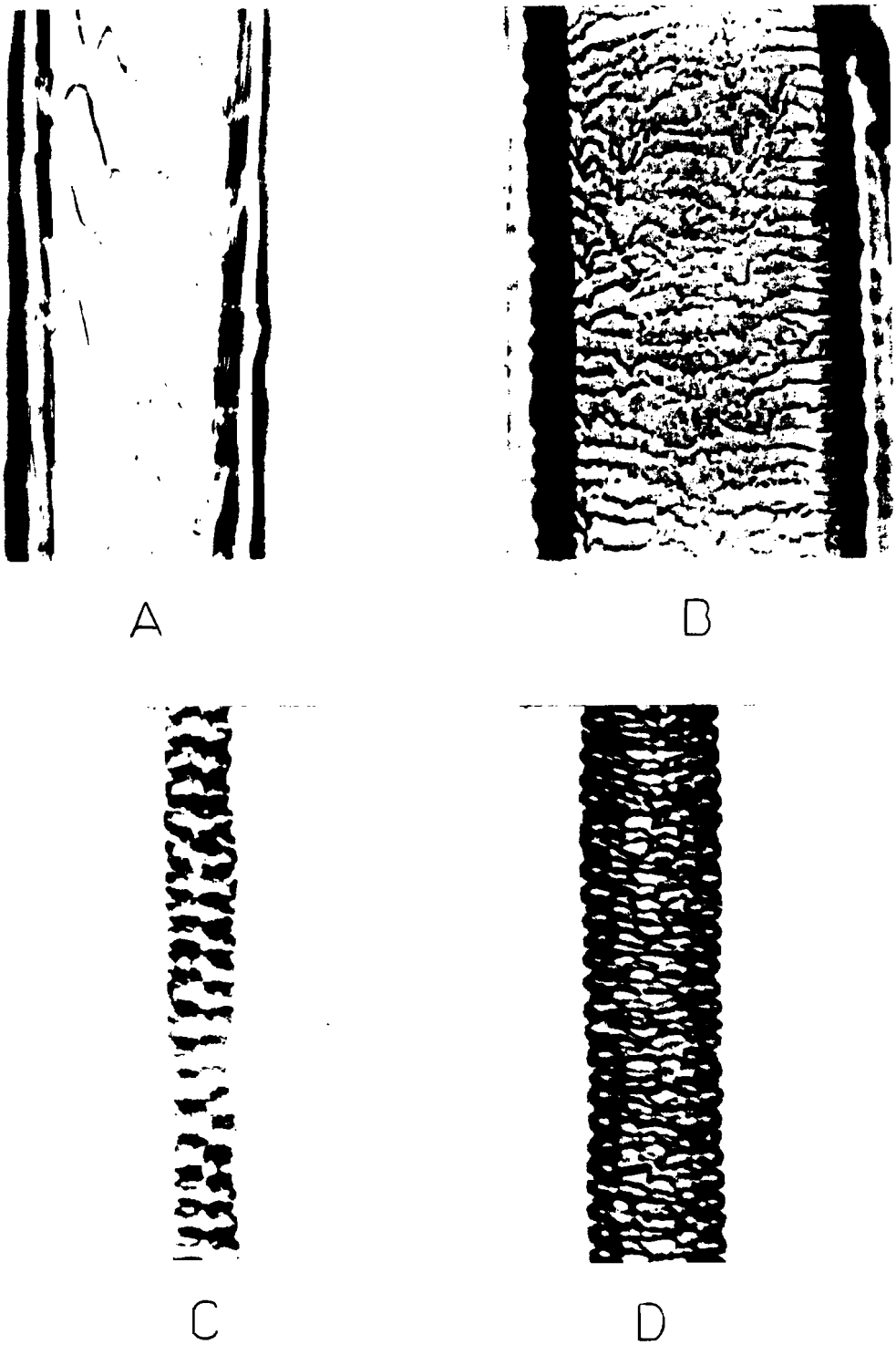


Fig. 23. Cuticular scale pattern and medulla configuration for Rattus sp.: A.lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper medulla.

Mus musculus (House Mouse) Figure 24

Banded hair: Banding sequence - black, yellow, gray; extremely small and difficult to discern under a dissecting scope; selection of individual hairs from an unknown sample would be difficult; maximum and medulla diameters not measured.

Unbanded hair: Hair dark; average length 6 mm; medulla uniserial ladder changing to unbroken with cortical intrusions; maximum diameter 0.0419 mm (± 0.0069 mm); medulla diameter 0.0340 mm (± 0.0080 mm).

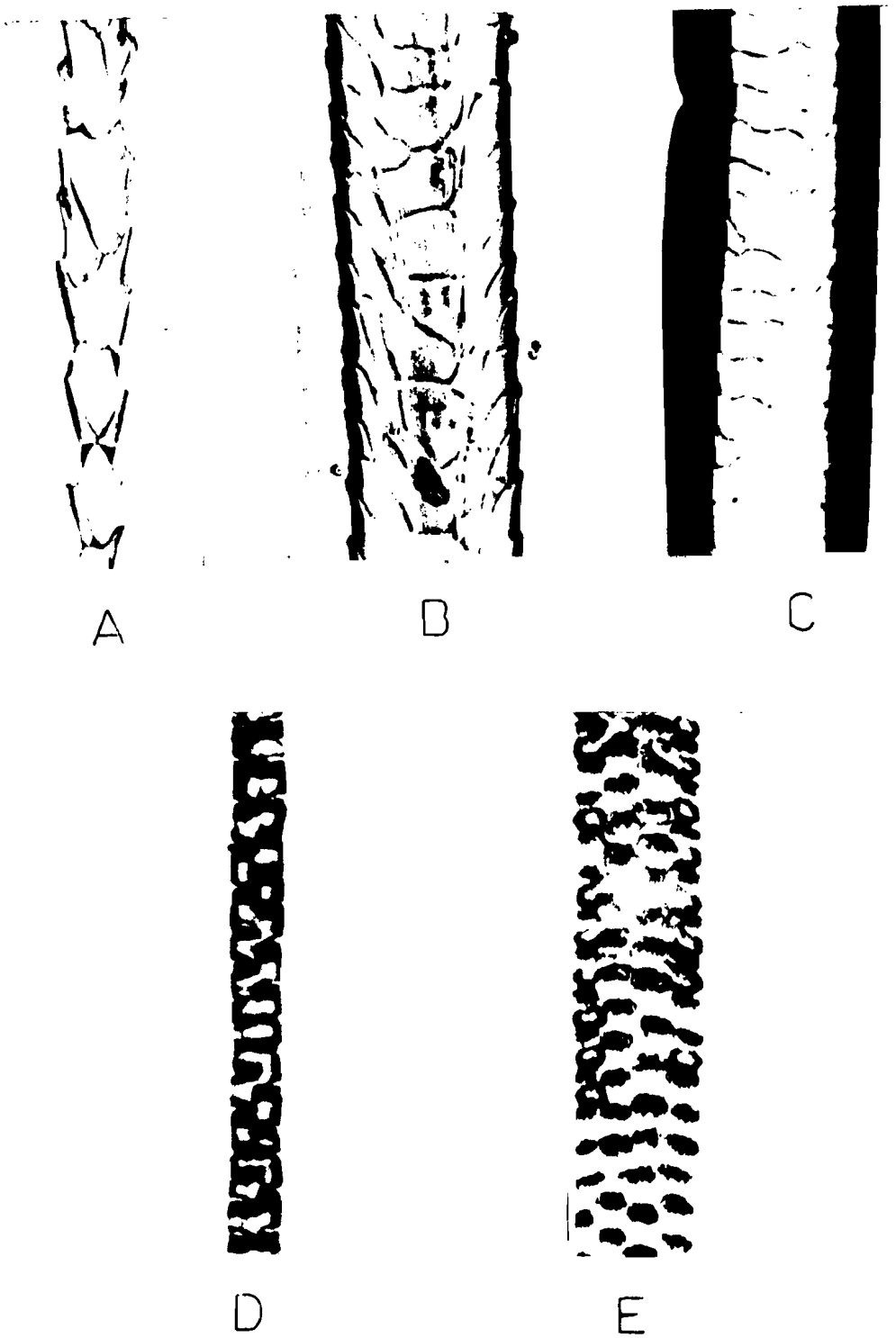


Fig. 24. Cuticular scale pattern and medulla configuration for Mus musculus: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla partially cleared by mountin medium.

Zapus hudsonius (Meadow Jumping Mouse) Figure 25

Banded hair: Banding sequence - white or light colored, black or brown; extremely small and similar to underhair; no measurements taken.

Unbanded hair: Hair dark; average length 8 mm; medulla unbroken with cortical intrusions; some with uniserial ladder in base; maximum diameter 0.0928 mm (± 0.0013 mm); medulla diameter 0.0793 mm (± 0.0013 mm); shield begins near base of hair.

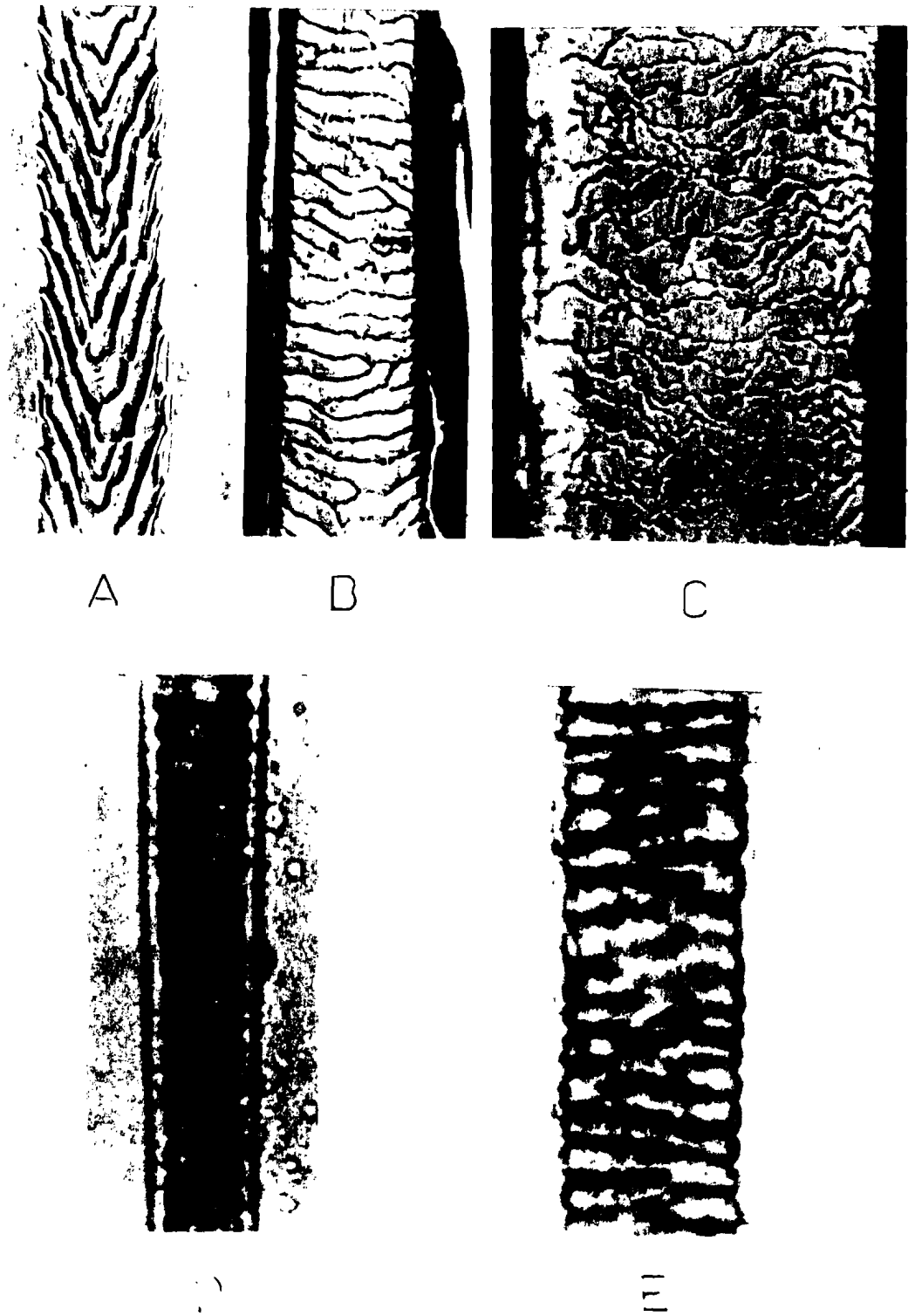
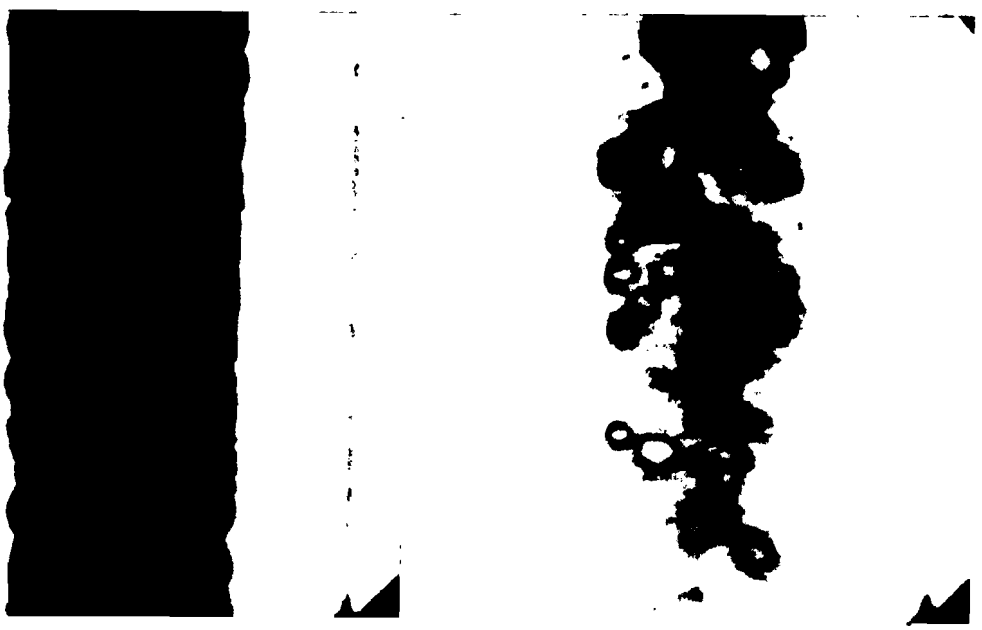


Fig. 25. Cuticular scale pattern and medulla configuration for Zapus hudsonius: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. lower medulla, E. upper medulla.

Erethizon dorsatum (Porcupine, 1 specimen) Figure 26

Banded hair: Banding sequence - black, yellow, black; hair is long and from one (1) specimen measured 160 mm; medulla is difficult to see due to large amounts of pigment in the cortex; xylene doesn't clear medulla but medulla appears to be unborken with coritcal intrusions; maximum diameter ranged from 0.3218 mm to 0.4719 mm and is located near the base of the hair; medulla diameters were not measured because they were not clearly visible.

A



B C

Fig. 26. Cuticular scale pattern and medulla configuration for Erethizon dorsatum: A. scale pattern for entire length of hair, B. medulla configuration, C. medulla partially cleared by mounting medium.

Canis latrans (Coyote) Figure 27

Banded hair: Banding sequence - black, white, black, white; average length 70 mm although some may measure over 100 mm; medulla is unbroken cellular changing to unbroken with cortical intrusions; maximum diameter 0.1429 mm (± 0.0244 mm); medulla diameter 0.0994 mm (± 0.0202 mm); maximum diameter usually occurs in the first white band.

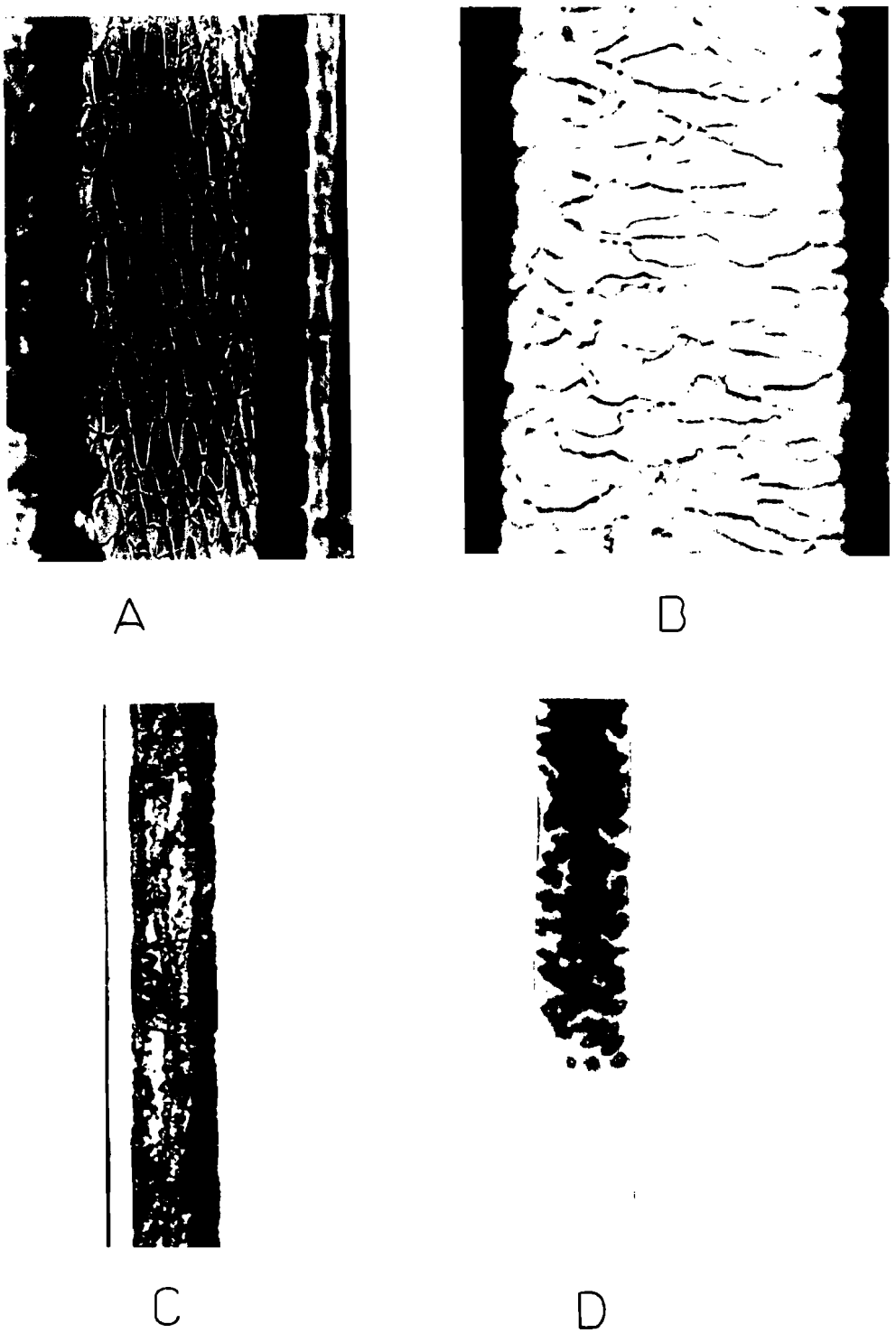


Fig. 27. Cuticular scale pattern and medulla configuration for Canis latrans: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla partially cleared by mounting medium. D. upper medulla partially cleared by mounting medium.

Vulpes Figure 28

V. vulpes (Red Fox)

Banded hair: banding sequence - orange, white, black; average length 44 mm; medulla unbroken vacuolated; maximum diameter 0.0979 mm (± 0.0168 mm); medulla diameter 0.0733 mm (± 0.0197 mm).

V. velox (Swift Fox, 1 specimen)

Banded hair: Banding sequence - black, white, black; hair on this specimen averaged 25 mm; medulla unbroken vacuolated; maximum diameter ranged from 0.1125 mm to 0.1400 mm; medulla diameter ranged from 0.0959 mm to 0.1250 mm.

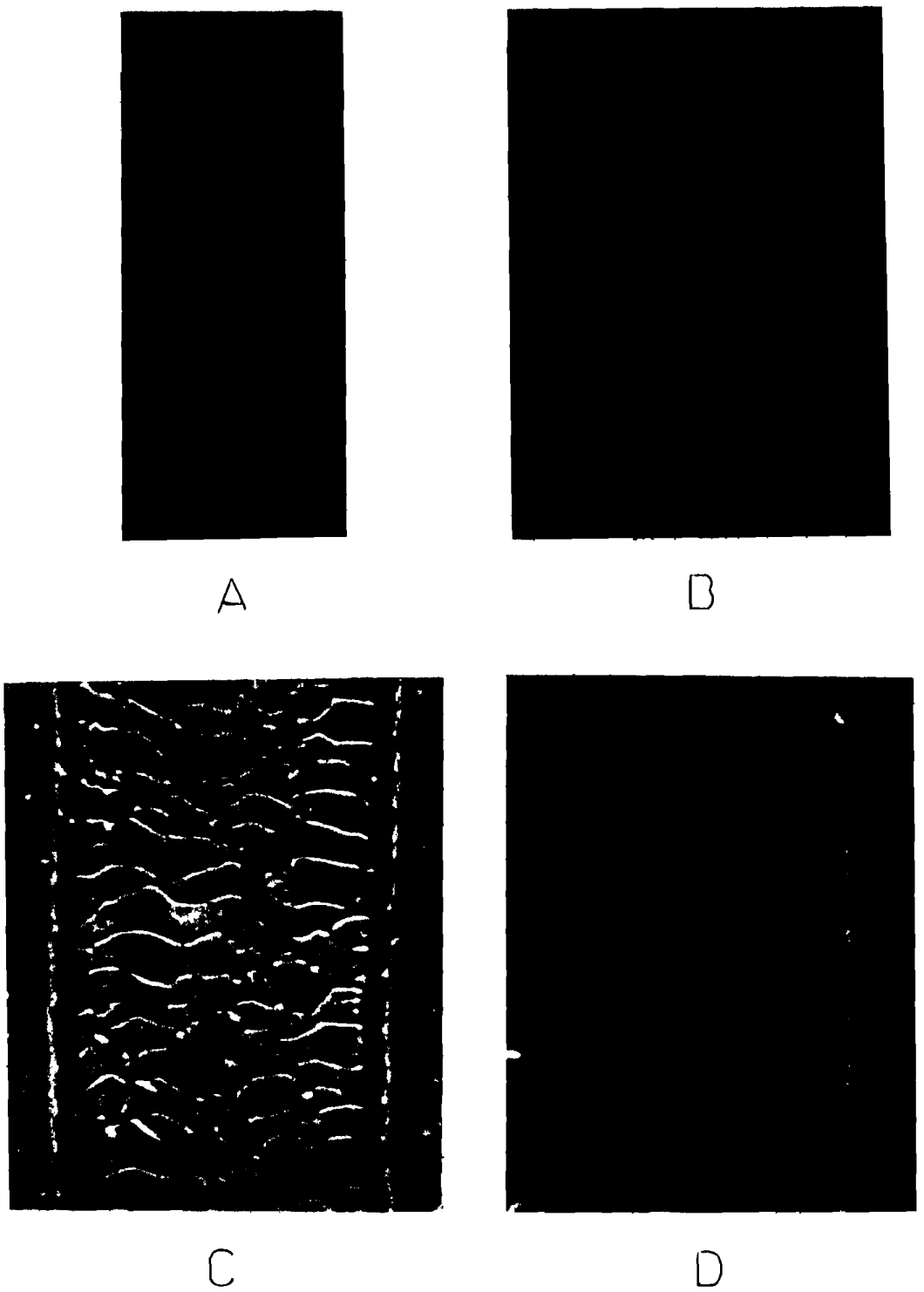


Fig. 28. Cuticular scale pattern and medulla configuration for Vulpes sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla partially cleared by mounting medium.

Urocyon cinereoargenteus (Gray Fox, 2 specimens) Figure 29

Banded hair: Banding sequence - black, white (approximately half as long as the black tip), black; banding is similar to V. velox, but the black tip is longer than the white band in Urocyon: average length 44 mm; maximum diameter ranged from 0.1175 mm to 0.1625 mm; medulla diameter ranged from 0.0750 mm to 0.1200 mm.

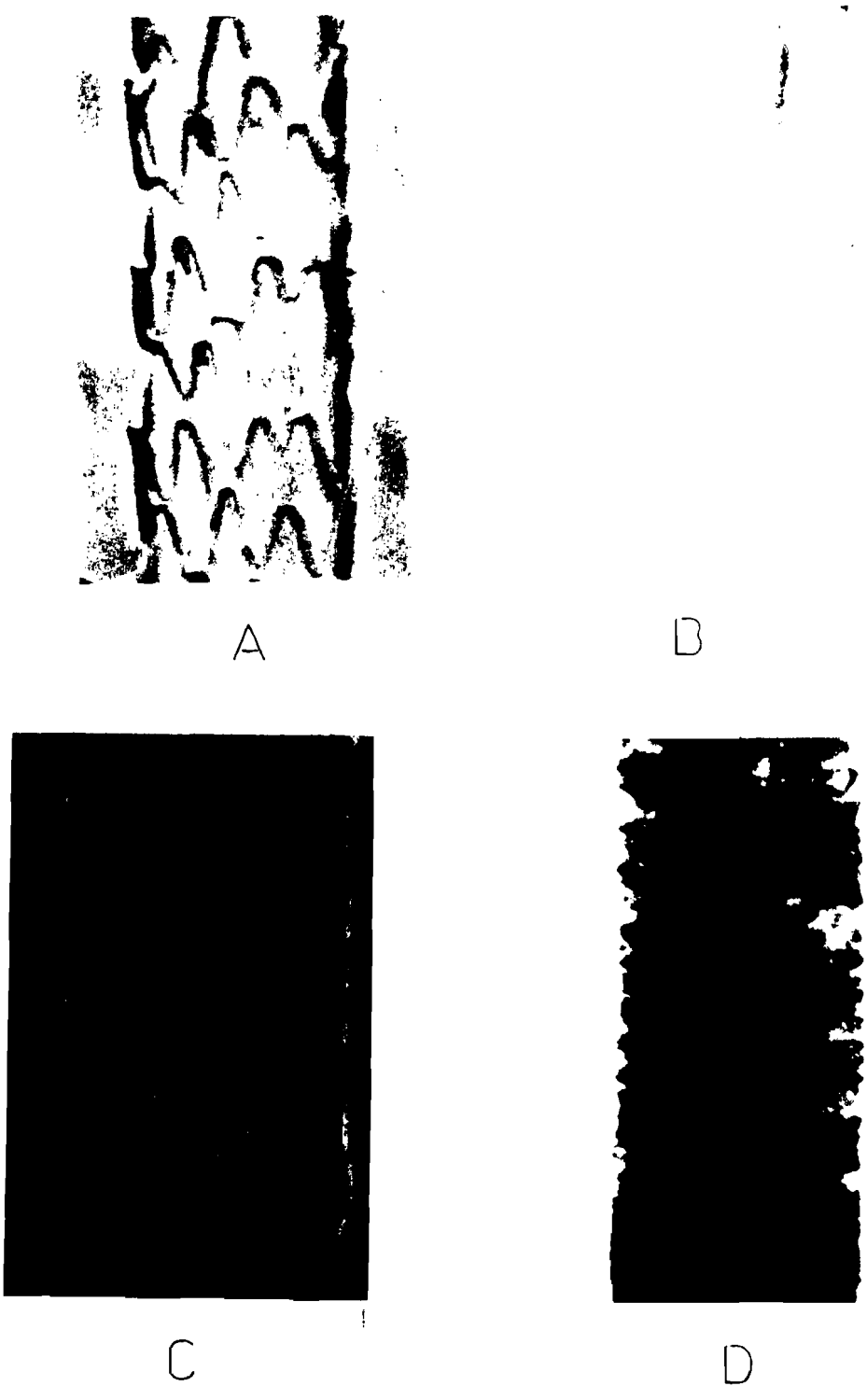


Fig. 29. Cuticular scale pattern and medulla configuration for Urocyon cinereoargenteus: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Procyon lotor (Raccoon) Figure 30

Banded hair: Banding sequence - black, white or yellow, black or gray; average length 54 mm; medulla unbroken cellular changing to unbroken vacuolated; maximum diameter 0.1265 mm (± 0.0016 mm); medulla diameter 0.0829 mm (± 0.0164 mm).

Unbanded hair: Hair black; all other aspects of hair same as banded hair; medulla margins sometimes not clear in both banded and unbanded.

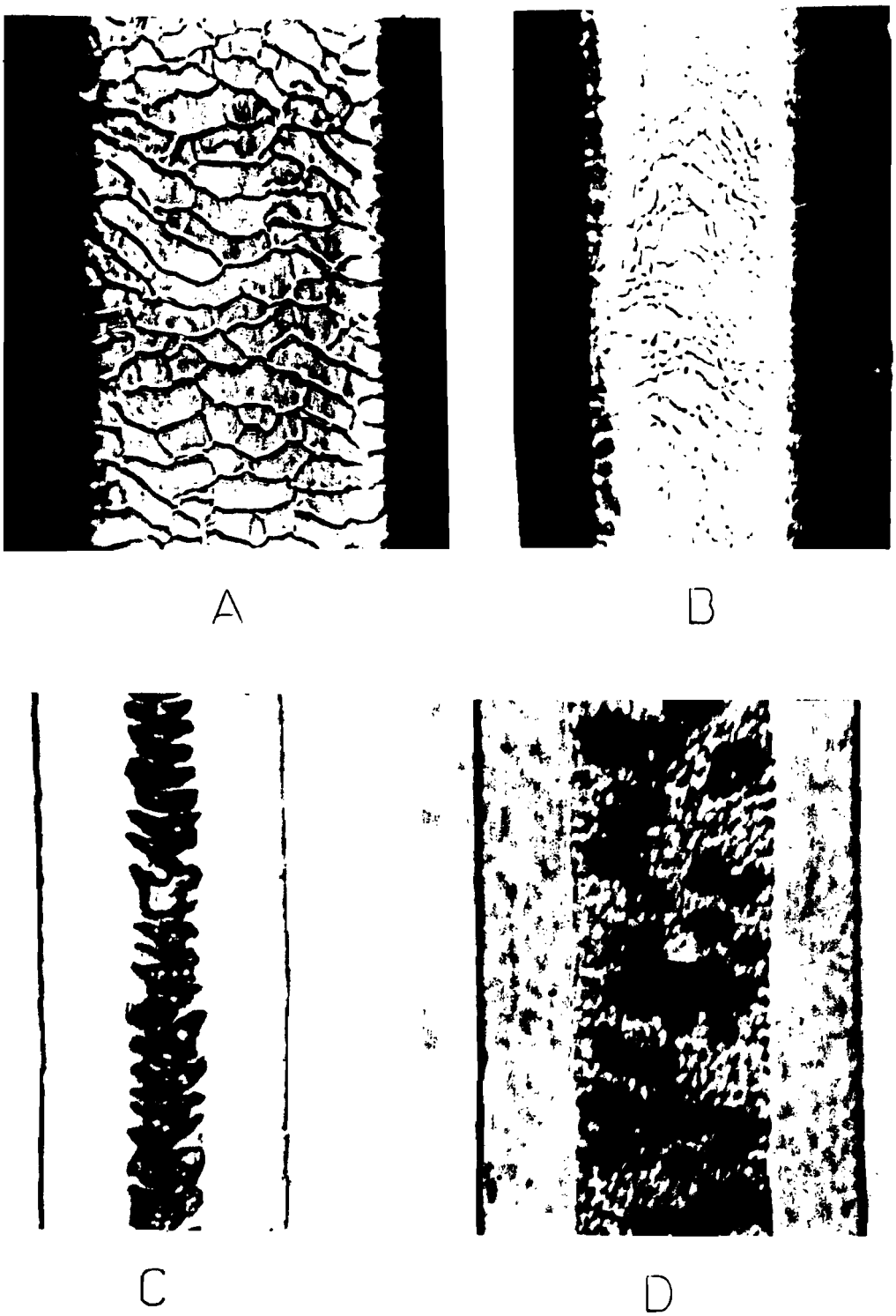


Fig. 30. Cuticular scale pattern and medulla configuration for Procyon lotor: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper medulla partially cleared by mounting medium.

Mustela Figure 31

M. vision (Mink)

Unbanded hair: Hair black or brown; average length 16 mm; medulla unbroken with cortical intrusions; maximum diameter 0.1220 mm (± 0.0051 mm); medulla diameter 0.0835 mm (± 0.0032 mm).

M. frenata and M. nivalis (Long-tailed Weasel and Least Weasel)

Unbanded hair: hair brown or sometimes white in winter specimens; average length 7 mm (M. nivalis tends to be shorter); medulla configuration same as M. vison; maximum diameter 0.0801 mm (± 0.0098 mm); medulla diameter 0.0628 mm (± 0.0106 mm); the major difference between M. vison and M. frenata/nivalis is maximum diameter; M. frenata may be larger than M. nivalis, but due to small sample size no conclusions could be drawn.

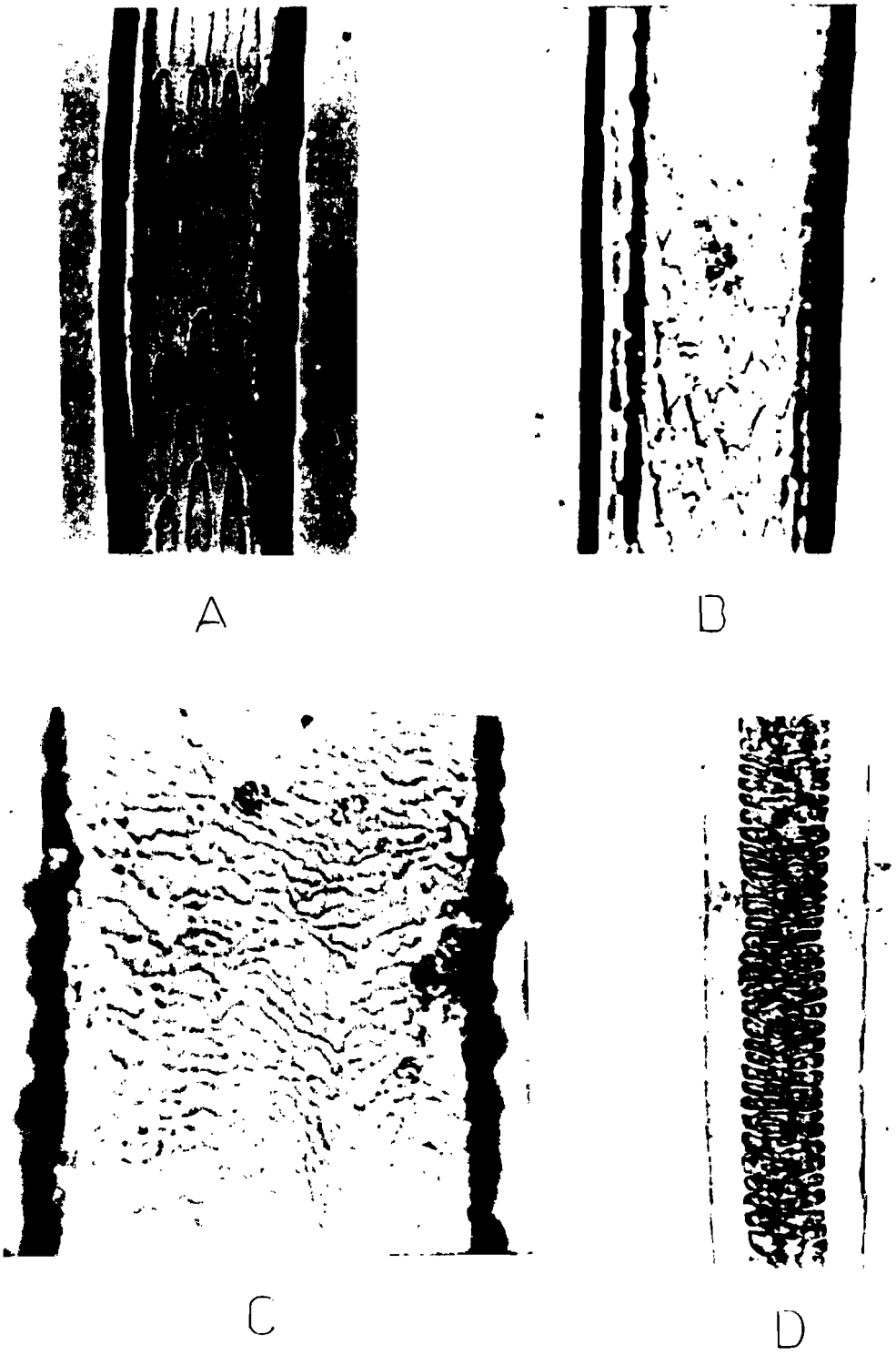


Fig. 31. Cuticular scale pattern and medulla configuration for Mustela sp.: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Taxidea taxus (Badger, 2 specimens) Figure 32

Banded hair: Banding sequence - white, black, white (light colored); average length 30 mm; medulla (most visible in the white bands) fragmented in base changing to unbroken with cortical intrusions; maximum diameter ranged from 0.1125 mm to 0.1725 mm; medulla diameter ranged from 0.0875 mm to 0.1075 mm.

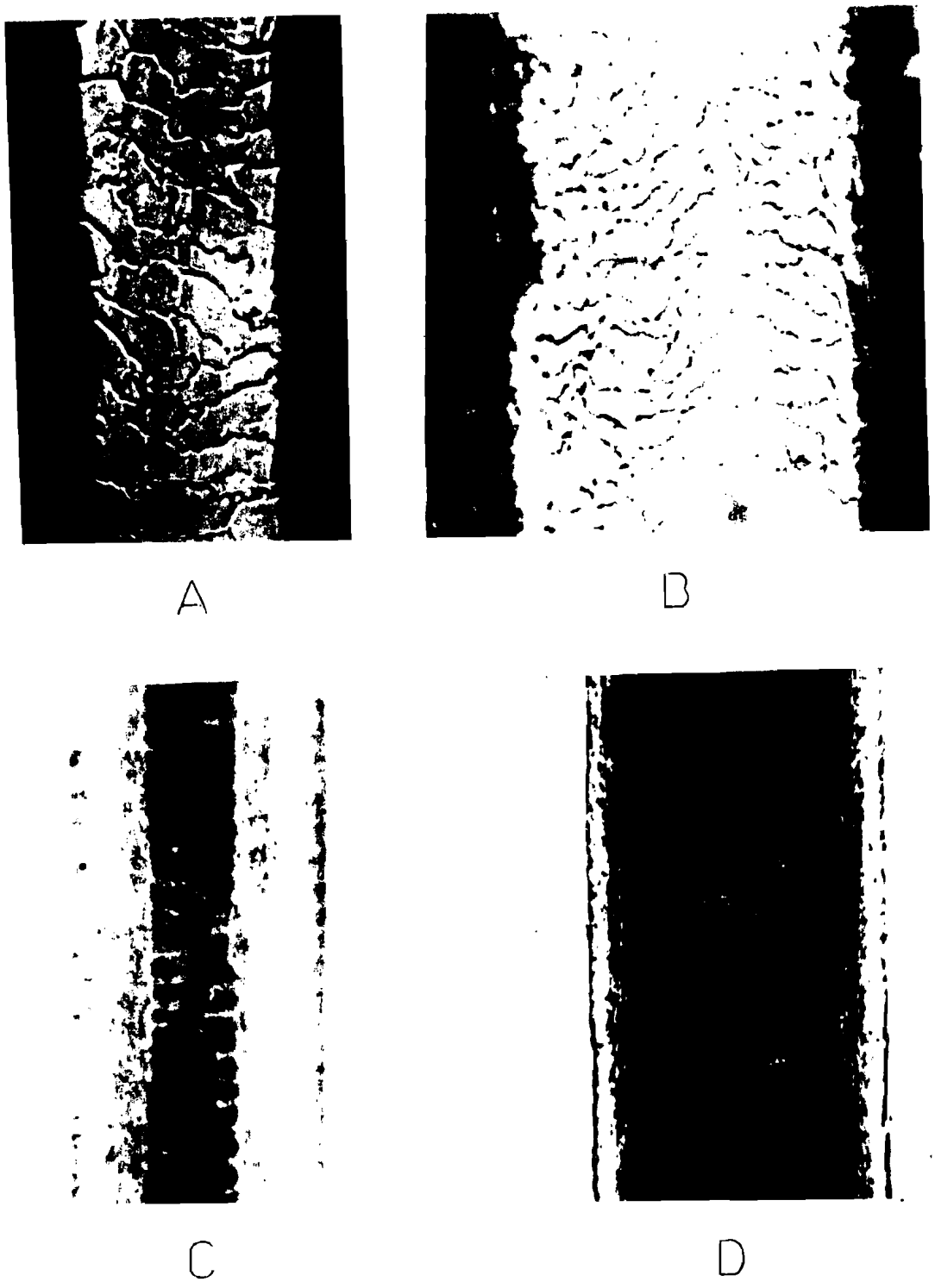


Fig. 32. Cuticular scale pattern and medulla configuration for Taxidea taxus: A. lower shaft scale pattern, B. upper shaft scale pattern, C. lower medulla, D. upper medulla partially cleared by mounting medium.

Spilogale putorius (Eastern Spotted Skunk) Figure 33

Unbanded hair (A): hair black; average length 33 mm; medulla uniserial ladder changing to unbroken cellular; medulla absent in tip; medulla may be difficult to see due to large amounts of pigment in the cortex; maximum diameter 0.0999 mm (± 0.0050 mm); medulla diameter 0.0715 mm (± 0.0096 mm).

Unbanded hair (B): Hair white; average length 33 mm; medulla configuration same as unbanded hair (A); maximum diameter 0.1021 mm (± 0.0199 mm) medulla diameter 0.0708 mm (± 0.0130 mm); shield not well defined in either white or black hair.

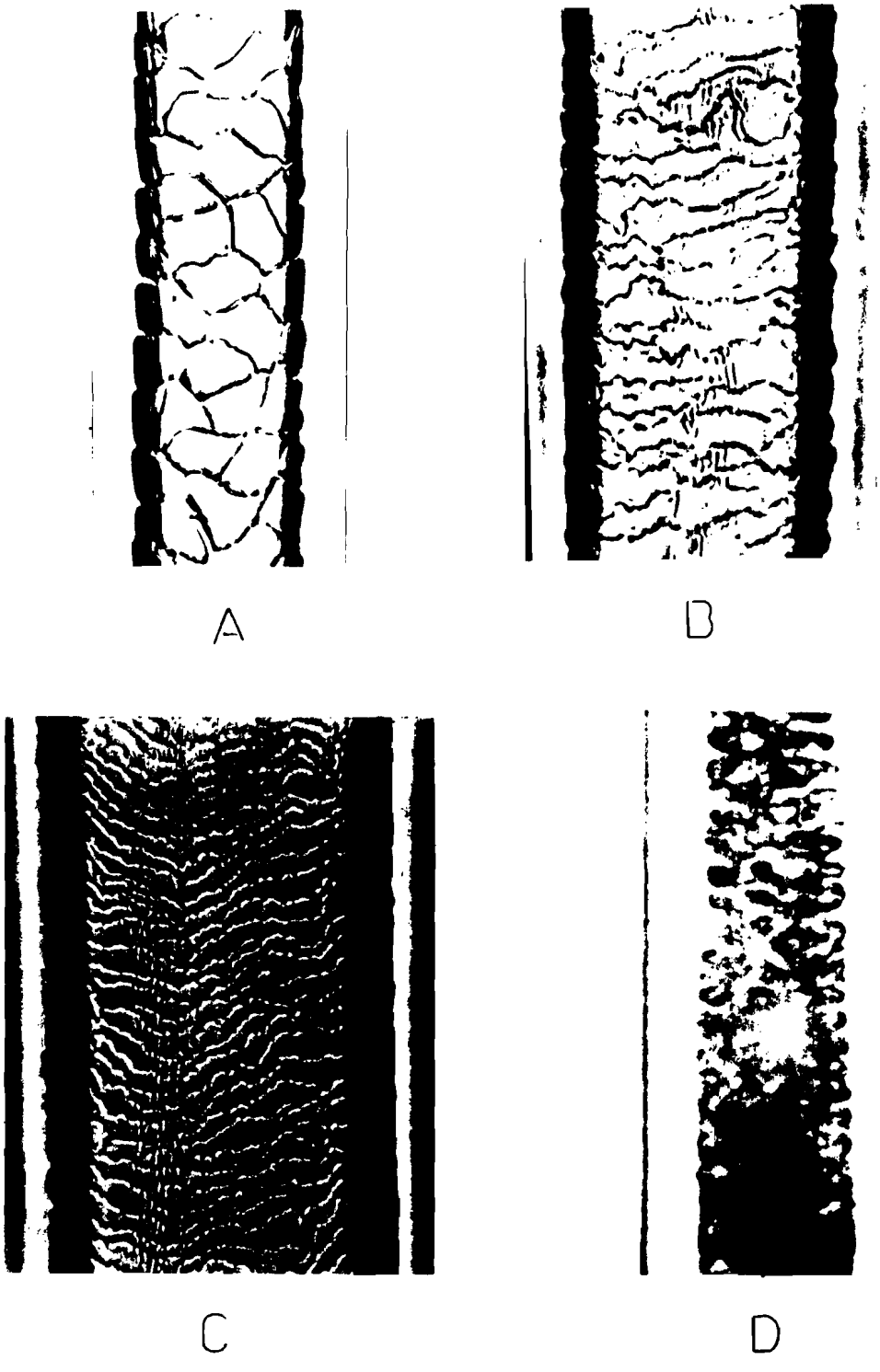


Fig. 33. Cuticular scale pattern and medulla configuration for Spilogale putorius: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Mephitis mephitis (Striped Skunk) Figure 34

Unbanded hair (A): Hair black; average length 54 mm; medulla unbroken vacuolated; maximum diameter 0.1292 mm; (± 0.0109 mm); medulla diameter 0.0839 mm (± 0.0117 mm).

Unbanded hair (B): Hair white; average length and medulla configuration same as unbanded hair (A); maximum diameter 0.1430 mm (± 0.0156 mm); medulla diameter 0.0492 mm (± 0.0052 mm); both types of hair have a wrinkled appearance and the shields are not well defined; hair diameter is uniform except at the extremities.

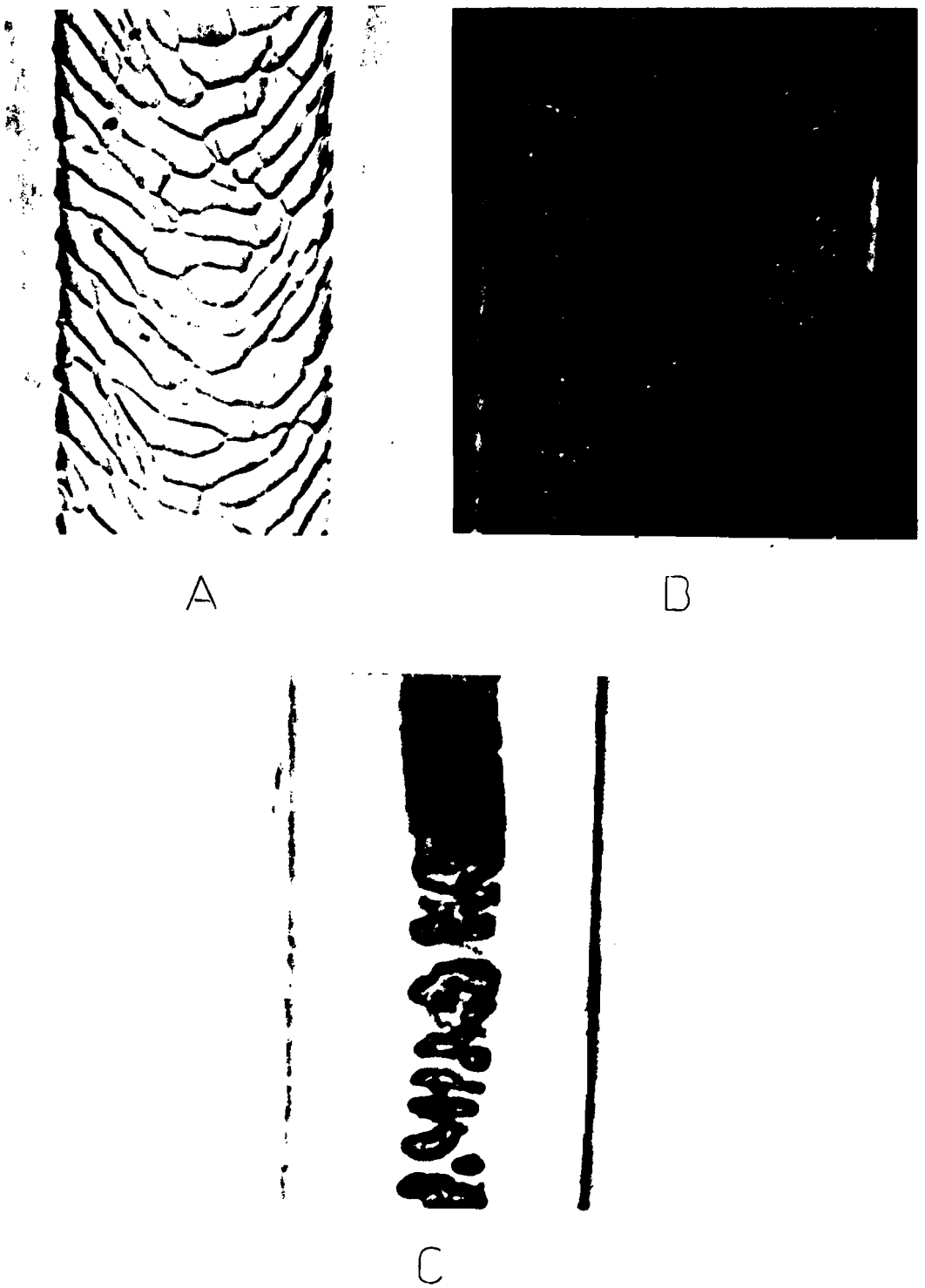


Fig. 34. Cuticular scale pattern and medulla configuration for Mephitis mephitis: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration partially cleared by mounting medium.

Felis rufus (Bobcat) Figure 35

Banded hair (A): Banding sequence - yellow, black, yellow, black; average length 40 mm; medulla unbroken vacuolated; maximum diameter 0.0959 mm (± 0.0047 mm); medulla diameter 0.0696 mm (± 0.0078 mm).

Banded hair (B): Banding sequence - black, yellow; all other characteristics same as banded hair (A).

Unbanded hair: Hair black; length and medulla configuration same as banded (A) and (B); hairs were not measured but are probably similar to banded (A) and (B); medulla difficult to see due to pigment in the cortex.

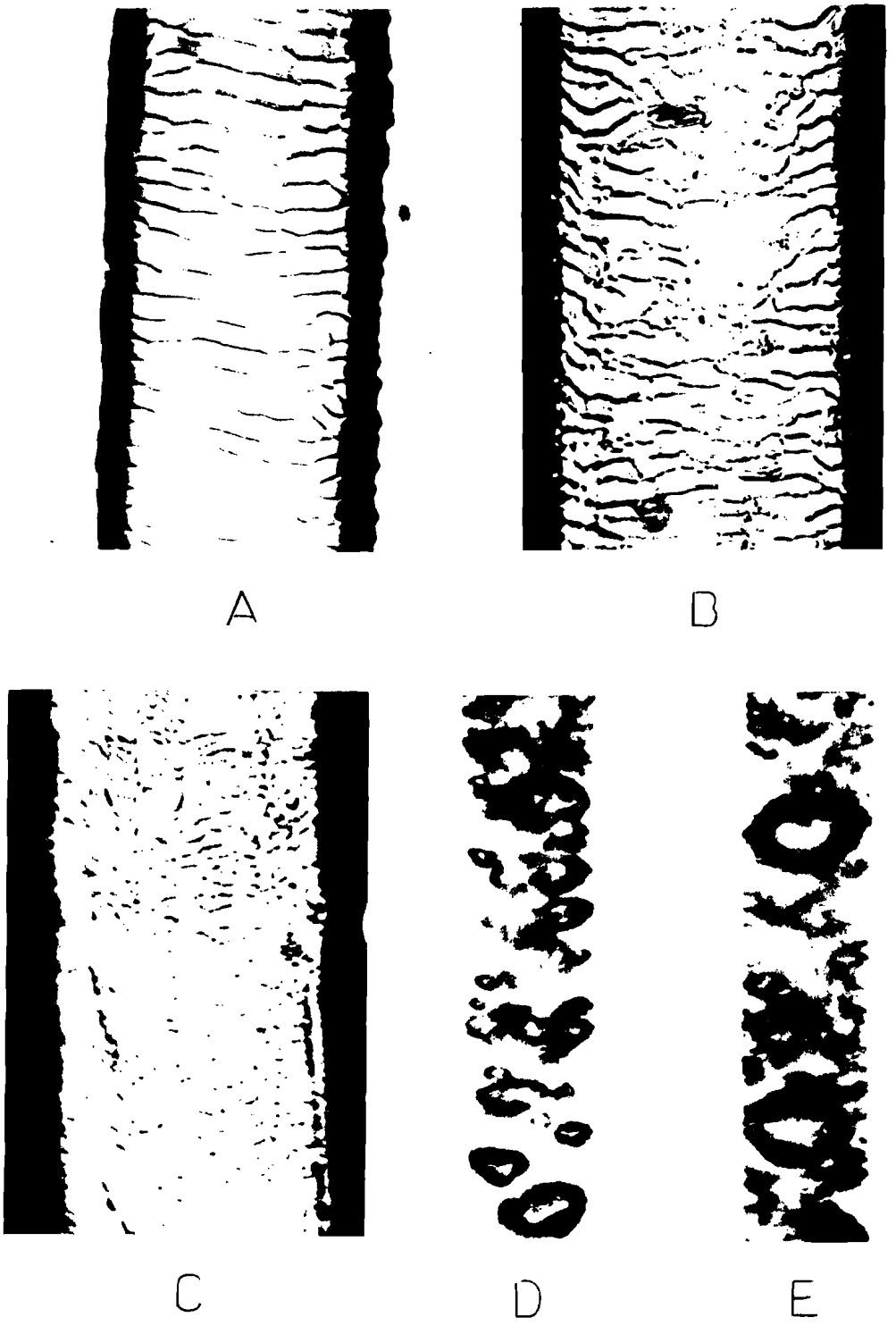


Fig. 35. Cuticular scale pattern and medulla configuration for Felis rufus: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D and E. two views of medulla showing vacuoles.

Odocoileus (Deer, 2 specimens) Figure 36

Banded hair: Banding sequence - black (small black tip), white, black or brown; average length 60 mm; medulla unbroken lattice; maximum diameter ranged from 0.1750 mm to 0.2600 mm; medulla is as wide as hair and was not measured; hair with many undulations; hair similar to Antilocapra although much smaller in diameter.

Antilocapra americana (Pronghorn, 1 specimen) Figure 36

Banded hair: Banding sequence - brown fading to white; average length 43 mm; medulla unbroken lattice; maximum diameter ranged from 0.4147 mm to 0.4290 mm; medulla is as wide as hair and was not measured; hair has no defined shield with the maximum diameter occurring near the base; many undulations throughout entire length of hair.

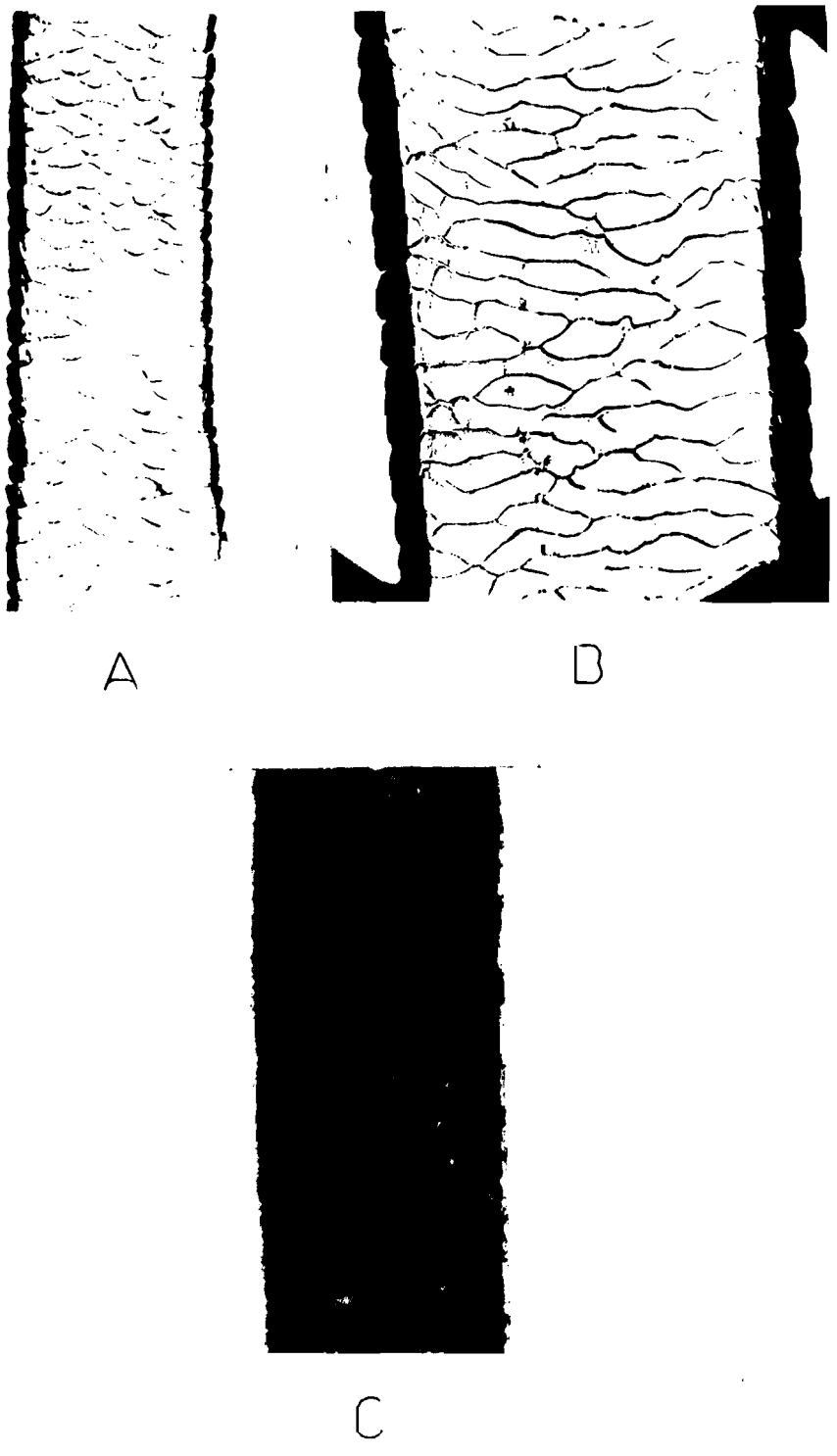


Fig. 36. Cuticular scale pattern and medulla configuration for Odocoileus sp. and Antilocarpa americana: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

Felis domesticus (House Cat, Yellow Tabby, 1 specimen)

Figure 37

Unbanded hair: Hair yellow; may lighten toward tip; average length 45 mm; medulla unbroken vacuolated; maximum diameter ranged from 0.0750 mm to 0.1375 mm; medulla diameter ranged from 0.0525 mm to 0.0875 mm.

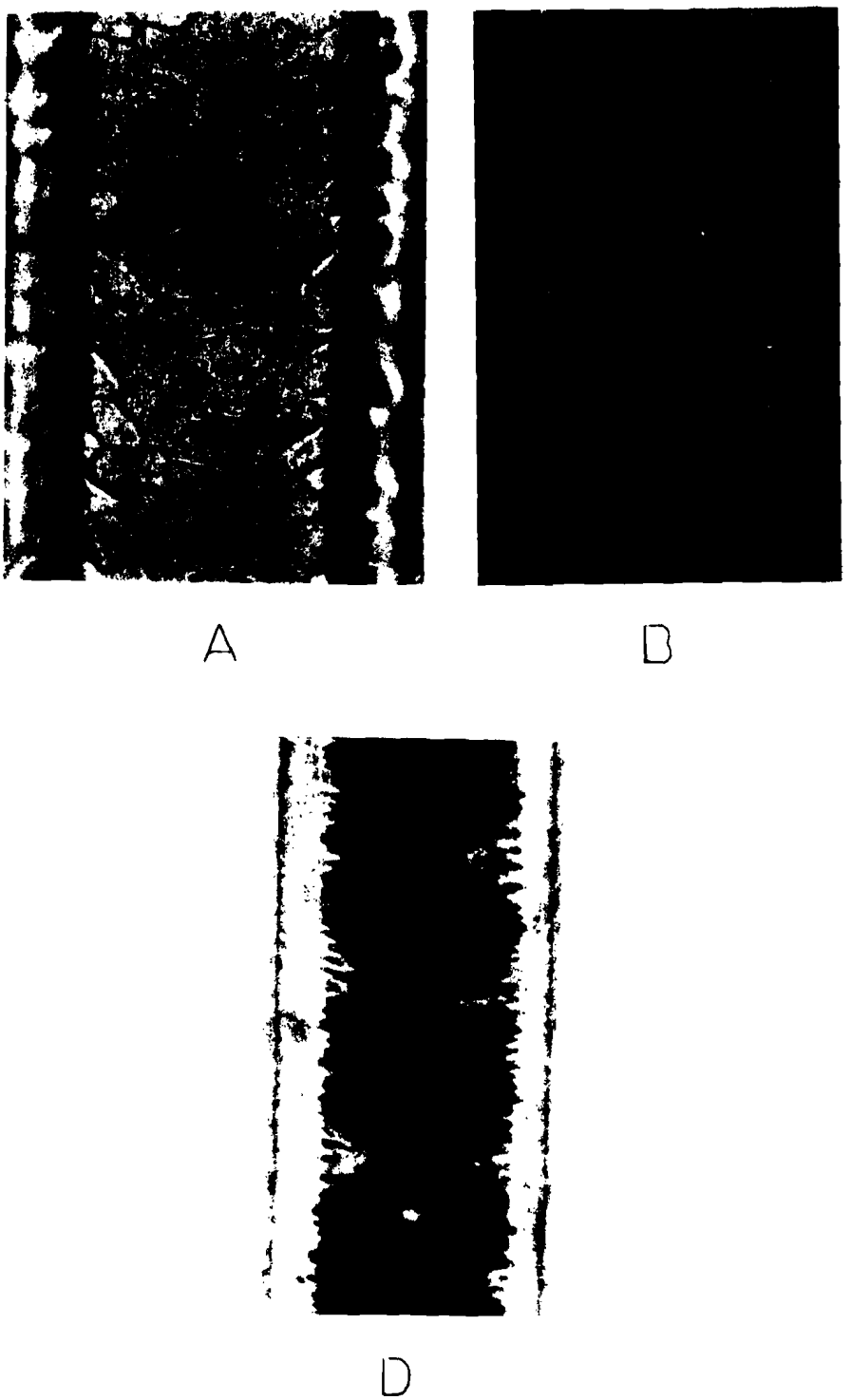


Fig. 37. Cuticular scale pattern and medulla configuration for Felis domesticus: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla showing vacuoles.

Ovis aries (Domestic sheep, 2 specimens) Figure 38

Unbanded hair: Hair may be light or dark; length is highly variable; medulla is absent or fragmented; maximum diameter variable and difficult to determine; ranging from 0.0271 mm to 0.0395 mm; hair curly and distal end may be blunt.

Bos tarus (Cattle, 2 specimens) Figure 38

Unbanded hair: Hair can be a variety of colors; average length 70 mm; medulla absent or fragmented; maximum diameter ranged from 0.0875 mm to 0.0959 mm.

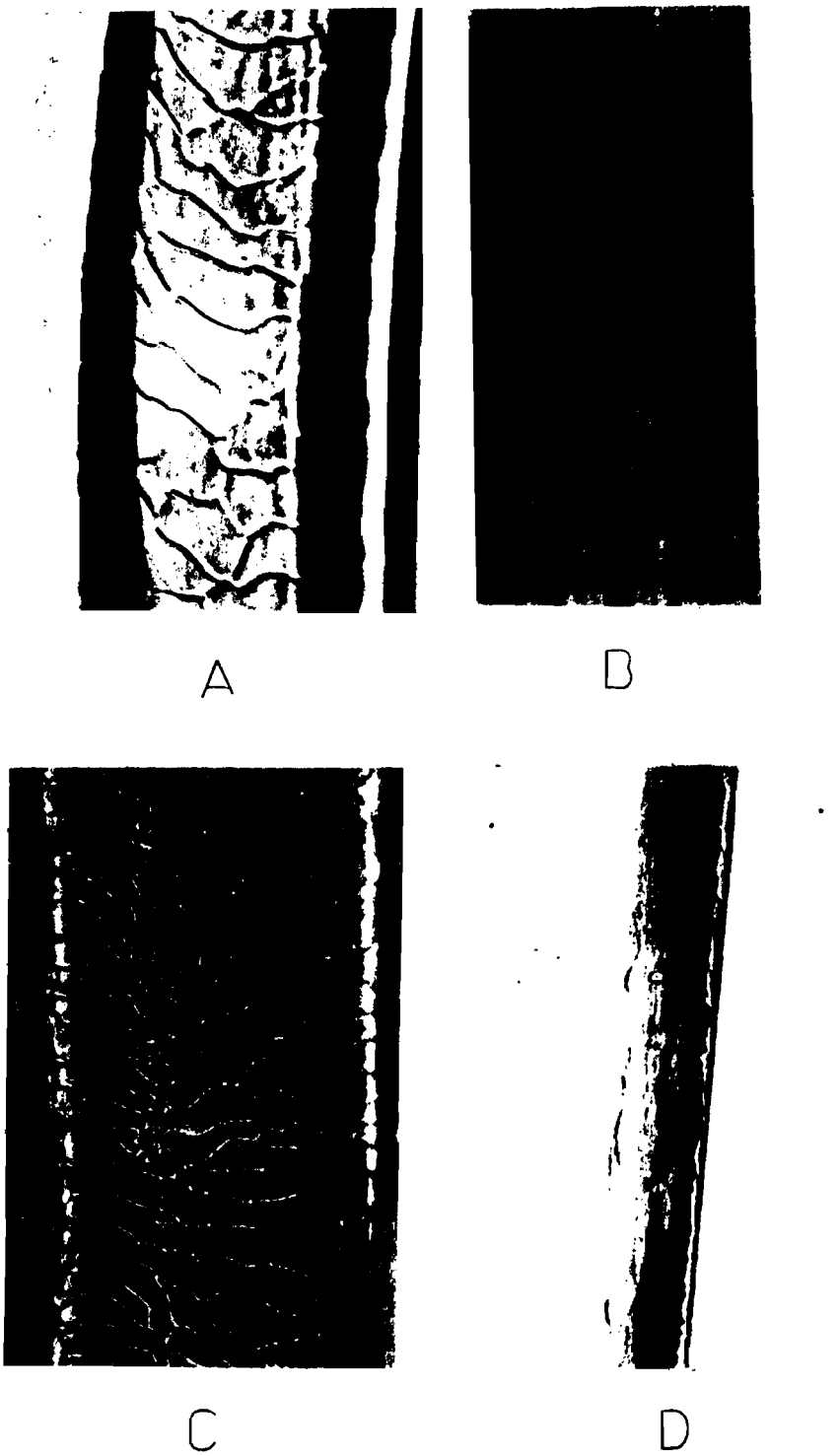
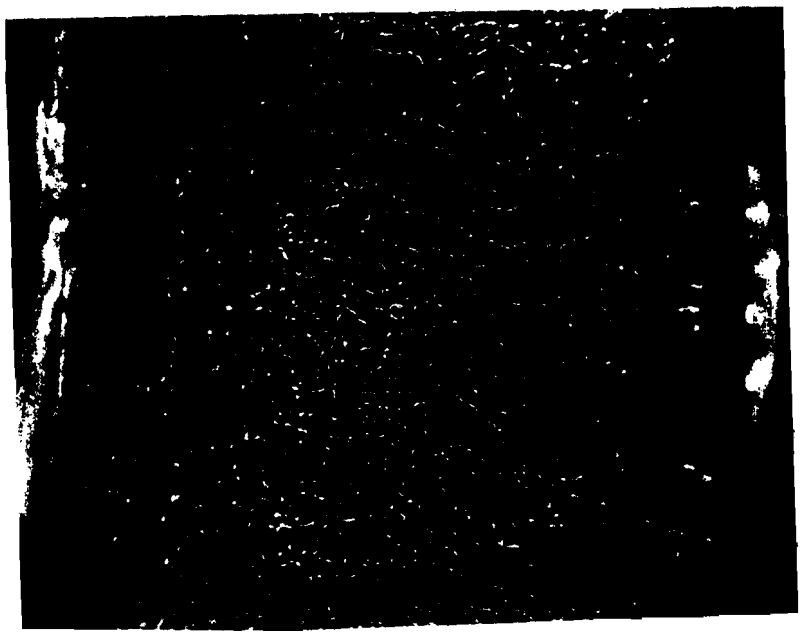


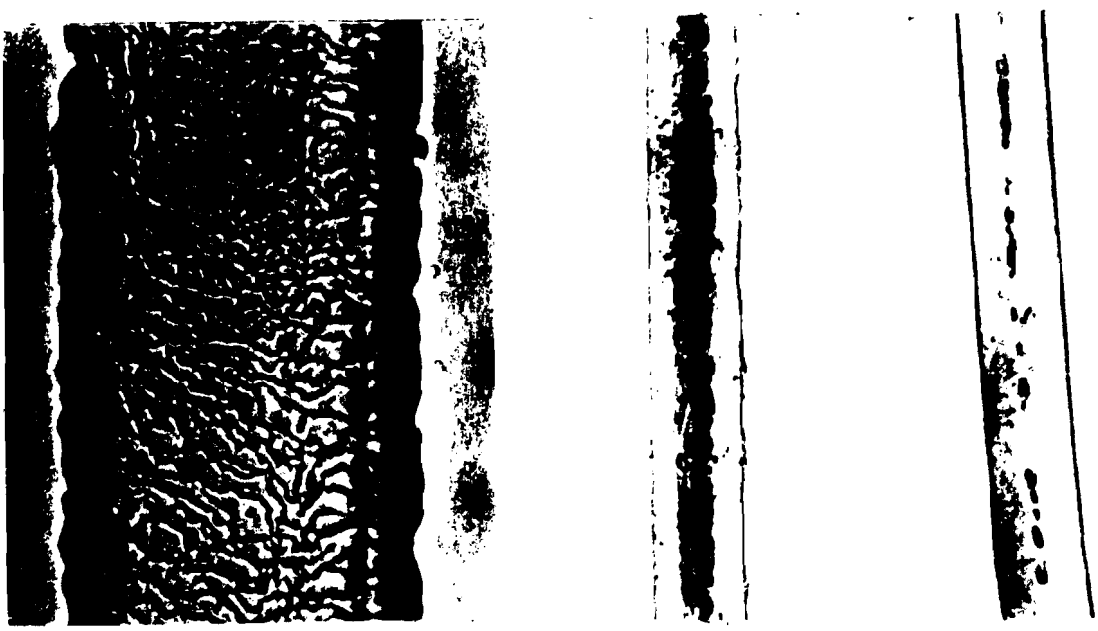
Fig. 38. Cuticular scale pattern and medulla configuration for Ovis aries and Bos tarus: A. scale pattern for Ovis, B. medulla for Ovis, C. scale pattern for Bos, D. medulla for Bos.

Sus scrofa (Domestic Pig, 3 specimens) Figure 39

Unbanded hair: Hair can be a variety of colors; average length 65 mm; medulla is absent or fragmented; maximum diameter ranged from 0.1875 mm to 0.2500 mm; hair is stiff and bristle-like.



A



B C D

Fig. 39. Cuticular scale pattern and medulla configuration for Sus scrofa: A and B, two scale pattern types common to Sus, C and D, two medulla configurations found in Sus hair.

Canis familiaris (Dog, German Shepard, 1 specimen) Figure 40

Banded hair (A): Banding sequence - black (5 mm), white, black; average length 50 mm; medulla is unbroken cellular; maximum diameter ranged from 0.0750 mm to 0.0950 mm; medulla ranged from 0.0274 mm to 0.0500 mm.

Banded hair (B): Banding sequence - black, white; average length and medulla same as banded (A); maximum and medulla diameter same as banded (A).

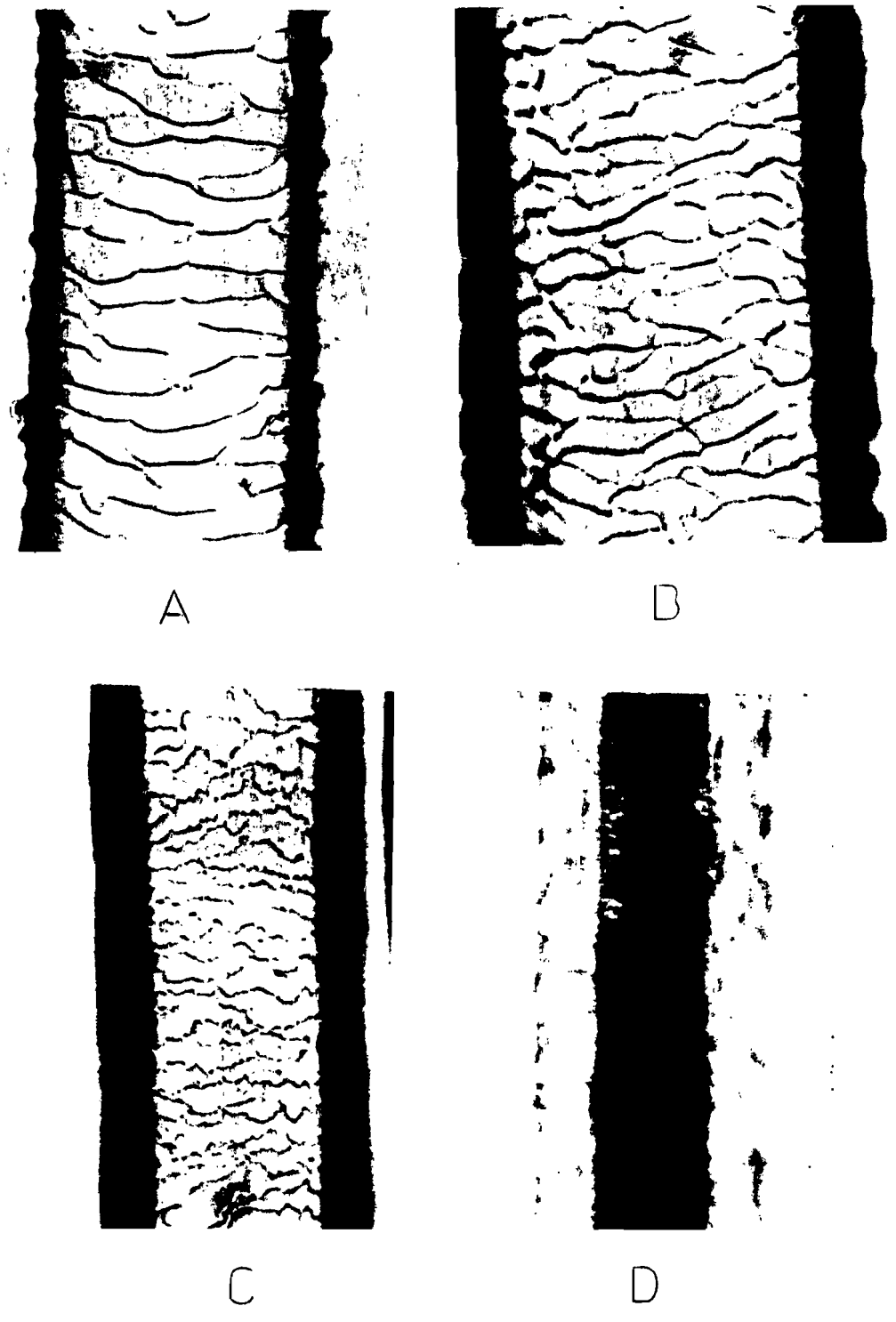


Fig. 40. Cuticular scale pattern and medulla configuration for Canis familiaris: A. lower shaft scale pattern, B. mid shaft scale pattern, C. upper shaft scale pattern, D. medulla configuration.

Equus sp. (Horse) Figure 41

Unbanded hair: Hair can be a variety of colors; length is variable; medulla is absent or fragmented.

Maximum diameter and medulla diameter varied greatly among breeds of horses. A quarter horse had a maximum diameter of 0.0590 mm and a medulla of 0.0390 mm. A shetland pony had a maximum diameter of 0.1030 mm and a medulla of 0.0655 mm. Both specimens were collected in October of the same year. It appears that quarter horses may have finer hair than shetland ponies and other similar horses, but no conclusions were drawn due to the small sample size.

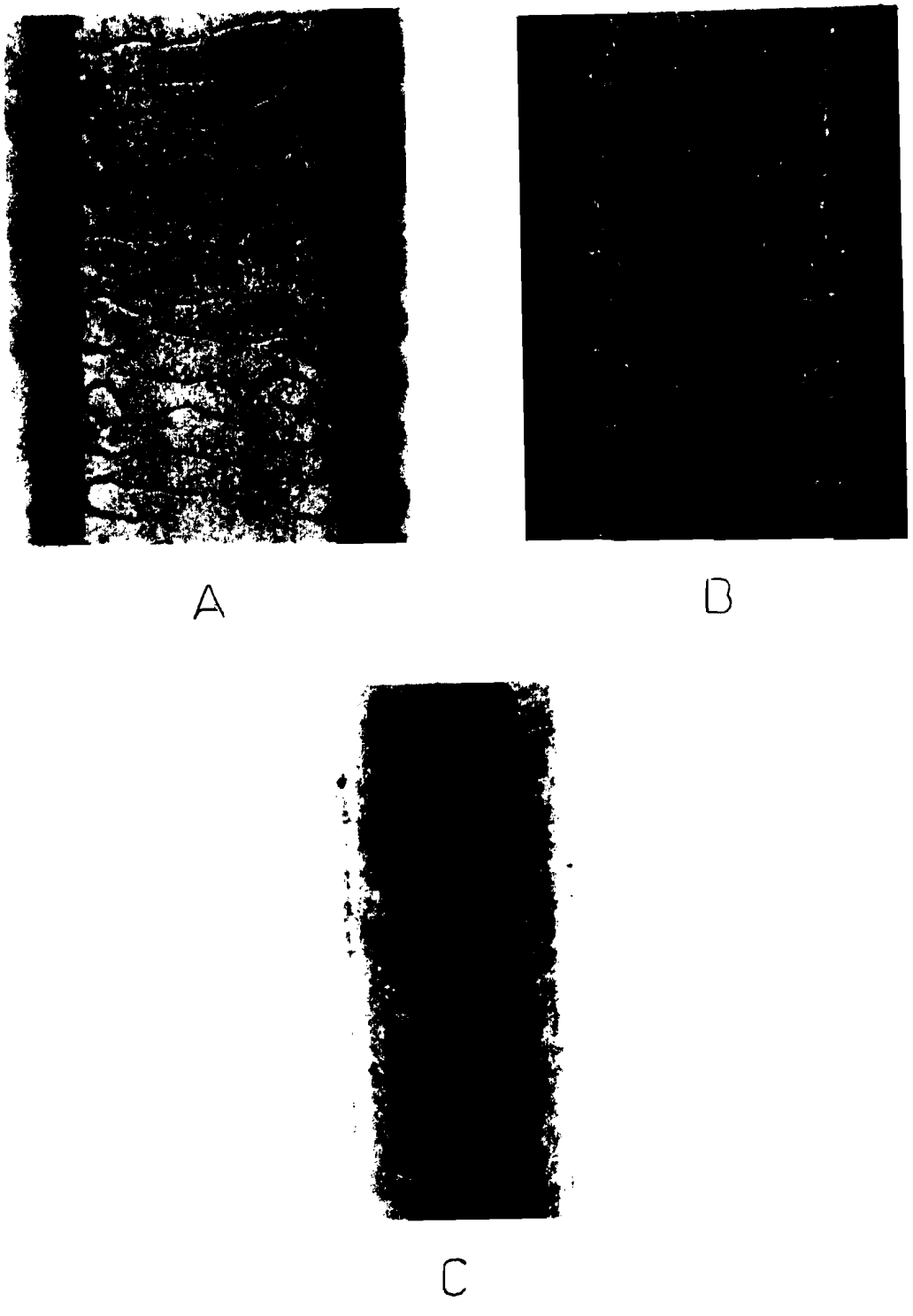


Fig. 41. Cuticular scale pattern and medulla configuration for Equus sp.: A. lower shaft scale pattern, B. upper shaft scale pattern, C. medulla configuration.

SUMMARY

Many keys have been prepared for the identification of dorsal guard hairs, but none has been written for Kansas mammals. This study was undertaken with the objective being to write a key to dorsal guard hairs of Kansas mammals, and of providing hair descriptions and photographs for all genera.

Identification was based primarily on maximum hair diameter, sequences of banding and cuticular scale pattern. For each genera/species in the key a description of the hair was provided along with photographs of scale patterns and medulla configurations.

Thirty-seven genera and 41 species of wild Kansas mammals were included in the key, and descriptions and photographs were provided for each. Descriptions and photographs were provided for 6 domestic species, but they were not included in the key because of high variability among different breeds of domestic animals.

The key, when used in conjunction with descriptions and photographs, should provide a useful tool to field biologists and others with a need to identify unknown mammal hair.

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