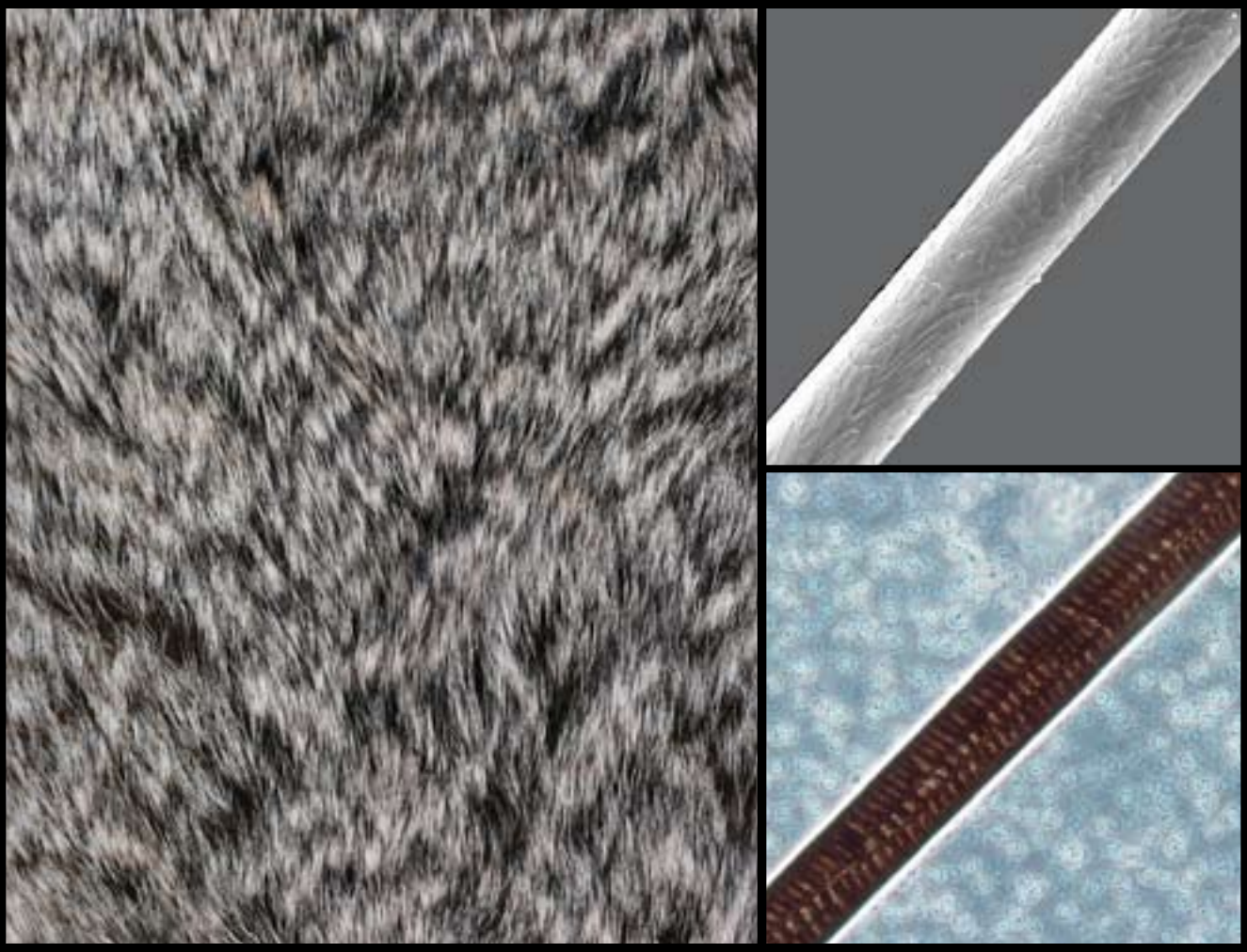
TEXAS TECH UNIVERSITY
Natural Science Research Laboratory

Atlas and Key to the Hair of Terrestrial Texas Mammals



Anica Debelica and Monte L. Thies

Special Publications
Museum of Texas Tech University
Number 55 26 August 2009

Front cover: Pelage, SEM image, and photomicrograph of black-tailed jackrabbit, *Lepus californicus* (pelage of SHM 510; SEM and micrograph of SHM 38). Cover design by M. L. Thies.

Atlas and Key to the Hair of Terrestrial Texas Mammals

Anica Debelica and Monte L. Thies

Sam Houston State University

Layout and Design: Lisa Bradley
Cover Design: Monte L. Thies

This book was set in Times New Roman and printed on acid-free paper that meets the guidelines for permanence and durability of the Committee on Production Guidelines for Book Longevity of the Council on Library Resources.

Printed: 26 August 2009

Library of Congress Cataloging-in-Publication Data

Special Publications of the Museum of Texas Tech University, Number 55
Series Editor: Robert J. Baker

Atlas and Key to the Hair of Terrestrial Texas Mammals

Anica Debelica and Monte L. Thies

ISSN 0169-0237
ISBN 1-929330-17-0
ISBN13 978-1-929330-17-1

Museum of Texas Tech University
Lubbock, TX 79409-3191 USA
(806)742-2442

Atlas and Key to the Hair of Terrestrial Texas Mammals

Anica Debelica and Monte L. Thies

Abstract

Even though some hairlike structures may be found on organisms such as birds, insects, and plants, true epidermal hair is a unique characteristic of mammals. Samples of guard hairs from over 150 mammalian species found in Texas were collected from specimens housed in natural history collections or, as in the case for domestic farm animals, were obtained from living animals. An atlas and key were developed after examining several characters of hair samples, including average diameter of the hairs, structure of the medulla, and arrangement of cuticular scales. Digital photographs of the medulla and SEM images of the hair's surface accompany the key and should provide a helpful tool for hair identification.

Key words: atlas, dorsal guard hair, hair identification, key, terrestrial mammals, Texas

Introduction

Even though hairlike structures may be found on organisms such as birds, insects, and plants, true epidermal hair is a unique characteristic of mammals. In most mammals, hair is conspicuous, but in some, such as some whales, hair is represented by only a few bristles on the embryo (DeBlase et al. 2001).

Most hair identification in the past has been done by specialists who learned their craft by comparing unknown with known samples. This process necessitated patience, years of practice, and an extensive reference collection of hairs (Williams 1938). Williams (1938) believed that "there is a real need for the definition and illustration of diagnostic characters of hairs and the preparation of keys that may be used successfully by others than specialists." Keys and atlases to mammalian hair of different regions of the world would be of great help in studies of food habits of predatory mammals and birds, such as mountain lions and owls, respectively, because in these studies scientists often examine hairs found in fecal samples in order to determine what those animals were eating. These keys could also facilitate identification of hair found at crime scenes or be useful in species identifications of material recovered in illegal trade of wildlife parts.

Despite the potential uses that keys to mammalian hairs may have, few fully developed keys and atlases have been published. Numerous scientists in the United States, such as Hausman (1920), Cole (1924), Mathiak (1938), Williams (1938), Brown (1942), Nason (1948), Mayer (1949, 1952), Benedict (1957), Stains (1958), Miles (1965), Short (1978), Moore et al. (1974), Gaisler and Barus (1978), Homan and Genoways (1978), Hess et al. (1985), Hickey and Fenton (1987), Stangl and Grimes (1987), van Staaden and Jones Jr. (1997), and Amman et al. (2002) have conducted descriptive and comparative studies of mammalian hairs. They have expanded our knowledge on structure and appearance of hair, as well as the taxonomic and phylogenetic value of hair. Unfortunately, most of these studies, with the exception of Mathiak (1938), Mayer (1952), Stains (1958), and Moore et al. (1974), focused on a limited number of taxa from specific families or genera instead of focusing on all of the mammals from a specific region. In addition, scientists conducting these studies argued about the usefulness of hair properties in resolving phylogenetic problems in groups such as New World bats. Cole (1924), Nason (1948), Benedict (1957), Miles (1965), and Short (1978) believed that hair is of very limited taxonomic value, whereas

Mathiak (1938), Williams (1938), and Brown (1952) believed the opposite. Amman et al. (2002) provided an analysis of hair structure in bats from Colorado, effectively demonstrating the utility of SEM in differentiation among a limited number of species from a limited geographic area.

In the last few decades, only a few scientists have provided complete regional keys to mammalian hairs such as "A key to the hairs of the mammals of Southern Michigan" (Mathiak 1938), "The hair of California mammals with keys to the dorsal guard hairs of California mammals" (Mayer 1952), "Field key to guard hair of Middle Western furbearers" (Stains 1958), and "Identification of the dorsal guard hairs of some mammals of Wyoming" (Moore et al. 1974). In Europe, Lochte (1938) published an atlas to hairs, Keller (1978; 1980; 1981a, b) published papers providing keys and valuable information concerning hair characters, and Teerink (1991) published an atlas and identification key to hair of Western European mammals.

Hair formation.—The primary development of hair begins as a localized proliferation of epidermal cells forming a dense aggregation of cells, which elongates downward into the dermis. The dermal cells, beneath this downward-elongated, flask-shaped depression of the epidermal cells, form a dense mass that ultimately forms the papilla of the hair. This flask-shaped depression becomes lined with cells of the epidermis becoming a follicle (Hausman 1920). The epithelial contents of the growing follicle elongate into an avial strand of fusiform, spindle cells, which undergoes keratinization and forms the hair shaft. The lower part of the shaft expands into a bulb that wraps the papilla while the shaft elongates upward and emerges through the epidermis and continues to grow. Growth is confined to the proximal portion of the shaft where matrix cells continuously convert into keratinized hair shaft cells (Hausman 1920).

Hair structure.—The hair shaft consists of four structural units, the *medulla*, *cortex*, *pigment granutes*, and *cuticle* (Hausman 1920, Fig.1). *Medulla*: built up from many shrunken and variously disposed cells or chambers, representing dried and cornified epithelial structures connected by a branching filamentous network, which sometimes completely fills the medullary column, but is interrupted in many cases. *Cortex*: shell surrounding the medulla that is composed of elongate, fusiform cells (hair spindles) coalesced together into a horny, almost homogenous, hyaline mass and forming, in many cases where the medulla is reduced, a larger proportion of the hair shaft. *Pigment granules*: structures primarily responsible for the color of the hair; in some mammals pigment is difuse instead of granular. Granules are scattered within or between the hair spindles, and in some hairs they are arranged in definite patterns. *Cuticle*: outermost integument of a hair shaft composed of thin, hyaline, colorless scales of varying forms and dimensions.

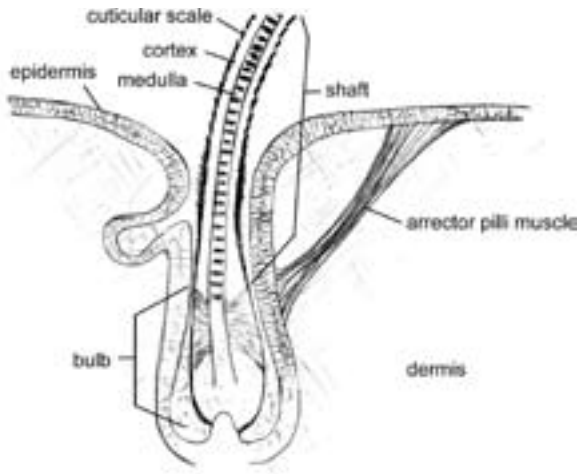


Figure 1. Sectional view of skin showing hair and various structures in dermis and epidermis (after Duperron 1997).

Classification and function of hair.—Hair can be divided into two major groups: (1) hairs with sensory function, and (2) all other or "normal" hair. "Normal" hair can be further divided into three subgroups: (a) heavy overhairs that are usually longer, straighter, and more robust throughout their length than the general coat in most mammals; (b) curly overhairs that are usually enlarged only in the distal third or half of their lengths, the basal portion being decidedly weaker and more flexible; and (c) furhairs that are uniformly weak and flexible except at the tip and base (Williams 1938). Both (a) and (b) are together known as guard hair.

The objective of this project was to provide a key and atlas to the hairs of Texas land mammals that would be relatively easy for anyone to use. Digital photographs of the medulla and SEM images of the surface (scales) of guard hairs accompany the key to provide aids in hair identification.

METHODS AND MATERIALS

Hair samples of over 150 species of land mammals found in Texas (following Schmidly 2004) were collected from specimens in the mammal holdings of the Sam Houston State Vertebrate Museum (SHM), Huntsville, Texas; the Angelo State Natural History Collection (ASNHC), San Angelo, Texas; the Texas Cooperative Wildlife Collection (TCWC) at Texas A&M University, College Station, Texas; the Oklahoma State University Collection of Vertebrates (OSUCOV), Stillwater, Oklahoma; and the Museum of Texas Tech University (TTU), Lubbock, Texas. In addition, samples were provided by the Houston Zoological Park, Houston, Texas; and R. Smith, Huntsville, Texas.

Although underhair had been used in previous studies (Hausman 1920, 1930; Cole 1924), this study focused on dorsal guard hair. This is the type of hair that scientists or law enforcement investigators would most likely encounter in their work. Guard hair is more robust and larger in length and diameter than underhair and is most likely to be detected in biological samples and at crime scenes. Nason (1948) pointed out that "hairs from the center of the mid-dorsal region would be typical for a species and be an adequate basis for comparing one with another." According to Teerink (1991), there are three types of guard hair: GH0, GH1, and GH2. GH0 hair is stiff, firm, and straight, but it seldom occurs within pelage. GH1 hair is usually stiff and firm, occurs very often within pelage, and its shield (hair's thickest part) is somewhat closer to the tip. In some mammals, it can be slightly wavy or bent. In GH2, the shield and shaft usually form an angle with each other. The shaft is usually straight, but it can also be wavy to different degrees. It also occurs often in pelage like GH1. Teerink (1991) suggested that GH1 and GH2 provide the most information that can be used to build a key, and that four features of GH1 and GH2 are important for identification: (1) the cuticula in shaft and proximal shield; (2) cross-section through the shield; (3) medulla in the thickest part of the shield; and (4) medullar margins in the thickest part of the shield. However, Benedict (1957), Gaisler and Barus (1978), Hickey and Fenton (1987), and van Staaden and Jones Jr. (1997) all agreed "that only the scales in the mid-region of a hair shaft are the mature and uniform types" (Benedict 1957). In this study, dorsal guard hairs were collected from the central mid-dorsal region of specimens and scales and medulla from the mid-region of the hair shaft were used.

Preparation of slides.—Hairs were cleaned and freed of grease (in tepid water with detergents) and stored in 70% ethanol. For medullar slides, hairs were immersed in paraffin oil before being mounted on slides and covered with a cover glass: the paraffin oil penetrates the medulla and enables visualization of the medulla structure (Teerink 1991). Slides were examined with Olympus BX41 and Olympus DP11 compound microscopes at 400X magnification.

The medulla was classified following Hausman (1920) as Discontinuous (Fig. 2 Simple, Fig. 3 Compound, Fig. 4 Fragmental) or Continuous (Fig. 5 Nodose, Fig. 6 Homogeneous).

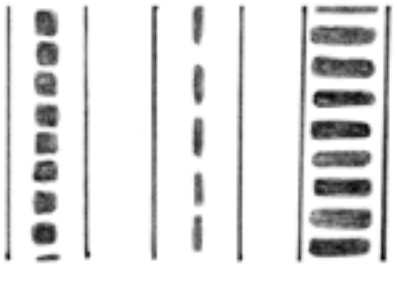


Figure 2. Simple medulla types: (a) Ovate, (b) Elongate, and (c) Flattened.

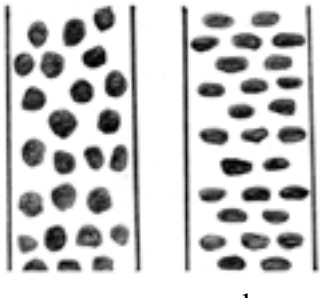


Figure 3. Compound medulla types: (a) Ovate and (b) Flattened.

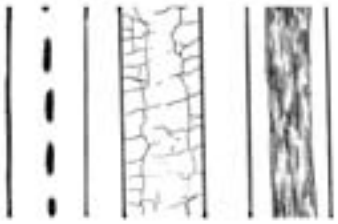


Figure 4. Fragmental medulla types (a), (b), and (c).

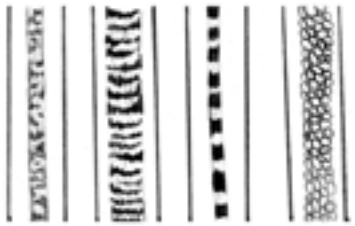


Figure 5. Nodose medulla types (a) and (b).

Figure 6. Homogeneous medulla types (a) and (b).

Hair profile slides were used for the measurements (length and diameter). Following Moore et al. (1974) hairs were examined for shape and shield location, color (bicolored or multicolored), and color band pattern (number and position of bands). However, of these characteristics, only diameter was included in the keys because length, coloration, banding pattern, and shield position are too variable and may be misleading due to the seasonal changes. Complete hairs are also often lacking in a sample.

Preparation of SEM material.—Scanning electron microscope (SEM) images of hair surfaces (scales) were taken following methods as described by Stangl and Grimes (1987). Entire hairs were mounted on specimen stubs using two-sided tape. Stubs were then sputter coated with gold and the coated specimens examined with a HiVac SEM "Vega TC."

Because bat hair lacks a medulla, has limited variation in scale types, and is generally difficult to distinguish, scale indexes (SI = maximum scale width/maximum scale length) and width index (WI = maximum/minimal scale width) were determined as an additional identification tool. All hairs were classified according to their scales type (Figs. 7-8) following Hausman (1920) and Nason (1948).

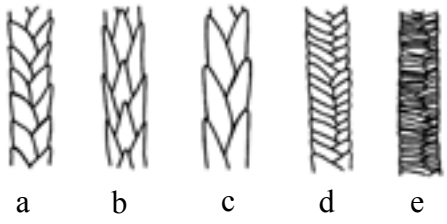


Figure 7. Imbricate cuticula types: (a) Ovate, (b) Acuminate, (c) Elongate, (d) Crenate, and (e) Flattened.

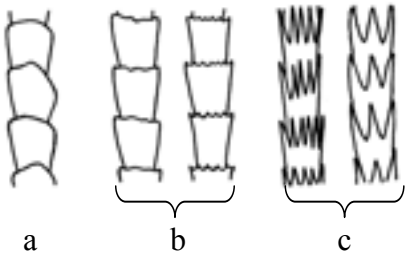


Figure 8. Coronal types of scales: (a) Simple, (b) Serrate, and (c) Dentate.

RESULTS

An ordinal key to the hair of terrestrial Texas mammals, as well as the species keys for each order, were constructed using three primary hair characteristics: medulla type, scale type, and shaft diameter. For Chiroptera (bats), medulla type was replaced by two characters – scale index (SI) and width index (WI). Each key to order is followed by an atlas of species occurring in Texas, a brief description of hair characteristics, a digital photograph of the medulla, and an SEM image of the cuticula (Figs. 9-159). Common domestic or non-native but free-ranging species such as house mice (*Mus musculus*), feral hogs (*Sus scrofa*), and nutria (*Myocastor coypus*) are indicated by an asterisk.

Glossary of Terms

"Cells" – The shape of medullar "cells" may be oval, rectangular, square, or flattened.

Columns/rows – The absence, presence, arrangements, and any disturbances of medullar cells within columns and/or rows.

Coronal cuticula (Fig. 8) – Only one scale in each row completely encircling the hair.

Discontinuous medulla (Figs. 2-4) and C*ontinuous medulla* (Figs. 5-6) – Type of arrangement of "cells" and chambers within medullar column.

Imbricate cuticula (Fig. 7) – There are at least two scales in a single row of the cuticula.

Medulla – Central hair portion built up from many shrunken and variously disposed cells or chambers.

Medulla occupies entire shaft – Medulla is spread throughout the entire shaft, from one side to the other.

Medulla occupies >1/2 of the shaft – Medulla is spread throughout the central part of the shaft; it occupies more than 1/2 of the shaft, but not the entire shaft.

Medulla occupies 1/2 of the shaft – Medulla is found only in central part of the shaft and covers overall 1/2 of it.

Medulla occupies 1/3 of the shaft – Medulla is found only in central part of the shaft and covers overall only 1/3 of it.

Penetrated/not penetrated – If medullar structure is visible, then medulla is penetrated by the light. If medullar structure cannot be seen and the entire shaft appears dark, then medulla is not penetrated by the light.

*Scale index (SI) – C*alculated by dividing maximum width of the scale by the length of the scale. Replaces type of medulla in the identification of bat hair.

Vacuolated – Presence or absence of vacuoles in medulla.

Width index (WI) – Calculated by dividing maximum width of the scale by the minimal width of the scale. Replaces type of medulla in the identification of bat hair.

ORDINAL KEY TO THE HAIR OF TERRESTRIAL TEXAS MAMMALS

1. Medulla absent.....Chiroptera
   Medulla present.....2

2. Medulla discontinuous.....3
   Medulla continuous.....14

3. Medulla simple (Fig. 2).....4
   Medulla other than simple.....7

4. Medulla type a (Fig. 2).....5
   Medulla type c (Fig. 2).....6

5. Medulla occupies 1/3 of shaft.....Soricomorpha
   Medulla occupies entire shaft.....Rodentia

6. Medulla visible in cuticular photographs.....Soricomorpha
   Medulla not visible.....Rodentia

7. Medulla compound (Fig. 3).....8
   Medulla fragmental (Fig. 4).....10

8. Medulla other than ovate.....Rodentia
   Medulla ovate (Fig. 3).....9

9. Medulla with flattened cuticula (Fig. 7e).....Carnivora
   Medulla with other than flattened cuticula (Fig. 7a-d).....Rodentia

10. Medulla type b or c (Fig. 4).....Rodentia
    Medulla type a (Fig. 4).....11

11. Medulla with flattened cuticula (Fig. 7e).....Perissodactyla
    Medulla with crenate cuticula (Fig. 7d).....12

12. Medulla with cortical intrusions.....Rodentia
    Medulla with no cortical intrusions.....13

13. Medulla extremely fragmented and present in small fragments, medulla occupies less than 1/3 of shaft.....Primates
Medulla present in large fragments, medulla occupies almost 1/2 of shaft.....Artiodactyla

14. Medulla homogeneous (Fig. 6).....15
Medulla nodose (Fig. 5).....17

15. Medulla occupies less than 1/3 of shaft.....Cingulata
Medulla occupies more than 1/3 of shaft.....16

16. Medulla not penetrated, scales flattened (Fig. 7e).....Artiodactyla
Medulla not penetrated, scales crenate (Fig. 7d).....Carnivora

17. Medulla nodose type a (Fig. 5a).....18
Medulla nodose type b (Fig. 5b).....20

18. Medulla vacuolated.....Carnivora
Medulla not vacuolated.....19

19. Shaft d>100µm.....Didelphimorphia
Shaft d< 100µm.....Rodentia

20. Medulla ordered into columns.....Lagomorpha
Medulla not ordered into columns.....21

21. Medulla disturbed.....22
Medulla undisturbed.....24

22. Cuticula flattened (Fig. 7e).....Artiodactyla
Cuticula crenate (Fig. 7d).....23

23. Medulla occupies 1/3 of shaft.....Artiodactyla
Medulla occupies more than 1/2 of shaft.....Rodentia

24. Medulla "cells" not flattened.....Artiodactyla
Medulla "cells" flattened.....25

25. Medulla vacuolated.....Carnivora
Medulla not vacuolated.....Rodentia

ORDER DIDELPHIMORPHIA - OPOSSUMS

Medulla continuous, nodose type a (Fig. 5a), non-vacuolated, occupies more than 1/2 of shaft. Cuticula imbricate, crenate (Fig. 7d), disturbed rows. Midshaft dia. 130µm.....*Didelphis virginiana* (Fig. 9)

Family Didelphidae

***Didelphis virginiana* - Virginia Opossum** (SHM 6)

Medulla continuous, nodose type a, occupies more than 1/2 of shaft. Cuticula imbricate, crenate, disturbed rows. Midshaft dia. 130µm.

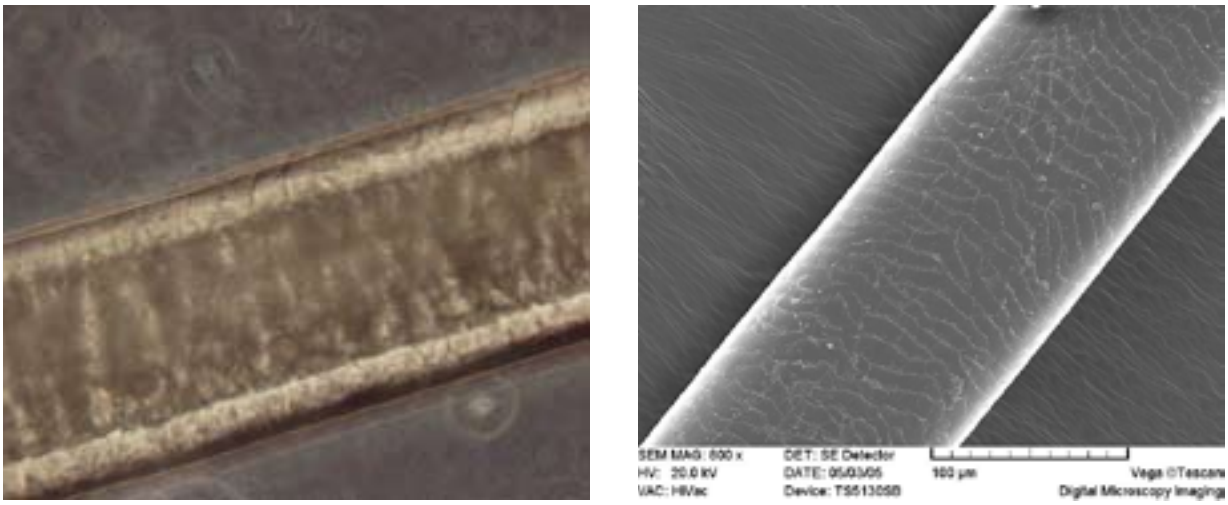


Figure 9. Medulla (left) and cuticula (right) of *Didelphis virginiana*.

ORDER CINGULATA - ARMADILLOS

Medulla continuous, homogeneous type a (Fig. 6a), occupies less than 1/3 of shaft. Cuticula imbricate, crenate (Fig. 7d), irregular scales with no apparent rows. Midshaft dia. 200µm.....*Dasypus novemcinctus* (Fig. 10)

Family Dasypodidae

***Dasypus novemcinctus* - Nine-banded Armadillo** (SHM 171)

Medulla continuous, homogeneous type a, occupies less than 1/3 of shaft. Cuticula imbricate, crenate, scales irregular with no apparent rows formed. Midshaft dia. 200µm.

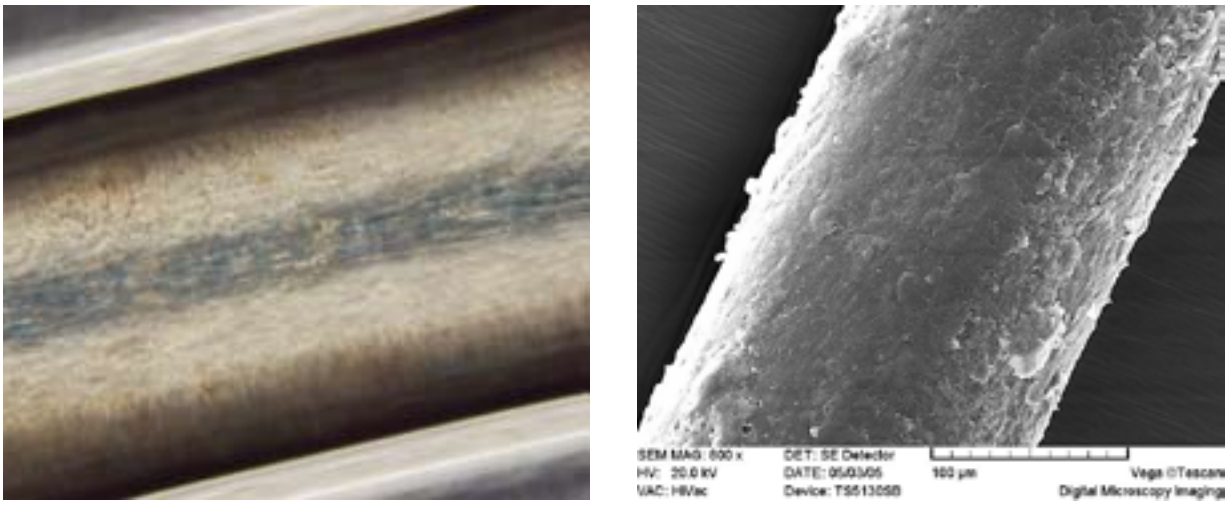


Figure 10. Medulla (left) and cuticula (right) of *Dasypus novemcinctus*.

ORDER SORICOMORPHA - SHREWS AND MOLES

All have discontinuous simple medulla (Fig. 2).

1. Medulla simple type a (Fig. 2a).....*Blarina carolinensis* (Fig. 11)
   Medulla simple type c (Fig. 2c).....2

2. Medulla "cells" flattened.....3
   Medulla "cells" not flattened.....4

3. Cuticula crenate (Fig. 7d).....*Blarina hylophaga* (Fig. 12)
   Cuticula elongate (Fig. 7c).....*Cryptotis parva* (Fig. 13)

4. Medulla "cells" rectangular.....*Notiosorex crawfordi* (Fig. 14)
   Medulla "cells" variably shaped.....*Scalopus aquaticus* (Fig. 15)

Family Soricidae - Shrews

***Blarina carolinensis* - Southern Short-tailed Shrew** (SHM 380)

Medulla discontinuous, simple type a, occupies 1/3 of shaft. Cuticula imbricate, crenate, medulla visible. Mid-shaft dia. 44µm.

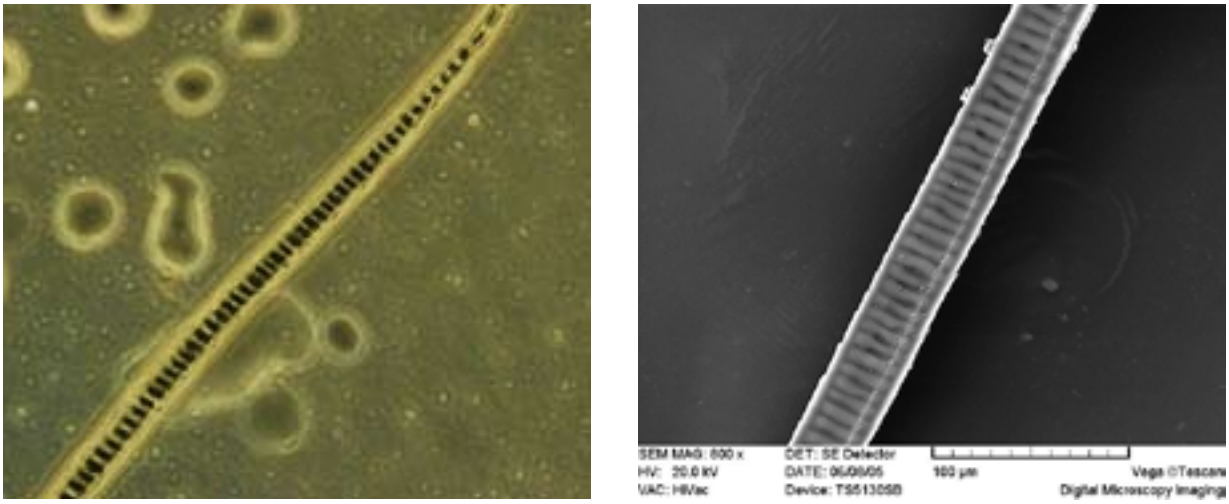


Figure 11. Medulla (left) and cuticula (right) of *Blarina carolinensis*.

***Blarina hylophaga* - Elliot's Short-tailed Shrew** (TTU 100794)

Medulla discontinuous, simple type c, very flattened "cells", occupies more than 1/2 of shaft. Cuticula imbricate, crenate, medulla visible in middle. Midshaft dia. 34µm.

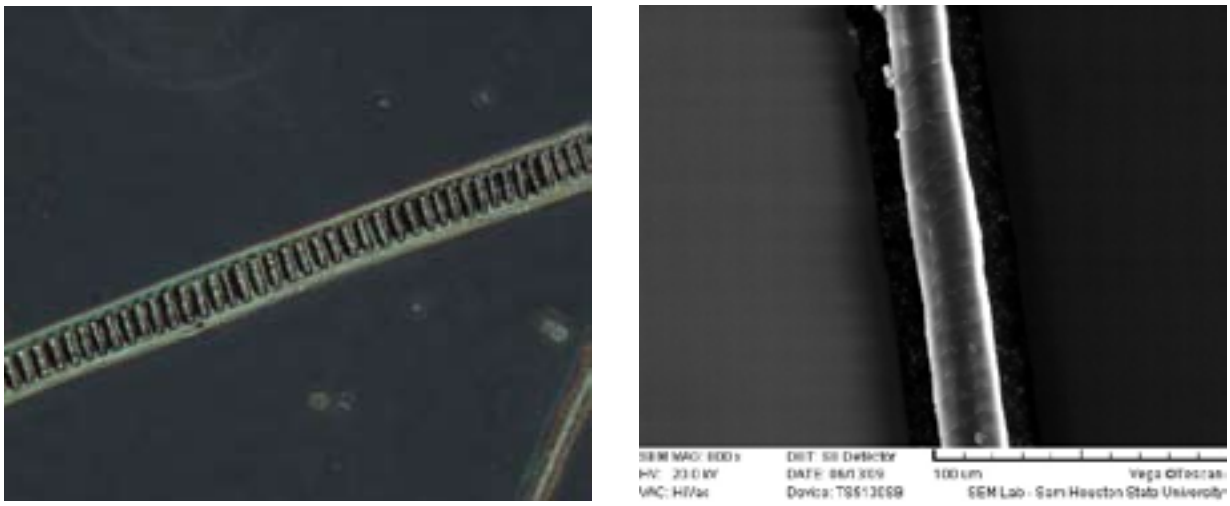


Figure 12. Medulla (left) and cuticula (right) of *Blarina hylophaga*.

***Cryptotis parva* - Least Shrew** (SHM 163)

Medulla discontinuous, simple type c, very flattened "cells", occupies more than 1/2 of shaft. Cuticula imbricate, elongate, medulla visible. Midshaft dia. 21µm.

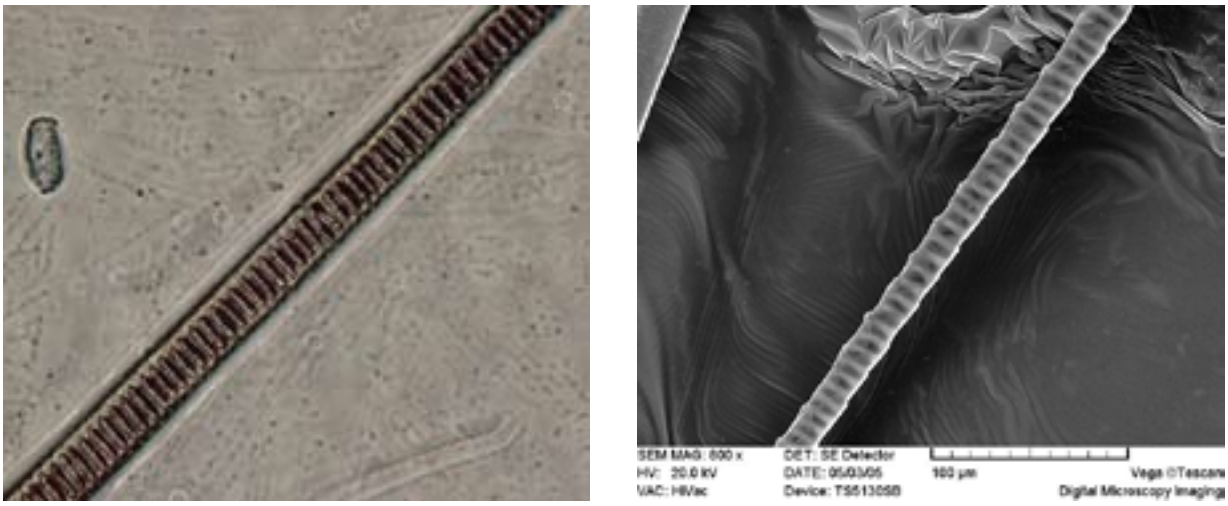


Figure 13. Medulla (left) and cuticula (right) of *Cryptotis parva*.

***Notiosorex crawfordi* - Desert Shrew** (SHM 37)

Medulla discontinuous, simple type c, rectangular "cells", occupies entire shaft. Cuticula imbricate, elongate, visible medulla. Midshaft dia. 23µm.

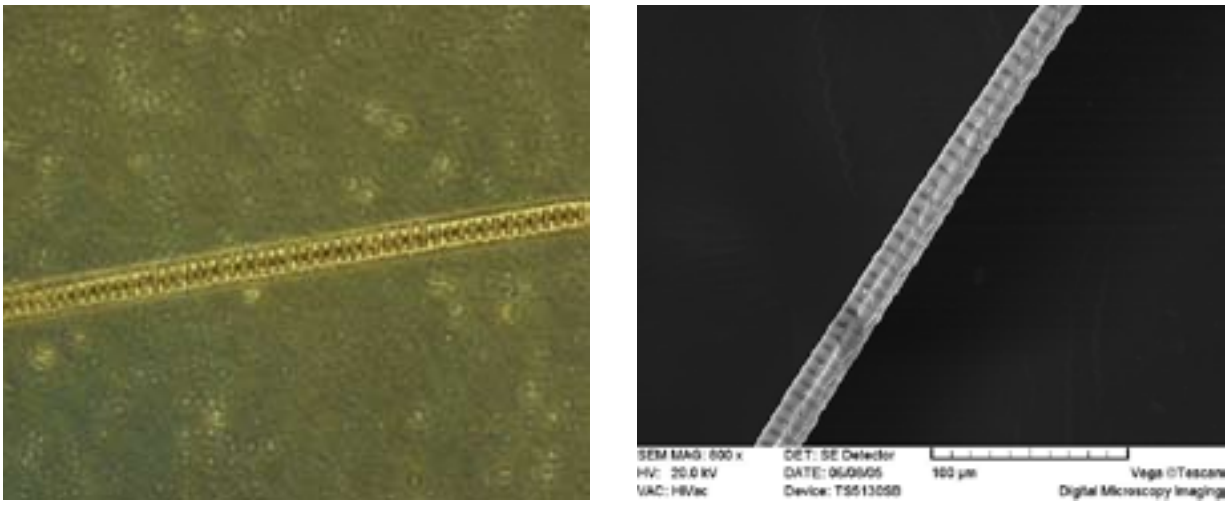


Figure 14. Medulla (left) and cuticula (right) of *Notiosorex crawfordi*.

Family Talpidae - Moles

***Scalopus aquaticus* - Eastern Mole** (SHM 198)

Medulla discontinuous, simple type c, mixed shapes of "cells" (elliptical, rectangular, and square), occupies entire shaft. Cuticula imbricate, elongate, visible medulla. Midshaft dia. 41µm.

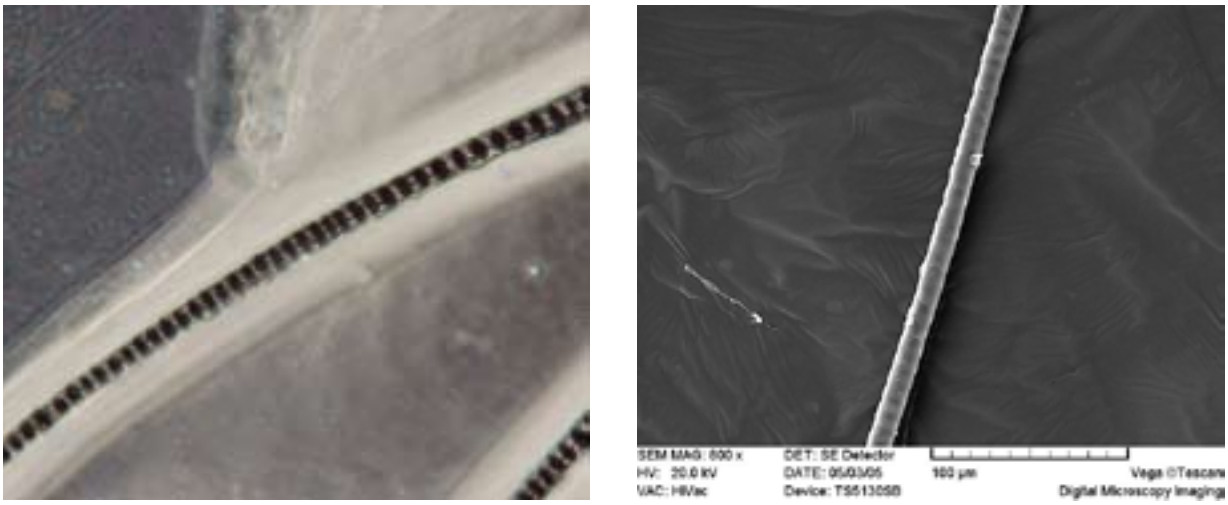


Figure 15. Medulla (left) and cuticula (right) of *Scalopus aquaticus*.

ORDER CHIROPTERA – BATS

All members of Chiroptera in Texas lack medulla and have coronal scales (Fig. 8). Scale index (SI) and width index (WI) are given for each species.

1. Cuticula dentate (Fig. 8c).....2
   Cuticula other than dentate.....5

2. Dentations very deep with one extremely deep.....*Tadarida brasiliensis* (Fig. 44)
   Dentations very small.....3

3. WI>2.....*Nyctinomops femorosaccus* (Fig. 45)
   WI<2.....4

4. WI<1.2.....*Eumops perotis* (Fig. 47)
   1.2<WI<2.....*Nyctinomops macrotis* (Fig. 46)

5. Cuticula serrate (Fig. 8b).....6
   Cuticula simple (Fig. 8a).....7

6. Scales relatively equal in size.....*Mormoops megalophylla* (Fig. 16)
   Each large scale followed by 2 small scales at each side.....*Leptonycteris nivalis* (Fig. 18)

7. SI<1.....8
   SI≥1.....26

8. WI≥2.....9
   WI<2.....11

9. Scale maximum d≥12µm.....*Corynorhinus rafinesquii* (Fig. 41)
   Scale maximum d<12µm.....10

10. Scale maximum d=10µm.....*Myotis californicus* (Fig. 21)
    Scale maximum d<10µm.....11

11. SI=0.4, WI≥2, scale maximum d=7µm.....*Myotis septentrionalis* (Fig. 23)
    SI=0.5, WI≥2, scale maximum d=7µm.....*Myotis volans* (Fig. 26)

12. WI=1.5 13
WI<1.5 17

13. SI=0.9 ..... *Myotis austroriparius* (Fig. 20)
SI<0.9 14

14. SI=0.7 15
SI<0.7 16

15. Scales funnel-shaped, uneven ..... *Lasiurus blossevillii* (Fig. 28)
Scales funnel-shaped, evenly shaped but unevenly arranged ..... *Myotis thysanodes* (Fig. 24)

16. SI=0.5 ..... *Antrozous pallidus* (Fig. 43)
SI=0.6 ..... *Myotis velifer* (Fig. 25)

17. Each large scale accompanied by single small scale ..... *Diphylla ecaudata* (Fig. 19)
All scales relatively same size 18

18. WI=1.4 ..... *Myotis ciliolabrum* (Fig. 22)
WI<1.4 19

19. Scale maximum d=10µm 20
Scale maximum d<10µm 21

20. Scales with uneven sizes and orientation ..... *Lasiurus ega* (Fig. 31)
Scales are very slanted, one side smooth while other is bumpy ..... *Lasiurus intermedius* (Fig. 32)

21. SI=0.8 ..... *Euderma maculatum* (Fig. 40)
SI<0.8 22

22. SI=0.7 23
SI=0.5 24

23. Scales slanted and even ..... *Lasionycteris noctivagans* (Fig. 35)
Scales rope-like in arrangement, one side smooth while other bumpy ..... *Lasiurus cinereus* (Fig. 30)

24. Scale maximum d<10µm, scales rope-like, smooth ..... *Lasiurus borealis* (Fig. 29)
Scale maximum d<10µm, scales not rope-like 25

25. Scales unevenly shaped and arranged.....*Lasiurus seminolus* (Fig. 33)
Scales uneven with ridges on both sides.....*Nycticeius humeralis* (Fig. 39)

26. SI>2.....*Corynorhinus townsendii* (Fig. 42)
1≤SI<2.....27

27. SI=1.5.....*Pipistrellus hesperus* (Fig. 36)
1≤SI<1.5.....28

28. 1<SI<1.5.....29
SI=1.....30

29. Scale maximum d=10µm.....*Eptesicus fuscus* (Fig. 38)
Scale maximum d=8µm.....*Myotis yumanensis* (Fig. 27)

30. WI=1.5.....*Lasiurus xanthinus* (Fig. 34)
WI<1.5.....31

31. Scales mildly slanted.....*Choeronycteris mexicana* (Fig. 17)
Scales slanted and uneven.....*Pipistrellus* (*Perimyotis*) *subflavus* (Fig. 37)

Family Mormoopidae

***Mormoops megalophylla* - Ghost-faced Bat** (ASNHC 11582)

Medulla not present. Cuticula coronal, serrate, with somewhat even scales. SI=1.1; WI=1.2; scale maximum d=20µm.

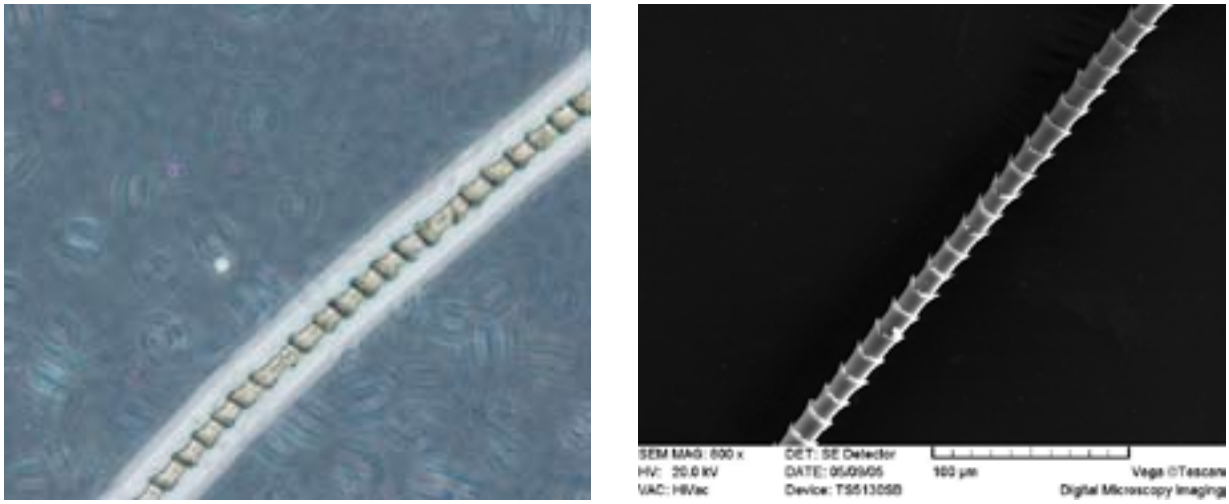


Figure 16. Medulla (left) and cuticula (right) of *Mormoops megalophylla*.

Family Phyllostomidae

***Choeronycteris mexicana* - Mexican Long-tongued Bat** (TTU 44743)

Medulla not present. Cuticula coronal, simple, with mildly slanted scales. SI=1; WI=1; scale maximum d=10μm.

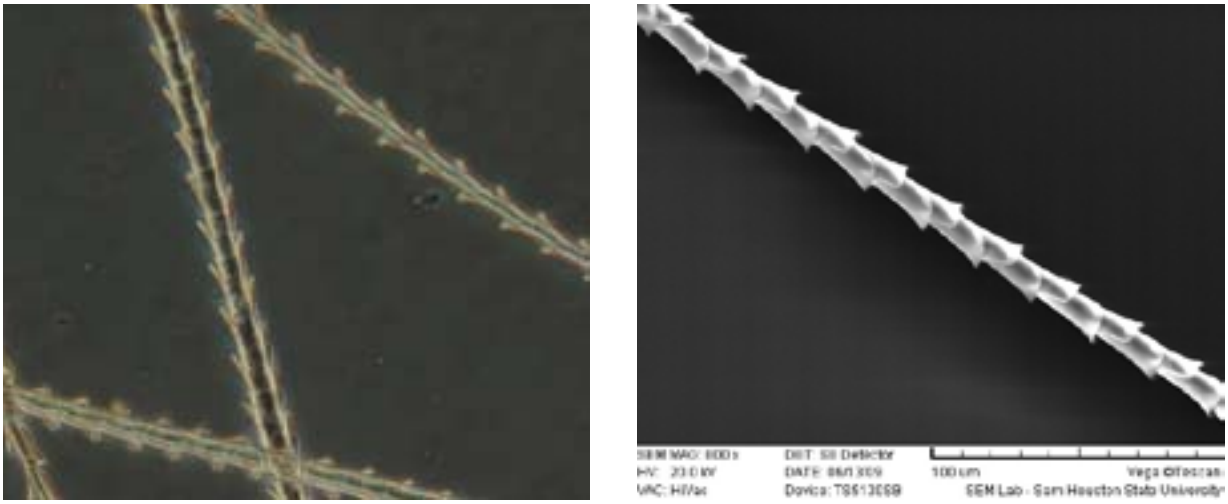


Figure 17. Medulla (left) and cuticula (right) of *Choeronycteris mexicana*.

***Leptonycteris nivalis* - Mexican Long-nosed Bat** (TTU 9208)

Medulla is not present. Cuticula coronal, serrate. Each large scale accompanied by one small scale on each side. SI=0.9; WI=1.5; scale maximum d=20μm.

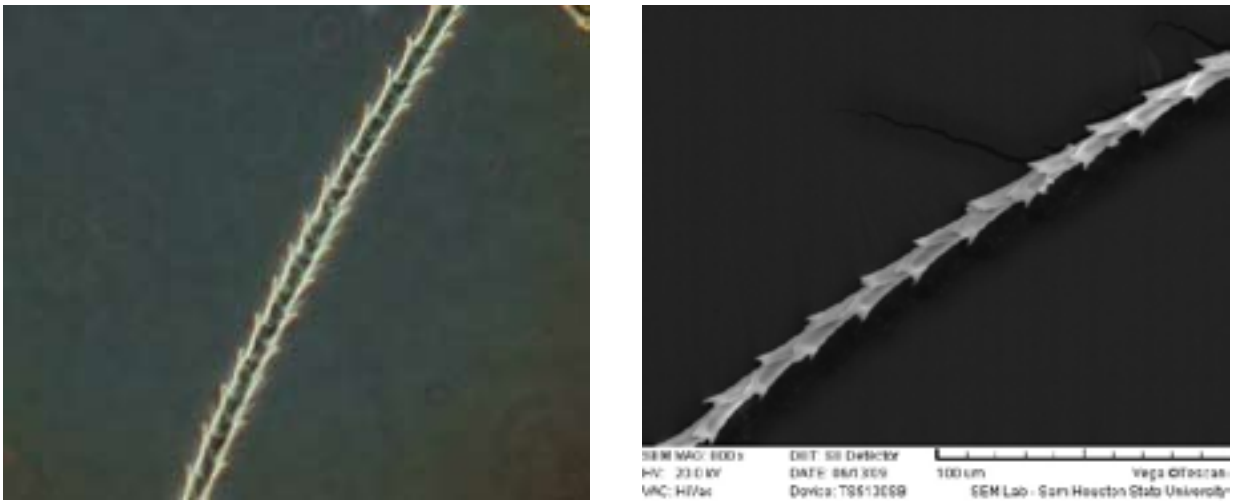


Figure 18. Medulla (left) and cuticula (right) of *Leptonycteris nivalis*.