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KEYS TO THE HAIRS OF THE FAMILIES SORICIDAE, VESPERTILIONIDAE, AND MURIDAE WITHIN TENNESSEE

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ABSTRACT

Keys were constructed to the dorsal guard hairs of seven species of Soricidae, 13 species of Vespertilionidae, and 19 species of Muridae occurring within Tennessee. It was found that by using a character set derived from bright-field light microscopy and scanning electron microscopy, it was possible to separate all but two species of murids and three species of vespertilionids. A description of the guard hairs for each family is presented as well as those characters that distinguish these families from other families in their respective orders occurring within Tennessee.

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INTRODUCTION

The usefulness of hair as a taxonomic character in identifying species of mammals has been well documented in the literature (Cole, 1924; Mathiak, 1938; Williams, 1938; Mayer, 1952). The problem which has hampered many of these studies is that hairs of certain taxa of mammals are variable and considerable overlap occurs between certain species making identification difficult.

An analysis of the literature dealing with mammalian hair identification reveals contradictory reports of the taxonomic use of hair for certain mammalian groups. Spiers (1973), in constructing a key to the land mammals of Virginia, failed to separate shrews, bats, and cricetid rodents to genus, but indicated that it was possible to identify some species by comparing an unknown hair sample with known hair samples. Cole (1924) and Nason (1948) studied the characteristics of bat hairs and concluded that hair has limited taxonomic value for this group. Mathiak (1938), in constructing a key to the mammals of southern Michigan, and Williams (1938), in constructing a key to shrews and moles, concluded that it was essentially impossible to separate certain species of shrews. Mayer (1952), working with California mammals, was able to separate most species of shrews, bats, and rodents using hair characteristics. For a general review of hair structure, characters, and nomenclature see Wildman (1954) or Mayer (1952). The nomenclature used in this study follows that of Wildman (1954).

The value of using hair as a taxonomic tool for certain mammalian groups is uncertain. Because of the questions posed by this uncertainity, it was felt that a more statistical treatment of this problem was in order. In addition, there have been only two studies addressing identification of hair for the mammals of the southeastern United States (Nason, 1948; Spiers, 1973). It is apparent that additional studies are needed to determine the usefulness of hair in the identification of mammalian groups, most notable shrews, bats, and rodents. Primarily because of the importance of hair identification to wildlife-oriented personnel, the purpose of this investigation was to construct keys to the hair of selected species of the families Soricidae, Vespertilionidae, and Muridae, and to examine the accuracy with which these species can be identified.

MATERIALS AND METHODS

Samples were obtained from the dorsum of museum specimens having adult pelage by pulling a small tuft of hair from the skin with forceps. Samples were then placed in glassine envelopes for storage and later examination. Only those specimens taken within the borders of Tennessee were used in the analysis (see Table 1 for a list of species and the number examined). For most species, five individual specimens were examined.

In all cases five guard hairs were examined per specimen. This resulted in 25 guard hairs being examined for most species. Hairs were cleaned in ether and mounted on glass slides using Kleermount. Several guard hairs on each slide were broken or cut so that mounting media would infuse into the medulla. This allowed both the pattern of air spaces and the pattern of pigment granules within the medulla to be observed on the same slide. The hairs were examined at 40x magnification to determine the banding pattern, color, and the number of strictures. The hairs were then examined at 440x magnification to determine the medulla pattern and distribution of pigment between the medulla and cortex within the shield region. The following measurements were taken on each hair to the nearest micron using an ocular micrometer fitted onto the eyepiece of the microscope: width of the hair at the widest point (HWID) and width of the medulla at this same point (MWID). Length of the hair was not routinely used as this measurement would be of little use if the hair was broken. A third measurement, the ratio of medulla width to hair width (MHRAT) was also computed. The Statistical Package for the Social Sciences (Nie et al., 1975) was used to determine the mean, standard error, and 95% confidence interval for each species assuming a random effects model.

The cuticular scale patterns were determined using scanning electron microscopy (Verhoeven, 1972). Several guard hairs were examined from each individual; however, only one individual was examined using electron microscopy from each species unless the pattern differed significantly from patterns already reported in the literature (Spiers, 1973). Hairs were cleaned in ether and mounted on metal stubs using double-sticky cellophane tape. The samples were then plated with gold to a thickness of 200Å using a Hummer II sputter coater. Hairs were examined at 800x magnification in a Novascan 30 scanning electron

microscope. Photographs of both distal and proximal regions of the hair were made using Polaroid P/N 55 film.

All specimens examined are housed in the Memphis State University Museum of Zoology or the East Tennessee State University Museum of Zoology. A reference collection of permanently mounted hairs on glass slides and metal stubs made during this study are housed at the Memphis State University Museum of Zoology.

Results and Discussion

The 95% confidence intervals of each measurement for each species is presented in Table 1. HWID and MWID were found to be easy to measure, and were easily repeatable. Banding patterns along the length of the hair were found to be useful in separating several species and were quite constant within a species. Cuticular scale patterns, while constant within a species, were used as little as possible due to the time and expense involved in making electron micrographs. Alternatively, cuticular scale patterns could be obtained using any one of the standard embedding techniques (Wildman, 1954; Weingart, 1973). It should be emphasized that in using these keys a sample of several hairs must be examined for an accurate identification. All measurements used in the keys are taken to be means of a sample of guard hairs and are not measurements of individual hairs.

TABLE 1. *95% confidence interval of the mean for hair measurements. All linear measurements are in microns. Number in parenthesis is the number of individuals examined.*

	HWID	MWID	MHRAT
Soricidae			
Blarina brevicauda (5)	38.9-43.4	24.8-29.7	0.60-0.73
Cryptotis parva (5)	33.7-36.1	23.6-27.7	0.68-0.73
Sorex cinereus (5)	30.9-38.7	23.1-30.0	0.71-0.82
Sorex fumeus (5)	34.2-38.8	25.1-31.9	0.73-0.83
Sorex longirostris (1)*	43.8	35.5	0.81
Sorex palustris (5)	28.9-31.7	16.7-18.0	0.54-0.61
Sorex dispar (2)+	36.9-38.8	30.1-31.0	0.80-0.82
Vespertilionidae			
Eptesicus fuscus (5)	9.1-11.2		
Lasionycteris noctivagans (2)+	10.0-10.6		
Lasiurus borealis (5)	10.6-12.0		
Lasiurus cinereus (1)*	17.0		
Nyctecius humeralis (5)	11.6-13.6		
Myotis austroriparius (5)	14.4-17.1		
Myotis grisiscens (5)	10.3-11.8		
Myotis keeni (5)	11.8-14.4		
Myotis leibii (2)+	9.5		
Myotis lucifigus (5)	16.9-21.5		
Myotis sodalis (5)	13.0-16.6		
Pipistrellus subflavus (5)	9.3-10.4		
Plecotus rafinesquii (1)*	14.5		
Muridae			
Clethrionomys gapperi (5)	54.5-70.0	39.5-56.8	0.72-0.82
Microtus chrotorrhinus (1)*	34.4	28.1	0.82
Microtus ochrogaster (5)	52.8-63.4	42.2-55.4	0.77-0.89
Microtus pennsylvanicus (2)+	41.7-48.1	21.7-26.2	0.52-0.54
Microtus pinetorum (5)	55.5-62.3	46.6-55.4	0.83-0.90
Mus musculus (5)	28.3-33.8	26.7-30.8	0.86-0.96
Neotoma floridana (5)	48.8-55.0	38.6-42.4	0.75-0.80
Ochrotomys nuttalii (5)	27.2-31.3	18.6-23.5	0.68-0.77
Ondatra zibethicus (5)	102.2-118.0	43.1-50.0	0.38-0.47
Oryzomys palustris (5)	52.4-73.4	42.9-62.3	0.81-0.86
Peromyscus leucopus (5)	29.6-36.9	20.8-28.6	0.69-0.79
Peromyscus maniculatus (5)	28.0-37.6	20.9-29.2	0.71-0.81
Peromyscus gossypinus (4)	37.2-47.4	28.4-42.1	0.76-0.90
Rattus norvegicus (2)+	130.0-131.3	104.4-117.5	0.80-0.87
Rattus rattus (2)+	115.8-124.4	92.5-99.4	0.80-0.81
Reithrodontomys fulvescens (5)	45.1-51.0	31.7-42.1	0.70-0.84
Reithrodontomys humulis (2)+	30.0-38.1	20.2-26.9	0.68-0.70
Sigmodon hispidus (5)	88.7-115.0	76.4-98.4	0.84-0.88
Synaptomys cooperi (4)	53.1-72.5	47.1-62.2	0.83-0.90

* Due to sample size of one reported the mean for the hairs of one individual.

\+ Due to small sample size reported the range rather than the 95% confidence interval.

Soricidae The hair of Insectivora is quite distinctive from that of other mammalian orders occurring in Tennessee. The hairs have a simple discontinuous medulla (Fig. 1a), with strictures or nodes along the shaft (Fig. 1b). Guard hairs of Insectivora are slightly longer than the underfur and the distal section (shield) of the guard hair is longer than any of the other internodal regions. All measurements presented in Table 1 were taken from these longer hairs at the widest portion of the shield. Mole hairs can be distinguished from shrew hairs by being wider, usually having six or more strictures, and having a MHRAT of less than 0.60. Mathiak's (1938) key to insectivores should be consulted if a sample is suspected of being mole hair.

No character was found that would consistently separate *Sorex fumeus* and *Cryptotis parva.* MWID was most different between the two species, but had approximately 25% overlap between the two species. *Sorex fumeus* has a rather restricted range in Tennessee as well as in the southeastern United States, thus the locality of the sample may be useful in determining the identification of a particular sample.

Vespertilionidae North American bat hairs are easily distinguishable from other mammalian hairs as these are the only hairs that lack a medulla (Fig. 1c). Bat hairs are narrower and shorter than hairs of other mammals. Only one family of bats occurs in Tennessee. The genus *Tadarida,* family Molossidae, occurs in several adjacent states; however, *Tadarida* is easily distinguished by its long spine-like scales. Most species of bats have both guard hair and underfur. The guard hairs are only slightly longer, wider, and usually have an imbricate scale pattern. Banding patterns of the underfur closely matches that of the guard hairs. *Myotis grisescens* is unique in having only one type of hair.

Most species could be accurately identified on the basis of hair width and banding patterns. As most bats had the same imbricate scale pattern, cuticular scales were of little

use in identifying bat hairs. Three species could not be separated by any character used in this study; *Myotis keeni, Myotis sodalis,* and *Nyctecius humeralis.*

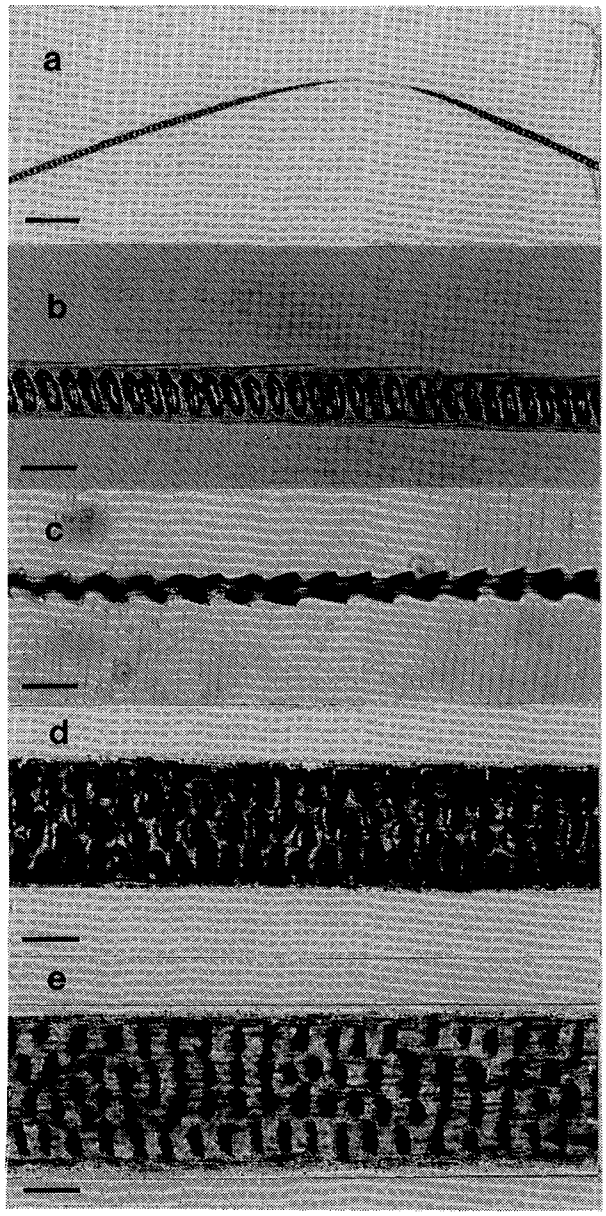

FIG. 1. a) Sorex fumeus *showing a stricture;* b) Sorex fumeus *showing a simple discontinous medulla;* c) Plecoctus rafinesquii *showing the lack of a medulla in bats;* d) Synaptomys cooperi *showing a complex medulla, no media has infused the medulla;* e) Oryzomys palustris *showing the arrangement of pigment granules in the medulla, media has infused the medulla. The bar in 1a represents 250 microns; the bar in 1b-1e represents 25 microns.*

Muridae Rodents in general have two distinctive types of hair, guard hair and underfur. Guard hairs are longer, straighter, and have a wide distal region called the shield. Underfur hairs are shorter, wavy, and generally have the same width along their entire length. Species of Muridae can be separated from other rodents occurring in Tennessee easily. Zapodid hair has a rapidly tapering base, whereas sciurid hair is often strongly banded and has a much more complex medulla pattern. Castorid hair is wider than 120 microns, and has a MHRAT less than 0.60. If a sample is suspected of being from any of these families, the key to Virginia land mammals (Spiers, 1973) should be consulted. The use of a reference collection would also be very helpful and should not be ignored.

Many species of the family Muridae have two sizes of guard hairs. The key is based on these larger hairs, and only these hairs should be used to obtain the measurements used in the key. Members of this family have a complex medulla with invagination of the cortex into the medulla (Fig. 1d). Pigment granules are typically deposited within the medulla in more than one row (Fig. 1e).

Most species could be separated with at least a 95% chance of making the correct identification. Two notable exceptions were found. *Microtus chrotorrhinus* was difficult to separate from several species of rodents; however, the very limited distribution of the animal in Tennessee would make encountering this animal unlikely. It was necessary to use cuticular scale patterns in several places to distinguish between species. Only two species, *Peromyscus maniculatus* and *P. leucopus,* could not be separated as their hairs were essentially identical.

ARTIFICIAL KEYS TO THE HAIRS OF THE MAMMALS OF SORICIDAE, VESPERTILIONIDAE, AND MURIDAE IN TENNESSEE

Soricidae

1 HWID greater than or equal to 39.0 microns.....2
1 HWID less than 39.0 microns 3
2 MHRAT less than 0.75 ..... *Blarina brevicauda*
2 MHRAT greater than or equal to 0.75 ..... *Sorex longirostris*
3 MHRAT less than or equal to 0.64 ..... *Sorex palustris*
3 MHRAT greater than 0.64 4
4 Medullary spaces not filled with air in the central region of the shield, even if hair is undamaged ..... *Sorex cinereus*
4 Medullary spaces filled with air in the central region of the shield 5
5 Shield region wide and lightly pigmented, darkly pigmented at the tip 6
5 Entire hair darkly pigmented, except the tip which is lightly pigmented ..... *Sorex dispar*
6 MWID less than or equal to 27.0 microns ..... *Cryptotis parva*
6 MWID greater than 27.0 microns ..... *Sorex fumeus*

Vespertilionidae

1 HWID greater than or equal to 17.0 microns.....2
1 HWID less than 17.0 microns 3
2 Hair is banded dark-light-dark along its length ... *Lasiurus cinereus*
2 Hair is dark at base, light at tip ..... *Myotis lucifigus*
3 Hair is uniformly pigmented along its length 4
3 Hair is at least darker in one region along its length 5
4 HWID is less than 12.0 microns ..... *Myotis grisescens*
4 HWID is greater than or equal to 12.0 microns ..... *Plecotus rafinesquii*
5 Hair is banded dark-light-dark along its length 6
5 Hair is not banded dark-light-dark along its length 9
6 HWID is less than or equal to 10.5 microns 7