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Observations on the Surface Structure of the Hairs of Tasmanian Monotremes and Marsupials

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WITH 108 TEXT FIGURES

SUMMARY

In this paper brief observations are made on the principal dimensions, cross-sectional shapes and cuticular scale patterns of hairs of the Tasmanian monotremes and marsupials.

The observations on the cuticular scale patterns alone, without considering other elements of the hair shaft, are of only limited value in a comparative study of marsupial hairs. However, it is suggested that a detailed microscopic examination of these hairs would probably prove to be of taxonomic value.

The marked changes in scale form, which are usually found along a single hair, are considered to be of an inherent and genetic character and are not caused by varying amounts of attrition or by dehydration of the hair shaft.

The cross-sectional shape, although not always constant, is found to be a useful character in the identification of Tasmanian monotreme and marsupial hairs. The unique structure of the protective hairs of *Isoodon* and *Perameles* is indicated.

INTRODUCTION

The present paper deals very briefly with the surface structure of a small sample of mid-dorsal body hairs taken from at least one representative of each of the Tasmanian monotremes and marsupials. The details of the specimens are set out in Table I, and the principal dimensions of the hairs examined are recorded in Tables II and III.

The principal object of this investigation is to draw attention to the probable taxonomic value of the arrangement of the cuticular scales in marsupial hairs. At the beginning it was hoped to be able to build a simple key to the characteristics. This could most probably be achieved in a more detailed examination.

Although numerous studies have been made of the mammalian coat, only a few workers have made any detailed study of the surface structure of hair. Both the type of hair and the general colour of the coat are important external characters and they are used extensively for taxonomic purposes. However, the microscopic structure of hair from this point of view has been largely neglected.

Hausman (1920*a*, 1920*b*, 1920*c*, 1930), Brown (1942) and others have emphasized the importance of the scale patterns on hairs. Hausman (1930) has shown that the cuticular scale types are directly related to the diameter of the hair shaft. In a study of the head hair of humans Wynkoop (1929) has shown that age has little or no bearing on the microscopic appearance of the cuticular scales. Brown (1942) considers that little additional information is gained from a microscopic examination of hair gathered from different regions of the human body.

The present contribution does not attempt to add anything new to the papers by Hausman (1920*a*) and Wildman and Manby (1938) on the hair structure of the monotremes. The notes on this group are included for comparison with those on the Tasmanian marsupials.

The scarcity of publications on the scale pattern arrangement in marsupial hairs suggests that it is worth recording these short preliminary observations.

The taxonomic nomenclature used is that of Iredale and Troughton's check-list (1934).

TABLE I

List of Specimens

Species	Animal No.	Source	Sex	Age
Ornithorhynchus anatinus	1	Central Tasmania. August, 1950	?	Adult
Tachyglossus setosus	1	Lake Leake, Tasmania. August, 1949	♂	Adult
Antechinus swainsonii	1	Sandy Bay, Tasmania. July 25, 1950	♂	Adult
Antechinus minimus	2	Queen Victoria Museum, Launceston, Tasmania	♂	Adults
Sminthopsis leucopus	1	National Museum, Melbourne	?	Adult ?
Dasyurus quoll	1	Sandy Bay, Tasmania. September, 1950	♀	Adult
Dasyurops macultas	1	Zoology Department, University of Tasmania	♀	Adult
Sarcophilus harrisii	1	Queenstown, Tasmania, June 16, 1949	♂	Adult
	1	Ellendale, Tasmania. August 29, 1949	♂	Juvenile
Thylacinus cynocephalus	1	Queen Victoria Museum, Launceston, Tasmania	?	Adult
	1	Queen Victoria Museum, Launceston, Tasmania	?	Juvenile
Isoodon obesulus	1	Lindisfarne, Tasmania. July 10, 1950	♂	Adult
Perameles gunnii	1	Rifle Range, Hobart, Tasmania. June 6, 1950	♀	Adult
Cercartetus nanus	1	National Museum, Melbourne	?	?
	1	Tasmanian Museum, Hobart, Tasmania	?	Adult
Eudromicia lepida	1	Zoology Department, University of Tasmania	♀	Adult
Petaurus breviceps	1	Miena, Central Tasmania, August, 1949	♂	Adult
Pseudocheirus convolutor	2	Ulverstone, Tasmania. July 15, 1950	♂ and ♀	Adults
Trichosurus vulpecula	1	Branxholm, Tasmania. June, 1950	♀	Adult
Vombatus ursinus	1	Southern Tasmania. October, 1950	♂	Adult
Bettongia cuniculus	1	Taranna, Tasman Peninsula, Tasmania. March 18, 1950	♀	Adult
Potorous tridactylus	1	Rifle Range, Hobart, Tasmania. July, 3, 1950	♀	Adult
Thylogale billardierii	1	Miena, Central Tasmania. July 17, 1950	♀	Adult
Wallabia rufogrisea	2	Branxholm, Tasmania. June and August, 1950	♂ and ♀	Adults
Macropus tasmaniensis	1	Gladstone, Tasmania. July, 1950	♀	Adult

TABLE II

Principal Dimensions of Protective Hairs from Adult Specimens

Species	Approx. Length in mm.	Diameter or greatest wdith in microns.			
		Base	Widest region.		
			Min.	Mean	Max.
Ornithorhynchus anatinus	15	60-66	185	200	215
Tachyglossus setosus *	25	95-120	200	253	350
Antechinus swainsonii	17	12-18	45	62	75
Antechinus minimus	17	9-18	25	38	50
Sminthopsis leucopus	15	7-9	24	32	45
Dasyurus quoll	27	20-27	35	64	85
Dasyurops maculatus	25	18-34	40	78	105
Sarcophilus harrisii	32	30-65	70	100	120
Thylacinus cynocephalus *	16	25-35	45	62	78
Isoodon obesulus	22	25-40	200	249	295
Perameles gunnii	21	17-25	90	124	155
Cercartetus nanus **	8	7-9	13	20	26
Eudromicia lepida **	10	6-14	12	20	34
Petaurus breviceps **	15	8-13	12	17	28
Pseudocheirus convolutor	31	20-25	34	49	63
Trichosurus vulpecula	60	20-30	55	73	92
Vombatus ursinus **	38	90-150	130	190	240
Bettongia cuniculus	31	17-24	35	58	78
Potorous tridactylus	40	12-22	29	68	95
Thylogale billardierii	58	17-25	43	54	82
Wallabia rufogrisea	57	25-38	45	71	90
Macropus tasmaniensis *	42	19-27	25	52	75

* The dimensions given here are of the straight hairs.

** The dimensions of all the hairs examined are recorded above.

TABLE III

Principal Dimensions of Fur Hairs from Adult Specimens

Species	Approx. Length in mm.	Diameter or greatest wdith in microns.			
		Base	Widest region.		
			Min.	Mean	Max.
Ornithorhynchus anatinus	10	8-9	12	14	20
Tachyglossus setosus *	20	25-38	50	72	85
Antechinus swainsonii	12	7-9	16	18	22
Antechinus minimus	10	6-8	12	17	20
Sminthopsis leucopus	11	6-7	10	11	13
Dasyurus quoll	18	15-18	15	19	25
Dasyurops maculatus	18	9-12	12	22	30
Sarcophilus harrisii	26	18-30	25	48	65
Thylacinus cynocephalus *	14	12-20	20	32	40
Isoodon obesulus	12	6-9	18	24	34
Perameles gunnii	15	7-11	13	20	22
Cercartetus nanus **	....	....	....	....	....
Eudromicia lepida **	....	....	....	....	....
Petaurus breviceps **	....	....	....	....	....
Pseudocheirus convolutor	22	8-20	13	25	30
Trichosurus vulpecula	37	8-20	15	32	40
Vombatus ursinus **	....	....	....	....	....
Bettongia cuniculus	20	11-14	19	22	30
Potorous tridactylus	25	12-15	20	25	35
Thylogale billardierii	37	8-13	13	22	30
Wallabia rufogrisea	40	15-30	20	31	40
Macropus tasmaniensis *	35	15-18	19	27	30

* The dimensions given here are of the wavy hairs. ** See Table II.

Methods

I. The methods employed for the examination of the surface structure of hairs are simple and the materials needed are easily obtainable.

First Method

Dry Mounting. The hair specimens are washed in alcohol-ether and mounted dry. Small strips of gummed paper are used for fastening the cover-glass on to the slide. These dry preparations are used for making observations on the general shape of the longitudinal section, for making measurements of the diameter of the hair shaft and, where suitable, for checking the contour of the scales and obtaining the scale indices. Transmitted light will sometimes detail the scales but it is usually found necessary to use a beam of light from one side and just above the horizontal.

Second Method

Negative Impressions. The method described by Bachrach (1946) is satisfactory for revealing the surface structure of hair. With slight modifications this method is used for making most of these observations. Photographic plates ($3\frac{1}{2} \times 2\frac{1}{2}$ Process Plates are recommended as they may be handled under an OA safelight and are a convenient size for manipulation on the microscope stage) are washed in running water to remove backing. Fix plates in plain hypo solution and wash for 45 minutes. Place in " Photo-Flo " solution for five minutes to reduce the surface tension and thus assist even drying. Wipe off surplus water with a viscose sponge. Place in a glass jar to dry and cover to exclude dust. When the emulsion is quite dry to a depth of from 1-2 mm. from the edges, place the plates emulsion side up upon a level surface. The hair specimens are now carefully laid upon the still damp centres of the plates; if possible with all the tips facing the same direction. The plates are now covered with a piece of " Kodatrace " or thick cellophane to prevent the specimens from being crushed when weight is applied to them. The " Kodatrace " may be electrically charged in which case the hairs will be attracted to it thus upsetting any pre-determined arrangement. This charge may usually be removed by breathing upon the " Kodatrace ". On top of the " Kodatrace " is placed a sheet of thick glass to protect it from uneven pressure. On the sheet of glass are placed books or other heavy objects in which the weight is evenly distributed. Twelve to fifteen pounds of weight is found most satisfactory. The specimens are left under the weight for about 30 minutes; the weights, glass and " Kodatrace " are then removed, and the photographic plates are replaced on edge in a glass jar, covered to exclude dust, and left to thoroughly dry. The hair specimens are then removed with a soft camel hair brush. The hair impressions are now ready for examination under the microscope. No cover-glasses are used as a mounting medium would fill up the specimen-moulds and thus lower their visibility. The impressions obtained by this method, when viewed directly, are negatives of the scale structure.

All the line drawings in this paper are made from photomicrographs of negative impressions obtained by the above method and all text figures are $\times$ 195.

Third Method

Positive Impressions. Koonz and Strandine (1945) describe a simple method for revealing the surface structure of hair. This method is rapid and gives good results when examining fine hairs but it is of little value when studying coarse hairs. A thin film of glycerin is placed on a clean large cover-glass. The hair specimens are then placed on the cover-glass and covered with several drops of water soluble nigrosin solution. The excess fluid is removed by tilting or by placing blotting paper at the edge of the cover-glass. The nigrosin is then dried over a low flame or other heating unit. The hair specimens are removed from the dry nigrosin film and the cover-glass is inverted and placed on a microscope slide. The hair impressions are now ready for examination under the microscope. Using this method positive impressions are readily obtained.

II. Two methods are used for the examination of the cross-sectional shapes of hair specimens.

FIRST METHOD

Examination of Cut Ends. A tuft of hairs is held tightly with a small piece of split carrot or potato and cut transversely, in the desired region, with a sharp blade razor. The piece of carrot or potato containing the cut hairs is then transferred to a microscope slide. Using reflected light useful information regarding the cross-sectional shape may often be obtained by this quick method.

SECOND METHOD

Embedding in Celloidin and Paraffin. It is sometimes, though fortunately not frequently, found necessary to prepare transverse sections of the hair shafts to determine their contours. The usual process of embedding in celloidin, impregnating with benzol and infiltration with paraffin is used. Staining is not necessary for obtaining the cross-sectional shape.

All the measurements of diameter or greatest width are obtained by using an ocular micrometer.

THE TYPES OF MAMMALIAN HAIR

In general, all hair can be divided into two types; the protective or guard hair, and the underfur or fur hair. The protective hair is usually long, coarse and straight; whereas the fur hair is usually shorter, fine and woolly. These two types of hair may be quite obvious but sometimes they are difficult to detect, and occasionally there is no definite line of demarcation between them.

THE STRUCTURE OF HAIR

The structure of the hair shaft may vary in different animals but, in general, it is composed of an outer sheath of relatively structureless imbricate horny scales, called cuticle. Below the cuticle is the more solid part or cortex. In addition to these two layers, many types of hair also contain a central medulla filled with air cells.

In cross-section hairs present a variety of forms from circles to strongly flattened ovals, or they may be triangular, polygonal, dumb-bell-shaped or kidney-shaped. The shape of the cross-section, although not always constant, is found to be most useful and will sometimes eliminate many genera. The two Tasmanian members of the Peramelidae; *Isoodon* and *Perameles*, may each be identified from the cross-sectional shape of the broadest part of a single protective hair. In this family the transverse sections of the protective hairs will probably prove to be of important taxonomic value. The cross-sectional shape of a single hair shaft is usually constant but it may be variable throughout its length. The majority of hair shafts show some variation in diameter throughout their length. The base is usually of less diameter than the mid-region. In most of the Tasmanian marsupials the protective hairs are widest distal of the mid-region and the tip usually tapers off to practically nothing.

For the identification of hair; the general colour, the shape of the longitudinal section, the shape of the cross-section, the scale pattern of the cuticle, the pigment contained in the cortical area and the structure of the medulla are all helpful guides.

The nomenclature used for the various kinds of cuticular scales was formulated by Hausman (1920*b*). This classification of scale types is used throughout this paper. The ratio of the length of the free proximo-distal portion of the cuticular scale (F) and the diameter of the hair shaft (D) is called the scale index (S.I.), F/D = S.I. The scale index usually varies inversely with the diameter. Because of this, scale indices may be applied only when hairs of similar diameter are being compared. In most of the Tasmanian marsupials the scale indices are so variable that they will not be included here, and it is doubtful whether they will prove to be of taxonomic value. In his paper devoted to the hairs of the North American Carnivora, Brown (1942, p. 252) remarks on the variability of their scale indices.

The cuticular scales on mammalian hairs fall readily into two types; the imbricate and the coronal. Imbricate scales are the most common type, whereas coronal scales are characteristic of the Chiroptera. In the Tasmanian marsupials coronal scales are sometimes found on the thinnest hairs and at the tips of the larger hairs.

A variety of scale forms is often found in a single hair. Hardy and Plitt (1940, p. 5) consider that, for practical purposes, four regions of the hair shaft may be considered as bearing characteristic scales. These regions are: 1. the base or proximal end; 2. the part adjacent to it; 3. the widest part of the shaft; and 4. the tip or distal end. Although hair specimens from different species may exhibit similar characteristics in one position, yet when all four regions are considered, differences can often be detected. In a detailed examination, it is necessary to consider the structural characteristics throughout the entire length of the hair shaft.

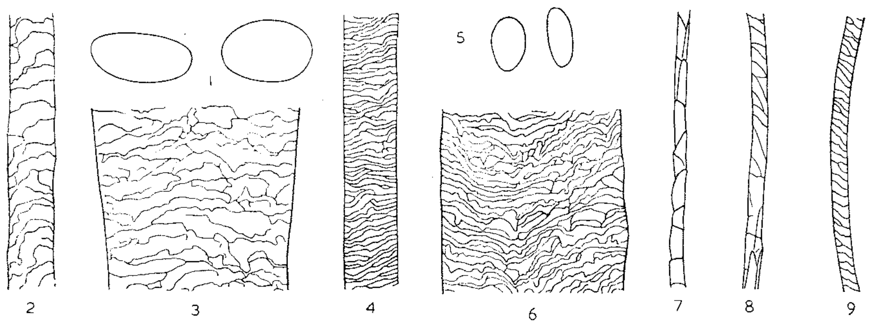
Monotremata

(FIGS. 1-9)

Hausman (1920*a*, p. 484) considers that the type of hair characteristic of the Monotremata is the flattened type represented by the protective hairs of *Ornithorhynchus*, and by the flattened and wavy hairs of *Tachyglossus*.

The presence of two distinct types of hairs in *Ornithorhynchus* will separate hair specimens of this animal from those of *Tachyglossus* in which there is no definite line of demarcation between the hair types.

The cuticular scales of the straight and wavy hairs of *Tachyglossus*, and the shields of the protective hairs of *Ornithorhynchus* are mostly of the flattened, crenate or irregular-margined type. The fur hairs of *Ornithorhynchus* are fine, circular in cross-section, and possess several types of cuticular scales. These scales are usually elongate to acuminate in the basal region and flattened in the distal region.



FIGS. 1-4 *Tachyglossus setosus* × 100.

Fig. 1. Wavy hair; transverse sections of mid-shaft.
Fig. 2. Wavy hair; basal.
Fig. 3. Straight hair; mid-shaft.
Fig. 4. Straight hair; distal.

FIGS. 5-9 *Ornithorhynchus anatinus* × 100.

Fig. 5. Protective hairs; transverse sections of distal region.
Fig. 6. Protective hair; widest region.
Fig. 7. Fur hair; basal.
Fig. 8. Fur hair; mid-shaft.
Fig. 9. Fur hair; distal.

Marsupialia

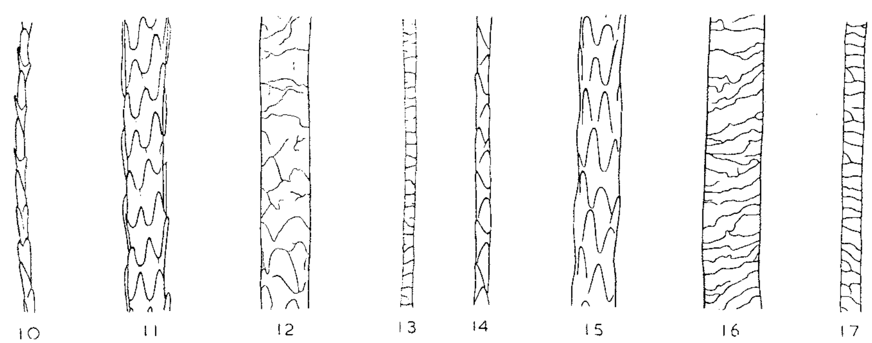
Suborder *POLYPROTODONTIA*

Family DASYURIDAE

(FIGS. 10-46)

The type of hair characteristic of most of the Dasyuridae is circular in cross-section. In all the Tasmanian representatives of this family, except *Thylacinus*, the coat is composed of two distinct types of hair.

At the extreme base of the protective hairs the cuticular scales are often flattened. This character is most noticeable in *Dasyurops* and *Sarcophilus*. Prominent elongated scales with smooth margins are the predominant type along the basal half of the protective hair shaft. As the full width of the hair is approached these elongated scales change form to a flattened, usually irregular-margined type. At the tip of the hair the scales may be of a simple coronal type.



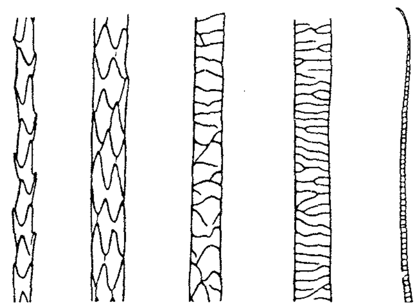
FIGS. 10-13 *Antechinus minimus* × 100.

Fig. 10. Fur hair; basal.
Fig. 11. Protective hair; basal.
Fig. 12. Protective hair; distal.
Fig. 13. Fur hair; distal.

FIGS. 14-17 *Antechinus swainsonii* × 100.

Fig. 14. Fur hair; basal.
Fig. 15. Protective hair; basal.
Fig. 16. Protective hair; distal.
Fig. 17. Fur hair; distal.

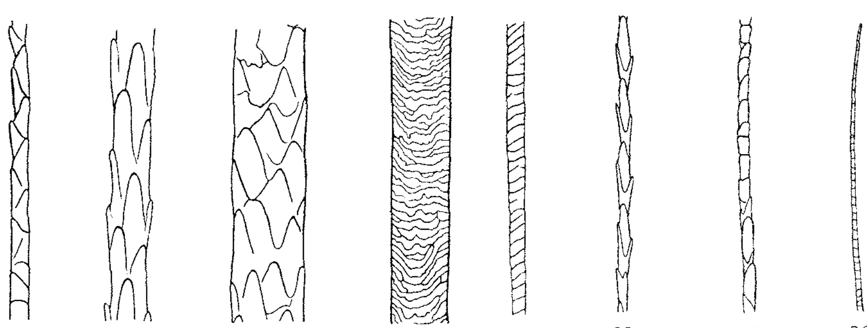
There is sometimes an amazing variety of scale forms along a single fur hair. At the extreme base the cuticular scales are usually closely adpressed to the hair shaft and they appear flattened. This short region of flattened scales is often followed by alternate regions of elongate and flattened scales. At the tip simple coronal scales are often present.



18 19 20 21 22

Sminthopsis leucopus × 100.

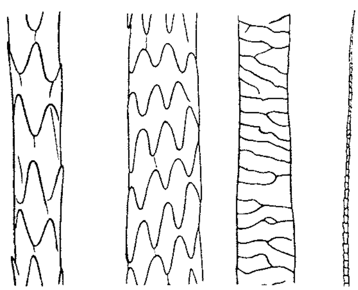
Fig. 18. Protective hair; basal.
Fig. 19. Protective hair; basal.
Fig. 20. Protective hair; distal
Fig. 21. Protective hair; distal.
Fig. 22. Protective hair; tip.



23 24 25 26 27 28 29 30

Dasyurus quoll × 100.

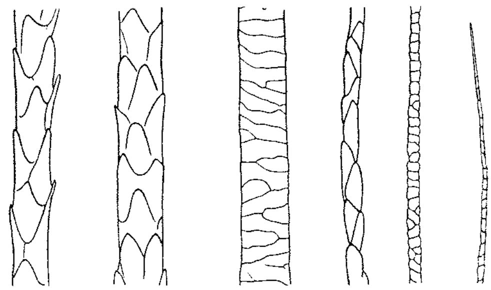
Fig. 23. Protective hair; basal.
Fig. 24. Protective hair; basal.
Fig. 25. Protective hair; mid-shaft.
Fig. 26. Protective hair; distal.
Fig. 27. Fur hair; base.
Fig. 28. Fur hair; basal.
Fig. 29. Fur hair; distal.
Fig. 30. Fur hair; tip.



31 32 33 34

FIGS. 31-34 *Dasyurops maculatus* × 100.

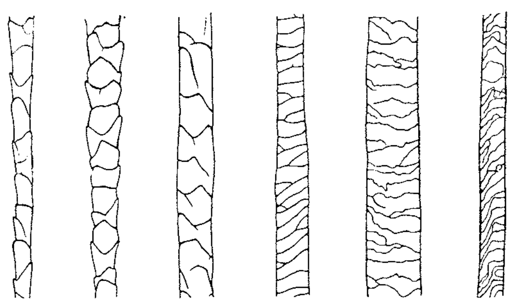
Fig. 31. Protective hair; basal.
Fig. 32. Protective hair; mid-shaft.
Fig. 33. Protective hair; distal.
Fig. 34. Protective hair; tip.



35 36 37 38 39 40

FIGS. 35-40 *Sarcophilus harrisii* × 100.

Fig. 35. Fur hair; mid-shaft.
Fig. 36. Fur hair; mid-shaft.
Fig. 37. Protective hair; basal.
Fig. 38. Fur hair; basal.
Fig. 39. Fur hair; distal.
Fig. 40. Fur hair; tip.



41 42 43 44 45 46

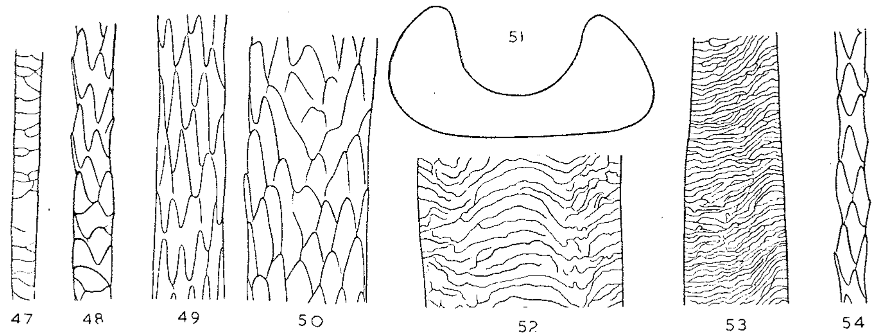
Thylacinus cynocephalus × 100.

Fig. 41. Wavy hair; basal.
Fig. 42. Wavy hair; basal.
Fig. 43. Wavy hair; mid-shaft.
Fig. 44. Wavy hair; distal.
Fig. 45. Straight hair; distal.
Fig. 46. Wavy hair; distal.

Family PERAMELIDAE

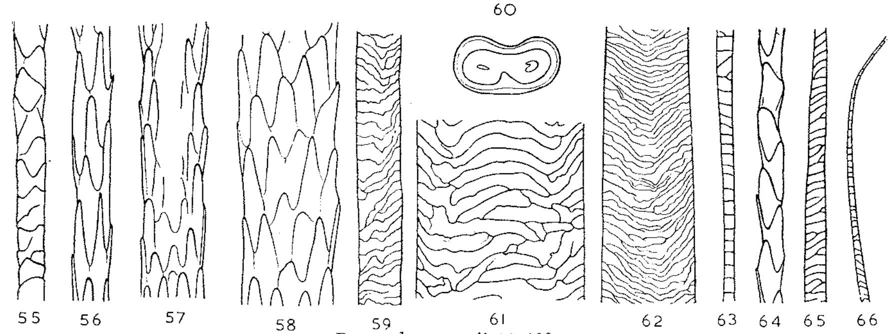
(FIGS. 47-66)

The two Tasmanian members of the Peramelidae may be recognized immediately by the characteristic shape of the protective hairs. In *Isoodon* the protective hairs are coarse, flattened and grooved on the anterior side along the greater part of the shaft (fig. 51). In most respects the hairs of *Perameles* are similar to those of *Isoodon* but there is a distinct difference in the cross-sectional shape (fig. 60). The fur hairs of both genera are fine and circular in cross-section.



Isoodon obesulus × 100.

Fig. 47. Protective hair; base.
Fig. 48. Protective hair; basal.
Fig. 49. Protective hair; basal.
Fig. 50. Protective hair; mid-shaft.
Fig. 51. Protective hair; transverse section of mid-shaft.
Fig. 52. Protective hair; distal.
Fig. 53. Protective hair; distal.
Fig. 54. Fur hair; basal.



Perameles gunnii × 100.

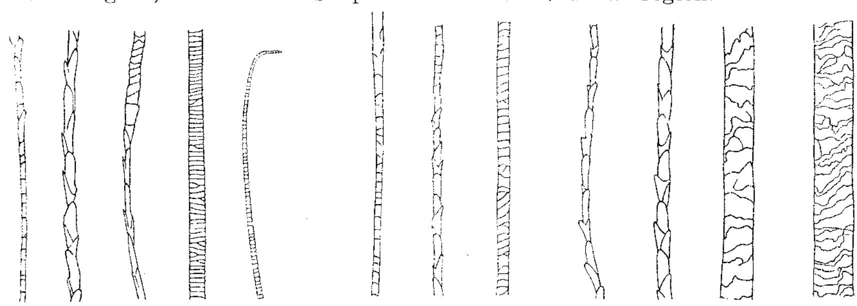
Fig. 55. Protective hair; base.
Fig. 56. Protective hair; basal.
Fig. 57. Protective hair; basal, beginning of groove.
Fig. 58. Protective hair; mid-shaft.
Fig. 59. Protective hair; distal.
Fig. 60. Protective hair; transverse section of mid-shaft.
Fig. 61. Protective hair; mid-shaft.
Fig. 62. Protective hair; distal.
Fig. 63. Fur hair; base.
Fig. 64. Fur hair; basal.
Fig. 65. Fur hair; mid-shaft.
Fig. 66. Fur hair; tip.

The cuticular scales of the protective hairs are flattened at the extreme base. This is followed by a short region of ovate scales and an extensive region of elongate, smooth-margined scales together with an increase in diameter and a flattening of the hair shaft. Near the basal end of the longitudinal groove the scales change form to a flattened irregular-margined type which is continued along the shaft to its distal extremity. Similar scales are found on both the concave and convex side of the hair shaft. The cuticular scales of the fur hairs are mostly elongated in the basal region and flattened in the distal region.

Suborder *DIPROTODONTIA*
Family PHALANGERIDAE
(FIGS. 67-84)

In *Cercartetus*, *Eudromicia* and *Petaurus* the coat is composed of fine soft hairs which are circular in cross-section. In *Pseudocheirus* and *Trichosurus* there are two distinct types of hair and the transverse sections usually present a slightly flattened or ovoid appearance.

In the hairs of *Cercartetus* and *Eudromicia* the cuticular scales are similar. Alternate regions of elongate and flattened or simple coronal scales are usually present along a single hair shaft. In the basal region the scales are prominent and usually elongated with smooth margins. In the distal region simple coronal scales are the most common form encountered. In the hairs of *Petaurus* the cuticular scales of the distal region are often of a flattened irregular-margined type, but in other respects the hairs of this animal are similar to those of *Cercartetus* and *Eudromicia*. In *Pseudocheirus* and *Trichosurus* the cuticular scales of the protective hairs are flattened at the extreme base. This is usually followed by elongate scales in the basal region and flattened smooth-margined scales in the distal region. The scales of the fur hairs are elongated and prominent in the basal region; flattened or simple coronal in the distal region.

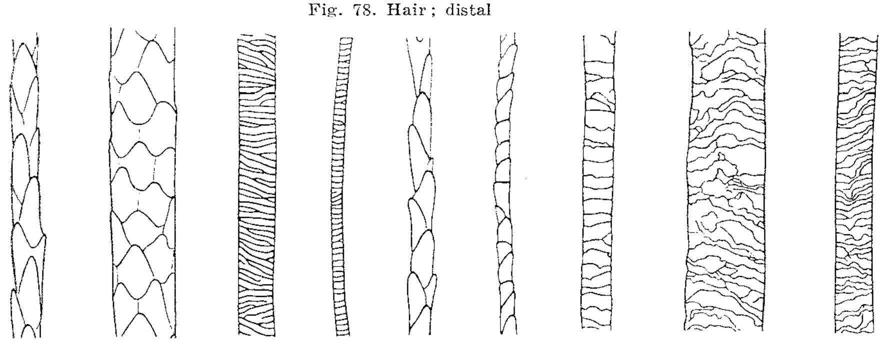


67 68 69 70 71 72 73 74 75 76 77 78

FIGS. 67-71 *Cercartetus nanus* × 100.
Fig. 67. Hair; base
Fig. 68. Hair; basal.
Fig. 69. Hair; mid-shaft.
Fig. 70. Hair; distal.
Fig. 71. Hair; tip.

FIGS. 72-74 *Eudromicia lepida* × 100.
Fig. 72. Hair; base.
Fig. 73. Hair; mid-shaft.
Fig. 74. Hair; distal.

FIGS. 75-78 *Petaurus breviceps* × 195.
Fig. 75. Hair; basal.
Fig. 76. Hair; basal.
Fig. 77. Hair; distal.
Fig. 78. Hair; distal



79 80 81 82 83 84 85 86 87

FIGS. 79-82 *Pseudocheirus convolutor* × 100.
Fig. 79. Protective hair; basal.
Fig. 80. Protective hair; mid-shaft.
Fig. 81. Protective hair; distal.
Fig. 82. Protective hair; distal.

FIGS. 83 and 84 *Trichosurus vulpecula* × 100.
Fig. 83. Fur hair; basal.
Fig. 84. Fur hair; distal.

FIGS. 85-87 *Vombatus ursinus* × 100.
Fig. 85. Hair; mid-shaft.
Fig. 86. Hair; mid-shaft.
Fig. 87. Hair; distal.

Family VOMBATIDAE

(FIGS. 85-87)

One representative of the Vombatidae is found in Tasmania. The coat is composed of fairly long and very coarse protective hair; fur hair almost or entirely absent. The hairs are oval in cross-section and the medulla is absent. These two characters alone will separate the hairs of *Vombatus* from those of the other Tasmanian Marsupials. The average size of the transverse section taken through the broadest part of the mature hair is $190\mu \times 125\mu$. The base of the hair usually measures from 90μ-150μ across.

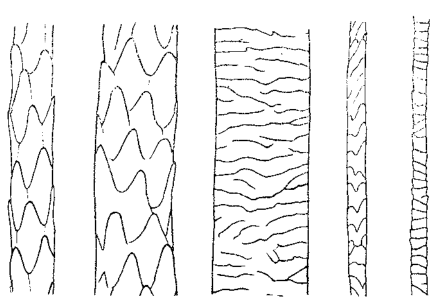
All the hairs show but one type of cuticular scale, the flattened irregular-margined type with almost no variation.

Family MACROPODIDAE

(FIGS. 88-108)

In *Bettongia*, *Potorous*, *Thylogale* and *Wallabia* the coat is composed of two types of hair. In *Macropus* the fur hair is almost or entirely lacking. In *Bettongia* and *Potorous* the transverse sections vary in contour from oval to an almost circular shape. In *Thylogale*, *Wallabia* and *Macropus* the contour of the transverse sections is for the most part elliptical. Glaister (1931, p. 83) examined cross-sections of " Wallaby " hair and remarks that " In several of the sections, however, a unilateral concavity is present which in certain instances is of a pronounced character and imparts to the sections a ' kidney ' or ' bean ' shaped appearance ". This does indicate a slight resemblance between hairs of the Macropodidae and those of the Peramelidae.

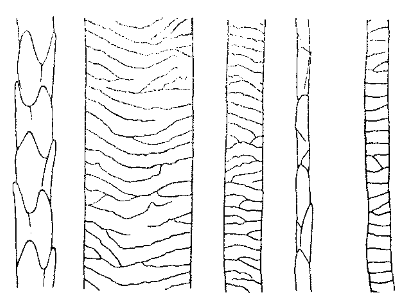
In *Bettongia* and *Potorous* the protective hairs possess cuticular scales which are mostly elongated and protruding in the basal region and flattened in the distal region. At the tip of the hair the scales may be of a simple coronal type. In *Thylogale* and *Wallabia* the cuticular scales are usually elongated in the basal region and flattened or simple coronal elsewhere. In *Macropus* the scales are mostly of a simple coronal or flattened type with very little variation along the hair shaft.



88 89 90 91 92

FIGS. 88-92 *Bettongia cuniculus* × 100.

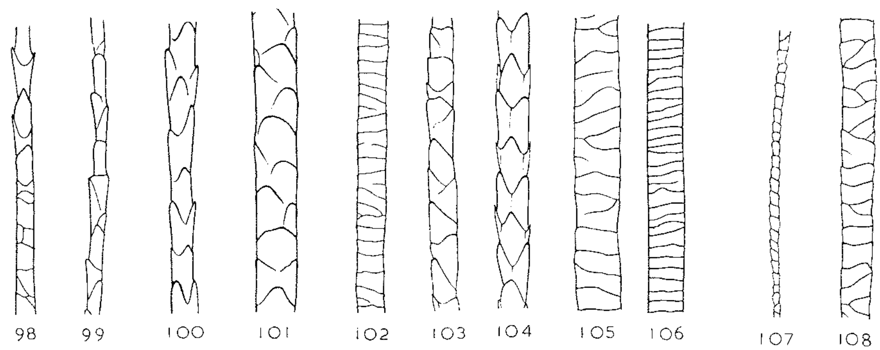
Fig. 88. Protective hair; basal.
Fig. 89. Protective hair; mid-shaft.
Fig. 90. Protective hair; distal.
Fig. 91. Fur hair; mid-shaft.
Fig. 92. Fur hair; distal.



93 94 95 96 97

FIGS. 93-97 *Potorous tridactylus* × 100.

Fig. 93. Protective hair; basal.
Fig. 94. Protective hair; distal.
Fig. 95. Protective hair; distal.
Fig. 96. Fur hair; basal.
Fig. 97. Fur hair; distal.



FIGS. 98-102 *Thylogale billardierii* × 100.

Fig. 98. Fur hair; base
Fig. 99. Fur hair; basal.
Fig. 100. Fur hair; basal.
Fig. 101. Fur hair; mid-shaft.
Fig. 102. Fur hair; distal.

FIGS. 103-106 *Wallabia rufogrisea* × 100.

Fig. 103. Fur hair; basal.
Fig. 104. Fur hair; basal.
Fig. 105. Fur hair; mid-shaft.
Fig. 106. Fur hair; distal.

FIGS. 107 & 108 *Macropus tasmaniensis* × 100.

Fig. 107. Wavy hair; distal.
Fig. 108. Wavy hair; mid-shaft.

REMARKS

This paper does indicate the probable taxonomic value of a detailed microscopic examination of the hairs of the marsupials. However, the cuticular scales are often so much alike in the hairs of unrelated animals that a useful key for the accurate identification of hair, based on scales alone, would be of little value in a comparative study of mammalian hair.

Cuticular scales show some variation on contemporaneous hairs from a single specimen. Also, differences exist in scale form along the same hair, from base to tip. Some marsupials show this character much more strongly marked than others. An extreme instance of this change in structural character from the base to the tip of the hair, involving not only the cuticular scales but other elements of the hair shaft structure as well, is furnished by the protective hair of *Isoodon*.

Hausman (1930, p. 262) considers that the differences in scale form along a single hair " are the results of the differences in the activities of the cells of the hair papilla, plus also, it is believed, some differences in the gradual drying out of the hair shaft, plus also the effects of wear on the free ectal edges of the scales, particularly at the tip of the shaft. The activities of the papillal cells produce differences both at the tip and the base of the shaft, i.e., when these cells begin, and close, their mitosis. Along the middle of the shaft the scales are fairly uniform in shape and relationships ".

The authors are of the opinion that neither dehydration nor attrition could cause the changes in scale form from the basal to the distal portions of a single hair. This is in close agreement with the findings of Wildman and Manby (1938, p. 343) in which they say that " A study of the scale-pattern along hairs, not only of the Monotremata but of other mammals, provides conclusive evidence that generally the changes in scale form from proximal to distal portions are innate and genetic in character, and are not caused by varying amounts of attrition ".

The gross structure of many protective hairs, such as those of *Isoodon*, suggest that they have a limited growth period and are periodically shed.

In surface structure there does not seem to be any exact distinction between the hairs of the Polyprotodontia and those of the Diprotodontia. However, the cross-sectional shape is probably of more taxonomic value; but the character of the cuticle, cortex, and medulla, as revealed by transverse section, must be considered in a detailed microscopic examination of mammalian hair.

Minor differences between hair samples from different regions of the body of a single specimen will not be discussed here.

Insufficient material has been examined to discuss the intraspecific variation for any of the animals examined. Where hair samples from more than one specimen have been examined there is some variation in the surface structure but the sequence of scale forms along the hairs is usually the same.

The types of hair will not be discussed here. Hardy (1947, p. 145) draws attention to the need for examining the relation between the follicle types in the skin and the hair types in the pelage.

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