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Identification of Primate Hair

On occasion the forensic scientist is faced with the problem of hair identification. The problem at hand may be to determine whether the hair is human or is that of some other mammal and/or whether the hair belongs to a specific individual in question. This study investigated the head hair of over 200 nonhuman primates representing 25 genera and 42 species and should be of aid in hair identification cases. Prior to this study only the hair of the mid-dorsum of nonhuman primates had been studied [*1*]. The evolutionary and taxonomic trends evidenced in the microanatomy of primate head hair has been presented previously [*2*].

Hair Diameters

The most traditional metric evaluation of the hair shaft is the measurement of the maximum (D_1) and minimum (D_2) diameters of the hair in cross section. In man the maximum diameters range from a low of 63.93 (Dutch) to 126.6 μm for Hawaiians. The nonhuman primate maximum diameters exceed human averages at both ends of the range, yet 65 percent of the primate genera studied fall within the human range (Table 1). The human minor diameters range from 47.28 (Dutch) to 63.70 μm for some Hawaiians. Less than five percent of the nonhuman primate head hair is within the minimum diameter range of man. Thus, it appears that the minimum hair diameter is a more reliable metrical gage for hair identification.

Cross-Sectional Area

The cross-sectional shape of primate head hair is generally elliptical. The cross-sectional area is calculated by using the formula for the area of an ellipse, $(D_1 \times D_2/4)\pi$. Human hair varies in cross-sectional area from a low of 2910 μm^2 (Paracas Indian mummies) to some 6380.70 $\pm$ 1981 μm^2 for Hawaiians. Only about 35 percent of nonhuman primate head hair falls within the human range. As with maximum and minimum diameters, the cross-sectional areas of human hair are generally similar to those of the Old World monkeys (Table 1).

Hair Index

The hair index has generally been held to reflect the shape of a hair in cross section. The formula for the index is $(D_2 \times 100)/D_1$. An index of 50.0 reflects the shape of a

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Table 1. Primate maximum and minimum hair diameters, cross-sectional areas, and hair indices.

Primate	Mean Max Dia, μm	Mean Min Dia, μm	Mean μm²	Mean Hair Index
Lemur	35.03 ± 5.91	23.94 ± 3.54	668.49 ± 193.60	69.28 ± 10.52
Slow Loris	44.33 ± 8.61	29.33 ± 7.30	1062.91 ± 504.17	65.90 ± 6.89
Angwantibo	42.67 ± 3.27	29.33 ± 3.27	986.46 ± 160.49	68.84 ± 7.08
Potto	35.33 ± 9.00	25.33 ± 9.00	723.62 ± 278.91	73.78 ± 13.90
Galago	38.17 ± 10.81	25.17 ± 7.22	797.44 ± 432.42	68.84 ± 22.19
Prosimians	39.11 ± 7.52	26.62 ± 5.25	847.78 ± 313.92	69.33 ± 12.12
Marmoset	57.33 ± 8.33	42.67 ± 2.31	1914.28 + 233.50	75.83 ± 14.74
Pygmy Marmoset	32.00 ± 8.00	18.67 ± 2.31	477.52 ± 164.81	59.72 ± 8.67
Titi	68.00 ± 4.00	45.33 + 12.22	2429.50 ± 729.00	66.61 ± 16.99
Owl Monkey	72.00 ± 6.93	48.00 ± 8.00	2739.48 ± 674.85	66.45 ± 6.28
Uakari	88.00 ± 0.00	44.00 ± 0.00	3041.07 ± 0.00	50.00 ± 0.00
Capuchin	82.00 ± 12.33	54.00 ± 8.29	3535.35 ± 966.05	65.95 ± 5.23
Squirrel	57.67 ± 19.48	43.00 ± 13.11	2104.87 ± 1066.06	76.30 ± 14.61
Woolly	76.00 ± 22.63	44.00 ± 16.97	2777.17 ± 1794.93	57.10 ± 5.33
Howler	129.33 ± 10.07	45.33 ± 2.31	4603.49 ± 395.46	35.20 ± 3.29
New World Monkeys	73.57 ± 10.20	42.78 ± 7.28	2624.76 ± 667.30	61.45 ± 8.35
Macaque	77.79 ± 17.18	63.62 ± 17.83	4102.71 ± 2029.35	81.34 ± 9.85
Celebes Black Macaque	81.00 ± 18.92	66.17 ± 16.17	4423.90 ± 1989.86	81.83 ± 7.55
Baboon	103.38 ± 17.91	78.62 ± 13.71	6511.33 ± 2067.68	76.63 ± 9.88
Mandrill Baboon	108.00 ± 17.44	89.33 ± 15.14	7715.77 ± 2396.59	82.64 ± 0.64
Guenon	68.00 ± 0.00	48.00 ± 0.00	2563.55 ± 0.00	70.59 ± 0.00
Colobus	73.33 ± 2.31	56.00 ± 4.00	3221.19 ± 152.01	76.51 ± 6.92
Lungur	102.00 ± 2.83	68.00 ± 11.31	5434.97 ± 755.29	66.85 ± 12.95
Old World Monkeys	87.64 ± 10.00	67.10 ± 11.17	4854.77 ± 1341.54	76.63 ± 6.92
Hylobatids Gibbon	104.00 ± 12.00	78.67 ± 4.62	6450.75 ± 1101.00	76.03 ± 5.70
Orangutan	144.00 + 10.58	96.00 ± 10.58	10916.01 ± 1952.30	66.54 ± 2.55
Chimpanzee	122.96 ± 21.81	96.44 ± 14.82	9526.73 ± 2957.18	79.02 ± 6.78
Gorilla	109.45 ± 21.11	86.55 ± 19.78	7676.93 ± 3030.06	79.28 ± 10.56
Pongids	125.47 ± 17.83	93.00 ± 15.06	9373.22 ± 2646.51	74.95 ± 6.63
Hominids (Man)	91.85 ± 2.48	64.65 ± 1.72	4811.55 ± 2262.90	71.65 ± 1.19

flattened ellipse while an index of 100.0 represents a circle. The hair indices of man generally fall between values of 50 and 98 [*3*], negroids having the flattest and mongoloids the most circular hair. The nonhuman primates generally conform to this range. As has been shown for man [*4*], the hair indices of nonhuman primates do not always accurately describe cross-sectional shapes.

Cuticle Scale Counts

Scale counts, that is, the number of cuticle scales per unit of measure (40 μm), present little variation in man. The range is 4.7 to 5.2 scales per 40 μm. The mean average of nonhuman primates (4.51 ± 1.38) is indicative of their counts exceeding both ends of the human range (Table 2). While one cannot differentiate between human and other primate hair on a basis of scale count alone, it is a pattern with which individual specimens of all primates are very consistent in this feature.

TABLE 2—*Primate cuticle scale counts, scale widths, and scale indices.*

Primate	Mean Scale No. per 40 μm	Mean Scale Width, μm	Mean Scale Index
Lemur	5.82 ± 1.01	8.00 ± 2.47	23.76 ± 9.09
Slow Loris	4.50 ± 0.58	12.00 ± 0.00	27.91 ± 4.80
Angwantibo	4.00 ± 1.41	10.00 ± 2.83	23.69 ± 6.10
Potto	1.75 ± 0.96	22.00 ± 4.00	67.24 ± 23.81
Galago	3.37 ± 2.00	13.50 ± 6.74	34.92 ± 16.12
Prosimians	3.89 ± 1.19	13.10 ± 4.01	63.98 ± 11.98
Marmoset	5.00 ± 0.00	8.00 ± 0.00	14.17 ± 20.21
Pygmy Marmoset	3.00 ± 0.00	24.00 ± 0.00	78.33 ± 20.21
Titi	8.00 ± 0.00	4.00 ± 0.00	5.90 ± 0.35
Owl Monkey	5.00 ± 0.00	8.00 ± 0.00	11.18 ± 1.14
Uakari	4.00 ± 0.00	12.00 ± 0.00	13.64 ± 0.00
Capuchin	4.50 ± 0.71	10.00 ± 2.83	12.65 ± 4.29
Squirrel	4.00 ± 0.00	12.00 ± 3.27	22.35 ± 6.12
Woolly	n.a.	n.a.	n.a.
Howler	4.00 ± 0.00	12.00 ± 0.00	9.32 ± 0.72
New World Monkeys	4.69 ± 0.09	11.25 ± 0.90	20.94 ± 4.38
Macaque	4.69 ± 0.81	11.59 ± 5.17	15.77 ± 7.08
Celebes Black Macaque	4.75 ± 0.46	11.50 ± 1.41	15.14 ± 4.53
Baboon	3.44 ± 3.44	12.00 ± 0.00	11.94 ± 3.51
Mandrill Baboon	3.00 ± 0.00	24.00 ± 0.00	22.65 ± 4.01
Guenon	4.00 ± 0.00	12.00 ± 0.00	17.65 ± 0.00
Colobus	4.00 ± 0.00	20.00 ± 0.00	27.29 ± 0.84
Langur	5.00 ± 0.00	12.00 ± 0.00	11.77 ± 0.33
Old World Monkeys	4.13 ± 0.31	14.73 ± 1.34	17.46 ± 2.90
Hylobatids Gibbon	5.00 ± 0.00	12.00 ± 2.11	11.64 ± 1.35
Orangutan	5.00 ± 0.00	12.00 ± 0.00	8.36 ± 0.64
Chimpanzee	4.22 ± 0.44	10.22 ± 2.11	8.54 ± 2.13
Gorilla	5.25 ± 1.26	9.00 ± 2.00	8.50 ± 1.87
Pongids	4.82 ± 0.57	10.41 ± 1.37	8.47 ± 1.55
Hominids (Man)	4.95 ± 0.50	12.80 ± 2.40[1]	16.00 ± 0.00[1]

n.a. = data not available.
[1] Hawaiians.

Cuticle Scale Width

Hausman [5], Kneberg [4], and Smith [6] maintained that scale width is inversely proportional to hair shaft diameters. In the nonhuman primates, this is not found to be the case; in fact, a slightly direct proportional relationship exists in the other primates.

A great range of widths is found in the nonhuman primates (Table 2). Unfortunately the literature does not include recorded scale width figures; but from a study of Hawaiian hair and accepted caucasoid hair in the author's laboratory, it appears that the human range is between 4.0 and 5.0 μm.

Scale Index

The relative sizes of cuticle scales are reflected in the scale index, (scale width × 100)/D_1. Human scale indices generally range from a value of 16 to 33 [5]. The nonhuman primate range is considerably larger (Table 2).

Conclusions

In terms of metrical features, the head hair of man is not particularly unique compared to that of other primates. The forensic scientist is on unstable ground when attempting to identify a single individual from one or a few hairs. Even though a sophisticated technique such as neutron activation analysis exists [7], there is no completely reliable hair identification technique. The most potentially fruitful approach is the use of microanatomical, micrometrical, and physical-chemical techniques in forensic cases.

Summary

The results of a comparative study of the head hair of man and a large number of nonhuman primates have been presented. The metrical features of human head hair are not distinct enough from those of other primates to use micro-measurement as a sole means of hair identification. It is suggested that a broad range of techniques be employed in hair identification cases.

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