A Descriptive Study of Hair Morphology of Three Carnivore families (*Canidae*, *Ursidae* and *Herpestidae*)

Original Research Article

ABSTRACT

Aim: To study the morphological characteristics of dorsal guard hair of five carnivoran species native to Tamil Nadu for the creation of an identification key for application in wildlife forensics.
Study Design: The experiment was designed to observe the physical characters of each hair strand and measure widely used morphological parameters from native species of the state. The results were compared with previous findings to validate the differences and similarities with our study.
Place and Duration of Study: Advanced Institute for Wildlife Conservation (AIWC), Tamil Nadu Forest Department, Vandalur, Chennai, Tamil Nadu, between August 2020 and September 2021.
Methodology: Hair samples were collected for golden jackal, Indian fox, dhole, sloth bear and Indian grey mongoose. Hair characters such as scale pattern, scale distance and scale margin, medulla structure, cortex thickness, medulla thickness, medullary index and cross-sectional structure were observed.
Results: The hair length of golden jackal, Indian fox, dhole, sloth bear and Indian grey mongoose were as follows 44.94 ± 2.24 mm, 29.70 ± 1.51 mm, 29.60 ± 0.97 mm, 83.83 ± 2.93 mm, 54.60 ± 2.03. The cuticular characters showed few variations compared to previous studies. The medullary structure was wide medulla with vacuoles for all three canid species while sloth bear has a narrow simple unbroken medulla and Indian grey mongoose had wide medulla with lattice. The medullary index for golden jackal, Indian fox, dhole, sloth bear and Indian grey mongoose were 0.73 ± 0.05 (S.D.), 0.77 ± 0.071 (S.D.), 0.66 ± 0.06 (S.D.), 0.18 ± 0.08 (S.D.) and 0.63 ± 0.05 (S.D.) respectively.
Conclusion: The morphometric characters of hair showed variation in scale pattern, scale margin, scale distance and medullary index when compared to the previous studies. The research was successful in creating a taxonomic key for identifying the five mammalian species from their guard hair.

Keywords: Tricho-taxonomy; hair morphometry; carnivores; species identification; reference repository.

1. INTRODUCTION

India is home to 427 species of terrestrial and marine mammals [1] that face survival threat from humans in the form of widespread illegal hunting and poaching [2]. Mammals constitute to a major share in international illegal wildlife trade mainly for their skin, body parts, meat, and live animals [3]. In most cases hair ends up as only physical evidence for examination [4]. Species identification from hair characteristics has become an integral part of wildlife forensics and study of diet ecology of carnivores because, the properties of the hair do not get affected by the digestive process and takes more time to decay [5].

The mammalian skin is covered by guard hair or protective hair and fur hair or under-hair [6]. For species identification, dorsal guard hair is generally used because hair from other regions of the body lack clear morphological properties [7]. Microscopic and macroscopic characteristics of wild mammalian hair was pioneered by Hausman [6] and was later refined [8]. In India, tricho-taxonomical research on various families of mammals was expansively carried out by Chakraborty and De [9-11], De et al. [12-15], Sahajpal et al [4,16], Bahuguna [17] and in recent past decade by Kamalakannan et al [18-21].

The purpose of this study is to create a standard identification key based on morphological and morphometric data from five species of carnivores, Golden jackal (*Canis aureus* Linnaeus, 1758), Indian Fox (*Vulpes bengalensis* Shaw, 1800), Dhole (*Cuon alpinus* Pallas, 1811) (Family: *Canidae*), Sloth bear (*Melursus ursinus* Shaw, 1791) (Family: Ursinidae) and Indian Grey Mongoose (*Herpestes edwardsii* É. Geoffroy Saint-Hilaire, 1818) (Family: *Herpestidae*), which are overlooked species in conservation point of view. Among the five, the three canid species and Indian grey mongoose belong to schedule II and sloth bear belong to schedule I of Wildlife (Protection) Act (1972) but are still hunted in different parts of India. The golden jackal and Indian fox hunting is driven by superstitious beliefs [22,23] and threatened by loss of habitat [24]. The sloth bear is poached for their meat, skin, teeth, claws, bile gland and derivatives used as traditional medicine in local and international markets [2]. The Indian grey mongoose and other species of mongooses had been under constant threat due to poaching for their fine quality hair, a characteristic feature that has high demand in the making of painting and shaving brushes [4]. These species are often seized by forest department officials in the state of Tamil Nadu in illegal wildlife trade and this work intends to aid in the prompt identification.

2. MATERIALS AND METHODS

2.1 Sample Collection

Naturally fallen hair from captive Golden Jackal (*Canis aureus*) (two individuals), Indian Fox (*Vulpes bengalensis*) (two individuals), Dhole (*Cuon alpinus*) (four individuals), Sloth bear (*Melursus ursinus*) (four individuals) were collected from their enclosures at Aringar Anna Zoological Park, Vandalur and Kurumbapatti Zoological Park, Salem, between 2019 and 2021. For Indian grey mongoose (*Herpestes edwardsii*) (one individual), hair sample was obtained from a dead specimen from Vandalur reserve forest.

2.2 Sample Preparation

Pre-treatment included washing hair samples with tap water followed by acetone treatment to remove exogenic impurities from the hair. The cleansed hair was then dried and used for further observation [20]. A total of thirty (n=30) hair samples from each species (150 hair for all five species) was used for morphometric analysis.

2.3 Morphometric Analysis

Physical characteristics such as colour of the hair, banding, length of each strand, root length was observed. Cuticular characters such as cuticular width, scale pattern, scale margin, scale distance was observed for each hair strand at proximal, medial and distal ends of the hair [7].

For observation of cuticular characters, cuticle imprints of the hair were made on a 1% - 2% gelatine smear on a clear glass slide [16]. Medullary characters such as type of medulla, medullary width, medullary index and percentage along with cross-section were observed for each hair strand by soaking the hair pieces in xylene [25].

All the images were taken at 400x magnification except for the root of sloth bear which was taken at 100x as they have the longest root observed among the five species. Hair length was measured from digital photograph of hair using ImageJ® software [26], while other microscopic measurements were carried out via Magnus CX23 microscope with Magvision® software. The hair characteristics is described using the Nomenclature [6,8].

3. RESULTS

3.1 Physical Characters

The hair colour and texture of Golden Jackal (GJ) had brown or umber colour with dark tips at distal end with a smooth texture. The Indian Fox (IF) had soft hair with grey to buff colour depending on the part of the body. The Dhole (D) had a distinct brown to orange colour with dark distal ends and a rough textured hair. The Sloth Bear (SB) had long black human-like hair with kinks and a very rough texture. The Indian Grey

Mongoose (IGM) had brown tips followed by alternating light and dark bands with smooth texture to its hair. The macroscopic appearance of hair of all the species is given in the figure (Fig. 1).

The structure and length of hair root (Table 1) were observed for providing additional information of hair samples. The root of GJ and F had similar appearing roots but the later had comparatively shorter roots. The D had much longer root than the other two canid species. The SB had the longest root among the five species that tapers to the tip and the IGM had an oblong root (Fig. 2). The morphometric data and physical characteristics of hair are given in Table 1.

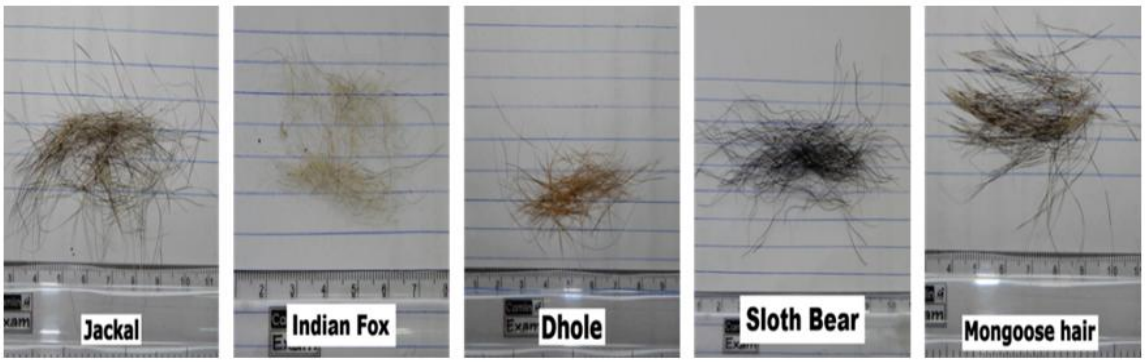

Fig. 1. Macroscopic appearance of hair. Jackal hair collected from two individuals of Aringnar Anna Zoological Park, Vandalur in 2020. Indian Fox hair collected from two individuals, one from Aringnar Anna Zoological Park, Vandalur and one from Kurumbapatti Zoological Park, Salem in 2021. Dhole hair collected from four individuals of Aringnar Anna Zoological Park, Vandalur in 2021. Sloth bear hair collected from two individuals of Aringnar Anna Zoological Park, Vandalur in 2020. Indian grey mongoose hair collected from one dead specimen from Vandalur Reserve Forest in 2020

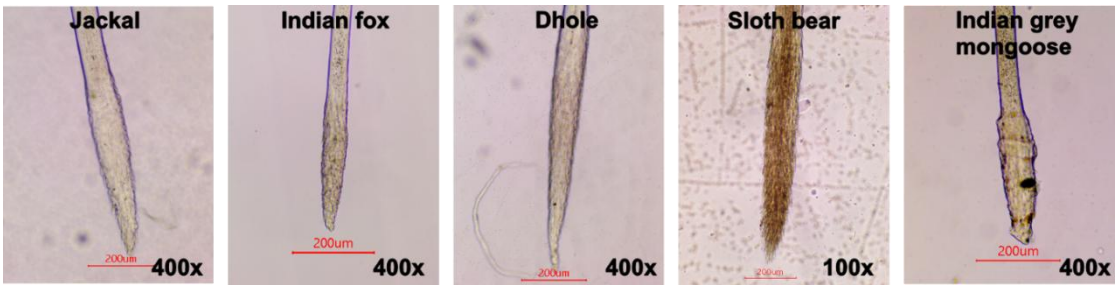

Fig. 2. Hair root structure of different species

Table 1. Physical characteristics of hair of the species under study

Features	Golden Jackal	Indian Fox	Dhole	Sloth Bear	Indian grey mongoose
Colour	Umber with dark tips	Grey to buff	Orange to brown	Black	Brown tips with alternate white and brown bands
Shape	Straight	Straight	Short Straight	Long with kinks	Straight
Texture	Rough	Smooth	Rough	Very rough	Smooth
Hair Length	44.94 ± 2.24 mm (S.E.)	29.70 ± 1.51 mm (S.E.)	29.60 ± 0.97 mm (S.E.)	83.83 ± 2.93 mm (S.E.)	54.60 ± 2.03 mm (S.E.)
Root length	585.21 ±11.96 µm (S.E.)*	319.54 ± 10.38 µm (S.E.)*	710.31 ±19.10 µm (S.E.)*	1235.58 ± 36.63 µm (S.E.)*	419.22 ± 15.68 µm (S.E.)*

S.E. - Standard error

3.2 Cuticular Characters

The cuticular characters varied along the length of each hair. Hence, it was documented in proximal, medial and distal parts of the hair. The cuticular scales are transversal in nature at distal and medial parts of the hair samples. The scale margin at the proximal end was observed to be smooth for all the species. In the medial region the scale margin of GJ, D and SB were crenate type, while IF had a mixture of smooth and crenate type and IGM had a combination of crenate and rippled margin type. The distal part of the hair of all species had crenate type margin.

The scale distance was observed to be distant at the proximal end for GJ, IF, D and SB while the Indian grey mongoose had nearer scales. At medial region, scales were nearer in GJ, D, SB and IGM but the IF had distant scales. Similarly, the scales at distal region were nearer in GJ, IF and D while SB and IGM had both nearer and cuticular scales.

The scale pattern of GJ had a mixture of diamond petal and regular wave in the proximal end of their hair. The IF had broad diamond petal in the proximal end. The D hair had a regular wave pattern in most of the hair with broad petal in a few samples. The scale pattern of SB and IGM had regular wave patterns in their proximal ends. The scale pattern at medial and distal end of GJ, D, SB and IGM had irregular wave type pattern with few outliers. The IF showed a diamond petal scale pattern in the medial and distal end of its hair (refer Table 2 and Fig. 3).

3.3 Medullary Characters

~~In our study~~ It was observed that GJ and IF had wide medulla lattice with vacuoles (> 0.70 medullary index). A similar structure was observed in D but the thickness of medulla was much less with vacuoles (< 0.70 medullary index). The SB hair had a simple narrow continuous medulla (< 0.20 medullary index) and the IGM hair had a wide medulla (> 0.60 medullary index) with intrusion of cortex. Cross sections of GJ, IF and D exhibited circular to oval shape with pigments around the medulla. SB hair exhibited oval shape with heavy pigmentation in the cortex. The IGM exhibited oval to oblong shaped hair (Fig. 4). The medullary index values and medulla percentage for all the five species is given in the table (Table 3).

Table 2. Cuticular characteristics comprising scale margin, scale distance and scale pattern

Cuticular characteristics		Golden Jackal	Indian Fox	Dhole	Sloth Bear	Indian grey mongoose
Scale margin	**Basal (proximal)**	Smooth	Smooth	Smooth	Smooth	Smooth
	Medial	Crenate	Smooth to Crenate	Crenate	Crenate	Crenate
	Apical (distal)	Crenate	Crenate	Crenate	Crenate	Crenate
Scale distance	**Basal (proximal)**	Distant	Distant	Distant	Distant	Near (Intermediate)
	Medial	Near (Intermediate)	Distant	Near (Intermediate)	Near (Intermediate)	Near (Intermediate)
	Apical (distal)	Near (Intermediate)	Near (Intermediate)	Near (Intermediate)	Close	Close
Scale pattern	**Basal (proximal)**	Broad Diamond Petal to Regular wave	Broad diamond petal	Broad Diamond Petal to Regular wave	Regular wave	Regular wave
	Medial	Irregular wave	Broad Diamond Petal regular wave	Irregular wave	Irregular wave	Irregular wave
	Apical (distal)	Irregular wave	Irregular wave	Irregular wave	Irregular wave	Irregular wave

Table 3. Medullary characteristics of hair

Medullary characteristics	Golden Jackal	Indian Fox	Dhole	Sloth Bear	Indian grey mongoose
Medulla type	Wide medulla with vacuoles	Wide medulla with vacuoles	Wide medulla with vacuoles	Narrow unbroken medulla	Wide medulla lattice
Medullary index	0.73 ± 0.05 (S.D.)	0.77 ± 0.071 (S.D.)	0.66 ± 0.06 (S.D.)	0.18 ± 0.08 (S.D.)	0.63 ± 0.05 (S.D.)
Medullary percentage	73.44%	76.91 %	66.66%	18.52%	63.99%
Cross-section type	Circular	Circular	Circular	Oval to oblong	Oval to oblong

S.D. - Standard deviation

A graph (Fig. 5) was plotted using OriginPro 9.0 with average medullary index against the cortical thickness of five species of carnivores. This simple method is useful to understand the relationship between hair thickness (width) and medulla thickness (width) and can be applied to unknown hair samples to find their relatedness to standard values.

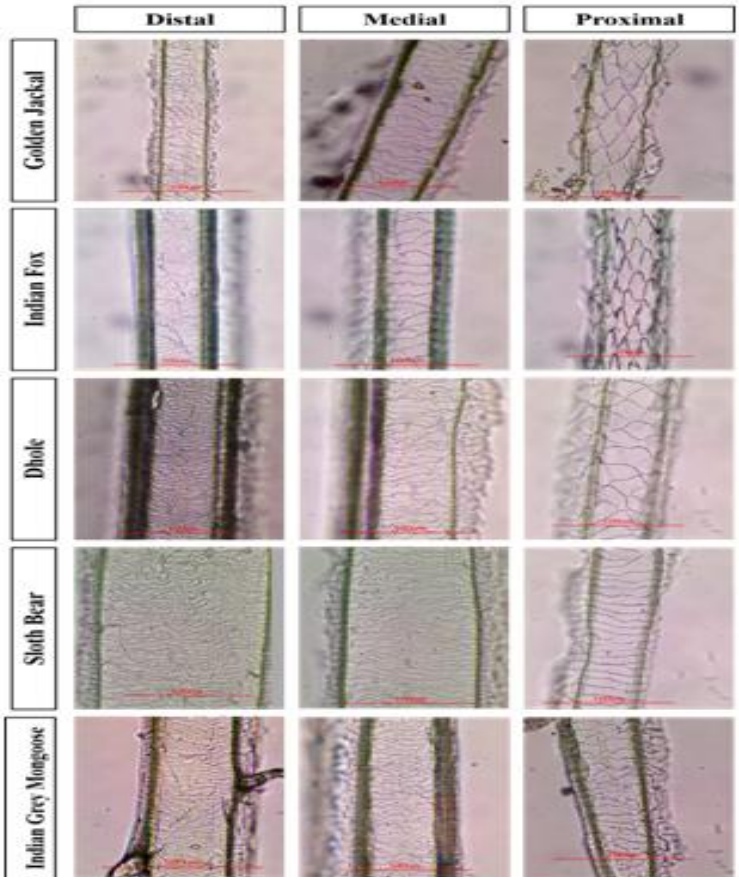

Fig. 3. Cuticular characteristics of hair at distal, medial and proximal regions

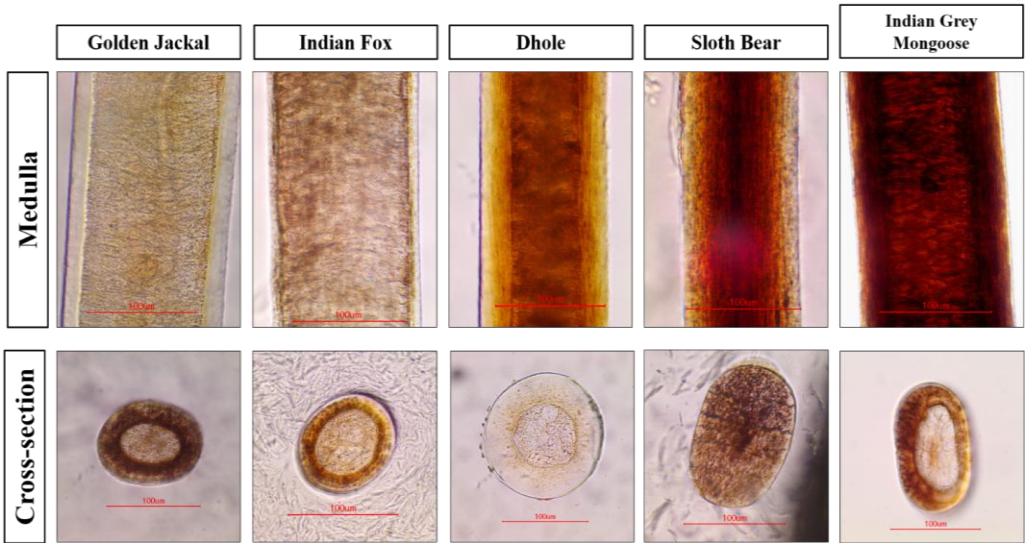

Fig. 4. Medullary structures and cross-sections of hair of golden jackal, Indian fox, dhole, sloth bear and Indian grey mongoose

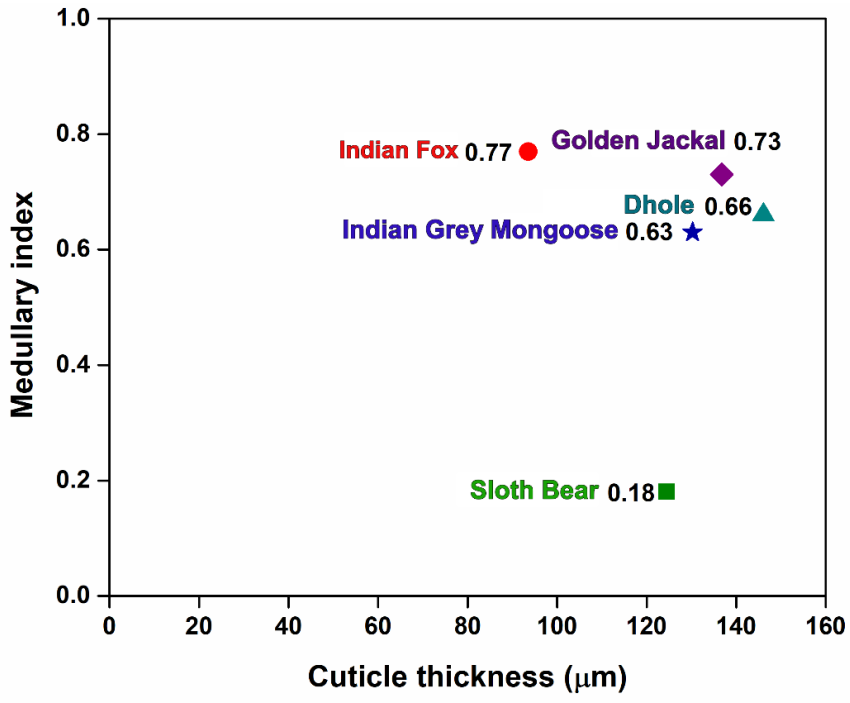

Fig. 5. Cuticle thickness and medullary index of hair of carnivores. The Golden Jackal and Indian Fox can be seen at the top of the graph indicating higher medullary index but the golden jackal has comparatively thicker hair than Indian fox. The dhole and Indian grey mongoose also has similar medullary index but the difference in hair thickness shows dhole away from Indian grey mongoose. The sloth bear with its lowest medullary index is at the bottom of the graph

4. DISCUSSION

A cross reference with previously published literature for all five species provided the similarities and differences in hair characteristics present in our current research. The average hair length of golden jackal showed minor difference between Indian populations, 44.94 ± 2.24 (S.E.) mm of our observation to 46.76 ±13.14 (S.E.) mm [10]. Arpacık [7] reported an average length of 6.66 ± 1.22 (S.E.) cm from the golden jackal of Turkey. The average hair length of Indian fox was 29.70 ± 1.51 mm (S.E.) was greater than what Chakraborty and De [10] reported 26.6 ± 2.9 (S.E.) mm. Chakraborty and De [10] reported an average hair length of 44.2 ± 3.6 (S.E.) mm for Dhole while we got a much lower average length of only 29.60 ± 0.97 (S.E.) mm. The average hair length of sloth bear, 88.83 ± 2.93 (S.E.) mm was comparatively greater than the previous observation of 69.44 ± 3.02 (S.E.) mm [14]. In case of Indian grey mongoose hair length, De and Chakarborty [13] reported a much lower length of 25.61±3.34 (S.E.) mm compared to our average length of 54.60 ± 2.03 mm (S.E.).

The scale pattern of golden jackal at proximal end of the hair was reported to be broad diamond petal [17] while we observed both broad diamond petal and regular wave pattern. The Indian fox showed irregular wave pattern in the distal end and diamond petal scale pattern [10] which was in line with our observation. The scale pattern of dhole is described to be of regular wave type at the proximal end [17] and irregular wave type of hair [7] but our observation had regular waves with some broad diamond petal pattern at proximal end and irregular wave pattern along distal and medial portion of the hair. In case of sloth bear the scale pattern at proximal end was reported to have regular mosaic wave [14] and broad petal [17] though we observed only regular wave pattern from our samples.

The Medullary index of golden jackal was at 0.73 ± 0.05 S.D. while Arpacık [7] reported 0.72 ± 0.005 S.D. and Chakraborty and De [10] reported 0.67 ± 0.02 S.D. Indian fox had a medullary index of 0.77 ± 0.071 (S.D.) compared to the previous report of 0.81 ± 0.012 (S.D.) [10]. In case of dhole a much higher medullary index was obtained 0.66 ± 0.06 (S.D.) in the study

compared to the previous study 0.59 ± 0.02 (S.D.) [10]. De and Chakraborty [15] reported a higher medullary index for sloth bear at 0.91± 0.008 (S.D.) but our observation gave a lower index value of 0.18 ± 0.08 (S.D.). For Indian grey mongoose the medullary index was at 0.82 ± 0.003 (S.D.) (13) and 0.792 ± 0.005 (S.D.) [4] while our observation had an average medullary index of 0.63 ± 0.05 (S.D.).

5. CONCLUSION

Through this study we were able to create an identification key for the five mammalian species based on their hair morphometrics. Members of the canid family share similar morphological features like cuticular pattern, medullar structure and cross-section shape of the hair but can be differentiated based on the measurement values. The medullary index graph can aid in ascertaining unknown hair samples based on their medullary index value and cortical thickness. A replication of this work for different mammalian species and application of statistical methods can yield valuable information about hair morphometry that can be effectively applied in wildlife forensics, taxonomical and ecological studies.

ETHICAL APPROVAL

The present work does not involve any kind of experimentation on live animals. As the study involved non-invasive biological sampling of mammalian hair, which are generally considered as animal waste, permissions from ethical committees on animal experimentation and conservation are not required.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Golden Jackal (*Canis aureus*)

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness(µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
1	59.16	583.45	98.18	72.44	73.783	0.738
2	65.48	640.7	118.77	91.71	77.216	0.772
3	58.98	578.61	86.06	59.93	69.637	0.696
4	73.13	703.03	95.77	64.189	67.024	0.670
5	44.32	526	94.57	56.59	59.839	0.598
6	49.92	698.05	158.97	118.66	74.643	0.746
7	29.87	614.02	98.44	71.79	72.928	0.729
8	46.36	461.47	73.34	49.93	68.080	0.681
9	56.72	696.08	189.96	136.89	72.063	0.721
10	48.69	601.95	139.2	104.49	75.065	0.751
11	49.95	572.72	145.68	103.15	70.806	0.708
12	51.8	542.63	142.86	96.61	67.626	0.676
13	52.81	509.93	117.51	84.2	71.653	0.717
14	32.33	573	159.48	110.24	69.125	0.691
15	41.81	451.69	97.21	74.82	76.967	0.770
16	37.51	534.23	163.32	127.98	78.361	0.784
17	27.9	524.43	148.12	116.23	78.470	0.785
18	29.85	562.97	146.8	111.51	75.960	0.760
19	29.56	632.11	148.07	118.87	80.280	0.803
20	38.58	590.47	167.13	130.26	77.939	0.779
21	37.76	518.56	136.57	106.79	78.194	0.782
22	56.25	555.53	122.52	80.91	66.038	0.660
23	22.76	580.42	147.08	97.08	66.005	0.660
24	35.29	591.59	166.02	133.83	80.611	0.806
25	56.72	705.27	148.84	104.53	70.230	0.702
26	41.42	624.89	170.79	134.61	78.816	0.788
27	34.78	610.61	130.63	96.64	73.980	0.740
28	53	651.32	189.19	141.6	74.845	0.748
29	50.7	573.6	163.25	124.66	76.361	0.764
30	35.05	546.99	138.56	111.64	80.572	0.806
	44.949 ± 2.247 (Standard error)	585.211 ± 11.96 (Standard error)	136.763 ± 30.613 (Standard deviation)	101.093 ±25.814 (Standard deviation)	73.437 ± 5.162 (Standard deviation)	0.734 ± 0.052 (Standard deviation)

Indian fox (*Vulpes bengalensis*)

S. No.	**Hair length (mm)**	**Root length (µm)**	**Cortical thickness(µm)**	**Medullary thickness (µm)**	**Medulla Percentage in hair (%)**	**Medullary index**
1	23.06	399.6	80.04	62.01	77.474	0.775
2	19.71	403.45	66.13	44.4	67.140	0.671
3	25.61	298.35	49.43	33.28	67.328	0.673
4	46.07	352.37	53.62	34.16	63.708	0.637
5	22.73	377.82	95.72	77.08	80.527	0.805
6	44.04	363.43	135.81	120.19	88.499	0.885
7	31.19	346.17	89.63	64.91	72.420	0.724
8	49.08	392.79	138.48	113.18	81.730	0.817
9	28.77	374.77	108.68	86.71	79.785	0.798
10	26.9	337.28	132.47	104.39	78.803	0.788

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness(µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
11	27.59	270.86	81.47	62	76.102	0.761
12	25.36	233.58	147.05	127.66	86.814	0.868
13	29.47	315.86	74.31	58	78.051	0.781
14	29.54	314.57	103.86	84.48	81.340	0.813
15	25.76	388.57	82.43	67.45	81.827	0.818
16	24.87	304.78	75.39	55.09	73.073	0.731
17	31.67	382.13	54.96	43.8	79.694	0.797
18	26.59	327.28	148.47	124.490	83.849	0.838
19	24.57	285.92	78.24	56.3	71.958	0.720
20	30.29	275.26	135.01	107.04	79.283	0.793
21	36.21	299.4	71.46	54.82	76.714	0.767
22	31.3	206.86	118.89	97.23	81.781	0.818
23	34.04	252.12	103.52	82.56	79.753	0.798
24	30.09	339.1	119.17	100.86	84.635	0.846
25	19.79	221.18	57.37	36.05	62.838	0.628
26	20.45	296.34	83.3	67.3	80.792	0.808
27	31.46	381.52	60	38.36	63.933	0.639
28	26.24	261.04	118.42	98.97	83.575	0.836
29	18.14	240.66	67.01	43.36	64.707	0.647
30	50.48	343.21	77.21	61.01	79.018	0.790
	29.702 ± 1.516 (Standard error)	319.542 ± 10.38 (Standard error)	93.585 ± 30.204 (Standard deviation)	73.571 ± 28.738 (Standard deviation)	76.905 ± 7.144 (Standard deviation)	0.769 ± 0.071 (Standard deviation)

Dhole (*Cuon alpinus*)

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness (µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
1	23.18	927.42	122.88	70.61	57.463	0.575
2	26.37	931.83	160.42	121.69	75.857	0.759
3	34.25	811.31	142.68	86.99	60.969	0.610
4	29.67	768.72	182.08	147.08	80.778	0.808
5	28.69	746.06	156.79	88.65	56.541	0.565
6	39.22	744.24	135.05	87.31	64.650	0.647
7	26.12	702.97	138.85	78.31	56.399	0.564
8	23.72	823.06	162.57	117.52	72.289	0.723
9	37.6	965.94	148.29	107.24	72.318	0.723
10	40.25	694.56	136.16	75.91	55.751	0.558
11	30.24	611.93	156.86	109.6	69.871	0.699
12	29.57	728.16	152.24	88.93	58.414	0.584
13	37.76	587.56	164.08	124.75	76.030	0.760
14	31.14	766.7	159.92	106.75	66.752	0.668
15	25.96	687.84	161.58	101.64	62.904	0.629
16	26.85	718.77	153.46	89.54	58.347	0.583
17	27.49	783.53	158.52	107.38	67.739	0.677
18	29.52	658.29	159.81	115.23	72.104	0.721
19	28.72	659.31	162.55	120.38	74.057	0.741
20	35.86	727.76	178.53	133.27	74.649	0.746
21	23.9	634.27	171.52	130.29	75.962	0.760
22	31.64	605.37	112.12	70.39	62.781	0.628
23	29.91	619.71	153.92	104.62	67.970	0.680
24	26.32	572.33	140.87	97.69	69.348	0.693

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness (µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
25	15.47	635.76	93.88	59.64	63.528	0.635
26	29.75	674.89	128.51	87.22	67.870	0.679
27	26.07	702.23	121.51	80.57	66.307	0.663
28	28.84	559.62	126.52	83.22	65.776	0.658
29	35.96	647.86	101.9	62.34	61.178	0.612
30	28.07	611.43	137.86	89.76	65.110	0.651
	29.604 ± 0.976 (Standard error)	710.310 ± 19.109 (Standard error)	146.064 ± 21.396 (Standard deviation)	98.151 ± 21.898 (Standard deviation)	66.657 ± 6.821 (Standard deviation)	0.667 ± 0.068 (Standard deviation)

Sloth bear (*Melursus ursinus*)

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness(µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
1	71.6	1128	94.1	10.57	11.233	0.112
2	77.76	961.53	151.35	32.75	21.639	0.216
3	68.73	1017.42	100.21	29.64	29.578	0.296
4	83.93	1488.28	106.33	26.01	24.462	0.245
5	75.22	1325.52	134.66	16.02	11.897	0.119
6	77.49	1439.72	152.07	25.29	16.630	0.166
7	98.77	1200.48	184.53	19.04	10.318	0.103
8	91.59	1056.17	158.1	16.1	10.183	0.102
9	79.25	1087.35	147.9	45.63	30.852	0.309
10	114.38	1574.53	138.97	34.02	24.480	0.245
11	76.27	1094.82	121.95	32.42	26.585	0.266
12	87.08	1251.19	107.09	32.9	30.722	0.307
13	93.39	1021.46	106.08	29.2	27.526	0.275
14	93.63	1528.21	137.58	33.3	24.204	0.242
15	105.19	1208.82	141.16	32.29	22.875	0.229
16	100.73	1112.51	145.48	31.95	21.962	0.220
17	107.02	1514.19	131.82	31.29	23.737	0.237
18	98.74	1103.38	126.93	30.72	24.202	0.242
19	88.48	1313.43	148.29	50.33	33.940	0.339
20	89.85	1144.92	106.4	20.15	18.938	0.189
21	92.85	1158.68	102.9	7.34	7.13	0.071
22	43.84	1500.17	100.9	6.72	6.66	0.067
23	79.91	1434.25	136.03	13.41	9.86	0.099
24	64.82	1279.2	136.03	20.02	14.72	0.147
25	70.7	1455.99	102.69	12.38	12.06	0.121
26	68.66	1095.53	122.3	12.44	10.17	0.102
27	64.54	1349.53	101.02	11.4	11.28	0.113
28	93.31	939.72	87.28	7.52	8.62	0.086
29	100.01	850.53	88.68	15.03	16.95	0.169
30	57.28	1431.75	115.82	20.62	17.80	0.178
	83.834 ± 2.930 (Standard error)	1235.57 ± 36.63 (Standard error)	124.488 ± 23.834 (Standard deviation)	23.550 ± 11.302 (Standard deviation)	18.707 ± 8.033 (Standard deviation)	0.187 ± 0.080 (Standard deviation)

Indian grey mongoose (*Herpestes edwardsii*)

S. No.	Hair length (mm)	Root length (µm)	Cortical thickness(µm)	Medullary thickness (µm)	Medulla Percentage in hair (%)	Medullary index
1	48.96	112.5	153.43	102.37	66.72	0.67
2	39.88	423.18	134.78	78.67	58.37	0.58
3	49.44	494.79	139.88	89.61	64.06	0.64
4	48.3	444.15	130.12	86.53	66.50	0.67
5	61.94	388.95	85.59	56.24	65.71	0.66
6	47.61	456.18	123.35	76.5	62.02	0.62
7	50.57	538.36	129.45	83.56	64.55	0.65
8	53.22	508.83	128.74	69.49	53.98	0.54
9	52.9	341.25	118.48	86.69	73.17	0.73
10	49.02	436.14	131.13	91.62	69.87	0.70
11	35.52	276.93	120.62	84.78	70.29	0.70
12	55.14	409.46	130.13	79.85	61.36	0.61
13	46.84	452.6	136.57	92.93	68.05	0.68
14	53.13	387.63	114.15	84.23	73.79	0.74
15	43.91	443.02	148.21	95.93	64.73	0.65
16	49.69	347.08	115.04	63.74	55.41	0.55
17	44.45	395.29	138.72	79.59	57.37	0.57
18	41.68	362.54	92.14	64.44	69.94	0.70
19	44	444.74	142.26	85.16	59.86	0.60
20	45.49	462.7	129.39	73.25	56.61	0.57
21	73.64	482.28	122.73	68.72	55.99	0.56
22	69.77	475.55	139.88	88.27	63.10	0.63
23	59.12	461.29	148.88	89.11	59.85	0.60
24	61.13	348.26	148.58	91.63	61.67	0.62
25	71.77	464.36	145.53	91.34	62.76	0.63
26	74.99	391.35	137.67	92.68	67.32	0.67
27	58.62	317.98	98.2	69.06	70.33	0.70
28	76.23	498.13	122.21	83.9	68.65	0.69
29	66.57	514.96	151.57	93.97	62.00	0.62
30	64.63	496.06	150.56	98.9	65.69	0.66
	54.605 ± 2.033 (Standard error)	419.21 ± 15.68 (Standard error)	130.266 ± 17.150 (Standard deviation)	83.092 ± 11.236 (Standard deviation)	63.991 ± 5.330 (Standard deviation)	0.640 ± 0.053 (Standard deviation)