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**Research Paper**

# Hair Histology and Ultrastructure of Few Wild and Semi-Wild Mammals: A Forensic Approach

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**ABSTRACT**

Hair is physiologically an important structure as it protects the mammalian body from external injury, insect bite and electromagnetic rays. In modern days hair is considered as important tool of study in forensic science to solve the complicated vetero-legal cases. Forensic science deals with the exposition of those medical problems which by their nature have to come before the court of law. The examinations of hair from the scene of crime is extremely important in the criminal investigation as hair is an appendage of the skin and resist putrefaction; thus, is of an evidential value when other evidences are not available. The present investigation was undertaken to study the hair of few species of wild and semi wild mammals e.g. Bengal tiger (*Panthera tigris*), Indian one horn Rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), Mithun (*Bos frontalis*), Barking deer (*Cervulus muntjac*) and Yak (*Bos grunniens*), to find out the specificity of the hair to the animal based on indices like colour, length, average diameter of the hair- shaft, cortico-medullary index and cuticular scale pattern to develop a base line information to solve the vetero-legal cases. Present study revealed that the cuticular scale pattern of tiger was coronal simple, imbricate crenate in rhinoceros, imbricate flattened in elephant, imbricate crenate in mithun, imbricate flattened in barking deer, and imbricate crenate in yak. Again, the mean diameter of their shafts (in µm) were found to be tiger 140 ± 0.417, rhinoceros 160 ± 1.199, elephant 200 ± 1.958, mithun 150 ± 2.665, barking deer 135 ± 1.864 and yak 150 ± 3.670. Therefore, a cumulative data derived from these indices are helpful to determine the species of animal they belong to.

**Keywords:** Hair, Anatomy, Forensic Approach, Hair medulla, Cuticle Scale pattern

Hair in mammals is composed of the hair follicle, root and hair shaft. Follicles are formed only once in the life time of an individual. Physiologically hair fibres forms protective layer on the surface of epidermis protecting one from injury, snake bites and electromagnetic rays. Hair responds to external stimuli and any movement of the fibre is picked up by the follicle to transmit a message to the nervous system. The hair fibre can be said as an "antenna" of the mammals to receive sensory signals. Hair also plays a part in controlling the body heat by providing insulation against sudden heat loss or gain.

Hair is not only important from physiological point of view, but also from forensic aspect as it can help to solve the most completed vetero-legal cases. Due to human activities like poaching and deforestation most of the mammals are now endangered. Efforts are being made to preserve wild animals by establishing wild life sanctuaries, national parks and prohibition of poaching and trading of wild life substances under WLP Act 1972. Due to this reason, identification of animal species became important in the investigation of crimes in case of poaching and trading of animal parts.

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All hairs, whether used in textiles or not, will be found to have scales on their surfaces, and most hair (ordinarily exempting wool) will show a medulla or core in its centre, the width of which will be half or more of the total diameter (Kirk, 1953). Again, hair resists putrefaction and thus its evidential value is enhanced in case where other evidence are either not available or have been rendered unsuitable for examination due to adverse natural environmental conditions. Chernova (2014) provided a proof of principle that hair examination can give some evidence of the age. Again Hair morphology is another important tool that can be used to identify animal species (ENFSI, 2015). Keeping the above facts in mind, the following investigation was undertaken to study the hair of six different species of wild and semi-wild mammals to find out the specificity of the hair to the animal based on indices like colour, length of hair (excluding hair root), diameter of the hair- shaft, medullary index, cortico-medullary index and cuticular scale pattern to develop a base line information to solve the vetero-legal cases which shall help in species identification.

## MATERIALS AND METHODS

As many as 20 strands of randomly selected hairs from each animal belonging to Bengal tiger (*Panthera tigris*), Indian one horn Rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*) and Barking deer (*Cervulus muntjac*) were collected from the Assam State Zoo, Guwahati, Assam. Hair of mithun (*Bos frontalis*) was collected from National Research Centre on Mithun (ICAR), Jharnapani, Medziphema, Nagaland and Yak (*Bos grunniens*) hair was collected from National Research Centre on Yak, Dirang, West Kameng District, Arunachal Pradesh and utilized in the present study.

To study the length of Hair, Linear scale was used. To record the colour of hair Compound Microscope (Carl Zeiss) was utilized. For studying the Medullary Index and Cortico-medullary Index the hair strands were processed by the standard technique advocated by Bhanobakode *et al.* (2008). Width of cortex and medulla were recorded with the help of ocular micrometer and calculated as:

Medullary Index = Width of medulla/ width of shaft (Kirk, 1953),

Cortico-medullary Index = C × 100/M, where C = Cortical Width in μm, and M = medullary width in μm.

To examine the cuticular scale pattern (Sarma *et al.* 2008) of the hair samples, hairs of each animal were processed and separately coated with suitable coater and processed as per the standard techniques and examined with Scanning Electron Microscope (JOEL 6280) in the Directorate of Forensic Science, Kahilipara, Guwahati.

## RESULTS AND DISCUSSION

From the stand point of species identification, study of hair played an important role in vetero-legal aspect. The colour of hair gave the first hand information regarding the identification of species. In the present study, the colour of hair of Bengal tiger was brown with black stripes and the abdominal part had white coloured hair. Both brown and white coloured hair was observed in barking deer. The hair colours of other species have been depicted in Table 1.

The length of the hair was studied in the present investigation and it was found that there was variation in the length and wide of hair in different regions of the body of the same animal. The hair on the neck region of Yak was about 6 to 7 times the length of that of the hair on the body. Therefore it was found that this parameter was having no taxonomic value.

From the histological study it was observed that hair of the six species under study consisted of three parts - root, shaft and tip. The root was located in the skin beneath the dermis and the shaft projects beyond the skin surface to a variable distance. The shaft was composed of medulla, cortex and cuticle. Medulla was the innermost core of the hair, varied in width in different species and was irregularly cylindrical in shape as was opined by Kirk (1953). Study on pattern of the hair medulla played an important role in forensics. The medulla contained airspaces and was of various shapes and size. Study on the Medullary index (Kirk, 1953) of these six species revealed that it was species specific (Table 1).

Cortex was the intermediate layer which contained pigment in varying quantities. The pigment distribution in the hair cortex was one of the important parameter that was taken into account


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**Table 1:** Showing the different parameters on hair shaft

| Sl. No. | Species | Hair colour | Hair length (cm) (Mean ± SE) | Diameter of hair shaft (μm) (Mean ±SE) | Medullary index | Cortico-medullary index | Pattern of medulation | Cuticular scale pattern |
|---|---|---|---|---|---|---|---|---|
| 1 | Bengal tiger (*Panthera tigris*) | Brown, Black, White | 1.905 ± 0.149 | 103.80 ± 0.417 | 0.549 | 41.05 | Continuous | Coronal, simple |
| 2 | One horned rhinoceros (*Rhinoceros unicornis*) | Black | 3.525 ± 0.413 | 173.20 ± 1.199 | 0.339 | 97.27 | Patterned (globular) | Imbricate, crenate |
| 3 | Asian elephant (*Elephas maximus*) | Black | 3.280 ± 0.121 | 124.74 ± 1.958 | 0.828 | 10.37 | | Imbricate, flattened |
| 4 | Mithun (*Bos frontalis*) | Black, White, Brown | 3.400 ± 0.162 | 121.20 ± 2.665 | 0.861 | 8.04 | Continuous | Imbricate, crenate |
| 5 | Barking deer (*Cervulus muntjac*) | Brown, White | 1.730 ± 0.076 | 217.00 ± 1.864 | 0.824 | 10.60 | Continuous | Imbricate, flattened |
| 6 | Yak (*Bos grunnien*) Course Fiber | Black, White | 11.540 ± 1.074 | 66.08 ± 3.670 | 0.895 | 5.81 | | Imbricate, crenate |

in this study and in the cross section of the hair strands it was observed that the pigment was uniformly distributed in the Bengal tiger, elephant and barking deer. In Great Indian one horned rhinoceros and coarse hair of Yak pigment was more towards the medulla. However, in mithun pigment was concentrated towards the periphery. Cortico-medullary index value of hair was another important parameter that was taken into account in respect to species identification (Table 1). Bhanubakode *et al.* (2008) reported that the cortico-medullary index value was an important study in regards to species identification; they observed that the Cortico-medullary index value of tiger was 93.0. jackal 76.56, sambhar 37.66, hyena 29.92, leopard 25.86 and chital 15.25.

Contour of hair shaft studied in the cross section of hair strands showed that it was different in different species. Contour of the hair shaft in tiger, rhino, mithun and barking deer was round. In elephant and yak it was oval.

Cuticle was a thin layer composed of scales. Type of cuticular scales is a very important consideration in species identification. Distinctive types of cuticular scales were identified in the six different mammals under study. Based on the study of the cuticular scale pattern (Fig. A) and diameter of the hair shaft an attempt was made to identify the animal species from hair in accordance with the findings of Sarma *et al.* (2008). According to the system adopted (Kirk, 1953) for classification of scale pattern, the hair of Indian one horned rhinoceros, mithun and yak were in the same category of imbricate crenate (Fig. A). But it was found that the scales of yak was smooth and stuck to the shaft as compared to the scales of Great Indian one horned rhinoceros and mithun which protruded outward from shaft. Again, the scales of Indian one horned rhinoceros were broader as compared to the scales of mithun. Considering the height of the scales it was found that it was different in different species. In the present study it was recorded that the diameter of hair shaft (μm), medullary index and cortico medullary index of mithun and yak were 121.20±2.665, 0.861, 8.04 and 66.08±3.670, 0.895, 5.81 respectively. Whereas in one horned rhinoceros it was observed to be 173.20±1.199, 0.339 and 97.27.

In Asian elephant and barking deer the cuticular scale pattern was observed to be Imbricate, flattened. In the present study it was recorded that the diameter of hair shaft (μm), medullary index and cortico medullary index in Asian elephant and barking deer were 124.74±1.958, 0.828, 10.37 and 217.00±1.864, 0.824, 10.60 respectively. However, Yasser A. *et al.* (2018) reported that the cuticle scales were imbricate in large herbivores (buffalo, cow,

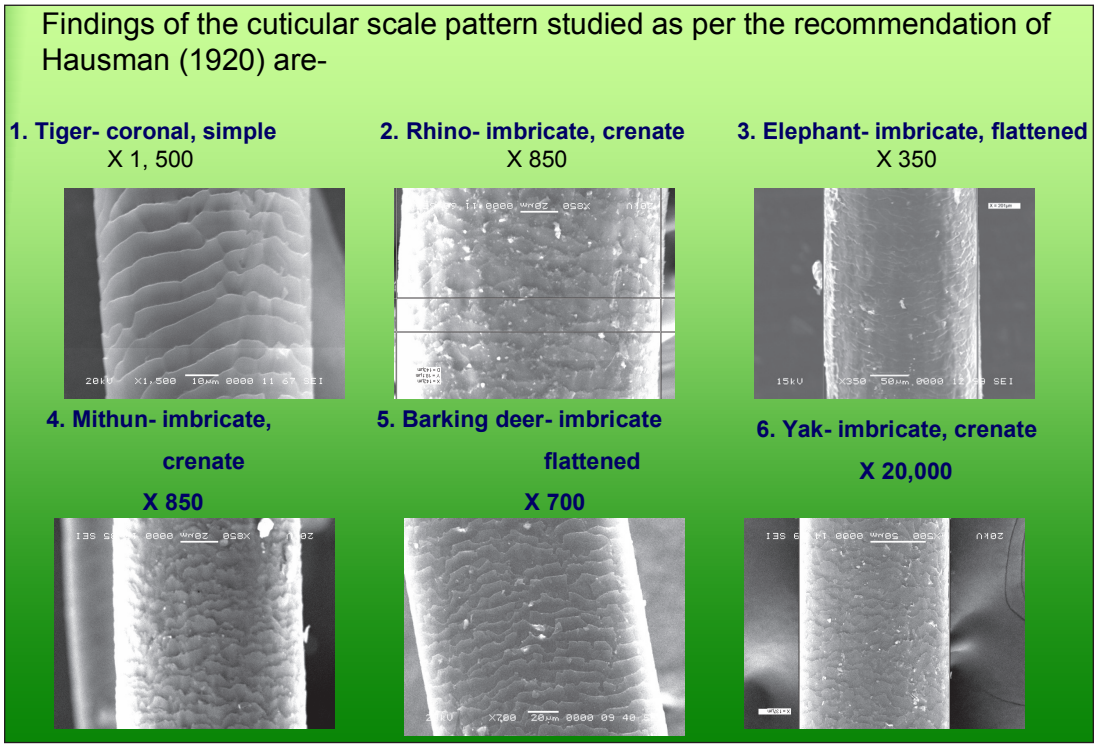


**Fig. A:** Showing the cuticular scale pattern of different mammalian species under study

camel, horse) small herbivores (sheep, goat) and carnivores (dog, cat) except in donkey, in which coronal scales were identified. They also reported that based on scale margin type, shape and distance the tested animals were clearly differentiated. In buffalo, rippled cuticle margins, close-distant, double-chevron shaped were detected. Whereas, cuticle scales with smooth margins, irregular mosaic shape, and wide distant were found in sheep. In dog, the scale margin type and distance were similar to that of sheep, but regular in shape. In cat, crenate scale margins, irregular in shape with close distances were detected. In horse and camel, the scale margin type, shape and distance were similar, appeared as crenate irregular waves with intermediate distances. In cow, the scale margins were also crenate with intermediate distances, but appeared as regular waves in shape.

In Bengal tiger, the cuticular scale pattern was observed to be coronel, simple and hair colour was brown black to white. The diameter of hair shaft (µm), medullary index and cortico medullary index in Bengal tiger was 103.80±0.417, 0.549 and 41.05. However, Yasser A. *et al.* (2018) reported that the cuticle scales were smooth margins, regular mosaic shape with wide distant in dog and in cat cuticular scale was crenate slightly serrated, close margin with continuous irregular wave.

## CONCLUSION

There are about 1800 or more different mammals species found in the world. According to Housman (1944), there are 8 (eight) different types of Cuticular Scale pattern that are found in all mammals species. Out of 1800 mammals, 225 different species of mammals will have the same type of cuticular scale pattern. In this case, study of cuticular scale alone is not sufficient for identification of animal species. However, detailed study of the micro – structure of the cuticular scales showed certain minute characters which were different from one another which helped in species identification. Besides, parameters like average diameter and colour of hair which were taken into consideration contributed in the purpose. Therefore, from the present investigation, it can be concluded that –

- Although there are 8 types of hair fibre in case of mammals, there was characteristic difference in their cuticular scale pattern.
- Average diameter of Hair shaft, medullary index and cortico-medullary index of hair


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shaft played an important role in species identification.

- Hair colour gave first-hand information regarding its species.

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