Forensic Characterization of Hair in Spotted Deer (*Axis axis*)

Abinaya, S.*, S.Jayachitra, S.Sivagnanam, M.Veeraselvam, T.A.Kannan, N.Hemavathi and C.Kavena

Department of Veterinary Anatomy, Veterinary College and Research Institute, TANUVAS, Orathanadu - 614 625

**Email: abivsa0407@gmail.com*

Received: November 2025 24/25 Accepted: December 2025

ABSTRACT

To facilitate precise forensic species identification of spotted deer through hair is undertaken. The gross and microanatomy of hair with ultrastructural details were observed and interpreted in this study. The hairs of spotted deer showed a banded pattern of alternating black and brown colour. The surface view of the hair was made up of cuticle, cortex and medulla from without inwards. A regular wave pattern with a smooth margin was a predominant cuticular scale pattern present in different parts of hair. A characteristic multiseriate lattice-type medulla was observed in the middle part of the hair. In the cross-section, the hair shaft was oval in shape. Micrometry of the hairs in the head, trunk and tail regions was recorded and compared.

Keywords: Spotted deer, Forensic anatomy, Micrometry, Ultrastructure

INTRODUCTION

Forensic veterinary anatomy has emerged as an interdisciplinary and evolving domain that underscores the indispensable collaboration among anatomists, forensic educators, investigators and scientists. The accurate identification of animal species from biological evidence constitutes the cornerstone of wildlife forensic investigations (Charjan *et al.,* 2019). Among various biological materials, mammalian hair has proven to be a particularly valuable diagnostic tool in species determination. For instance, the spotted deer, a species now recognized as endangered, enjoys statutory protection under the Indian Wildlife Act, 1972 (Sheela *et al.,* 2022).

MATERIALS AND METHODS

Hair samples from six spotted deer at Arignar Anna Zoological Park, Vandalur, were obtained from the head, trunk and tail region after grooming with approval of the Principal Chief Conservator of Forests and Chief Wildlife Warden. Gross features were observed without processing the hair samples. For microanatomical study, the hair samples were washed thoroughly, treated with 70 % alcohol for 30 minutes and xylene for 15 minutes and divided into proximal, middle and distal parts for light microscopic examination (Sheela *et al.,* 2022). Cross sections were made by embedding the hair tufts in paraffin wax at 58^0 C. Cuticular scale pattern was studied by the cast method (Sallawad and Sahu, 2017) and the middle part of hair from the trunk region was sputter-coated with palladium and observed under Vega Tescan scanning electron microscope for ultrastructure (Kaur *et al*., 2021).

RESULTS AND DISCUSSION

The hair was made up of root, shaft and tip in all the collected hairs as reported by Sarma *et al.* (2021) in wild and semi-wild mammals. The hair colour was observed as a banded pattern with alternate black and brown as noted by Lungu *et al.* (2007) in deer, whereas it was plain and monocoloured in the hairs of other animals. The surface view of hair showed three distinct layers *viz.,* cuticle, cortex and

medulla from without inwards. The cuticle was seen as the outermost layer of hair, and it was made up of flat, transparent keratinized cells. The cortex formed almost the entire hair shaft in the proximal part of the hair. The medulla started to appear from the upper portion of the proximal part as scattered fragments and became continuous as it moved upwards, and started disappearing towards the tip of the hair. The middle portion of the hair is composed of a distinct cortex and continuous medulla. The medullary portion gradually reduced, tapered, and was almost absent at the tip. The medulla started to appear from the proximal part of the hair as small-sized fragments, and its diameter gradually increased towards the middle part of hair. Afterwards, its diameter reduced towards the distal part, became fragmented, and it was completely absent at the tip of the hair. As per Sheela *et al*. (2022), a wide multiseriate lattice-type medulla was seen in the middle part, which gave honey comb like appearance (Figures 1 and 2). Contrary to this, Charjan (2020) observed the same type of medulla in all three parts of the hair in the head region. The medulla began as a wide triangle with fragments in the proximal part of the hair and ended in a narrow-pointed triangle in the distal part of the hair. In contrast, Charjan (2020) observed a wine glass-shaped medulla in the proximal part of the hair. The medullary margins were scalloped, as mentioned by Sheela *et al*. (2022) in Indian spotted deer. A similar type of medullary margin was observed in the goat by Marinis and Asprea (2005). An oval-shaped structure of hair was observed in cross-section (Figure 3) (Sheela *et al.,* 2022). The findings of the cuticular scale pattern were in accordance with Desai *et al.* (2019), who observed a regular wave pattern in the proximal and middle parts of hair in spotted deer, but the distal part of hair showed a single chevron pattern (Fig 4). In the goat, the distal part of the hair showed a single chevron pattern (Desai *et al.,* 2019). In some hairs, the middle part also showed mixed regular wave and chevron scale patterns. Desai *et al.* (2019) noted that the scale margin was smooth in proximal, crenate in distal and mixed smooth and crenate in the middle part of hair (Figure 4). Joshi *et al.* 2012 in spotted deer also observed a smooth margin in the proximal and middle part, whereas a crenate margin in the distal part of the hair. The scale distance was distant in the proximal part, nearest in the middle part and closest in the distal part. In contrast, Desai *et al.* (2019) observed a near distance in the proximal and middle parts,

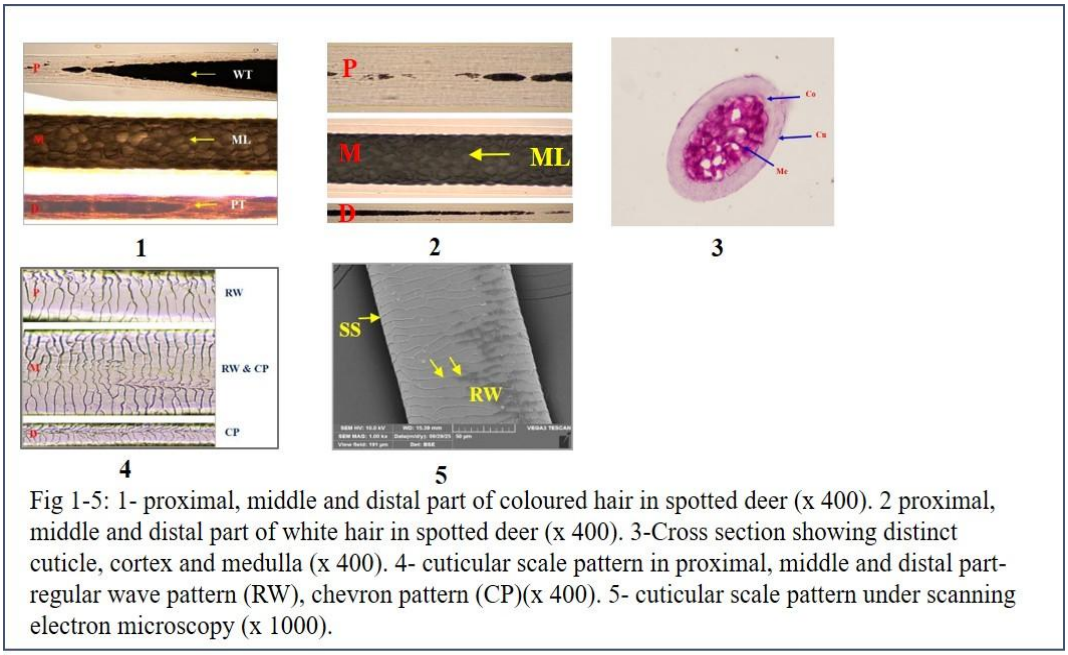

Fig 1-5: 1- proximal, middle and distal part of coloured hair in spotted deer (x 400). 2 proximal, middle and distal part of white hair in spotted deer (x 400). 3-Cross section showing distinct cuticle, cortex and medulla (x 400). 4- cuticular scale pattern in proximal, middle and distal part- regular wave pattern (RW), chevron pattern (CP)(x 400). 5- cuticular scale pattern under scanning electron microscopy (x 1000).

distance in the distal parts of hair. Under scanning electron microscopy, the scales were smooth with a regular wave pattern and distantly placed successive scales in the middle part of the hair (Figure 5). These findings were in accordance with Charjan (2020), who noted a similar pattern in the proximal part of hair. The average diameter of hair shaft, cortex and medulla were in the range of 51.86 - 126.57 µm, 49.48 - 122.74 µm and 28.96 - 98.75 µm, respectively (Table I). The range of average hair shaft thickness and medullary thickness of spotted deer was matched with the findings of Sheela *et al.* (2022).

Diameter	Part of hair	Head	Trunk	Tail
Hair shaft	Proximal (µm)	78.94 ± 1.42^{a}	89.14 ± 6.56^{ab}	93.89 ± 1.82^{b}
	Middle (µm)	108.52 ± 1.81^{a}	120.76 ± 2.46^{b}	126.57 ± 0.71^{c}
	Distal (µm)	51.86 ± 1.45^{a}	55.00 ± 6.63^{a}	59.51 ± 0.68^{a}
Cortex	Proximal (µm)	76.20 ± 1.16^{a}	84.10 ± 7.59^{ab}	91.66 ± 1.82^{b}
	Middle (µm)	105.79 ± 1.82^{a}	116.99 ± 2.99^{b}	122.74 ± 0.92^{b}
	Distal (µm)	50.60 ± 1.22^{a}	49.48 ± 6.47^{a}	57.47 ± 1.12^{a}
Medulla	Proximal (µm)	45.30 ± 2.84^{a}	46.21 ± 9.77^{a}	57.60 ± 0.89^{a}
	Middle (µm)	75.03 ± 1.19^{a}	90.18 ± 3.62^{b}	98.75 ± 3.04^{c}
	Distal (µm)	38.36 ± 2.57^{ab}	28.96 ± 5.21^{a}	49.40 ± 4.07^{b}

Table I: Means ± SE of diameter of hair shaft, cortex and medulla in head, trunk and tail region; Means ± SE bearing different superscripts between columns differ significantly ($p < 0.05$)

SUMMARY

The present study analysed the gross morphological features, microanatomical structure and ultrastructural details of hair in spotted deer which enabled reliable species identification. In forensic examination of hair, this reference database provides a validated source for identifying the unknown hair sample.

REFERENCES

Charjan, R., N.C.Nandeshwar, S.B.Banubakode, N.V.Kurkure and S.W.Bonde (2019), Cuticular and Medullary Structure of Some Wild Herbivores of India, *Ind. J. Vet. Sci. and Biotech.*, **15**(1): 14-16.

Desai, B.S.P., A.H.D'costa and S.K.Shyama (2019), A comparative analysis of hair morphology of wild and domestic ungulate prey species of Leopard Panthera pardus fusca (Mammalia: Carnivora: Felidae) from Goa, India, *J. of Threatened Taxa,* **11**(15): 14971-14978.

Joshi, H.R., S.A.Gaikwad, M.P.S.Tomar and K.Shrivastava (2012), Comparative trichology of common wild herbivores of India, *Advances in Applied Science Research*, **3**(6): 3455-3458.

Kaur, G., K.Kaur, S.Harith and C.Deka (2021), Review on forensic analysis of hair by scanning electron microscope in domestic and wild animals, *J. of Sci. and Tech.*, **6**(5): 1-6.

Lungu, A.N.C.A., Recordati, C.A.M.I.L.L.A.Ferrazzi and D.Gallazzi (2007), Image analysis of animal hair: morphological features useful in forensic veterinary medicine, *Lucrari stintifice medicina veterinara,* **40**: 439-446.

Sallawad, S. and M.Sahu (2017), Species Identification through Morphological Features of Animal Hair-A Method for Species Identification in Wildlife Forensic Cases, *Int. J. Multidiscip. Res. Mod. Educ.*, **3**(5): 130-132.

Sarma, M., K.B.Choudhury, A.Singson, J.Ahmed and N.Sarma (2021), Hair Histology and Ultrastructure of Few Wild and Semi-Wild Mammals: A Forensic Approach, *Indian J. of Vet. Sci. & Biotechnology.*, **17**(4): 1.

Vinaya Sheela, S., G.Purushotham, D.P.Kumar and M.Lakshman (2022), Anatomical structure of hair shaft of Indian spotted deer (Axis axis), *The Pharma Innovation*, **11**(8): 473-476.