

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(3): 342-346
www.biochemjournal.com
Received: 11-12-2025
Accepted: 13-01-2026

Pushpendra Rawat

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

SK Gupta

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

Yogita Pandey

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

Alka Suman

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

VS Kushwah

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

Corresponding Author:

SK Gupta

Department of Veterinary
Anatomy and Histology,
College of Veterinary Science
and A.H., MHOW, Nanaji
Deshmukh Veterinary Science
University, Jabalpur, Madhya
Pradesh, India

Trichological analysis on hair of German shepherd dog

Pushpendra Rawat, SK Gupta, Yogita Pandey, Alka Suman and VS Kushwah

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i3e.7868>

Abstract

For species identification the macro and microanatomical study conducted on the guard hair of German shepherd dog, these hair samples were collected by the combing method from back, neck, umbilical and tail regions. To know the macro-anatomical features of hair, the colour, shape and band pattern of the guard hair were recorded. For assessment of cuticular scale pattern of hair, on a clean glass slide cuticular impressions were prepared and examined under the light microscope to know the detailed structure of hair cuticle. For medullary configuration study each hair sample was cleaned with detergent and cleared with xylene then mounted on microscopic slide in a drop of DPX for light microscopic observations. After preparation of histological slides of hair the numerical measurements of cortex and medulla width were taken using an ocular micrometer in micron. For scanning electron microscopic examination, the hair sample was fixed in 3% glutaraldehyde for detailed hair cuticular observations. In German shepherd dogs the colour, shape and band patterns were different in different body regions, while the hair of all body regions was flat. Under microscope it was seen that the hair was made up of cuticle (outermost), cortex (middle) and medulla (central core). The cuticular scales were in the form of regular waves in all body regions. Scale margins were smooth in back, neck and umbilical regions and rippled in tail region. The medulla of hair in all body regions of present study was continuous and vacuolated. The medullary composition was unicellular with a typical cloisonne pattern with single ladder shaped structure in all body regions. The margins of the medulla were smooth and scalloped type. The average medullary index of hair was 0.42 which varied from 0.33 to 0.52.

Keywords: Cuticle, dog, German shepherd, hair, medulla, trichological

1. Introduction

Hair is the mammalian epidermal exoskeleton and having distinctive specialized anatomical structure. The hair consists of cells which are placed in three concentric layers viz. cuticle (outermost), cortex (middle) and medulla (central core). The hair configuration varies in different species, and this can be used to identify a particular species by implementing various methods of hair analysis. The hair morphology is useful for species identification as. Hairs normally fall from the body over the course of a period. These stick to various materials especially fabric, clothing, etc. and remain for a longer period of time without putrefaction. By a single morphological feature, the identification of hair may not be always sufficient as a reliable proof for that species hence for the proper identification of hair material a series of tests is required which includes study on cuticular pattern, medullary configuration, medullary indices and application of advanced equipment like scanning and transmission electron microscope. Hence the present study aim is using gross, light and scanning electron microscopy to obtain some features of hair samples obtained from different body regions of German shepherd dog to explore the possibility of identification of this breed of dog.

2. Materials and Methods

The study on guard hairs of German shepherd dogs was performed in the Department of Anatomy, Veterinary College, Mhow, NDVSU, Jabalpur (M.P.). For present study six guard hairs from each body region (back, neck, umbilical and tail regions) from six adult and apparently healthy German shepherd breed of dog irrespective of sex were collected from the Veterinary Clinical Complex of the College and nearby private clinics of Indore region.

For gross anatomical study the colour, shape and band pattern of the hair sample was examined with naked eye. The shape of the hair was felt by putting the hair between thumb and index finger.

For cuticular scale pattern observation, on a clean glass slide using thin gelatin the cuticular impressions were prepared and examined under the light microscope to know the detailed structure of hair cuticle of animals. To know the medullary structure of the hair, the hair sample was cleaned with detergent and cleared with xylene then it was put on microscopic slide and examined under light microscopic. The measurement of cortex and medulla in micron were recorded by using an ocular micrometer in a histologically prepared slide. For scanning electron microscopic examination, the hair sample was fixed in 3% glutaraldehyde for detailed hair cuticular observations at IIT Indore (M.P.).

3. Results and Discussion

Histologically, from outer to inner side the hair was made up of three layers. The outer layer was the keratinized cuticle, middle layer was the cortex, and the inner layer was the medulla. The gross, microscopic, micrometrical and scanning electron study present on guard hair of German shepherd dog was done with an aim of species and breed identification.

Grossly, the colour, shape and band pattern of hair was examined by naked eye. There were huge variations in colour, band pattern and hair profile from region to region in the same individual species. So, these features could not be considered as an important tool for species identification. The same was mentioned by Sarkar *et al.* (2011) [9].

In present study, in dog variation in colour was noted amongst all the body regions as per the breeds of the animals. The same was reported by Vaishnav *et al.* (2021) [12] when they studied different Canidae breeds. In German shepherd hair of back, neck and tail regions showed black and brown colour, while the umbilical region had light brown and white coloured hair. Vaishnav *et al.* (2021) [12] reported black and tan coloured hair in dorsal portion of the German shepherd dogs and white coloured hair in dorsal portion of the labrador dogs.

The hair found in different body regions were of variable length and texture. The texture of hair varied from fine to coarse. Shape of hair was identical by feeling the hair between thumb and index finger and it was same in all regions. In present study, the hairs of German shepherd dogs were flat in all body regions. The flat configuration of hairs in sambar and black deer and cylindrical configuration in the hair of deer and Nilgai was reported by Kushwah (2024) [6] reported. In German shepherd band pattern was seen in the hair of back and umbilical regions. Similarly, Kushwah (2024) [6] reported band pattern in the hair of tail region of sambar and back region of deer.

4. Cuticular Scale Pattern

In German shepherd dog, cuticular scales of hair in all body regions (back, neck, umbilical and tail) of present study were positioned transversely. These cuticular scales were arranged in the form of imbricate pattern with regular waves in back, neck umbilical and tail regions and these were placed nearly in all body regions (Figs 1, 2, 3 and 4). Similarly, Yasser *et al.* (2018) [14] in dog reported that the cuticle show regular scale patterns. Whereas Vaishnav *et al.*

(2021) [12] in dog reported that the cuticle consists of both the regular and irregular wave patterns. Ahmed *et al.* (2018) [1] and Bhosale *et al.* (2019) [2] in dog reported that the cuticle scales were imbricated. Gharu and Trivedi (2014) [4] in leopard and Yadav *et al.* (2018) [13] in panther reported that the cuticle shows regular wave patterns. Yadav *et al.* (2018) [13] in sloth bear, hyena and lion and Yasser *et al.* (2018) [14] in Bengal tiger reported that cuticles show irregular scale patterns.

The scale margin in the hair of German shepherd dog was smooth in back, neck and umbilical regions but rippled in tail region (Figs 1, 2, 3 and 4). Smooth margin in dogs was also reported by Ahmed *et al.* (2018) [1] and Yasser *et al.* (2018) [14]. While Bhosale *et al.* (2019) [2] reported crenate margin in dogs. However, Vaishnav *et al.* (2021) [12] reported crenate, smooth and rippled margin in different breeds of dogs. Gharu and Trivedi (2014) [4] in leopard and Yadav *et al.* (2018) [13] in panther reported the smooth margin. Yadav *et al.* (2018) [13] in sloth bear and hyena reported the crenate margin. While Yadav *et al.* (2018) [13] in lion reported the rippled margin.

In all the body regions (back, neck, umbilical and tail regions) of present study in German shepherd dogs the cuticular scales were nearly placed (Figs 1, 2, 3 and 4). However, Ahmed *et al.* (2018) [1] and Sarma *et al.* (2021) [10] reported wide cuticular distance. In present study of all body regions, the numbers of scales per row was 1 to 2. Bhosale *et al.* (2019) [2] reported that maximum number of scale count in dog hair was 1.

5. Medullary Pattern of Hair

In all body regions of present study, the medulla was absent at the tip of the hair and it tapered from the proximal part of hair towards the tip. The medulla was made up of closely packed and shrunken cells. In agreement with the findings of Krause and Cults (1975) [5] these cells and the air-filled spaces between the intercellular connections, were responsible for the specific characteristic of the medulla.

The medulla of hair in all body regions (back, neck, umbilical and tail) in present study was continuous and vacuolated. The medullary composition was unicellular with a typical cloisonné pattern with single ladder shaped structure in all body regions (Figs 5, 6, 7 and 8). Ahmed *et al.* (2018) [1] in dog reported that medulla was continuous and occupying approximately half of the hair shaft along with vacuolated structure. Senthilkumar *et al.* (2018) [11] in dog reported that the medulla was not prominent structure. Mukherjee *et al.* (2016) [7] in dog reported that the medulla has vacuolated pattern. Vaishnav *et al.* (2021) [12] observed that in dogs the medulla was unbroken, broken, ladder and miscellaneous pattern type.

The margins of the medulla in all body regions were smooth and scalloped type (Figs 5, 6, 7 and 8). Similar to present findings, the smooth margins in dogs were also reported by Ahmed *et al.* (2018) [1]. Vaishnav *et al.* (2021) [12] in dog observe that the medullary margin was straight, fringed, and scalloped.

6. Micrometrical Observations

The diameter of the hair was variable throughout the length, it was maximum and nearly symmetrical at the middle portion of the shaft; therefore in this portion the diameter/width of the hair was measured. The medullary index of the hair was obtained by using the formula. In present study the

average medullary index of hair was 0.42, which varied from 0.33 to 0.52.

The average length and width of the hair in back, neck, umbilical and tail regions were 71.23 ± 0.38 mm & 52.67 ± 2.87 μ m; 67.52 ± 0.26 mm & 77.11 ± 4.22 μ m; 85.53 ± 0.18 mm & 73.68 ± 4.77 μ m and 96.82 ± 0.37 mm & 57.87 ± 4.00 μ m, respectively. Similarly, Senthil Kumar *et al.* (2018) [11] reported hair width in scapular region, lumbar region and croup region as 96.21 ± 0.32 μ m, 94.36 ± 1.11 μ m and 88.81 ± 0.98 μ m in dog. However, Derunov *et al.* (2021) [3] reported that the hair width in the hair of head, neck, blade, back, stomach, tail and paw region of dog was 63.51 ± 0.41 μ m, 63.01 ± 0.35 μ m, 64.76 ± 0.26 μ m, 70.33 ± 0.29 μ m, 112.23 ± 0.19 μ m, 99.64 ± 0.17 μ m, 104.47 ± 0.19 μ m, respectively. Yadav *et al.* (2018) [13] reported that the hair width in hyena, lion and panther was 14.11 ± 1.67 μ m, 15.69 ± 2.87 μ m and 10.81 ± 0.96 μ m, respectively.

Average thickness of one side cortex and diameter of medulla in the hair of back, neck, umbilical, and tail regions were 13.96 ± 0.76 μ m & 24.75 ± 1.35 μ m; 18.51 ± 1.02 μ m & 40.09 ± 2.19 μ m; 24.31 ± 1.43 μ m & 25.05 ± 1.62 μ m; 19.39 ± 1.34 μ m & 19.09 ± 1.32 μ m, respectively. Derunov *et al.* (2021) [3] reported that the thickness of one side cortex and diameter of medulla in the hair of head, neck, blade, back, stomach, tail and paw region of dog was 9.58 μ m & 46.44 μ m, 8.78 μ m & 49.67 , 7.26 μ m & 54.26 μ m, 8.19 μ m & 55.53 μ m, 9.51 μ m & 95.79 μ m, 7.4 μ m & 86.67 μ m and 8.20 μ m & 84.21 μ m, respectively.

In the hair of German shepherd the average medullary index was 0.42, which varied from 0.33 to 0.52 in different body regions. It was 0.47, 0.52, 0.34 and 0.33 in back, neck, umbilical and tail regions, respectively. However, Derunov *et al.* (2021) [3] reported that the medullary index in the hair of head, neck, blade, back, stomach, tail and paw region of dog was 0.73, 0.78, 0.83, 0.78, 0.85, 0.86, 0.80, respectively.

Scanning electron microscopic examination of the guard hair collected from different body regions was done at the middle part of the hair and the scale pattern was observed at 500X, 1000X, 2500X, 5000X magnification under scanning electron microscope. One scanning electron microscopic observation is found that the cuticular scales of guard hair were directed towards the tip or distal part of the hair shaft and showed free cuticular scale margins. The same was reported in porcupine by Rajaram and Menon (1986) [8].

In German shepherd dog the cuticular scale of hair in all body regions (back, neck, umbilical and tail) were positioned transversely. These cuticular scales were arranged in the form of irregular waves in back, neck umbilical and tail regions. Free surface was thick and slightly convex in back region, but in neck and umbilical region it was thin and straight to slightly convex. In tail region free surface was thin, convex and had many small projections (Figs 100, 101, 102, 103, 104, 105, 106 and 107).

Number of scales per row was 1 to 2 in back, neck, umbilical, and tail regions (Figs 9, 10, 11, 12, 13, 14, 15 and 16). Bhosale *et al.* (2019) [2] reported that dog hair has maximum 1 number of scale count. The maximum distance between two scales in back, neck, umbilical and tail region was 9.80 ± 0.03 μ m, 9.80 ± 0.03 μ m, 9.20 ± 0.04 μ m and 9.70 ± 0.04 μ m, respectively. The width of the scale in back, neck, umbilical and tail region was 35.11 ± 3.01 μ m, $51.40 \pm$

2.97 μ m, 49.12 ± 3.03 μ m and 38.58 ± 2.88 μ m, respectively, (Figs 9, 10, 11, 12, 13, 14, 15 and 16).

It is concluded that in German shepherd dogs, the colour, shape and band pattern of hair was variable in different body regions. These were flat in all body regions. While the cuticular pattern was regular with smooth scale margin in all body regions. The medullary configuration was continuous type with scalloped margin and unicellular cloisonne pattern in all body regions of present study.

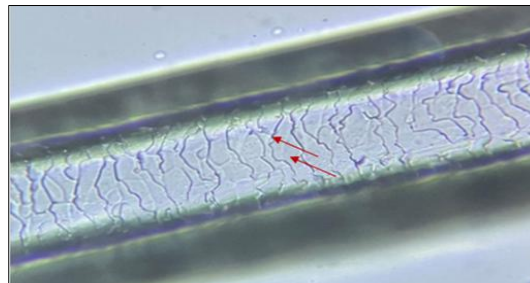


Fig 1: Cuticular scale patterns in hair of back region in German shepherd dog showing transversal scales in regular wavy pattern with smooth margin (X 400)

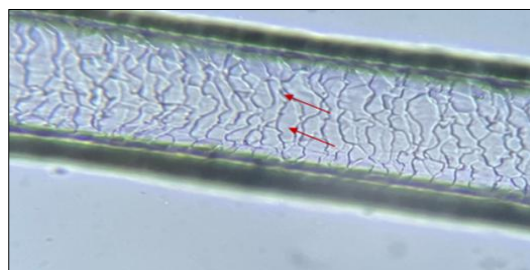


Fig 2: Cuticular scale patterns in hair of neck region in German shepherd dog showing transversal scales in regular wavy pattern with smooth margin (X 400)

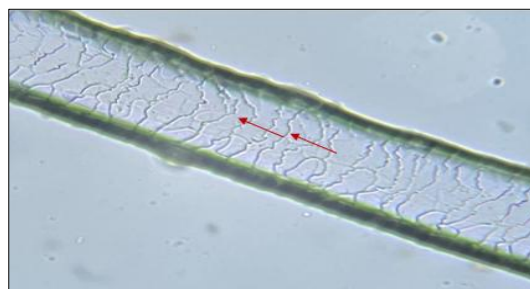


Fig 3: Cuticular scale patterns in hair of umbilical region in German shepherd dog showing transversal scales in regular wavy pattern with smooth margin (X 400)



Fig 4: Cuticular scale patterns in hair of tail region in German shepherd dog showing transversal scales in regular wavy pattern with rippled margin (X 400)

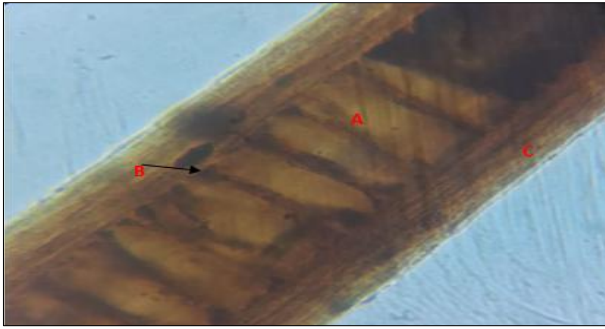


Fig 5: Hair of back region of German shepherd dog showing Medulla having cloisonne pattern
Scalloped margin
Thick cortex (X 1000)

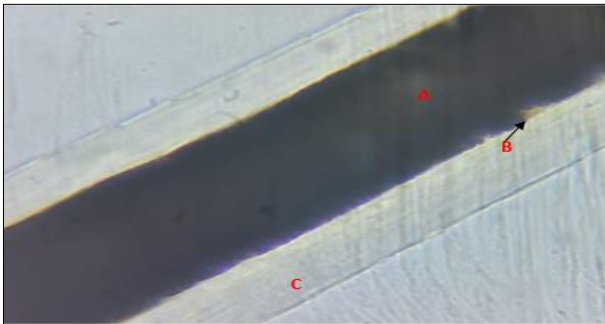


Fig 6: Hair of neck region of German shepherd dog showing Medulla having cloisonne pattern
Scalloped margin
Thick cortex (X 1000)

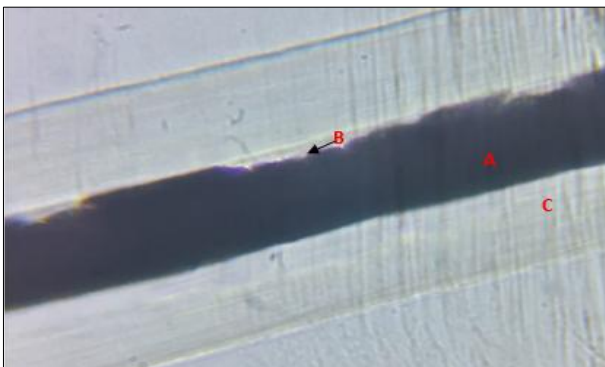


Fig 7: Hair of umbilical region of German shepherd dog showing Medulla having cloisonne pattern
Scalloped margin
Very Thick cortex (X 1000)

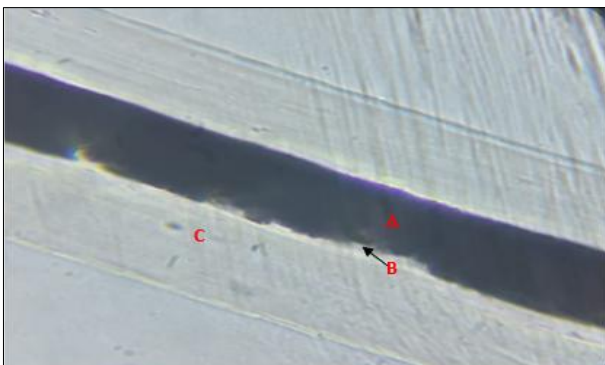


Fig 8: Hair of tail region of German shepherd dog showing Medulla having cloisonne pattern
Scalloped margin
Very Thick cortex (X 1000)

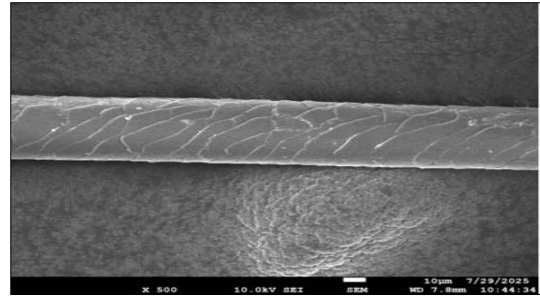


Fig 9: Cuticular scale patterns of hair in back region of German shepherd dog under SEM at X 500

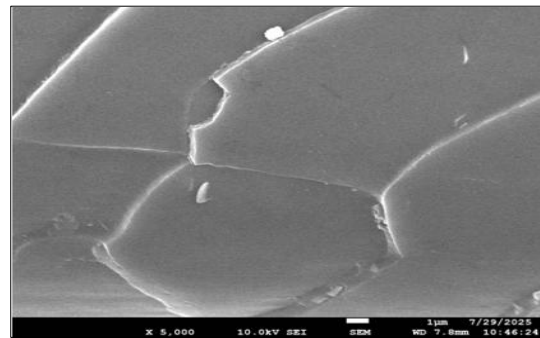


Fig 10: Cuticular scale patterns of hair in region of German shepherd dog under SEM at X 5000

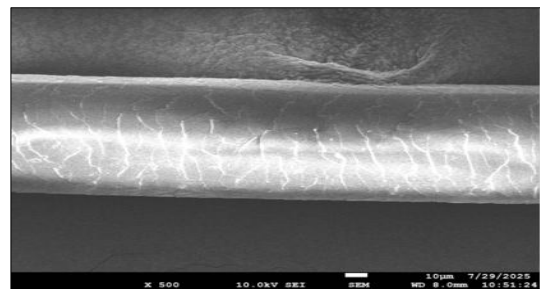


Fig 11: Cuticular scale patterns of hair in neck region of German shepherd dog under SEM at X 500

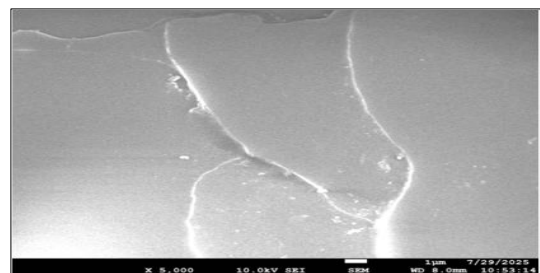


Fig 12: Cuticular scale patterns of hair in neck region of German shepherd dog under SEM at X 5000

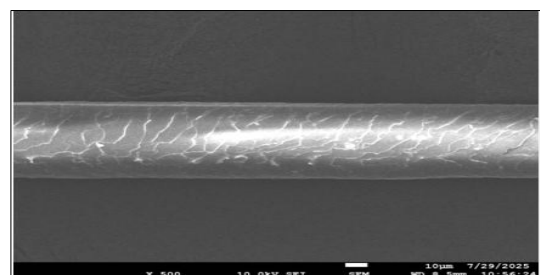


Fig 13: Cuticular scale patterns of hair in umbilical region of German shepherd dog under SEM at X 500

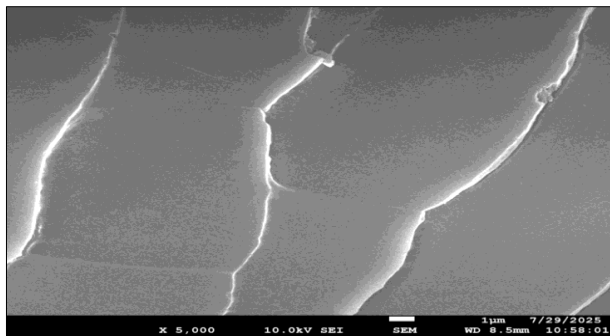


Fig 14: Cuticular scale patterns of hair in umbilical region of German shepherd dog under SEM at x 5000

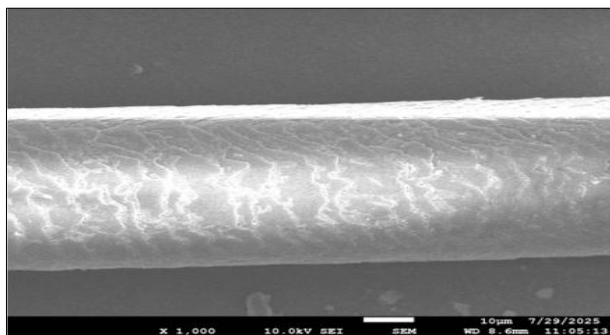


Fig 15: Cuticular scale patterns of hair in tail region of German shepherd dog under SEM at X 1000

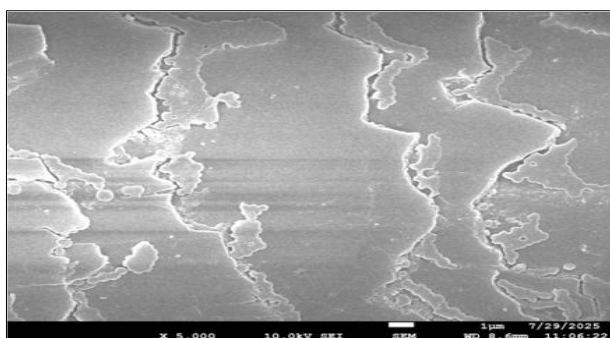


Fig 16: Cuticular scale patterns of hair in tail region of German shepherd dog under SEM at X 5000

References

1. Ahmed YA, Ali S, Ghallab A. Hair histology as a tool for forensic identification of some domestic animal species. *Experimental and Clinical Science Journal*. 2018;17:663-670.
2. Bhosale MS, Nanhe BV, Sheth DD. SEM studies of some animal hairs with reference to scale pattern and scale count. *Journal of Emerging Technologies and Innovative Research*. 2019;6(6):783-787.
3. Derunov D, Chasovskih O, Sukhih O, Buldakova K, Kokorina A. Comparative analysis of wild and domestic animals hair species. *IOP Conference Series: Earth and Environmental Science*. 2021;677(4):042007. doi:10.1088/1755-1315/677/4/042007.
4. Gharu J, Trivedi S. Cuticle scale patterns, medulla and pigment in hairs of some carnivores. *Journal of Chemical, Biological and Physical Sciences*. 2014;5(1):538-544.
5. Krause WJ, Cutts JH. *Essentials of Histology*. 1976. p. 405-407.
6. Kushwah V. Comparative trichological analysis on shed hair of wild animals from Indore Zoo. Jabalpur: Nanaji Deshmukh Veterinary Science University; 2024.
7. Mukherjee P, Pasi C, Patel S, Dhurwey S. Comparative trichological analysis of common domestic mammals of Jabalpur district. *International Journal of Advance Research in Biological Sciences*. 2016;3(2):93-98.
8. Rajaram A, Menon RK. Scanning electron microscope study of the hair keratins of some animals of the Indian subcontinent: a preliminary report. *Journal of the Bombay Natural History Society*. 1986;83:427-429.
9. Sarkar PS, De JK, Manna CK. Identification of dorsal guard hairs of five species of the family Cercopithecidae (Primates: Mammalia). *Current Science*. 2011;100(10):1725-1728.
10. Sarma M, Choudhury KB, Singson A, Ahmed J, Sarma N. Hair histology and ultrastructure of few wild and semi-wild mammals: a forensic approach. *Indian Journal of Veterinary Sciences and Biotechnology*. 2021;17(4):66-69.
11. Senthilkumar S, Gnanadevi R, Kannan TA, Arunaman CS, Ramesh G. Microanatomical observations of hair in domestic animals: a comparative study. *Journal of Entomology and Zoology Studies*. 2018;6:1925-1925.
12. Vaishnav L, Parashar S, Kumar A, Sachdeva MP. A study on hair analysis of different Canidae breeds. *Forensic Science International Reports*. 2021;3:100169.
13. Yadav MM, Srivastava A, Nigam K, Yadav VK. Comparative analysis of wild animal hairs. *Global Journal of Engineering Science and Researches*. 2018;5(11):239-245.
14. Yasser AA, Safwat A, Ahmed G. Hair histology as a tool for forensic identification of some domestic animal species. *Experimental and Clinical Science Journal*. 2018;17:663-670.