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COMMUNICATION

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CHARACTERIZATION OF DORSAL GUARD HAIR OF THE WILD GOATS AND SHEEP (BOVIDAE: CAPRINAE) OCCURRING IN THE HIMALAYA AND WESTERN GHATS OF INDIA

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Abstract: The morphological and microscopic characteristics of dorsal guard hair of six species of the Indian goat-antelopes are described. Although the cuticular characteristics of hair of all the six species studied are similar, the morphological, medulla and transverse section characteristics of hair are varied between the species. The hair of Indian caprines can easily be identified on the basis of their unique medulla and transverse section. The high-resolution microphotographs and key characteristics of hair are presented here and can be used as an appropriate reference for species identification of the wild goats and sheep occurring in the Himalaya and Western Ghats of India.

Keywords: Argali, Bharal, caprines, Himalayan Goral, Himalayan Serow, Himalayan Tahr, Nilgiri Tahr, morphological characteristics, microscopic characteristics, tricho-taxonomy.
INTRODUCTION

Both the morphological and microscopic characteristics of the hair are relatively significant in the study of mammalian species identification along with the diet-ecology and control of the illegal trade of wildlife or its derivatives (Stains 1958; Brunner & Coman 1974; Koppikar & Sabins 1976). The tricho-taxonomy (the study of mammalian hair) has been developed by many workers of the world (Hausman 1920; Mathiak 1938; Mayer 1952; Adorjan & Kolenosky 1969; Moore et al. 1974; Keogh 1983). In India, the tricho-taxonomic studies on different orders of class Mammalia: Carnivora (Chakraborty & De 2010), Primates (De 1993; Sarkar et al. 2011), and Rodentia (Bahuguna 2008) have been carried out; however, very meagre information is available on the species of wild goats and sheep (Indian caprines), except for a few studies by Bahuguna & Mukherjee (2011), and Rodentia (Bahuguna 2008) have been carried on; however, very meagre information is available on the species of wild goats and sheep (Indian caprines), except for a few studies by Bahuguna & Mukherjee (2000) (Tibetan Antelope), Sahajibal et al. (2010) (Capra sp.), and Kamalakannan (2018) (Takin).

As per Wilson & Reeder (2005), there are 11 species of the subfamily Caprinae under the family Bovidae distributed in the Himalaya (10 species) and Western Ghats (one species) of India, of which six species, namely Himalayan Serow Capricornis thar (Hodgson, 1831), Himalayan Tahr Hemitragus jemlahicus (C.H. Smith, 1826), Himalayan Goral Naemorhedus goral (Hardwicke, 1825), Nilgiri Tahr Nilgitragus hylocrius (Ogilby, 1838), Argali Ovis ammon (Linnaeus, 1758), and Blue Sheep Pseudois nayaur (Hodgson, 1833) are available at the National Zoological Collections of the Zoological Survey of India (ZSI), Kolkata, India, as preserved skins.

Except for Bharal, the other species of Indian caprines are the threatened as per the IUCN Red List (2018), and are listed under Schedule I (except N. goral in Schedule III) of the Indian Wildlife (Protection) Act, 1972. As per CITES (2018), C. thar and N. goral are listed under the Appendix I. The aim of the study is to give a complete morphological and microscopic of characteristics of dorsal guard hair of Indian caprines for species identification.

MATERIAL AND METHODS

The dorsal guard hairs were collected from the 4–5 identified specimens of each species housed at the National Zoological Collections of Zoological Survey of India (ZSI), Kolkata, India. The hair samples were washed thoroughly with Acetone ((CH₃)₂CO = 58.08) and Carbon tetrachloride (CCl₄ = 153.82) to remove the dirt of exogenous materials. The morphological characteristics of hair (n=20) such as colour, number of bands, shape and length were recorded using a hand lens and dial-caliper (Mitutoyo), and the diameter of hair was measured using the digital camera fitted on an optical microscope (Olympus BX41).

To study the characteristics of cuticula, the hair samples (n=20) were washed with various grades (40–90 %) of acetone; the processed hairs were chopped into small pieces, placed over the clear varnish coated-microscopic glass slide; after 2–3 hours, the dried hairs were dragged gently with a fine forceps for leaving the imprint or casts of scales over the microscopic glass slide.

To study the characteristics of medulla, the processed hairs (n=20) were chopped into small pieces and whole mounted over the microscopic glass slide with the help of D.P.X. To study the shape of transverse section, a simple hand sectioning (slicing) method was done and the slicing samples (n=20) were whole mounted over the microscopic glass slide with the help of D.P.X.

The cuticular scale characteristics of hair such as scale position, scale patterns, structure of scale margins and distance between scale margins; the medullary characteristics of hair such as width composition, structure and form of margins of the medulla and the shape of transverse section of hair was examined under 400x magnification with the help of the digital camera fitted an optical microscope (Olympus BX41) and the observed microscopic characteristics of hair were photographed. The measurement values include minimum, maximum, average and standard deviation records.

The methods and nomenclature of morphological, cuticular, medullary and transverse sectional characteristics of hair were followed according to the descriptions provided by Brunner & Coman (1974) and Teerink (1991) and the nomenclature of colour of hair was followed as per Ridgway (1886).

RESULTS AND DISCUSSION

Morphological characteristics of hair (Table 1)

The colour of the coat and individual hair of the six species had shown different shades of brown, black and grey. Among the six species, the hair of C. thar, H. jemlahicus and N. goral was observed as bicoloured with two bands, whereas N. hylocrius, O. ammon, and P. nayaur were observed as unicoloured and unbanded. The pelage of H. jemlahicus and N. hylocrius adults are sexually dimorphic thus, male and female have distinct
coat colour (Menon 2014). The shape of the hair of all the six species was observed also slightly different: *H. jemlahicus*, *N. hylocrius*, *O. ammon*, and *P. nayaur* were undulated whereas *C. thar* and *N. goral* were slightly wavy. The average length of hair of six species was ranged from 27.3mm to 42.2mm, the maximum length of hair was observed in *P. nayaur* (42.2±7.9 mm) and minimum in *N. hylocrius* (27.3±7.7 mm). The diameter of hair varied greatly from 182.7±79.1 µm as a maximum in *O. ammon* and 62.3±12.5 µm as a minimum in *H. jemlahicus*.

The specific morphological characteristics of hair (Table 1) preliminarily distinguish the six species studied. Teerink (1991) reported that the straight and undulated types of hair are one of the features of hair of bovids and according to Kopplik & Sabins (1976) and De & Chakraborty (2013), the species of the family Bovidae may be identified by their combination of physical and microscopic characteristics of hair.

**Cuticular scale characteristics of hair (Table 2; Image 1–6a)**

Among the six caprine species, the cuticular scale characteristics show no variations among the species and were observed as the scale position - ‘transversal’, scale patterns - ‘regular wave’, structure of scale margins - ‘smooth’ (‘rippled’ in *N. goral*) and the distance between scale margins - ‘near’. The measurement values of cuticular scales of hair show great variations between the species, average scale count per millimetre length of hair were observed as maximum in *N. hylocrius* (276.5±20.1 µm) and minimum in *P. nayaur* (113.6±23.2 µm). The average length of scale of hair vary greatly from 137.1±2.1 µm as a maximum in *O. ammon* and 55.2±3.2
µm as a minimum in *C. thar*. Similarly, the maximum and minimum scale width of hair range was recorded in *O. ammon* (17.1±3.2 µm) and *C. thar* (7.4±1.5 µm), respectively.

Although the cuticular scale characteristics are almost similar in all the six species studied, the measurement values can be considered for species identification. According to Chakraborty & De (2010) the cuticular scale values along with the other combination of characteristics of hair should be taken for species identification, if the cuticular scale characteristics of hair are same between the species.

### Medullary characteristics of hair (Table 2; Image 1–6b)

The medullary characteristics of hair show substantial variations among all the six species studied. The composition of the medulla was observed as ‘multicellular in rows’ in all species except in *C. thar* (‘unicellular regular’). The structure of the medulla is ‘wide medulla lattice’ in *H. jemlahicus*, *O. ammon* and *P. nayaur*, ‘simple’ in *C. thar*, ‘wide aeriform lattice’ in *N. goral*, and ‘reversed cloisonné’ in *N. hylocrius*. The form of the medulla margins observed as ‘straight’ in all species except in *N. hylocrius* (‘scalloped’). The average width of the medulla also varies considerably from 120.8±2.1 µm as a maximum in *P. nayaur* and 42.5±1.6 µm as a minimum in *N. hylocrius*. The medulla of hair of the six species illustrate the different characteristics for identification of the species.

### Transverse section of hair (Table 3; Image 1–6c)

The shape of the transverse section of hair shows variations among all the six species studied and was observed as an ‘oval’ shape in *C. thar* and *N. goral*, ‘circular’ in *P. nayaur*, ‘biconvex’ in *N. hylocrius* and *O. ammon*, and ‘dumb-bell’ in *H. jemlahicus*. The transverse section of hair of *O. ammon* (‘biconvex’) and *P. nayaur* (‘circular’) only determines the species identity among the six species in particular, as other characteristics are similar between the species. Dharaiya & Soni (2012) found in their study that the shape of the transverse section is one of the important characteristics for hair identification of the species.

### Key characteristics of hair to identify the species

Apart from the morphological characteristics and
Table 2. Cuticular scale characteristics of dorsal guard hairs of the Indian caprines.

<table>
<thead>
<tr>
<th>Species</th>
<th>Scale position</th>
<th>Scale patterns</th>
<th>Structure of scale margins</th>
<th>Distance between scale margins</th>
<th>Scale count/mm length of hair</th>
<th>Length of scale (µm)</th>
<th>Width of scale (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Capricornis thar</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>164–256 (187.5±24.2)</td>
<td>50.6–58.9</td>
<td>4.1–9.7 (7.4±1.5)</td>
</tr>
<tr>
<td><em>Hemitragus jemlahicus</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>159–200 (177.2±10.4)</td>
<td>70.2–79.8</td>
<td>9.7–13.9 (10.7±2.2)</td>
</tr>
<tr>
<td><em>Naemorhedus goral</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>108–146 (127.6±11.4)</td>
<td>85.1–98.5</td>
<td>10.6–20.5 (14.9±2.8)</td>
</tr>
<tr>
<td><em>Nilgiritragus hylocrius</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>254–320 (276.5±20.1)</td>
<td>96.0–125.0</td>
<td>6.9–17.4 (12.3±3.1)</td>
</tr>
<tr>
<td><em>Ovis ammon</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>96–152 (118.5±17.6)</td>
<td>134.1–140.1</td>
<td>13.9–23.7 (17.1±3.2)</td>
</tr>
<tr>
<td><em>Pseudois nayaur</em></td>
<td>Transversal</td>
<td>Regular wave</td>
<td>Smooth</td>
<td>Near</td>
<td>87–162 (113.6±13.2)</td>
<td>81.1–95.1</td>
<td>11.1–20.3 (14.3±1.6)</td>
</tr>
</tbody>
</table>

Table 3. Medullary characteristics and shape of cross-section of dorsal guard hairs of the Indian caprines.

<table>
<thead>
<tr>
<th>Species</th>
<th>Composition of medulla</th>
<th>Structure of medulla</th>
<th>Margins of medulla</th>
<th>Width of medulla (µm)</th>
<th>Shape of transverse section</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Capricornis thar</em></td>
<td>Unicellular regular</td>
<td>Simple</td>
<td>Straight</td>
<td>98.6–116 (107.7±5.3)</td>
<td>Oval</td>
</tr>
<tr>
<td><em>Hemitragus jemlahicus</em></td>
<td>Multicellular in rows</td>
<td>Wide medulla lattice</td>
<td>Straight</td>
<td>90.2–123 (103.4±9.9)</td>
<td>Dumb-bell</td>
</tr>
<tr>
<td><em>Naemorhedus goral</em></td>
<td>Multicellular in rows</td>
<td>Wide aeriform lattice</td>
<td>Straight</td>
<td>76.1–90.1 (85.1±4.9)</td>
<td>Oval</td>
</tr>
<tr>
<td><em>Nilgiritragus hylocrius</em></td>
<td>Multicellular in rows</td>
<td>Reversed cloisonné</td>
<td>Scalloped</td>
<td>40.4–46.3 (42.5±1.6)</td>
<td>Biconvex</td>
</tr>
<tr>
<td><em>Ovis ammon</em></td>
<td>Multicellular in rows</td>
<td>Wide medulla lattice</td>
<td>Straight</td>
<td>72.3–79.5 (76.4±2.5)</td>
<td>Biconvex</td>
</tr>
<tr>
<td><em>Pseudois nayaur</em></td>
<td>Multicellular in rows</td>
<td>Wide medulla lattice</td>
<td>Straight</td>
<td>117.5–124.3 (120.8±2.1)</td>
<td>Circular</td>
</tr>
</tbody>
</table>

Table 4. Key characteristics of hair to identify the species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Key characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Capricornis thar</em></td>
<td>Composition of medulla - unicellular regular; structure of medulla - simple; transverse section - oval</td>
</tr>
<tr>
<td><em>Hemitragus jemlahicus</em></td>
<td>Structure of medulla - wide medulla lattice; transverse section - dumb-bell</td>
</tr>
<tr>
<td><em>Naemorhedus goral</em></td>
<td>Structure of scales margins - rippled; structure of medulla - wide aeriform lattice; transverse section - oval</td>
</tr>
<tr>
<td><em>Nilgiritragus hylocrius</em></td>
<td>Structure of medulla - reversed cloisonné; margins of medulla - scalloped; transverse section - biconvex</td>
</tr>
<tr>
<td><em>Ovis ammon</em></td>
<td>Transverse section - biconvex</td>
</tr>
<tr>
<td><em>Pseudois nayaur</em></td>
<td>Transverse section - circular</td>
</tr>
</tbody>
</table>

Measurement values of cuticular scale and medulla of the hair, the following important key characteristics may help to identify the species of Indian caprines correctly (Table 4).

Caprines are highly trafficked in the illegal trade after carnivores, used mainly for local bushmeat consumption, and for their skin and other derivatives (Menon & Kumar 1999). On the other hand, they are the chief prey to the large carnivores (Menon 2014). Therefore, the identification keys along with high-resolution microphotographs presented here may be used in animal forensic science as well as food-habit analysis of predator, as an appropriate reference for species identification of Indian caprines.
Dorsal guard hair of wild goats and sheep

Kamalakannan

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Articles

‘Non-protected’ primates as bushmeat, pets and pests in southeastern Democratic Republic of Congo
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— Lief Erikson Gamalo, Joselito Baril, Judeline Dimalibot, Augusto Asis, Brian Anas, Neovong Puna & Vachel Gay Paller, Pp. 13287–13294

Current data on the reproduction of Four-horned Antelope Tetracerus quadricornis in zoological parks
— Gérard Dubost, Stéphane Labes & Armelle Lutz, Pp. 13295–13303

Characterization of dorsal guard hair of the wild goats and sheep (Bovidae: Caprinae) occurring in the Himalaya and Western Ghats of India
— Manokaran Kamalakannan, Pp. 13304–13309

Rediscovery of the ‘extinct’ bee Hesperocolletes douglasi Michener, 1965 (Colletidae: Colletinae: Paracolletini) in Western Australia and first description of the female
— Juliana Pille Arnold, Mark V. Murphy, Raphael K. Didham & Terry F. Houston, Pp. 13310–13319

Butterflies of the myristica swamp forests of Shendurney Wildlife Sanctuary in the southern Western Ghats, Kerala, India
— Prabakaran Chandrika Sujitha, Gopal Prasad & Kalesh Sadasivan, Pp. 13320–13333

Pollination ecology of three ecologically valuable carpetweed herbs, Mollugo cerviana, M. nudicaulis and M. pentaphylla (Molluginaceae)
— Maddala Sulakshana & Aluri Jacob Solomon Raju, Pp. 13334–13349

Sacred groves: a traditional way of conserving plant diversity in West Midnapore District, West Bengal, India
— Uday Kumar Sen, Pp. 13350–13359

Review

Media reporting on the protected areas in Maharashtra, India: a thematic analysis
— Trupthi Narayan & Pankaj Sekhsaria, Pp. 13360–13376

Short Communications

Avian survey in tourist sites near Putao in northern Myanmar
— Alexey E. Scopin, Vladimir N. Sotnikov, Dmitry V. Skumatov & Alexey A. Sergeyev, Pp. 13377–13384

New record of Blue-eyed Eastern Spadefoot Toad Leptobrachium bompu (Amphibia: Megophryidae) from Sarpang District in Bhutan
— Jigme Tenzin & Jigme Thelthrim Wangyal, Pp. 13385–13389

New record of Low’s Flatfaced Longhorn Beetle Sarothrocera lowii White, 1846 (Coleoptera: Cerambycidae: Laminiidae: Lamini) in Nagaland, India, along with first-time descriptions of male and female genitalia
— Kolla Sreedevi, Manisha Sharma & Hemant Vasant Ghate, Pp. 13390–13394

On the rediscovery of Onychomesa susainathani, an emesine bug endemic to India (Heteroptera: Reduviidae: Emesinae)
— Hemant Vasant Ghate & Balasaheb Sarode, Pp. 13395–13401

First record of the callianassid ghost shrimp Neocallichirus jousseaumei (Nobili, 1904) (Decapoda: Axiidea) from India
— Imtiyaz Beleem, Paresh Poriya & Bharatsinh Gohil, Pp. 13402–13405

New distribution records of four species of crop wild relatives to India

Note

— Todd F. Elliott, Camille Truong, Olivier Séné & Terry W. Henkel, Pp. 13415–13418