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Histomorphological comparison of human hair among Brahmins and Domars of Uttar Pradesh

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Abstract:

Scene of crime is rich in information that reveals the nature of the criminal activity and the identities of those person involved. During the course of a criminal investigation, many types of physical evidence are encountered from the scene of crime. One of the most commonly recovered evidence is hair in different cases like sexual assault, murder, mass disaster etc. Hairs help the investigators in scrutinizing the valuable information for potential leads. Human hair has both anthropological as well as forensic identification significance. Morphological and histological characteristics of human scalp hair have found its importance for racial classification, in forensic investigations, nutritional aspects and other biological studies. Anthropologists for a long time have recognized the colour, form and texture of the human scalp hair as a criterion for racial classification. In the present study, two diverse population groups (Brahmins and Domars) of Uttar Pradesh, India were considered and 823 individual's samples were collected. In which 418 were Brahmins and 415 were Domar ranging in the age of 10 to 70. Every single hair has been examined for the thirteen different features such as hair colour, hair shaft form, hair texture, hair quantity, hair distal end characteristics, medulla distribution, hair shaft diameter, medulla diameter, medullary index, scale shape, number of scales per unit (2mm) length, scale count index, hair index for studying the range of variability that exists in terms of histomorphological characters of hair among population of Uttar Pradesh, India.

Key Words: *Human Hair, Hair Colour, Hair Shaft Form, Hair Texture, Hair Quantity, Hair Distal End Characteristics, Medulla Distribution, Hair Shaft Diameter, Medulla Diameter, Medullary Index, Scale Shape, Number of Scales Per Unit (2mm) Length, Scale Count Index, Hair Index.*

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Introduction

During the course of a criminal investigation, many types of physical evidence are encountered as Sir Edmund Locard's principle (1930) also states that "whenever two objects come into contact, a transfer of material will occur. Trace evidence that is transferred can be used to associate objects, individuals, or locations" (Scientific Working Group on Materials Analysis, 1999). With the increasing rate of crime, identification of the person is the concern of the police and the identification is entirely based on fingerprints, hair samples, birth mark, eyes, voice etc. In all evidences, hair is one of the most common found evidence in majority of crime scenes. Human hair has been of interest to anthropologists, biologists and forensic scientists for establishing the identity or studying the variation. Human hair identifications are subjective interpretations of objective criteria. The variability and distribution of the microscopic characteristics are useful in determining whether or not a questioned hair could have originated from a particular individual.

It is recognized that hair comparisons do not constitute a basis for absolute personal identification. Whereas hairs cannot be positively identified as originating from a particular individual, it is unusual to find different people having the same hair characteristics.

In spite of processing like ageing, digestion and change in environment, hair is chemically most stable than any other biological sample. The microanatomy of the hair is characterized on its histological traits such as the cuticle, medulla, cortex, pigment granules, cortical fusi and others is important in the description of hair (Joshi *et al.,* 2012). Hair analysis can indicate whether the source is human or animal, and also whether the source is a member of a particular race. It can determine if the hair has been dyed, cut in a certain way or pulled out, and where on the body it was located. In some cases, evidence of poisoning shows up in the hair. Vernon J. Gerberth, in Practical Homicide Investigation, points out that hair (and fiber) evidence is useful in helping to establish the scope of the crime scene, placing a perpetrator at a scene, connecting a suspect with a weapon, supporting witness statements, connecting crime scene areas (abduction, vehicle used, dump site). Many chemicals and biological substances that accumulate in hair can be detected and measured and makes hair samples good resource biomaterials in forensic science and physical anthropology (Chang *et al.*, 2005).

Ever since the formulation by Huxley (1865) several anthropologist (Deniker 1900, Martin 1928, Hooton 1946, Koonz 1945, Garn 1948) have used morphological traits of hair for differentiation of human races. Interest in the microscopic aspects of hair was a relatively late phenomenon (Hausman 1925, Wynkoop 1929) and population variations in this world have not drawn much emphasis (Hrdy 1973, Das- Chaudhari & Chopra 1984). Marx (1906), metric and microscopic characters of humans have attracted the attention of forensic scientists, particularly due to its better chemical stability and resistance to decomposition as compared to other body tissues. It has been realized that hair evidence can provide useful clues to race, sex and site of the body. Das-Chaudhuri & Chopra (1983) have suggested the involvement of significant genetic component in the histo-morphological variables of human scalp hair thus highlighting their utility for studying population variations. Various histo-morphological hair parameters, such as medullation, hair index, medullary and scale count index have forensic applications for individualization (Chowduri 1963, Bhatis *et al.* 1971, 1976, 1980, Banerjee & Banerjee 1986) (Gaur *et al.*, 2007). The present study was undertaken on two diverse population groups (Brahmins and Domars) of Uttar Pradesh, India in which 823 individual's samples were collected for studying the range of variability that exists in terms of histomorphological characters of hair among population of Uttar Pradesh, India.

Materials and Methodology

Materials Required

In the present study, two diverse population groups (Brahmins and Domars) of Uttar Pradesh were considered and 823 individual's samples were collected. In which 418 were Brahmins (206 male and 212 female) and 415 were Domar (202 male and 203 female) ranging in the age of 10 to 70. For examination, a total of 25 scalp hair strands from different part of head were taken either by plucking or cutting methods after the written consent given by the subject. Every single hair has been examined for the thirteen different features such as hair colour, hair shaft form, hair texture, hair quantity, hair distal end characteristics, medulla distribution, hair shaft diameter, medulla diameter, medullary index, scale shape, number of scales per unit (2mm) length, scale count index, hair index. Below are the material used during examination:

1. Packets to collect sample
2. Stickers (to label the packet)
3. Marker
4. Tweezers (to pluck the hair)
5. Cotton
6. Methanol
7. Gloves
8. Magnifying Glass (to check the hair bulb)
9. Slides

10. Cover Slips
11. Tape
12. Dropper
13. Nail Polish (Transparent)
14. Compound Microscope
15. 5x, 10x, 15x eye Piece of Compound Microscope

The data were mainly collected from a house-to-house survey during October - November, 2010-2011. Hair samples were plucked from five different places i.e. Frontal, Temporal left, Temporal Right, Vertex Anterior, and Vertex Posterior on the scalp with the help of tweezers. The samples were collected in the transparent packets after numbering and mentioning all details by the marker. During collection of the sample care has been taken that the subject must be mentally and physically fit and were not blood relatives. The subject were grouped into six age groups of 10 years each. Age wise distribution of the sample is presented in Table 1.

Table 1: Distribution of the present sample in various age categories according to population groups and sex

	Population Groups		
Age	**Sex**	**Brahmins**	**Domars**
10-19	♂	44	36
20-29	♂	29	31
30-39	♂	66	59
40-49	♂	22	23
50-59	♂	11	16
60 &<70	♂	34	37
	Total	**206**	**202**
10-19	♀	37	37
20-29	♀	37	28
30-39	♀	63	63
40-49	♀	33	31
50-59	♀	20	18
60 &<70	♀	22	26
	Total	**212**	**203**

Methodology

Collected hairs samples were washed in tap water followed by soap water and then they were kept in distilled water. After blotting the dry hair were steeped in a mixture of Ether and absolute alcohol in equal proportions for 10 minutes. Then they were washed in xylene for 5 minutes and mounted in Canada balsam under square cover. The presence of artificial treatment such as dyes or rinses were identified through microscopical examination. After trace debris had been removed from items of evidence, appropriate types and number of hairs for examination were selected.

First the washed hair samples were visually examined for under the magnifications of 6X to 20X. All hairs strands were used for mounting on microscope slides for further examination. For proceeding further collected hairs sample were cut into the length of approx. 15 mm and covered with cover slip of 24mm x 40 mm. Each hair strand was examined under a microscope for hair shaft diameter, diameter of medulla, scale count, type of medulla, hair index, medullary index and scale-count index. Various measurements of the hair strands were taken in microns (0.001 mm) with the help of a monocular microscope fitted with a mechanical stage and having a calibrated ocular micrometer in the eyepiece. The scale of the ocular micrometer (having 100 small divisions) was calibrated against a stage micrometer (using a 15 x eye piece and a 40 x objective) the smallest division of which was 0.01 mm or 10-5 m or 10 μ.

Results

Collected 823 hair samples were examined for thirteen different features such as hair colour, hair shaft form, hair texture, hair quantity, hair distal end characteristics, medulla distribution, hair shaft diameter, medulla diameter, medullary index, scale shape, number of scales per unit (2 mm) length, scale count index, hair index for studying ethnic variation among Uttar Pradesh population. After visual and microscopic examination of all hair samples, the

statistical result was obtained for checking the significant and non-significant difference "ANOVA Analysis".

1. **Hair Colour –** Fischer–Saller scale is used to determine the shades of hair colour and the hair colour is classified into 4 categories as black, brown, grey and white. Table 2 shows the percentage wise distribution of hair colour, in which it's clearly visible that the brown colour is predominant in Brahmins and Domars (43.30 and 47.16 respectively) both, in comparison to other shades of hair colour.

Table 1: Percentage wise distribution of Hair Colour

S.NO	POPULATION	Black	Brown	White	Grey
1	**Brahmins**	31.10	43.30	13.39	12.20
2	**Domars**	32.84	47.16	11.60	8.40

2. **Hair Shaft Form –** According to Mollison's (1938), the hair shaft form is classified into Straight, Smooth, Flat Wavy, Broad Wavy, Narrow Wavy, Curly. Table 2 shows the percentage wise distribution of hair shaft form, in which it's clearly visible that the broad wavy hair shaft form (50.37) is predominant in Domars whereas smooth hair shaft form (38.84) is predominance in Brahmins in comparison to other type of hair shaft form.

Table 2: Percentage wise distribution of Hair Shaft Form

S.NO	POPULATION	Straight	Smooth	Flat Wavy	Broad Wavy	Narrow Wavy	Curly
1	**Brahmins**	5.89	38.84	26.98	19.87	12.12	1.95
4	**Domars**	1.23	7.41	11.36	50.37	25.93	3.70

3. **Hair Texture** – Hair texture was classified into three types as coarse, medium and fine. Table 3 shows the percentage wise distribution of hair texture in which it's clearly visible that the medium type of hair texture is predominant in Brahmins and Domars (49.76 and 67.65 respectively) both, in comparison to other type of hair texture.

Table 3: Percentage wise distribution of hair texture

S.NO	POPULATION	Coarse	Medium	Fine
1	**Brahmins**	15.07	49.76	35.16
4	**Domars**	24.69	67.65	7.65

4. **Hair Quantity** – Hair quantity is classified into five categories as Thin (100 or less), Medium (100-150), Normal (150-200), Thick (200-250), and Dense (250 or more) which is measured by the occurrence of hair strand in per-square-inch area. Table 4 shows the percentage wise distribution of hair quantity, in which it's clearly visible that the normal hair quantity (55.06) is predominant in Domars while Brahmins have predominance in medium hair quantity (29.66) in comparison to others hair quantity.

Table 4: Percentage wise distribution of hair quantity

S.NO	POPULATION	Thin	Medium	Normal	Thick	Dense
1	**Brahmins**	28.70	29.66	26.55	12.91	2.15
4	**Domars**	24.20	16.30	55.06	3.46	0.99

5. **Hair Distal End Characteristics –** Hair distal end characteristics were observed in each hair sample as following tapered tips (uncut), rounded or abraded, angular cut, and split. Table 5 shows the percentage wise distribution of hair distal end characteristics, in which it's clearly visible that the rounded or abraded hair distal end characteristics (45.43) is predominant in Domars while Brahmins have predominance in angular cut characteristics (29.43) in comparison to other hair distal end characteristics.

Table 5: Percentage wise distribution of Hair Distal End Characteristics

S.NO	POPULATION	Tapered Tips	Rounded or Abraded	Angular Cut	Split
1	**Brahmins**	18.42	22.97	29.43	29.19
4	**Domars**	25.68	45.43	4.44	24.44

6. **Medulla Distribution –** Medulla distribution are categorized into following types as continuous type, discontinuous type, fragmented type, and absent type. Table 6 shows the percentage wise distribution of medulla distribution in which it's clearly visible that the medulla is absent in Brahmins and Domars (34.92 and 32.84 respectively) both, in comparison to other type of medulla distribution.

Table 6: Percentage wise distribution of Medulla Distribution

S.No.	Population	Absent	Continuous	Dis-continuous	Fragmented
1	**Brahmins**	34.92	11.72	22.24	30.10
4	**Domars**	32.84	13.33	23.21	30.62

7. **Hair Shaft Diameter –** Hair shaft was the average of the shaft diameters of a hair strand recorded at five different places. Table 7 shows the percentage wise distribution of hair shaft diameter in which it's clearly visible that the Brahmins shows maximum hair shaft diameter (52.34 – male, 54.56 – female) whereas Domars shows the minimum hair shaft diameter (40.69 – male, 38.71 - female) in male and female both.

Table 7: Percentage wise distribution of Hair Shaft Diameter

S. No.	Population	Male		Female	
		Mean	S.D.	Mean	S.D.
1	**Brahmins**	52.34	4.425 (206)	54.56	2.082 (212)
4	**Domars**	40.69	2.356 (202)	38.71	2.349 (203)

8. **Medulla Diameter –** Medulla Diameter, if present, is the average of the diameters recorded at five different places over the entire length of each hair strand. Table 8 shows the percentage wise distribution of medulla diameter, in which it's clearly visible that the Brahmins shows the maximum medulla diameter (13.56 – male, 12.87 – female) whereas Domars shows minimum medulla diameter (12.59 – male, 10.91 – female) in male and female both.

Table 8: Percentage wise distribution of Medulla Diameter

S. No.	Population	Male		Female	
		Mean	S.D.	Mean	S.D.
1	**Brahmins**	13.56	0.186	12.87	0.265
4	**Domars**	12.59	0.983	10.91	0.872

9. **Medullary Index –** Medullary Index is the ratio between the mean diameter of the medulla and the mean diameter of the hair shaft. Table 9 shows the percentage wise distribution of medullary index in which it's clearly visible that the medulla index is higher in male in comparison to female in both the populations such as Brahmins and Domars.

Table 9: Percentage wise distribution of Medullary Index

S. No.	Population	Medullary Index	
		Male	Female
1	Brahmins	0.26	0.24
4	Domars	0.31	0.28

10. **Scale Shape –** Scale shape were categorized into following such as smooth-having, crenate- having and rippled-having. Table 10 shows the percentage wise distribution of scale shape in which it's clearly visible that the crenate scale shape is predominant in Domars and Brahmins (68.64 and 58.61 respectively) both in comparison to other scale shape

Table 10: Percentage wise distribution of Scale Shape

S. No.	Population	Smooth	Crenate	Rippled
1	Brahmins	23.20	58.61	18.18
2	Domars	22.72	68.64	8.64

11. **Number of Scales Per Unit (2mm) Length –** Table 11 shows the percentage wise distribution of medulla diameter in which it's clearly visible that the medulla diameter is maximum (25.91 – Brahmins, 27.91 – Domars) in male whereas minimum (24.0 – Brahmins, 25.81 – Domars) in female.

Table 11: Percentage wise distribution of Medulla Diameter

S. No.	Population	Male		Female	
		Mean	S.D.	Mean	S.D.
1	Brahmins	25.91	2.126	24.0	1.459
4	Domars	27.13	2.943	25.81	2.953

12. **Scale Count Index -** Scale count index was computed as the ratio between the diameter of hair in microns and the number of scales per unit length (2mm in this study) following Bhatia et al. (1976). Table 12 shows the percentage wise distribution of medullary index in which it's clearly visible that the scale count index is maximum (1.55 – Brahmins, 1.43 – Domars) in female whereas minimum (1.30 – Brahmins, 1.33 – Domars) in male.

Table 12: Percentage wise distribution of Scale Count Index

S. No.	Population	Scale Count Index	
		Male	Female
1	Brahmins	1.30	1.55
4	Domars	1.33	1.43

13. **Hair Index –** Hair index is the ratio between the lesser diameter of the hair and the greater diameter of the hair multiplied by 100 (Chowdhuri 1963). Table 13 shows the percentage wise distribution of hair index in which its clearly visible that the Brahmins male has maximum number (86.28) of hair index in comparison to Domars male whereas Domar females has maximum number (90.91) of hair index in comparison to Brahmins female.

Table 13: Percentage wise distribution of Hair Index

S. No.	Population	Hair Index	
		Male	Female
1	**Brahmins**	86.28	84.55
4	**Domars**	86.41	90.91

Discussion

Hair is most commonly encountered physical evidence in numerous crime scene and has both anthropological as well as forensic identification significance. In the present study, 823 hair samples of two diverse population groups (Brahmins and Domars) of Uttar Pradesh, India were collected for studying the range of variability that exists in terms of histomorphological characters of hair among population. Every single hair samples has been examined for thirteen different features such as hair colour, hair shaft form, hair texture, hair quantity, hair distal end characteristics, medulla distribution, hair shaft diameter, medulla diameter, medullary index, scale shape, number of scales per unit (2mm) length, scale count index, hair index.

In the present research, study on hair colour, hair texture and hair distal end characteristics in Indian population has been proposed. Brown hair colour is predominant in Brahmins and Domars both in comparison to other shades of colour but the occurrence percentage is more in Domars (47.16%). The medium type hair texture is predominant among Brahmins and Domars both in comparison to other type's hair texture but the occurrence percentage is more in Domars (67.65%). The rounded or abraded hair distal end characteristics (45.43) is predominant in Domars while Brahmins have predominance in angular cut characteristics (29.43) in comparison to other hair distal end characteristics.

There are few studies which is already present in the reference of the other traits like Das (1971) had studied on eight population groups from Assam and observed hair shaft form and hair density. In hair shaft form he observed that no population group showed straight and curly type hair whereas **Banerjee (1965)** had studied on seven different population groups and found that Pahira and Sabara shows a very high frequency of smooth type of hair. In Hair density, there was not a single population groups which fall under the 'thin' and 'dense' hair quantity type whereas in present study the Brahmins and Domars have 'thin' as well as 'dense' type of hair quantity. In present study, the broad wavy hair shaft form (50.37%) is predominant in Domars whereas the smooth hair shaft form (38.84%) is predominance in Brahmins in comparison to other type of hair shaft form. The normal hair quantity (55.06%) is predominant in Domars while Brahmins have predominance in medium hair quantity (29.66%) in comparison to others types of hair quantity.

Banerjee (1957), reported that the lowest incidence of medullation in Onge females (21.5%) and males (31.6%) whereas the highest incidence of medullation has been reported among Jarwas males (90.67%) by **Das-Chaudhari (1979).** Sharma et al. in 2002 studied on twins on Punjab and reported to have low incidence of medulla (32.54%). Altogether data on 35 population groups is available on the type of medulla property. **Banerjee (1962),** reported the highest incidence of the 'absent' medulla type among Onge males (91.00%) and the least among the Jarwas (9.63%). In present study, the medulla is absent in Brahmins and Domars both, 34.92% and 32.84% respectively, in comparison to other type of medulla distribution.

Das-Chaudhari & Chopra (1984) studied Indian population and reported that the highest shaft diameter was shown among the Oraons (95.95 µ) whereas least shaft diameter shown among Rajput's of Punjab (M=27.975 µ, F=29.573 µ), reported by Jasuja & Minakshi (2002). All other studied population also have diameter between 60 µ to 91.90 µ. But in present study the Brahmins and Domars shows shaft diameter below the normal range of other Indian population

studied. The hair shaft diameter in Brahmins is 52.34 µ – male, 54.56 µ– female whereas Domars shows the hair shaft diameter 40.69 µ – male, 38.71 µ - female.

According to the reports of Jasuja & Minakshi (2002), Gaur et al. (2007) and Sharma et al. (2002), medulla diameter among the males ranges from 7.28 µ (Rajputs of Punjab) to 15.68 µ (General population of Punjab). In the present study, Brahmins (13.56 µ) and Domars (12.59 µ) have their medullary diameters within range of those of other studied populations. As per the different survey, medullary index among the human populations is always below 0.33. Mistry et al. (2010) studied population of Bengalees and reported the least medullary index (0.09) whereas the highest medullary index (0.31 – M, 0.28 – F) has been reported in the present study among the population of Domars of Uttar Pradesh. Mistry et al., (2010) studied Benagalees population and reported that the crenate shape scale is predominant. Similar type of result was reported in present also. The Crenate shape scale is predominant in both the population's i.e Brahmins (58.61 %) and Domars (69.75 %).

Gaur et al., 2007 studied number of scales per unit length (2mm) and scale count index among the population of Punjabi Banias and Brahmins and reported that the mean number of scales per unit length does not show much variation among the studied population. In present study, scale count index is higher in females as compared to the males in both the population such as Brahmins and Domars whereas populations of Punjab show a reverse result the males show a higher scale count index as compared to their female. As per Gaur et al. (2007), Jasuja & Minakshi (2002) and Sharma et al. (2002) reported relatively lower hair indices among the general population of Punjab, Rajputs and some twins from Punjab males as compared to the presently studied Brahmins population groups. In present study, Domars female shows higher hair indices in comparison to Domar male.

Conclusion

Observation obtained in the present study support the work done previously by different researchers that the histomorphological traits such hair shaft form, hair quantity, medulla distribution, hair shaft diameter, medulla diameter, medullary index, scale shape, number of scales per unit (2mm) length, scale count index, hair index shows a significant variation and can be used to investigate inter-population variations...

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