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A Study on "Morphological Characteristics of Hair Collected From Tribal, Urban and Coastal Population"

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ABSTRACT

Hair is one of the most significant evidence types in forensic investigations. It often gives crucial information that helps in the identification of victim or suspect, and it has a substantial impact on the forensics and judicial systems. It could disclose information about a person's species, sex, age, race, and country of origin. Humans lose 100 head hairs on average per day, and as hair is easily transferred during physical contact, it is frequently used as forensic evidence to establish connections between individuals such as victim or a suspect and a crime scene. Such associative evidence is particularly helpful in sever crimes like sexual assault, homicide, and aggravated assault where physical contact is likely to have taken place. Clothing or other objects that may have picked up hair that may be used to identify suspects are often collected in crimes that are less likely to have entailed physical contact, such as armed robbery. Identifying the morphological characteristics of hair samples collected from Tribal, Urban, and Coastal people is the aim of the study. 96 individuals from the three communities – both men and women between the ages of 20 and 60 – had their hair collected for this project. It aims to determine the morphological characteristics of hair by using six factors, including the Medulla pattern, Cuticle thickness, Cuticle margin, Cortex, and

Shaft diameter. A compound microscope is used for the examination, and an ocular micrometer is used to measure the shaft diameter and medullary index. The analysis found that each individual has unique hair qualities and different morphological properties since all six parameters show higher variations in the morphological structure of the hair. The outcome could serve as a clue to matching the victim or suspect on the scene of the crime.

1. INTRODUCTION

Evidence is a form of proof that can be any photos, documents, recordings, videos, or marks that are more valuable in an inquiry and that must be shown in court to establish guilt or innocence. The most frequent biological component found at the scene of an incident is hair. It is mostly used to compare the distinctive characteristics of known hair samples with questioned hair samples that are retrieved from crime scenes to determine whether there is a connection between the crime and the suspect [1]. One of the main sources in the forensic investigation of crime scenes is human hair samples, which frequently provide valuable information that aids in the identification of a suspect or a casualty. It could reveal details about a person's species, sex, age, race, and place of origin - information that is crucial for identifying them. Most frequently, hair is discovered in crimes like rape, murder, suicide, etc. Furthermore, human hair naturally sheds without warning regularly basis, increasing the likelihood that it may be found at the scene of an incident and, occasionally, on the victim's and suspect's clothing. The location of the hair's root reveals precise details about the person it came from or belonged to. If there is no root, the physical characteristics of the hair will be everything [2]. The morphological analysis is consistently regarded as a preliminary forensic hair analysis step.

Hair is among the most prevalent and significant physical evidence found at a crime scene. Identification of human hair, including whether it comes from the head or the body. Hair that has been removed forcibly may have blood or skin at the root. DNA typing is possible in certain situations. The most distinctive forensic attribute of hair is its morphology, which includes its structure and colour, when there is no root, blood, or other evidence that may be used for typing. Strong corroboration proof can be obtained by collecting and examining hair properly. It is simple to distinguish between hair that has been chopped, removed forcibly, or dropped. A typical illustration of Locard's theory of mutual

exchange of traces is the mutual transmission of hair caused by contact. In many cases, hair is discovered after a thorough examination. It was one of the first kinds of physical evidence that was taken into account, gathered, examined, and used in forensic work. The evidence suggests that the offender may have been present at the crime site. If there has been a hair transfer, it indicates the touch. If some hair is held at a place of entrance or exit, it reveals the pathways of entry or exit. Examining human hairs in a forensic laboratory is done using light microscopy. In it, questioned hairs are identified, and questioned and known hair are compared. The presence of two or more people or the presence of a person who came into contact with an object is determined by microscopic analysis. The value of hair evidence is tied to the variation in hair features across individuals in the population, which can be seen through the application of comparison microscopy.

1.1. STRUCTURE OF HAIR

Hair is a protein filament that emerges from the hair follicles found in the dermis, or skin, and the hair follicle is found in the fatty layer of the scalp. Keratin, a fibrous protein with a helix-like shape that makes up a portion of the skin and all of its appendages, makes up 95% of the hair. The synthesis of keratin by Keratinocytes and the fact that keratin is water-insoluble provide the hair its impermeability and defence. Proline, threonine, leucine, and arginine are just a few of the 18 amino acids that can be found in hair. Cysteine, a sulfurated amino acid that creates disulfide connections between molecules, is particularly abundant in keratin, giving the material more rigidity and resilience overall. Each hair consists of a hair root and a hair shaft. The visible portion of the hair that protrudes from the skin is called the shaft. The skin's deeper layers are reached by the hair's root, which is located in the skin. The sebaceous gland and the hair follicle, which surrounds it, are both connected to it. The follicles sprout in groups of 1-4 hairs and are known as "Follicular units," yet each hair grows as a single strand. The follicles within the dermis are fed through blood vessels. Depending on the body, the location of hair follicles varies. Specifically, the scalp, forearms, legs, and even genital areas have more hair follicles than the palm and sole. Each hair follicle is connected to an arrector pili, a small muscle that can curl the hair strand. These nerves also terminate at the hair follicle. These nerves are sensitive to even the smallest airflow and can detect hair movement. The hair root spreads to form a spherical hair bulb at the hair's base. The blood supply to the hair root is provided by the hair papilla, which is located at the base of the hair bulb. In the hair bulb, near the papilla, new hair cells are continuously being produced.

1.1.1. Medulla - The medulla, which is the innermost part of the hair, is an open, invisible layer that is frequently the most delicate and tender. It is the cell's nucleus, which can be found in the hair. There are several mammals without a medulla. It is possible for the medulla to be continuous, interrupted, or fragmented.

- *Continuous medulla* - The medulla pattern is one in which there are no breaks in the medulla line. The medulla in animal hair is often continuous and organized, and it typically occupies an area greater than one-third of the hair shaft's entire diameter.

- *Discontinuous medulla* - Where the medulla pattern line is broken yet the space between medulla lines is evenly spaced, it is also known as the interrupted medulla.
- *Fragmented medulla* - The pattern is poorly spaced and appears as little fragments in the medulla pattern.

- *Absent medulla* - where there is no trace of the medulla pattern. The medulla line impression won't be visible.

1.1.2. *Cortex* - Between the hair cuticle and the medulla, the cortex is a highly structured and organized layer. It is the layer of the hair that is the thickest. The cortex, which contains melanin that gives the hair filament its colour depending on the quantity, distribution, and kind of melanin granules, is the main source of mechanical strength and uptake. The form of the cortex is determined by the shape of each hair strand, and the texture of the hair—whether it is straight or curly—is related to the shape. Round hair fibers are seen in people with straight hair, but oval and other shaped hair fibers are more curly or wavy.

1.1.3. *Cuticle* - The outermost layer of hair filament is called the hair cuticle; it is made of dead cells and serves to fortify and shield the hair shaft. It has scales that cover the shaft and is transparent. From the proximal end of the hair to the distal end of the hair, the cuticle scales are always pointed. The Coronal Scale, Spinous Scale, and Imbricate Scale are the three primary basic cuticle scale structures.

- Coronal Scale - It is a crown-like scale pattern, which resembles a stack of paper cups and is present in fine hairs. It is mostly present in insect hairs but is uncommon in human hair.

- Spinous Scale - The triangular scales that sprout from the hair shaft resemble petals and are petal-shaped. They are mainly located near the ends of animal hairs. Human hair does not have these scales.

- Imbricate Scale - It is known as flattened scales and is made up of scales with close borders that overlap. Human hair and many other animals most frequently include this kind of scaling.

The hair swells due to the intricate structure of the cuticle, which also has a lipid molecular layer that makes the hair follicles water-repellent. Human hair can be anywhere between 0.017 and 0.18mm in diameter.

1.2. THE ROOT OF HAIR

Hair fragments have an expansion at the end of the root known as the hair bulb. Compared to the shaft, it is whiter and has a softer feel. The external root sheath, internal root sheath, cuticle, cortex, and medulla are all parts of the hair bulb. It also consists of a glassy membrane, fibrous connective tissues, epithelium, and granular strata.

1.3. CLASSIFICATION OF HAIR

The three different forms of hair are as follows:

1. *Lanugo hairs*: Terminal and vellus hairs, which make up the lanugo. The long hairs known as "lanugo" are those that coat the foetus during the pregnancy. one month before delivery and shed.

2. *Vellus hairs:* These are short, unmedullated hairs that cover some areas of the body's surface and take the place of lanugo hair soon before childbirth.

3. *Terminal hairs:* Male alopecia patterns cause terminal hairs to change into vellus hairs, while hirsutism causes terminal hairs to turn into vellus hairs. Terminal hairs are long, coarse, medullated hair that is affected by androgen-level circulation.

1.4. HAIR TEXTURE

Different textures can be found in hair. The pattern of the curls, the thickness, and the consistency make up the bulk of hair texture. The hair shafts shape is determined by the shape of the hair follicle. The

hair's curl pattern is then determined by the curvature of the hair shaft. Straight hair grows from round hair shafts. Wavy or curly hair is produced by hair shafts with irregular shapes, such as ovals. The thickness of hair is a function of hair follicle size. When compared to thinner, thicker hair has more volume. The quantity of hair follicles and the state of the hair shaft influence the consistency of hair. Hair is typically divided into three categories: fine, medium, and coarse. The smallest circumference is found in fine hair, and coarse.

The shape, form, and structure of hair can be studied morphologically to learn important details about its physical features and internal and external structural traits. To connect the properties of hair with two possible individual hair samples, the preliminary morphological analysis of hair includes a macroscopic and microscopic investigation. The specimens that are more consistent macroscopically with the questioned sample can be subjected to further examination, including microscopic examination. The Macroscopic examination involves observing a specimen in a low-magnified stereo microscope with the naked eye, and it may exclude all, some, or all of the known samples from consideration. In a microscopic inspection, the entire morphology of hair will be examined at first at low magnification and then at medium to high magnification. Microscopic inspection using the wet mount method can show the hair's internal structure.

In this study, the morphological properties of hair collected from Tribal, Urban, and Coastal populations in Kerala were examined. Additionally, a comprehensive analysis of the morphological characteristics of hair was conducted, using 6 parameters: Medulla pattern, Medullary index, Cuticle thickness, Cuticle margin, Cortex, and Shaft diameter. Recent research on morphological features have been published by Amna Khan et *al*. (2016) [3], Sabyasachi Nath et *al*. (2020) [4], Nataraja Moorthy T et *al*. (2015) [5], Ranjeet Kumar Singh et *al*. [6], Deepshika Singh et *al*. [7], Lee et *al*. (2019) [8], M.K. Mishra et *al*. [9], and Misty A Weitzel [10]. Young Jaat inhabitants of Western Uttar Pradesh were researched by Amit Chauhan et *al*. (2018) [11] for the existence of medulla-type hair. The medulla of each hair is identified among Uttarakhand's scheduled castes by H. B. S Chauhan et *al*. [12] in 2016. According to a study, the frequency of continuous hair medulla differs by sex, with males having a higher frequency than females. Mukesh Kumar Thakkar et *al*. (2002) [2] examined the morphological characteristics of twins' hair. To determine whether both have any intra- and inter-personal variances, the twin individuals can offer an exact analysis for variations.

Hair contains a medulla that can be continuous, discontinuous, or fragmented. When it is missing from the hair, it will be divided into several groups. There may be gender-specific differences in the medullary index in the population [4]. The thickness or thinness of a hair's cuticle varies depending on the person's age, gender, and sex. There are situations when thick cuticles displayed differences whereas thin cuticle frequency and sequences were the same in both genders [5]. In human hair, the cuticle edge may or may not be present. If a cuticle margin is present, take note of the outer cuticle margin's appearance, including whether it is flat, smooth, cracked, or serrated, as well as the inner cuticle margin's appearance, including whether the cuticle touches the cortex or not and whether it has a distinct or diffuse texture. One piece of literature demonstrates that the inner cuticle edge varies among populations of different genders, with some showing a more defined type than others, while others have exhibited a more indistinct type [3]. When analyzing the cortex of the hair, it is important to consider its texture, which can be coarse, medium, or fine, as well as any distinctive features, such as striate or curly hair.

By using an ocular micrometer, it is possible to measure the medullary index and calculate the shaft diameter. By taking a cross-section of the hair, the morphological analysis of the hair can be performed using a microscopic examination and the wax method. Examining the hair can show whether or not it has been forcibly removed. The compound microscope, comparative microscope, and stereo microscope can all be used to examine hair particles. The examiner can observe a known and unknown material through the eyepiece lens simultaneously with the aid of a comparison microscope, which is made up of two compound microscopes that are connected by an optical bridge. Additionally, a multi-phase examination using a comparison microscope enables researchers to determine whether samples are known to be from human hair and those that are unknown to be from animal hair. Depending on how the hair is distributed and arranged and how each person looks, the human skin's hair will be able to identify different people.

2. METHODOLOGY

Human scalp hair samples were taken from people in the tribal, urban, and coastal populations. For the study, 96 individual hair samples from 24 males and 21 females, 13 males and 13 females from the tribal community, and 10 males and 15 females from the urban population, were gathered. Each person had an average of 5 hair samples pulled with tweezers from various parts of the head and placed inside a zip-lock bag. All of the hair samples that were taken from people had the appropriate labels on them.

Individuals' names, sexes, and ages were also noted. Each person's gathered hair was mounted on a glass slide by adding glycerine and covering the sample with a coverslip. Each hair strand was laid out on a glass slide for cuticle analysis, and transparent nail paint was applied on top. At 10X and 40X magnification under a compound microscope, all observations were recorded. The following measurements were looked at for each hair sample:

2.1 *Type of Medulla*: Each hair was checked to see whether a medulla was present or not, and the medulla was then categorized as one of the following:

a. Continuous
b. Discontinuous
c. Fragmented
d. Absent

The medulla in humans may be absent, fractured, or discontinuous, but it may also be continuous in animals.

2.2 *Cuticle Thickness*: The distance between the cuticle's outer margin and the cortex is known as the cuticle's relative thickness (Forensic human hair examination guidelines, 2005). Typically, this is classified as Thick, Medium, or Thin.

2.3 *Cuticle Margin*: The cuticle and cortex appear to have a border at the inner cuticle margin (Nataraja Moorthy T et. al, 2015). It includes:

a. Distinct
b. Indistinct
c. Varied

Note the outside cuticle margin if there is a cuticle. Included are:

a. Flat
b. Smooth
c. Cracked
d. Serrated

2.4 *Cortex Thickness*: The Cortex is the area between the medulla pattern and the cuticle. It comprises assessing its texture (coarse, medium, fine, thick, or thin) and determining whether it has any peculiar appearance (Cellular or Striated).

***2.5** Hair shaft diameter*: In healthy people, hair shaft diameter ranges between 40 and 120 micrometers. They are Fine, Medium, and Thick.

3. ANALYSIS AND INTERPRETATION

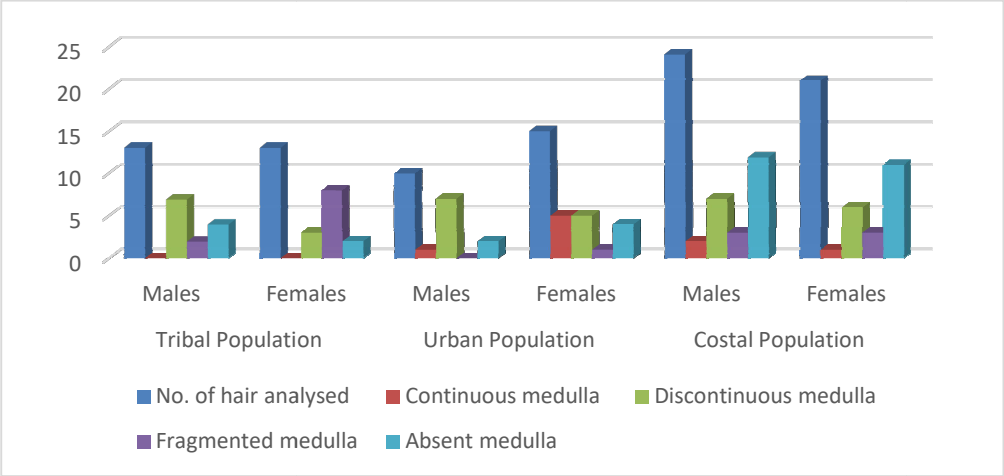
After observing all hair samples for six parameters, following results were observed:

3.1. MEDULLA PATTERN

Table 3.1.1: Medulla types among three population.

Medulla Types	Tribal population		Urban population		Coastal population	
	Males	Females	Males	Females	Males	Females
Continuous	0 (0.0%)	0 (0.0%)	1 (10%)	5 (33%)	2 (8.3%)	1 (4.7%)
Discontinuous	7 (53.8%)	3 (23.07%)	7 (70%)	5 (33%)	7 (29.16%)	6 (28.5%)
Fragmented	2 (15.3%)	8 (61.5%)	0 (0.0%)	1 (6.6%)	3 (12.5%)	3 (14.2%)
Absent	4 (30.7%)	2 (15.3%)	2 (20%)	4 (26.6%)	12 (50%)	11 (52.3%)
Total	13	13	10	15	24	21

Graph. 3.1.2: Graphical representation of features of medulla



The human hair medulla was divided into four categories: Continuous, Discontinuous, Fragmented, and Absent. The Microscopic comparison of medulla types of three populations has been shown in Figure 3.1.1. The results in Table (3.1.1) showed that in males of the Tribal population seven samples were observed as discontinuous (53.8%), four were absent (30.7%), and only two showed fragmented medulla (15.3%), and females showed three discontinuous medullae (23.07%), eight fragmented (61.5%), and two showed absent medulla (15.3%) type and the continuous type of medulla is completely absent in both genders. In the case of males of the Urban population seven samples were observed as discontinuous (70%), two were absent (20%), and only one showed continuous medulla (10%) type, and females showed five discontinuous medullae (33%), five continuous medullae (33%), four absent medulla (26.6%), and one showed fragmented (6.6%) type of medulla. Whereas males of the Coastal population showed seven samples observed as discontinuous medulla (29.16%), twelve were absent (50%), three fragmented medullae (12.5%), and only two showed continuous (8.3%) type medulla and females showed six discontinuous medullae (28.5%), eleven absent medulla (52.3%), three fragmented medullae (14.2%), and one shows continuous (4.7%) type of medulla.

The graphical representation of medulla features has been given in graph 3.1.1. It observed that continuous medulla type is more observed in males of Coastal population but less in both Tribal and Urban population and females of Urban population has more continuous medulla but less in both other populations. The discontinuous medulla is more equal in three population of males and females of Coastal population. The fragmented type of medulla pattern is more in males of Coastal population but less in other populations and more in females of Tribal population but less in other two populations. In case of absent medulla, it observed that both males and females of Coastal population have more but less in other two populations.

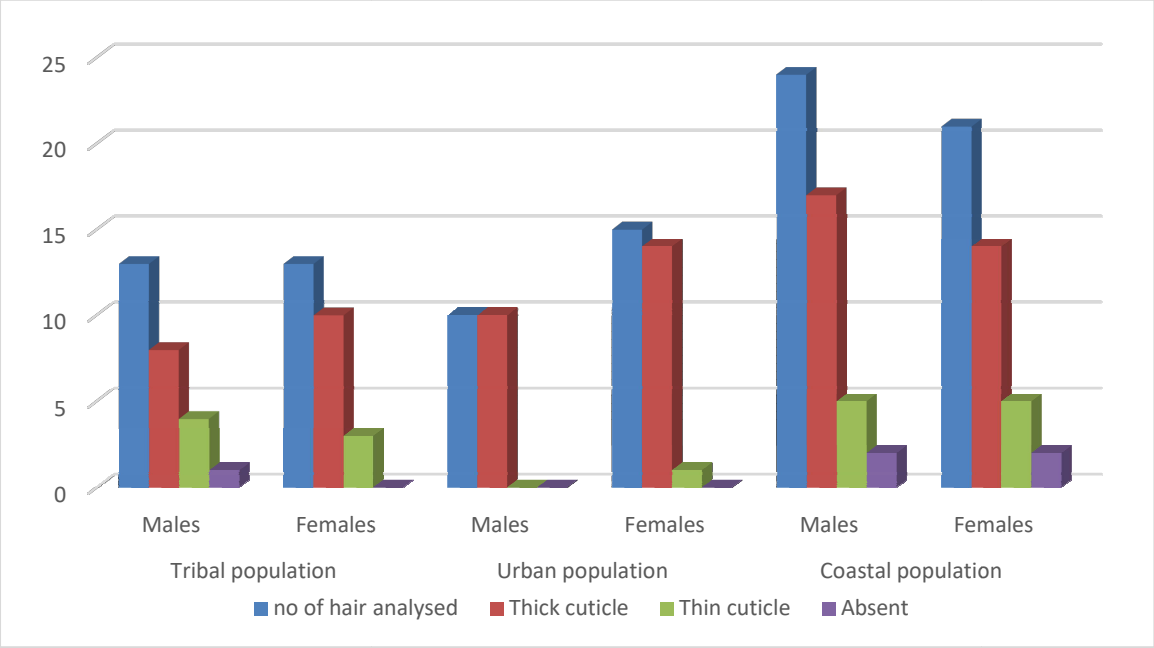
3.2. CUTICLE THICKNESS

Table 3.2.1: Cuticle thickness among three population.

Cuticle Thickness	**Tribal population**		**Urban population**		**Coastal population**	
	Males	Females	Males	Females	Males	Females
Thick	8 (61.5%)	10 (76.9%)	10 (100%)	14 (93.3%)	17 (62.9%)	14 (66.6%)

Thin	4 (30.7%)	3 (23.07%)	0 (0.0%)	1 (6.6%)	5 (20.8%)	5 (23.8%)
Absent	1 (7.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (8.3%)	2 (9.5%)
Total	13	13	10	15	24	21

Graph 3.2.2: Graphical representation of features of Cuticle Thickness



Samples showed different medulla types and were then further examined for cuticle thickness. For this parameter, males of Tribal showed eight thick cuticles (61.5%), four thin cuticles (30.7%), one showed absent (7.6%) in cuticles, and females showed ten thick cuticles (76.9%), and three showed thin cuticle (23.07%). In the case of males of the Urban population 10 samples were observed and the ten-population showed thick cuticles (100%), and thin cuticles were completely absent, and females showed 14 samples observed as cuticle thickness (93.3%), and only one showed thin cuticle (6.6%). Whereas males of the Coastal population showed seventeen thick cuticles (62.9%), 5 showed thin cuticles (20.8%)

and two showed absent (8.3%) cuticles. Females showed 14 thick cuticle (66.6%), 5 thin cuticle (23.8%), and 2 shows absent cuticle (9.5%).

The graphical representation of cuticle thickness has been given in the graph 3.2.2. It shows males of the Coastal population and females of the Urban population has thicker cuticle when compared to the two other populations. In the case of thinner cuticles and absent cuticles, it is more in both males and females of the Coastal population when compared to the other two populations.

3.3. CUTICLE MARGIN

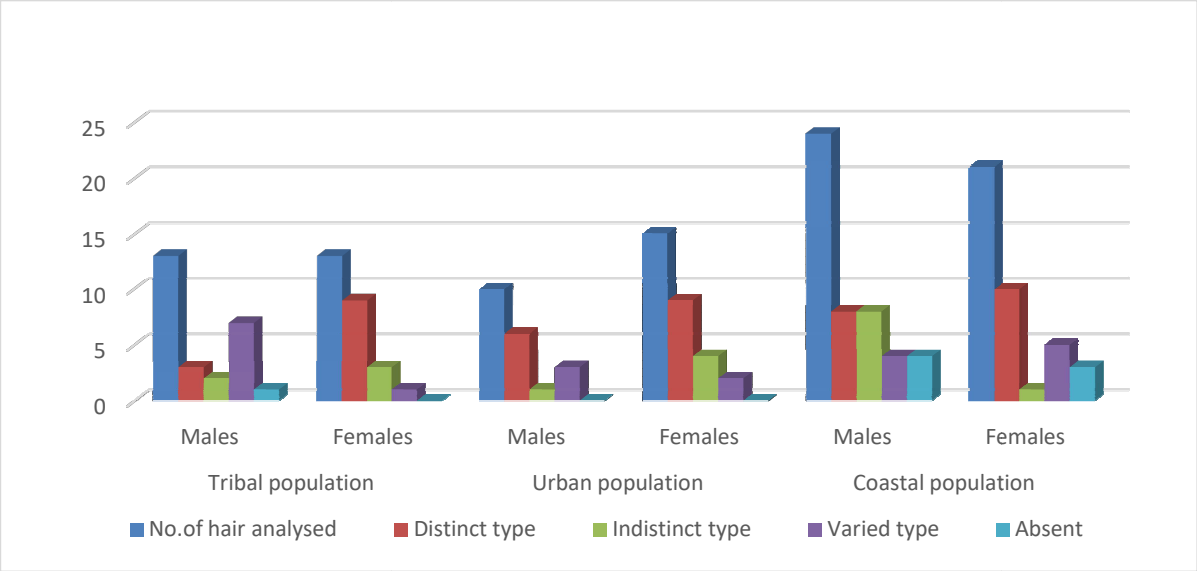
Table 3.3.1: Cuticle margin among three population.

Cuticle Margin	**Tribal population**		**Urban population**		**Coastal population**	
	Males	Females	Males	Females	Males	Females
Distinct type	3 (23.07%)	9 (69.2%)	6 (60%)	9 (60%)	8 (33.3%)	10 (47.6%)
Indistinct type	2 (15.3%)	3 (23.07%)	1 (10%)	4 (26.6%)	8 (33.3%)	1 (4.7%)
Varied type	7 (53.8%)	1 (7.6%)	3 (30%)	2 (13.3%)	4 (16.6%)	5 (23.8%)
Absent	1 (7.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (16.6%)	5 (23.8%)
Total	13	13	10	15	24	21

Cuticle margin can be categorized into Distinct, Indistinct, Varied and Absent types. Table 3 shows that males of Tribal population showed 3 distinct type (23.07%), 2 were Indistinct type (15.3%), 7 varied type (53.8%), and 1 shows completely absent (7.6%) cuticle margin and females showed 9 Distinct type (69.2%), 3 Indistinct type (23.07%), and 1 showed varied type (7.6%) of cuticle margin. Similarly, males of Urban population showed 6 Distinct type (60%), 1 indistinct type (10%), and 3 showed Varied type (30%) and females showed 9 Distinct types (60%), 4 showed Indistinct type (26.6%), and 2 showed varied type (13.3%) of cuticle margin. Whereas, males of Coastal population show 8 each Distinct type (33.3%) and Indistinct type (33.3%) and 4 each shows varied (16.6%) and absent (16.6%) type of cuticle

margin. Females shows 10 Distinct types (47.6%), 1 Indistinct type (4.7%) and 5 each Varied (23.8%) and Absent (23.8%) of cuticle margin.

Graph 3.3.2: Graphical representation of features of Cuticle Margin



From the graphical representation of cuticle margin (graph. 3.3.2) observed that distinct type of cuticle margin is more in males of coastal population but less in both males of Tribal and Urban population and for females, distinct type of cuticle margin is more in Coastal population but less in both Tribal and Urban population. Whereas, for indistinct type it is more in males of Coastal population but less in both Tribal and Urban population and for females the indistinct type is more in Urban population but less in both Tribal and Coastal population. The varied type of cuticle margin is more in males of Tribals but less in both Urban and Coastal population and it is more in females of Coastal population but less in both Tribal and Urban population. Similarly, cuticle margin is more absent in both males and females of Coastal population but less in both Tribal and Urban population.

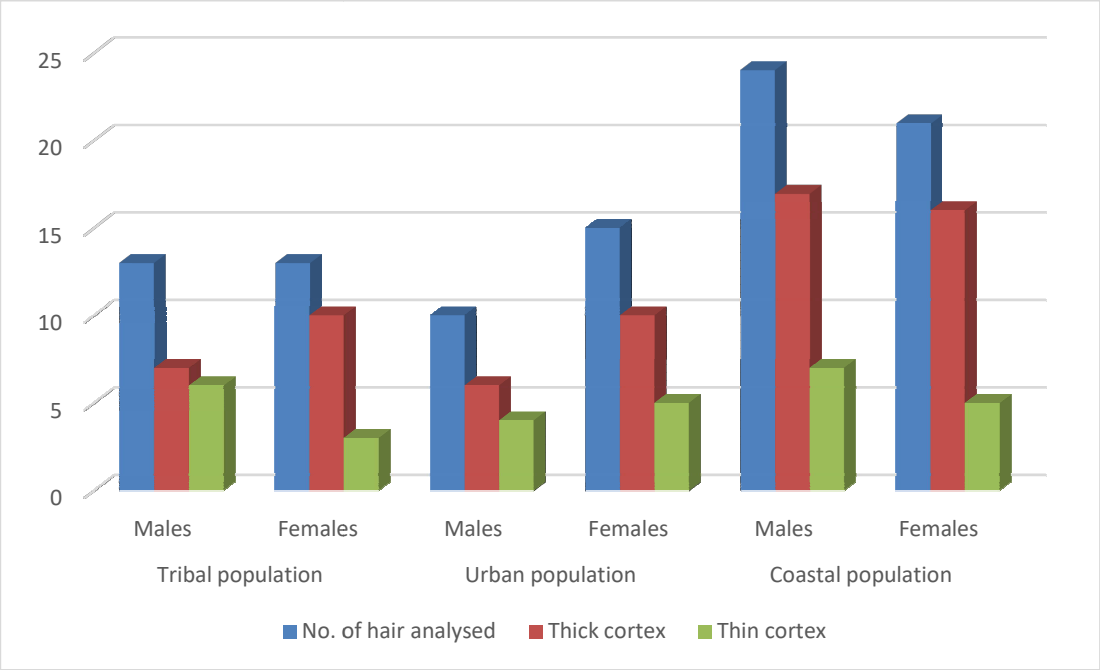
3.4. CORTEX ANALYSIS

Table 3.4.1: Cortex analysis among three population.

Cortex analysis	**Tribal population**		**Urban population**		**Coastal population**	
	Males	Females	Males	Females	Males	Females
Thick cortex	7 (53.8%)	10 (76.9%)	6 (60%)	10 (66.7%)	17 (70.8%)	16 (76.1%)

Thin cortex	6 (46.1%)	3 (23.07%)	4 (40%)	5 (33.3%)	7 (29.1%)	5 (23.8%)
Total	13	13	10	15	24	21

Graph. 3.4.2: Graphical representation of Features of Cortex



Cortex characteristics observed has been given in table 3.4.1. Cortex analysis can be categorized as examination of thick cortex or thin cortex. After the analysis of hair samples among three population observed that males of tribal population 7 shows thick cuticle (53.8%) and 6 shows thin cortex (46.1%) and females shows 10 thick cuticle (76.9%) and 3 thin cortex (23.07%). Similarly, males of urban population show 6 thick cortex (60%) and 4 thin cortex (40%) and females shows 10 thick cortex (66.7%) and 5 thin cortex (33.3%). Whereas males of Coastal population show 17 thick cortex (70.8%) and 7 thin cortex (29.1%) and females shows 16 thick cortex (76.1%) and 5 thin cortex (23.8%).

In graphical representation of cortex (Graph 3.4.2) shows thick cortex is more observed in males of Coastal population than Tribal and Urban population and females of Coastal population shows thicker cortex in hair. The thinner cortex is more observed in males of Coastal population than other two population and females of Urban population shows thinner cortex than other two population.

3.5. MEDULLARY INDEX

Table 3.5.1: Medullary index of three population

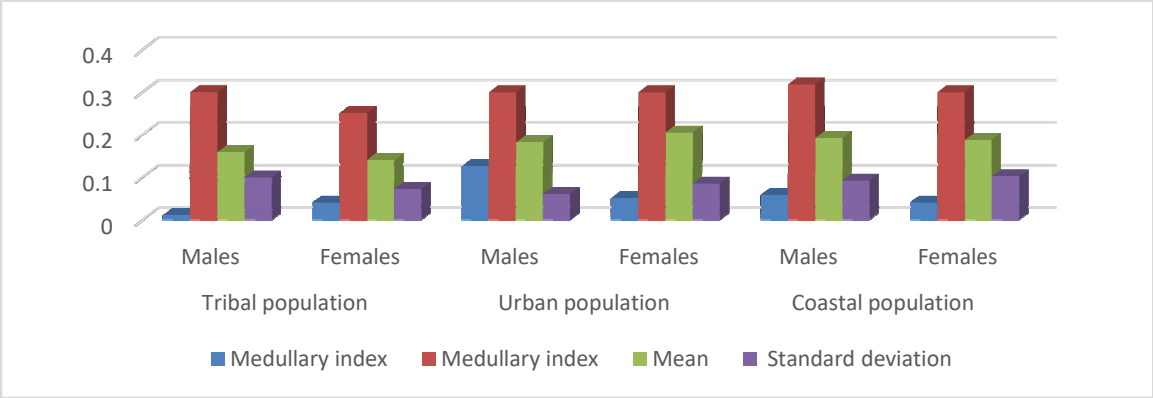
Population	Gender	Medullary index		Mean	Standard deviation
		Minimum	Maximum		
Tribal population	Males	0.01	0.3	0.15833	0.098812
	Females	0.04	0.25	0.14	0.071351
Urban population	Males	0.125	0.3	0.1815	0.059662
	Females	0.05	0.3	0.2045	0.08435
Coastal population	Males	0.058	0.318	0.1915	0.091755
	Females	0.04	0.3	0.187	0.101297

Medullary index has been given in table 3.5.1. In males of Tribal population, the minimum medullary index is 0.01µm and maximum is 0.3µm with a mean and standard deviation about 0.15833 and 0.098812 and for females the minimum medullary index is 0.04µm and maximum is 0.25µm with a mean and standard deviation about 0.14 and 0.071351 respectively. Similarly, males of Urban shows minimum medullary index are 0.125µm and maximum is 0.3µm with a mean and standard deviation about 0.1815 and 0.059662 and for females the minimum medullary index is 0.05µm and maximum is 0.3µm with a mean and standard deviation about 0.2045 and 0.08435 respectively. For males of Coastal population, the minimum medullary index is 0.058µm and minimum are 0.318µm with a mean and standard deviation about 0.1915 and 0.091755 respectively and for females the minimum medullary index is 0.04µm and maximum are 0.3µm with a mean and standard deviation about 0.187 and 0.101267 respectively.

The graphical representation of medullary index of three population shows in graph. 3.5.2. It shows males of coastal population and both females of coastal and urban population have maximum medullary index. The minimum medullary index is more present in both males and females of Urban population. Similarly, the mean of medullary index is more present in males of coastal population and females of

urban population. Whereas, the standard deviation shows more in both males and females of coastal population.

Graph. 3.5.2: Graphical representation of Medullary index

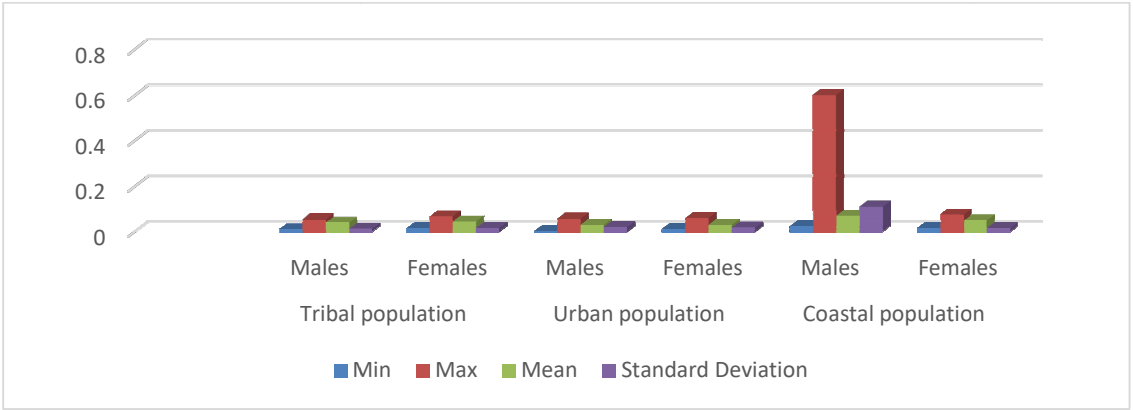


3.6. SHAFT DIAMETER

Table 3.6.1: Hair shaft diameter of three population

Population	Gender	Shaft Diameter		Mean	Standard Deviation
		Minimum	Maximum		
Tribal population	Males	0.01	0.055	0.040885	0.01332
	Females	0.015	0.067	0.044231	0.01601
Urban population	Males	0.002	0.0575	0.030591	0.020743
	Females	0.0125	0.06	0.03013	0.017948
Coastal population	Males	0.025	0.6	0.070543	0.113389
	Females	0.015	0.075	0.049286	0.014743

Graph. 3.6.2: Graphical representation of Shaft Diameter



Hair shaft diameter has been given in table. 3.6.1. In males of Tribal population, the minimum diameter of hair shaft is 0.01µm and maximum is 0.055µm with a mean and standard deviation about 0.040885 and 0.01332 and for females the minimum diameter of hair shaft is 0.015µm and maximum is 0.067µm with a mean and standard deviation about 0.044231 and 0.01621 respectively. Whereas, for males of Urban population the minimum hair shaft diameter is 0.002µm and maximum is 0.0575µm with a mean and standard deviation about 0.030591 and 0.020743 and for females the minimum hair shaft diameter is about 0.0125µm and maximum is 0.06 with a mean and standard deviation is about 0.03013 and 0.017948 respectively. Similarly, in case of Coastal population the minimum hair diameter of males is 0.025µm and maximum is 0.6µm with mean and standard deviation about 0.070543 and 0.113389 and for females the minimum hair shaft diameter is 0.015µm and maximum is 0.075µm with a mean and standard deviation about 0.049286 and 0.014743 respectively

Table 4.7: Compound microscope (40X) of Medulla pattern

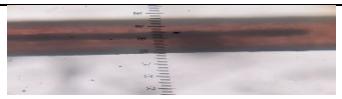
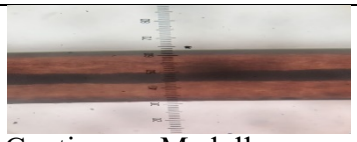
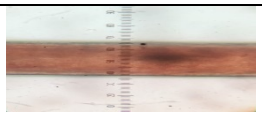
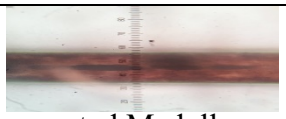
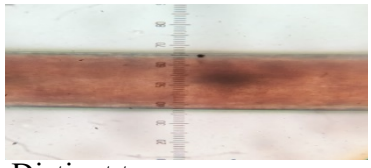
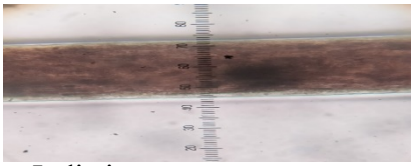
 a. Discontinuous Medulla	 b. Continuous Medulla
 c. Absent Medulla	 d. Fragmented Medulla

Table 4.8: Compound Microscope (40X) of Cuticle Thickness and Cuticle Margin

 a. Distinct type	 b. Indistinct type

4. DISCUSSION

One of the most crucial tools in the forensic examination of crime scenes are hair samples, which frequently provide significant details that might assist identify a suspect or victim. Slender fibrous outgrowths from the skin known as hairs have a variety of microscopic features, including shape, colour, and root appearance. Forensic scientist can identify the age, gender, and race of the person who shed the hair by varying these features. They can also determine which part of the body the hair originated from. DNA can be extracted from hair and utilised in analyses to assist identify potential criminal aspects.

The main objective of the present study was to find the morphological characteristics of hair among Tribal, Urban and Coastal population with the given parameters such as Medulla pattern, Cuticle thickness, Cuticle margin, Cortex and Hair shaft diameter. Amit Chauhan. et. *al*. (2018) reported the types of Medulla present in young Jaat residents of Western Uttar Pradesh in between the age groups of 20-50, results shows that the absent medulla is present in 306 (61.80%) samples which is higher than other medulla types. While fragmented medulla samples observed in 97 samples (97.50%), discontinuous medulla observed in 86 samples (17.30%) and continuous medulla observed in 5 samples which is approximately 1% of samples. It was concluded that the medulla types present in hair are highly affected by age that is the absent type is more in lower age groups and there is an increase of fragmented type and discontinuous medulla with increase in age. A study reported by H. B. S Chauhan et. *al*. shows the gender based significant differences was seen in medulla types among scheduled caste individuals of Uttarakhand. In this present study it was observed among three population that the continuous type of medulla is more observed in males of Coastal population and females of Urban population, the discontinuous medulla observed as equal for three population and the females of Coastal population. Whereas, fragmented type of medulla is more in males of Coastal population and females of Tribal population and the absent type of medulla is more in both males and females of Coastal population but less in other two populations. It shows the medulla types among all individuals can be unique, all have unique characteristics of medulla types.

Amna Khan et. *al*. (2014) reported about cuticle thickness and cuticle margin differences among four different castes. This study designed for an investigation of gender and individual based comparison of castes in Pakistan. It was concluded that there were no significant comparisons among those selected castes. The results of present study shows that the cuticle thickness and cuticle margin among three populations has more frequency of variations, each individuals including males and females

has different type of cuticle thickness and cuticle margins were present. Similar comparative study about cuticle structures was conducted for dominant races in Malaysia for forensic investigation reported by T. Nataraja Moorthy (2015).

Medullary index and Shaft diameter of three populations shows more differences, the minimum, maximum, mean and standard deviation of medullary index and shaft diameter for three population are calculated. In males of Coastal population and females of Urban population has high frequency of maximum medullary index and both males of tribals and females of coastal population has high frequency of standard deviation shows in medullary index. Both males and females of Coastal population shows high frequency of shaft diameter. Similar comparative study about Medullary index and Shaft diameter in twins and non-twins were conducted by Mukesh Kumar Thakkar et. *al*. (2015).

The present study was designed to investigate individual based comparison of hairs of different castes including Tribal, Urban, and Coastal population. Number of studies has conducted based on morphological characteristics of hair and it serves as a clue to matching the victim or suspect on the scene of crime. The outcome could serve as a clue to matching the victim or suspect on the scene of the crime.

5. CONCLUSION

This study was formulated to determine the morphological characteristics of hair collected from Tribal, Urban, and Coastal populations in the age groups of 20-60 years of age. The analysis of study was conducted based on the selected parameters such as Medulla pattern, Cuticle thickness, Cuticle margin, Cortex, Medullary index, and Shaft diameter of each hair. All the individuals have unique characteristics of hair, different morphological qualities are found on hairs. The present study shows variations in six parameters of hair including both genders of three populations. The morphological characteristics of hair have been determined from 96 samples of hair collected from the selected three populations. A compound microscope is used for the examination, and an ocular micrometer is used to measure the shaft diameter and medullary index. Medulla pattern such as Discontinuous, Continuous, Fragmented and Absent medulla shows different in all individuals and about the parameters it is also different. The findings regarding medulla types demonstrate that the continuous type is more frequently observed in males of the Coastal population but less frequently in both Tribal and Urban population, and that females of the Urban population have more continuous medulla but fewer than in either of the other populations. In the three male and female Coastal population populations, the discontinuous type is more

equal. Males in the Coastal population have more fragmented medulla than the other populations, but females in the Tribal population have more than the other two populations combined. Both males and females in the Coastal population had more missing medullas than in the other two populations, which have less. Similar findings on cuticle thickness indicate that, when compared to the two other populations, males of the Coastal population and females of the Urban population had thicker cuticles. When compared to the other two populations, the Coastal population has more males and females with thinner and absent cuticles. Similar results were found when the cortex and cuticle margin were analysed. Additionally, it is present in the cases of shaft diameter and medullary index. There are significant differences in the minimum, maximum, mean, and standard deviation of both parameters. After observing the results, it is characterized that, various morphological features that is medulla pattern, cuticle thickness, cuticle margin, cortex, medullary index, and shaft diameter can play a vital role in the forensic analysis and physical comparison of hair recovered from the scene of crime.

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