CHAPTER I: INTRODUCTION

A friction ridge is a raised portion of the epidermis on the digits (fingers and toes), the palm of the hand or the sole of the foot, consisting of one or more connected ridge units of friction ridge skin. These are sometimes known as "epidermal ridges" which are caused by the underlying interface between the dermal papillae of the dermis and the interpapillary (rete) pegs of the epidermis. These epidermal ridges serve to amplify vibrations triggered, for example, when fingertips brush across an uneven surface, better transmitting the signals to sensory nerves involved in fine texture perception. These ridges may also assist in gripping rough surfaces and may improve surface contact in wet conditions. [5]

Human fingerprints are detailed, nearly unique, difficult to alter, and durable over the life of an individual, making them suitable as long-term markers of human identity. They may be employed by police or other authorities to identify individuals who wish to conceal their identity, or to identify people who are incapacitated or deceased and thus unable to identify themselves, as in the aftermath of a natural disaster. A fingerprint is formed on any opaque surface and is the impression of the friction ridges on the finger of a human. The matching of two fingerprints is among the most widely used and most reliable biometric techniques. Fingerprint matching considers only the obvious features of a fingerprint. [9]

Fingerprint identification, known as dactyloscopy, is the process of comparing two instances of friction ridge skin impressions (see Minutiae), from human fingers or toes, or even the palm of the hand or sole of the foot, to determine whether these impressions could have come from the same individual. The flexibility of friction ridge skin means that no two finger or palm prints are ever exactly alike in every detail; even two impressions recorded immediately after each other from the same hand may be slightly different.[citation needed] Fingerprint identification, also referred to as individualization, involves an expert, or an expert computer system operating under threshold scoring rules, determining whether two friction ridge impressions are likely to have originated from the same finger or palm (or toe or sole).[6]

A fingerprint is an impression left by the friction ridges of a human finger. The recovery of partial fingerprints from a crime scene is an important method of forensic science.

Moisture and grease on a finger result in fingerprints on surfaces such as glass or metal. Deliberate impressions of entire fingerprints can be obtained by ink or other substances transferred from the peaks of friction ridges on the skin to a smooth surface such as paper. Fingerprint records normally contain impressions from the pad on the last joint of fingers and thumbs, though fingerprint cards also typically record portions of lower joint areas of the fingers. [2]

An intentional recording of friction ridges is usually made with black printer's ink rolled across a contrasting white background, typically a white card. Friction ridges can also be recorded digitally, usually on a glass plate, using a technique called Live Scan. A "latent print" is the chance recording of friction ridges deposited on the surface of an object or a wall. Latent prints are invisible to the naked eye, whereas "patent prints" or "plastic prints" are viewable with the unaided eye. Latent prints are often fragmentary and require the use of chemical methods, powder, or alternative light sources in order to be made clear. Sometimes an ordinary bright flashlight will make a latent print visible. [4]

When friction ridges come into contact with a surface that will take a print, material that is on the friction ridges such as perspiration, oil, grease, ink, or blood, will be transferred to the surface. Factors which affect the quality of friction ridge impressions are numerous. Pliability of the skin, deposition pressure, slippage, the material from which the surface is made, the roughness of the surface, and the substance deposited are just some of the various factors which can cause a latent print to appear differently from any known recording of the same friction ridges. Indeed, the conditions surrounding every instance of friction ridge deposition are unique and never duplicated. For these reasons, fingerprint examiners are required to undergo extensive training. The three basic patterns of fingerprint ridges are the arch, loop, and whorl:

- Arch: The ridges enter from one side of the finger, rise in the centre forming an arc, and then exit the other side of the finger. These occur in about 5% of the encountered fingerprints.
- Loop: The ridges enter from one side of a finger, form a curve, and then exit on that same side. These can be seen in almost 60-70% of the fingerprints that are encountered

- Whorl: Ridges form circularly around a central point on the finger. These can be founded in about 20-35% of the fingerprints that are encounter.

Scientists have found that family members often share the same general fingerprint patterns, leading to the belief that these patterns are inherited. [8]

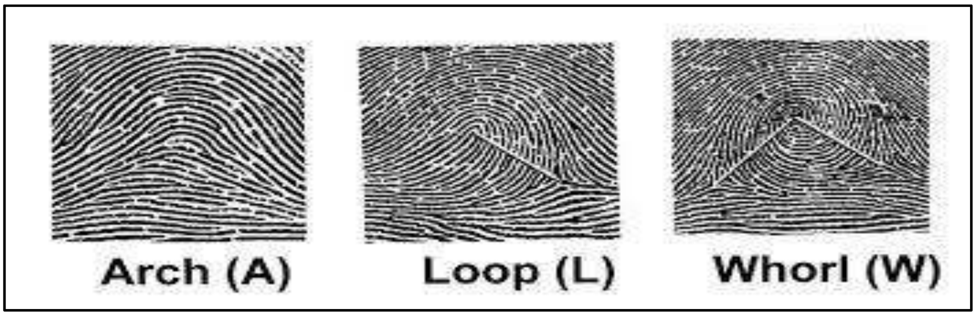


Figure 1: Basic Fingerprint Patterns

Subcategories of these patterns are

There are two sub-types of arch patterns

Plain arch: Raised ridges characterize this pattern and they extend from one side of the finger to the other in a continuous fashion. This pattern makes up a mere 5% of the total population, making it the rarest type.

Tented arch: Similar to the plain arch, the tented arch also has raised ridges flowing in the same fashion. The distinct difference comes in the pitch of the raised ridge. The tented arch has a sharper edge compared to the plain arch, which forms a tent like shape.

There are two sub types of loop patterns

Ulnar loop: In this pattern, the ridges turn backward, but they don't make a full turn. To identify an ulnar loop, you will notice the loops moving towards the small finger. You will see these turns only if you viewed them on the hand and not on a card.

Radial loop: This pattern is similar to the ulnar loop, but the difference is the turns point toward the thumb instead of small finger.

There are three sub types of whorl patterns

Plain whorl; A plain whorl will make a circular pattern which represents a swirl or a spiral. This circular pattern is unbroken and this revolution formed at the centre is a result of at least a single ridge. This is the simplest form of whorl and also most common.

Central pocket loop whorl: These whorls consists o at least one re-curving ridge or an obstruction at right angles to the line of flow with two delta and if an imaginary line is drawn in between then no re-curving ridge within the pattern area will be touché or cut. These whorl ridges make one complete circuit and may be oval, circular, spiral or any variant of a circle.

Accidental whorl: The comparison of the pattern in the accidental whorl is derived from two distinct types of patterns that have least two deltas. Therefore whorls containing ridges that match the characteristics of a particular whorl sub-grouping are referred to as accidental whorls.

Double loop: This pattern consists of two distinct loop formations. It has two distinct and separate shoulders for each core, two deltas and one more ridges that make a complete circuit. There is at least one re-curving ridge with in the inner pattern area between the two loop formations that gets touched or cut when an imaginary line is drawn. [4]

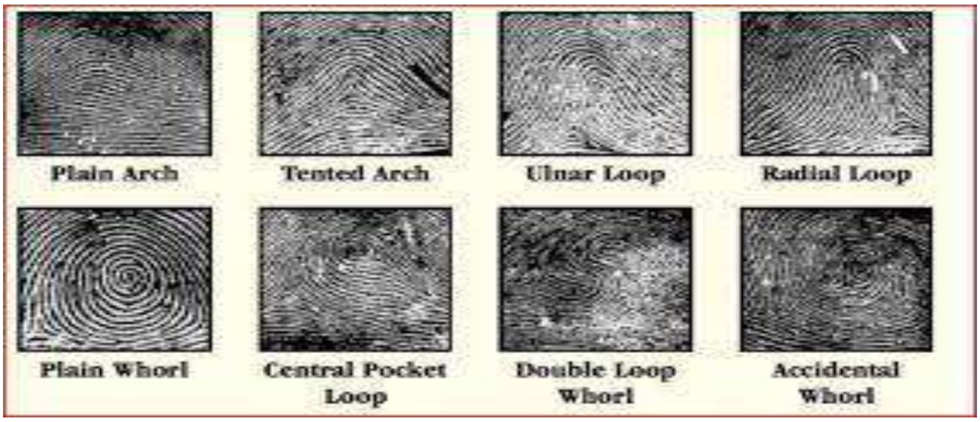


Figure 2: Subcategories of Patterns

Features of fingerprint ridges, called **minutiae**, include:

- Ridge ending: The abrupt end of a ridge
- Bifurcation: A single ridge dividing in two
- Short or independent ridge: A ridge that commences, travels a short distance and then ends
- Island or dot: A single small ridge inside a short ridge or ridge ending that is not connected to all other ridges
- Lake or ridge enclosure: A single ridge that bifurcates and reunites shortly afterward to continue as a single ridge
- Spur: A bifurcation with a short ridge branching off a longer ridge
- Bridge or crossover: A short ridge that runs between two parallel ridges
- Delta: A Y-shaped ridge meeting

- Core: A circle in the ridge pattern

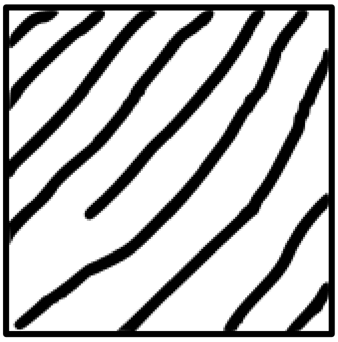


Figure 3: Ridge ending

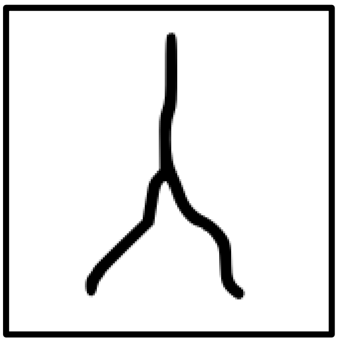


Figure 4: Bifurcation

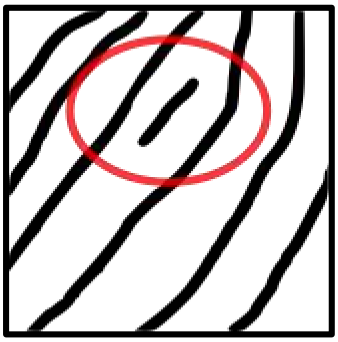


Figure 5: Short ridge (dot)

CHAPTER II: LITERATURE REVIEW

Vinod C. Nayak MD et.al. (2010) studied on Sex differences from fingerprint ridge density in the Indian population. The present study was undertaken to study the differences in fingerprint ridge density in Indian population. The study done on 100 males and 100 females revealed that significant sex differences occur in the fingerprint ridge density. The present study shows a statistically significant difference in people of Indian origin. A mean fingerprint ridge density of 12 ridges/25 mm2 or less is found to be more likely to be of males and a mean ridge count of more the 12ridges/25mm2 is more likely to be of female origin.

Hale Oktem et.al. (2015) studied on Sex differences in fingerprint ridge density in a Turkish young adult population: A sample of Baskent University. In this study they aimed to study fingerprint ridge density in Turkish population sample of Baskent University students. Fingerprints were obtained from 118 women, 88 men a total of 206 students aged between 17 and 28 years old by means of simple inking method. Fingerprints from all right and left hands fingers were collected in three different area of each. The ridges on fingerprints were counted diagonally on squares measuring 5 mm * 5 mm on radial, ulnar and inferior areas. The fingerprint ridge density in radial, ulnar and inferior areas and between sexes was compared statistically Mann Whitney U test and Friedman test. The ridge density was significantly greater in women in every region studied and in all fingers when compared to men. The fingerprint ridge density in the ulnar and radial areas of the fingerprints was significantly greater than the lower area. Fingerprint ridge density can be used by medico-legal examination for sex identification.

Vinod C. Nayak et.al.(2010) studied on Sex differences from fingerprint ridge density in Chinese and Malaysian population. The fingerprints are very typical for a human being. The present study was undertaken to study the gender differences in fingerprint ridge density in Chinese and Malaysian population. The study done on 200 subjects (100 males and 100 females) of Chinese origin and 100 subjects (50 males and 50 females) of Malaysian origin revealed that significant gender differences occur in the finger ridge density. Fingerprint mean ridge density of 12 ridges/25 mm2 or less is found to be more likely to be of males and a mean ridge count of more the 13 ridges/25 mm2 is more likely of female origin in Chinese subjects. Fingerprint mean ridge density of 11 ridges/25 mm2 or less is found to be more likely to be of males and a mean ridge count of more the 13 ridges/25 mm2 is more likely of female origin in Malaysian subjects.

Richard jonathan O. Taduran et.al.(2016) studied on Sex determination from fingerprint ridge density and white line counts in Filipinos. This study derived Filipino-specific probability formulae from fingerprints to be used for sex discrimination in human identification cases. Ridge density from three different areas – distal radial area, distal ulnar area, and proximal area – as well as white line counts from fingerprints of 200 male and 200 female Filipinos were collected and analyzed statistically. Ridge densities of radial and ulnar areas emerged as displaying significant differences between the sexes, with 16 ridges/25 mm2 or more in radial area and 15 ridges/25 mm2 or more in ulnar area being more likely to be female, whereas 13 ridges/25 mm2 or less in radial area and 12 ridges/25 mm2 or less in ulnar area were more likely to be male. A white line count of 0 was more likely to be male while a white line count of 2 or more was more likely to be female. The results of this study show sex differences in Filipino fingerprints and support the observation of previous studies that females have finer ridges than males.

Kewal Krishan et.al.(2013) studied on A study of sex differences in fingerprint ridge density in a North Indian young adult population. The present research is an attempt to distinguish sex from fingerprint ridge density in the radial, ulnar and lower areas of a fingerprint in a North Indian population. A total of 194 individuals (97 males and 97 females) aged between 18 and 25 years were included in the study and fingerprints were collected from each finger of the participants. The radial and ulnar areas are the 5 mm × 5 mm areas on the radial and ulnar side of the central core respectively while the lower area is designated as 5 mm × 5 mm area adjoining the flexion crease of the terminal phalanx on a fingerprint. The results indicate that the females tend to have a significantly higher ridge density than males in the three areas analyzed in the study. The fingerprint ridge density in the ulnar and radial areas of the fingerprints is significantly higher than the lower area.

Mark A Akree (1999) studied gender difference in fingerprint ridge density. The goal of this study is to determine if women have significantly higher ridge density, hence finer epidermal ridge detail, than men by counting ridges that occur within a well defined space. If significant gender differences do exist then the likelihood of inferring gender from given ridge densities will be explored. This study focused on 400 randomly picked ten-print cards representing 400 subjects. The demographic composition of this sample population represents 100 Caucasian males, 100 African American males, 100 Caucasian females and 100 African American females all within the age range of 18–67. Results show that women tend to have a significantly higher ridge density than men and that this trend is upheld in subjects of both Caucasian and African American descent ($F=81.96$, $P<0.001$). Application of Bayes' theorem suggests that a given fingerprint possessing a ridge density of 11 ridges/25 mm2 or less is most likely to be of male origin. Likewise a fingerprint having a ridge density of 12 ridges/25 mm2 or greater is most likely to be of female origin, regardless of race

Neeti Kapoor et.al. (2015) studied on Sex differences in the thumbprint ridge density in a central Indian population. The study was conducted on 200 subjects (100 males and 100 females) in the age group of 18–30 years. Ridge densities on the right- and left-hand thumbprints were determined using a newly designed layout and analysed statistically. The results showed that females tend to have a higher thumbprint ridge density in both the areas examined, individually and combined. Applying the t-test, the differences in the ridge densities of males and females at LoC (Left of Centre), RoC (Right of Centre) and Combined (LoC + RoC) were found to be statistically significant at $p < 0.01$ levels, proving the association between gender and fingerprint ridge density. Probability densities for men and women derived from the frequency distribution (at LoC, RoC and Combined) were used to calculate the likelihood ratio and posterior probabilities of gender designation for the given ridge count for subjects using Baye's theorem.

Esperanza Gutierraze-Redomero et.al.(2013) studied on A comparative study of topological and sex differences in fingerprint ridge density in Argentinian and Spanish population samples. The goal of this study was to determine the topological and sexual differences in fingerprint ridge density (RD) in native subjects from two samples of northwestern Argentina (Jujuy province) living at different altitudes. The results were compared with those obtained from a Spanish population sample. The study was based on data from all 10 fingerprints of 393 adult Argentinian men and women, 193 from the Puna-Quebrada region (more than 2500 m above sea level) and 200 from Ramal (500 m above sea level). Ridge density was assessed for three different areas (radial, ulnar and proximal) for all 10 fingers of each subject. In both samples, significant differences between areas were obtained, so radial RD > ulnar RD > proximal RD. No significant differences were found between samples in males, while females from both samples significantly differed in the radial and proximal areas. Females have higher RD, so narrower ridges, than men, in all areas and all fingers.

Pattanawit Soanboon et.al.(2016) studied on Determination of sex difference from fingerprint ridge density in northeastern Thai teenagers. Although, there has already been much research on the differences between sexes in fingerprint ridge density and its variability in the Thai population, such studies have not included native northeastern Thais aged between 14 and 24 who are descended from northeastern Thai ancestry. This study intends to determine the topological, agegrouping and sexual differences in fingerprint ridge density (RD) in such populations. Fingerprints were collected from 353 unrelated volunteers (191 males and 162 females) and classified into three groups, that is, group A (total subjects), group B (14–18 years old) and group C (18–24 years old). RD was assessed for two topological areas, radial and ulnar. Significant differences between genders and age groups were obtained in both counting areas. Females exhibit higher RD i.e. narrower ridges, than males. A decrease in RD values with increasing age was also detected. The RD threshold for discrimination of sexes, computed based on Bayes' theorem, was achieved in all groups and counting areas, enabling its use in forensic investigation.

Esperanza Gutierraze-Redomero et.al. (2014) studied on Assessment of the methodology for estimating ridge density in fingerprints and its forensic application. In recent times, some studies have explored the forensic application of dermatoglyphic traits such as the epidermal ridge breadth or ridge density (RD) toward the inference of sex and population from fingerprints of unknown origin, as it has been demonstrated that there exist significant differences of fingerprints between sexes and between populations. Part of the population differences found between these studies could be of methodological nature, due both to the lack of standardization in the position of the counting area, as well as to the differences in the method used for obtaining the fingerprint. Therefore, the aim of this study was to check whether there are differences between the RD of fingerprints depending on where the counting area is placed and how the fingerprints are obtained. Fingerprints of each finger were obtained from 102 adult Spanish subjects (50 females and 52 males), using two methods (plain and rolled). The ridge density of each fingerprint was assessed in five different areas of the dactylogram: two closer to the core area (one on the radial and the other on the ulnar side), two closer to the outermost area of each of the sides (radial and ulnar), and another one in the proximal region of the fingertip. Regardless of the method used and of the position of the counting area, thumbs and forefingers show a higher RD than middle, ring, and little fingers in both sexes, and females present a higher RD than males in all areas and fingers. In both males and females, RD values on the core region are higher than those on the outer region, irrespective of the technique of fingerprinting used (rolled or plain). Regardless of the sex and location of the count area (core or outer), the rolled fingerprints exhibit RD greater than that of the plain ones in both radial and proximal areas, whereas the trend is inverted in the ulnar area, where rolled fingerprints demonstrate RD lesser than that of the plain ones. Therefore, in order for the results of different studies to be comparable, it is necessary to standardize the position of the count area and to use the same method of obtaining the fingerprint, especially when involving a forensic application.

CHAPTER III: AIMS AND OBJECTIVES

AIM:

To study the difference of fingerprint ridge density between males and females

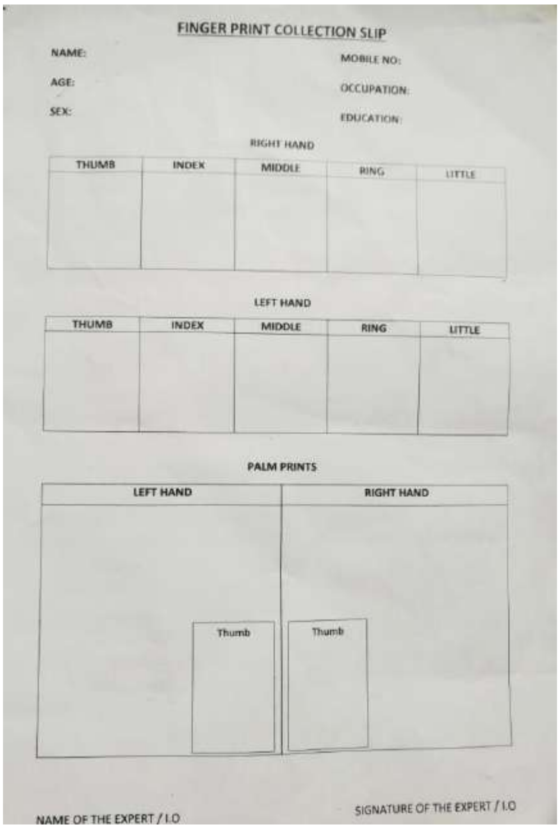
OBJECTIVES:

- To identify variations in ridge density of males.
- To identify variations in ridge density of females.
- To identify variations in ridge density according to age.

CHAPTER IV: MATERIALS AND METHODOLOGY

MATERIALS

1. A quality black ink formulated for this purpose (Generally black printers ink)
2. Ink roller
3. Inking plate (constructed of glass)
4. Ink cleaning supplies
5. Fingerprint or palm print cards for recording the prints
6. Magnifying Glass
7. Measuring scale
8. Markers



FINGER PRINT COLLECTION SLIP

NAME:
AGE:
SEX:
MOBILE NO:
OCCUPATION:
EDUCATION:

RIGHT HAND

THUMB	INDEX	MIDDLE	RING	LITTLE

LEFT HAND

THUMB	INDEX	MIDDLE	RING	LITTLE

PALM PRINTS

LEFT HAND	RIGHT HAND
Thumb	Thumb

NAME OF THE EXPERT / I.O
SIGNATURE OF THE EXPERT / I.O

Figure 6: Fingerprint Collection Slip

Figure 7: Rubber ink roller

METHODOLOGY

The samples for the selected study consisted of fingerprints from 25 males and 25 females were chosen randomly from Malappuram city, aged between 18 years to 40 years. The purpose of this study was explained and verbal informed consent was taken from all the subjects' individually. Before taking fingerprints, the subjects were asked to clean their hands. A plain glass plate of 15 cm^2 is smeared with fingerprinting black ink with the help of a roller that was used for the collection of prints. The subjects were asked to roll their finger from the radial side (thumb) to the ulnar side (little finger) on the smeared plate and then transferred their finger prints in the same manner onto the specified space on the bond paper. In this manner, fingerprints of all the ten fingers were obtained from each individual.

For analysis, constructed two squares of 5×5 mm^2 each and placed them on the second ridge above the central core in both the radial and ulnar areas. In each square ridges were counted from one corner to the diagonally opposite corner. Dots won't be counted, while forks and lakes are counted as two ridges. To count the ridges, each fingerprint on a collected fingerprint card was scanned to an image format file. The images are then superimposed on the two squares of 5×5 mm^2, each with one diagonal line, which are constructed on a spreadsheet using the Microsoft Word program. The superimposed images are enlarged five times for more precise ridge counting. Value was obtained for all 10 fingers and the mean was calculated. This mean represented single data point for that particular individual.

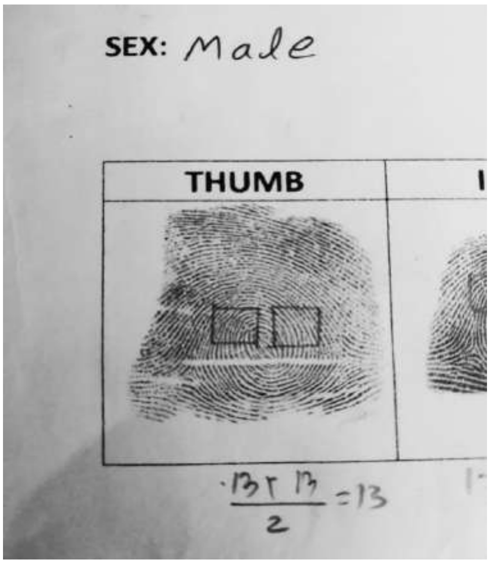


Figure 8: Fingerprint of male.

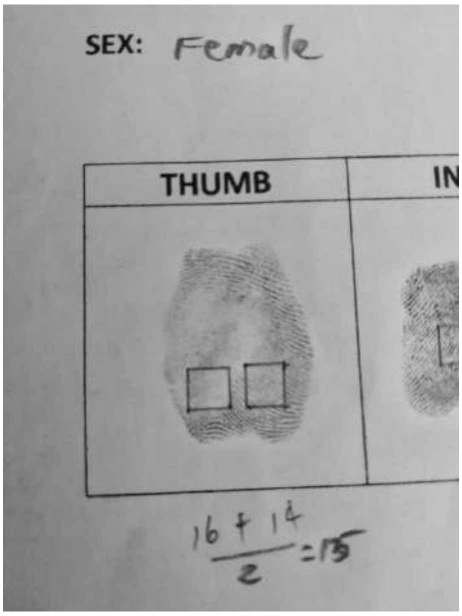


Figure 9: Fingerprint of female.

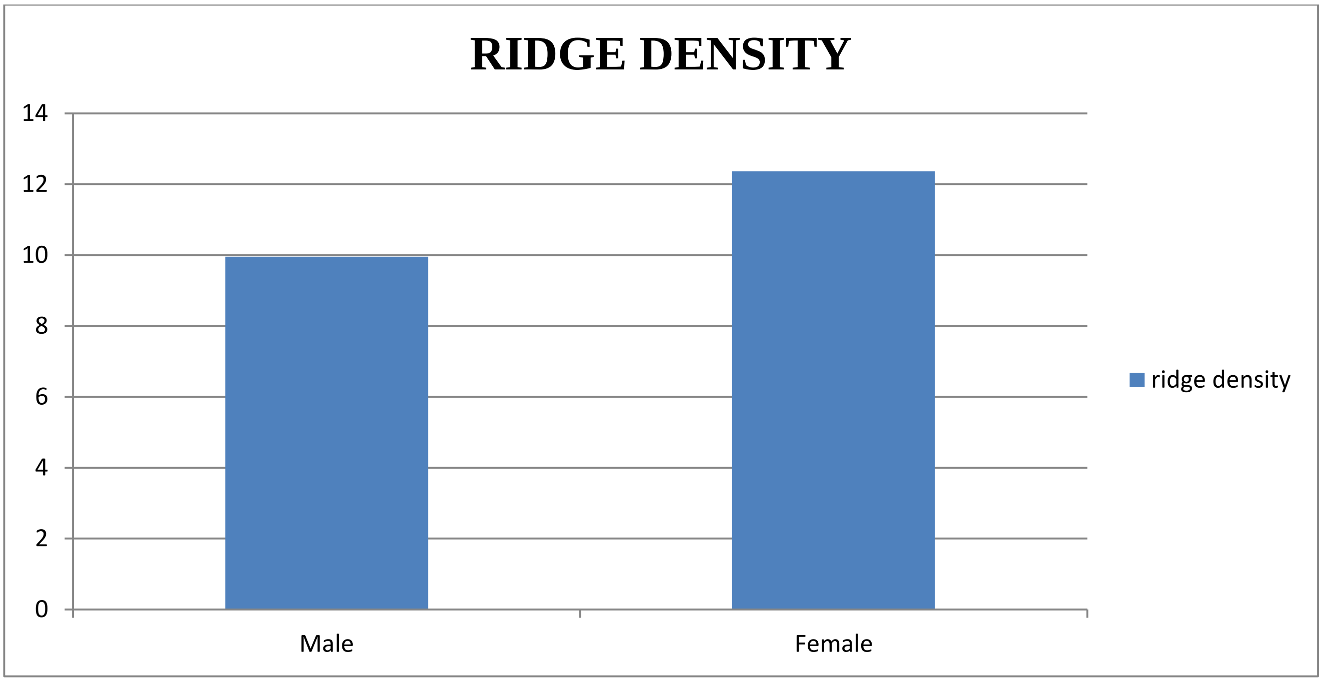
CHAPTER V: OBSERVATION AND CALCULATION

Table 1: Ridge Density of Male

SAMPLES	AGE	RIGHT HAND	LEFT HAND	AVERAGE	TOTAL AVERAGE
1	22	12.8	11.5	12.8	9.956
2	22	13.2	11.9	12.5	
3	40	12.7	10.4	12.5	
4	40	13.5	13.6	13.55	
5	32	12.8	11.9	12.35	
6	40	10.6	10.8	10.7	
7	30	12.8	12.5	12.7	
8	29	12	11.3	11.65	
9	40	11.3	10.2	10.75	
10	20	11	9.3	10.15	
11	29	11.9	11.1	11.5	
12	32	11.4	11.9	11.65	
13	30	14.5	13.4	13.95	
14	27	12	12.7	12.35	
15	21	12.2	13	12.6	
16	24	12.1	12.7	12.4	
17	26	12.9	13.4	13.15	
18	30	12.5	12.5	12.5	
19	32	11.9	12.2	12.05	
20	23	11.3	11.4	11.65	
21	25	11.8	12	11.9	
22	18	13	12.5	12.75	
23	34	10.8	11.2	11	
24	28	13.6	12.2	12.9	
25	20	12.4	12.8	12.6	

Table 2: Ridge Density of Female

SAMPLES	AGE	RIGHT HAND	LEFT HAND	AVERAGE	TOTAL AVERAGE
1	20	15.3	14	14.65	12.365
2	33	15.1	16.4	15.75	
3	37	15.1	15.2	15.15	
4	19	16.4	15.4	15.9	
5	20	16.35	16.4	16.35	
6	34	13	14.5	14.7	
7	40	12.3	11.8	12.05	
8	25	14.9	19.3	17.1	
9	35	16	16.2	16.1	
10	36	13.7	14.5	14.1	
11	38	15.4	14.2	14.8	
12	22	17	18.3	17.65	
13	18	16.3	16.3	14.3	
14	35	13	13.1	13.05	
15	40	13.2	12.9	13.05	
16	28	15	15.5	15.25	
17	26	14.9	15.2	15.05	
18	31	13.8	14	13.9	
19	19	16.2	15.7	15.95	
20	23	15.3	15.1	15.2	
21	33	13.6	14	13.8	
22	40	12.5	12.4	12.45	
23	18	15.4	14.8	15.1	
24	24	14.4	14.7	14.55	
25	30	16.1	15	15.55	



Graph 1: Graph of total average of fingerprint ridge density

CHAPER VI: RESULTS AND CONCLUSION

Results:

In the present study the average ridge density for Male in the age group 18-40 years is calculated as 9.956 and the average of ridge density for Female in the age group 18-40 years is 12.365.

Conclusion:

In the present study, the average of ridge density of Female is greater than the average of ridge density of Male in Malappuram city. Thus it is concluded that ridge density in fingerprint pattern is the best parameter for identification of sex. The fingerprint ridge density of females is more than that of males.

In the future this study can be done to differentiate fingerprint ridge density in various age groups and population of various regions of Kerala.

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