

## ORIGINAL ARTICLE

**Sexual Dimorphism from Palmprint Ridge Density among Malaysian Tamils for Person Identification***Nataraja Moorthy T<sup>1\*</sup>, Rajathi S<sup>1</sup>**<sup>1</sup>Department of Diagnostic and Allied Health Science, Faculty of Health and Life Sciences, Management and Science University, Shah Alam, Selangor State, Malaysia***Abstract**

*Background:* Fingerprints and palmprints form a valuable physical evidence in the scenes of crime. Palmprint ridge density is a vital tool used for person identification during forensic investigation. Palmprints are found impressed on the surface when a person touches a surface. *Aim and Objectives:* This research was aimed to investigate the ridge density on six areas in a palmprint on both sides among Malaysian Tamils for person identification. *Material and Methods:* This study sample consisted of 280 adult Malaysian Tamils including 140 males and 140 females. By inking technique 560 palmprint samples were collected from the subjects for sexual dimorphism analysis. The six prominent areas on the palmprints were chosen that included Thenar region (P1), Hypothenar region (P2), Triradius of second digit (P3), Triradius of fifth digit (P4), Triradius of third digit (P5) and Triradius of fourth digit (P6) for examination. *Results:* The results revealed that the mean palmprint ridge density was significantly greater in females (10.26-12.03) than males (9.57-11.26) in all the designated areas (P1 to P6). The ridge density in the left hand was not the mirror image of right hand, showing the bilateral asymmetry. *Conclusion:* The study findings revealed that palmprint ridge density was sexually dimorphic among Malaysian Tamil population.

**Keywords:** Forensic Anthropology, Palmprint, Sexual Dimorphism, Malaysian Tamil

**Introduction:**

The crime scene is a critical element of criminal investigations and wherein forensic science

begins. Inadequately managed scenes lead to poor evidence and risk of wrongful convictions [1]. Hence the crime scene investigators should be more knowledgeable in searching and recognizing the evidence material found in the crime scenes and apply their knowledge and skill to identify the fact in the crime scenes, so that the fact may be accepted by the sentencing authority in the courts. Crime scenes contain physical evidence that is pertinent to a criminal investigation. Physical evidence is anyone and all subjects used to establish that crime has been committed [2]. Crime scenes mostly contain impression evidence such as fingerprints, palmprints, footprints, since the perpetrators used to walk and touch the objects during the crime operations. Researchers have been developing regression formulae to determine stature [3], body weight [4] and gender [5] from footprints. Also similar research works have been conducted to determine stature from handprint [6], fingerprint [7] and palmprint [8]. Literature review shows that human sex can be determined even from morphometry of eyes [9]. Limited studies were conducted on gender determination from fingerprint and an attempt was made by the researchers on sexual dimorphism from palmprint. Palmprint recognition is a biometric authentication method based on the unique patterns of various

characteristics in palms of the people's hand [10]. During crime scene investigations, a full or partial palmprint may sometimes obtained even in the absence of fingerprints. Literature review did not show any palmprint study for sexual dimorphism for crime scene application. Hence the present study was aimed to investigate sexual dimorphism from palmprint ridge density among Malaysian Tamils for person identification.

### Material and Methods:

The study recruited 280 consented adult Malaysian Tamils (140 males and 140 females), an ethnic group born and living in Malaysia. The subjects were healthy with age ranged from 18 to 55 years. Subjects with any deformity or injury in the hands were excluded from the study. Ethical approval was obtained from the University Human Ethics Committee. The subjects were fully explained about this research and they were ready to participate in this study. Just before the sample collection, the subjects were advised to wash their hands with soap solution and clean with cotton towel. By using plain clean glass plate, fingerprint roller and fingerprint ink, the palmprints of both hands were collected in white A4 size paper, following the standard procedure of inking technique [6,9]. All palmprints of the subjects and information relating to participants were coded with sample ID for anonymity. There are many crime incidents wherein the investigators could find only partial or incomplete palmprint with fragmented areas that may not be found useful for identification. In order to overcome this lacuna, the present study used six designated areas (P1 to P6) in a palmprint, and ridge density was calculated in 5mm × 5mm square in all areas and

calculated the ridge density to study sexual dimorphism and ease the investigation. The palmprint density in all these areas were analysed by using a Magnifier (Waltex model) with appropriate magnification and recorded the findings. The data was analysed statistically and the p value for gender variation was calculated by using Mann-Whitney U test and ascertained the gender variation. The findings were presented in the form of tables and figures.

### Results:

Fig. 1 shows the designated areas in a palmprint for ridge density analysis. Earlier researchers have used only P1 to P4 areas while the present study added two more areas viz. P5 and P6.

P1: Thenar Region

P2: Hypothenar Region

P3: Triradius of Second Digit

P4: Triradius of Fifth Digit

P5: Triradius of Third Digit

P6: Triradius of Fourth Digit

Table 1 shows the mean ridge density in all designated areas (P1-P6) among male palmprints. The study examined 140 right and 140 left palmprints with a total of 1680 number of areas among male population. The mean ridge density is comparatively higher in P6 area in both left and right palm prints and least ridge density in P1 area. The p values are statistically significant.

Table 2 presents the mean ridge density in all designated areas among female palmprints on both sides. The study also analysed 140 right and 140 left hands with a total of 1680 number of areas among female population. The mean ridge density is comparatively higher in right palm area P2 and least in P4. The ridge density analysis shows that

females have higher ridge density than males in all the designated area in both sides. The p values were also found to be statistically significant. Figures 2 and 3 depicted the mean ridge densities observed in all designated areas, P1 to P6 among males and females. It showed that the mean palm ridge density was found to be higher in females than males in all the six designated areas of palmprints. Another important feature observed in

the investigation is the existence of bilateral asymmetry in palmprint ridge density.

The measure of asymmetry has been used in population and genetic studies [11-12]. The present study reflected bilateral asymmetry in palmprint ridge density in both sides and gender except P4 region in female palmprint showing similar ridge density (10.26) on both sides.

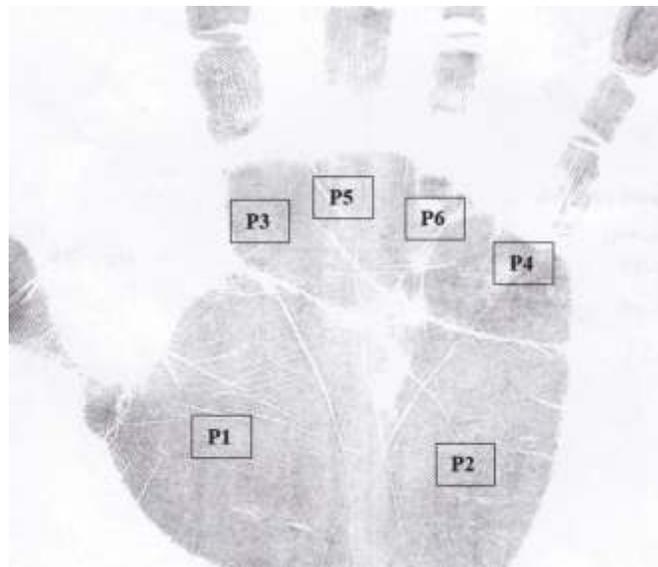


Fig. 1: Six Designated Areas in a Palmprint of a study subject

Table 1: Descriptive Statistics of Ridge Density in Male Palmprint Areas

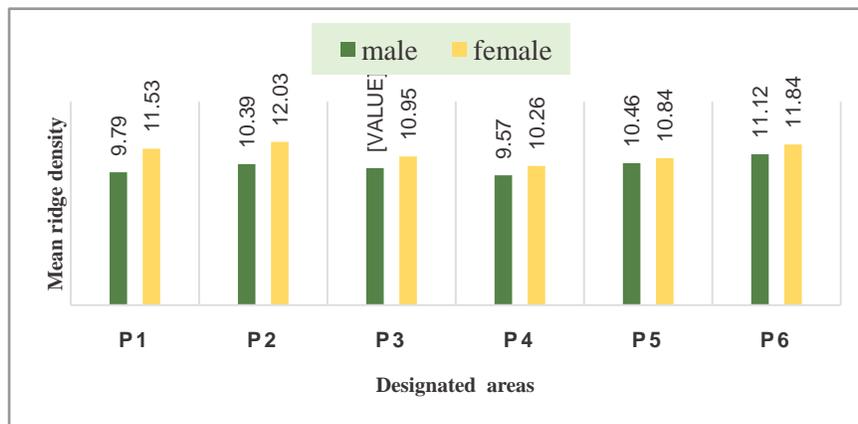
Areas	P1		P2		P3		P4		P5		P6	
	R	L	R	L	R	L	R	L	R	L	R	L
<b>N</b>	140	140	140	140	140	140	140	140	140	140	140	140
<b>Mean</b>	9.79	9.68	10.39	10.77	10.10	10.42	9.57	10.10	10.46	10.76	11.12	11.26
<b>SD</b>	1.48	1.54	1.38	1.12	1.67	1.10	1.15	1.23	1.10	1.12	1.26	1.30
<b>Range</b>	7-14	6-15	7-14	8-14	7-13	8-13	7-14	8-13	7-14	7-15	8-14	8-14
<b>P</b>	0.519		0.016		0.01		0.698		0.013		0.449	

N: Sample size, R: Right, L:Left, SD: Standard deviation, P1 to P6: Designated areas in palmprints on both sides

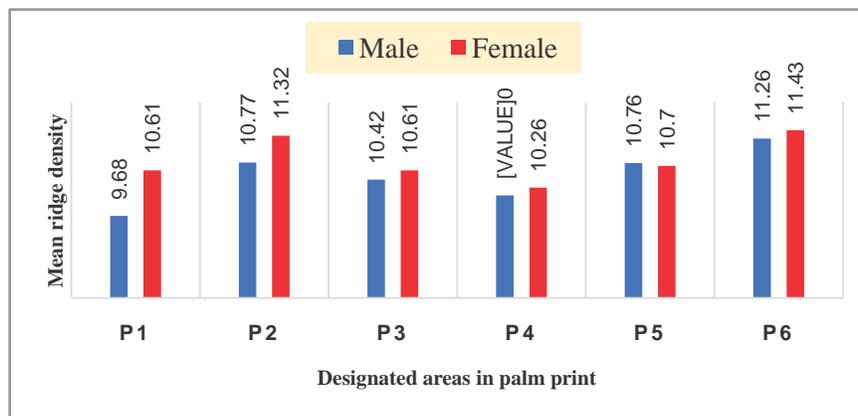
**Table 2: Descriptive Statistics of Ridge Density in Female Palmprint Areas**

Areas	P1		P2		P3		P4		P5		P6	
Side	R	L	R	L	R	L	R	L	R	L	R	L
N	140	140	140	140	140	140	140	140	140	140	140	140
Mean	11.53	10.61	12.03	11.32	10.95	10.61	10.26	10.26	10.84	10.70	11.84	11.43
SD	1.66	1.36	1.55	1.38	1.23	1.26	1.21	1.38	1.53	1.41	1.71	1.23
Range	7-15	7-14	6-15	7-14	7-14	7-14	6-13	6-14	6-14	7-14	7-14	9-15
P	0.000		0.000		0.011		0.698		0.344		0.006	

N: Sample size, R: Right, L: Left, SD: Standard deviation, P1 to P6: Designated areas in palmprints on both sides



**Fig. 2: Mean Ridge Density in All Designated Areas in Right Palmprint**



**Fig. 3: Mean Ridge Density in All Designated Areas in Left Palmprint**

**Discussions:**

The human hand is the most essential part of our body that aids the scientific community for use in person identification, in the form of physical evidence viz. fingerprint, palmprint and handprint in many crime scenes. Gender determination plays a crucial role during crime scene investigation and the investigators feel free once the sex is decided in a mysterious crime. Palmprints are found in the crime scenes either as visible prints, or latent/invisible prints in burglary and sexual assault cases. The forensic crime scene experts used various techniques for enhancement of latent print to visible for further examinations. In the past, fingerprint examiners assumed that women have finer epidermal ridge detail while men have coarse ridge detail. Acree conducted the study by using record of Federal Bureau of Investigation ten-print card containing all ten inked fingerprints (200 males and 200 females) of an individual. Based on Bayes' theorem, he found out that ridge density of 11 ridges/25 mm or less is most likely to be of male origin and ridge density of 12 ridges/ 25mm or greater is most likely to be of female origin [13]. Then fingerprint researchers have conducted study on fingerprint ridge density in various populations in different countries and recorded their research findings [14-20].

Thus the fingerprint ridge density results provided useful information for gender determination across the world and the same technique was applied to investigate on footprint and toeprint ridge density [21-23]. In the same way, anthropological researchers are showing interest in the determination of gender from palmprint for crime scene investigation [24-27]. Limited studies were

conducted relating palmprint ridge density and gender [9, 25] and the authors have analysed the ridge density only on four areas in a palmprint. But the present study investigated 6 areas in a palmprint and thus providing appreciable scope for identification, even though partial palmprints are found in the crime scenes. The present study showed that the ridge densities are found to be greater in P6, P2 regions and lesser in P4, P1 regions, while north Indian population study recorded greater ridge densities in P4, P3 and lesser in P2, P1 regions showing the population variation [25]. It is the duty of the investigators to understand the value of palmprint ridge density so as to apply in real crime scenarios. Some of the investigators have been still underestimating the value of this physical evidence and neglected from the initial stage of investigation [28] and even closed the investigation, recorded with "No clue/evidence" in the crime scenes. These impression evidence such as fingerprint, footprint and palmprints are found almost in all crime scenes. They may be present in the form of either two dimensional [29] or three dimensional [30], and also left by the perpetrators as latent [31] or visible impression [7] and found useful to solve crime mystery. It is the duty of the investigators to recognize the latent impression through enhancement techniques and may be used for person identification [32].

**Conclusion:**

It is concluded that the present study revealed the existence of sexual dimorphism from palmprint ridge density among Malaysian Tamils. The palmprint ridge density results may be used as a corroborative evidence in the initial stage of

investigation for inclusion or exclusion of potential suspects, followed by person identification during crime scene investigation. It is important to note that this study findings were suitable for Malaysian Indians only and unfit to use for any other population in the world.

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\***Author for Correspondence:** Dr. Nataraja Moorthy, Department of Forensic Sciences, Faculty of Health and Life Sciences, Management and Science University, Shah Alam, Selangor State, Malaysia  
Email: natrajamoorthy@rediffmail.com Cell: +6 0129224610