

**UNIVERSITI SAINS MALAYSIA  
PROJEK PENYELIDIKAN JANGKA PENDEK  
LAPORAN AKHIR**

**TRACING THE ORIGIN OF THE MALAY  
RACE THROUGH THE MORPHOLOGICAL,  
HISTORICAL, SOCIO-CULTURAL AND  
GENETIC ANALYSES**

**PENYELIDIK**

**DR. ZAFARINA ZAINUDDIN**

**PENYELIDIK BERSAMA**

**PROF. NORAZMI MOHD. NOR**

**PROF. OOI KEAT GIN**

**PROF. MADYA DR. ZILFALIL ALWI**

**PROF. MADYA DR. ZAINUL AHMAD RAJION**

**PROF. MADYA DR. LIZA SHARMINI AHMAD TAJUDIN**

**MR. S.PANNEERCHELVAM**

**2011**

*FINAL REPORT*  
**FUNDAMENTAL RESEARCH GRANT SCHEME**

*TITLE:*

**TRACING THE ORIGIN OF THE MALAY RACE THROUGH THE  
MORPHOLOGICAL, HISTORICAL, SOCIO-CULTURAL AND  
GENETIC ANALYSES.**

*PROJECT LEADER:*

**DR ZAFARINA ZAINUDDIN**

*CO-RESEARCHERS:*

**Prof Norazmi Mohd Nor**

**Prof Ooi Keat Gin**

**Prof Madya Dr Zilfalil Alwi**

**Prof Madya Dr Zainul Ahmad Rajion**

**Prof Madya Dr Liza Sharmini Ahmad Tajudin**

**Mr S.Panneerchelvam**

**UNIVERSITI SAINS MALAYSIA**

**2007-2010**

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## FINAL REPORT FUNDAMENTAL RESEARCH GRANT SCHEME (FRGS)

*Laporan Akhir Skim Geran Penyelidikan Asas (FRGS) IPT*

*Pindaan 1/2009*

**A RESEARCH TITLE :** Tracing the origin of the Malay race through the morphological, historical, socio-cultural and genetic analysis.  
*Tajuk Penyelidikan*

**PROJECT LEADER :** Dr. Zafarina Zainuddin  
*Ketua Projek*

**PROJECT MEMBERS (including GRA) :**

1. Prof Norazmi Mohd Nor
2. Prof Ooi Keat Gin
3. Prof Madya Dr Zilfalil Alwi
4. Prof Madya Dr Zainul Ahmad Rajion
5. Prof Madya Dr Liza Sharmini Ahmad Tajudin
6. Mr S.Panneerchelvam

RESEARCH FINDINGS

**B**

### ACHIEVEMENT PERCENTAGE

Project progress according to milestones achieved up to this period

0 - 50%

51 - 75%

76 - 100%

Percentage

100%

### RESEARCH FINDINGS

	Indexed Journal	Non-Indexed Journal
Number of articles/ manuscripts/ books	1. Edinur, H.A., Zafarina, Z., Spínola, H., Nurhaslindawaty, A.R., Panneerchelvam, S. and Norazmi, M.N (2009) HLA polymorphism in six Malay sub-ethnic groups in Malaysia. <i>Human Immunology</i> . 70: 518-526.	1. Zafarina, Z. and Nurhaslindawaty A.R. (2008) The mitochondrial DNA diversity of Kelantanese Malays. In <i>Prosiding Seminar Antarabangsa Pemandiran Budaya Tamadun Timur Laut</i> , Universiti Teknologi MARA, Shah Alam, Selangor. pp 19-23
	2. Abd Rashid Nur Haslindawaty, Sundararajulu Panneerchelvam, Hisham Atan Edinur, Mohd Nor Norazmi and Zainuddin Zafarina (2010) Sequence polymorphisms of mtDNA HV1, HV2 and HV3 regions in the Malay population of Peninsular Malaysia. <i>International Journal of Legal Medicine</i> 124:415-426.	2. Nurhaslindawaty, A.R., Panneerchelvam, S. and Zafarina Z. (2009) Analysis of mitochondrial DNA polymorphism in Kelantan Malays. <i>Proceedings of 8<sup>th</sup> Malaysia Congress on Genetics</i> , p: 139-143.
	3. Mapping human genetic diversity in Asia (2009) The HUGO Pan-Asian SNP Consortium <i>Science</i> 326, 1541-1545.	3. STR variation in Malays of Kelantan and Minang. Hoh BP, Nur Shafawati AR, Ooi KG, Zilfalil BA. (2008). <i>Pertanika Journal of Tropical Agricultural Science</i> 31:135-140  4. Zainul Rajion, Ali Al-Khatib, Ahmad Yusdirman Yusof, Sam'an Masudi and Rozita Hassan (2009)

**Paper presentations**

Siza and Shape Analysis of Female Nose in Malay Ethnic. *dentika Dental Journal* vol 14(1): 24-28

**International**

**National**

1) Nurhaslindawaty A.R, Zafarina Z. and Panneerchelvam S., A preliminary study of mtDNA sequence polymorphisms in Malay sub-populations, in *International DNA symposium 2007*, 11-13<sup>th</sup> November 2007, Kuala Lumpur.

2) Human Genome Organization (HUGO), Cebu, Philippines. 2<sup>nd</sup> -6<sup>th</sup> Apr 2008

3) International Joint Symposium in Gadjah Mada University, Yogyakarta. 24<sup>th</sup> -25<sup>th</sup> Nov 2008

4) Zafarina Z. and Nurhalindawaty, A.R. (2008) Mitochondrial DNA diversity of the Kelantanese Malays, in Seminar Antarabangsa Pemandiran Budaya Tamadun Timur Laut, 25-26 August, Universiti Teknologi MARA, Shah Alam, Selangor.

5) Al-Khatib AR, Rajion ZA, Masudi SM and Hassan R (2009) Evaluation of error in soft tissue landmarks aquired from MyCranio 3D stereophotogrammetry. 66<sup>th</sup> MDA AGM and MDA/FDI International Scientific Convention and Trade Exhibition.

6) Zaw TA, Al-Khatib AR, Rajion ZA, Luddin N, Johari Y and Husein A. Prevalence of Torus Palatinus in HUSM (2009). 66<sup>th</sup> MDA AGM and MDA/FDI International Scientific Convention and Trade Exhibition.

7) Alia Shahril, Zafarina Zainuddin and Norazmi Mohd Nor (2009) HLA analysis of four Malay sub-ethnic groups of Peninsular Malaysia. International symposium of forensic and environmental health. 9-11 Nov, PWTC, Kuala Lumpur, Malaysia.

8) Zainul Ahmad Rajion and Ali R Al-Khatib (2009). Computer aided photogrammetry for nasal analysis. Regional Dental Meeting and Exhibition, Faculty of Dentistry University of Sumatera Utara, Medan, Indonesia.

9) . Al-Khatib, A.R., Rajion, Z.A. Masudi, S.M. and Hassan, R. (2009) The relationship of facial and dental arch morphology in Malay adults: 3D assessment using stereophotogrammetry. 67<sup>th</sup> MDA AGM and

1) Al-Khatib AR, Rajion ZA and Yusdirman AY (2008) Comparison of the facial features between two Malay ethnics applying geometric morphometric method: A preliminary study. 13<sup>th</sup> National Conference on Medical Sciences. 22<sup>nd</sup> - 23<sup>rd</sup> May 2008, Kelantan, Malaysia.

2) 10<sup>th</sup> Symposium of the Malaysian Society of Applied Biology. 6<sup>th</sup> - 8<sup>th</sup> Nov 2008

3) Edinur Hisham, Zafarina Zainuddin, Spinola helder, Panneerchelvam, S., Norazmin Mohd Nor and Nadia, T.P (2008) HLA polymorphism in six Malay ethnic groups in Malaysia. 3<sup>rd</sup> International Conference on Postgraduate Education, 16-17 December, Penang, Malaysia.

4) Ali R Al-Khatib, Zainul Ahmad Rajion, Rozita Hassan and Sam'an Malik Masudi (2009). Angular photogrammetric assessment of facial profile in Malay adults. 14<sup>th</sup> National Conference on Medical and Health Sciences. 21<sup>st</sup>-22<sup>nd</sup> of May 2009.

5) Regional Conference on Molecular Medicine (RCMM), 2<sup>nd</sup> -4<sup>th</sup> of May 2009, Kelantan.

6) Nurhaslindawaty, A.R, Panneerchelvam S and Zafarina Z. (2009) Analysis of mitochondrial DNA polymorphism in Kelantan Malays. 8<sup>th</sup> Malaysia Congress on Genetics, 4-6 August, Genting Highlands, Malaysia.

7) Naliny Paliany, Kaneez Fatima Amla, Zainul Ahmad Rajion and Ali Rajih (2009). An anthropometric study of upper lip in Malays. 7<sup>th</sup> Student Scientific Conference.

8) Wan Nur Hatim Wan Isa, Nur Shafawati Ab Rajab, Mohd Khairi

	MDA/FDI International Scientific Convention and Trade Exhibition.	<p>Zahri, Shuhua Xu, Li Jin, Mohammed Rizman Idid and Bin Alwi Zilfalil (2010) Population genetic structure and ancestry of Peninsular Malaysia Malay sub-ethnic groups. 15th National Conference on Medical Sciences and Health Sciences. 21<sup>st</sup> - 22<sup>nd</sup> July 2010.</p> <p>9) Che Nor Ayunni ZB, Bakiah S, and Liza-Sharmini AT (2010).A study on the ocular features of malays: comparison among 7 subethnic groups. 15<sup>th</sup> National Conference on Medical Sciences and Health Sciences. 21<sup>st</sup>-22<sup>nd</sup> July 2010.</p> <p>10) Ali R, Al-Khatib, Zainul AR, Sam'an, MM and Rozita, H. (2010) Differences in dental arch between 13 and 30 years in Malay samples. 15<sup>th</sup> National Conference on Medical Sciences and Health Sciences. 21<sup>st</sup> - 22<sup>nd</sup> July 2010.</p>
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<b>Others (Please specify)</b>	Conference And Exhibition -- ITEX 2008 (silver medal) Conference And Exhibition – BIO MALAYSIA (bronze medal) 'The Genesis of Peninsular Malay Kingdoms, c. 5 <sup>th</sup> century CE to 17 <sup>th</sup> century CE'. Ed: Ooi Keat Gin, Penerbit USM, Penang. ( <i>in press</i> )
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#### HUMAN CAPITAL DEVELOPMENT

Human Capital	Number		Others (Please specify):
	On-going	Graduated	
PhD Student	3	-	Two of the PhD students are in the final process of submitting their theses.
Masters Student	4	1	
Undergraduate Students	-	3	
Temporary Research Officer		1	
Temporary Research Assistant		4	
<b>Total</b>		16	

#### C Project 1: Historical and Socio-Cultural analysis (Prof Ooi Keat Gin) 203/PHUMANITI/671103

<b>Budget Approved</b> ( <i>Peruntukan diluluskan</i> )	: RM 102,495.00
<b>Amount Spent</b> ( <i>Jumlah Perbelanjaan</i> )	: <u>RM 65,782.02</u>
<b>Balance</b> ( <i>Baki</i> )	: <u>RM 36,712.98</u>
<b>Percentage of Amount Spent</b> ( <i>Peratusan Belanja</i> )	: 64.18%

**Project 2: Mitochondrial DNA analysis (Dr Zafarina Zainuddin) 203/PPSK/6171005**

**Budget Approved** (*Peruntukan diluluskan*) : RM 156,900.00  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 156,899.95  
**Balance** (*Baki*) : RM 0.05  
**Percentage of Amount Spent** : 100%

**Project 3: Autosomal STR and Y STR analysis (Mr S Panneerchelvam) 203/PPSK/6171006**

**Budget Approved** (*Peruntukan diluluskan*) : RM 183,400.00  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 181,273.97  
**Balance** (*Baki*) : RM 2,126.03  
**Percentage of Amount Spent** : 98.8%  
(*Peratusan Belanja*)

**Project 4: SNP analysis (Prof Madya Dr Zilfalil Alwi) 203/PPSP/6170025**

**Budget Approved** (*Peruntukan diluluskan*) : RM 580,385.00 (Bajet asal=RM577,885.00 + RM2500 dari Projek 1)  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 580,319.33  
**Balance** (*Baki*) : RM 65.67  
**Percentage of Amount Spent** : 99.99%  
(*Peratusan Belanja*)

**Project 5: HLA analysis (Prof Norazmi Mohd Nor) 203/PPSK/6171007**

**Budget Approved** (*Peruntukan diluluskan*) : RM 120,000.00  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 118,866.57  
**Balance** (*Baki*) : RM 1,133.43  
**Percentage of Amount Spent** : 99%  
(*Peratusan Belanja*)

**Project 6: Dental morphology (Dr Zainul Ahmad Rajion)**

**Budget Approved** (*Peruntukan diluluskan*) : RM 116,300.00  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 115,496.52  
**Balance** (*Baki*) : RM 803.48  
**Percentage of Amount Spent** : 99.31 %  
(*Peratusan Belanja*)

**Project 7: Ocular Morphology (Dr Liza Sharmini Ahmad Tajudin) 203/PPSP/6171009**

**Budget Approved** (*Peruntukan diluluskan*) : RM 179,300.00  
**Amount Spent** (*Jumlah Perbelanjaan*) : RM 179,297.00  
**Balance** (*Baki*) : RM 2.77  
**Percentage of Amount Spent** : 99.99%  
(*Peratusan Belanja*)

**Total budget approved** : RM1,438,738.00  
**Total amount Spent** : RM1,397,935.36  
**Percentage of amount spent** : 97.16%

**D**

International		
Activity	Date (Month, Year)	Organizer
(e.g : Course/ Seminar/ Symposium/ Conference/ Workshop/ Site Visit)	-None-	

National		
Activity	Date (Month, Year)	Organizer
(e.g : Course/ Seminar/ Symposium/ Conference/ Workshop/ Site Visit)	-None-	

# E

The most difficult part in this study was sample collection. We had trouble in getting the '3 generations' of Malay from each sub-ethnic group. Most of them were either of mixed-marriages or refused to participate in this study. The Yunnan group was excluded in this study since most of them opted not to participate. We have only managed to collect 2 blood samples from the Yunnan sub-ethnic group despite multiple visits to do so. The blood samples were obtained from 2 elderly men, who did not fit with other projects' criteria (eye and dental morphology). Both samples were therefore excluded from this study.

The Kerinchi and Mandailing sub-ethnic groups were also excluded from this study since these people have almost assimilated into the "Modern" Malay society. Their scattered location made sampling impossible due to budget and time constraints.

2017年12月15日 星期五

**F**

The continuation of this project on the mitochondrial DNA and HLA analysis is ongoing. Based on the mitochondrial DNA molecular clock analysis, the Malay population was dated around 65,000 years old, but with high SD of 25-30,000 years. This is due to many reticulated branches that were not able to be resolved using the control region sequences alone. In order to reduce the SD to an acceptable value, full mtDNA genome sequencing is required. This project is now supported by the RU grant from USM. We have now completed quite a number of complete mtDNA genome sequencing and targeting to publish the data by May 2011.



## G Project 1: Morphology, Anthropology and Genetic Profile of the Malay Race of Peninsular Malaysia

This study traces the roots and origins of the present-day nine Malay states of West/Peninsular Malaysia, namely Perlis, Kedah, Kelantan, Terengganu, Perak, Selangor, Negeri Sembilan, Pahang, and Johor, and in turn an attempt to uncover the genesis of Malay ethnicity. Although on the 5th to 17th centuries CE, the 3rd century BCE to c. 5th century CE will be explored when the Malay Peninsula had interactions with the Indian sub-continent. Port polities along the west coast appeared to be the beginnings of the later Malay states, hence a closer analysis of the Bujang and Kinta valleys, and Beruas. Thereafter focus is on the transformation of these port kingdoms to entrepôts on the Straits of Melaka. Equal interest is directed at the east coast where *Ho-lo-tan* (Kelantan) appeared in Chinese chronicles as early as the 5th century CE. Kelantan, in fact, may be considered as an alternative starting point of the root beginnings of peninsular Malay kingdoms (*kerajaan*). The pertinent historical inquiry is to identify the early state-builders and the extent of indigenization of the various influences from without. It combines historical documentation with archaeological artifacts, and taps traditional literary works (*hikayat*) and anthropological findings in the reconstruction of the past.

## Project 2: Mitochondrial DNA analysis of Malay population of Peninsular Malaysia

The uniparentally inherited mitochondrial DNA (mtDNA) is in the limelight for the past two decades, in studies relating to demographic history of mankind and in forensic kinship testing. In this study, human mtDNA hypervariable segments 1, 2, and 3 (HV1, HV2, and HV3) were analyzed in 248 unrelated Malay individuals in Peninsular Malaysia. Combined analyses of HV1, HV2, and HV3 revealed a total of 180 mtDNA haplotypes with 149 unique haplotypes and 31 haplotypes occurring in more than one individual. The genetic diversity was estimated to be 99.47%, and the probability of any two individuals sharing the same mtDNA haplotype was 0.93%. The most frequent mtDNA haplotype (73, 146, 150, 195, 263, 315.1C, 16140, 16182C, 16183C, 16189, 16217, 16274, and 16335) was shared by 11 (4.4% of individuals). The nucleotide diversity and mean of pair-wise differences were found to be  $0.036063 \pm 0.020101$  and  $12.544022 \pm 6.230486$ , respectively.

## Project 3: STR analysis of Malay population of Peninsular Malaysia

A total of 290 unrelated Malay individuals belonging to 9 Malay sub-ethnic groups were genotyped for 15 autosomal STRs using Identiler kit and 155 unrelated Malay males were typed for 16 Y-STR loci using Y-filer kit. Calculation of the allele frequencies for each of the autosomal 15 STR loci has completed. Other population genetic parameters such as heterozygosity, genetic distance and AMOVA were also calculated. Principal Coordinate Analysis (PCA) of autosomal STR data using Nei's genetic distance show that the Banjar and Jawa sub-ethnic groups were closer compared to other population groups. On analysis of Y-STR data, 131 unique haplotypes were found. PCA analysis of Y-haplotype also shows that Banjar, Jawa, Kelantan and Minangkabau are genetically closely related than other population.

## Project 4: HLA analysis of the Malay population of Peninsular Malaysia

Blood samples of 298 Malay individuals from 10 different Malay sub-ethnic groups were collected thus far: Champa (63), Kedah (25), Kelantan (79), Pattani (19), Aceh (11), Minangkabau (34), Jawa (30), Rawa (23), Banjar (33) and Bugis (31). Sequence specific primer based HLA typing on HLA-A, -Cw, -B, -DQB1 and -DRB1 loci were carried out. The most frequent alleles in combined Malay populations are HLA-A\*24 (35.1%), HLA-Cw\*7 (28.9%), HLA-B\*15 (21.8%), HLA-DQB1\*3 (39.4%) and DRB1\*12 (26%). The data of each Malay sub-ethnic group were compared with each other and with other published populations. Phylogenetic analysis shows that Aceh and Kedah Malays have close genetic relationship to each other compared to other Malay sub-ethnic groups. Similarly, Champa and BBJ (Bugis Banjar, Jawa) and Rawa and Minangkabau show closer genetic relationship to each other than to other Malay sub-ethnic groups. In Principle Coordinate Analysis (PCO) graph constructed using HLA-A-B-DRB1 and HLA-A-Cw-B loci the studied Malay sub-ethnic groups were plotted near to each other as well as with several Malaysian indigenous populations (Kadazan, Iban, Temuan and Jahai).

Our study also provides statistical parameter for forensic applications. The H, PD, PIC, PE values and statistical data obtained from the 5 loci haplotype (genetic diversity and probability of random match) will enable the application of HLA loci for forensic paternity and individualization. In conclusion, this study was successfully analyze the HLA class I and class II polymorphisms among the Malay sub-ethnic groups, establish the application of PCR-SSP-based typing of HLA class I and II loci in Malaysia and providing HLA data for population studies, forensic and medical applications. Further studies on the other Malay sub-ethnic groups are necessary for understanding their precise genetic background and

origin, disease association studies, searching suitable donor for transplantation and for other related field in the future.

#### **Project 5: SNP analysis of Malay population of Peninsular Malaysia.**

Asia harbors substantial cultural and linguistic diversity, but the geographic structure of genetic variation across the continent remains enigmatic. Here we report a large-scale survey of autosomal variation from a broad geographic sample of Asian human populations. Our results show that genetic ancestry is strongly correlated with linguistic affiliations as well as geography. Most populations show relatedness within ethnic/linguistic groups, despite prevalent gene flow among populations. More than 90% of East Asian (EA) haplotypes could be found in either Southeast Asian (SEA) or Central-South Asian (CSA) populations and show clinal structure with haplotype diversity decreasing from south to north. Furthermore, 50% of EA haplotypes were found in SEA only and 5% were found in CSA only, indicating that SEA was a major geographic source of EA populations..

#### **Project 6: Dental morphological analysis of Malay population of Peninsular Malaysia**

##### **1) Angular assessment of facial profile**

The comparison of size revealed that Bugis female was smaller in upper and lower nasal region by about 17%- 33%. Bugis female shape showed differences in the upper, lower nasal area by 20%. In lateral profile there was a decreased in size at the lower nasal area in Bugis female by 17%- 33% and difference in shape by 20%. The nasal region was significantly smaller in size and differs in shape for the Bugis female in comparison to Jawa's. Computer aided photogrammetric analysis has the ability to depict and quantify local shape and size changes of nasal soft tissue differences between Jawa and Bugis female groups.

##### **2) Angular photogrammetric assessment of facial profile**

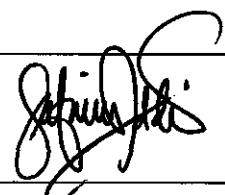
The source population of this study was the Malay males and females from Johor, Kedah, Negeri Sembilan, Pinang. A cross sectional study was carried out in a random sample of 82 individuals (42 males and 40 females); ages 19 – 40 years with class I molar occlusion. Sexual dimorphism was found for several measurements. Nasofrontal, n-prn-pog, , n-prn-sn angles were significantly higher(  $p < 0.05$ ) in male, whereas and nasolabial angle was higher in women.

#### **Project 7: Ocular analysis of the Malay sub-ethnic groups**

The ocular characteristics of seven Malay sub-ethnic groups residing in Peninsular Malaysia: Kelantanese, Bugis, Jawa, Rawa, Banjar, Champa and Kedah were analysed. A cross sectional study was conducted involving 185 healthy subjects (370 eyes) from 7 sub-ethnic groups. Those with systemic or ocular diseases were excluded. Ocular parameters include vertical fissure height, eyelid to eyebrow measurement, margin-reflex distance, eyelid crease, upward slanting of the lateral canthal, interpalpebral distance and exophthalmometer measurement. Optic nerve head parameters were evaluated using GDxVcc machine. Analysis was done using a One-Way Anova and followed by post hoc analysis (Scheffe procedure). There was a statistical significant difference in most of ocular parameter between 7 sub ethnic groups of Malay. Significant difference was observed between the distance of upper eyelid to eyebrow, with Javanese has the highest upper eyelid to eyebrow distance ( $p = 0.001$ ). Javanese also has the highest degree of upward slanting of the lateral canthal ( $p < 0.001$ ). Vertical fissure height (VFH) also shown significant difference ( $p > 0.001$ ) between subethnic groups with Rawa has the highest VFH. Similar finding was also observed in marginal reflex distance (MRD) with Rawa has in highest MRD and exophthalmometer measurement. Kelantanese and Kedahan have almost similar ocular parameter findings. However, retinal nerve fiber layer measurement did not show any significant difference among the Malay sub-ethnic group.

Date : 11/1/2011  
Tarikh

Project Leader's Signature:  
Tandatangan Ketua Projek



.....

.....

.....

**Nama:**

**Tandatangan:**

**Tarikh:**

# Sequence polymorphisms of mtDNA HV1, HV2, and HV3 regions in the Malay population of Peninsular Malaysia

Abd Rashid Nur Haslindawaty · Sundararajulu Panneerchelvam ·  
Hisham Atan Edinur · Mohd Nor Norazmi · Zainuddin Zafarina

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**Abstract** The uniparentally inherited mitochondrial DNA (mtDNA) is in the limelight for the past two decades, in studies relating to demographic history of mankind and in forensic kinship testing. In this study, human mtDNA hypervariable segments 1, 2, and 3 (HV1, HV2, and HV3) were analyzed in 248 unrelated Malay individuals in Peninsular Malaysia. Combined analyses of HV1, HV2, and HV3 revealed a total of 180 mtDNA haplotypes with 149 unique haplotypes and 31 haplotypes occurring in more than one individual. The genetic diversity was estimated to be 99.47%, and the probability of any two individuals sharing the same mtDNA haplotype was 0.93%. The most frequent mtDNA haplotype (73, 146, 150, 195, 263, 315.1C, 16140, 16182C, 16183C, 16189, 16217, 16274, and 16335) was shared by 11 (4.44%) individuals. The nucleotide diversity and mean of pair-wise differences were found to be  $0.036063 \pm 0.020101$  and  $12.544022 \pm 6.230486$ , respectively.

**Keywords** Mitochondrial DNA · Hypervariable regions · Malay population

## Introduction

The entire human mtDNA genome was first sequenced in 1981 [1] and subsequently revised with a few changes in

base composition later known as the revised Cambridge Reference Sequence (rCRS) [1, 2]. The maternal inheritance, high copy number per cell, high rate of mutation, and lack of recombination have made mtDNA a valuable tool in forensic identification [3]. The mtDNA control region of approximately 1.1 kb consists of three hypervariable regions (HV1, HV2, and HV3) and was found to be highly polymorphic in humans providing a high degree of discrimination between unrelated individuals.

Peninsular Malaysia or West Malaysia is situated in the southeastern tip of the Asian mainland, bordering Thailand at the north and separated from East Malaysia (Sabah and Sarawak) by the South China Sea [4]. The Malays represent about 50.4% of the total Malaysian population and regarded as one homogenous group [5], although we have shown that they can be quite different in their genetic makeup [6]. Mitochondrial DNA data on Malay population is so far very scanty. Zafarina and Goodwin [5] have reported only the HV1 data for the Modern Malays in Peninsular Malaysia, while Wong et al. [7] have published the HV1 and HV2 data for the Malays living in Singapore. Recently, Maruyama et al. [8] have published the HV1, HV2, and HV3 mtDNA database for Malay individuals living in Kuala Lumpur. In this study, we report a comprehensive mtDNA data with higher number of samples than the previously reported data as well as taking great care in ascertaining their background for at least three generations without mix-marriage.

## Methods and materials

### Samples

A total of 248 Malay individuals were sampled from several locations in Peninsular Malaysia: 60 from Kelantan,

**Electronic supplementary material** The online version of this article (doi:10.1007/s00414-010-0469-x) contains supplementary material, which is available to authorized users.

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