

## Dermatoglyph Groups Kinh Vietnamese to Mon-Khmer

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**Abstract** Kinh is the largest population in Vietnam. It belongs to Mon-Khmer linguistically, but there is no last word for its origin. There are three hypotheses for the homeland of Kinh. The formation of Kinh population is also hypothesized to have occurred by one of two different modes. One is demic diffusion of Mon-Khmer, the other is Daic population assimilated by Mon-Khmer. Population studies such as dermatoglyphics can be used to determine the relevant mode. Fingerprints, palm prints, and sole prints of 135 individuals from Kinh populations all over Vietnam were collected in this project. Principle component analysis and dendrogram analysis were done based on the dermatoglyphic data of populations from south China and Vietnam. Kinh Vietnamese was found to be quite close to Deang and Blang, which belong to the Mon-Khmer group, but are not closely related to the Daic populations. This study supports the demic diffusion mode of the formation of the Kinh population. The interaction with the Daic population was never a significant course in the formation of Kinh.

**Keywords** Kinh Vietnamese · Dermatoglyph · Mon-Khmer · Daic · Ethnic origin

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## Introduction

Vietnam is on the east side of Indo-China peninsula and in the connecting area of East and Southeast Asia. In the studies on the origin of the populations in the whole East and Southeast Asia, the population in Vietnam is very important. There are more than 82 million people in Vietnam, among which, more than 65 million are Kinh people [6]. The origin of the Kinh Vietnamese is greatly disputed. The opinions can be classified into three hypotheses. (1) Aborigine of Vietnam: The Kinh are the descendants of *Daic Kloc (Luo Yue)* which was an ancient population that lived in Tonkin Plain in north Vietnam [8]. (2) Migration from Yangtze area: The Kinh were a Daic tribe living around Yangtze River and were driven southward by Han Chinese migrants from north China. (3) Emigration from central Indo-China Peninsula: The culture and language of the Kinh were rooted in the Mon-Khmer (Austro-Asiatic) family, so they could have originated in Mon-Khmer in the west and came to Vietnam quite recently.

The Aborigine Hypothesis is a popular one accepted by the government of Vietnam and has been written in the history textbooks. This hypothesis insists that *Daic Kloc*, a Daic population which lived in Tonkin Plain around Hanoi in north Vietnam, was the ancestor of not only modern Daic but also Kinh Vietnamese [12]. However, the Kinh is linguistically Austro-Asiatic and not Daic. The early culture according to archaeology is a Bai Yue (ancient Daic) system, but there is no strong evidence that the Kinh are the direct descendants of the people of that culture. Most of the people think that the earliest people that lived in a certain area should have sovereignty; the Aborigine Hypothesis is supported by the government of Vietnam. However, no one will have doubt that the sovereignty of Vietnam belongs to the people of Vietnam such as the Kinh who has lived there for more than a thousand years. So there is no excuse to choose academic conclusions based on political reason.

Yangtze Migrant Hypothesis has even less evidence, but was imposed by the right wing of Vietnam in the early 1980s to destroy the friendship between China and Vietnam. This hypothesis even suggested that all the area south of the Yangtze was the home area of the Kinh's ancestor; the Han Chinese moved southward from north China, occupied south China, and drove the Kinh to Vietnam. As the studies of ethnic history in south China was not well done at the time, the Daic's homeland in south China was changed to the Kinh's ancestor's, and the migration and assimilation was explained as a banishment. These rationalizations are not logical at all, especially as today, the south China ethnic history is much clearer. This hypothesis has been rejected by academia.

Central Indo-China Peninsula Emigration Hypothesis was formed step by step with the linguistic research on the Vietnamese. This hypothesis is supported by scientific evidence. There have been several steps in the taxonomic research of Vietnamese. At first, as Vietnamese has tones and shares a large vocabulary with Chinese, it was grouped into Sino-Tibetan. Later, it was found that the tones of Vietnamese appeared very recently [7] and the Chinese-like vocabulary is also borrowed from Han Chinese during their shared history [13]; these two aspects had nothing to do with the origin of Vietnamese. Vietnamese was then classified into the Kam-Tai subfamily of Daic together with Zhuang (including Nung and Tày in North Vietnam) and Thai, after removing the surface influences of Chinese. Nevertheless, the Daic aspects were also borrowed from Zhuang in their long history of being neighbors, not original aspects of Vietnamese. Finally, Vietnamese was classified into the Austro-Asiatic linguistic family, the Mon-Khmer subfamily, Viet-Muong branch [5] after more studies were done. There are ten languages in Viet-Muong branch: Arem, Maleng, Chut, Hung, Tho, Bo, Muong, Nguôn, Aheu, Kinh (Vietnamese). Most of the languages are found around Khammoun Province in central Laos (including those connected areas in Vietnam and

Thailand) and are classical Mon-Khmer languages, except Kinh and Mung, spreading to north Vietnam and being influenced by Chinese and Daic [6]. So, the origin of Kinh could be traced back to central of Laos or even westward. It may not be as early as we had thought that Kinh and Mung arrived in Vietnam becoming the masters of Tonkin Plain in north Vietnam, displacing Nung, Tày and Cham, etc. The beginning of the migration may be only hundreds of years before the recorded history of Vietnam from 939 A.D.

As far as linguistic classification of the Vietnamese language has been almost ensured, the formation of Vietnamese population remains to be unknown. As the Kinh language originated in Mon-Khmer and influenced by Chinese and Daic linguistically, it is not sure what the proportions of Mon-Khmer, Chinese, and Daic are in the Kinh population. The human biological studies are required to address this problem. Human biology studies on Vietnam have seldom been reported, so the genetic structure also remains unknown. The Center for Anthropological Studies at Fudan University has studied the Y chromosome in several samples of Kinh and Mung and found they were close to the Mon-Khmer, not the Daic [9]. The Kinh population from central Vietnam has also been studied on HLA diversity and was differentiated from the populations of China by Guangxi Medical University [17]. The ethnic populations are extremely complex and important to the anthropological studies on East Asia, which requires deeper studies of human biology. In 2003, a cooperative study on the populations from all over Vietnam was carried out between Fudan University, Guangxi Medical University and Huê Medical College. In this study, dermatoglyph specimens were collected. In this paper, we studied the general structure by analyzing the dermatoglyph of the Kinh and revealed the biological history of the Kinh.

Dermatoglyph is the patterns of skin on the palms and soles of primates. There are two kinds of patterns, refined ridges and cursory creases. The history of dermatoglyphics is quite long [1], and the heredity of dermatoglyph was proven [3, 4, 15], especially for ridges which are closely related with the neural system. So, dermatoglyphs are always a very important human biological index for ethnic populations [14, 18]. The formation of the dermatoglyphic patterns are influenced by a number of genes. Although the subsections are monogenic, the whole dermatoglyph can be considered as polygenic character. Some subsections will be influenced by the environment during development, which adds to its complexity. Dermatoglyphic indexes can represent the holistic genetic structure of a certain population in a certain extent. Analyzing the relationships among the populations with dermatoglyphs can result in the summation of all kinds of the historical processes and is useful in discerning the formation of an ethnic population.

## Materials and Methods

### Samples

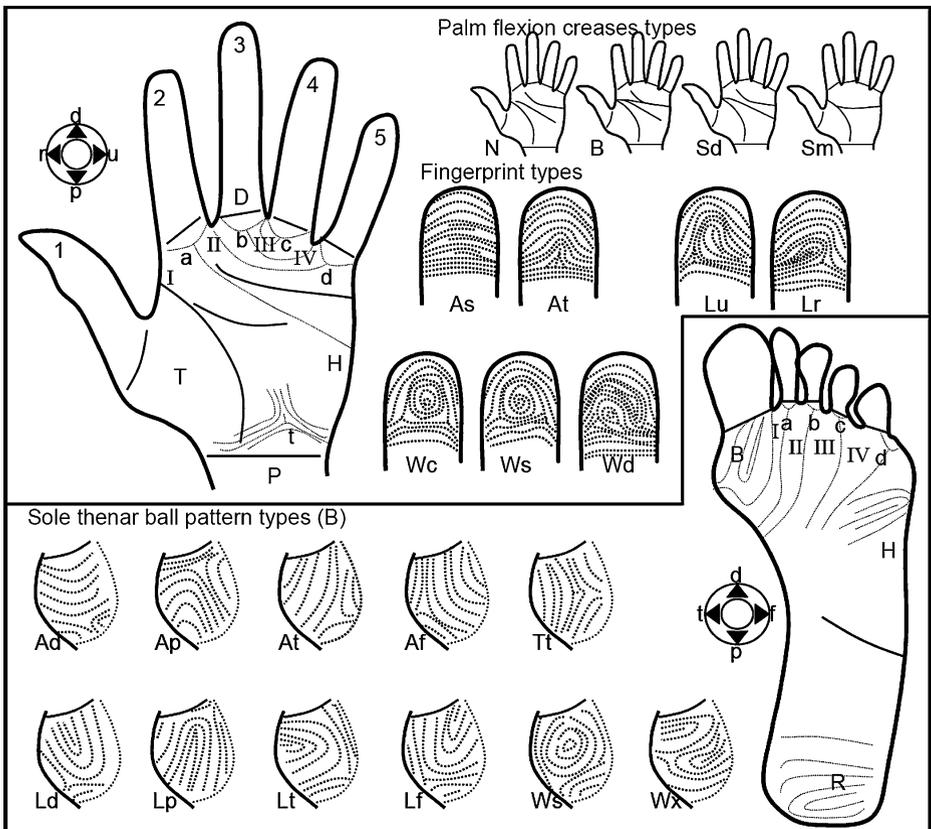
The samples are Kinh people from all over Vietnam, mainly from Hanoi and Huê. As the Kinh people are mostly in north and middle of Vietnam, our sample can represent the whole Kinh population in Vietnam. Our samples were collected from healthy adults with ages 20 to 40, which can avoid the data biases caused by samples that are too old or too young. The sample size is male 66, female 69. Our sample size is not very impressive, but according to the previous studies [2], 135 should be enough to describe the population. Although the population of Kinh is quite large nowadays, the efficient population size could be rather small, as the population may have gone through a demic expansion recently. Every subject signed the informed consent.

Methods of Dermatoglyph Rubbing and Classification

The dermatoglyph on fingers, palms, and soles of the subjects were printed on white paper with printing ink. Both front and two side faces were printed. The specimen contained the intact dermatoglyph from every subject.

Parameters of dermatoglyph are classified into three types, pattern types counting, palm measuring, and ridge number counting [1]. The pattern types and partitions [2] are shown in Fig. 1.

*Partition* For hands and feet, we used L for left and R for right. For fingers, we used digits 1 to 5 for thumb, forefinger, middle finger, ring finger, little finger. The front part of the palm is interdigital area; the rear part is the thenar eminence. There is a triradius formed by the ridges going in three different directions on the palm in the rear area of every finger. They are presented by a, b, c, d from forefinger to little finger. The area between triradius a and the thumb is called interdigital area I, and those between a, b, c, d are called interdigital area II, III, IV, separately. The palm area in rear of the thumb is called the thenar (T), and that in rear of triradius d is called the hypothenar (H). The inter-toe area is parted in the



**Fig. 1** Partition and classification of dermatoglyph. *Solid lines* are creases and *broken lines* are major ridges. Direction: *d* (distal), *f* (fibular), *p* (proximal), *r* (radio), *t* (tibial), *u* (ulnar). Other abbreviations are explained in the following paragraphs

same way as interdigital area. The sole thenar ball is in rear of halluces toe. The patterns in sole hypothenar and calcar (R) areas are also counted usually.

*Pattern Classification* The frequencies of ridge patterns on fingers, interdigital areas, thenar, and hypothenar eminences, inter-toe areas, sole thenar ball, sole hypothenar, and calcaneal areas were counted. The patterns are usually classified into three major types: Arch (A), Loop (L), Whorl (W). Loops and whorls are considered as a true pattern. Usually, the interdigital areas, inter-toe areas, thenar eminences, and calcaneal areas only contain loops; thus, only true pattern frequencies were counted in these areas. All of the pattern types were counted in fingerprints and sole thenar balls. Fingerprint patterns are classified into simple arch (As), tent arch (At), ulnar loop (Lu), radio loop (Lr), screw whorl (Ws), circle whorl (Wc), double loop whorl (Wd). Sole thenar ball patterns are classified into distal arch (Ad), proximal arch (Ap), tibial arch (At), fibular arch (Af), distal loop (Ld), proximal loop (Lp), tibial loop (Lt), fibular loop (Lf), simple whorl (Ws), complex whorl (Wx), and triradius (Tt). Palm flexion creases are classified into normal style (N), bridge style (B), Sydney line (Sd), and Simian line (Sm).

*Palm Measuring* (1) Percent distance of palm axial triradius (tPD). The palm axial triradius ( $t$ ) is located in the rear part of the palm. The length of the perpendicular form  $t$  triradius to palm proximal crease (P) is tP value, the length of the beeline between the midpoints of the palm distal crease and the proximal crease is the PD value. Percentage of tP to PD is the tPD value. (2)  $\angle atd$  is the angle of triradii  $a$ ,  $t$ , and  $d$ .

*Ridge Number Counting* (1) The finger ridge count (FRC) is the number of the ridges between the central point of the pattern and the closest triradius. The central point and the triradius are not counted. The FRC of the arch pattern is 0. There are two triradii and two FRC for a whorl, and only the bigger one is counted. The summation of the FRC of the ten fingers is called the total finger ridge count (TFRC). (2) a–b Ridge count (a–bRC) is the number of ridges between triradii  $a$  and  $b$ , and not including  $a$  and  $b$ .

## Data Analysis

The dermatoglyphic data of Kinh Vietnamese were compared with those published data of the ethnic groups in south China [2]. Principle component (PC) analysis and dendrogram cluster analysis were done by SPSS13.0. Data were standardized before PC analysis [11]. PC plots were drawn with the first four PCs, and the distributions of the populations were observed in the plots. Median clustering classification in SPSS, a cluster method in which squared Euclidean distances are commonly used, was used to draw out the dendrogram and figure out the similarity among the populations.

## Results

### Fingerprints of Kinh Vietnamese

Table 1 presents the frequencies of the fingerprint types. Ulnar loop and screw whorl were the most frequent types, while tent arch and circle whorl were not found. Ulnar loops were mostly found on little and middle fingers. Screw whorls were mostly found on ring fingers.

**Table 1** Frequencies of the fingerprint types (%) and FRC of Kinh Vietnamese

Gender	Finger	As	At	Lu	Lr	Ws	Wc	Wd	FRC
Male	L1	3	0	47	0	34.9	0	15.2	11.9
	L2	10.6	0	40.9	6.1	37.9	0	4.6	14.3
	L3	1.5	0	59.1	0	36.4	0	3	11.9
	L4	0	0	28.8	4.6	65.2	0	1.5	10.7
	L5	0	0	62.1	3	28.8	0	6.1	17.0
	R1	3	0	27.3	0	43.9	0	25.8	11.3
	R2	4.6	0	27.3	10.6	51.5	0	6.1	12.5
	R3	1.5	0	65.2	0	33.3	0	0	11.1
	R4	4.6	0	19.7	0	75.8	0	0	10.0
	R5	3	0	60.6	0	33.3	0	3	17.8
	total	3.9	0	43.8	1.7	44.1	0	6.5	124.1
Female	L1	5.8	0	39.1	0	26.1	0	29	11.9
	L2	11.6	0	39.1	8.7	39.1	0	1.5	14.5
	L3	11.6	0	53.6	1.5	29	0	4.4	12.7
	L4	5.8	0	39.1	0	55.1	0	0	12.3
	L5	7.3	0	72.5	1.5	18.8	0	0	14.5
	R1	4.4	0	44.9	1.5	40.6	0	8.7	11.2
	R2	8.7	0	43.5	1.5	44.9	0	1.5	14.7
	R3	7.3	0	69.6	1.5	20.3	0	1.5	11.5
	R4	2.9	0	31.9	0	62.3	0	2.9	11.1
	R5	2.9	0	66.7	1.5	27.5	0	1.5	16.3
	Total	6.8	0	50	1.7	36.4	0	5.1	130.0
Total		5.4	0	46.9	1.7	40.2	0	5.8	128.0

The types of forefingers of left hands were the most various, which suggested that the left forefinger shall be the best finger to be used for fingerprint on bargains in Vietnam. Double loop whorls were mostly found on thumbs, and mostly on the right hand for male and the left for female. There was no significant difference between the two genders ( $P=0.996$ ).

The finger ridge count data are shown in Table 1. FRC of the fingers were fairly similar to each other, which fit the character of a large population. The difference between genders was not big ( $P=0.63$ ).

#### Palm Patterns of Kinh Vietnamese

Frequencies of the palm true pattern of Kinh Vietnamese are shown in Table 2. The highest frequency appeared in interdigital area IV. The frequencies of area III pattern on right hands

**Table 2** Palm parameters of Kinh Vietnamese

Gender	Hand	Frequencies of palm patterns (%)					Frequencies of palm flexion crease types (%)				tPD	$\angle$ atd	a-bRC
		II	III	IV	T	H	N	B	Sm	Sd			
Male	L	1.52	9.09	65.15	0	13.64	93.94	6.06	0	0	18.04	38.95°	36.12
	R	1.52	22.73	62.12	0	12.12	90.91	7.58	1.52	0	18.12	40.16°	35.8
Female	L	0	4.35	71.01	1.45	7.25	95.65	4.35	0	0	17.85	41.94°	37.17
	R	1.45	13.04	62.32	0	4.35	97.1	2.9	0	0	18.41	48.85°	35.93

were higher than left hands, but not significantly ( $P=0.139$ ). No significant difference were observed between the two genders ( $P=0.167$ ).

The frequencies of the palm flexion crease types are shown in Table 2. As we only collected those healthy individuals, the crease types were mostly normal, and Sydney lines or Simian lines were not found on left hands. However, that does not mean these types are absolutely absent, but the frequency may be too low for us to observe within our limited sample size. The same annotate should be applied to the following unobserved types.

Values of tPD,  $\angle atd$ , and a–bRC of Kinh Vietnamese are shown in Table 2. The palm axial triradius on right hands were a little higher than left hands ( $P=0.262$ ).

### Sole Patterns of Kinh Vietnamese

The frequencies of true patterns in the sole areas of Kinh Vietnamese were shown in Table 3. The highest frequency was found in the inter-toe area III and the hypothenar. No true pattern in the calcar areas was found.

Distal loop and simple whorl is the most frequent type of sole thenar ball pattern of Kinh Vietnamese, which is similar to other populations.

### Comparison of Dermatoglyph of Kinh Vietnamese and Chinese Populations

With the efforts of Chinese Cooperation Team of Dermatoglyphics Study in the past several years, there have been more populations in China studied on dermatoglyph than those in any other country. Dermatoglyph data of most of the Chinese ethnic groups have been published. There are a lot of minorities in south China related to the Kinh, especially those of the Mon-Khmer and Daic Families, which may have had some affect on the genetic structure of Kinh Vietnamese. Table 4 listed out the dermatoglyph of those south China populations compared to Kinh Vietnamese. Male and female data were combined according to the method of Ding et al. [2]. As we aforementioned, sexual difference is not significant on fingerprint.

Parameters of Kinh Vietnamese are closest to Deang, which is also a Mon-Khmer population. Chinese Kinh is rather different from other Mon-Khmer populations, for a strong effect of genetic drift may have taken place when they moved to the Kinh Islands in recent history.

### Principal Component Analysis

A PC analysis was applied to the dermatoglyphic data of the Kinh Vietnamese and the south China populations. Two PC plots based on PC1–PC2 and PC3–PC4 are displayed in Fig. 2.

**Table 3** Frequencies of sole patterns of Kinh Vietnamese

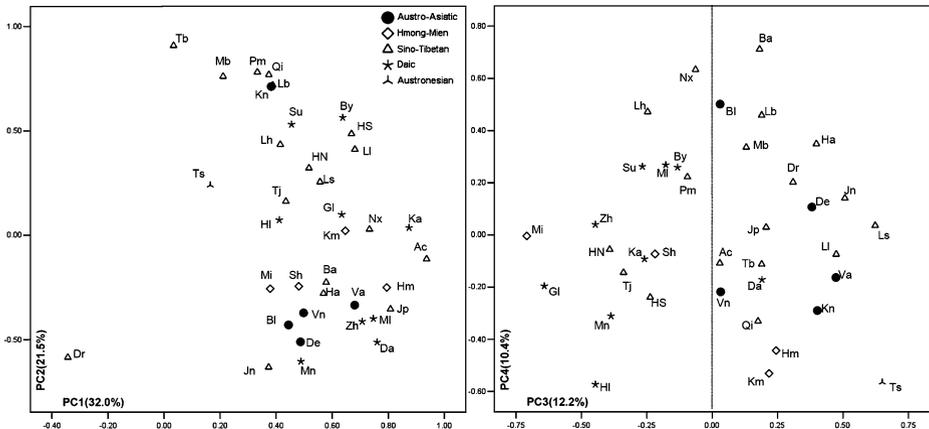
Gender	Foot	Frequencies of sole area patterns (%)						Frequencies of sole thenar ball patterns (%)								
		I	II	III	IV	H	R	Ad	Ap	Af	Ld	Lp	Lt	Ws	Wx	Tt
Male	L	0	9.09	46.97	12.12	33.33	0	7.58	1.52	1.5	51.52	12.12	0	24.24	0	1.52
	R	0	6.06	50	13.64	24.24	0	6.06	1.52	1.5	63.64	7.58	0	18.18	1.52	0
Female	L	1.45	1.45	28.99	11.59	39.13	0	2.9	0	1.5	62.32	11.59	0	21.74	0	0
	R	1.45	7.25	30.43	7.25	37.68	0	1.45	0	0	68.12	7.25	1.45	20.29	0	1.45

**Table 4** Comparison of dermatoglyph between Kinh Vietnamese and South China populations

Family	Population	Abbr.	Size	TFRC	a–bRC	A	Lu	Lr	W	T/I	II	III	IV	H	
Sino-Tibetan	Achang	Ac	467	134.0	37.8	3.0	48.5	2.6	45.9	5.1	1.4	13.5	70.1	14.0	
	Bai	Ba	800	128.3	36.0	2.0	49.0	2.9	46.1	3.4	0.4	15.6	78.3	14.6	
	Drung	Dr	498	126.1	35.7	4.5	47.0	7.3	41.2	5.6	0.4	12.1	73.3	9.0	
	Hani	Ha	1420	131.9	37.8	2.7	51.9	2.7	42.7	6.0	0.7	14.4	79.1	20.7	
	Jingpho	Jp	1496	132.6	36.6	2.5	50.1	3.0	44.5	2.6	1.1	12.9	69.2	9.8	
	Jino	Jn	1074	123.5	36.2	3.3	55.4	2.3	39.0	2.0	0.6	7.3	78.5	15.6	
	Lahu	Lh	746	146.9	34.9	0.9	45.6	2.0	51.5	5.1	1.1	16.0	73.1	10.1	
	Lhoba	Lb	332	147.1	38.4	1.5	41.7	1.5	55.3	8.6	0.2	13.0	82.5	14.3	
	Lisu	Ls	988	139.0	38.3	1.9	48.3	3.3	46.5	2.1	0.5	9.9	74.6	6.7	
	Monba	Mb	217	157.9	39.5	1.1	39.1	1.8	57.9	7.1	0.0	17.1	72.8	25.6	
	Naxi	Nx	620	132.0	36.5	1.9	46.5	2.2	49.4	2.3	1.0	16.0	81.5	13.6	
	Pumi	Pm	297	157.8	39.3	1.6	38.1	1.4	58.9	13.0	1.4	14.1	86.5	8.6	
	Qiang	Qi	979	156.6	39.8	1.9	46.4	2.7	49.0	9.5	1.2	14.0	64.0	10.9	
	Tibetan	Tb	4447	156.0	38.2	1.9	43.6	2.8	51.7	9.0	0.7	11.7	60.9	15.0	
	Tujia	Tj	505	120.0	38.5	2.4	45.8	1.9	49.9	8.5	1.5	13.0	60.8	16.4	
	Lolo	Ll	2767	141.1	38.5	1.6	49.4	2.6	46.4	3.6	0.5	13.8	65.1	12.9	
	Han S.	HS	6113	134.4	37.6	2.1	45.3	2.4	50.2	7.2	1.5	14.4	64.1	10.3	
	Han N.	HN	2959	126.0	31.6	3.2	45.6	2.5	48.6	8.1	1.4	7.6	61.6	11.5	
	Hmong-Mien	Kimmun	Km	346	140.1	37.2	2.0	53.4	1.8	42.8	4.3	1.2	11.7	57.7	10.3
		She	Sh	425	134.2	37.2	3.7	49.4	2.7	44.3	10.6	1.5	15.2	70.7	13.2
Mien		Mi	1339	125.2	34.8	2.9	47.4	2.2	47.5	6.7	1.7	17.1	59.0	7.5	
Hmong	Hm	763	132.5	38.7	2.8	52.9	2.6	41.9	2.4	1.6	12.7	67.0	10.0		
Austro-Asiatic	Blang	Bl	1,391	127.6	34.1	1.9	51.4	1.8	44.8	2.8	0.9	10.7	74.3	13.2	
	Deang	De	300	128.3	37.2	4.3	49.6	2.9	43.2	5.1	0.5	12.8	73.2	11.1	
	Kinh (cn)	Kn	741	142.9	39.2	1.7	45.1	2.8	50.5	3.7	0.7	9.2	61.9	9.0	
	Ava	Va	900	139.6	38.2	2.3	57.6	2.8	37.2	2.7	1.1	14.4	73.7	13.7	
	Kinh (vn)	Vn	135	128.0	36.3	5.4	46.9	1.7	46.0	0.4	1.1	12.3	65.2	9.3	
Daic	Bouyei	By	450	133.0	36.7	0.8	45.1	2.0	52.1	3.2	0.9	12.8	65.9	8.9	
	Dai	Da	1,607	127.1	37.8	3.4	51.5	2.9	42.2	2.2	1.2	14.2	69.7	10.0	
	Kam	Ka	1,091	137.1	37.1	2.6	47.7	2.5	47.2	3.4	1.6	14.2	67.1	13.5	
	Glao	Gl	410	136.0	37.3	2.0	46.8	2.4	48.8	4.4	2.8	18.8	65.0	8.7	
	Hlai	Hl	1,086	138.5	36.8	2.8	47.4	2.6	47.3	3.9	1.9	12.3	58.1	14.5	
	Maonan	Mn	480	130.7	36.3	3.5	52.9	2.4	41.3	4.0	2.8	13.8	67.9	14.9	
	Mulam	Ml	1,007	131.0	36.9	3.5	49.8	2.2	44.5	7.3	1.5	16.1	78.6	14.1	
	Sui	Su	411	136.6	37.1	1.8	41.6	1.9	54.8	2.5	1.6	11.0	72.3	13.4	
	Zhuang	Zh	1,070	131.4	37.0	3.4	50.3	2.3	44.0	5.4	2.1	19.7	71.8	16.5	
Austronesian	Tsat	Ts	223	145.6	38.4	1.9	54.5	2.3	41.3	6.2	0.0	6.1	48.9	9.0	

The data of South China populations are cited from Ding et al. [2].

In PC1–PC2 plot, the Kinh Vietnamese are quite close to some of the Mon-Khmer populations, Blang, Deang, and Ava, while the Chinese Kinh is out of the cluster and grouped with the Tibet and west Sichuan populations. In total, PC1 does not show any differentiations for populations. PC2 differentiates highland populations in west Sichuan and Tibet from lowland populations in Southeast. PC3 shows the polarization of the Daic and the Mon-Khmer, with a border at value 0. The Kinh Vietnamese and Blang are somewhat close to the Daic cluster, and the Tai-Le (Xishuang-Banna Dai) is in the Mon-Khmer cluster. The Kinh Chinese is close to the Ava. In PC3 there are no clusters for Sino-Tibetan and Hmong-Mien.



**Fig. 2** Principal component plots based on dermatoglyphic data of Kinh Vietnamese and South China populations. Abbreviations of population names are the same as they are in Table 4

**Dendrogram Analysis**

In Fig. 3, a dendrogram was drawn based on the same set of dermatoglyphic data. The outer cluster is the highland group from Tibet and Sichuan. An Austronesian population, Tsat from Hainan Island and a Sino-Tibetan population, Drung from northwest Yunnan Province beside Tibet, are also on the outside branches. The Kinh Vietnamese is still closest to the Daeng.

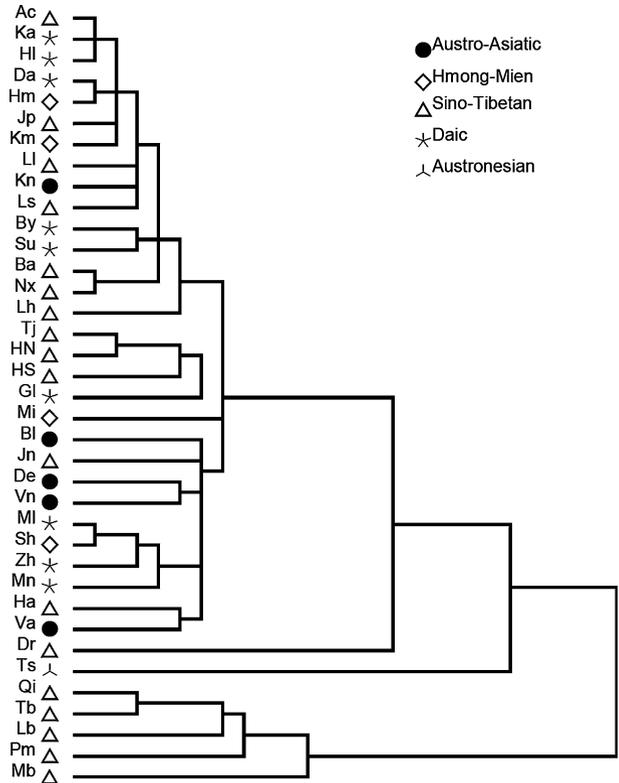
**Discussion**

**Assimilation Between Neighbors Shown by Dermatoglyphics**

As dermatoglyphics has a complex genetic background, the data presented here shows complex relationships, which mean compositive distances [10]. In PC analysis, PC1 did not show any anthropological meaning, but formed a lune with PC2. Actually, as the parameters we chose to do PC analysis are different in their data distribution and this kind of differentiation was always displayed by PC1, a lune shape is ordinary in PC analysis based on different kind of parameters. PC2 and PC3 manifested the more concrete anthropological significance. In PC2, Tibeto-Qiang populations from Sichuan and Tibet were recognized by a certain genetic isolation between themselves and southern populations. The Daic and Mon-Khmer were differentiated in PC3.

As ethnic differences of dermatoglyphic data was confirmed, we can observe those cross-border populations to see the changes of dermatoglyph after interactions among populations. Tibeto-Burman of Sino-Tibetan is a quite complex ethnic group, which originated in Gansu and Qinghai and migrated southwards with a long history [16]. Hani, Jino, Jingpho, and Bai are earliest populations moved to the south and have lived with Mon-Khmer for a long time in southwest Yunnan, which assimilated their genetic structures with Mon-Khmer and is shown with dermatoglyphic data. On another hand, the dermatoglyphs of those Tibeto-Burman populations in the north away from the Mon-Khmer are quite different from the Mon-Khmer. There has never been evidences for contact between Hmong-Mien and Mon-Khmer, while their dermatoglyphs are similar, which may be because of the original close relationship between them.

**Fig. 3** Median clustering dendrogram based on dermatoglyphic data of Kinh Vietnamese and south China populations. Abbreviations of population names are the same as they are in Table 4



The similarity between the groups out of touch in the history can be explained by a recent common origin. On the contrary side, the similarity between neighbor groups which belong to different ethnic families was most likely caused by interactions. In PC3 of dermatoglyphic data, it was most likely caused by interactions that the Blang and Kinh Vietnamese of the Mon-Khmer family were close to the Daic family. The Blang lives entirely inside Tai-Le population of the Daic and is the most affected Mon-Khmer population by the Tai. It cannot be denied that Kinh-Vietnamese have been affected by the Zhuang of Daic. It is a similar reason that caused dermatoglyphic data of the Tai-Le to be grouped into the Mon-Khmer cluster, that the Tai assimilated a lot of the native Mon-Khmer since it arrived in the Yunnan province. Those ethnic groups with fewer interactions can still show a difference between the Daic and the Mon-Khmer. After all, it is likely that ethnic mixing and assimilation has happened in the history of North Vietnam.

**Demic Diffusion Caused Expansion of Kinh**

The Kinh Vietnamese were grouped into the Mon-Khmer cluster tightly both in PC analysis and dendrogram analysis, which indicates the Kinh Vietnamese mainly belongs to the Mon-Khmer family, although it has certainly absorbed a proportion of the Daic family. The data are extremely similar between the Kinh Vietnamese and the Mon-Khmer populations in the west part of the Indo-China Peninsula. In Vietnam, it is Daic group in the north who has had the most interactions with the Kinh, not the Mon-Khmer group in the west. Thus, the similarity between Kinh and Mon-Khmer in the west indicates that the Kinh may have originated in the Mon-

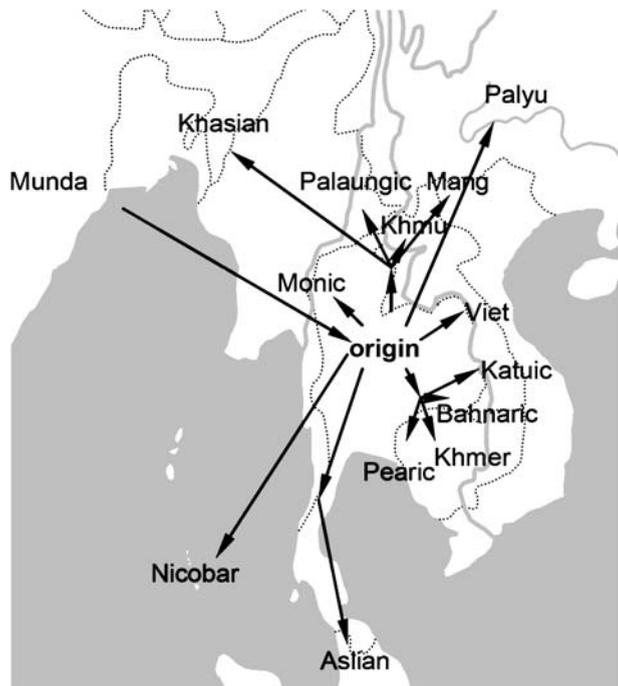
Khmer, not only linguistically, but also genetically. It was mostly because of the demic diffusion not assimilation of other populations which drove Kinh people out of the Mon-Khmer in the west and to become the biggest ethnic group in the long land of Vietnam.

According to the related historical records, the population history of the Kinh, which we extrapolated also, conforms to the pattern of demic diffusion. In North Vietnam, the early inhabitant is the *Luo-Yue* of Daic family. In the Han dynasty, there was a war between the Chinese central government and the Southern *Yue* government, which resulted in heavy political pressure on the *Yue* (Daic) population, which lasted into *Wu* dynasty of the Three States Period. A large number of Daic populations including the *Luo-Yue* moved westwards to *Guizhou*, west *Guangxi*, Laos, and as far as north Thailand. It was nearly empty along Tonkin Bay, including North Vietnam and east *Guangxi*. In the following, the *Jing* dynasty and the Southern-Northern States Period, as the northern nomads invaded central China, the Chinese government ignored Tonkin Bay and left it for the growing Kinh population. Since then, the Kinh appeared in the records of north Vietnam. After a long time of development in the *Sui* and *Tang* dynasties, a country of Kinh people was founded during the China’s civil strife in the late *Tang* dynasty.

Further Research on Origin of Kinh Population

We cannot yet judge the exact time and locus of the origin of Kinh by dermatoglyphic data. What we can be sure is that the Kinh must have had some close relationships with Mon-Khmer in the west, especially those proto-Viet-Moung populations in central Laos. Figure 4 shows the most possible cradle of Mon-Khmer in North Thailand, judging from the distribution and structure of the whole Mon-Khmer subfamily of the Austro-Asiatic family.

Fig. 4 Origin of Austro-Asiatic family



A lot of branches spread out in all directions from this area, and there was no graduated structure as the Daic family which migrated from South China. Those Daic populations in Southeast Asia spread from Guangxi of China to Thailand and were subordinate branches in linguistics though large in population [6]. The genetic ages of the Daic populations are younger and younger along the way from China to Thailand [9]. There has not been a lot of work done on the population genetics of the Mon-Khmer, and also, there are still too many ethnic populations to be studied. The origin of Kinh Vietnamese will be clearer and clearer after more studies on the populations concerned are finished.

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