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Exploration of Dermatoglyphic Statistics Based on Analysis of Leme in Bai Nationality

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Dermatoglyphs and nationality are genetically close related. In this report it it analysed by statistics. The dermatoglyphs of Leme, a branch of Bai nationality located in Lanping Bai-Pumi Autonomous County of Yunnan Province were collected and compared it with 26 related ethnic populations. We found it quite a pure population of Bai, and shall be one of the most valuable representatives while studying the origin and development of Tibeto-Burman and Bai ethnic system. We also transformed the data to fit the principal component analysis, which broke through the limitation of cluster analysis in former dermatoglyphic studies. As this statistics method worked well, it brought out new space for development of dermatoglyphic studies.

Key word: Leme Bai Nationality; Dermatoglyph; cluster analysis; principal component analysis

Introduction

Dermatoglyphs were grouped by Pukinje in 1823, and the word "dermatoglyphics" was coined by Cummins and Midlo in 1926. Generally speaking, the study was limited in image-describing and statistical comparing. Not until Dermatoglyphics International Conference (now named International Dermatoglyphics Institute) was established in 1961, did the study of Dermatoglyphics take the attention of Biologists and medicine researcher. Then the study got quiet great progress in genetic and developmental principles, researching techniques and clinical applications. In China, although fingerprints have been used as signatures according to the difference of dactylograms between individuals from Tang Dynasty (618 AD), systematical study of Dermatoglyphics did not begin until 1960s. And the research on dermatoglyphs of minorities started in the early of 1980s [1].

Statistical analysis is one of the most important researching techniques. Clustering analysis is used broadly, but there is an implicit limitation in it. The relationships between nationalities educed from it may be misunderstandings causing by the extrinsic similarities, but not the inevitable original or evolutional relations. Compared with the conclusions drawn from clustering analysis, those drawn from principal component analysis are the intrinsic common tendencies of the parameters. So this method can supply the gap in clustering analysis [2]. Though principal component analysis is familiar in other realms, it has never been used in

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analysis of dermatoglyphs. The main reason is the averages of each parameter are quite discrepant. The variance of a parameter whose average is large is generally large, so the tendency it reflects is very obvious. If another parameter with smaller average reflects both this tendency and another, the latter will probably be overlooked, which leads to result simplification. This time, we try to improve the applicability of principal component analysis by introducing some pretreatment.

The people of Leme call themselves "Boni" (the word "Leme" comes from Lisu language), which means "people of Bai". In the system of languages, Leme is grouped in Bai nationality, Tibeto-Burman of Sino-Tibetan. They speak language of Bai, without their own characters [3]. There were more than ten thousand people of Leme, most of who live in Lanpin County and Luobenzhuo Area of Bijiang County, Nujiang District, Yunnan Province, China; else are scatter all over other areas in Nujiang District and along the Qiujiang River in Burma [4]. Leme emigrated from the principal part of Bai before fifteenth century, moving from one place to another, stopping in Lanpin at last [5]. That makes them different from Bai groups in the more developed places such as Dali and Jianchuan, and decides their value in research. Therefore in July 1999, we collected the data of dermatoglyphs, visages and blood from Leme in our fieldwork in northwest of Yunnan.

Materials and Methods

Objects

Objects to research is the population of Leme-a branch of Bai nationality in Hexi Village, Lanpin Bai-Pumi Autonomous County, Niujiang Lisu Autonomous District, Yunnan Province, P.R.China, including 38 males and 25 females, all of whom were health adults and signed the agreements to be sampled.

Method of Sampling

We sampled dermatoglyphs with the method of ink print [1]. We smeared printing ink on the palms of objects, and then pressed the palms down on blank paper to get dermatoglyphs on the palms; smeared the printing ink on the fingertip of ten fingers to get dermatoglyphs on the fingers.

Data Analysis

We used the statistical method introduced by Chinese Dermatoglyphics Association of Chinese Genetics Academy [6] to analyze the dermatoglyphic samples. We recorded fingerprint patterns and finger ridge count on ten fingers, flexion crease patterns, digital a and b total ridge count (a-bRC), and interdigital pattern count. Then we measured atd angle. At last we calculated percent distance of axial triradius (tPD) and total finger ridge count (TFRC).

We compared 11 parameters of Leme such as TFRC，a-bRC，percents of fingerprint

Fig.1 A Photo of Leme people.

Fig. 2 Location of Leme people

patterns, percents of interdigital patterns with those of 26 related nationalities and groups [7], and analyzed them with statistical methods:

(1) Clustering Analysis: This method mainly applies in analyzing Between-group Linkage and forming the final dendrogram.

(2) Principal Component Analysis: We catalogued the parameters of 27 nationalities and groups then looked for the maximum and minimum in each parameter space. For parameter x^i, we noted $x^i_{\max} = \max\left(x^i_j\right)$ and $x^i_{\min} = \min\left(x^i_j\right)$, $j = 1,2,\mathrm{K}\ ,k,\mathrm{K}\ ,27$.

If the distribution patterns of parameters had been acquired, we could standardize the data with correlation matrix [8]. Since the distribution patterns of dermatoglyphic data are unknown, the simplest standardization is applied. The formula is $X^i_k = \dfrac{x^i_k - x^i_{\min}}{x^i_{\max} - x^i_{\min}}$.

After standardization, the data is ready for principal component analysis. We hope that with the further development in statistical dermatoglyphics, more suitable methods can be introduced.

We used the software SPSS version 10.0 to process the above analysis procedures.

Results

The parameters of dermatoglyphs on Leme people's fingers

The percents of 10 types of dermatoglyphs on Leme people's each finger are listed in Table 1.Leme people's ridge counts of each finger and TFRC are listed in Table 2.

The parameters of dermatoglyphs on the Leme people's palms

The parameters measured of dermatoglyphs on Leme people's palms are listed in Table 3. The percents of true patterns in each area on Leme people's palms are listed in Table 4. Percents of flexion crease patterns on Leme people's palms are listed in Table 5.

Comparison of The Dermatoglyphs between People of Leme and Other Nationalities and Groups.

The dermatoglyphs of the 55 nationalities in the mainland of China have been analyzed. In accordance with the standard given by Chinese Dermatoglyphics Association [6], we summarized the data of Leme people's dermatoglyphs into 11 parameters which are listed in Table 6, compared with 21 other populations belonging to Sino-Tibetan linguistic phylum and 5 populations settling in Yunnan Province too.We analyzed the data in Table 6 with clustering analysis and got the Dendrogram in Figure 3.

Table 1 Frequencies of Types of Dermatoglyphs on Leme People's Fingers (%)

Gender	Finger	A^s	A^t	L^r	L^u	P^r	P^u	W^s	W^{pr}	W^{pu}	W^d
Female	L5				72.00		4.00	20.00			4.00
	L4				48.00		4.00	48.00			
	L3	4.00			52.00		4.00	32.00			8.00
	L2	4.00		20.00	32.00		4.00	36.00			4.00
	L1	4.00			44.00			36.00			16.00
	R1	8.00			40.00			52.00			
	R2	8.00	4.00		36.00	4.00		44.00			4.00
	R3				60.00			32.00			8.00
	R4				40.00		4.00	48.00	8.00		
	R5				76.00			20.00	4.00		
Male	L5				78.38		2.70	10.81		2.70	2.70
	L4				37.84		13.51	40.54	2.70	2.70	
	L3	5.41		2.70	51.35		5.41	21.62		2.70	8.11
	L2	2.70	10.81	10.81	24.32		5.41	32.43	2.70	2.70	5.41
	L1	5.41			40.54		2.70	35.14			13.51
	R1	2.63		2.63	34.21			50.00			5.26
	R2	2.63	7.89	18.42	21.05		2.63	31.58			10.53
	R3			5.26	57.89			28.95			2.63
	R4			2.63	21.05		2.63	63.16		5.26	
	R5				63.16		13.16	15.79		2.63	

Note: A^s simple arch, A^t tented arch, L^r radial loop, L^u ulnar loop, P^r radial purse, P^u ulnar purse, W^s simple whorl, W^{pr} radial purse-whorl, W^{pu} ulnar purse-whorl, W^d double loop whorl. L1~L5 are the numbers of fingers from thumb to little finger on the left hand, Rs are corresponding numbers on the right hand. Same below.

Table 2 Ridge Counts on Leme People's Fingers

Gender	L5	L4	L3	L2	L1	R1	R2	R3	R4	R5	TFRC
Female	11.76	15.72	13.12	11.40	14.84	16.00	12.28	13.44	14.52	10.24	133.32
Male	11.89	16.61	13.36	10.78	15.56	18.06	13.14	14.14	15.92	11.33	140.78

Table 3 Parameters of Dermatoglyphs on Leme People's Palms

Gender	a-bRC_L	a-bRC_R	$\angle atd_L$	$\angle atd_R$	tPD_L	tPD_R
Female	35.92	35.75	42.31	44.58	16.54	17.05
Male	37.03	38.32	41.26	43.96	17.35	17.36

Note: The subscripts L and R respectively mean left hand and right hand.

Table 4 Frequencies of authentic patterns in each area on Leme people's palms (%)

Gender		I	II	III	IV	T	H
Female	L	4.00	0.00	16.00	92.00	20.00	8.00
	R	0.00	0.00	24.00	96.00	0.00	0.00
Male	L	5.41	0.00	16.22	89.19	21.62	2.70
	R	0.00	2.63	34.21	76.32	2.63	0.00

Note: I~IV are the numbers of interdigital areas; T means thenar pattern, and H means hypothenar pattern.

Table 5 Frequencies of Flexion Crease Patterns on Leme People's Palms (%)

Gender	Normal		Bridge		Sydney Line		Simian Line	
	L	R	L	R	L	R	L	R
Female	84.00	92.00	8.00		4.00	4.00	4.00	4.00
Male	89.19	89.47	10.81	7.89		2.63		

In Figure 3, the populations separate into two sorts, one of which consists of HAN in Sichuan, QIANG, ANU, KAMBA, LHOBA, PRIMI, MONBA, TIBETAN in Lhasa; the other consists of the rest. We analyzed the standardized data with principal component analysis, and got the plot of the first two principal components.

Discussion

The statistical differences between clustering analysis and principal component analysis

Clustering analysis is called as "study without direction". We do not know how

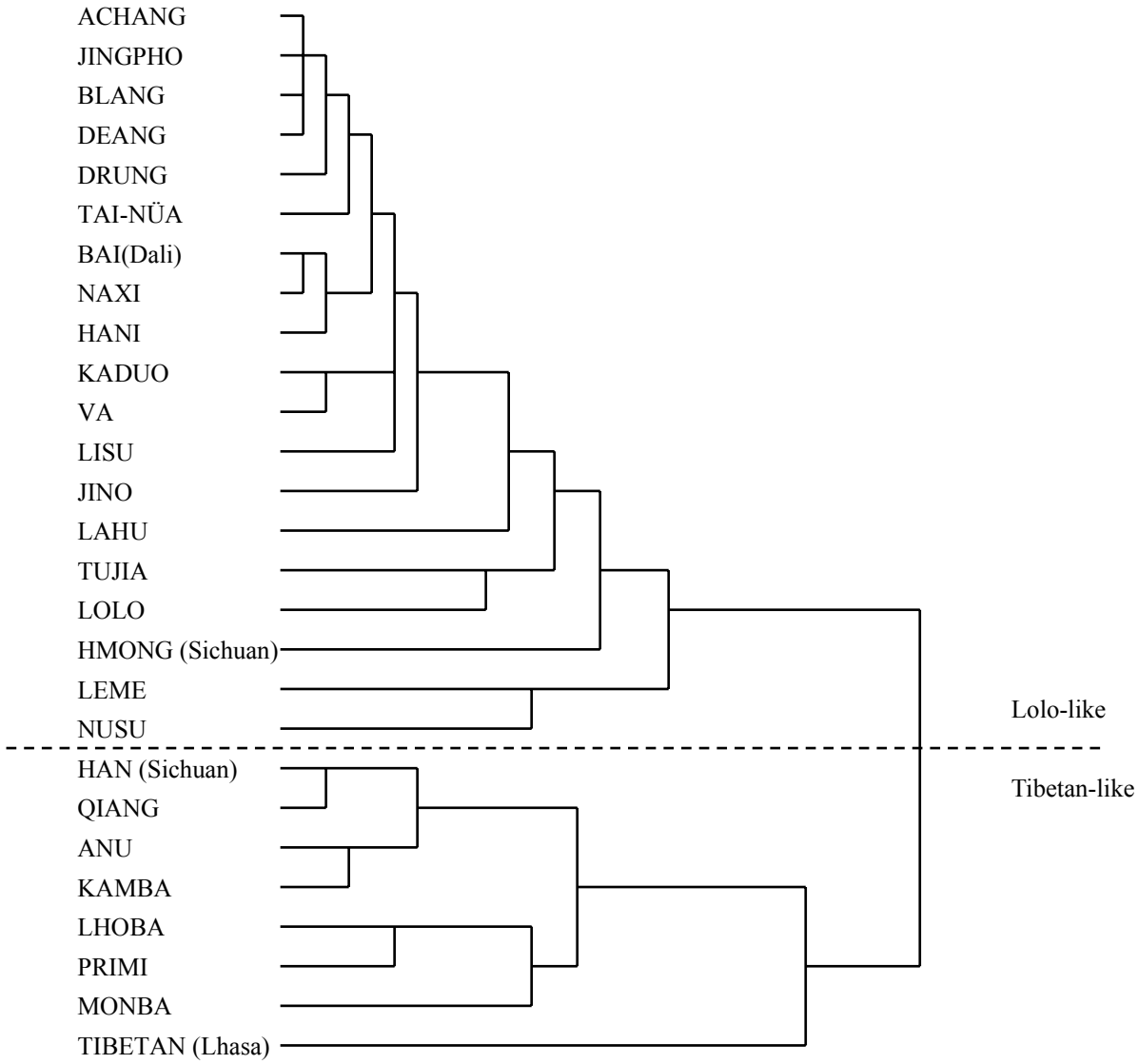

Figure 3 Dendrogram using average linkage between groups of Leme and other ethnic groups

Table 6 Comparison of Dermatoglyphic Parameters between Leme and 26 Related Nationalities and Groups

Linguistic Classification			Population	ΓFRC a-bRC		A	L^u	L^r	W	T/I	II	III	IV	H
Sino-Tibetan	Tibeto-Burmanese	Bai	LEME	37.05	36.93	3.55	50.87	3.42	42.17	13.42	0.66	22.61	88.38	2.68
			BAI (Dali)	28.30	36.00	2.00	49.00	2.90	46.10	3.40	0.40	15.60	78.30	14.60
		Lolo-Burmanese	ACHANG	34.00	37.80	3.00	48.50	2.60	45.90	5.10	1.40	13.50	70.10	14.00
			JINO	23.50	36.20	3.30	55.40	2.30	39.00	2.00	0.60	7.30	78.50	15.60
			HANI	31.90	37.80	2.70	51.90	2.70	42.70	6.00	0.70	14.80	77.10	18.20
			LAHU	41.30	35.00	1.10	57.50	2.80	38.70	5.90	1.10	8.70	80.30	19.70
			LISU	39.00	38.30	1.90	48.30	3.30	46.50	2.10	0.50	9.90	74.60	6.70
			NAXI	32.00	36.50	1.90	46.50	2.20	49.40	2.30	1.00	16.00	81.50	13.60
			NUSU	32.50	36.90	1.70	45.80	1.80	50.70	6.20	0.40	9.10	91.30	10.10
			LOLO	35.10	32.80	1.10	44.20	1.50	53.30	4.00	0.00	12.80	67.20	17.80
			KADUO	34.00	40.10	2.30	55.90	1.80	39.90	5.50	0.70	14.10	71.10	7.00
		Tujia	TUJIA	20.00	38.50	2.40	45.80	1.90	49.90	8.50	1.50	13.00	60.80	16.40
		Jingpho-Konya-Bodo	JINGPHO	32.60	36.60	2.50	50.10	3.00	44.50	2.60	1.10	12.90	69.20	9.80
		Nungish	DRUNG	26.10	35.70	4.50	47.00	7.30	41.20	5.60	0.40	12.10	73.30	9.00
			ANU	49.00	39.20	1.30	45.90	2.70	50.10	6.40	0.40	16.80	73.80	8.40
		North Assam	LHOBA	47.10	38.40	1.50	41.50	1.50	55.30	8.60	0.20	13.00	82.50	14.30

Linguistic Classification			Population	ΓFRC a-bRC		A	L^u	L^r	W	T/I	II	III	IV	H
Sino-Tibetan	Tibeto-Burmanese	Himalayish	TIBETAN (Lhasa)	46.00	39.30	1.20	38.10	1.50	59.20	4.80	0.60	4.10	50.80	17.00
			KAMBA	60.60	39.80	1.90	45.20	3.00	49.90	9.00	0.40	15.80	73.60	11.90
			MONBA	57.90	39.50	1.10	39.10	1.80	57.90	7.10	0.00	17.10	72.80	25.60
		Tangut-Qiang	QIANG	56.60	39.80	1.90	46.40	2.70	49.00	9.50	1.20	14.00	64.00	10.90
			PRIMI	57.80	39.30	1.60	38.10	1.40	58.90	13.00	1.40	14.10	86.50	8.60
Chinese			HAN (Sichuan)	51.00	39.00	2.30	45.00	2.60	50.10	8.30	0.90	11.60	56.20	11.40
Austro-Asiatic			DEANG	28.30	37.20	4.30	49.60	2.90	43.20	5.10	0.50	12.80	73.20	11.10
			BLANG	27.60	34.10	1.90	51.40	1.80	44.80	2.80	0.90	10.70	74.30	13.20
			VA	39.60	38.20	2.30	57.60	2.80	37.20	2.70	1.10	14.40	73.70	13.70
Tai-Kadai			TAI-NÜA	25.40	37.50	4.00	53.70	3.20	39.10	2.80	1.50	14.40	67.90	9.60
Hmong-Mien			HMONG (Sichuan)	31.90	38.50	4.00	60.90	2.90	32.20	1.40	1.60	13.90	59.80	11.60

many sorts the statistical data can be divided into, not talking about what sorts or what concrete criterions according to. Based some parameters from each population and on some algorithms in software, the populations are sorted automatically according to general similarity. But since the classification is according to general similarity, it cannot avoid two limitations: Firstly, when the data were considered in general, the significances of the parameters are not discriminated, and the relativities among them are not taken into consideration. So maybe some minor relationship among populations is reflected in many parameters, and is exaggerated, and vice versa. Secondly, similarities are external and static relations among populations. Though we can conjecture about the reasons of them and how they came to today, we cannot avoid mistaking coincidental similarities for inevitable relations, or dissevering populations of affinities due to

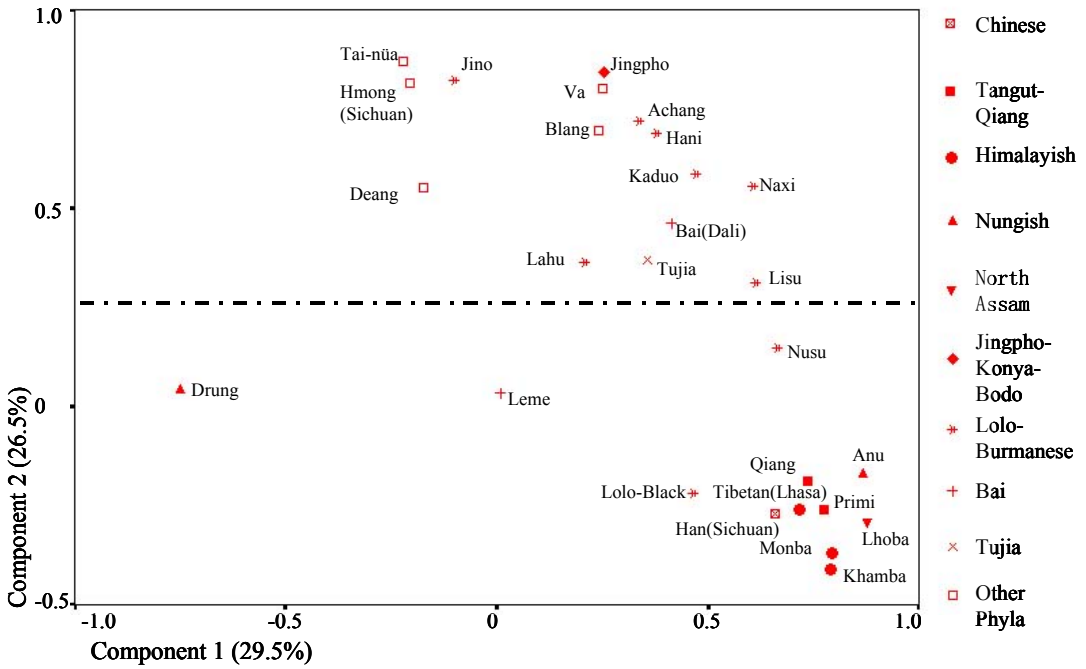

Fig.4 1st and 2nd Component plot of Leme and other ethnic groups

ostensible differences. That is very terrible for study on the origin, variation and evolution of nationalities.

In principal analysis, we transform the original data into linear components, so we can get advantages below: Firstly, principal components, which are the common regularities taken out from the original parameters, reflect internal and dynamic tendencies but not simple external and static similarities. Secondly, the useful information in original data is kept as much as possible after transformation, so the principal component analysis generally bears comparison with clustering analysis in integrity of information. Thirdly, based on distinctness of each trend in the original parameters, i.e. the number of original parameters which reflect some trend, the principal components named 1st, 2nd, 3rd, … n principal component. The significance of each principal component is very clear. Fourthly, the linearity of principal components avoids distortion cause by relativities.

Considering those mentioned above, clustering analysis and principal component analysis can be used to solve different problems in Dermatoglyphics.

Crases in Sino-Tibetan linguistic phylum inferred from clustering analysis

In the dendrogram got from clustering, the 27 nationalities and groups separate into two sorts-Lolo-like and Tibetan-like:

(1) Lolo-like:

In the first sort, Achang, Naxi, Hani, Kaduo, Lisu, Jino, Lahu, Lolo and Nusu are all in the Lolo-Burmanese, Tibeto-Burmanese, Sino-Tibetan; the Tujia linguistic branch which Tujia belongs to and the Bai linguistic branch which Bai (Dali) and Leme belong to are both used to be in the Lolo-Burmanese [9]. The classification of Jingpho, Blang, Deang, Drung, Tai-nüa, Va and Hmong (Sichuan) indicates their dermatoglyphic traits are similar to that of Lolo-Burmanese.

(2) Tibetan-like:

In the other sort, Tibetan (Lhasa), Kamba and Monba are all in the Himalayish, Tibeto-Burmanese, Sino-Tibetan; Lhoba is in the North Assam, Tibeto-Burmanese living in south brae of Himalaya. The classification of Han (Sichuan), Qiang, Anu and Primi indicates their dermatoglyphic traits are

similar to that of Himalayish people.

The classification above embodies the national crases caused by geographical location and communication. The populations classified in Lolo-like live on the Yunnan-Guizhou Plateaus in China and areas near the Plateaus. Lolo whose territory is very broad on the table influences other populations there more or less. Tibetan-like live on the Qinghai-Tibet Plateaus in China and areas near the Plateaus, the populations classified in which are all greatly affected by Tibetan. There has been communication in economy and culture among populations in both these two sorts for long time, so close relations were built. And there is even intermarriage in each sort, leading to genetic communication. Therefore, national crases can be seen in dermatoglyphic traits. We can call these two crases "Lolo-infected" and "Tibetan-infected".

If we used clustering analysis in the way before-conjecturing internal relationships from external similarities in dendrogram, we can see the populations belonging to Sino-Tibetan separate-Loloiod has the same origin with populations belongingto Austro-Asiatic linguistic phylum such as Blang, Deang and Va but not with Tibetan-like belongs to the same linguistic phylum. The conclusion may be "Lolo-origin" and "Tibetan-origin", which is incompatible with the knowledge of national origin and language system. The limitation of clustering analysis in research of national origin, variation and evolution is exposed here.

The inner difference and foreign communication of Sino-Tibetan linguistic phylum inferred from principal component analysis

In the plot got from principal component analysis, the first and second principal components represent the inner difference and foreign communication of *Di-Qiang* ethnic group of Sino-Tibetan linguistic phylum.

(1) The second principal component:

This principal component represents the inosculation with Austro-Asiatic in some linguistic branches of Sino-Tibetan linguistic phylum, which we call as "Austro-Asiatic-infected". The aborigines in Yunnan are Austro-Asiatic people, who were accepted by the ancient *Di-Qiang* nation immigrants. In the plot, the populations of non-Sino-Tibetan language families are above, and the pure populations of Sino-Tibetan linguistic phylum are most below. The projections of populations on the second principal component indicate their inclinations to non-Sino-Tibetan linguistic phylum and to Sino-Tibetan linguistic phylum. The Sino-Tibetan linguistic phylum populations above the dashed are the ones "Austro-Asiatic-infected", such as Bai (Dali) of Bai branch, Jingpho of Jingpho branch, Tujia of Tujia branch, Achang, Hani, Kaduo, Naxi, Lahu, Lisu, Nusu of Lolo-Burmanese, Tai-nüa of Tai-Kadai linguistic phylum and Hmong (Sichuan) of Hmong-Mien linguistic phylum. The populations below the dashed are the ones not "Austro-Asiatic-infected", who are representatives of the linguistic branches in Sino-Tibetan linguistic phylum, such as Drung and Anu of Nungish linguistic branch, Leme of Bai linguistic branch, Lolo o f Lolo-Burmanese linguistic branch, Han (Sichuan) of Chinese, Qiang and Primi of Tangut-Qiang linguistic branch, Tibetan (Lhasa), Monba, Kamba of Himalayish linguistic branch, and Lhoba of North Assam linguistic branch.

(2) The first principal component:

This principal component represents the inner difference among populations of Sino-Tibetan linguistic phylum. Pure populations as representatives, from left to right, there are Nungish, Bai, Jingpho-Konyak-Bodo, Tujia, Lolo-Burmese, Chinese, Himalayish, Tangut-Qiang and North

Assam linguistic branches [10]. Because actually Anu is grouped Nungish linguistic branch provisionally, it is not impenetrable that Anu is located in different end of the first principal component from Drung of Nungish linguistic branch.

From the plot, we can perceive that though principal component analysis shows the communications and crases among populations with one of the principal components, it show the origins of populations legible with another principal component. Division of origins and crases is the preponderance of principal component analysis to clustering analysis.

The origin and genetic traits of Leme

From principal component analysis, we know Leme is a pure population of Bai linguistic branch, which has not been Austro-Asiatic-infected; and from clustering analysis, we know Leme is classified to "Lolo-like". These conclusions tally with cultural and historical records and anthropological conclusions before.

Leme people sing "soul-delivering song" for the decedents to lead their souls back to the place where their ancestors lived. Tracking the way said in the song, Leme people are proved coming from Dali east of Nujiang River, living along Lancang River in Lanpin County, Nujiang District first, then moving along Nujiang River [5]. It is said they have settled in the place they live now for three to four hundred years [3]. And many national festivals of Leme are the same with those of Bai population in Dali [5]. All of these illuminate that Leme is a branch of Bai nationality.

But there are also some differences betweem Leme and Bai population in Dali. From Clustering Analysis Dendrogram of 8 National Populations' Facial Traits, we can see great difference between them [11]. Leme people speak pure Bai language, which is different from Chinese-infected Bai language spoken in Dali and other places for its abundance of original words and scarcity of loanwords [3]. And some primitive religions that have been sublated by Bai population in Dali are still embraced by Leme people [12]. These tell us that Leme is comparatively more pristine than Bai population in Dali, and their genes are somewhat pure.

Bai population in Dali was mighty there, so it assimilated other weak nationalities. The result was Bai population got impure by absorbing many traits of other nationalities. As for Leme, after emigration, it was weak in new residences. And the people were so conservative that their communication with other nationalities did not comprise intermarriage [12] with often happened in cousinship [4]. This may be the reason for their pure Bai bloodline.

As conclusion, compared with Bai population in Dali, Leme is a pristine population of Bai nationality. It is eligible representative of Bai nationality.

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