Landmark-Based Geometric Morphometrics in Describing Facial Shape of the Sama-Banguingui Tribe from the Philippines

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***Abstract*—Studies of human forms using traditional methods only show minimal variations. However, advances in image analysis and statistics have resulted to highly quantitative descriptions of detailed variations. To be able to describe detailed variations and to understand the human face of tribes practicing consanguineous marriages like the Sama-Banguingui tribe, landmark-based geometric morphometrics was used. Selected purebreed individuals (25 males and 21 females) of the tribe participated in the study. Face images were landmarked using the 28 anatomical landmarks defined in this study. Relative warps scores generated were used for the analysis of shape variations. Visualization of variations was done using histograms and boxplots. Results showed minor differences in the shapes of the whole face in RW2 and RW3 but not in RW1, RW4, RW5 and RW6 where variations observed were not significantly different. The similarity in the facial characters within and between sexes observed in this study could be attributed to common ancestry and possibly due to consanguinity. This study have shown that the tools of geometric morphometrics can be used for detailed quantification of variations in shapes of morphological structures.**

***Index Terms*—Landmarks, geometric morphometrics, relative warps, Sama Banguigui.**

I. INTRODUCTION

Based on traditional morphometric methods, analysis of human form show the existence of low morphological variation among modern humans [1]-[4]. Because of these low levels of morphological variation, there is therefore a need to explore other methods that allow the capture of subtle shape differences. With advances in computer science, statistics, geometry and biology, morphological analysis have become more quantitatively described. One of this is the method of geometric morphometrics (GM) [5], [6] which have been popularly used to the study of human form over the last decade. GM focused on methods that capture the geometry of morphological structures and preserve this information throughout the analyses. More powerful morphometric analyses can be performed using these more comprehensive data [7], [8] and very subtle shape differences can be visualized [5], [9]. The landmark-based geometric morphometric methods provide new insights into patterns of biological shape variation that could not be evaluated by traditional methods [9]-[13]. With these theoretical and empirical reasons, geometric morphometrics techniques can be considered very useful for the study of intraspecific morphological variation among human populations like the Sama-Banguigui tribe.

The Sama-Banguingui tribe is a very social, peace-loving and very pious of the Muslim tribes [14], [15]. The concept of *Sama-Sama* (togetherness) is carefully observed by the adult members of this tribe and serves as a guide in how they will socially interrelate with each other [14], [16]. Like other Muslim tribes, the Sama-Banguinguis also believe in arranged marriages regarded as the best method in obtaining their lifetime partners within the overall perspective of the Islamic traditions. Children of distant family relatives or even those closely related individuals are said to be often married off to each other. The possible genetic consequences of this practice make this tribe an ideal group for face analysis studies. In other countries, several face analysis studies has already been done in health-related fields [17]-[20] in ethnicity gender identification [21], [22] and ontogenesis [23], [24]. In the Philippines, however, scientific literatures of this sort are found wanting. Facial data in some of the above-mentioned studies were usually acquired through traditional anthropometric measurements [1], [25] thus to be able to describe subtle differences in morphometric characters, data is obtained through landmarks and analyzed using landmark-based geometric morphometrics (GM) methods.

II. METHODOLOGY

The participants, who may either be a male or a female, were chosen by purposive sampling according to the

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following inclusion criteria: (a) individuals who are true-blooded Sama-Banguingui; (b) aged 18 years or over; (c) able to understand the Tagalog dialect; and (d) willing to take part in the study. The individual's rights and anonymity were kept secret. The objectives of the study, data collection procedure, and the right to refuse to participate were carefully explained to those who fit in with the above-mentioned criteria as well as to the Village Chairman who provides the needed permit to conduct the study in the area. Those who were willing to take part in the study were told of the confidentiality of the data and the results reported as a group.

Only 46 (21 females and 25 males) Sama-Banguingui participated in the study. The participants' front view images of their face, with neutral expression, eyes looking straight in front, closed mouth, and hair pulled back from the forehead, were captured using a digital camera.

In each image of the whole face, forty three (43) anatomical landmarks were marked in areas that illustrate the morphological variations (Table I). Landmarking of the digitized images was done in triplicates and the Cartesian coordinate scores of these landmarks were recorded using the tpsDig version 1.40 [26]. The landmark sites in the face are illustrated in Fig. 1. Each landmark was classified into type I landmark, a point that occurs at joints of tissues or bones, or type II landmark, a point defined by local properties such as maximal curvatures [27].

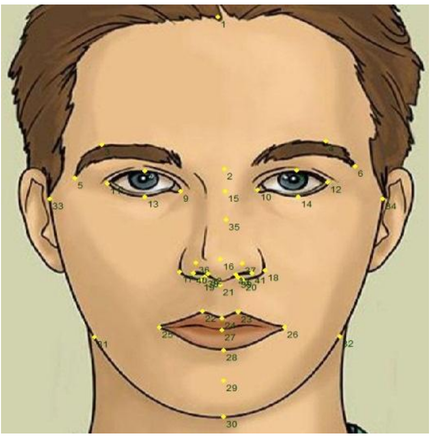

Figure 1. Location of anatomical landmarks of the whole face.

Landmark data were used to determine differences within and between male and female shape of the face. Calculation of variables, such as consensus, partial warps, and relative warps, which describe variation in shape, was done by using the tpsRelw version 1.49 program [28]. The relative warp scores obtained were used for the generation of histograms and boxplots using the Paleontological Statistics software (PAST) version 2.17 [29]. These histograms and boxplots are visual representations of the distribution of individuals of the male and female groups.

The Kruskal-Wallis test, a nonparametric test used to compare independent groups of sampled data[14] was done using PAST 2.17. This test was used to determine the significance of differences (at 0.05 level of significance) in the shape variations between males and females of the Sama-Banguingui tribe.

III. Results and Discussion

TABLE I. Anatomical Landmarks of the Face

Landmark	Description of Landmark	Type
1	Midpoint of the hairline	II
2	The midpoint of the nasofrontal suture	II
3	The highest point on the upper margin of the middle portion of the eyebrow (left)	II
4	The highest point on the upper margin of the middle portion of the eyebrow (right)	II
5	The most lateral point of the eyebrow (left)	II
6	The most lateral point of the eyebrow (right)	II
7	The highest point of the eyelid (left)	II
8	The highest point of the eyelid (right)	II
9	Medial hinge of the eyelid (left)	I
10	Medial hinge of the eyelid (right)	I
11	Lateral hinge of the eyelid (left)	I
12	Lateral hinge of the eyelid (right)	I
13	Lowest point on the middle of the margin of the lower eyelid (left)	II
14	Lowest point on the middle of the margin of the lower eyelid (right)	II
15	The deepest point of the nasofrontal angle	II
16	Most protruded point of the nasal tip	II
17	Most lateral point on the nasal ala (left)	II
18	Most lateral point on the nasal ala (right)	II
19	Most lateral point of the nose (left)	I
20	Most lateral point of the nose (right)	I
21	Most inner point between the nose tip and the upper lip	I
22	Highest point of the upper lip (left)	I
23	Highest point of the upper lip (right)	I
24	The midpoint of the vermilion border of the upper lip	I
25	Most lateral point where the upper and lower lip meet (left)	I
26	Most lateral point where the upper and lower lip meet (right)	I
27	Midline point where the upper and lower lip meet	II
28	Midpoint of the lower margin of the lower lip	I
29	Most anterior point of the chin	II
30	Lowest point in the midline on the lower border of the chin	II
31	Most lateral point at the angle of the mandible (left)	II
32	Most lateral point at the angle of the mandible (right)	II
33	The most lateral point on the zygomatic arch (left)	II
34	The most lateral point on the zygomatic arch (right)	II
35	Nose bridge	II
36	Medial point of the nasal ala outer margin (left)	II
37	Medial point of the nasal ala outer margin (right)	II
38	Lowest lateral point of the nasal ala inner margin (left)	II
39	Lowest lateral point of the nasal ala inner margin (right)	II
40	Highest point of the nasal ala inner margin (left)	II
41	Highest point of the nasal ala inner margin (right)	II
42	Medial point of the nasal ala inner margin (left)	II
43	Medial point of the nasal ala inner margin (right)	II

Fig. 2 shows the consensus shape and the grid deformations of each of these characters in male Sama-Banguinguis as one move along the axes. Distribution of individuals in the sample population with regard to each of these characters, as visualized by the histograms, is also illustrated. Majority of the individuals (mean population) in the male Sama-Banguingui population exhibit face shapes similar to the consensus shape. Relative warps (RW) show the different variations in the face shapes as one move along the X axis. These variations are described in Table II.

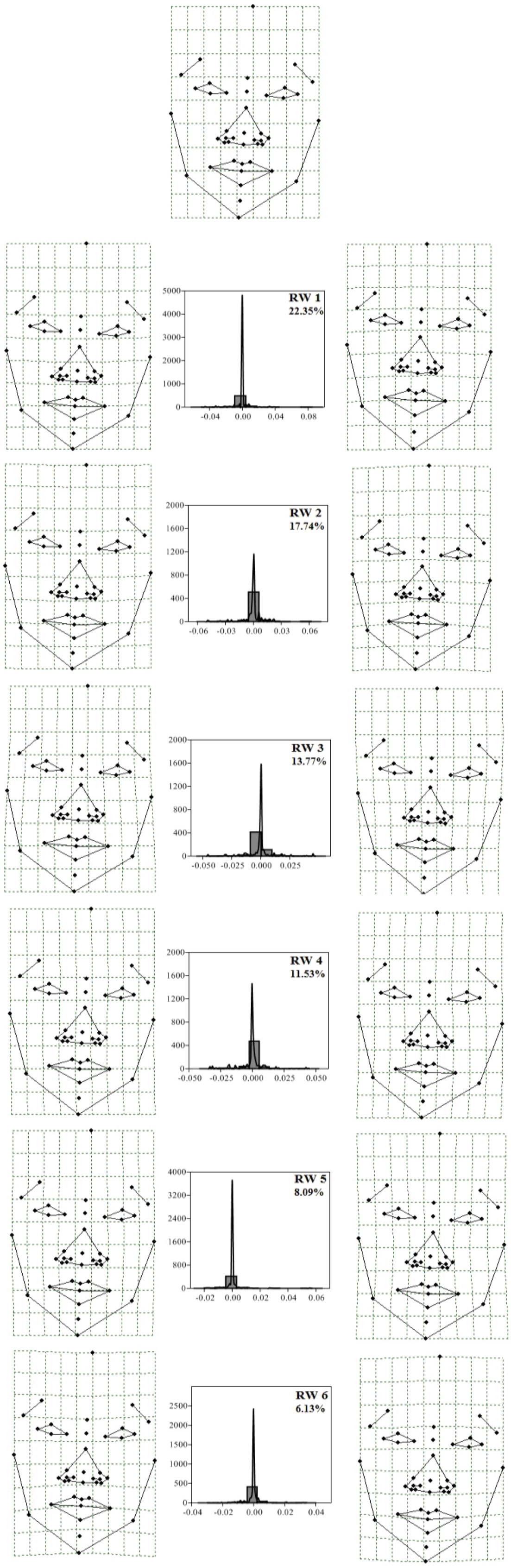

Figure 2. Relative warps of male Sama-Banguingui's face.

TABLE II. DESCRIPTION OF MALE FACE SHAPE VARIATIONS EXHIBITED BY DIFFERENT RELATIVE WARPS

RW	POSITIVE X-AXIS	NEGATIVE X-AXIS
1	Increased size of forehead; elongated chin	Increased size of forehead; smaller chin
2	Wider forehead; slightly wide eyes; lowered cheekbones	Smaller forehead; lowered cheekbones
3	Wider jaw	Narrower jaw
4	Slightly smaller chin	Slightly smaller chin; lowered cheekbones
5	Slightly smaller jaw	Wider jaw; smaller nose
6	Wider forehead; increased distance between the lips and the nose	Smaller forehead; lips slightly drooping at the sides

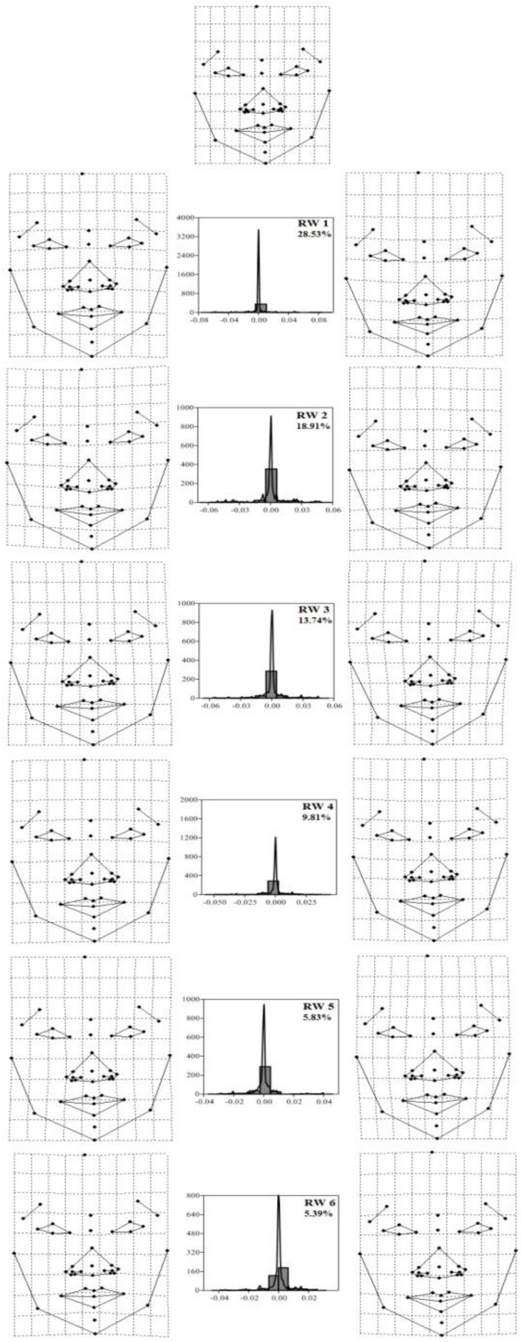

Figure 3. Relative warps of female Sama-Banguingui's face.

Fig. 3 shows the consensus shape and the grid deformations of the facial characters in female Sama-Banguinguis as one move along the axes. Distribution of individuals in the sample population with respect to each of these characters, as pictured by the histograms, is also shown.

Fig. 3 also shows that the mean population of female Sama-Banguinguis exhibits face shapes similar to the consensus shape. Relative warps (RW) show the different variations in the face shapes as one move along the X axis. These variations are described in Table III below.

TABLE III. DESCRIPTION OF FEMALE FACE SHAPE VARIATIONS EXHIBITED BY DIFFERENT RELATIVE WARPS

RW	POSITIVE X-AXIS	NEGATIVE X-AXIS
1	Slightly wider forehead; slightly shorter chin; nose is closer to the lips; lower lips slightly thin	Small forehead; longer chin; nose slightly farther from the lips; corners of the lips slightly drooping; slightly thicker lower lips
2	wider forehead	Smaller forehead
3	Shorter distance between eyebrows; smaller lips	Increased distance between eyebrows; wider lips
4	Slightly longer chin; slightly high cheekbones	Slightly narrower chin; slightly lowered cheekbones
5	Slightly narrow face; increased distance between nostrils	Slightly wider face; distance between nostrils decreased
6	Slightly wider forehead; corners of lips lifted up	Slightly smaller forehead; corners of lips drooping

TABLE IV. DESCRIPTION OF MALE AND FEMALE FACE SHAPE VARIATIONS EXHIBITED BY DIFFERENT RELATIVE WARPS

RW	POSITIVE X-AXIS	NEGATIVE X-AXIS
RW1 23.36%	Wider forehead; nose region moves down; corners of lips lifted up; thinner lower lip; smaller chin	Smaller forehead; corners of lips slightly drooping; elongated chin
RW2 15.81%	Wider forehead; cheekbones goes down	Smaller forehead; cheekbones lifted up; slightly thinner upper lip
RW3 12.95%	Wider eyebrows; smaller lips; narrow face	Shorter distance between the two eyebrows; wider lips; broader face
RW4 10.07%	Cheekbones moves down; smaller chin	Cheekbones slightly lifted up; slightly longer chin
RW5 7.03%	Slightly wider lips	Wider distance between nostrils; smaller lips
RW6 5.33%	Wider forehead; eyebrows moves down; corners of lips lifted up	Smaller forehead; shorter nose; corners of lips drooping

Comparison between male and female individuals of the ribe is shown in Fig. 4. Results show the consensus shape and the grid deformations of the various facial characters of both male and female Sama-Banguingui's as one move along the axes. Distribution of individuals in the sample population with regard to each of these characters, as pictured by the boxplots, is also presented. Looking at Fig. 4, results show the face shapes of male and female individuals are, on average, alike. These are also comparable to the generated consensus shape. There also existed variations in some individuals as demonstrated by the relative warps results and graphically shown in the boxplots. These individuals have faces described in Table IV.

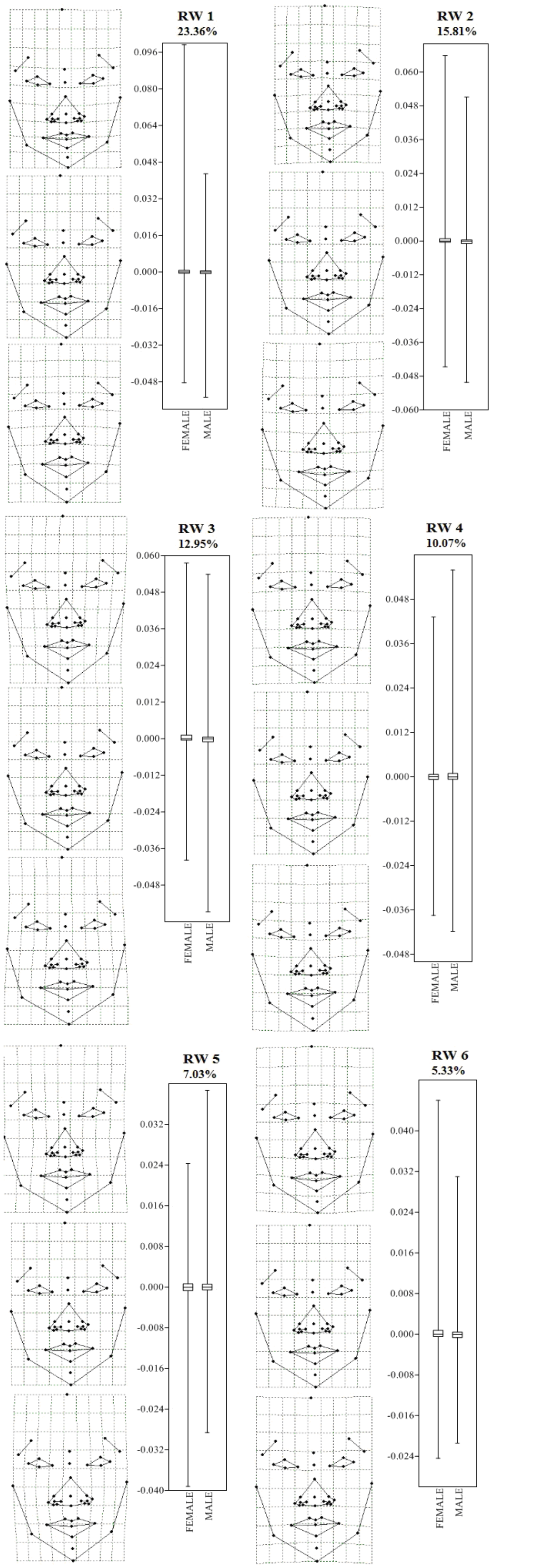

Figure 4. Relative warps of male and female Sama-Banguingui's face.

Kruskal-Wallis test show significant variations between sexes observed at RW2 and RW3 (28.76%) (Table V). These variations observed can be attributed to the very early, possibly prenatal, development of major aspects of the tribal population-specific morphology.

TABLE V. RESULTS OF THE KRUSKAL-WALLIS TEST ON THE MALE AND FEMALE FACE SHAPE VARIATIONS

RW	P value	Remark
1	0.2242	Not Significant
2	0.0035	Significant
3	0.0017	Significant
4	0.7760	Not Significant
5	0.5826	Not Significant

While there were variations observed between sexes at RW1, RW4, RW5 and RW6, these differences were not significant.

The similarities in the shapes of the face within and between the male and female Sama-Banguinguis can be attributed to a possible common ancestry. Looking at the history of the village of Taluksangay, the original inhabitants are said to be the descendants of the Sama Banguingui who were named by history as "pirates of Southeast Asia, but never conquered." Furthemore, the said forefather of this village was Hadji Abdullah Nuño Ma-as, son of Panglima Taupan, a Banguingui chieftain [30]. With this scenario, inbreeding is very much possible thus similarities in character traits within this tribe are notable. These hypotheses however need more detailed analysis and involved more individuals at various developmental stages.

IV. CONCLUSION

In early morphometric studies, facial shapes were most often characterized by means of a small number of measurements. Even with the introduction of multivariate techniques increasing the number of measurements, these are sometimes ineffective because they cannot describe effectively most biological forms and patterns. Landmark-based geometric morphometrics using two dimensional coordinates of landmarks has successfully obtained more information on the facial shapes of the Sama-Banguingui tribe because the geometric relationships among landmarks are kept as shown by the present study.

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