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Correlation Analysis Based on Distances of Facial Shapes of the Four Moro Groups in Taluksangay, Zamboanga City, Philippines

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ABSTRACT

The human face has been the focus of many researches which include medicine, evolution, behavior, psychology, social evaluation, and in this current study on human population, studies which focused on the Moro minorities in a small village of Taluksangay, Zamboanga City. These groups include the Badjao, Tausug, Sama-Banguingui, and the Yakan living in close proximity to each other. These tribes are said to be practicing the tradition of arranged marriage thus the effect of this custom in the physical features of their children especially facial features warrant an evaluation. Variations of the facial shapes of the male and female populations of each tribe were therefore examined by applying the advanced tools of geometric morphometrics. Image analysis was performed based on the 43 anatomical landmarks outlined in the face. Relative warp scores from the procrustes-fitted landmark coordinates were used for the generation of grid deformations and consensus shapes. The Canonical Variate Analysis (CVA)/ Multivariate Analysis of Variance (MANOVA), pairwise comparisons, binary regression and correlation analysis, and Correlation Analysis Based on Distances (CORIANDIS) were also utilized to describe variations in shapes between the groups. Results revealed similarity in the face shapes among individuals within each tribe but not between groups. These findings indicate the distinctness of the Moro groups and that the similarities observed within each group can be attributed to consanguineous marriages. This study has shown the significance of applying landmark-based geometric morphometrics and CORIANDIS in describing variations in human face shapes.

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INTRODUCTION

There are several ethno-linguistic groups that comprise the Moros in Mindanao. Four of which are the Badjao, Tausug, Sama, and the Yakan. These groups have identified themselves as *Bangsamoro*. *Bangsa* is a Malay word which means nation while *Moro* is a name given to these people by the Spaniards [1].

The home of Bangsamoro people consisted of domains under the sphere of control of their government. One such territory is Barangay Taluksangay in Zamboanga City, a small community that is separated from the mainland by a creek. This islet barangay is a dwelling place to several Moro minority tribes that include the Badjaos, Tausugs, Sama-Banguingui and the Yakans.

The Badjaos are drifters who are very well trained in sea navigation. They can be easily identified by their sturdy built and dark brown hair, which is due to prolonged exposure to the sea environment. The Tausugs, on the other hand, are fine seamen who are very skillful and knowledgeable in the trading of clothing and jewelry. The Sama-Banguingui is considered a major group within the Sama tribe. The term "Sama" is derived from the word Sama-Sama, meaning togetherness. This is reflected in their well-developed social organization. The Yakans are exceptionally skillful in weaving and are considered to be excellent farmers and cattle raisers [2].

The four above-mentioned Moro tribes are very devout not only in their Islamic faith but also in the practice of their traditions. One such tradition is prearranged marriage where the parents are the ones who will choose the future spouses of their children, preferably from close relatives. This practice of consanguinity not only has reproductive risks [3] and high health impact [4,5] but it also has genetic consequences on the physical attributes

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of the offspring making these minority groups the ideal subjects for this study using advanced methods in morphometrics.

In the past, traditional methods were being used in the analysis of patterns of human morphology variations but these provided very low evaluation of such patterns of differences. However, over the last decade, Geometric morphometric (GM) methods [6,7] have been increasingly applied. These techniques capture the geometry of human form and keep this information throughout the analyses resulting to a gathering of more complete data. As such, more robust morphometric analyses can be done [8,9] and the consequential visualization of very subtle shape differences [6,10]. With these reasons, GM is considered useful in this current study. There are also many programs nowadays that compute for associations among multivariate datasets. One such software is the Correlation Analysis Based on Distance (CORIANDIS). This program offers a number of methods for different types of data [11] including 2-D landmark data [12,13,14] thus, this was also included in the analysis of facial shapes of the Moro populations. Studies on facial analysis have been vast especially those with applications to human races and health. Such studies in the areas of ontogeny [15] human sexuality [16] ancestry [17,18] and certain health conditions such as Diabetes [19] and Hypertension [20] have been substantial.

MATERIALS AND METHODS

The participants of this study were chosen by purposive sampling based on the following inclusion conditions: (a) individuals who are true-blooded members of the four Moro tribes considered in this study; (b) 18 years old or over; (c) able to comprehend the Tagalog dialect; and (d) willing to take part in the study. The individual's rights and anonymity were observed. The purposes of the study, method of data collection, and the right to refuse to participate were thoroughly explained to those who fit in with the above-mentioned criteria as well as to the Barangay Chairman, Hon. Hadji Abdurahman Nuño, in order to acquire the needed permit to perform the study in the locality. Willing individuals were informed and assured of the confidentiality of the data that will be collected and that the results will be reported as a group [18].

A total of 126 residents of Barangay Taluksangay have participated in the study. Forty-six (46) of these are of the Sama-Banguingui tribe (21 females and 25 males), thirty (30) are of the Tausug tribe (17 females and 13 males), twenty-eight (28) are of the Badjao tribe (13 females and 15 males), and twenty-two (22) are of the Yakan tribe (10 females and 12 males). Front view images of the subjects' face, with neutral expression, eyes looking straight in front, closed mouth, and hair pulled back from the forehead, were taken using a digital camera. Forty three (43) anatomical landmarks were marked in areas that demonstrate the morphological variations in each image of the face (Anies, 2013). 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. 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 [17]. Landmark data were used to describe differences within and between male and female shapes of the face.

Computation of variables, such as consensus, partial warps, and relative warps, which illustrate variations in shape, was done by using the tpsRelw version 1.49 program. Calculation of the partial warps was also performed using this said tps program and deformation grids were produced which served to visualize and reveal the shape patterns as one moves along the X and Y axes. The relative warp scores were obtained. Canonical Variate Analysis (CVA)/Multivariate Analysis of Variance (MANOVA), pairwise comparisons between the Moro groups, and the correlation between face shapes and centroid size using binary regression and correlation analysis were also done using the Paleontological Statistics software (PAST) version 2.17 [8].

The Correlation Analysis Based on Distances or CORIANDIS ver. 1.1 Beta [11] was employed to analyze the similarities and/or differences in the shape patterns of the face between the male and female populations of each tribe and between the four Moro groups considered in this study. In this software, the option "Squared distances to centroid for individual sets" generates a "stacked-bar chart where total height equals the total or standardized sum of squared distances of each trait/dataset to the origin (a measure of variance or disparity), and this allows looking into how much each species differs from the rest and to interpret such differences in terms of individual traits." The scores obtained from this are employed in the Cluster analysis through the use of the above-mentioned Paleontological Statistics software (PAST) version 2.17 [21].

RESULTS AND DISCUSSION

Canonical variate analysis of relative warps scores generated from the landmark data from the whole face, eyes, nose, and lips show shape variations within and between male and female individuals from each tribe as well as between the four Moro tribes. The consensus face shapes are presented in Figure 1. It can be seen that all tribes have faces that are generally wide except for the Yakan group, which is a bit narrow in shape. The CVA of relative warps scores and the distribution of individuals in a plot (Table I and Figure 2) show variations

among the Moro tribes although the Sama-Banguingui is quite distinct from the rest. Pairwise comparisons show that each tribe has face shapes that are significantly different from each other (Tables II). Facial characters such as the nose, lips, and the eyes have shapes which are distinct of each tribe. Confusion matrix (Table III) show the correct classification of the Moro group when compared to other Moro tribes. The descriptions of the variations in the face of the four tribes and the percentage variance of each RW are presented in Tables IV and V.

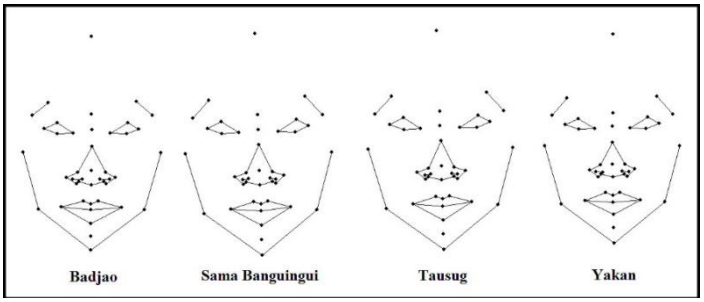

Fig. 1: Consensus shapes of the whole face of the four Moro tribes based on the relative warp scores.

Table I: Canonical variates analysis of RW scores.

	Wilks' lambda	df1	df2	F	p	Pillai trace	df1	df2	F	p
FACE	0.0002875	240	900.6	22.66	7.283E-265	2.435	240	906	16.27	2.629E-214
NOSE	0.08665	72	1065	18.74	7.159E-143	1.445	72	1074	13.86	5.387E-109
LIPS	0.7088	24	1080	5.667	2.001E-16	0.3181	24	1122	5.545	5.454E-16
EYES	0.2395	66	1070	9.951	5.232E-73	1.077	66	1080	9.168	8.357-67

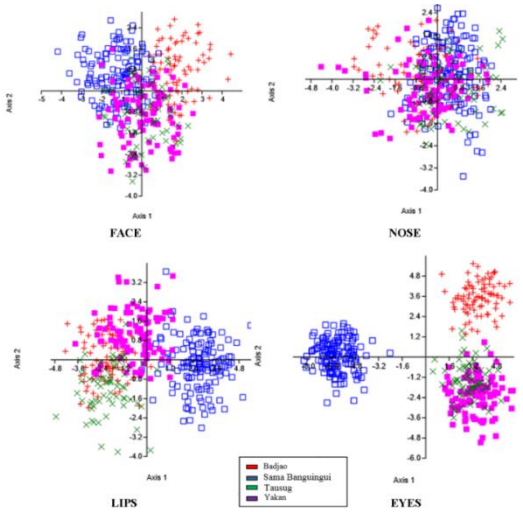

Fig. 2: CVA plot showing the distribution of individuals of the four Moro tribes along the X and Y based on RW scores.

Table II: Pairwise comparisons based on RW scores.

	Badjao	Sama Banguingui	Tausug	Yakan
FACE				
Badjao		1.8983E-70	2.1391E-28	2.5823E-15
Sama Banguingui			1.7518E-76	2.7715E-54
Tausug				4.0883E-12
Yakan				
NOSE				
Badjao		6.2151E-68	2.8562E-19	1.3907E-11
Sama Banguingui			4.0029E-52	5.7356E-58
Tausug				1.1248E-18
Yakan				
LIPS				
Badjao		9.4435E-10	5.8035E-04	4.2681E-08
Sama Banguingui			3.0247E-08	7.5344E-03
Tausug				3.2733E-05
Yakan				

EYES				
Badjao		2.5051E-37	7.8028E-21	8.4327E-16
Sama Banguingui			1.9737E-22	2.0728E-17
Tausug				8.5835E-05
Yakan				

Table III: Confusion matrix based on RW scores.

	Badjao	Sama Banguingui	Tausug	Yakan	Total
FACE					
Badjao	84	0	0	0	84
Sama Banguingui	0	137	0	0	137
Tausug	0	0	96	0	96
Yakan	0	0	0	66	66
NOSE					
Badjao	68	1	3	12	84
Sama Banguingui	0	126	10	1	137
Tausug	12	6	73	5	96
Yakan	13	0	6	47	66
LIPS					
Badjao	43	13	12	16	84
Sama Banguingui	23	59	24	31	137
Tausug	21	14	44	17	96
Yakan	8	18	10	30	66
EYES					
Badjao	70	0	7	7	84
Sama Banguingui	4	106	17	10	137
Tausug	8	12	59	17	96
Yakan	6	8	7	45	66

Table IV: Description of male and female face shape variations exhibited by different relative warps (RW).

RW	Axes	Badjao	Sama-Banguingui	Tausug	Yakan
1	positive	smaller forehead; eyebrows slightly moves down; nasofrontal area slightly moves up; tip of the nose slightly lifted up; angles of mandibles slightly lowered; longer chin	Wider forehead; nose region moves down; corners of lips lifted up; thinner lower lip; smaller chin	slightly increased length of forehead; shorter nose; shorter chin	longer length of forehead; eyebrows slightly move upward; nasofrontal area slightly moves downward; nose moves downward; angles of mandibles move upward; corners of the lips slightly moves upward; thinner lower lip; shorter chin
	negative	wider forehead; shorter chin	Smaller forehead; corners of lips slightly drooping; elongated chin	slight decrease in the length of forehead; longer chin	smaller forehead; nose slightly moves upward; angles of mandibles slightly move downward; longer chin
2	positive	wider forehead; longer eyebrows; outer corners of the eyes moves down; lowered cheekbones; upper lip slightly thicker; lowered angles of the mandibles; longer chin	Wider forehead; cheekbones goes down	slightly increased length of forehead	smaller forehead; eyebrows more curved than angular; outer corners of the eyes slightly move upward; cheekbones move upward; thinner lower lip; angles of the mandibles move upward; shorter chin
	negative	smaller forehead; eyebrows slightly more curved than angular; outer corners of the eyes moves up; slightly higher cheekbones; thinner upper lip; slightly higher angles of the mandibles; shorter chin	Smaller forehead; cheekbones lifted up; slightly thinner upper lip	slight decrease in the length of forehead	longer length of forehead; longer eyebrows; outer corners of the eyes slightly move downward; lowered cheekbones; thicker lower lip; angles of the mandibles slightly move downward; longer chin
3	positive	distance between eyebrows decreased; smaller eyes; slightly increased distance between lateral outer margins of nasal ala; slightly increased distance between the 2 corners of lips; slightly increased distance between the 2 angles of the mandibles	Wider eyebrows; smaller lips; narrow face	slight decrease in the width of the lips	distance between eyebrows slightly decreased; angles of mandibles slightly far apart; corners of the lips slightly far apart
	negative	slightly decreased distance between the 2	Shorter distance between the two	slightly wider lips	distance between eyebrows slightly increased; angles of

		corners of the lips; slightly decreased distance between the 2 angles of the mandibles	eyebrows; wider lips; broader face		mandibles slightly closer to each other; corners of the lips slightly closer to each other
4	positive	nasofrontal area moves down; inner corners of the eyes slightly moves down; slightly higher cheekbones; longer chin	Cheekbones moves down; smaller chin	cheekbones slightly lowered	cheekbones slightly move upward
	negative	lowered cheekbones; shorter chin	Cheekbones slightly lifted up; slightly longer chin	cheekbones move slightly higher; slightly longer chin	cheekbones slightly lowered
5	positive	wider face; wider nose	Slightly wider lips	slight decrease in the width of the lips; slightly wider nose	slightly narrower face; the 2 nasal ala slightly farther apart
	negative	narrower face; smaller nose	Wider distance between nostrils; smaller lips	slightly wider lips	slightly broad face; the 2 nasal ala slightly closer to each other

Table V: Percentage (%) variance of RW scores.

RW	Badjao				Sama-Banguingui				Tausug				Yakan			
	Face	Nose	Lips	Eyes	Face	Nose	Lips	Eyes	Face	Nose	Lips	Eyes	Face	Nose	Lips	Eyes
1	33.71	29.52	60.05	31.79	23.36	48.28	49.90	47.91	26.77	38.59	55.73	28.0	33.88	32.08	40.98	33.57
2	15.66	19.61	15.85	21.29	15.81	13.35	22.76	19.25	14.99	15.64	18.49	24.47	21.12	24.26	23.84	23.26
3	11.03	18.48	10.06	13.78	12.95	9.34	13.35	10.23	11.06	14.80	10.68	17.23	8.78	15.94	17.80	22.09
4	9.09	12.97	8.50	12.30	10.07	9.15	6.23	6.90	8.30	8.23	7.45	10.93	7.18	8.62	9.73	6.45
5	6.69			8.16	7.03	6.91			7.55	6.95		5.05	5.50	5.87		

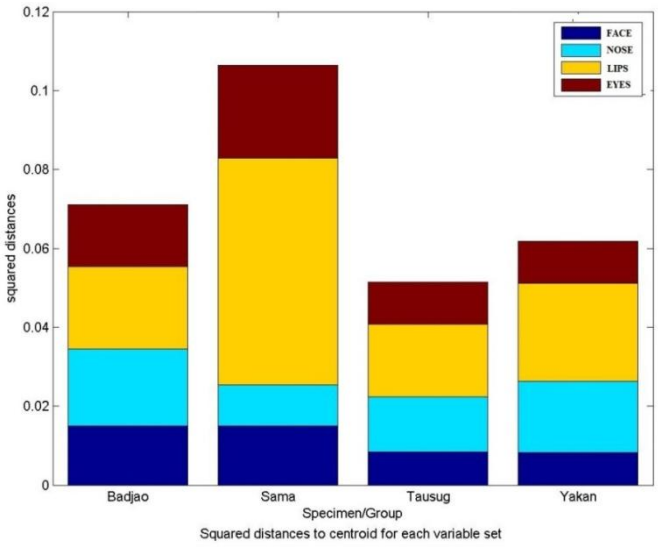

Fig. 3: Stacked bar graphs showing disparity among all individuals of the four Moro tribes.

Results of Correlation Analysis Based on Distance (CORIANDIS) which integrates all the selected facial characters (whole face, nose, lips, and eyes) so as to see underlying variations and sources of variability among the groups in terms of similarity among characters [22,23,13] show disparity between Moro tribes in terms of specific facial characters (Figure 3). It can be seen that the Sama-Banguingui tribe departs considerably from the other tribes. The lip shape character largely contributes to its disparity. Notable also is the slight difference between the Tausug and the Yakan groups, a function of the lips and of the nose shape characters. Looking at the relationship between face shape and centroid size based on binary regression and correlation analysis show a generally weak correlation for the variations in facial shapes as observed at RW2 and 3 (Table VI) and no correlation can be seen between face shape and centroid size at RW1, 4, 5, and 6 since the r values are far from +/- 1.0. These results indicate that face shapes of the participants in this study are not dependent on the size. A

visualization of these results is shown in Figure 4. This indicates that the differences between groups can be attributed to the distinctness of the shapes of the faces of each of the tribes.

Table VI: Results of binary regression and correlation analysis on face shape and centroid size.

RW	Slope	r values	p values	Remarks
1	8.0457	0.020641	0.68719	No correlation
2	-140.01	-0.35918	4.1782E-13	Negatively weak correlation
3	-81.957	-0.21026	3.3565E-05	Negatively weak correlation
4	25.987	0.06667	0.19294	No correlation
5	-18.826	-0.048297	0.34586	No correlation
6	-36.682	-0.094106	0.065805	No correlation

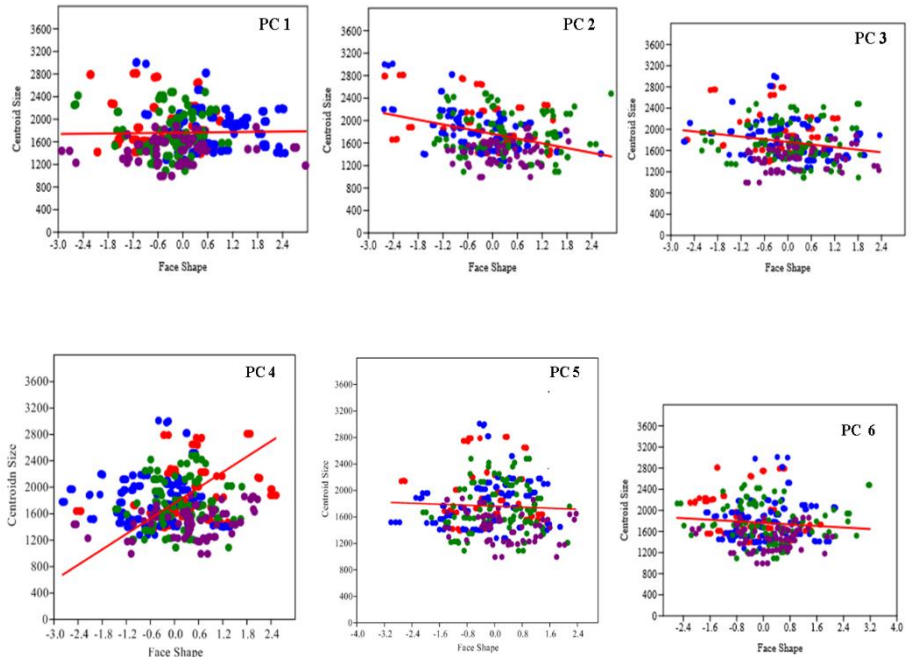

Fig. 4: Visual presentation of the results of binary regression and correlation analysis.

To further show the degree of differences between the Moro tribes considered in this study, their overall relationship is shown in the dendogram below (Figure 5). The Tausug tribe is clustered with the Yakan tribe with 62% similarity. The Badjao, however, is quite distant from the two above-mentioned tribes while the Sama-Banguingui could be seen as the most distant tribe among the rest.

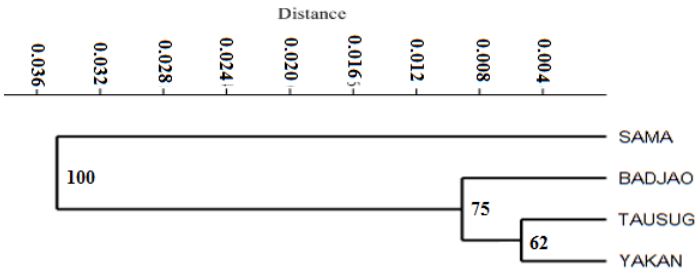

Fig. 5: A dendogram showing the relationship of the four different Moro tribes.

It can be seen from the above results that within groups there were similarities on the shapes of their faces but not between groups. Results also disclose no positive correlation between shape and the size of the face indicating that the variations observed could only be attributed to a common ancestor and the genetic consequence of the practice of consanguineous marriage. If one looks at the history of Barangay Taluksangay in Zamboanga City, the Sama-Banguinguis are the first settlers in this community. Trading activities and the richness of the sea near this islet barangay may have lured other tribes, such as the Tausug, Badjao, and the Yakan, from other parts of Mindanao and the neighboring countries to inhabit this said area. Despite this scenario, each of this tribe had maintained their practice of pre-arranged marriages preferably between close

relatives hence, similarities of facial shapes within each tribe is expected [24]. These hypotheses, however, need further in depth studies.

Conclusion:

This study have shown the relevance of applying landmark-based geometric morphometrics and correlation analysis based on distance (CORIANDIS) in describing variations in human face shapes as revealed in the four Moro tribes. Differences can be quantitatively described and the significance of the variations observed can be efficiently analyzed with the applications of multivariate methods of statistics. With these advanced tools in morphometric studies, the current study have shown that each tribe look more or less alike if one takes into consideration the shape of their whole face, an expected genetic consequence of inbreeding as practiced by these cultural minority groups.

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