

## **Numerical Taxonomy and Group Divergence in Five Koch Subgroups of Meghalaya, India**

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*Analysis of morphological affinities and differences arises when necessary to evaluate intergroup relationships. Five subgroups of the Koch community living in Meghalaya, India, were evaluated for the type and degree of biometric diversity based on anthropometric data. The study indicates that the shape distance mean is higher than the size distance mean. Because of the overall morphological variations and dissimilarities between these groupings, shape distance is therefore more significant than size distance. Two different clusters emerged based on generalized distance. The other subgroup has a significant distance from the other two clusters. Numerous biological and environmental factors may be linked to intra- and interpopulation heterogeneity among five Koch subgroups, according to the study.*

**Keywords:** *Morphometry; Inter-group relationship; Phylogeny; Subpopulations.*

### **Introduction**

Evaluating the intergroup relationships using a univariate analysis of the data is somewhat difficult. The issue of biological taxonomy arises in this situation. Multivariate distance analysis aids in our comprehension of this issue. Determining the morphological affinities and differences between and among the groups is essential for population classification. Therefore, it is necessary to analyse overall distance differences and mutual relationships among all possible pairs from a matrix of all multivariate distances between the groups obtained by using an appropriate measure of taxonomic distance in order to estimate the numerical taxonomy and group divergence of some specific groups (Adak and Das 1996).

Numerical taxonomy, also known as phenetics, classifies organisms based on overall observable similarities (phenotypic traits) using mathematical and statistical methods. It uses a high number of characters, assigning equal weight to each one. In human population studies, the principles of numerical taxonomy (e.g. using a large number of traits, employing computational cluster analysis) have had a lasting influence on current methods (<https://www.google.com/search?q=Numerical+taxonomy+and+group+divergence+in+human+populations&oq>). For the purpose of measuring the group divergence, the discriminant function, a simplified generalized distance, proposed by Penrose (1954) is generally used.

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It has been demonstrated by Majumdar and Rao (1960) that there exist regional differences between individuals of the same caste, or tribe, and indicated that the different caste or social groups living in contiguous district have greater resemblance than in districts remotely situated.

Dutta (1967) examined the anthropometric traits of the Gandhabanik, a caste population in southern West Bengal, India, and how they differed biometrically from those of nearby population groups. Adak and Das (1994) investigated numerical taxonomy and group divergence among five Mongoloid population groups in Assam, India, based on anthropometric characteristics. Additionally, they looked at seven endogamous groups in the same area (Adak and Das 1996). In a different study, Boruah et al. (2006) investigated the morphometric traits of the Tai-Phake of Assam, India, as well as the kind and degree of morphometric variation with five other nearby Mongoloid population groups. Adak (2001) examined morphometric characters of adult males of the Thingbu-pa and the nature and extent of morphometric variation among four neighboring Monpa tribes of Arunachal Pradesh, India.

Five subgroups of the Koch population living in Meghalaya State, India, differ significantly in terms of demographic composition, according to a previous study by the same authors (Kotal et al. 2025). The numerical taxonomy and group divergence between these five Koch population subgroups are investigated in this work. This is accomplished by evaluating the type and degree of biometrical diversity between these groups.

## **Material and Methods**

This investigation is based on anthropometric data collected from five Koch subgroups (Chapra, Sanga, Satpari, Tintikiya and Wanang) of Meghalaya, India by MK (Murali Kotal). Altogether 16 anthropometric measurements ((height vertex (HV), sitting height vertex (SHV), height tragus (HT), height acromion (HA), head length (HL), head breadth (HB), head height (HH), head circumference (HC), minimum frontal breadth (MFB), bizygomatic breadth (BB), bigonial breadth (BGB), total facial length (TFL), upper facial length (UFL), nasal height (NH), nasal breadth (NB) and chest girth (CG)) were considered on all the subjects. A total of 250 adult males (Chapra=51, Sanga=41, Satpari=41, Tintikiya=61 and Wanang=56) were measured aged between 20 and 60 years. An effort had been made to take into consideration those methods and techniques of measurement suggested by the International Biological Programme given in Weiner and Lourie (1981) and Sen (1994). The present study was carried out in five villages of West Garo Hills district, Meghalaya, India. A detail of area of study and people has been described in Kotal et al. (2025).

The "size" and "shape" distances were computed using Penrose's measures (1947, 1954). The distance has been estimated using common standard deviations for each character. Additionally, the pooled standard deviation unit is used to denote the combined means. The approach of Rao (1952) has been used to analyze the value of " $D^2_p$ " or  $mC^2_H$  (generalized distance). This was done in order to determine the five subgroups' intra- and inter-cluster averages. The following are the size, shape, and  $D^2_p$

mathematical formulae:

$$\begin{aligned} \text{Size distance} &= C^2_Q = \\ &[(d_1+d_2+d_3+\dots\dots\dots+d_m)/m]^2 \\ \text{Shape distance} &= C^2_Z = mS_1(d)^2/m - [ \\ &mS_1(d)]^2/m^2 \\ D^2_P &= mC^2_H = \text{Mean square distance} = S^{12}_1(d)^2/m \end{aligned}$$

where,  $d_1, d_2, d_3, \dots, \dots, \dots, d_m$  represent the difference between standardized means for  $m$  characters in two populations.

## Results

Descriptive statistics of 16 anthropometric characters of the Chapra, Sanga, Satpari, Tintikiya and Wanang have been furnished in Table 1. The characters do not represent distinct physical polytypes. This justifies treating the material of each subgroup as single breeding population. Exceptional cases in this respect are upper facial length (7.11) and nasal breadth (8.87) in the Chapra, head height (8.14), nasal breadth (8.17), upper facial length (8.89) and nasal height (9.45) in the Sanga, nasal height (8.08) and head height (8.70) in the Satpari, nasal breadth (7.28), head height (10.86) and upper facial height (16.83) in the Tintikiya, nasal height (7.38), nasal breadth (7.43), head height (7.50) and minimum frontal breadth (7.68) in the Wanang. This departure from the general trend may be due to small sample size of the present study. Nevertheless, there are some determining differences of variation in greater or lesser order in the measurements. Considerably higher variation is noticed in case of bigonial breadth (6.35), head height (6.46) and nasal height (6.48) in the Chapra, sitting height vertex (6.22), total facial length (6.34) and bigonial breadth (6.63) in the Sanga, upper facial length (6.03) in the Satpari, bigonial breadth (6.17) and total facial length (6.19) in the Tintikiya, upper facial length (6.38) and sitting height vertex (6.92) in the Wanang also show a moderately high variation. Such a variation in these measurements, as explained by Pearson and Davin (1924) is possible due to the spanning of cavities between the space of corresponding measuring landmarks and the varying degrees of thickness of the involved soft tissues of the subjects. In a normally distributed sample of a given population, however, the observed variability in different body measurements are not unexpected. Thus, on the whole, the five subgroups of the Koch population represented by the present sample is homogenous.

**Table 1.** Biometric Data of five Koch Subgroups (males)

Measurements (in cm)	Chapra (n=51)			Sanga (n=41)			Satpari (n=41)			Tintikiya (n=61)			Wanang (n=5in6)		
	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE	Mean±SE	SD±SE	CV±SE
HV	159.41 ±0.76	5.45 ±0.54	3.42 ±0.34	160.53 ±0.89	5.69 ±0.63	3.54 ±0.39	158.04 ±1.02	6.55 ±0.72	4.14 ±0.46	159.55 ±0.68	5.29 ±0.47	3.31 ±0.30	158.77 ±0.71	5.3 ±0.50	3.34 ±0.31
SHV	80.49 ±0.53	3.77 ±0.37	4.68 ±0.46	80.90 ±0.78	5.03 ±0.55	6.22 ±0.69	81.4 ±0.53	3.42 ±0.37	4.20 ±0.46	80.34 ±0.51	4.01 ±0.36	5.0 ±0.45	82.06 ±0.76	5.68 ±0.53	6.92 ±0.65
HT	145.95 ±0.76	5.41 ±0.53	3.71 ±0.37	147.26 ±0.84	5.41 ±0.60	3.67 ±0.40	144.60 ±0.98	6.29 ±0.69	4.35 ±0.48	145.57 ±0.71	5.52 ±0.5	3.79 ±0.34	146.02 ±0.70	5.22 ±0.49	3.50 7±0.34
HA	128.05 ±0.72	5.14 ±0.51	4.01 ±0.40	130.67 ±0.83	5.35 ±0.59	4.09 ±0.45	129.08 ±0.91	5.84 ±0.64	4.52 ±0.50	128.44 ±0.68	5.31 ±0.48	4.13 ±0.37	128.32 ±0.60	4.53 ±0.43	3.53 ±0.33
HL	18.71 ±0.09	0.69 ±0.07	3.69 ±0.36	18.43 ±0.13	0.85 ±0.09	4.61 ±0.51	18.65 ±0.08	0.53 ±0.05	2.84 ±0.31	18.96 ±0.07	0.59 ±0.05	3.11 ±0.28	18.69 ±0.06	0.49 ±0.05	2.62 ±0.25
HB	14.16 ±0.08	0.58 ±0.06	4.10 ±0.40	14.22 ±0.08	0.53 ±0.06	3.73 ±0.41	14.05 ±0.06	0.37 ±0.04	2.63 ±0.29	14.13 ±0.07	0.52 ±0.05	3.68 ±0.33	13.99 ±0.06	0.49 ±0.05	3.50 ±0.33
HH	13.46 ±0.12	0.87 ±0.09	6.46 ±0.64	13.27 ±0.17	1.08 ±0.12	8.14 ±0.90	13.45 ±0.18	1.17 ±0.10	8.70 ±0.96	13.81 ±0.19	1.50 ±0.14	10.86 ±0.98	12.8 ±0.13	0.96 ±0.09	7.50 ±0.71
HC	53.24 ±0.23	1.65 ±0.16	3.10 ±0.31	53.05 ±0.22	1.41 ±0.15	2.66 ±0.29	53.33 ±0.20	1.30 ±0.14	2.44 ±0.27	53.88 ±0.17	1.3 ±0.12	2.41 ±0.22	53.01 ±0.19	1.42 ±0.13	2.68 ±0.25
MFB	10.16 ±0.06	0.41 ±0.04	4.03 ±0.40	10.55 ±0.08	0.54 ±0.06	5.12 ±0.56	10.34 ±0.06	0.39 ±0.04	3.77 ±0.42	10.52 ±0.07	0.52 ±0.05	4.94 ±0.45	10.54 ±0.11	0.81 ±0.08	7.68 ±0.73
BGB	10.55 ±0.09	0.67 ±0.07	6.35 ±0.63	10.56 ±0.11	0.70 ±0.08	6.63 ±0.73	10.51 ±0.07	0.48 ±0.05	4.57 ±0.50	10.69 ±0.08	0.66 ±0.06	6.17 ±0.56	10.64 ±0.07	0.51 ±0.05	4.79 ±0.45
BB	13.33 ±0.07	0.53 ±0.05	3.97 ±0.39	13.34 ±0.07	0.44 ±0.05	3.30 ±0.36	13.25 ±0.06	0.40 ±0.04	3.02 ±0.33	13.44 ±0.09	0.69 ±0.06	5.13 ±0.46	13.36 ±0.05	0.42 ±0.04	3.14 ±0.30
TFL	12.45 ±0.09	0.63 ±0.06	5.06 ±0.50	12.77 ±0.13	0.81 ±0.09	6.34 ±0.70	12.21 ±0.10	0.67 ±0.07	5.49 ±0.60	12.76 ±0.10	0.79 ±0.07	6.19 ±0.56	12.67 ±0.07	0.53 ±0.05	4.18 ±0.39
UFL	7.87 ±0.08	0.56 ±0.05	7.11 ±0.70	7.99 ±0.11	0.71 ±0.08	8.89 ±0.98	7.63 ±0.07	0.46 ±0.05	6.03 ±0.66	8.08 ±0.17	1.36 ±0.12	16.83 ±1.52	7.84 ±0.06	0.50 ±0.05	6.38 ±0.60
NH	6.02 ±0.05	0.39 ±0.04	6.48 ±0.64	6.03 ±0.09	0.57 ±0.06	9.45 ±1.04	5.94 ±0.07	0.48 ±0.05	8.08 ±0.89	6.09 ±0.04	0.34 ±0.03	5.58 ±0.50	6.10 ±0.06	0.45 ±0.04	7.38 ±0.70
NB	3.72 ±0.05	0.33 ±0.03	8.87 ±0.88	3.67 ±0.05	0.30 ±0.03	8.17 ±0.90	3.56 ±0.03	0.18 ±0.02	5.06 ±0.56	3.71 ±0.03	0.27 ±0.02	7.28 ±0.66	3.77 ±0.04	0.28 ±0.03	7.43 ±0.70
CG	82.17 ±0.45	3.22 ±0.32	3.92 ±0.39	83.40 ±0.62	3.98 ±0.44	4.77 ±0.53	83.26 ±0.64	4.12 ±0.45	4.95 ±0.55	82.56 ±0.49	3.80 ±0.34	4.60 ±0.42	81.58 ±0.48	3.58 ±0.34	4.39 ±0.41

SD: standard deviation, SE: standard error, CV: Coefficient of variation

Table 2 displays the pooled standard deviation unit for the mean values of 16 anthropometric characteristics. Differences in measurements and derived distances between any two subgroups are displayed in Table 3. Tables 4-6 present the results. For each comparison (ten in number), the mean size and shape distance have been computed once again using  $mC^2_Q$  and  $(m-1)C^2_Z$ . It has been done, for an overall view about size and shape factors which are involved to find out the divergence of the subgroups. To determine generalized distance, values of  $D^2_P$  or  $mC^2_H$  have been computed.

**Table 2.** Means of Anthropometric Characters in Terms of pooled Standard Deviation Unit

Populations	MEASUREMENTS															
	HV	SHV	HT	HA	HL	HB	HH	HC	MFB	BGB	BB	TFL	UFL	NH	NB	CG
Chapra	28.41	17.97	26.29	24.58	29.70	27.76	11.70	79.46	18.14	17.29	25.63	18.04	9.48	14.00	13.28	22.09
Sanga	28.61	18.06	26.53	25.08	29.25	27.88	11.54	79.18	18.84	17.31	25.65	18.51	9.63	14.02	13.11	22.42
Satpari	28.17	18.17	26.30	24.77	29.60	27.55	11.69	79.60	18.46	17.23	25.48	17.69	9.19	13.81	12.71	22.38
Tintikiya	28.44	17.93	26.37	24.65	30.09	27.70	12.01	80.42	18.82	17.52	25.85	18.49	9.73	14.16	13.25	22.19
Wanang	28.30	18.32	26.31	24.63	29.67	27.43	11.13	79.12	18.82	17.44	25.69	18.36	9.44	14.19	13.46	21.93
Pooled SD	5.61	4.48	5.55	5.21	0.63	0.51	1.15	0.67	0.56	0.61	0.52	0.69	0.83	0.43	0.28	3.72

**Table 3.** Differences between Measurements and derived Distances between any Two Subgroups

Character	Differences	Chapra vs Sanga	Chapra vs Satpari	Chapra vs Tintikiya	Chapra vs Wanang	Sanga Vs Satpari	Sanga Vs Tintikiya	Sanga vs Wanang	Satpari Vs Tintikiya	Satpari vs Wanang	Tintikiya vs Wanang
1. HV	$d_1$	-0.2	0.24	-0.03	-0.11	0.44	0.17	0.31	-0.27	-0.13	0.14
2. SHV	$d_2$	-0.09	-0.2	0.04	0.35	-0.11	0.13	-0.26	0.24	-0.15	-0.39
3. HT	$d_3$	-0.24	-0.01	-0.08	0.02	0.23	0.16	0.22	-0.07	-0.01	0.06
4. HA	$d_4$	-0.5	-0.19	-0.07	0.05	0.31	0.43	0.45	0.12	0.14	0.02
5. HL	$d_5$	0.45	0.1	-0.39	-0.03	-0.35	-0.84	-0.42	-0.49	-0.07	0.42
6. HB	$d_6$	-0.12	0.21	0.06	-0.33	0.33	0.18	0.45	-0.15	0.12	0.27
7. HH	$d_7$	0.16	0.01	-0.31	-0.57	-0.15	-0.47	0.41	-0.32	0.56	0.88
8. HC	$d_8$	0.28	-0.14	-0.96	-0.34	-0.42	-1.24	0.06	-0.82	0.48	1.3
9. MFB	$d_9$	-0.7	-0.32	-0.68	0.68	0.38	0.02	0.02	-0.36	-0.36	0
10. BGB	$d_{10}$	-0.02	0.06	-0.23	0.15	0.08	-0.21	-0.13	-0.29	-0.21	0.08
11. BB	$d_{11}$	-0.02	0.15	-0.22	0.06	0.17	-0.2	-0.04	-0.37	-0.21	0.16
12. TFL	$d_{12}$	-0.47	0.35	-0.45	0.32	0.82	0.02	0.15	-0.8	-0.67	0.13
13. UFL	$d_{13}$	-0.15	0.29	-0.25	-0.04	0.44	-0.1	0.19	-0.54	-0.25	0.29
14. NH	$d_{14}$	-0.02	0.19	-0.16	0.19	0.21	-0.14	-0.17	-0.35	-0.38	-0.03

15. NB	$d_{15}$	0.17	0.57	0.03	0.18	0.4	-0.14	-0.35	-0.54	-0.75	-0.21
16. CG	$d_{16}$	-0.33	-0.29	-0.1	-0.16	0.04	0.23	0.49	0.19	0.45	0.26
Sum of d values $S^{16}_1(d)$		-1.8	1.02	-3.8	0.42	2.82	-2	1.38	-4.82	-1.44	3.38
A.		1.55	0.99	2.05	1.37	2.04	2.94	1.43	2.92	2.26	3.13
B.		0.01	0	0.06	0	0.03	0.02	0.01	0.09	0.01	0.04
C.		0.09	0.06	0.12	0.08	0.12	0.17	0.08	0.17	0.13	0.18
D.		1.00	0.06	0.13	0.08	0.13	0.18	0.09	0.18	0.14	0.19
Size = $mC^2_Q$		0.16	0	0.96	0	0.48	0.32	0.16	1.44	0.16	0.64
Shape = $(m-1)C^2_Z$		1.45	0.93	1.92	1.29	1.91	2.76	1.34	2.74	2.12	2.94
$D^2_P = mC^2_H$		1.55	0.99	2.05	1.37	2.04	2.94	1.43	2.92	2.26	3.13

- A. Sum of squares of 'd' values =  $S^{16}_1(d)^2$
- B. Size distance  $C^2_Q = [S^{16}_1(d)]^2/16^2$
- C. Shape distance =  $m-1/mC^2_Z = S^{16}_1(d^2)/16-[S^{16}_1(d)]^2/256$
- D. Mean square distance =  $C^2_H = S^{16}_1(d)^2/16$

The calculated mean value for the size and shape distances between ten pair is 0.43 and 1.94, respectively. It demonstrates that shape distance has a higher value than size distance. Therefore, it may be concluded that there is a tendency for the five Koch population subgroups to differ more in shape distance than in size distance. However, here, the shape distance plays more important role than size distance because of overall morphological dissimilarity and differences.

**Table 4.** Values of Size Distance ( $mC^2_Q$ ) between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	0.16	0.00	0.96	0.00
Sanga	-	-	0.48	0.32	0.16
Satpari	-	-	-	1.44	0.16
Tintikiya	-	-	-	-	0.64
Wanang	-	-	-	-	-

**Table 5.** Values of Shape Distance  $(m-1)C^2_Z$  between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	1.45	0.93	1.92	1.29
Sanga	-	-	1.91	2.76	1.34
Satpari	-	-	-	2.74	2.12
Tintikiya	-	-	-	-	2.94
Wanang	-	-	-	-	-

**Table 6.** Values of generalized Distance ( $D^2_P$ ) between any Two Koch Subgroups

Subgroups	Chapra	Sanga	Satpari	Tintikiya	Wanang
Chapra	-	1.55	0.99	2.05	1.37
Sanga	-	-	2.04	2.94	1.43
Satpari	-	-	-	2.92	2.26
Tintikiya	-	-	-	-	3.13
Wanang	-	-	-	-	-

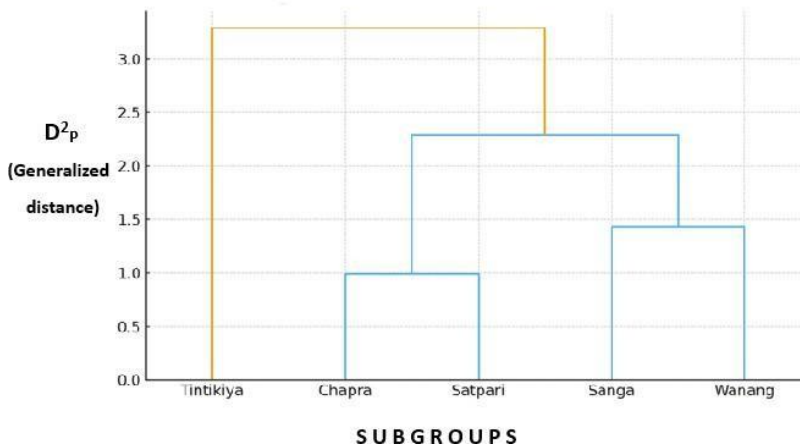
The generalized distance, or  $D^2_p$ , values between these subgroups are displayed in Table 7 in ascending order of magnitude. It shows that Satpari and Chapra keep the smallest distance (0.99). Wanang and Chapra, standing side by side, likewise keep a close distance (1.37). Wanang and Satpari (2.26), Wanang and Tintikiya (3.13), on the other hand, keep a far distance from these groups. Tintikiya and Satpari (2.92) and Sanga and Tintikiya (2.94) also keep a considerable distance from one another.

**Table 7.** Values of generalized Distance i.e.  $D^2_p$  (based on 16 characters) between any Two Koch Subgroups arranged in increasing order of Magnitude

Chapra	Sanga	Satpari	Tintikiya	Wanang
0.99	1.43	0.99	2.05	1.37
Satpari	Wanang	Chapra	Chapra	Chapra
1.37	1.55	2.04	2.92	1.43
Wanang	Chapra	Sanga	Satpari	Sanga
1.55	2.04	2.26	2.94	2.26
Sanga	Satpari	Wanang	Sanga	Satpari
2.05	2.94	2.92	3.13	3.13
Tintikiya	Tintikiya	Tintikiya	Wanang	Tintikiya

Based on the information provided in Table 6, a dendrogram has been generated (Figure 1) using the method of Mardia et al. (1979). There are two distinct clusters. Cluster I: Chapra and Satpari. Cluster II: Sanga and Wanang. On the other hand, Tintikiya found to be maintaining a far distance with these clusters. However, cluster I maintains a close distance in comparison with cluster II.

**Figure 1.** Dendrogram based on Generalized Distance ( $D^2_p$ ) of Five Subgroups



**Discussion**

Anthropology is primarily concerned with the taxonomic classification of human being at both micro and macro levels with a view to understanding the process of human evolution in space and time. Physical anthropology deals with the phylogenetic position

of human populations in terms of their differences and similarities mainly in respect of morphological or anthropometric characters (Harrison 1977). Human populations are highly polymorphic, thereby indicating that they are basically the unit of ongoing process of evolution (Kotal 2003).

This anthropometric study was carried out among five subgroups of Koch population residing in Meghalaya, India. These subgroups mainly marry within their own group practicing endogamy. Differences exist among themselves in terms of social and economic conditions. It may be necessary to look into inter-subgroup variation within the Koch population.

It becomes quite clear from the higher computed mean value for 'shape' distance than that of the 'size' distance that the population sample which we are dealing with can only be classified effectively in terms of their morphology, 'shape' being related to morphology, and not by the 'size' differences of the populations.

Two distinct clusters appeared on the basis of generalized distance. Cluster I by Chapra and Satpari and Cluster II by Sanga and Wanang. On the other hand, Tintikiya maintain a far distance with these clusters. However, cluster I maintains a close distance in comparison with cluster II. Thus, this is the inter-subgroup relationship of the Koch subgroups on the basis of numerical taxonomy and group divergence.

In fine, it can be said that intra- and interpopulation variation among five Koch subgroups may be associated with many biological and environmental factors. In this context, it can be mentioned here that in fact selection operates ultimately on the overall phenotype of the individual, and every component of the environment determines the nature and intensity of the selection (Harrison 1966).

## **Conclusion**

Phenetics gives us the chance to examine the similarities and differences between various population groups residing in the same ecological zone based on the general observable similarities of phenotypic features. Five sub-groups of the Koch population inhabiting Meghalaya state of India appear to be important to investigate morphological traits and the type and degree of variation and similarity. The size and shape of population groups living in the same ecological zone can differ. On the basis of generalized distance clustering of five Koch sub-groups indicate overall morphological variations and dissimilarities. Role of various biological and environmental factors cannot be ruled out in this study.

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