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Body morphology and the savanna - forest transition: a West african example

Four Cameroonian populations were studied for a large set of anthropometric measurements. Three groups live in the forest (two Bantu speaking, and one pygmoid tribe) and the fourth one in the savanna plateau. Multivariate analysis of the morphological features showed that the two Bantu groups have very similar body morphology. This is interpreted to be a result of common genetic origin and of the fact that they inhabit the same environment Whereas the Pygmoids segregate apart. The savanna dwellers are morphologically equidistant from the two former groups, and when compared to other savanna peoples living in Burkina-Faso, are seen to be more similar to forest populations. Some climatic influences can be identified, mainly on limb proportions and nose and face dimensions. They seem to play a larger part in body differentiation than do nutritional and/or pathological conditions. Differences between the forest Bantu and the savanna-dwellers are mostly due to a shape component, whereas the Pygmoids display an overall reduction in size. Savanna highlanders also exhibit a size reduction, which results in their being more similar in shape to the Pygmies than are the other groups compared. A fruitful approach to morphological differentiation must take advantage of opportunities to compare peoples sharing the same genetic origin but having migrated to occupy contrasting environments. The hypothesis is raised that a common African stock has differentiated in contrasting ecosystems.

Key words: Africa, Cameroon, morphology, climate, pygmoid, Bantu, adaptation.

Introduction

Subsaharan Africa is the land where modern man originated (BRAUER, 1984) and therefore where human evolution has had the longest history. African populations display the widest range of variability for most biological characteristics (HIERNAUX, 1968a). Cameroon is a particularly interesting field for the anthropologist, for it includes examples of virtually all the ecosystems existing on the continent; a wide variety of cultures is encountered, and 240 different languages have been identified (ALCAM, 1983). Among them, the groups of the Benue - Cross River area are considered as the focus of the Bantu expansion in the early Iron Age (GREENBERG, 1963). As part of an extensive multidisciplinary program designed to study the effect of ecological constraints upon societies living in tropical areas a biomedical survey has been conducted in Cameroon since 1984 to study the relationship between health and foodways. Various fields were considered, including food consumption, nutritional status, spirometry, dynamometry, blood pressure, parasitology, hematology, serum biochemistry, seroepidemiology and energy balance. An anthropological approach to social systems, food technology, ethnoscience, linguistics and kinship, was also carried out under the direction of Prof. Igor de Garine. This preliminary paper is restricted to anthropometric results and, as a tribute to Prof. Jean Hiernaux's extensive work in Africa, will refer especially to his own studies.

The rationale of the study is to compare the morphology of populations of different origin but sharing the same equatorial environment (Pygmoid and Bantu populations), of populations genetically related but using different food strategies (two Bantu tribes) and finally of unrelated peoples living in different ecosystems (savanna highlanders and forest dwellers).

Anthropometric data for Cameroonian populations are scarce. The oldest are summarized in HIERNAUX (1986a) and derive almost exclusively from the studies of OLIVIER & VALLOIS. AUGER (1967) beautifully reanalyzed Olivier's data using PENROSE'S (1967) coefficient of morphological distance and concluded to a relative proximity of populations living in the forest. In North Cameroon Huizinga conducted a comprehensive survey of the Fali between 1968 and 1974 (see HUIZINGA 1977) and compared them to other savanna populations. In all the cases individual data were not accessible for multivariate analysis, therefore in this paper only subjects measured by the author, in Cameroon and in West Africa, were included in order to refine the analysis and eliminate divergence due to different techniques and observers.

Sample and Methodology

1. *Description of the populations*

Of the four populations described, three inhabit an area of coastal rain forest near the border between Cameroon and Equatorial Guinea (see map, *Figure 1*).

The Yassa tribe is specialized in sea fishing. Their refined knowledge of fish species and their habits indicates a long period of familiarity with the ocean. The Yassa live mainly in Equatorial Guinea, and their number in Cameroon is estimated at less than 3,000. Their language (A 80 in Greenberg's classification) is a bantu language related to those of larger coastal group such as the Batanga and the Duala. Their diet is based almost exclusively on cassava, fruits, fish and palm oil.

The Mvae tribe belongs to the large Beti-Bulu-Fang cultural complex which occupies all the central part of Cameroon and northern Gabon. Their language (A 70) belongs to the same equatorial family as that of the Yassa, but is on another branch, and there is no mutual comprehension. The Mvae have lived in the deep forest during several centuries and reached the sea-shore less than fifty years ago. They are clever agriculturalists and complete their diet based on tubers, leaves and bananas, with game and fish. In our sample, half of the people lived in the forest and the other half on the coast, but they never practice fishing themselves, except in the rivers. The Mvae are estimated to number around 2,000 but show no clear-cut separation from other Beti-Fang-groups.

The Gyeli group is, according to CAVALLI-SFORZA (1972), the tallest Pygmy group measured thus far (men average 159.3 cm, women 148.9 cm). In this regard they are better designated as Pygmoids. In fact the anthropological definition of Pygmies refers less to their short stature that to their way of life based on hunting and gathering in rain forest. This traditional style is now shifting towards an elementary agriculture, based mainly on cassava; permanent villages are built but can be deserted during several weeks as game remains the principal interest. The Bagyeli are the westernmost Pygmy group, separated from the others (Baka of Eastern Cameroon) by a zone from which Pygmies are absent. Like Pygmies elsewhere, they have lost their original language and now speak a Bantu language related to Ngumba (or Kwasio, or Mvumbo, A 80). Ngumba is spoken around Loldorf by a Bantu agriculturalist group whose migrations, accompanied by the Pygmies, were interrupted by wars with the Bassa, Batanga and Beti populations one century ago, when the first German explorers arrived in Cameroon. The Pygmies reached the sea near Kribi without the Ngumba and have no relation of dependency with Mvae

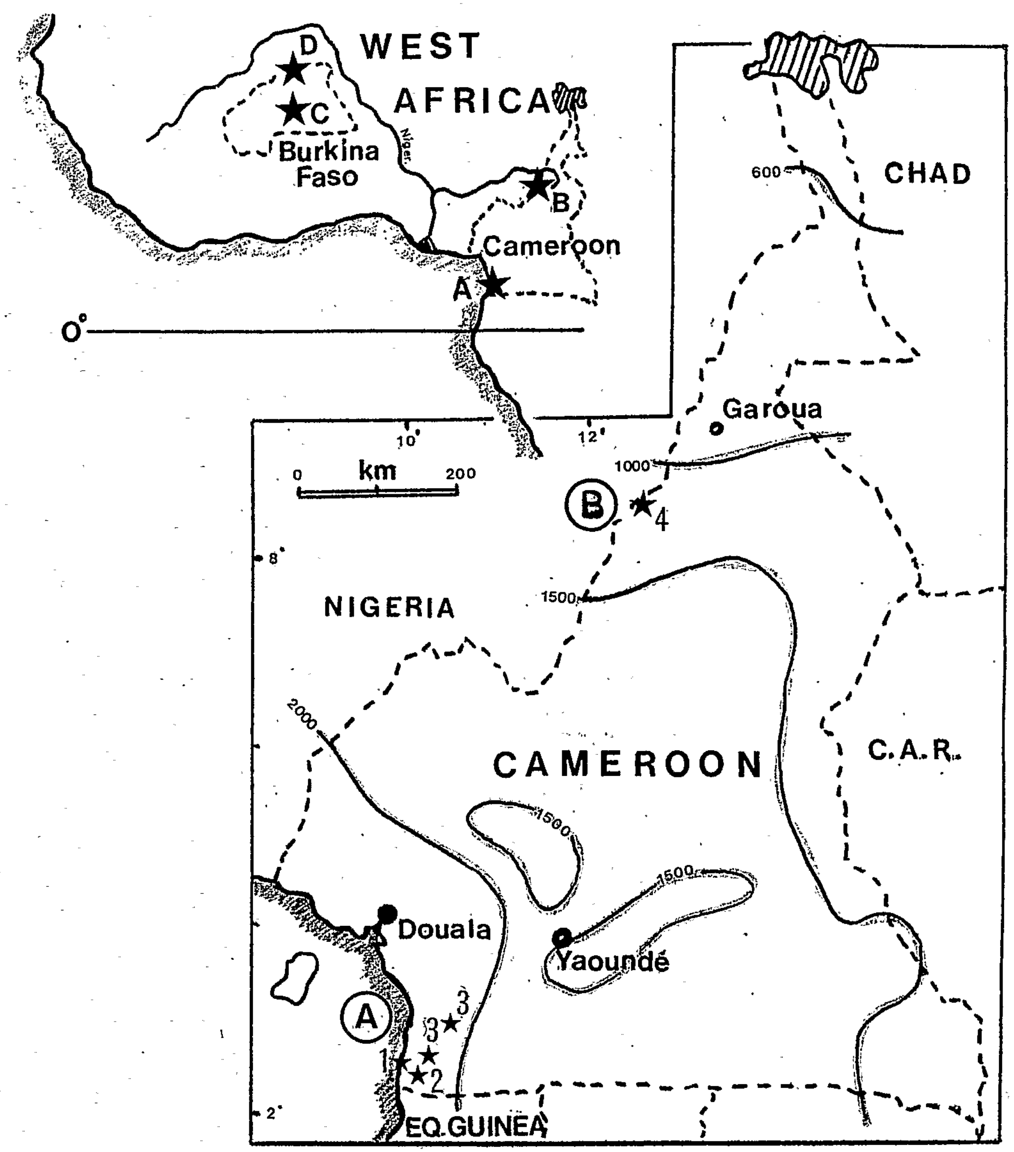

Figure 1 - Map of the research area. Isohyets in mm.
Cameroon: A = Equatorial forest B = Savanna highland
Burkina: C = Sudanian zone D = Sahelian zone

In area A: 1 = Yassa group; 2 = Mvae; 3 ; Bagyeli
In area B: 4 = Koma group.

villagers, who sometimes marry Pygmy women as second wives. The situation is different around Akom II, where Bulu villagers behave like «patrons» and do not intermarry. Our sample is based on subjects met in Akom II and in the Kribi area. They belong to the same cultural community, which counts less then 1,000 subjects. Their diet is based on cassava (cultivated or purchased from villagers) and meat.

There is no genetic admixture between the Gyeli and the Yassa. The frequency of intermarriage (which is reciprocal) between the Yassa and the Mvae averages 5% of mates (at least legally, since many illegitimate births now occur in the villages, as well as in the major cities to which the young people tend to emigrate).

The climate in this equatorial area (2° N) is characterized by high humidity, abundant rainfall occurring throughout the year but concentrated during as a short and a long rainy season, and low solar radiation, except on the shore. Food is usually abundant throughout the year and seasonal variations of weight are almost negligible. Only Mvae women, at the time of heavy field work, showed a significant weight loss of around 2 kilograms in 1985, but not in 1986. In Mvae males, and in the two other groups for both sexes, the average variation in weight over the year was less than 1 kg. Child malnutrition can thus be attributed to poor sanitary conditions, diarrheal diseases and a heavy parasite load both in the gut and in the blood.

The fourth group studied, the Kôma Gëmbë, lives in a completely different environment, the savanna and highlands along the border with Nigeria at 9° N latitude. Originally inhabitants of the plain, they took refuge from Fulani invaders (arriving around 1830) in well-protected mountains (maximum altitude 1,700 m). They are now tending to come down to the plain, which lies about 350 m above sea level. Climate there is hot and dry, with only one rainy season, and more marked extremes of temperatures, though attenuated at higher altitudes. The subjects in the sample were all living in the plain, but around one-third were born in highland villages. Their language belongs to the Admawa-Ubanguian branch of the great Niger-Congo subdivision. This branch is very far from the Benue-Congo branch, to which are appended bantu languages. Endogamy is over 95%, but the size of the population, around 2,000, is not limited by geographical barriers. The group expands on the Nigerian slopes of the mountains where their number is unknown, but probably higher than on the Cameroonian side. The Koma are good agriculturalists; sorghum, millet, groundnuts, bambara groundnuts, maize and yams are the main crops. Meat is rare but there are some cattle, goats and poultry. Endemic goiter affects 3% of the men and 22% of the women. Their environment, cultural particularity, and great distance from the equatorial area make them completely different from the forest peoples. The anthropological situation herein described is somewhat similar to the one comparing Sara Majingay, Twa and Oto (Hiernaux, 1977), where females were not included nor were West Africa populations (except Bedik) used. The present study can therefore be considered as complement of the latter one, and populations of the Niger bend were used as a useful comparison term to achieve the gradient between thorn savanna, dry savanna, wet savanna and forest.

2. *Anthropometry*

Nearly 2,000 children and adults belonging to the four groups were repeatedly measured between 1984 and 1987 to assess their nutritional status and seasonal variations. Detailed anthropometry was limited to a representative subsample of each group totaling 230 adults (108 men, 122 women). Anthropometric measurements were taken (see list in *Table 1*) according to IBP recommendations (Weiner & Lourie, 1981) and inspired by their full list. Sitting height was taken using the technique of Pales, (1953). The normality of distribution of the variables was acceptable, as well as the equality of variances.

3. *Calculations*

Data were analyzed by univariate and multivariate procedures, using the SPSS/PC+ software run on an IBM-PC microcomputer. In *Tables 1* to *3*, means are compared using one-way analysis of variance with the Student-Newman-Keuls test. Discriminant analysis was carried out using the Mahalanobis method (cf. SPSS). This is a stepwise procedure using canonical discriminant functions, where the variable that has the largest D^2 for the groups that are closest is selected for inclusion. It is noteworthy that SPSS/PC+ produces neither a D^2 matrix nor bidimensional projection with the least possible distortion, of the position of populations in the hyperspace defined by the variables chosen. It produces only scatter plots of groups on the first two discriminant functions. More refined multivariate programs are not available in Cameroon at the moment. However, the use of discriminant functions was considered acceptable, as in all the computations the first and second functions accounted for 83 to 95% of the total variance observed. This technique was used by Kurisu (1970), Gomila & Desmarias (1980) and Milton (1983) with fruitful results. The dendrograms were also obtained through the command «cluster» of SPSS/PC+.

Results and Discussion

Means and standard deviations of all the anthropometric measurements are displayed in *Table 1*.

Analyses were performed on four groups of variables: 1) all variables, 2) limb and trunk measurements, 3) cephalic measurements, and 4) measurements of «soft parts» (i.e. muscle and fat).

Factotial analysis identified six functions, grouping respectively a) all bone lengths and biiliocristal diameter, b) all skinfolds, c) all widths, d) weight, muscle, and sitting height, e) cephalic measurements, and lastly, f) nose width and ear dimensions. The «soft parts» variables were later omitted in order to compare the skeletal frame and not the present nutritional status, but weight was kept in the analysis, because body mass is involved in climatic adaptation processes (Hiernaux *et al.*, 1975) and not only dependent on diet and activities. Many combinations of variables were run using SPSS discriminant analysis but all gave similar results, comparable in both sexes (*Figure 2*). Bantu villagers (Yassa and Mvae) are closer together than either is to Pygmies, the Koma are equidistant from both Bantu and Pygmy populations, with a tendency to be closer to the Bantu, and the Mvae show a trend to occupy an intermediate place between the Yassa and the Gyeli.

The body morphology of Mvae and Yassa women is quite similar (as is their nutritional status), whereas Mvae men have more similarity with Pygmoids in measurements of the upper limb, bone width and trunk.

A first problem is to discuss whether the intermediate position of the Mvae is due to genetic mixture between a «Bantu» and a Pygmy stock. As mentioned earlier, some Mvae men marry Gyeli women (unidirectional genetic flux), which is never observed among the Yassa. This problem is similar to the one examined by Hiernaux (1966) on the proximity between the Twa and the Mbuti. Though our research was not oriented towards popula-

TABLE 1 - [illegible] differ at a 5% significance level. Weight in kg, all other dimensions in mm.

Group	Yassa		Mvae		Gyeli		Koma	
	1	2	3	4	5	6	7	8
Sex	male	female	male	female	male	female	male	female
N=	26	21	29	30	17	28	36	43
1 Weight	61.8± 7.2d	51.0± 6.9bc	61.3± 8.1d	54.8± 9.3c	49.5± 4.7bc	44.8± 5.6a	53.2± 6.8bc	50.0± 5.7b
2 Stature	1662.1±45.6c	1570.0±61.5b	1648.8±70.9c	1570.2±57.5b	1571.8±48.0b	1489.2±51.6a	1632.7±52.9c	1540.8±61.0b
3 Iliac spine hgt	950.3±32.7c	906.2±44.9b	945.0±48.1c	912.3±45.0b	891.5±31.2b	840.1±40.5a	947.3±41.0c	891.1±48.5b
4 Tibial length	454.7±19.4c	428.7±23.5b	458.0±27.8c	435.7±27.4b	429.9±17.9b	401.4±20.4a	456.3±22.1c	424.1±27.3b
5 Upper limb length	771.8±16.6d	716.7±32.6b	750.2±38.2c	712.3±30.3b	721.1±29.4b	669.5±29.4a	761.4±32.9c	704.1±38.1b
6 Forearm length	450.9±17.8c	420.5±19.4b	439.8±23.6c	418.0±18.1b	325.7±21.2b	396.2±19.2a	446.8±21.3c	412.1±24.5b
7 Arm length	324.0±14.6c	300.0±15.0b	316.9±17.3c	298.4±12.2b	301.6±10.7b	276.0±15.6a	320.4±17.6c	297.6±15.9b
8 Wrist breadth	52.9± 3.3d	48.7± 2.6bc	52.1± 3.7d	48.3± 3.1bc	49.8± 3.8c	46.9± 2.3a	52.8± 3.1d	49.0± 2.3c
9 Hand length	191.8± 6.6gf	180.7± 7.8ce	186.1±10.3gef	177.5± 6.3ac	181.8± 8.5cef	171.9± 8.2ab	187.3±10.5gf	175.2±10.2abc
10 Hand breadth	83.3± 3.5d	75.7± 3.9b	81.1± 3.7c	75.5± 3.3b	76.6± 3.2b	71.8± 3.0a	82.9± 4.1d	76.5± 3.8b
14 Biacromial dia.	372.0±15.7d	336.3±17.0b	371.3±15.9d	340.1±15.9b	351.6±14.3c	322.0±14.6a	365.0±13.7d	337.8±18.2b
15 Transverse chest	265.5±15.8e	235.4±13.4bc	259.0±16.3de	237.5±16.3b	245.6± 9.1c	226.6±12.7a	253.6±12.4d	236.2±10.9b
16 Antero post. chest.	189.5±13.1de	168.8±11.6a	193.1±12.6de	175.2±12.3b	184.2±10.2cd	167.2± 8.6a	186.7±11.6de	178.1±10.0bc
17 Biiliocrist. diam.	252.9±13.2c	253.5±14.1bc	252.9±12.2c	250.3±13.9bc	247.8± 9.0bc	238.5± 8.8a	248.2±12.3bc	244.0±12.6ab
25 Sitting height	849.4±25.9d	800.3±35.0bc	846.4±34.5d	804.3±33.7c	814.0±32.0c	779.9±30.4ab	818.4±27.6c	783.4±26.0a
26 Bicondylar humer.	68.0± 2.5i	61.1± 2.5cd	65.8± 3.1g	61.2± 2.8ce	63.3± 2.3df	57.4± 2.0a	65.1± 3.0gh	61.0± 3.5bc
27 Bicondylar femur	93.2± 3.7F	82.4± 3.7B	90.0± 5.2E	83.4± 4.4B	85.8± 2.9D	78.5± 3.6a	87.3± 3.6d	80.5± 3.1bc
28 Ankle breadth	69.8± 3.0d	63.1± 3.1b	69.3± 3.9d	62.5± 3.1b	66.6± 2.8c	61.3± 3.6a	68.8± 3.7d	62.7± 2.8b
29 Foot length	257.4±11.0d	238.4±11.8b	252.6±13.7cd	237.3±10.1b	246.4±10.7c	228.0±10.9a	253.6±12.3cd	233.6±12.8ab
30 Foot breadth	94.7± 6.9c	82.0± 5.8b	93.3± 8.3c	85.5± 5.5b	86.6± 4.5b	78.4± 5.8a	93.2± 5.3c	84.2± 5.9b
31 Head length	189.8± 5.1eg	180.7± 5.6a	190.8± 6.1ef	185.9± 4.7bd	185.6± 5.3bcd	181.0± 5.3a	187.2± 6.7def	182.9± 5.5ab
32 Head breadth	148.9± 4.1d	143.3± 4.0c	148.2± 5.1d	143.4± 5.4c	142.0± 3.6bc	138.5± 4.6a	144.1± 5.0c	140.0± 4.2ab
33 Minim. front. diam.	117.9± 3.8c	112.9± 4.0b	117.0± 4.7c	112.7± 3.7b	110.7± 3.8b	108.1± 3.7a	115.5± 4.8c	111.4± 4.2b
34 Bizygometric diam.	138.3± 4.2cd	131.0± 5.3b	138.7± 5.9cd	131.2± 4.1b	135.4± 4.2c	127.0± 4.5a	138.1± 5.4d	131.3± 4.1b
35 Morph. face height	121.2± 6.4e	116.0± 7.2bcd	118.0± 8.0ce	113.8± 6.0bc	119.9± 6.8ce	109.8± 5.9a	120.1± 6.1ce	114.0± 5.4d
36 Nose height	51.8± 4.5bd	51.4± 4.1bd	51.2± 3.6bd	51.6± 3.1bd	51.0± 4.1bcd	48.4± 3.2a	52.3± 3.7b	49.3± 3.1ab
37 Nose height	45.7± 2.3de	41.4± 2.6a	46.1± 3.7de	43.4± 3.0ab	47.2± 3.0ed	43.1± 2.8ab	44.6± 3.5bcd	42.2± 3.1a
38 Lip thickness	24.1± 4.1c	2.6± 3.1 bc	22.0± 3.8bc	22.1± 4.8bc	16.4± 4.2a	16.7± 4.0a	21.2± 3.1b	20.0± 3.9b
39 Mouth width	59.8± 3.4d	55.1± 3.1ab	58.7± 3.9cd	55.9± 2.9ab	59.3±3.5 vd	56.9± 3.1 abc	58.4± 4.1cd	55.9± 3.6ab
40 Ear length	60.8± 4.1bc	57.5± 3.7ab	61.3± 4.3c	60.0± 3.9bc	61.2± 3.8bc	60.1± 4.5bc	56.6± 4.4a	57.6± 4.0a
41 Ear breadth	36.3± 2.9bd	34.3± 2.4bc	36.8± 1.9d	34.9± 3.0bc	36.4± 2.6bd	34.9± 2.6bc	34.3± 2.4c	32.9± 2.3a

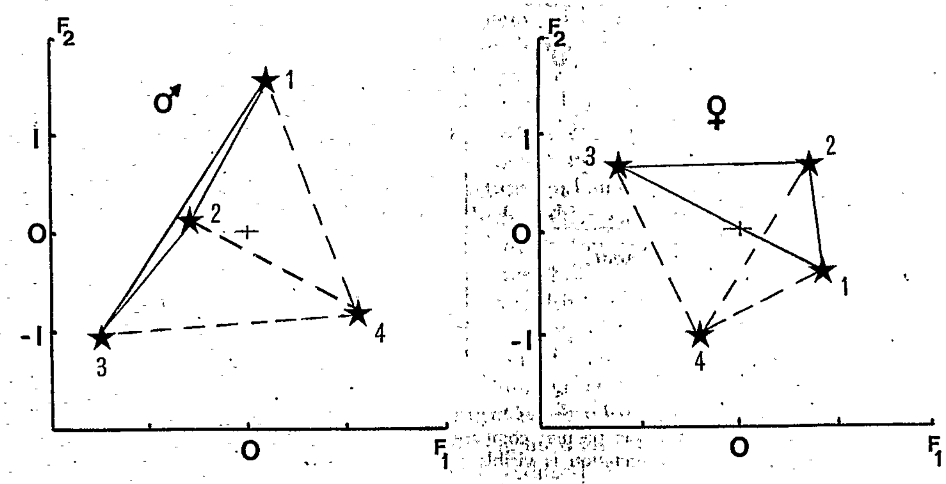

Figure 2 - Discriminant analysis of anthropometrical variables. Only the two first functions F1 and F2 are shown. In this example, trunk and limb measurements are used for males (left), and head measurements for females (right). Other combinations of variables would lead to similar results.
1 = Yassa; 2 = Mvae; 3 = Bagyeli; 4 = Koma.

tion-genetic studies, some blood polymorphisms were determined (*Table 2*). ABO gene frequencies were calculated according to HIERNAUX & TISSIER (1972). Haplotypes of the Rhesus complex were not studied, so only the percentage of the negative phenotypes is given. Frequency of the S allele was calculated after hemoglobin electrophoresis. Observed proportions conformed to Hardy-Weinberg equilibria.

From these few data a very crude genetic distance was calculated by the formula $X^2 = \Sigma(p_i - p_j)^2$ as discussed buy GOWER (1972). The squared distance between the Yassa and the Mvae is only .005, and .008 between the Yassa and the Gyeli, but .023 between the Mvae and the Gyeli. This result rules out the possibility that the intermediate position of the Mvae with respect to morphology is due to interbreeding between Bantu and Pygmy stocks. In our sample 8 out of 62 Mvae heads of households have a Pygmy spouse, but in the light of population movements during the last century, this phenomenon is too recent to have had perceptible effects on past generations. The Mvae have a very high frequency of B antigen and the Gyeli a very low one. CAVALLI-SFORZA (1969-1972) conducted genetic investigations among several Pygmy groups in Central Africa, and showed they usually display a high frequency of B, and a low frequency of the sickle-cell

TABLE 2 - *Gene frequencies in the ABO Rh system and sickle cell hemoglobin. Significant differences are marked with different letters.*

	Yassa n=260	Mvae n=184	Gyeli n=104
Gene p	.125 a	.142 a	.122 a
Gene q	.119 b	.185 c	.039 a
Gene S	.104 a	.089 a	.043 b
Rh neg %	.031 a	.043 a	.038 b

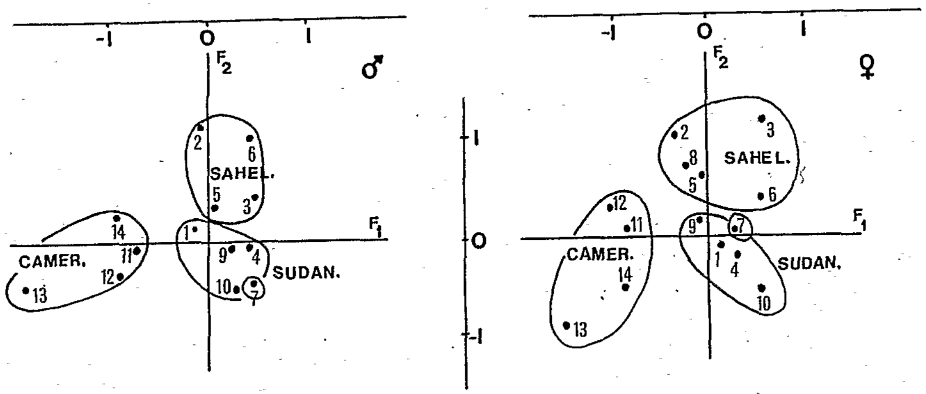

Figure 3 - Discriminant analysis limited to the less nutrition-sensitive variables (listed n° 2, 3, 6, 7, 35, 36 in *Table* 1). Cameroon and Burkina peoples compared.
A trend towards geographical association is visible.

1 = Mossi D	2 = Bella	3 = Rimaibe	4 = Gurmanche	5 = Mallebe
6 = Sonrai	7 = Dogon	8 = Peul	9 = Bwaba	10 = Mossi A
For Cameroon:	11 = Yassa	12 = Mvae	13 = Bagyeli	14 = Koma.

allele (S), except for the Mbuti (0.18). He sampled blood from people in three villages of the Kribi area, the area under study here, and speculates on an estimated 60% Bantu genetic admixture. As no gene flow into the Pygmy population is observed today, he notes that «if a mixture has occurred, much time has since elapsed». Genetic drift could well have played an important role since the time of that postulated exchange, which would have involved other Bantu groups other than the Mvae, possibly the Ngumba, from whom the Gyeli borrowed their language. The Bagyeli are remarkably tall, 8 cm more than the arbitrary limit defining a Pygmy population, and that is the reason why a mixture has been postulated. It is well known that the reduced size of the Pygmy has a genetic origin (Merimee *et al.*, 1982) and that it could confer adaptive advantages, though a thermoregulation hypothesis is not supported by the experimental work of Austin & Lansing (1986).

Koma people have a surface area/weight ratio more adaptive to their drier environment, as is the reduction of body fat. The women, however, do not show such a weight reduction, and more studies are needed on thermoregulatory processes and surface area/weight ratio in females.

From the results of this study it appears that the forest environment induces a certain modeling of body shape, and a savanna group is found to be as dissimilar to Bantu villagers as they are to Pygmies, to whom their genetic relationship is much more remote.

To enlarge the scope of the comparison, the four Cameroonian populations studied were compared to ten peoples in Burkina Faso, living in a semi-arid (sahelian) and in a moister (sudanian) savanna area (Fromen & Hiernaux, 1984). *Figure 3* presents results of the discriminant analysis for several non-nutrition-dependent variables (stature, upper limb proportions, nasal height). Similar results, not depicted in the figure, were obtained when other variables, such as cephalic dimensions, were used. No cluster appears but a geographical differentiation is visible, which can separate Sahelian, Sudanian and Cameroonian groups. Pygmies occupy the periphery of the plot but the expectation that the Koma would be closer to savanna peoples than to forest peoples is not fulfilled.

From *Table 3* it can be seen that the main discriminants on a morphological ba: concern, for the head, the cephalic and nasal indices which are considerably higher Cameroonian populations, while the facial index is low. These indices are independent nutritional status (Hiernaux, 1963) but influenced by climatic factors, namely pluvi metry, temperature and moisture (see Hiernaux & Froment, 1976 for review ar correlations). Head breadth, bizygomatic diameter and nose breadth increase, and no height decreases, with pluviometry and moisture, and all these dimensions increase wh extremes of temperature are minimal, which is the case in forest areas where tl temperature is fairly constant and lower than in the savanna. At the somatic lev Cameroonians are characterized by a high biacro-biiliac ratio (broader shoulders) wh compared with Sudanian groups but their hip width is also enlarged, though to a less degree. In Africa biacromial diameter is positively correlated with pluviometry and biili diameter negatively correlated, so that our results do not completely meet the predictio However, Hiernaux (1963) showed that shoulder and pelvic girths are sensitive nutritional status, which tends to be better in Cameroon than in Burkina Faso. Huizin & Birnie-Tellier (1966) suggested, comparing male and female body dimensions of tl Dogon, that the woman was a «harmoniously reduced male», or, more properly, that tl man is a «harmoniously enlarged female». We have noticed that savanna people ha narrower shoulders, which contributes to a more rectangular shape of the trunk in dri areas. But Huizinga also bases his observation on the comparison of the Dogon wi Europeans, who have the largest recorded hip width (Olivier, 1965), so that tl reference is not universal.

The thorax, which is rounder among Pygmies, does not show everywhere th tendency to be narrower in regions of high rainfall. On the contrary, the Yassa have large and flat chest. Among forest peoples the upper limb is short, with a shorter forearr and the lower limb is short as well (high cormic index). These features appear in oth populations in humid areas, possibly for reasons relating to thermoregulation. Pygmies c not display a very particular morphology, and fall within the range of other Africa populations, as Ghesquire & Karvonen (1981) pointed out. Koma highlanders, who ter to have reduced body dimensions, tend to be closer to forest peoples than to other savanı tribes. Living between 700 and 1,500 meters and at a lower latitude than other savanr tribes, they enjoy a moister and cooler climate. However, further investigations will ha to test for a possible influence of slight iodine deficiency on body morphology.

Studying the muscle, fat and bone measurements of the upper limb among the Sa Majingay, a savanna tribe from Chad, and the Twa, a forest Pygmoid populatio Hiernaux *et al.* (1974) noticed a significant reduction of the three components amor forest people and advanced the hypothesis of a gracilization of the body adaptive in humi environments because of thermoregulatory advantages, and especially by a reduction c basal metabolism through muscle mass lightening. We did not notice such a gracilizatio in bone, fat nor muscle in either the Koma/Bantu comparison, the comparison of Bant and Pygmoids (the latter having acclimated to the forest for a much longer time), or in th comparison between Burkina Faso savanna and Cameroonian forest tribes, but only reduction of stature.

In order to better understand morphlogical differences among our set of population we calculated Penrose's C^2_H, which has the advantage of povvinding a measure c interpopulation distance that is easily computable and includes both size and shap components. As Hiernaux, Huizinga and others have repeatedly noted, biological dat usually do not fulfill the requirements of sophisticated analyses. We computed C^2_H(*Tab* 4) and its size component C^2_Q (*Table 5*) expressed in % of the generalized distance. In th

TABLE 3a - *(Male populations). Means and standard deviation of 8 anthropometric indices compared by ethnic group. Values followed by the same letter do not differ at a 5% significance level.*

Group Population N=	1 Sudanian 140	2 Dogon 145	3 Sahelian 141	4 Bantu 55	5 Gyeli 17	6 Koma 36
1 Cormic index	49.9± 1.5 a	50.0± 1.5 a	49.7± 1.6 a	51.2± 1.3 b	51.8± 1.1 b	50.1± 1.2 a
2 Upper limb/stature	46.8± 1.1 c	46.3± 1.1 b	46.8± 1.4 c	45.9± 1.1 c	45.9± 1.0 ab	46.6± 1.0 bc
3 Forearm/upper arm.	141.2± 4.8 a	143.6± 5.2 b	141.4± 5.8 c	139.1± 5.9 a	141.2± 6.6 ab	139.6± 6.1 a
4 Biacromial/bicristal	148.1± 8.6 b	164.4± 8.3 bc	142.0± 8.7 a	147.2± 7.1 bc	142.0± 6.7 ac	147.3± 7.2 bc
5 Thoracic index	134.6± 9.1 a	139.3± 8.1 bc	135.3± 9.7 ab	137.3± 8.6 ab	133.6± 7.6 a	136.2± 8.3 ab
6 Cephalic index	73.9± 3.0 a	74.4± 2.7 a	75.4± 2.8 b	78.1± 3.1 c	76.5± 2.2 bc	77.0± 2.8 c
7 Facial index	87.5± 5.8 bc	87.1± 4.8 ac	88.9± 5.8 b	86.3± 5.4 ac	88.6± 3.7 bc	87.0± 3.8 a
8 Nasal index	87.2± 9.4 b	86.5± 9.6 b	89.3± 8.1 a	89.8±10.1 bc	92.9± 6.3 c	85.7± 7.5 bc

TABLE 3b - *(Female populations). Means and standard deviation of 8 anthropometric indices compared by ethnic group. Values followed by the same letter do not differ at a 5% significance level.*

Group Population N=	1 Sudanian 307	2 Dogon 51	3' Sahelian 154	4 Bantu 50	5 Gyeli 28	6 Koma 43
1 Cormic index	50.5± 1.4 a	50.7± 1.6 a	50.7± 1.5 a	51.1± 1.3 a	52.4± 1.7 b	50.9± 1.6 a
2 Upper limb/stature	46.1± 1.1 c	46.3± 1.0 cd	46.5± 1.3 d	45.5± 1.2 ab	45.0± 1.0 a	45.7± 1.3 b
3 Forearm/upper arm.	140.9± 5.7 b	146.2± 5.7 e	142.0± 5.7 cd	140.1± 4.3 abc	143.8± 8.2 d	138.5± 5.1 a
4 Biacromial/bicristal	135.0± 8.0 b	135.6± 8.9 abc	132.5± 8.2 a	134.7± 7.8 abc	135.2± 6.9 abc	138.7± 8.7 c
5 Thoracic index	137.8±10.8 b	132.3± 8.8 a	134.9±11.2 a	137.6±11.3 ab	135.7± 7.2 ab	132.9± 7.7 a
6 Cephalic index	73.9± 2.6 a	75.2± 3.6 bd	74.5± 3.1 b	78.1± 3.3 e	76.6± 3.1 ce	76.6± 2.8 cd
7 Facial index	87.9± 5.4 a	87.8± 4.3 a	89.9± 5.3 b	87.7± 5.4 ab	86.5± 4.4 a	86.9± 4.4 a
8 Nasal index	81.2± 7.9 b	80.5± 8.3 a	74.0± 7.1 a	82.6± 7.6 b	89.3± 7.9 c	86.0± 7.8 c

TABLE 4 - *Generalized distances (Penrose) between populations pooled by geographical affinities: mC^2_H formula.*

	Male populations						Female populations					
	Sudanian	Dogon	Sahelian	Bantu	Pygmoids	Koma	Sudanian	Dogon	Sahelian	Bantu	Pygmoids	Koma
1 Sudanian	0.00						0.00					
2 Dogon	0.03	0.00					0.03	0.00				
3 Sahelian	0.07	0.07	0.00				0.08	0.08	0.00			
4 Bantu	0.37	0.43	0.45	0.00			0.37	0.43	0.46	0.00		
5 Pymoids	0.72	+.84	0.79	0.26	0.00		1.64	1.66	1.84	1.07	0.00	
6 Koma	0.25	0.32	0.29	0.16	0.27	0.00	0.38	0.41	0.47	0.25	0.63	0.00

TABLE 5 - *Size differences between the six pooled populations in % of the coefficient of generalized distance C^2_H. The shape difference is obtained as (100% - size difference.*

	Male populations						Female populations					
	Sudanian	Dogon	Sahelian	Bantu	Pygmoids	Koma	Sudanian	Dogon	Sahelian	Bantu	Pygmoids	Koma
1 Sudanian	0.0%						0.0%					
2 Dogon	7.6%	0.0%					0.6%	0.0%				
3 Sahelian	6.2%	17.1%	0.0%				15.8%	15.3%	0.0%			
4 Bantu	0.9%	0.0%	3.5%	0.0%			6.0%	3.6%	0.0%	0.0%		
5 Pymoids	56.0%	49.7%	57.3%	75.7%	0.0%		41.3%	43.0%	46.4%	83.4%	0.0%	
6 Koma	33.6%	23.1%	38.8%	35.9%	57.4%	0.0%	1.0%	1.9%	8.2%	34.4%	74.9%	0.0%

analysis, skinfold and muscle available for both Cameroonian and Burkinabe populations, i.e. v01 to v10, v13 to v17, v25 to v28 and v31 to v37 were used. Obviously a selected choice of variables could lead to different results. For ease of analysis we have pooled the Sudanian populations (n° 1 Mossi D, n° 4 Gurmanche, n° 9 Bwaba, n° 10 Mossi A) and the Sahelian populations (n° 2 Bella, n° 3 Rimaibe, n° 5 Mallebe, n° 6 Sonrai, n° 8 Fulani), based on the results of our previous analysis, where the descriptions of these populations is given (FROMENT & HIERNAUX, 1984). The Dogon, who are quite distinct morphologically from both the two pooled groups, have been kept apart. The two «Bantu» populations (Yassa and Mvae) were pooled. Values of C^2_H confirm the marginal position of the Pygmoids and the grouping of the Bantu-Koma on one hand and of the Burkinabe populations on the other.

Examinations of *Table 5* shows very clearly that Bantu and sudano-sahelian populations differ, in both sexes, only in the shape component. In contrast, size reduction is very clear for Pygmoids, and not negligible for the Koma, especially in males. This would mean that the climatic adaptations discussed above have influenced body shape much more than body size. A general size reduction from plains savanna-dwellers and Bantu peoples (supposed to have migrated into the forest zone from the savanna during historical times), postulated to be a metabolic adaptation to moist environment, is not evident in our results. The Bagyeli do not necessarily share a common ancestry with the other Pygmy or

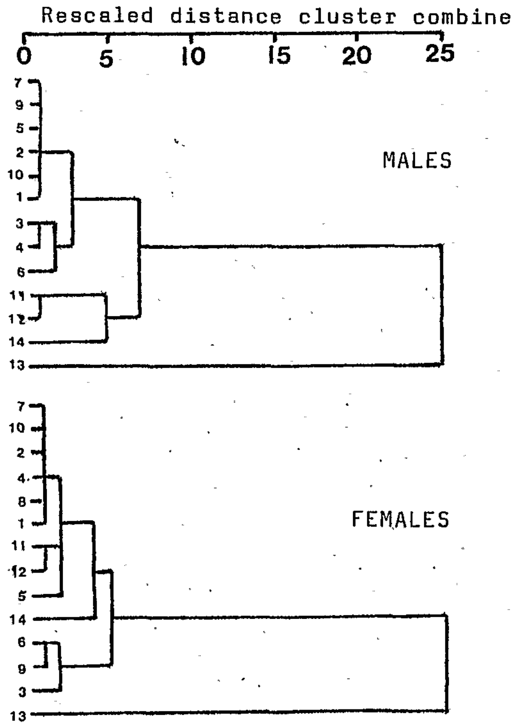

Figure 4 - Dendrograms derived from cluster analysis on means. Burkina-Faso and Cameroon groups. Same code as in *Figure 3* for the n° of populations.

Pygmoid group of Central Africa. They are taller, and geographically isolated. The hypothesis of a Bantu admixture is tenable but any such admixture must have occurred in the remote past. Other mechanisms, such as founder effects, random drift, of selection processes, cannot be excluded. However, the traditional opposition between Bantu and Pygmy people is not so clear cut as often thought, and a possible common genetic origin is not to be ruled out. A change in size can be controlled by one or a few genes, whereas changes in body shape involve a larger number of loci and thus perhaps require more time.

Morphological differences are relatively similar in both sexes but a differential response to environment can be expected. A dendrogram has been derived from a cluster analysis of means (*Figure 4*) after exclusion of skinfolds and muscle circumferences. Such a representation illustrates the phenetic similarity between groups. It is very clear that Pygmies (both sexes) form an outlying group, and that the Yassa and the Mvae, close together with the Koma, occupy an intermediate position. However, the females tend to aggregate more with Sahelo-Sudanian groups than do the males.

Conclusion

This preliminary analysis of the morphology of four Cameroonian groups living either 1) in the same forest environment but differing in genetic origin (Mvae/Gyeli) or in diet (Mvae/Yassa), or 2) in a savanna environment (Koma), and the comparison to other

savanna groups, demonstrate that variation in morphology is associated with climat variation. Nutritional influences are also detectable, and the next step will be to compa morphology with data derived from the food consumption survey and the time-budg study, which is still going on. By elimination of «soft parts» from the computations, v attempted to diminish nutritional influences in the interpretation of morphological diffe ences. This procedure of course does not rule out early consequences of possible dieta deficiencies for skeletal growth but, at least, among Cameroonian groups, no nutrition stress has been noticed. The two main components of the differences are therefore genet stock and climatic influences. Stature, sitting height, upper limb length, head breadth ar nose dimensions are very dependent on temperature and moisture, and explain a good de of the convergences between Bantus and Pygmoids, and between these two groups ar Koma highlanders, who are likely to belong to a West African savanna genetic stock b are influenced by the particular characteristics of their ecosystem. An alternative hypoth sis is that Bantu-speaking peoples and Admawa-Ubanguian peoples, while having ve different cultures, could have an old common genetic origin rooted in the vicinity of tl Adamawa plateau (Hiernaux 1968b; Rightmire 1976). When analyzed in detail, Africa populations show no tendency to cluster but range along continuum of geographic climes. For example, agriculturalist populations living in the same biome (either the moi forest or the savanna) tend to resemble each other more closely than they resemb populations of the other biome. Population-genetic studies usually concern single-loci traits, which are more easily influenced by unpredictable drift phenomena than a polygenic morphological characters. Morphological studies can provide more appropria measures of many aspects of the nature and degree of divergence between groups, and the scaling of microevolutionary changes related to environmental stress. In addition t genetic studies of human populations, careful anthropometric studies thus have a valuab and complementary role to play in the interpretation of population history.

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