A RE-SURVEY OF THE MORPHOLOGY OF THE NOSE IN RELATION TO CLIMATE.

By A. Davies.

The nasal characteristic chiefly dealt with in the present study is the degree of narrowness, or wideness, of the nose. This is represented by the nasal index,[1] which is the ratio of the width across the nostrils to the length from the root (at the bridge of the nose) to the angle made by the nose and lip. The nasal index is the proportion the width of the nose bears to its height. It varies among living types from a value of 57, which is a very narrow nose, to one of 115, a very wide nose. The values of the nasal index among different races and types are arbitrarily divided into four groups :—

N. Index.		
X–70	Leptorrhine	Narrow noses.
70–85	Mesorrhine	Medium ,,
85–100	Platyrrhine	Broad ,,
100 + ...	Hyperplatyrrhine.	

The nasal index varies greatly with the individual, but the average of a numerous group shows a marked constancy, according to its racial type. For example, the average nasal index (or N.I.) in France is 67·0. Individual Frenchmen may have indices from 55 to 90, but the average of any group of a hundred individuals would be very close to 67. This racial constancy has led anthropologists to place great value on the average nasal index as an indication of race. A. Hrdlicka[2] makes the following remarks : " Due to the numerous individual modifications in nose breadth, the nasal index must necessarily reflect these conditions and so be individually of but limited anthropometric value ; but in averages of appropriate groups it is a very serviceable character in anthropometric determinations, scarcely inferior in value to any of the indices of the head or skull."

Some idea of the reliance placed upon the nasal index as an indication of race may be gathered from the fact that Dr. A. C. Haddon[3] includes it among the five chief physical characters he employs to differentiate mankind. Deniker[4] includes the N.I. among his three chief characters. Professor R. B. Dixon[5] includes the N.I. among his three chief characters. Many others could be cited. In fact all modern anthropologists use the nasal index as a racial criterion, and, while many of them have dispensed one by one with other physical characters in an attempt

[1] Thomson and Buxton, *Journ. Roy. Anthrop. Inst.*, 1923.
[2] A. Hrdlicka, *The Old Americans.*
[3] A. C. Haddon, *Races of Man.*
[4] J. Deniker, *Races of Mankind.*
[5] R. B. Dixon, *Racial History of Mankind.*

to achieve simplification, scarce one has thought fit to dispense with the nasal index. Up to the present the N.I. has ranked as one of the most useful clues to racial type, and is interwoven with all the framework of racial divisions that have found favour in modern anthropology.

In the latter part of the nineteenth century Broca[1] (1872), and later Topinard[2] (1897), established the N.I. as a valuable criterion of race. Its position remained unchallenged until 1913 whenThomson[3] found reason to argue that the N.I. was not so much a result of race as of climate. Thomson and L. H. D. Buxton published in the *Journal of the Royal Anthropological Institute*, 1923, an important paper dealing with " Man's Nasal Index in Relation to Climate," to which the reader is referred. They approached the question of the relationship between N.I. and climate from the statistical side—the only method likely to give results of value in this case. They correlated the average nasal index of 146 groups of living populations with the average temperature and average relative humidity for the respective localities. The coefficient of correlation was $+ 0 \cdot 721$ where I is perfect correlation. A similar correlation was worked out for 60 series of crania with a result $+0 \cdot 5533$. The correlation between N.I. measured on living and N.I. measured on the skull was found, and a formula estimated relating the two indices. It was suggested that the nasal index, when more was known of its rate of change in its adjustment to climate, would be of considerable value in dealing with racial migrations.

Since 1923 this problem has not been materially advanced. The present writer read a paper before the British Association for the Advancement of Science at Leeds in 1927[4] which in the main confirmed Thomson's and Buxton's correlation of nasal index and climate in the continent of Africa, but it utilized rather different criteria of climate. The present paper attempts to carry this study a stage further.

The anthropological data have been collected from works and journals in English, American, French, German, Italian, Scandinavian and Russian. My grateful thanks are due to Miss R. M. Fleming for invaluable assistance with German and Russian references.

In all, 652 series of measurements of the nasal index were collected. They represent, it is believed, almost all the series that have been measured throughout the world, save in India and Algeria where the series are so numerous that a random selection of half of them has been taken. Maps I and II show N.I. for the world and for India.

For the nasal index measured on crania 160 series have been collected. This does not include all the measured series. It was felt that since no correlation was being attempted for crania a fairly representative selection of cranial series would suffice for the purpose of this study. It is unfortunate that the localities of the series measured are so rarely stated with any clearness. If every anthropologist would record the latitude and longitude of the locality of the group, physical characters could be mapped much more accurately and with a fraction of the time and labour that is wasted in trying to locate obscure villages and districts. The collection and plotting of the anthropological data involved much time and labour.

[1] Broca, *L'Anthropologie*, 1872.
[2] Topinard, *Anthropology*, 1897.
[3] Thomson, Brit. Assn., 1913.
[4] See *Man*, January, 1929.

The Meteorological data collected consisted of all the available statistics of average temperature and relative humidity, and of maximum mean monthly temperature and relative humidity for the world. These were not corrected to sea-level, but represent the actual climatic conditions of their respective localities.

The mathematical correlation was carried out according to standard theory as outlined in King, *Elements of Statistical Theory*; Wallace and Snedico, *Correlation and Machine Calculation.*

A correlation between nasal index, measured on the living, and climate has been determined for :—

(*a*) The World (590 series) $+ 0 \cdot 601 \pm 0 \cdot 0178$.
(*b*) The World excluding India (442 series) $+ 0 \cdot 714 \pm 0 \cdot 0149$.
(*c*) Africa (170 series) $+ 0 \cdot 81 \pm 0 \cdot 016$.
(*d*) Europe (53 series) $+ 0 \cdot 77 \pm 0 \cdot 037$.
(*e*) North and South America (61 series) $+ 0 \cdot 68 \pm 0 \cdot 046$.

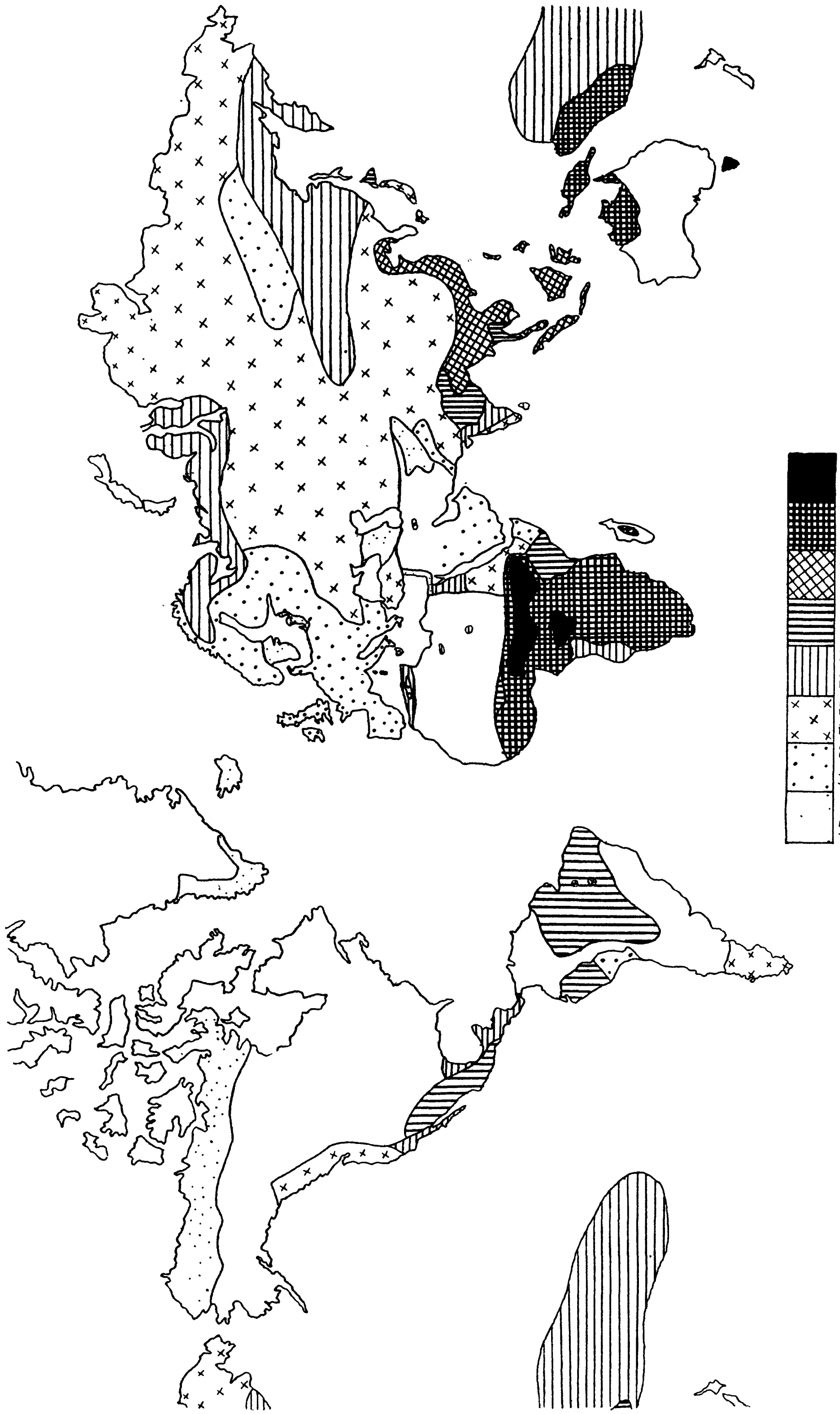
The labour involved in the above computations was lessened very considerably by the use of a calculating and of an adding machine for which I am indebted to the courtesy of Mr. Percy George, and Professor Stapledon.

Thomson and Buxton found World Correlation (146 series) was $+ 0 \cdot 7238 \pm 0 \cdot 0258$. Of these 146, 61 were from India and a higher correlation seemed to be indicated for these than for the world as a whole. The results of the present study of the correlation in the main confirm the work and conclusions of Thomson and Buxton—that the present distribution of nasal index in the world bears a close connection with climate.

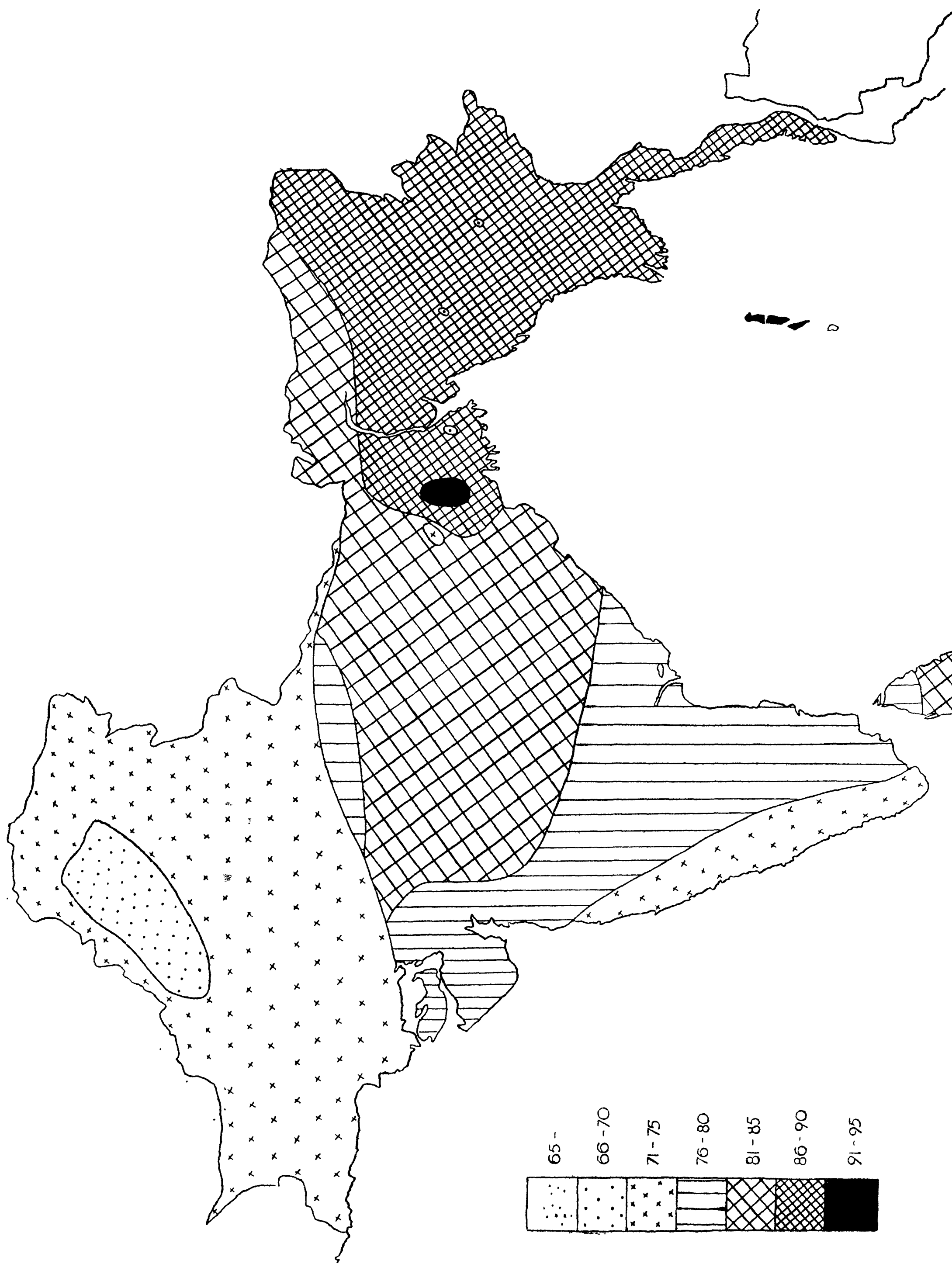
The result for India, however, is quite the reverse of that found by the previous workers. The majority of indices from India used in their correlation, and in the present one, are from N.W. India, the West Coast, and the Deccan. They include many immigrants of the 2nd millennium B.C. coming into a land much hotter and moister than their original homeland; it is hardly to be expected that they would show a higher correlation with climate than the rest of the world. Generally it seems to me that the results of Thomson and Buxton are weakened by the fact that they took average annual temperature and average annual relative humidity instead of mean monthly temperature and relative humidity for a typical summer month as used in the present study. The reasons for adopting this climatic standard are given later in this paper.

While the view is taken that the nasal index has a certain relation especially to maximum mean monthly temperature and maximum mean monthly relative humidity, it must not be thought that the nose is a passive respondent to environmental domination. It is suggested rather, that given a population progressively mastering its environment, and in touch more or less with the general movements of culture of mankind the nasal index will move more or less in accord with certain influences of climatic conditions. In cases of extreme isolation, however, with probable inbreeding and a halt of culture at a lowly stage this is not likely to occur and here we have three notable instances :—

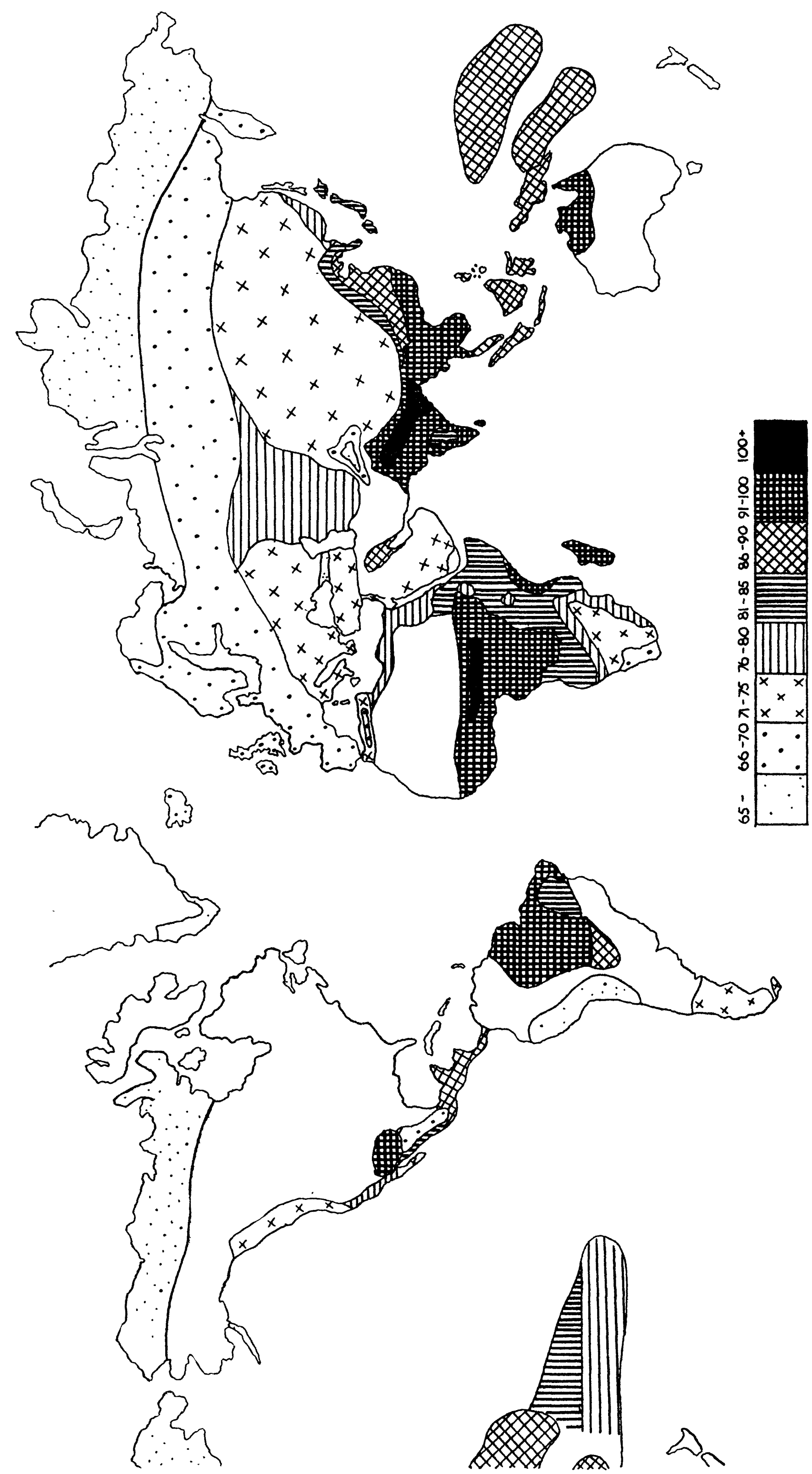
Australians N.I.	94
Tasmanians N.I.	98
Bushmen N.I.	100



MAP 1.—NASAL INDEX.



MAP 2.—NASAL INDEX, INDIA.



Map 3.—Theoretical Index.

This view is illustrated by Bates when describing Amazonian Indians of a lowly stage of culture who came into the Equatorial forest from a more temperate climate. He notes among these people a certain inflexibility, bodily and mental, a poverty of reproductive power and a high liability to disease. He writes : " I always noticed that Indians were much more cheerful in the cool hours of night and morning. There is something in their constitution of body which makes them feel excessively depressed in the hot hours of the day. Their skin is always hot to the touch. They certainly do not endure the heat of their own climate so well as the whites. The negroes are totally different in this respect ; the heat of mid-day has no effect on them and they dislike the cold nights on the river."

It is worthy of note that correlations grade in the following order :—Africa, Europe, World excluding India, North and South America, India.

If the correlation between nasal index and climate is low in any region it must be due to one of two causes. (1) That the N.I. has become very specialized and will no longer adapt to climate ; (2) relative recency of migration, *i.e.* the group has not been in the particular region sufficiently long to have adjusted to climate. Throughout India and the Americas the N.I. far from being specialized is of definitely mesorrhine or medium type. It appears that migration factors are chiefly responsible for the differences in degree of correlation between the continents. Thus one may suggest that the population has been most stable and has suffered least from major race movements in Africa and Europe, and least stable in the Americas and India. This is in accordance with the facts of racial history. Large numbers among the populations of both India and Pre-Columbian America are the results of immigration that is likely to date, in the former case at least, from not before the 2nd millennium B.C.

RECONSTRUCTION FORMULÆ.

The theoretical index represents that value of nasal index which would be in adjustment to the climate of the locality. It is apparent that when any one group is to be considered in reference to its adjustment to climate it is necessary to have a means of estimating accurately the theoretical index of its locality. The formula given by Thomson and Buxton in the *Journ. Roy. Anthrop. Inst.*, 1923, obtained from the correlation is unsatisfactory. Theoretical Index $=$ Av. Temp. $\times\ 0{\cdot}46 +$ Aver. R. Hum. $\times\ 0{\cdot}22 + 24{\cdot}9$.

It applies accurately only for indices between 72 and 87. For example, in the Sudan, where actual indices are 101 to 103 the formula gives an estimated value of 87.

When the above formula is applied throughout the world its weaknesses are seen to be of two kinds :—

(1) The estimated values of N.I. for Siberia, continental, and extreme climates are all too low.

(2) The estimated values in regions of broad noses (N.I. 90+) are too low, and in regions of narrow noses (N.I. 70—) are too high.

The first weakness results from the use of average climatic conditions in the formula. In the *Journ. Roy. Anthrop. Inst.*, 1923, the inclusion of 61 indices from India of peoples who are far from being adjusted to climate has unduly weighted the correlation, and has resulted in the adoption of average temperature and average relative humidity in the formula since this gives estimates which correspond closely in India. Taking the whole world, however, when highest mean monthly temperature and relative humidity, *i.e.* summer conditions, are used in the formula, the first weakness disappears. In regions of extreme climate it is found that winter conditions exert little influence on the nasal index. Average conditions are based partly on winter conditions and so are not accurate enough.

Nevertheless even if one uses summer conditions of temperature and relative humidity the second weakness is still apparent. This is due to the regression coefficients of the formula, *i.e.* 0·46 and 0·22. While these coefficients remain constant the formula is unsatisfactory for hottest and coolest climates.

The regression coefficient for temperature was obtained by correlating N.I. and temperature and multiplying the coefficient of correlation by a constant. Now all values of N.I. were correlated with the values of temperature in one correlation. Hence there could be only one correlation coefficient and so only one regression coefficient. Thus the regression coefficient would remain constant. If, however, the N.I. series and temperatures be grouped in sections of highest, medium, and lowest temperatures, and the correlation determined for each section it is quite possible that the coefficients of these sectional correlations will differ.

The N.I. series and temperatures were grouped in four sections from highest to lowest temperatures and the correlation determined for each section. The results showed that the section with highest temperatures had the highest correlation coefficient, which when multiplied by its appropriate constant gave the highest regression coefficient. The section with lowest temperatures in the same way gave the lowest regression coefficient. Similar results were obtained in a sectional correlation between N.I. and relative humidity, the correlation coefficients being smaller and their differences less marked than in the case of temperature.

From these results coefficients of regression were obtained which increased with rise in temperature and in relative humidity. The temperature regression coefficient varied from 0·57 at 93° F. to 0·33 at 75° F. The relative humidity regression coefficient varied from 0·21 at 40 per cent. to 0·28 at 91 per cent. The four values for temperature-coefficient-of-regression were plotted at the average temperature of their respective sections to form Graph I.—The temperature coefficient of regression. The four values for relative humidity in the same way were plotted to form Graph II.

From these graphs the necessary coefficients can be substituted in the new formula.

Theoretical Index = Temp. $\times$ C_T + R. Hum. $\times$ C_H + 36.
Where C_T = temperature coefficient at the given temperature T.
C_H = humidity coefficient at the given relative humidity H.

This formula has been used to calculate the theoretical index throughout the world. As the following examples demonstrate it applies to individual groups with a considerable degree of accuracy.

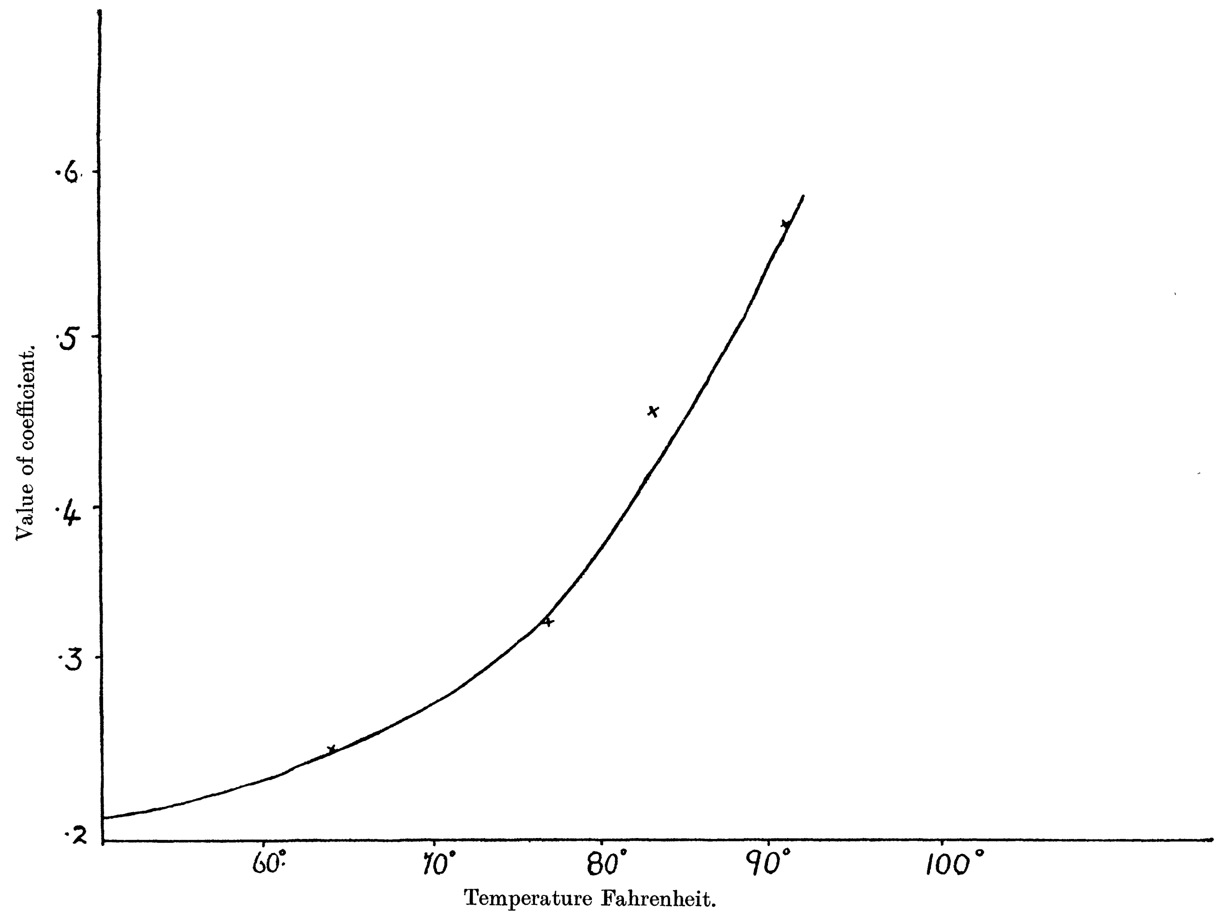


FIG. 1—GRAPH OF COEFFICIENT OF REGRESSION FOR TEMPERATURE.

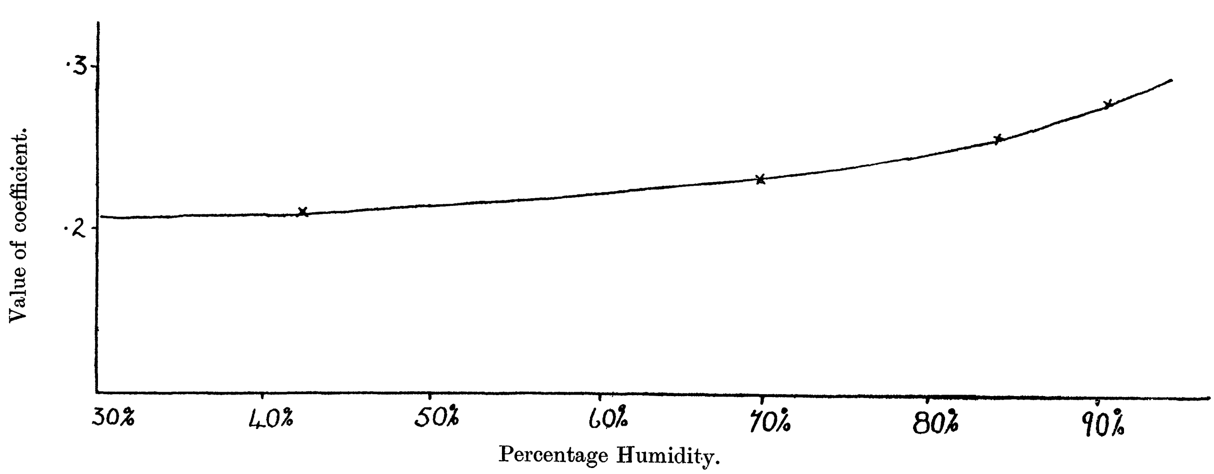


FIG. 2.—GRAPH OF COEFFICIENT OF REGRESSION FOR HUMIDITY.

	N.I.	Theoretical I.
Greenland Eskimo	64	65
Bordeaux	69	69
Lolo (Szechwan)	86	86
Fang	95	96
Haoussa	100	101

The actual nasal index of each group and the estimated theoretical index correspond closely throughout the world except where relative recency of migration has interfered. The correspondence can be seen in Maps I and III.

Considerable portions of America and Australia are left blank in the nasal index map in order to avoid confusion of European with non-European types. The general correspondence is very definite. The broadest noses are in the Tropics and the N.I. steadily decreases towards the Arctic regions. A close examination reveals that with the exception of India, South Africa, and the Amazon basin, the nasal index differs by not more than five units from the theoretical index. Here and there are interesting discrepancies which in most instances point to recency of migration.

Americas.—The Negro population of U.S.A. is too recent for observation of narrowing of the nose. The Amazonian Indians are obviously extra-tropical types forced into the forest and quite unsuited to an intertropical climate.

Asia.—The general sequence from broader to narrower noses as we go north is clear, but the tendency in Siberia for N.I. to be higher than theoretical index suggests that populations from Central Asia have moved northwards. This is true in fact. Especially noticeable are the Lapp-Samoyed group, and the Tungus group of East Siberia. The latter moved from Manchuria in early historic times; possibly the former represent a similar earlier dispersal.

Australasia.—The tendency for higher N.I. than theoretical index among Melanesian types is possibly a heritage of existence in South-east Asia.

Africa.—The general correspondence is very marked. Exceptions are the Arab nomads of Upper Egypt, from the Nile to the Red Sea, and the Somali, both of whom came from Arabia in historic times. Among the Bushman and Kaffir peoples of South Africa the nasal index is much higher than the theoretical index. The latter people are mainly the descendants of migrants southward in the 1st and 2nd millenniums A.D. The relative narrowness of nose in Portuguese East Africa is a feature of the half-breed population.

Apart from results of relative recency of migration a certain lack of correspondence is observable.

(a) Mountain regions.

Iceland, Pyrenees, Alps, Caucasus and Pamirs.—The nasal index seems to be less than the estimated theoretical index by about three units, though the temperatures used are those of the locality, *i.e.* not reduced to sea-level.

G. Senn[1] has pointed out that the respiration of animals and men has been found to show higher rates in the Alps than in the plains. For this greater intake of air a narrower nose is valuable, in order that it may be warmed and moistened. Here the nasal index is less than the estimated one and thus it seems that rate of respiration slightly modifies the nasal index.

(*b*) *Tropical forests.*

Congo forest.—The nose seems to be too broad by three or four units. This may be connected with weakness of wind, a strong cooling force, and the consequent increased use of the nasal organ as a means of cooling the body.

(*c*) *Egypt.*

Some of the Egyptian groups have a N.I. lower than theoretical index by three units. This may be due to Arab intrusion, or Greek elements, particularly in the Delta region and Sinai. It is possible, however, that the relative humidity taken is too high, the meteorological stations being along the Nile.

(*d*) *Italy.*

Italy shows curious discrepancy which cannot be explained by wind effects. The actual N.I.'s are narrower than the theoretical index by three or four units. Further the actual nasal indices are among the lowest in Europe though the summer is distinctly hot. It may be that Celtic peoples and Alpine types entering Italy in the last millennium B.C. and since, affect this result.

Comparison of Mathematical Results with Data Derived from Physiological Literature.

The mathematical results of the last section lead to some interesting conclusions as to the influence of climate on the human organism, more especially the nasal organ.

(1) The correlation coefficients of temperature are more marked than those of humidity. This implies that temperature exerts a stronger influence on the nasal organ than humidity. Thomson and Buxton found the same result. This is in accordance with the work of Paul[2] and Erklentz who found that physiological discomfort in England was occasioned by 79° F. and 50 per cent., and 75° and 77 per cent. in a closed chamber. Here 4° temperature change is equivalent to 27 per cent. change in relative humidity.

(2) The increase in value of the regression coefficients with higher temperatures and humidities indicates that 1° rise at 90° occasions greater discomfort and ill-health than 1° rise

[1] G. Senn, *Journal of State Medicine*, vol. 38, No. 6.

[2] Dr. Pierce, "Occupation and Health," International Labour Office.

at 60°. The task of keeping cool becomes increasingly difficult with the rise of temperature and relative humidity.

Huntington[1] has measured the change in efficiency of cotton operatives for each degree change in temperature. He finds—

1° drop at 30° F. means loss in efficiency of			0·2 per cent.	
1° ,, ,, 60° F.	,,	,,	0·2	,,
1° rise at 78° F.	,,	,,	0·5	,,
1° ,, ,, 87° F.	,,	,,	0·8	,,
1° ,, ,, 95° F.	,,	,,	2·2	,,

At higher temperatures the loss in efficiency, representing the strain on the body, is much more marked. The necessity for cooling becomes of vital importance and is increasingly difficult. In connection with this, the nose is found to be much wider and the regression coefficient very much larger at 90° than at 60°. This does not hold when temperatures are low. The loss in efficiency does not accelerate below 60° ; it will be noted that for temperatures below 60° the regression coefficient also is constant. Thus the results of Huntington's work on efficiency of cotton operatives under varying temperatures confirm the variability of the regression coefficients.

(3) The huge increase in the value of the temperature regression coefficient is from 78° upwards. Temperatures above 78° seem to involve need for special adaptation to keep cool—not only in the nasal organ but in the body as a whole.

This agrees with the work of Huntington already referred to, and with the findings of the Commission on Health in Factories. Great Britain, Factories Act 1911, prohibits artificial humidizing of factories when air is at a temperature over 75° F. as being dangerous to health. Below this temperature it is not so serious.

(4) Winter climatic conditions have comparatively little effect on the nasal index.

From the Sudan to Siberia in all types of climate the N.I. is found to correspond to the summer climate unless relatively recent migration (*e.g.* Indo-Aryan into India) has occurred. For example :—

Eskimo of Greenland, actual N.I.	64
Theoretical Index based on winter climate	37
,, ,, summer climate	65

The estimated theoretical indices in this study furnish such numerous instances of the correspondence of nasal index to summer climate that it seems that the adjustment of the nasal index to withstand summer conditions of heat and moisture is of vital importance.

Huntington's[1] work on cotton operatives shows the relative effect of winter and summer climate on output to be as follows :—

Total loss of efficiency at :

32° F. is 3·7 per cent.	78° F. is 4·1 per cent.
40° F. is 2 ,,	87° F. is 7·5 ,,
60° F. is 0	96° F. is 13·2 ,,

[1] E. Huntington, *Climate and Civilisation.*

It is apparent that winter conditions do not upset the human mechanism to anything like the same extent as the summer or hottest conditions. It is the latter which bring the most serious consequences and demand the greatest adaptation. Huntington's figures confirm the choice of summer climate conditions as the strongest climatic control in the development of the nasal organ.

(5) Strong winds aid very considerably in cooling the body and in reducing the effect of hot moist conditions. This is suggested by the extreme width of nose in the Congo Forest region where the influence of wind is weak. This agrees with Leonard Hill's[1] statement that "adequate air velocity in a factory could counterbalance increased heat and moisture."

These five results suggest that the human body finds more special difficulty in withstanding hot, moist conditions rather than cool, dry climates. Especially is this so in the Tropics where heat in association with humidity so often proves fatal. In the case of the nasal index the following explanation of its adjustment to summer climate is suggested.

The functions of the nasal organ include (1) the admission of air into the lungs in sufficient quantity; (2) the adjustment of this air to a temperature and a humidity suited to the lung tissue. Of these two functions it is the second that is chiefly influenced by climate. The efficiency of the nose in its first function, to admit air, is not impaired by increased width and larger aperture, so it can freely keep on widening with increased temperature and humidity. On the other hand the narrowing of the nose limits the area of the nasal aperture and volume of the respiratory channel, and so tends to restrict breathing. The lungs, however, must have sufficient air irrespective of the capacity of the nose to warm and moisten it, and so the narrowing of the nose is limited by this first function of the nasal organ. When the air is too cold and dry for the lungs, the nasal aperture adjusts to climate only to a certain stage. Beyond that, cold conditions result in other modifications of the body, possibly in development of unusual nasal shape, and in artificial aids, *e.g.* wearing of furs over the face to form an outer warming chamber. When the body has to adjust to a hot climate, devices for cooling are neither so numerous nor so effective as devices for conserving heat; and the widening of the nasal organ and consequent increase of the nasal index is pushed to the limit of efficiency. Thus it appears that the nasal organ, together with the respiratory system, has a third function of vital importance, particularly in hot climates, as a means whereby heat can be dissipated from the body, and thus is an important factor in the balance of heat production and heat loss in the human organism.

N.I. (Crania) in Relation to N.I. (Living).

The relation between the nasal index measured on the skull and the nasal index measured on the living head has never been clearly demonstrated. Haddon remarks in his *Races of Man* that "the two nasal indices are only relatively comparable."

If, however, the numerous series of N.I. measured on crania are to be of any real value, the exact relationship of N.I. (Crania) to N.I. (living) must be determined, at any rate the group average N.I.

[1] Hill, "The Kata Thermometer," *Science of Ventilation*, Part I.

Buxton correlated the group average N.I. (Crania) with N.I. (living) in 50 groups where measurements were available. The coefficient of correlation was $+0 \cdot 808$. From this he obtained the relation N.I. (living)=N.I. (Crania) $\times\ 2 \cdot 327 - 38 \cdot 08$.

This result needs careful investigation. It has been shown that one of the weaknesses of the correlation method is that it produces an average result. While there may be variation in the relationship of broad, as compared to narrow, apertures, the correlation method gives an average result. In other words, as in the case of temperature coefficients of regression, an apparent uniformity may mask real variation in relation of N.I. (Crania) to N.I. (living). One method of checking this lies in making a sectional correlation. The difficulty is that comparatively few pairs could be grouped in each section, and hence the probable error of this method would render the results open to grave suspicion. An alternative method is to make a careful selection of data, and to consider individual group averages of N.I. (Crania) and N.I. (living) in a graphical representation. If there is variation in the relationship it will certainly be apparent in the graph. The procedure was as follows: Measurements of average N.I. of numerous cranial series were collected. In many cases N.I. (Crania) and N.I. (living) were available for the same group or region. It was found, however, that many of these were not strictly comparable because the crania were not recent, and therefore did not represent the same population as the living types measured. Only those cranial series that had a high probability of belonging to the same period as the living series were used in the investigation. These numbered 20 groups and are given in Table I. All the main racial groups are represented. The living groups measured were all numerous. The figures in brackets, *e.g.* (39), give the number of crania measured.

TABLE 1.

Data used in Graph III. Relation of N.I. (living) to N.I. (Crania). The only data used are those in which there is a strong probability that the crania measured represent the same population as the living measured. All the main racial groups are represented.

Reference.	Group.	N.I. (Crania).	N.I. (living).
L'Anthropologie, 1926 ...	Greenland Eskimo (39)	43·6	64
	Syrian (16)	43·8	64
	Basques (54)	43·8	64
	Portuguese (494)	44·4	65·1
	Brittany (50)	46·0	68
	Chile (50)	45·0	69
	Polynesians (88)	47·9	73·6
	Buriats (17)	48·6	75
	Mongols (114)	48·6	76
	Modern Egyptians (137)	49·3	78
	Ainos (126)	50·9	82
	Malays (17)	51·9	82·6
	Quichua (61)	52·1	83
L'Anthropologie, 1923 ...	Papuans (22)	52·0	84
	Burmese (numerous)	53·4	86
	Kagoro (16)	56·0	93
	Australians (numerous)	56·4	94
	New Caledonians (31)	56·5	94
	Nilotic Negroes (29)	59·2	99
	Bambute (11)	59·2	100

N.I. (Crania) were plotted against N.I. (living) to give Graph III.

The resulting graph is not only a straight line but there is no variation in accuracy throughout. The narrow noses correspond to the narrow aperture as accurately as the wide noses to the wide aperture. Since the graph is a straight line the relation of N.I. (Crania) to N.I. (living) is uniform for all values of N.I. Hence Thomson's and Buxton's method of determining the relationship by correlation is correct. Their formula was N.I. (living) = N.I. (Crania) × 2·327 — 38·08.

The straight line graph indicates a simple linear relationship. From quadratics this relationship was found to be N.I. (living) = N.I. (Crania) × 2·330 — 37·90. This corresponds almost exactly with Buxton's result though the data used and the method followed were quite

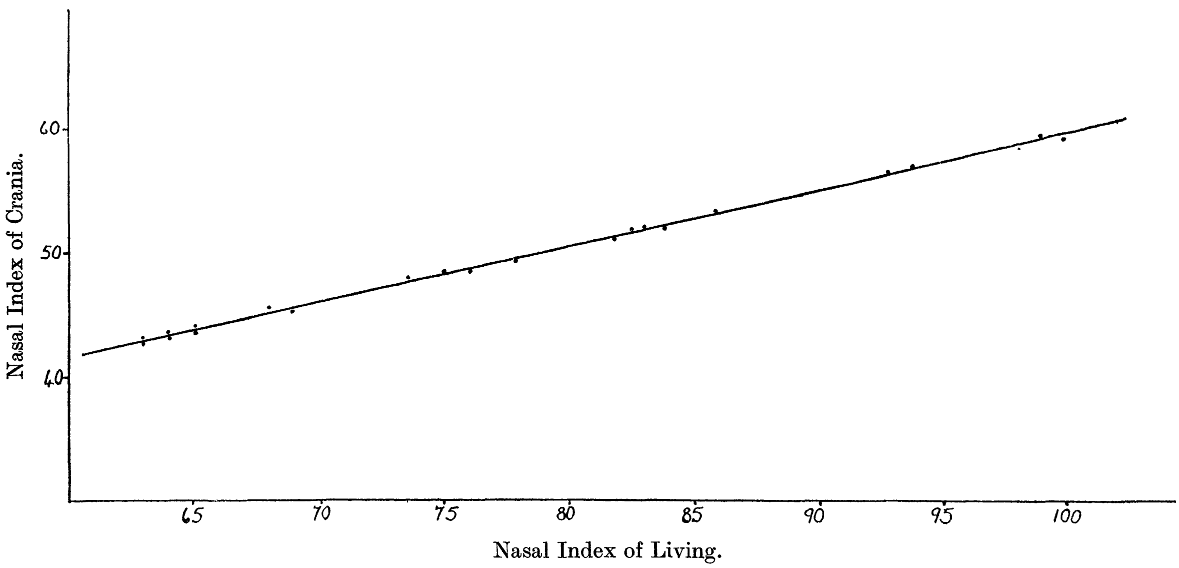


FIG. 3.—GRAPH SHOWING RELATION OF N.I. (LIVING) TO N.I. (CRANIA).

different This proves fairly conclusively that the N.I. (Crania) bears a constant mathematical ratio to the N.I. (living) when dealing with group averages of the same population. It proves nothing for individual indices.

Correlation of N.I. (Crania) and Climate.

Buxton correlated 98 N.I. (Crania) and climate with the following result :—

N.I. (Crania) and temperature + 0·532.
N.I. ,, relative humidity + 0·112.
N.I. ,, both together + 0·553.

Now the Correlation Coefficient $= \frac{A}{B.\ C.}$.

Where A is the mean product of deviations.
,, B ,, standard deviation of N.I.
,, C ,, ,, ,, theoretical index.

If any number, 10, 20 or 37·9 be taken from every figure in the set N.I. the individual deviations from the new arithmetic mean will be exactly the same. The correlation will not be altered.

If every N.I. value were reduced in the ratio 1/2·33 the correlation would still remain unaltered. To make the example simpler suppose every N.I. were doubled. The arithmetic mean of the N.I., the individual deviations of N.I., and the mean product would be doubled, *i.e.* 2A. The squares of the N.I. deviations would be four times their previous values, the mean square four times, and so the standard deviation of N.I., *i.e.* the square root of the mean square would be 2B.

$$\text{Correlation Coefficient} = \frac{2\text{A}}{2\text{B.C.}} = \frac{\text{A}}{\text{B.C.}},$$

i.e. remains unchanged.

Hence the correlation of N.I. (Crania) with climate should be the same as N.I. (living) and climate provided the climatic data used in the formula represent the climate synchronizing in period with the respective cranial series.

Buxton's results in his correlation of N.I. (Crania) and climate show a low correlation, because it was not possible to associate the correct temperature and humidity with all the cranial series, many of which were not recent. Because of the difficulty of associating the correct climate with the crania, and also because mathematical theory provides the result, no further correlation between N.I. (Crania) and climate has been attempted in this investigation.

Relation of Nasal Index to Factors other than Climate.

Apart from the influence of climate there are a number of factors that might affect the nasal index. Head form, stature, age, sex, facial index, interorbital width, size of palate, etc., must receive due consideration lest the relation of nasal index to climate is given undue importance. The possibility that the N.I. and nasal organ has been influenced by some of these features has been the subject of investigation by some leading anthropologists, amongst whom Hrdlička, Shirokogoroff, Knowles, and Thomson and Buxton have made the most important contributions.

The following résumé gives the results of these investigations to date.

C. S. Myers,[1] dealing with individuals of the Kena group in Egypt finds "correlation between facial and nasal indices is $-0\cdot467 \pm 0\cdot07$, *i.e.* in the individual the broader the face the broader the nose." It may be noted that the above conclusion is for individuals and not necessarily for group averages. The influence of facial index in a group average may be quite overshadowed by the influence of climate. For example, the Eskimos have wide faces on the average yet they have narrow noses. The Dinka with long heads and narrow faces have wide noses. It would appear that the facial index is an important factor in modifying individual nasal organs, but when dealing with group averages its influence is not apparent.

F. H. S. Knowles[2] in a very searching contribution deals with large series of crania in West Africa, Britain, and in Eskimos. He found "correlation between fronto-interorbital width and

[1] Myers, C. S., *Journ. Roy. Anthrop. Inst.*, 1908.
[2] Knowles, *Journ. Roy. Anthrop. Inst.*, 1913.

N.I. is negligible in the three series. Naso-occipital length shows correlation with nasal height in Negroes but no conclusive result in British and Eskimo."

The shape of the palate appears to influence the shape of the nose in individuals of certain races. It is uncertain whether this influence would be demonstrated in group averages, particularly since it does not obtain even among individuals of some races.

A. Hrdlička[1] has advanced furthest in this investigation. He found: "correlation of nasal height with stature, and nasal breadth with stature, is very weak in both sexes. The N.I. correlates slightly with stature, the greater the stature the lower the N.I. Cephalic Index has practically no relation to the N.I. Nasal height correlates directly, closely, and nearly evenly, in the two sexes with the anatomical height of the face. The correlation of facial breadth and nasal breadth is not so marked. The effect of age on the absolute dimensions of the nose is fairly definite, increasing with age, but there is no material effect on the nasal index."

Shirokogoroff[2] in China found "No appreciable correlation between N.I. and stature or between N.I. and Cephalic Index."

In this present study stature, nasal height, and N.I. were mutually correlated for three investigations :—

(1) Hagios Sergios, Cyprus .. .. .. average N.I. 64·3
(2) Embu, East Africa .. .. ,, N.I. 85
(3) 16 East African groups.

Two groups were investigated for individual correlation in case wide noses gave a different result from narrow noses. The East African groups were investigated so as to consider group averages rather than individuals.

In the Hagios Sergios group there appears to be a slight tendency for taller individuals to have greater nasal height. This is negligible in the Embu. A very definite association of taller stature in the groups with greater nasal height is evidenced, *i.e.* the tallest groups have the highest noses. A word of caution must be uttered, however. In East Africa the narrower nose of the tallest groups happens to be a climatic feature since the Somali, Masai, and Njemps have migrated to this region from drier lands. Hence the marked correlation between stature and nasal height that appears in the groups may be accidental. There is no justification for assuming that a series of groups taken at random from all races would exhibit such a marked correlation. In neither case, individuals nor group-averages, is there any appreciable correlation between stature and N.I.

In 28 groups the N.I. has been measured on males and females. In 3 groups the N.I. is the same for both sexes. In 15 groups the female N.I. is slightly higher. In 10 groups the male N.I. is slightly higher. In the majority of the 15 groups where the female N.I. was higher the manual outdoor labour is largely performed by the women.

[1] Hrdlička, *The Old Americans.*
[2] Shirkoogoroff, *Anthropology of North China.*

Shape of the Nose.

The shape of the nose varies from the concave profile of the negro to the straight but short nose of Classical Greece and the straight long nose of the Pamirs. When, however, the nose is narrowest, complex nasal shapes are found. Convex profile and " nostrility " of the Armenoid. " Nostrility " of the Semitic. High, thin, hooked nose, sometimes called " Roman." Long Nordic nose with a bulge at the tip. Each of these types occurs at the limit of narrow noses, as though in compensation for not being narrower. The Convex Armenoid nose with its large nasal chamber seems to be a result of racial development in the cold dry climate of the Anatolian mountains. It has been pointed out by Senn that the mountaineer in a rarified atmosphere has a higher rate of respiration and deep breathing. Some way of warming the air must be found without further narrowing of the nose since this would restrict free breathing. This is found in the large nasal chamber which gives a convex profile to the nose.

The Semitic nose has been the subject of much discussion. It is not Armenoid since the convex profile and large nasal chamber are absent. Jacobs[1] describes it as " a depression of the tip of the nose giving a smooth arch in the region A and a backward curl of the nostril or ' nostrility.' "

Now the actual effect of this, as may be experienced by pressing the finger against the tip of the nose, is to spread out the nostrils and admit a freer and cooler air current. This effect of nostrility can also be produced by contraction of the muscles above the nostril wings. The Semitic nose in Syria, Palestine, etc., seems to be too narrow for the climate. It is suggested that the nose has not widened sufficiently in these hotter climates and " nostrility " has occurred instead to produce the effect of cooling. It may be noted in passing, that despite popular opinion, neither the Semitic nor the Armenoid nose is typical of the Jews. About 14 per cent. of them have the former and 12 per cent. the latter according to Passarge.[2]

The Nordic nose is long with a bulge at the tip, *i.e.* the reverse of the Semitic condition in which the tip is depressed. The length is associated with the high stature and cold climate. The bulge may be due to contraction of the nostrils in the cold climate.

POSSIBILITY OF CHANGES IN THE NASAL INDEX RESULTING FROM A CHANGE IN CLIMATE.

Thomson and Buxton assert that " the nasal index loses much of its significance as a purely ethnic character, and it is to be interpreted largely as evidence of the habitat occupied."

Suppose for the moment that they are right, and that the nasal index is to be regarded as unsuitable for use as an ethnic criterion. What are the implications of this point of view ?

[1] In Passarge, *Das Judentum*.
[2] Passarge, *op. cit.*

One of the main concerns of Anthropology is the racial classification of man. This involves the adoption of certain physical characteristics of man as a basis for differentiating between the different races. Such physical characters must be persistent in the race and not subject to rapid variation under the influence of environment, otherwise racial distinctions would merge into hazy groups responding to various environmental influences. If the nasal index can no longer be accepted as a reliable criterion of race, then existing classifications of mankind into their racial stocks will be rudely shaken. The implications of Thomson's and Buxton's contention are so important that it cannot be allowed to stand without further investigation.

On what grounds have they concluded that the nasal index is an unreliable criterion of race ? They found that the present distribution of N.I. in the world was closely correlated with that of climate. Is this sufficient to justify their conclusion ? Haddon[1] states, " Whatever the physiological mechanism may have been, there seems to be good evidence that climatic conditions have indirectly become impressed on the germ plasm, so that definite responses have become heritable. In any case, natural selection, or rather elimination, has always been at work, and, combined with isolation areas, has produced stocks with certain associated characters and it is to such stocks that the term ' races ' can be applied."

It has long been thought that changes in climate have been the most potent influence in speeding up the evolution of mankind. Though the mechanism is not clear, the influence of environment, especially climate, seems to have been the dominant factor in the differentiation of different races. The nasal index is only one of many physical characters which have evolved in response to environment over a long period of time. So far then there is no justification for singling out the nasal index and dispensing with it as a racial criterion any more than other physical characters, like hair character, skin colour, thickness of skin, distribution of sweat glands, etc., which may also vary in relation to environmental influence.

Must hair character and skin colour be dispensed with in framing a classification of races ? Soon all the characters of the soft living tissue will be dispensed with and only those of the bony part remain. It will no longer be permissible to speak of races of men, only of types of skeletons ! But this is quite unnecessary. Although hair character evolved in some correlation with climate, it persists as an ethnic character. Once the hair character was determined, change in climate has had no effect. The wavy hair of the Ainu, the lank hair of the Amazon Indian, the crinkly hair of the Bushman and American negro, are as truly ethnic features as though they had always been independent of climate. The same remarks apply to a lesser degree in the case of skin colour.

The nasal index evolved under the influence of climate ; like hair and skin colour it may nevertheless become a persistent ethnic feature and a reliable criterion of race. If the population of the world had been shuffled about and mixed up on a huge scale within the past 2,000 years, it might well be argued that the demonstrated correlation with climate wipes out the racial persistence of the nasal index, and so renders it valueless as a racial criterion. This,

[1] Haddon, *Races of Man.*

however, is very far from being the case. The fact that N.I. correlates with the distribution of climate is not a proof that the N.I. does not persist as an ethnic feature. It remains to be proven that climate continues to alter the nasal organ, to make it narrower under colder conditions and broader under warmer conditions; and also that this change takes place in a relatively short time.

This possibility of change in the N.I. of groups has been investigated by comparing ancient and modern crania in certain districts. By means of Graph III the average N.I. of the older cranial series is expressed in terms of its equivalent N.I. (living).

The accompanying data in Table II shows the average N.I. for ancient and modern populations in the same district. It reveals a definite tendency to change in the direction of better adjustment to climate, but there can be no guarantee that the modern populations are descendants of the ancient ones. Against this has to be placed the fact that the changes are of comparatively small magnitude.

TABLE 2.

Group.	Ancient N.I.	Modern N.I.	Theoretical Index.
Sicily (180)	75·5	70	72
Sardinians (57)	75	67	67
Iroquois (26)	82	77	70
Bavarians (numerous)	76	66	67
Mecklenburg (23)	76	66	67
Brussels (55)	76	68	68
Laas (numerous)	76	68	68
Namur (33)	75	68	68
Disentis (numerous)	75	63	63
Tirolese (numerous)	73	63	63
N. France (125)	71·5	68	68
Lapp (17)	81	75	68
Chile (38)	75	69	70
Malta (418)	71·5	74	74
Andamans (37)	79	91	94
Lombardy (72)	75	67	70
Annamese (21)	79	86	88
Perm (29)...	82·5	79	67
Prague (115)	79	72	69
Britain (38)	75	66	67
British Crania	N.I.		
Neolithic	68		
Bronze Age	75		
Iron Age	71		
Anglo-Saxon	73		
Danes	71		
Modern English	69		
Living—			
English	66		
Irish	64·5		
Welsh	67·4	—	—
E. England	—	—	67

The data are open to criticism in one important respect. In many European districts though the ancient series are sufficiently numerous they may represent only one racial element. It is therefore possible that the change in value of N.I. is an apparent one only, the particular racial type having been numerically outweighed by other types of different N.I. in the living people measured. Neverthless when the N.I. in Britain is traced from Neolithic times, the evidence of change seems irrefutable. The modern N.I. is lower even than in Neolithic times. Further, the Bronze Age types and Anglo-Saxon types are by no means extinct or even hidden in the modern population. No one has remarked that Bronze Age types surviving in the present population of Britain are distinguished by a nose that is wider than the average for this country. To sum up, the weight of evidence points in the direction of gradual, though slow, changes in the nasal index in the direction of closer adjustment to climate.

The rate of change of N.I. is probably so slow that the nasal index remains largely an ethnic feature over periods of probably more than 2,000 years. It is always a reliable criterion for distinguishing between racial types in the same area. The gradual change in the N.I. under the influence of climate demands that a broad view be taken of the nasal index of any group ; insistence on the absolute recorded value of the average N.I. is of no aid in determining racial connections.

In 1922 Fleure[1] stated, " I have elsewhere argued against extreme views of the impermanence of race types . . . those doctrines may be considered to be discarded in serious Anthropology. Descent with modification is obviously a slow process."

The facts relating to change in the nasal organ are in entire agreement with this view. The process of change in N.I. is a slow one. The comparative stability of the nasal index when dealing with group averages makes it a valuable ethnic criterion when viewed in a broad sense.

Studies of N.I. in Certain Regions.

(1) Europe, Bronze Age Period: The uniformity of N.I. in a certain series of cranial collections found in many parts of Western Europe is striking.

——	Crania N.I.	Living Equivalent.
Ancient Bavarians	48·9	76
Mecklenburg	48·8	76
Brussels	48·8	76
Laas (Holland)	48·7	76
Namur	48·3	75
Trentino	48·5	75·5
Disentis (Switzerland)	48·6	76
Lombardy	48·3	75
Hissarlik (9)	48·9	76
British Bronze Age	48·3	75

[1]H. J. Fleure, *Races of England and Wales.*

In each case the number of crania measured was large except for Hissarlik where only nine were available. All these series date from a remote period but whether they were contemporaneous is not known. Only the British, Hissarlik, and Disentis series have been dated by anthropologists and these are in the Bronze Age.

Not only is the N.I. in these series uniform but it differs markedly from average N.I. of crania belonging to later periods in each district. They represent an intruding population with a N.I. appreciably higher than the average in Western Europe and also appreciably greater than the theoretical index which climate would produce. If these series are contemporaneous and represent the Bronze Age invaders referred to by Keith and Peake an interesting problem arises in the question of their origin.

Haddon[1] following Keith indicates Galicia as the possible homeland where the Bronze Age types originated. Peake[2] suggests that the area of origin of the Bronze Age invaders was North Hungary and Lower Austria. Both Peake and Keith are agreed that they resulted from fusion of Alpine and Nordic types in a region where they had opportunities for contact. If the series of crania under investigation do represent these Bronze Age invaders, as seems certain in Britain and probably elsewhere, then the average N.I. 76 leads to an interesting conclusion. The Nordic N.I. is leptorrhine. The Alpine N.I. from early times has been leptorrhine, *i.e.* under 70. It would seem that the Bronze Age invaders of Britain are a fusion of Alpine, not with narrow-nosed Nordic stock, but with medium nosed Proto-Nordic Steppe Folk of South Russia and Turkestan where in a moister period the theoretical index would have been 77. It is from this region that Peake brings the long-head steppe folk who, he thinks, attacked Hissarlik, and the N.I. of these is seen to be 76 like the other series. If this argument is correct the Neolithic movements in Eastern Europe may have been as follows, 2600 B.C. to 2200 B.C. Proto-Nordic Steppe folk moved westward as a result of desiccation and race movements in Western Asia. The northerly branch pushed on to Northern Europe and Scandinavia where eventually the Nordic type was evolved. The southerly branches in Galicia, and very likely in Hungary and Lower Austria, came into contact with broad-headed folk of the Central European highlands. The Beaker folk resulted from a fusion of these two types. In the Bronze Age these Beaker folk pushed still further westward via the Northern European plain to Britain.

(2) Britain from Neolithic times to the present: The living equivalents of the Cranial N.I. averages are as follows :—

Neolithic	68	Anglo-Saxon	73
Bronze Age	75	Danes	71
Iron Age	71	Modern English	69

Actual N.I. measured on living :—

English	66	Old Americans	66
Irish	65	Welsh	67

[1] Haddon, Races of Man.

[2] Peake, *Journ. Roy. Anthrop. Inst.*, 1916.

It is unfortunate that no N.I. measurements are available for the Hythe and Rothwell series of crania as they would fill in a considerable gap. The theoretical index for East England is 67. In spite of invading types the influence of a cool climate has narrowed the nose from Neolithic times to to-day.

In view of this general tendency it is all the more surprising therefore to find the following Cranial N.I. averages in the seventeenth century, Moorfields, 73 ; Whitechapel, 73 ; Faringdon St., 73.

These numerous series represent victims of the Plague in the seventeenth century in the poorer quarters in London. The N.I. is as high as that of Anglo-Saxon and nearly as high as that of the Bronze Age type. It is extremely improbable that no narrowing had taken place, and that Anglo-Saxon and Bronze Age types had congregated in the poorer quarters of London, to be specially singled out by malevolent Fate as harvest for the Plague. In addition there is the series of 72 crania in the Royal Army Medical College measured by Knowles[1] in 1911. English soldiers N.I. (Crania) 43·6. 63·5 living equivalent.

An enquiry sent to the librarian, Mr. Jackson, elicited the information that these soldiers died of bullet wounds, one of phthisis. The influence of stature may be responsible for the slightly lower N.I. of this series, but why the victims of the Plague should have.had such a wide nose is a problem that must be left to be dealt with elsewhere when discussing the N.I. in relation to disease.

(3) Egypt from 6000 B.C. to the present : The following data are available, the N.I. (Crania) having been converted to the living equivalent by means of Graph III.

	N.I.
Naquada, 6000–4000 B.C.	81
Egyptian, 3000 B.C.	81
Theban mummies, 1500 B.C.	79
Egyptian, 200 B.C.	77
Modern Egyptian	78
Modern Egyptian living	77 and 78.

Here we have two native samples from early times with average nasal indices over 80, and, in contrast to these, samples from later times with indices under 80 ; the contrast though not very marked indicates a reduction of the index which on the basis of the hypothesis here utilised suggests the influence of an increased dryness. That increased dryness is probable on general grounds.

[1] Knowles, *Journ. Roy. Anthrop. Inst.*, 1911.