

MORPHOLOGICAL CHARACTERS OF THE HUMAN FOOT

by S. S. SARKAR, *Research Fellow, N.I.S.I., Department of Anthropology,
University of Calcutta*

(Communicated by K. P. Chattopadhyay, F.N.I.)

(Received May 9, 1957; read June 26, 1958)

ABSTRACT

1. The contour method of studying the morphology of the human foot and its deviations from the International Agreement of Anthropometric Measurements have been described.
2. The human foot can be divided into three types on the basis of the relative lengths of the toes; (i) $1 > 2$; (ii) $2 > 1$ and (iii) $1 = 2$. Following Minami they have been called T, F and O respectively. The different homo- and heterotypes have been described.
3. In both the rural and urban females the type F occurs in a frequency higher than the males and it appears to be sex-limited in nature.
4. A scheme of 11 types of interspaces between the toes has been proposed. The females, both rural and urban, show more interspaces than the males. The influence of the footwear on the interspaces has been discussed.
5. The forms of interspaces appears to be hereditary.
6. The anthropometric characters, measured from the foot contours of 7 Bengal castes and 5 aboriginal tribes of Bihar and Orissa, have been discussed.

INTRODUCTION

Among the morphological characters of the human foot, the relative lengths of the first and the second toes have been the subject of some studies. The largest variability, however, appears to occur in the four interdigital spaces (*interstitium* of Martin) between the five toes, which have not been, as far as the present writer's knowledge goes, studied in detail. Martin (1928) appears to have emphasized this character of the foot, as seen in the interspace between the hallux and the second toe, and his contour drawing of the Senoi feet gives an excellent idea of all the interspaces between the toes.

A study of the interstitium of the toes is only possible from accurate contour tracing of the foot. The study of the contour tracings was recommended at the International Agreement of Anthropometric Measurements at Geneva in 1912 (Stewart, 1947) but so far, this method has practically received no serious study. The Geneva Agreement did not recommend any specific measurement on the contour tracings. Martin recommended this method of study and Osman Hill (1941) has applied it in his study of the Vedda foot. The contour method facilitates the study of the many morphological characters of the foot, *i.e.*, the length and breadth, the relative lengths of the first and the second toes, the angle of divergence of the hallux and the four interstitia between the toes. Thus, with these eight morphological characters it can serve an useful purpose of identification in criminology and forensic medicine.

In the present paper the contour method of study has been applied on five aboriginal tribes of Bihar and Orissa and a few caste groups, urban and rural, from Bengal. The urban Bengali data have been collected from the city of Calcutta and the rural data from the village of Dakshingram, Birbhum, West Bengal.

METHOD OF STUDY

In taking the contour of the foot, the subject is seated on a low stool so that the foot reaches the ground. The subject is then asked to place his foot lightly on a sheet of paper, the leg being perpendicular to it. The investigator then kneels before the toes of the subject and the left hand is placed on the arch of the foot. A thin pencil, with the lead exposed long, is held vertically and the outline is started from the middle point of the heel. From this point the outline is traced along the lateral margins of the foot. The two lateral borders being thus drawn, the toes and the interspaces in between them are carefully drawn. Only the natural interspaces are drawn and the lead of the pencil is slipped in only when an interspace is visible before the meeting point of the two toes. Before the subject is asked to remove his foot the two landmarks, metatarsale tibiale and metatarsale fibulare, are marked on the outline.

The above method thus appears to be slightly different from that suggested by the International Agreement. The latter recommends the contour of the foot to be drawn in the same manner as the hand in which, the fingers have to be "very slightly separated". It appears to the present writer that this process is not probably possible in the toes, firstly, because of their much lesser lateral mobility and secondly, any attempt at movement will cause distortion of the contour of the whole foot. The toes are difficult to be separated singly and laterally, like the fingers. The other recommendation of marking "the extreme end of each interdigital cleft" with a dot is not probably possible in all feet. Its purpose is also not explained. The extreme end of the interdigital cleft, where it is easily visible, will automatically be drawn in the procedure followed in the present study; but where the extreme end of the interdigital cleft is not visible, it has to be mechanically splayed out for dotting, which is likely again to distort the contour drawing. It is, therefore, desirable to look for the natural interspaces only.

The inner border of the foot is, of course, "always unreliable" but to complete a contour and to give the shape of a foot, it should be drawn and not left out.

RELATIVE LENGTHS OF FIRST AND SECOND TOES

The hallux usually attains the greatest length while the second toe occasionally surpasses the first toe in length. The third toe is also found to be the greatest in length in very rare instances (Wood Jones, 1949). In some cases the hallux and the second toe are found to be of equal length. Thus, on the above basis there can be three types of human feet :

$$1 > 2 ; 2 > 1 ; 1 = 2$$

Hawkes (1912) proposed the symbols L (LL) for $1 > 2$, S (SS) for $2 > 1$ and E (EE) for $1 = 2$ for the main homotypes in the right and left feet while six other symbols were used for the six heterotypes (LS-A ; SL-B ; LE-C ; EL-D ; SE-G ; ES-H), the symbol on the left standing for the left foot and that on the right for the right foot. Minami (1952) proposed T (tibial) for the hallux being greater, F (fibular) for the second toe being greater while O for both the toes being equal. The last, according to him, is a transitional type. He did not propose any symbol for the heterotypes and remarked that "there are no clear differences in these frequencies of heterotypes". This appears to be true in the case of the data presented in this paper. The frequency of the homotypes is predominantly higher than those of the heterotypes. The foetal researches of Schultz (1924) and Minami show that there is a clear racial difference among the three races, White, Negro and Mongolian, in the frequency of each of the above types.

TABLE I
Relative Lengths of the I & II Toes (Rt & Lt)

Sr. No.	Castes	Sex	No.	$\frac{I}{T} > 2$	$\frac{2}{F} > 1$	$\frac{1}{O} = 2$	Remarks	Locality
1.	Bengal Low Castes	male	160 %	124 77.50	30 18.75	6 3.75	Rural	Birbhum (W. Bengal)
2.	„ Artisan „	„	134 %	105 78.36	24 17.91	5 3.73	„	„
3.	„ Muslims	„	54 %	40 74.07	12 22.22	2 3.70	„	„
4.	„ Brahmans	„	130 %	98 75.38	22 16.92	10 7.69	„	„
5.	„ „	female	52 %	36 69.23	15 28.85	1 1.92	„	„
6.	„ High Castes	male	240 %	214 89.17	18 7.50	8 3.33	Urban	Calcutta
7.	„ „ „	female	100 %	78 78.0	16 16.0	6 6.0	„	„
<i>Tribes</i>								
8.	Juang	male	86 %	79 91.86	3 3.49	4 4.65	Rural	Orissa
9.	Oraon	„	88 %	82 93.18	5 5.68	1 1.14	„	Ranchi
10.	Pahira	„	58 %	46 79.31	7 12.07	5 8.62	„	Manbhum
11.	Mundari	„	90 %	73 81.11	12 13.33	5 5.56	„	Ranchi
12.	„	female	18 %	15 83.33	2 11.11	1 5.56	„	„

Table 1 shows the frequency of the above three types in the various castes and tribes of Bengal, Bihar and Orissa. All of them predominate in having the high frequency of the hallux (type $1 > 2$) being greater than the second toe and it is

TABLE II
Frequency of the Homo & Hetero Types

Sr. No.	Castes	Sex	No.	TT	FF	OO	TF	FT	TO	OT	FO	OF	Remarks
1.	Bengal Low Castes	male	80 %	55 68.75	9 11.25	—	8 10.0	2 2.50	3 3.75	1 1.25	1 1.25	1 1.25	Rural
2.	"	"	67 %	49 73.13	9 13.43	—	2 2.99	2 2.99	1 1.49	2 2.99	1 1.49	1 1.49	"
3.	"	"	27 %	18 66.67	3 11.11	—	1 3.70	3 11.11	—	—	—	2 7.41	"
4.	"	"	65 %	43 66.15	6 9.23	1 1.54	5 7.69	2 3.08	4 6.15	1 1.54	1 1.54	2 3.08	"
5.	"	female	26 %	16 61.54	6 23.08	—	1 3.85	2 7.69	1 3.85	—	—	—	"
6.	"	High Castes	120 %	104 86.67	6 5.00	2 1.67	1 0.83	3 2.50	—	2 1.67	1 0.83	1 0.83	Urban
7.	"	"	50 %	35 70.0	1 2.0	—	5 10.0	3 6.0	—	2 4.0	1 2.0	3 6.0	"
<i>Aboriginal</i>													
8.	Juang	male	43 %	37 86.05	—	—	—	2 1.72	3 2.58	—	1 0.86	—	Rural
9.	Orson	"	44 %	39 88.64	1 2.27	—	1 2.27	2 4.54	1 2.27	—	—	—	"
10.	Pahira	"	29 %	22 75.86	2 6.90	2 6.90	1 3.45	1 3.45	—	—	1 3.45	—	"
11.	Mundari	"	45 %	33 73.33	3 6.67	1 2.22	4 8.89	1 2.22	1 2.22	1 2.22	—	1 2.22	"
12.	"	female	9 %	7 77.78	1 11.11	—	—	—	1 11.11	—	—	—	"

true in the case of the female groups as well. In the latter sex, however, excepting the Mundari females, the frequency of the type F ($2 > 1$), appears in a much higher frequency than the males. Among the male rural Brahmans its frequency has been found to be 16.92 per cent in comparison to 28.85 per cent in the females. Among the urban high caste Bengali women its frequency of 16 per cent is more than double the male percentage of 7.5 per cent. The other type O ($1 = 2$) occurs in a low frequency of 1.92 per cent among the rural Brahmans females while it occurs in 7.69 per cent among the males. The urban samples, however, show just the contrary picture—the females (6 per cent) showing almost twice that of the males (3.33 per cent).

The rural and the urban samples of the two high caste groups also differ considerably from one another. Among the males the frequency of the type T shows a considerable increase among the urban peoples (89.17 per cent) as against 75.38 per cent of the rural group while the other two types F and O occur in much higher frequencies among the latter group than the former. Type F occurs in 16.92 per cent in the rural group as against 7.50 per cent in the urban group while the type O occurs in 7.69 per cent and 3.33 per cent in the rural and urban respectively. In respect of the female sex, the male order is retained in the case of types T and F while in the type O the urban females (6 per cent) show a higher frequency than the rural females (1.92 per cent).

It is difficult to explain this rural-urban difference at this stage though the use of shoes by the urban peoples deserves a mention. The second toe sometimes shows a curvature of the terminal phalanx and this might cause a reduction in its length when tight-fitting shoes are worn. Such a foot is likely to be diagnosed as belonging to type T.

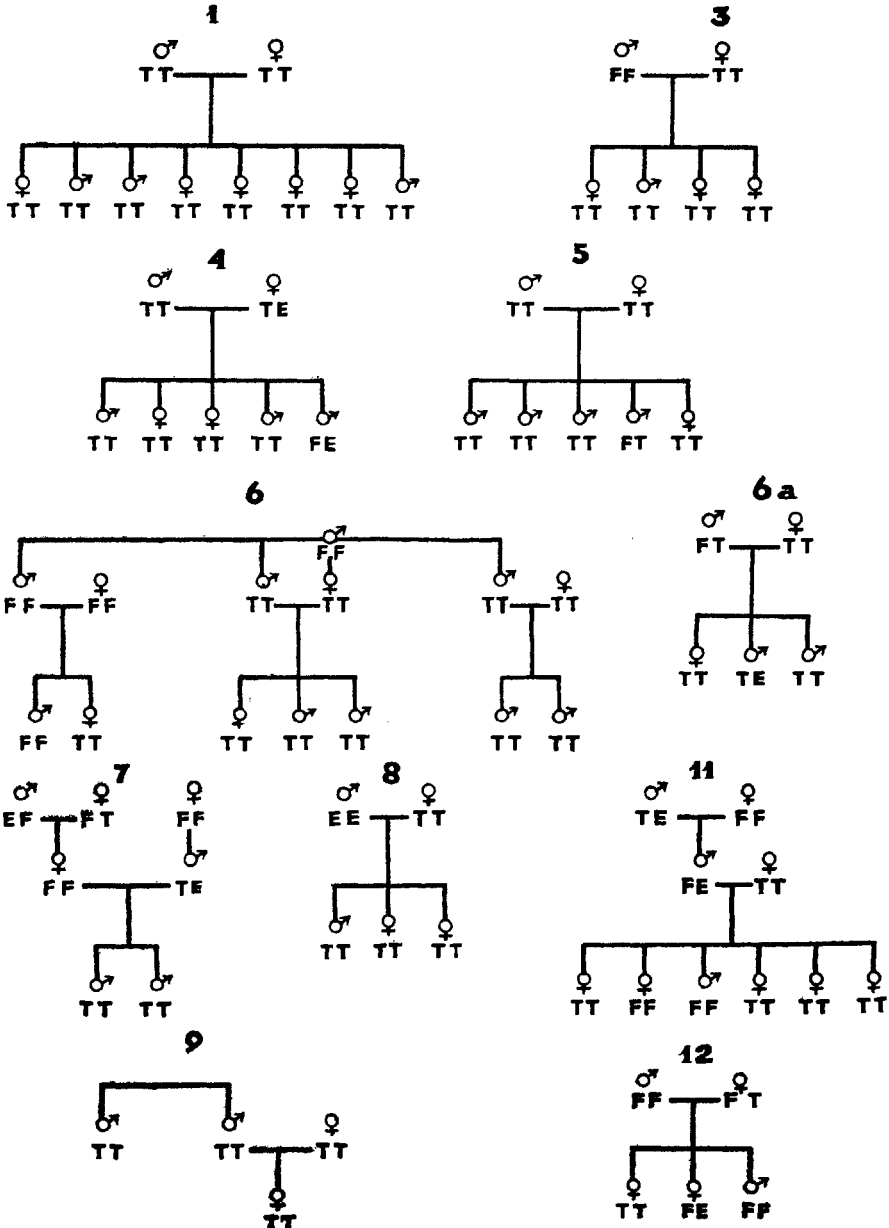
The sexual difference in the second toe appears to be genetic. Hawkes drew attention to the sex-limited nature of the F type of foot, which occurs more commonly in the females than in males. The T type of foot was also found to behave irregularly dominant over the F type of foot. According to Hawkes, besides the heterozygotes TF, FT, etc., both T (TT) and F (FF) behave as heterozygotes—the former in the males and the latter in the females.

In course of the present study, which for obvious reasons, has to be morphological first of all, some pedigrees were also collected and they will be discussed afterwards. Before we take up the pedigree material it will be worthwhile, first of all, to discuss the different homo and hetero-types in the general population. Hawkes has differentiated two heterozygotes, according to the right and the left limbs, *i.e.*, A for the right foot showing F and the left foot showing T, while B for the right foot showing L and the left foot showing S. In Table II the percentages of the various combinations have been shown :

It will be seen from the above table that the homotype TT occurs in the highest frequency while FF in the next highest in the majority of cases, the exceptions being the urban high caste Bengali females and the Mundari males. In both the latter cases, the heterotype TF occurs in the next highest frequency. If, however, the two heterotypes TF and FT are added together the second position of FF is considerably altered in the majority of the samples. The high frequency of 23.08 per cent of the homotype FF in the rural female Bengali Brahmans, however, stands in sharp distinction from 2.0 per cent of the same type in the urban high caste female Bengalis. The homotype OO appears to be very rare—only 6 instances have been found in course of the present study. Hawkes did not find any instance of the heterotypes of O in England. It is also a rare type in this country.

HEREDITY OF THE FOOT TYPES

The following pedigrees (A, 1-12) were collected in course of the morphological studies of the foot.

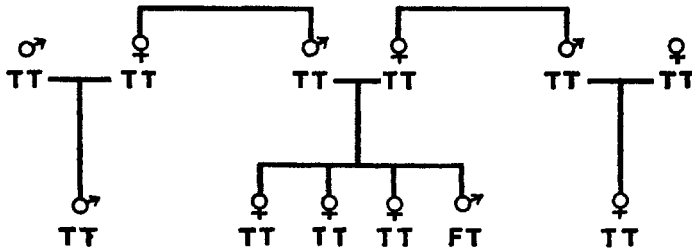


PEDIGREES A

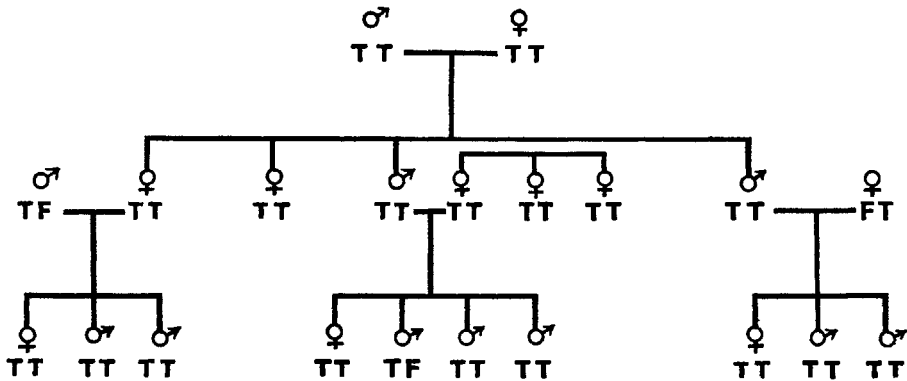
For facilities of comparison Hawkes' pedigrees (B) have been converted into the symbols followed in the present paper and are reproduced below.

HAWKES DATA (1912)

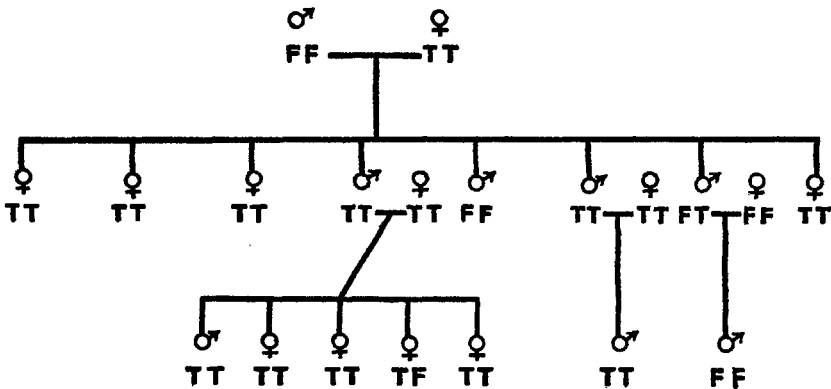
TREE B



TREE C



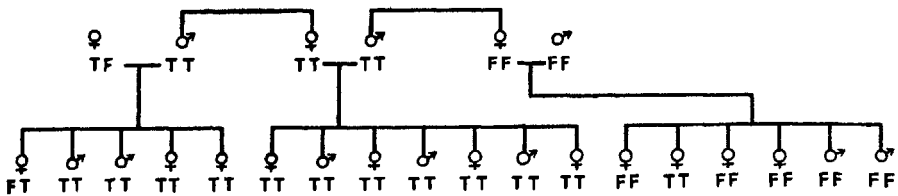
TREE D



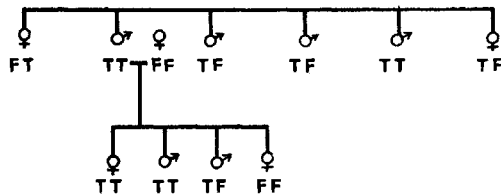
PEDIGREES B

HAWKES' DATA (1912)

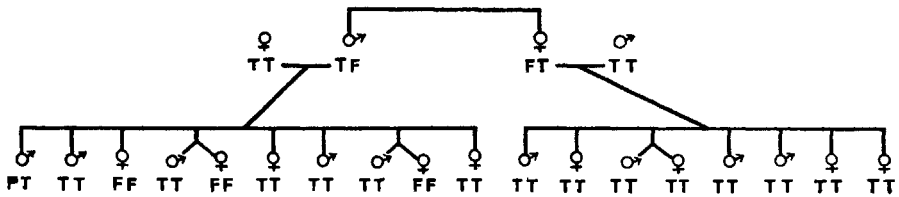
TREE E



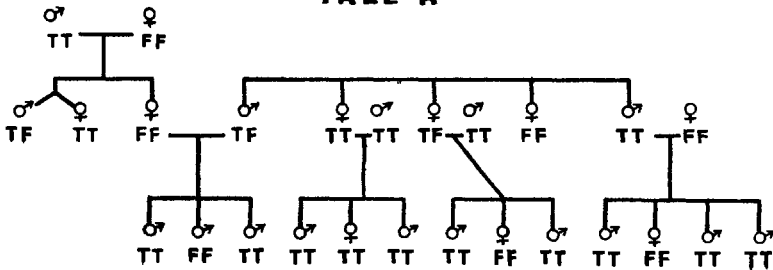
TREE F



TREE G



TREE H



PEDIGREES B

It will be seen from the above pedigrees that when TT×TT are crossed there are always chances of having TT children, which indicate that this type breeds true. An exception is, however, met with in Pedigree 5 where an FT child is born out of such a union. This child was found at the time of first enquiry to have the second toe of his left foot longer than the first. He was investigated again at the time of writing when he was found to belong to TT. The complete data are as follows :

Date	Age	Left		Right	
		I	II	I	II
22-12-54	12	203	203.5	202	198
21-2-57	14	237	231	236	228

There are thus chances of young children showing a different picture with the increase of age. This solitary example, however, goes against the observation of Hawkes who suggested that the "adult condition as regards toe type is reached by the age of two years". As a matter of fact, the present writer excluded all children below two years of age on the basis of the above suggestion of Hawkes.

Hawkes has also found 4 instances of TF or FT children in TT×TT matings, but these four exceptional cases were not investigated after a certain interval. Their ages are also unknown.

The dominance of TT over the other phenotypes FF, FT, OO, etc., is however, apparent. In Pedigree 3, though the mating TT×FF has resulted into all TT children, there are possibilities of FF or FT types, as will be evident from the data of Hawkes. Even an OO type has been found to occur in the above mating. Hawkes has recorded 25 matings of the above type and suggested a partial dominance approximating to 2.75 : 1. Data for FF×FF matings are too few. Hawkes found only two instances and the present author only one (Ped. 5). Hawkes found one TT child in a total of 9 children while the present data show one child each of TT and FF.

The matings involving the heterotype FT are only 2 in number (Ped. 6a and 12) and in the mating with each of the homotypes TT and FF an O child has come out. Both these two children are below 10 years of age.

Hawkes did not find any case of combinations of the O type and as such her pedigree material is not complicated with this genetic factor. The present writer has found all the three adult combinations OO, OT and OF and in the two Pedigrees 7 and 11, two matings with adult children are seen :

♂ OF × ♀ FT — FF ♀

♂ TO × ♀ FF — FO ♂

It will be apparent from the above scanty data that O also behaves hereditarily and the dominance of T over it is also indicated.

It is, however, worthwhile to point out that in the study of the heredity of the foot types or in the collection of pedigrees, sufficient time should be allowed for the completion of growth in the foot of the children. It appears that Hawkes' estimate of 2 years is probably too low, and children below 14 years of age cannot always be reliably taken into account. Growth studies, however, are necessary to arrive at the exact figure at which the child's foot ceases to grow.

INTERSPACES

A study of the interspaces between the toes shows the following 11 types (Fig. 1). They are :

1. Coalescent
2. Slit-like
3. Tubular
4. Bulbous 4a. circular base ; 4b. triangular base.
5. Rectangular
6. V form 6a. elongated ; 6b. constricted.
7. U form 7a. wide ; 7b. constricted.
8. Y form
9. Hooked
10. M form
11. Pointed

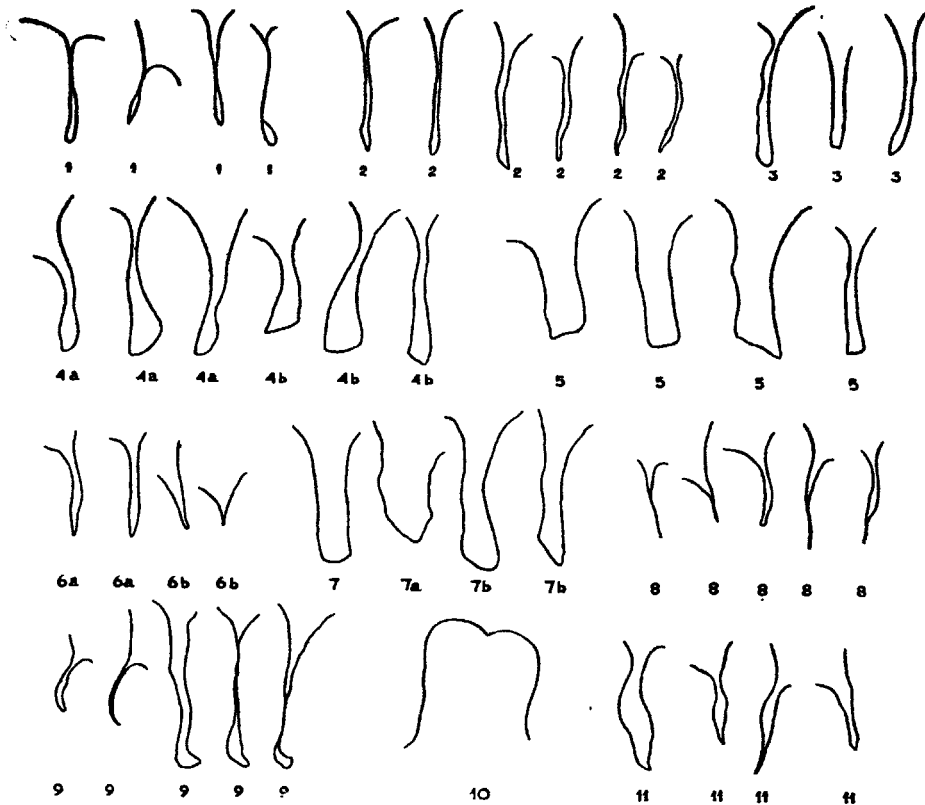


Fig. 1. Forms of interspaces.

The distribution of the above 11 types has been studied in the two sexes of two populations only—(i) Urban Bengali and (ii) Rural Bengali Brahmans. Sexual difference also appears to be very much marked in this character. It has been found that in both the rural and urban populations the females, as a whole, show more interspaces between the toes than the males. It will be evident from the following table (Table V) extracted out of Tables III and IV,

TABLE V
Frequency of Interspaces (in %)

Characters	Urban Bengali		Rural Bengali Brahmans	
	male	female	male	female
No interspace in either foot	21.55	4.0	16.92	0
„ „ „ right „	12.07	2.0	10.77	0
„ „ „ left „	5.17	2.0	1.54	0
„ „ „ per „	30.17	6.0	23.08	0

It will be apparent from Table V that the urban Bengali females show a significantly low percentage of the absence of interspaces between the toes than the urban males, while in the case of rural females this character of the foot is present in all. The interspaces, therefore, appear to be more a characteristic of the female foot than the male foot.

As regards the other interspaces, the I interspace (between hallux and the II toe) occurs in the highest percentage, excepting for the rural females, among whom the interspaces I-III occur in almost equal percentages. The IV interspace (between the IV toe and the little toe) occurs in the least frequency in all excepting the rural females. A wide variability is seen in the two sexes and also between the rural and urban samples. The detailed data for the left and right sides combined together are given in the Table VI below.

TABLE VI
Frequency of Interspaces (Rt. + Lt., in %)

		Rural							
		male				female			
Types		I	II	III	IV	I	II	III	IV
“ No ”		33.08	51.55	60.77	63.35	9.61	7.69	9.61	34.62
Others	(Fig. 1.)	66.92	48.45	39.23	36.65	91.39	92.31	90.39	65.38

		Urban							
		male				female			
Types		I	II	III	IV	I	II	III	IV
“ No ”		39.17	81.90	84.49	96.88	15.0	46.0	50.0	74.0
Others	(Fig. 1.)	60.83	18.10	15.51	3.12	85.0	54.0	50.0	26.0

In urban males the I interspace occurs in 60.83 per cent while in the females it is found in 85 per cent. In rural males and females the same is found in 66.92

TABLE
Statistical Constants

Sr. no.	Caste or Tribe	No.	Foot Length (mm)		Foot Breadth (mm)	
			Range	Mean \pm S.E.	Range	Mean \pm S.E.
♂						
1.	Bengal Low Castes	160	216-282.5	244.35 \pm 0.89	84-110.5	95.44 \pm 0.42
2.	Bengal Artisan Castes	134	217-285	248.30 \pm 1.08	84-113	95.80 \pm 0.46
3.	Bengal Muslims	54	219.5-258	241.70 \pm 1.46	86-113	96.89 \pm 0.73
4.	„ Rural Brahmans	130	213-279	246.25 \pm 1.01	75-109	94.78 \pm 0.51
5.	„ Urban High Castes	240	220-284	253.30 \pm 0.73	84-113	98.53 \pm 0.36
6.	Juang	86	211.5-268	241.95 \pm 1.25	85.5-118	95.90 \pm 0.62
7.	Oraon	88	225-279.5	259.90 \pm 1.12	84-116.5	101.20 \pm 0.69
8.	Pahira	58	191-257	229.70 \pm 1.60	75-109	92.80 \pm 0.93
9.	Mundari	90	227-274	251.20 \pm 1.14	88-115	100.30 \pm 0.65
10.	Vedda	26	173-249	230.00 \pm 2.65	71-103	85.34 \pm 1.45
11.	Abor	84	212-274	241.05 \pm 1.09	—	—
♀						
1.	Abor	10	219-239	228.3	—	—
2.	Mundari	18	198-253	227.0	86.5-97	90.94
3.	Beng. Rural Brahmans	52	209-247	228.80 \pm 1.25	77-96	86.61 \pm 0.55
4.	„ Urban High Castes	100	205-251	226.40 \pm 1.08	72-106	87.13 \pm 0.66

VII

of Foot

Leng. Range	Br. Index of Foot Mean \pm S.E.	Hallux Divergence Angle		Author
		Range	Mean \pm S.E.	
35.66-44.17	39.77 \pm 0.17	4.5°-10°	5.87° \pm 0.16	Present study
34.41-44.76	38.72 \pm 0.15	4°-9°	6.76° \pm 0.17	„
37.37-45.82	40.17 \pm 0.27	5°-8.5°	6.72° \pm 0.23	„
33.01-43.30	38.62 \pm 0.17	4.5°-10.5°	6.42° \pm 0.20	„
34.68-45.00	39.00 \pm 0.11	4°-9°	6.48° \pm 0.13	„
36.12-45.12	39.73 \pm 0.20	4°-10°	5.85° \pm 0.20	„
35.96-44.23	39.83 \pm 0.20	4.5°-9°	6.68° \pm 0.22	„
36.91-44.21	40.40 \pm 0.26	5.5°-10.5°	5.98° \pm 0.27	„
32.37-43.98	39.98 \pm 0.23	4.5°-9.5°	6.26° \pm 0.22	„
31.42-41.37	36.46 \pm 0.41	—	—	Osman Hill
—	—	—	—	Kemp
		—	—	Kemp
36.95-43.94	39.67	—	—	Present study
34.70-41.86	37.89 \pm 0.32	4.5°-10°	5.60° \pm 0.24	„
32.58-44.29	38.57 \pm 0.23	4.5°-10°	6.70° \pm 0.25	„

per cent and 91.39 per cent respectively. Correspondingly the IV interspace occurs in urban males and females in 3.12 per cent and 26 per cent respectively while in the rural Bengali Brahmans it is seen in 36.65 per cent and 65.38 per cent in males and females respectively.

The II and III interspaces appear in almost equal frequencies. They are found in 18.10 per cent and 15.51 per cent respectively in urban males ; in 54 per cent and 50 per cent respectively in urban females ; in 48.45 per cent and 39.23 per cent respectively in rural males and in 92.31 per cent and 90.39 per cent respectively in rural females.

It will be apparent, therefore, that a wide sexual variation is present in all the four interspaces while the rural-urban variation is manifested mostly in the three interspaces II, III and IV. The I interspace shows the least of it.

The rural percentages are always higher than the urban, particularly in the case of II-IV interspaces ; only in the case of I interspace do they nearly agree with one another. The rural-urban difference also appears to be higher in the case of males than the females and in the case of the IV interspace, the rural value is 12 times that of the urban. The position of the little toe may here be mentioned. It was observed in the case of a large number of urban samples that the little toe does not touch the ground but appears as an appendage at a slightly higher level and directed upwards. This upward direction of the toes is also more a character of the rural people than that of the urban, whose toes show a tendency to curve medially and downwards, particularly in the case of the IV and the V toes.

Wood Jones has pointed out that the little toe "suggests phylogenetic decrepitude" and the wearing of the boots has nothing to do with its general anatomical condition. Its structural changes are due to the demand of "functional requirements" and it is not a "degenerating member" of the human foot. He, however, mentions that "the boots of civilization often serve it badly". Whether the wearing of tight shoes in childhood, as is seen commonly in the cities, has any effect in shaping the toes or not, they are probably effective in obliterating or lessening the natural interspaces. Urban school children, below the ages of 12, show a tendency to wear tight-fitting shoe, so that the whole foot is encased as a compact whole. The rural-urban difference in the frequency of the interspaces, II, III and IV may have its origin in the use of footwear, which is commoner in the cities than in the villages. Shoes are a handicap in the villages, both from the social and ecological point of view.

The different forms of interspaces (Fig. 1) also show very clearly the sexual and the rural-urban variation. In urban males, the absence of interspaces occurs in 75.65 per cent (Table III) which renders the other forms of interspaces almost inconspicuous—the highest percentage of 4.53 is met with in the form 4a (bulbous with circular base). The next highest form is seen in 4b (bulbous with triangular base) with a percentage of 3.02. The rural males, on the other hand, show the absence of interspace in 52.31 per cent (Table IV) and the interspace form 1 (coalesced) occurs in the highest percentage of 10.96. The next highest percentage is seen in the form 4b (7.31 per cent). There is, however, a high element of the bulbous form in the urban sample, which is also shared by the rural people in addition to the coalesced form (type 1, Fig. 1). The bulbous form of interspace is also predominant among the females, both urban (15.75 per cent) and rural (18.27 per cent). The next highest form is seen in the types 3 and 7, which occur interchangeably in the two female samples. In urban females, types 3 and 7 occur in the equal percentage of 6.25, while in the rural sample the former type appears in 6.73 per cent and the latter in 15.39 per cent.

These observations are in harmony with our previous remark that the rural-urban difference is greater in the males than in the females. We have also shown

that the female foot shows more interspaces than the male foot. The cause of the rural-urban variation in the interspaces of the male foot probably lies, as already mentioned, in the footwear. The coalesced type of interspace may be easily obliterated due to a tight shoe and the male rural frequency of 10.96 per cent has been reduced to 1.83 per cent in the city. On the other hand, the bulbous type of interspace is probably the least affected by a footwear. The latter might cause the two toes to touch each other at the upper end due to lateral pressure, but the lower bulbous space, which is formed by the two lateral depressions at the base of the toe, almost remains unaltered. The rural-urban difference in the bulbous type is not so great as in the case of the coalesced type (1); it is 7.55 per cent for urban and 10.96 per cent for rural.

The higher frequency of interspaces in the females than in the males might be associated with the same sexual relationship in respect of the F type of foot, with its II toe longer than the hallux. Both the characters behave hereditarily and only further researches can lead us to useful conclusions of applied value. The Police authorities now retain foot prints along with finger prints for all undertrial prisoners. It will be useful to retain a foot contour as well with all interspaces, since the peculiarities of the toes and the interspaces may provide additional information for identification.

HEREDITY OF INTERSPACES

The form of the interspaces also appears to be hereditary. The presence of interspaces appears to be dominant over "no interspaces" as will be apparent from the interspaces of Pedigree 4 (Fig. 2).

Similarly, in Pedigree 1, while both the parents have interspaces, they are somewhat marked in the mother and the M form (Fig. 1, No. 10) of interspace (Fig. 3), which has also been found in other members of the mother's family, is inherited in the children. Other pedigrees also bear out the heredity of this M form of interspace.

ANTHROPOMETRIC CHARACTERS

The anthropometric measurements of the foot comprise: (1) foot length, (2) foot breadth and (3) hallux divergence angle. They are shown in Table VII along with the length-breadth index of foot, calculated from (1) and (2) given above. All the above measurements are taken on the outline (Figs. 4 and 5). In measuring the foot length, the greatest length has always been taken into account. A 300 mm. long sliding clipper was used for this purpose.

The statistical constants of the foot of the various peoples are given in Table VII.

It will be apparent from the above Table that the Pahiras (229.70 ± 1.60) of Dalma Hills, Manbhum show the smallest length, closely followed by the Veddas (230.0 ± 2.65) of Ceylon, while the Oraons (259.90 ± 1.12) show the greatest length of all. The Oraons also show the highest breadth of all (101.20 ± 0.69) while the lowest breadth is seen among the Veddas (85.34 ± 1.45). The Pahiras rank next to the Veddas in foot breadth (92.80 ± 0.93). Thus, both in length and breadth the Pahiras appear to be closer to the Veddas than the other groups—a fact which is also confirmed by other studies. The Oraons appear to be closer to the Mundas in foot breadth only; in foot length they stand wide apart.

The male rural Brahmans and the urban high castes show significant differences both in the length and breadth of the foot, while the females of the two groups appear to be close to one another. The rural females show a slightly greater length and lesser breadth than do the urban and they appear to be significantly similar to one another ('t' for length = 1.45; 't' for breadth = 0.60).

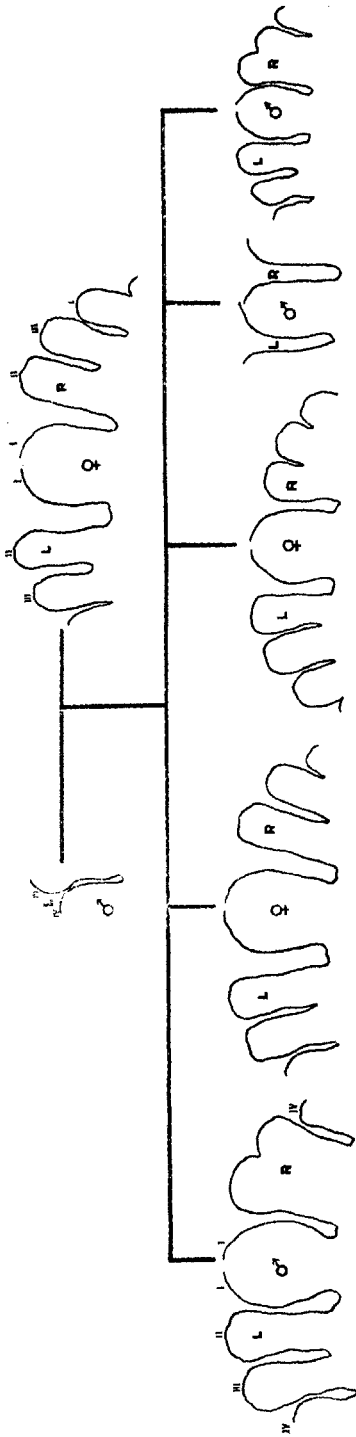


Fig. 2. Pedigree showing heredity of interspaces.

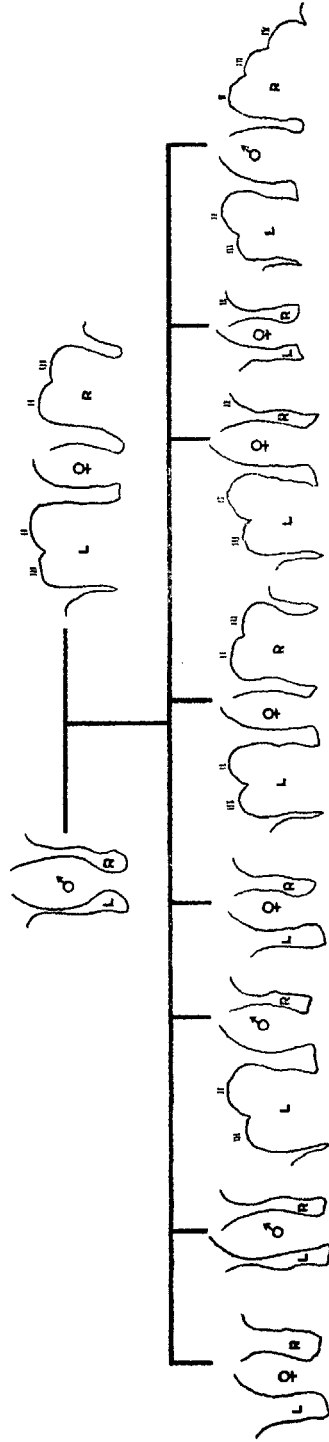
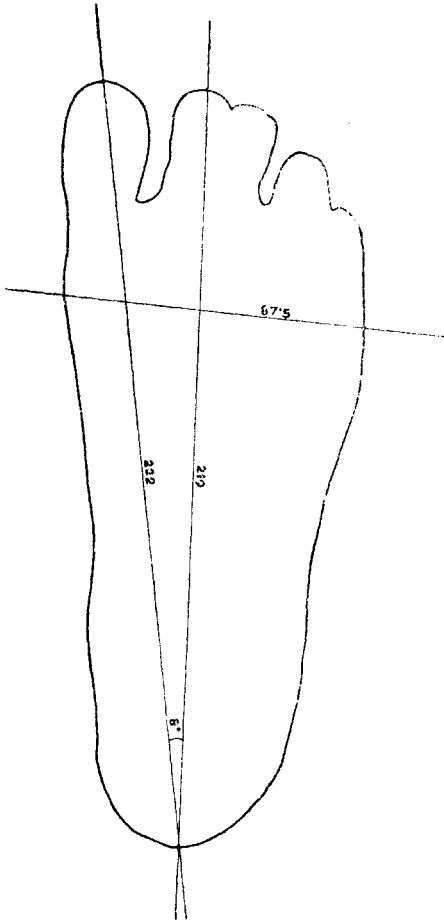
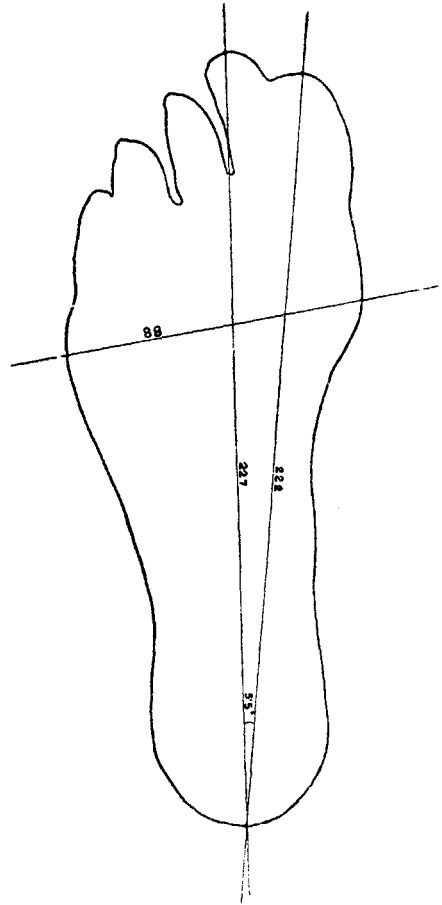


Fig. 3. Pedigree showing heredity of interspace (M from)

Fig. 4. Contour of foot type T ($1 > 2$).Fig. 5. Contour of foot type F ($2 > 1$).

The differences, found in respect of the absolute length and breadth of foot, are, however, evened out when the length-breadth index of foot is taken into consideration. In absolute length and breadth the rural Brahmans and the urban high castes were found to differ significantly, the values of 't' have been found to be 5.64 and 6.25 respectively, whereas in respect of the index, the value of 't' is 1.90, indicating a close relationship between the two. The females of the above two groups show the value of 't' to be 1.74 in respect of the above index, whereas the same for the length and breadth are 1.45 and 0.60 respectively. Similarly, the Mundari group shows an affinity in respect of this index, with the other aboriginal groups, Juang ('t' = 0.83), Oraon ('t' = 0.50) and Pahira ('t' = 1.20). They show close affinity with the Muslims ('t' = 0.53) and the Bengal low castes ('t' = 0.72). The latter caste group also shows close affinity with the Muslims ('t' = 1.25), Juang ('t' = 0.15) and Oraon ('t' = 0.23).

In the hallux divergence angle the least divergence of $5.85 \pm 0.20^\circ$ has been found among the Juangs while the highest divergence is seen among the rural artisan castes of Bengal ($6.76 \pm 0.17^\circ$). The range of variability does not appear to be great in the different samples studied in this paper.

REFERENCES

- Hawkes, Onera A. M. (1913-14). On the relative lengths of the first and second toes of the human foot, from the point of view of occurrence, anatomy and heredity. *J. Gen.*, **3**, 249.
- Martin, Rudolf (1928). *Lehrbuch der Anthropologie*, 1, Jena.
- Minami, Korin (1952). The digital formula in Japanese fetus, II—Study on the relative length between the 1st and 2nd toe. *Folia Anat. Jap.*, **24**, 295.
- Osman Hill, W. C. (1941). The physical anthropology of the existing Veddas of Ceylon, I. *Ceylon J. Sci.*, (G), **3**, 25.
- Schultz, A. H. (1924). Fetal growth in man. *Amer. J. Phys. Anth.*, **6**, 389.
- Stewart, T. D. (1947). *Hrdlicka's Practical Anthropometry*. Philadelphia.
- Wood Jones, F. (1949). *Structure and Function as seen in the Foot*. London.