ANTHROPOLOGICAL PAPERS
OF
THE AMERICAN MUSEUM OF NATURAL HISTORY

VOLUME XXXVIII, PART III

THE ANTHROPOMETRY OF PUKAPUKA

Based upon Data collected by Ernest and Pearl Beaglehole

By H. L. Shapiro

By Order of the Trustees
of
THE AMERICAN MUSEUM OF NATURAL HISTORY
New York City
1942

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CONTENTS

TABLES

INTRODUCTION

A generation ago no adequate definition of the Polynesian physical type existed. Reliable quantitative studies had been published only on the crania of a few islands and archipelagoes. As for the living population, the lacunae occupied an even greater part of the area and what little information that could be found consisted of isolated and scanty samples, which by their very scarcity enjoyed a far greater authority and a much wider application, if only by default, than they actually deserved, while at the same time giving, in retrospect, an erroneous impression of the existing type.

Since that day, the situation has altered radically. Under the aegis of the Bernice P. Bishop Museum a considerable number of studies have been completed on a wide selection of Polynesian groups. Many of them have already been issued, some still await publication. But enough has become available to give a working conception of what may be called the Polynesian type. Patterns of variations have become more distinct, and geographic correlations with intra-Polynesian deviations have begun to emerge with some clarity. The present study of a relatively small group of western Polynesians, inhabiting the coral atolls known as Pukapuka, constitutes another contribution to this growing definition.

Several islands in Polynesia bear the name, Pukapuka, either as a principal or as an alternative designation. The Pukapuka of this report is sometimes known as Danger Island and lies on the western periphery of Polynesia, about 390 miles northeast of Samoa and about 715 miles northwest of Rarotonga. More precisely, its position may be defined as latitude 10° 50′ South and longitude 165° 45′ West.

This essay is concerned primarily with an anthropometric description of the population of Pukapuka and with an attempt to discover its closest genetic congeners. It is based entirely upon the series of records collected by Doctor and Mrs. Ernest Beaglehole during their residence on the island from November 1934 to June 1935. The opportunity to study this material I owe to their generous cooperation.

The nearest insular neighbor to Pukapuka is Nassau, about forty-two miles to the southward, where a colony from Pukapuka was formerly settled. The closest large archipelago is Samoa almost four hundred miles away. Theoretically, this isolation from the principal centers of Polynesian population, except for the relative proximity to so large a focus as Samoa, might loom large in the history of Pukapuka. It would be easy to conceive of Pukapuka being inundated from Samoan sources and retaining the evidence of it through an absence of influence from other Polynesian areas.

Isolation, however, is not the only interesting feature of Pukapuka's geographical position. It lies in a part of the Pacific where Polynesia interdigitates with Micronesia and thereby suggests the possibility that influences from this source may play a part in the physical characteristics of its population.

POPULATION

Reliable information on the number of inhabitants of Pukapuka is quite recent.[1] Byron, the discoverer of Pukapuka, or the Islands of Danger as he named them, merely speaks of them as "swarmed with people, whose habitations we saw standing in clusters all along the coast." [2] Beagle-hole cites the belief, persistent among the present islanders, that ten generations ago the number of inhabitants reached eleven hundred. Although this seems excessive by comparison with the present numbers, it may not be far from the truth, since over-crowding and competition for food appears in various guises throughout the traditional history of the island. The following table presents the official censuses of total population up to 1938.[3]

Year	No.
1906	435
1911	490
1916	474
1926	526
1935	632
1938	682

These figures reveal an ascending curve of population growth with a slight reversal between 1911 and 1916, which is accounted for by the transportation of fifty-two islanders to Rarotonga in 1914 as a measure to relieve distress after a tidal wave had damaged Pukapuka. Despite this loss, the span from 1906 to 1938 forms a period of rapid increase with a total gain of 57 per cent. Such evidence of vigorous growth strikes a cheerful note among the all too prevalent records of Polynesian depopulation, and adds considerable weight to the native tradition of a formerly more extensive population. We may, in other words, be witnessing a substantial recovery to the pre-European level, for it is very likely that Pukapuka suffered a serious decline after European contact, as occurred almost universally in Polynesia. Because the contact, however, was relatively late and never very intensive the ravages suffered were probably less devastating than they were in such groups as Tahiti or the Marquesas, where contact with Europeans decimated the native population. At any rate, whatever may be the truth of these speculations, the rapid rise in population caught by these official censuses indicates that some kind of readjustment in the balance between numbers and subsistence is now taking place.

Although the rate of increase characteristic of the present Pukapuka is unusual in Polynesia,[4] a region generally noted for its declining or stationary populations, its true measure can be gained only by a wider comparison. Pearl has estimated that the mean annual growth rate of the world population in recent years ranges closely around 1 per cent which would produce, if continued, a doubling of the total every 69.7 years. The annual rate of increase for Pukapuka for the span between 1906 and 1938 is 1.75 per cent, which is well above the average for the world, although probably exceeded by individual groups. I assume that it is understood that this is only a rough comparison. The above rate for Pukapuka is hardly as reliable as one calculated for millions of people.

Another method of comparing the kinetics of Pukapukan population with other groups is provided by Sundbärg's observations. He was the first to notice that about 50 per cent of the total of most populations fall within the 15–49 year age class, an age division responsible for practically all of the reproduction of a population, and that the proportion of the total included in the pre-reproductive, or 0–14 year group, fluctuated inversely with the percentage in the post-reproductive group comprising those 50 years and over in age. Furthermore, Sundbärg reported that the reproductive vigor of a population

[1] For information on Pukapukan population, I have leaned heavily on the compilations made and published by the Beagleholes in their Ethnology of Pukapuka (*Bulletin 150, Bernice P. Bishop Museum*, Honolulu, 1938).

[2] *An Account of a Voyage round the World*, Commodore Byron. London, 1773 (109).

[3] *Cook Island Administration Reports, 1886–1935* and *American Polynesia* by Edwin H. Bryan, Jr. The totals cited probably include a few non-natives.

[4] Indications are increasing that the ebb of Polynesian depopulation has begun to turn in other islands as well, largely as the result of a vigorous fertility among the hybrid groups.

was correlated with the proportion of the pre-reproductive group to the total.

From these observations Pearl[1] has derived an index, which he has named the generative index, to measure the reproductive vigor of a specific population. This index is calculated by dividing the number in the pre-reproductive group by the number in the reproductive group and multiplying by 1000. This gives the number of future reproducers for every 1000 active or potential reproducers. Obviously, if the index is less than 1000, the population is likely to decline, and if greater, the population will increase, other things being equal.

Unfortunately, in this instance we cannot employ the generative index as defined above, since in a community such as Pukapuka the age of its older members cannot be determined accurately. We can, however, calculate the proportion of the pre-reproductive group to the total. Luckily, Doctor Beaglehole made an effort to obtain information on age divisions and he has cited two estimates. One made by Geoffrey Henry is based on village lists for food and copra money divisions. The other is derived from Beaglehole's own partial census of the population. I give them both below.

	Adults	Children	Total	Children Per Cent of Total
Henry	394	238	632	37.66
Beaglehole	210	138	348	39.66

In both enumerations the adults include the reproductive as well as the post-reproductive groups. The division between children and adults falls at about age 16 in Henry's data and at 15 in Beaglehole's, approximating quite closely the terminal age suggested by Sundbärg for the pre-reproductive group. Sundbärg's data cited by Pearl[2] show that the pre-reproductive group varies in proportion to the total from 22.2 per cent in Sweden to 42.7 per cent in Brazil. The corresponding ratio for Pukapuka is 39.66 per cent, as estimated from Beaglehole's data. Judging, therefore, from the position of Pukapuka near the maximum extreme, we are justified in concluding that its population is in the midst of an actively growing phase.

To calculate Pearl's generative index the number in the reproductive group (age 15 to 49) is essential. Since the actual numbers are not available, I have tried to estimate them by using Sundbärg's observation that this group generally comprises 50 per cent of the population. On this assumption, the reproductive group on Pukapuka contains 316 individuals. For Beaglehole's smaller sampling, the corresponding number could be 174. On these hypothetical bases, I obtained the respective generative indices of 1328 and 1261. The former is probably a shade too high since the size of the reproductive group in this case might have been a little larger, if the lower age limit had been 15 instead of the approximate 16 used. The difference, however, is slight and they both fall somewhere near the truth, in that they indicate a definitely high generative index. The highest for any of the states of the United States calculated from the censuses of 1840 and of 1930 was 1175 and the average for thirty states in 1840 was 911.

Supplementary evidence on the vigor of the present Pukapukan population is also cited by Beaglehole. During 1933 and 1934, forty-one births were recorded as against twenty-two deaths. Although this is too small a sample to support much speculation and, moreover, lacks information on other conditioning factors, it does, nevertheless, fit the picture of a rapidly growing population. Still another statistical fragment points in the same direction. Reliable birth records were available for sixteen marriages. These produced a total of seventy-seven children, with an average of 4.8 per mating. Although the death rate appears to be high, this birth rate seems to be more than ample for replacement.

The sex ratio, the number of males per hundred women, shows the normal excess of males in the younger age groups, with the customary reversal in the older groups.

[1] Pearl, Raymond, The Aging of Populations (*Journal, American Statistical Association*, Vol. 35, Part 2, 277–297, 1940).

[2] *Op. cit.*

I give below the ratios calculated from the accessible data. Although the trends indicated are reliable, the individual ratios show the effects of the small numbers involved and cannot be taken as definitive.

	Children	Adolescents	Adults
Beaglehole's[1]	126	164	95
Census—1935	—	—	98

[1] Adolescents include those from fifteen years to marrying age which is probably younger for girls than boys, thus accounting for the unexpectedly high sex ratio.

THE PRESENT SAMPLE

The sample of Pukapukans secured for this study numbered 232 adults and near adults, representing about 58 per cent of the adult population. Of the original series twenty-eight were discarded because they were senile, immature, or mixed in origin. The last category embraced twelve European mixtures, eight hybrids with other Polynesian groups, and four descendants of crosses between Gilbert Islanders and Pukapukans. The remaining two hundred and four were classified as pure-blooded natives of Pukapuka and were evenly divided between the sexes.

With regard to the purity of origin of the final working series, I quote the following comments from a personal communication from Doctor Beaglehole describing the basis of his classification.

> Regarding the purity of race in Pukapuka: our judgments on this matter were as rigorous as we could well make them. We did the work in our fourth month on the island when we were familiar with the people and their history and the amount of white blood in the island. The people we examined were carefully checked by our own knowledge, our own cautions to the people, and the impartial opinions of a group of old men who constituted themselves into a reference committee for our need, and who were never backward in giving opinions and advice throughout our measurements. It is extremely unlikely that anything was kept back from us, as everyone was aware of the importance we attached to measuring Pukapukans of pure blood only, and since there was no stigma attached to being of mixed parentage, there was little desire on the part of anyone to keep back information from us. There is, of course, white blood on the island, though I think the amount is hardly considerable.

In another letter, Doctor Beaglehole mentions the admixture of two Manihiki women about ten generations ago. Their descendants cannot now be segregated, nor is it likely that this degree of miscegenation would have any appreciable effect.

The distribution of the series by age, in many cases recorded roughly by lustrum or decade, is shown in the following table:—

Age	No.	Males	No.	Females
18–19	2	2.00	5	5.05
20–29	34	34.00	35	35.35
30–39	27	27.00	25	25.25
40–49	22	22.00	10	10.10
50–59	11	11.00	21	21.21
60–65	4	4.00	3	3.03
Not given	2		3	

TECHNIQUE

A paragraph on technique may be pertinent at this point, although a chapter would not be too much in which to expatiate on the significance of this sadly neglected variable. Shortly before departing for Pukapuka Doctor and Mrs. Beaglehole received anthropometric instruction from me. Their technique was stabilized as far as possible within the limited time available. Consultation with Doctor Beaglehole subsequent to his field experience did not reveal any noticeable departure from the established practices. Since my own methods are based on Martin's, these records by Beaglehole follow the same standards.

The following comprise the schedule of measurements systematically taken on the entire series:—

Stature
Sitting height
Maximum head length, from glabella to the occiput in the sagittal plane
Maximum head width
Minimum frontal diameter
Bizygomatic diameter
Bigonial diameter
Face height, from nasion to gnathion
Nose height
Nose width

From these dimensions it was possible to calculate the indices given below:—

Cephalic
Cephalo-Parietal
Zygo-Frontal
Zygo-Gonial
Total Facial
Nasal
Relative Sitting Height

In addition to these measurements, a limited number of qualitative observations were added to the schedule:—

Skin color: exposed and unexposed, von Luschan scale
Hair: form, texture, color, baldness
Facial hair: quantity
Body hair: quantity
Eye: color, folds
Eyebrows: thickness
Nose: height of bridge, shape of profile
Forehead: slope, height
Lips: thickness
Chin: prominence

It may be well to point out here that in general the qualitative observations are far less susceptible of standardization than are the direct measurements and that consequently the comparison of various groups studied by independent workers is far less trustworthy than in the case of the quantitative measures and their indices.

PUKAPUKA TABULATIONS

More for convenience of reference than for purposes of discussion I insert at this point the tables giving the statistical summaries of the physical characteristics of the total Pukapukan series. Tables 1 and 2 list the various measurements, their means, standard deviations, and coefficients of variation for males and females, respectively. Table 3 contains the qualitative observations for both sexes.

TABLE 1

SUMMARY OF ANTHROPOMETRIC CHARACTERS—MALES

	MEASUREMENTS	σ	V
Stature	165.87 ± .36 cm.	5.43 ± .26 cm.	3.27 ± .16
Sitting Height	86.03 ± .20 cm.	2.97 ± .14 cm.	3.45 ± .16
Head Length	188.90 ± .51 mm.	7.61 ± .36 mm.	4.03 ± .19
Head Width	155.40 ± .32 mm.	4.81 ± .23 mm.	3.10 ± .15
Minimum Frontal Diameter	104.69 ± .33 mm.	4.93 ± .24 mm.	4.71 ± .22
Face Width	148.85 ± .32 mm.	4.74 ± .22 mm.	3.18 ± .15
Bigonial Diameter	107.65 ± .40 mm.	6.04 ± .29 mm.	5.61 ± .27
Face Height	125.20 ± .41 mm.	6.15 ± .29 mm.	4.91 ± .23
Nose Height	54.18 ± .25 mm.	3.73 ± .18 mm.	6.88 ± .33
Nose Width	42.11 ± .20 mm.	3.03 ± .14 mm.	7.20 ± .34
	INDICES		
Cephalic	82.42 ± .27	3.93 ± .19	4.77 ± .23
Cephalo-Facial	95.78 ± .23	3.37 ± .16	3.52 ± .17
Fronto-Parietal	67.44 ± .20	2.93 ± .14	4.34 ± .21
Zygo-Frontal	70.42 ± .23	3.35 ± .16	4.76 ± .23
Zygo-Gonial	72.34 ± .25	3.76 ± .18	5.20 ± .25
Total Facial	84.19 ± .27	4.03 ± .19	4.79 ± .23
Nasal	77.97 ± .44	6.54 ± .31	8.39 ± .40
Relative Sitting Height	51.88 ± .07	1.11 ± .05	2.14 ± .10

TABLE 2

SUMMARY OF ANTHROPOMETRIC CHARACTERS—FEMALES

	MEASUREMENTS	σ	V
Stature	155.88 ± .34 cm.	5.05 ± .24 cm.	3.24 ± .15
Sitting Height	80.73 ± .19 cm.	2.89 ± .14 cm.	3.58 ± .17
Head Length	178.55 ± .42 mm.	6.33 ± .30 mm.	3.54 ± .17
Head Width	149.46 ± .32 mm.	4.83 ± .23 mm.	3.23 ± .15
Minimum Frontal Diameter	99.72 ± .28 mm.	4.24 ± .20 mm.	4.25 ± .20
Face Width	138.22 ± .30 mm.	4.47 ± .21 mm.	3.23 ± .15
Bigonial Diameter	100.65 ± .36 mm.	5.42 ± .26 mm.	5.38 ± .26
Face Height	112.35 ± .39 mm.	5.83 ± .28 mm.	5.19 ± .25
Nose Height	48.42 ± .24 mm.	3.63 ± .17 mm.	7.50 ± .36
Nose Width	39.35 ± .17 mm.	2.49 ± .12 mm.	6.33 ± .30
	INDICES		
Cephalic	84.04 ± .26	3.89 ± .18	4.63 ± .22
Cephalo-Facial	92.54 ± .17	2.59 ± .12	2.80 ± .13
Fronto-Parietal	66.73 ± .17	2.54 ± .12	3.81 ± .18
Zygo-Frontal	72.25 ± .19	2.77 ± .13	3.83 ± .18
Zygo-Gonial	72.84 ± .21	3.15 ± .15	4.32 ± .21
Total Facial	81.37 ± .25	3.69 ± .18	4.53 ± .22
Nasal	81.81 ± .57	8.54 ± .41	10.44 ± .50
Relative Sitting Height	51.77 ± .08	1.24 ± .06	2.40 ± .11

TABLE 3

OBSERVATIONS ON PUKAPUKANS

Trait	Male		Female	
	No.	%	No.	%
Skin Color: unexposed				
Von Luschan Scale				
14	3	3.49	23	23.71
15	4	4.65	28	28.86
16	2	2.33	5	5.15
17	23	26.74	38	39.18
18	11	12.79		
22	19	22.09	2	2.06
23	14	16.28	1	1.03
24	5	5.81		
25	4	4.65		
26	1	1.16		
Skin Color: exposed				
14			2	1.98
15			1	.99
16			1	.99
17	2	1.98	46	45.54
18	11	10.89	17	16.83
21	1	.99		
22	44	43.56	32	31.68
23	29	28.71	2	1.98
24	5	4.95		
25	6	5.94		
26	3	2.97		
Hair				
Form				
Straight	20	19.80	16	15.84
Low waves	21	20.79	50	49.50
Deep waves	20	19.80	28	27.72
Curly	36	35.64	1	.99
Frizzly	4	3.96	6	5.94
Texture				
Coarse	46	51.11	28	28.00
Medium	43	47.78	68	68.00
Fine	1	1.11	4	4.00
Color				
Black	90	96.77	88	89.80
Dark brown	3	3.23	10	10.20
Gray	21	20.79	3	3.06
Baldness				
None	72	85.71	94	96.91
Slight	1	1.19	0	0
Medium	7	8.33	3	3.09
Marked	4	4.76	0	0
Beard				
Upper Cheek				
Slight	53	52.48		
Medium	48	47.52		
Heavy	0	0		
Lower Cheek				
Slight	54	53.47		
Medium	46	45.54		
Heavy	1	.99		
Chin				
Slight	28	27.72		
Medium	70	69.31		
Heavy	3	2.97		
Moustache				
Slight	23	25.56		
Medium	66	73.33		
Heavy	1	1.11		
Body Hair				
Chest				
Absent	3	2.97		
Slight	80	79.21		
Medium	18	17.82		
Heavy	0	0		
Forearm				
Absent	1	.99	0	0
Slight	73	72.28	55	96.49
Medium	26	25.74	2	3.51
Heavy	1	.99	0	0
Leg				
Absent	0	0	0	0
Slight	52	51.49	26	45.61
Medium	49	48.51	31	54.38
Heavy	0	0	0	0
Eye				
Color				
Black	1	1.02	7	7.00
Dark brown	75	76.53	80	80.00
Light brown	18	18.37	8	8.00
Blue-brown	1	1.02	4	4.00
Gray-brown	3	3.06	1	1.00
Epicanthic Fold				
Absent	93	93.00	88	88.00
Trace	7	7.00	10	10.00
Medium	0	0	2	2.00
Marked	0	0	0	0
Eyebrows				
Thin	27	30.00	69	70.41
Medium	63	70.00	29	29.59
Thick	0	0	0	0
Nose				
Height of Bridge				
Low	10	10.20	32	31.68
Medium	60	61.22	62	61.39
High	28	28.57	7	6.93
Profile				
Concave	5			
Concavo-convex	1			
Convex	0			
No observation	95			
Forehead				
Slope				
Marked	6	6.06	8	8.08
Medium	86	86.87	90	90.91
Straight	7	7.07	1	1.01
Height				
High	36	40.91	27	27.27
Medium	52	59.10	72	72.73
Low	0	0	0	0
Lips				
Thin	14	13.86	17	16.83
Medium	73	72.28	63	62.38
Thick	14	13.86	21	20.79
Chin				
Prominent	18	20.22	27	27.27
Medium	52	58.43	63	63.64
Receding	19	21.34	9	9.09

RELATIONSHIP OF PUKAPUKA TO POLYNESIA

Because their geographical position is marginal to an area distinctive in race and culture, one of the first questions about the Pukapukans that comes to mind hinges on their physical relationship to the great body of Polynesians dispersed throughout the islands of the eastern Pacific. Are the Pukapukans typically Polynesian, or do they reflect kinship with the peoples further west in Melanesia and Micronesia? If they are unquestionably Polynesian, to what local group do they show the closest affinity?

As a first step in estimating the anthropometric kinship of Pukapuka with Polynesia in general, I have compared the respective means in Table 4. The table reveals that the Pukapukan averages fall within the extreme means of the available Polynesian data, except in three particulars. The average stature of Pukapukan males is 3.63 cms. less than that of any other group, which is a considerable deviation from the uniformly high Polynesian standards. The face width exceeds the nearest average by .45 mm., thus placing the Pukapukans just beyond the previous range, but not by a statistically significant margin. As a result of this excessive face width the cephalo-facial index of the Pukapukans is also correspondingly high and tops by .48 index units its closest mean. With these exceptions, the individual Pukapukan means are not exceptional for a Polynesian group.

The deficient stature of our series is the only serious departure, therefore, from the Polynesian ranges. It is statistically significant in magnitude and demands an explanation. Taken at its face value and without reference to other considerations, such a radical departure from the range typical of Polynesia might indicate the existence among the Pukapukans of a short, non-Polynesian strain. But before such a conclusion be drawn, however, certain other possibilities require examination.

Of these the personal equation is a persistent and vexatious alternative that all too frequently is omitted from consideration in comparative anthropometrics. Although in the present instance I have no direct measure of the personal equation involved, I am convinced that the deviation of the stature of the Pukapukans transcends any variation arising from technical sources. In the first place, stature is relatively more reliable as to technique than most other anthropometric traits. In corroboration of this the following evidence from Polynesian anthropometry is pertinent. Among the various island populations which have been measured three are represented by two samplings each and a fourth by three samplings.[1] Altogether these make six pairs of comparisons in each of which the population is the same, but the observer is different. The differences between each pair of series represent the combined effect of personal equation and of sampling process. I give below the ranges and averages of the differences for nine traits:—

	Range	Average
Stature	0.14–2.20 cms.	1.02 cms.
Head Length	0–2.34 mms.	1.06 mms.
Head Width	0.10–2.65 mms.	1.22 mms.
Minimum Frontal	0.07–3.10 mms.	1.41 mms.
Face Width	0.30–3.20 mms.	1.50 mms.
Bigonial	0.60–2.20 mms.	1.48 mms.
Face Height	1.08–7.40 mms.	4.00 mms.
Nose Height	1.79–6.20 mms.	3.54 mms.
Nose Width	0–1.70 mms.	0.74 mm.

From this crude comparison it is apparent, even without allowance for magnitude of dimension and variability of trait, that the technical reliability of these various measurements has a considerable range. It would, of course, be unfeasible, without statistical analysis, to attempt any rating from these inadequate figures, but it does strongly suggest that stature is among the more reliable measurements, especially since the various paired differences for stature nowhere reach statistical significance.

Turning now to the stature deviations between any two different Polynesian groups we obtain a range from 0 to 4.90 cms. Pukapuka, on the other hand, com-

[1] See Table 34 in The Physical Characters of the Cook Islanders by H. L. Shapiro and Peter H. Buck (Te Rangi Hiroa) (*Memoirs, Bernice P. Bishop Museum*, Vol. 12, No. 1, Honolulu, 1936).

TABLE 4

COMPARISON OF PUKAPUKA MALES WITH OTHER POLYNESIAN SERIES

	MEASUREMENTS									
	Stature, cms.	Sitting Height cms.	Head Length mms.	Head Width mms.	Minimum Frontal mms.	Face Width mms.	Bigonial mms.	Face Height mms.	Nose Height mms.	Nose Width mms.
Pukapuka	165.87±.36	86.03±.20	188.90±.51	155.40±.32	104.69±.33	148.85±.32	107.65±.40	125.20±.41	54.18±.25	42.11±.20
Maori	170.60		196.50	152.80		145.70		124.00	52.80	40.10
Mangaia	169.50±.24		194.10±.29	156.50±.25	103.30±.19	146.70±.23	114.60±.24	122.70±.29	54.90±.16	42.20±.12
Manihiki-Rakahanga	170.20±.64		195.20±.52	155.90±.50	104.60±.49	147.00±.56	118.30±.66	129.80±.60	58.90±.37	41.80±.22
Marquesas I	170.30±.58	87.40±.51	193.20±.76	153.20±.53	103.20±.57	143.20±.53	109.50±.59	124.10±.80	53.10±.43	43.20±.30
Marquesas II	170.44±.43	90.43±.20	193.20±.44	154.30±.37	102.70±.30	142.90±.38	108.10±.38	121.90±.46	55.60±.26	43.20±.19
Society I	171.35±.43	89.40±.25	188.01±.48	159.58±.36	102.93±.37	145.72±.38	107.76±.45	124.78±.46	54.21±.26	43.40±.20
Society II	171.02±.39	89.69±.19	190.35±.47	159.10±.38	103.00±.36	145.10±.36	109.60±.45	123.70±.57	56.00±.34	43.20±.25
Hawaii	169.51±.42		187.85±.47	157.67±.38	107.85±.35	144.50±.42	111.18±.41	125.43±.47	55.60±.27	43.53±.21
Rarotonga	174.40±.61		190.20±.49	158.90±.45	103.20±.40	147.20±.47	116.40±.51	129.00±.58	57.40±.31	42.60±.26
Mauke	170.00±.59		186.40±.57	160.90±.52	103.40±.42	147.80±.44	115.10±.53	125.50±.50	56.80±.30	40.80±.26
Atiu	170.90±.71		190.10±1.00	160.40±.71	104.70±.62	147.70±.79	116.90±.74	121.90±.75	54.10±.49	41.80±.35
Aitutaki	172.20±.40		187.80±.46	159.40±.36	105.60±.41	148.40±.36	114.50±.44	129.70±.50	58.40±.23	42.70±.19
Tongareva	170.00±.73		190.40±.99	157.70±.99	103.80±.92	148.40±.84	116.80±.86	130.40±1.03	61.60±.41	43.20±.37
Samoa I	171.70±.63		190.60±.69	154.80±.54	103.40±.72	145.90±.63	104.60±.62	131.10±.79	59.80±.43	43.80±.31
Samoa II	169.50±.44		190.20±.50	152.15±.30	104.70±.28	142.70±.38	105.20±.39	124.95±.53	56.60±.28	42.10±.18
Samoa III	170.60±.18		191.80±.23	154.70±.19	105.80±.15	145.40±.18	106.80±.19	123.70±.23	53.60±.14	42.80±.10
Tonga I	173.00±.54		191.00±.63	154.80±.39	104.80±.45	143.50±.55	104.80±.54	128.20±.63	57.50±.36	44.40±.27
Tonga II	171.70±.19		191.80±.23	155.20±.17	107.90±.14	145.20±.18	106.00±.19	122.30±.21	52.90±.13	43.60±.10
Easter	173.32±.70	93.05±.41	199.09±.72	148.45±.52	101.50±.46	141.32±.58	107.41±.56	122.00±.73	57.27±.39	43.00±.34

TABLE 4 (*Continued*)

COMPARISON OF PUKAPUKA MALES WITH OTHER POLYNESIAN SERIES

	INDICES							
	Cephalic	Cephalo-Facial	Fronto-Parietal	Zygo-Frontal	Zygo-Gonial	Total Facial	Nasal	Relative Sitting Height
Pukapuka	82.42	95.78	67.44	70.42	72.34	84.19	77.97	51.88 ± .07
Maori	77.70	95.30				85.10	75.90	
Mangaia	80.63 ± .17	93.87 ± .15	66.14 ± .13	70.99 ± .12	78.15 ± .15	83.64 ± .20	77.20 ± .31	
Manihiki-Rakahanga	79.89 ± .29	94.34 ± .33	67.14 ± .29	71.22 ± .27	80.51 ± .36	88.34 ± .37	71.19 ± .52	
Marquesas I	79.40 ± .38	93.50 ± .34	67.40 ± .41	72.00 ± .48	76.80 ± .44	87.00 ± .70	81.90 ± .85	51.20 ± .26
Marquesas II	79.89 ± .20	92.64 ± .20	66.66 ± .17	71.92 ± .19	75.68 ± .19	85.57 ± .39	77.84 ± .48	53.09 ± .07
Society I	84.96 ± .28	91.36 ± .19	64.56 ± .22	70.66 ± .24	74.01 ± .31	85.73 ± .33	80.32 ± .53	52.18 ± .12
Society II	83.61 ± .22	91.27 ± .20	64.98 ± .23	71.03 ± .25	75.52 ± .28	85.37 ± .38	77.35 ± .56	52.47 ± .08
Hawaii	84.01 ± .26	91.68 ± .21	68.44 ± .21	74.73 ± .23	77.06 ± .26	86.74 ± .35	78.41 ± .55	
Rarotonga	83.61 ± .32	92.66 ± .25	65.08 ± .19	70.13 ± .20	79.11 ± .31	87.66 ± .45	74.29 ± .46	
Mauke	86.48 ± .36	91.86 ± .33	64.25 ± .26	69.97 ± .21	77.87 ± .31	84.86 ± .35	72.04 ± .64	
Atiu	84.41 ± .41	92.15 ± .41	65.26 ± .32	70.91 ± .43	79.18 ± .41	82.64 ± .68	77.59 ± 1.10	
Aitutaki	85.04 ± .24	93.12 ± .20	66.62 ± .22	71.53 ± .21	77.05 ± .62	87.48 ± .34	73.47 ± .45	
Tongareva	82.87 ± .38	94.17 ± .38	65.79 ± .46	69.89 ± .41	78.70 ± .46	88.07 ± .83	69.86 ± .70	
Samoa I	81.30 ± .42	94.20 ± .34	66.80 ± .40	70.90 ± .43	71.70 ± .46	89.90 ± .59	73.60 ± .70	
Samoa II	80.17 ± .25	93.77 ± .23	68.84 ± .21	73.60 ± .21	73.77 ± .29	87.66 ± .36	74.78 ± .49	
Samoa III	80.74 ± .13	93.96 ± .11	68.43 ± .10	72.75 ± .11	73.36 ± .14	85.09 ± .16	80.07 ± .27	52.54 ± .04
Tonga I	81.10 ± .29	92.80 ± .43	67.60 ± .32	73.10 ± .39	73.20 ± .42	89.20 ± .41	77.60 ± .70	
Tonga II	80.98 ± .11	93.54 ± .10	69.52 ± .09	74.37 ± .10	73.08 ± .12	84.30 ± .15	82.72 ± .26	
Easter	74.61 ± .33	95.20 ± .44	68.39 ± .33	71.84 ± .39	76.00 ± .41	86.41 ± .51	75.36 ± .61	53.73 ± .16

pared with the various Polynesian series yields a range of differences from 3.63 to 8.53 cms. Thus even allowing for a technical bias of the order suggested above the Pukapuka average exceeds the probable limits of the personal equation.

We can examine the Pukapukan stature in relation to the Polynesian means in still another way. If the various averages are rounded off to half a centimeter and seriated, we obtain the following distribution:—

Cms.	
166.0	1
166.5	–
167.0	–
167.5	–
168.0	–
168.5	–
169.0	–
169.5	3
170.0	3
170.5	4
171.0	2
171.5	3
172.0	1
172.5	–
173.0	1
173.5	–
174.0	–
174.5	1

The distribution of means is closely centered around 170.5 cms. with fifteen out of nineteen means falling between 169.5 and 171.5 cms. The tallest group falls at 174.5 cms. which is 1.5 cms. from its nearest average. At the other end of the range are the Pukapukans, separated from the next mean by roughly 3.5 cms. This distribution, therefore, composed of a variety of means obtained by a number of workers, shows a sharp break between Pukapuka and the remainder of Polynesia, but fails to reveal any similar discontinuity at the other extreme of the range. Finally, my own observation of Beaglehole's technique leads me to abandon the notion that a personal equation is responsible for the greater part of the observed difference.

Aside from the possibility of personal bias, there remains, however, the consideration of a possible environmental factor peculiar to Pukapuka and acting to depress the stature of the Pukapukans. But this would be an assumption requiring stringent evidence. Actually, however, Pukapuka appears to be no poorer in natural resources and no more climatically differentiated than a number of islands included in our comparative series. It can, however, only be stated as unlikely that an environmental factor is the basic differential.

The only other tentative explanations I can adduce for the Pukapukan abnormality in stature are selection, genetic mutation, or admixture with a stock bearing non-Polynesian elements. The first two hypotheses are possible but difficult to demonstrate with the available data. The last may be examined more closely by comparing the Pukapukans with their nearest non-Polynesian neighbors.

Leaving in abeyance the problem of accounting for the atypical stature of the Pukapukans, let us continue to examine the manner in which their remaining traits fit into the pattern of Polynesian variation. Of all the trait complexes available for Polynesians, the variations of the cephalic dimensions and their resulting index reveal the nicest geographic pattern.[1] The means supporting this generalization are given in Table 5. Taking the Society and the adjacent islands of the Austral and Tuamotuan groups as a central point, we find concentrated here an area of extreme brachycephaly. The head lengths tend to fall between 187 and 190 mms. and the head widths between 158 and 160 mms. Such dimensions combine to yield cephalic indices grouped around 84–86. With the exception of Hawaii, which in these head dimensions conforms with central Polynesia, the tendency for head length to increase, for head width to decrease, and for cephalic index to fall is plainly associated with mounting distance from this focal area. As a result, the marginal islands, such as the Marquesas, the southeastern Tuamotus, Mangareva,[2] and New Zealand are characterized by the opposite extremes

[1] Shapiro and Buck, The Physical Characters of the Cook Islanders, *ibid.*; Shapiro, H. L., *The Physical Relationships of the Easter Islanders* in Métraux, Alfred, Ethnology of Easter Island (*Bulletin 160, Bernice P. Bishop Museum*, pp. 24–60, Honolulu, 1940).

[2] See Shapiro, *The Physical Characters of the Easter Islanders, op. cit.*

TABLE 5

DISTRIBUTION OF CEPHALIC DIMENSIONS AND INDEX

Group	Head Width mms.	Head Length mms.	Cephalic Index mms.
Mauke	160.90	186.40	86.48
Atiu	160.40	190.10	84.41
Society I	159.58	188.01	84.96
Aitutaki	159.40	187.80	85.04
Society II	159.10	190.35	83.61
Rarotonga	158.90	190.20	83.61
Tongareva	157.70	190.40	82.87
Hawaii	157.67	187.85	84.01
Mangaia	156.50	194.10	80.63
Manihiki-Rakahanga	155.90	195.20	79.89
Tonga II	155.20	191.80	80.98
Tonga I	154.80	191.00	81.10
Samoa I	154.80	190.60	81.30
Samoa III	154.70	191.80	80.74
Marquesas II	154.30	193.20	79.89
Marquesas I	153.20	193.20	79.40
Maori	152.80	196.50	77.70
Mangareva	152.67	195.95	77.90
Easter	148.45	199.09	74.61

from those of the central area. Here the head length has increased by 6 mms., the width diminished by about the same amount, and the cephalic index dropped from 84–86 to 78–80. Completely in keeping with this ripple-like pattern spreading south, southeast, and eastward from the Society Islands centrum are the recent data from Easter Island.[1] Indeed, this most marginal of all Polynesian islands presents the most extreme form of dolichocephaly encountered in Polynesia. With a head length of 199.09 mms., a head width of 148.45 mms., and a cephalic index of 74.61, the Easter Islanders present to the natives of the central islands the greatest contrast to be found in the entire Polynesian area.

This distribution lends itself to several explanations. It might be supposed that a strongly brachycephalic group invaded central Polynesia and forced out the earlier dolichocephalic group, the most marginal representing the earliest to be dispossessed and the least affected by the invaders. According to this interpretation the effect of miscegenation with the brachycephalic invaders would be strongest in the islands adjacent to the central area, becoming more and more attenuated with increasing distance and inaccessibility.

[1] *Op. cit.*

Another hypothesis which could equally well explain this pattern of distribution envisages not a single invasion of a strongly brachycephalic group, displacing the earlier, more dolichocephalic inhabitants of the central region and emanating biological influence into the surrounding groups, but rather a series of invasions, each successive one more brachycephalic than its predecessor and each pushing ahead the earlier people, producing a shingled overlapping of progressively intenser brachycephaly. Or, by a slight shift in emphasis, we might conceive of this movement rather as a more or less continuous streaming of population, a movement covering a relatively long period of time, perhaps centuries. In the course of this span sufficient time would elapse to permit the operation of a number of modifying factors upon the later comers.

Either of these hypotheses is acceptable in the light of the available evidence on the living. The geographic correlation of the cephalic index might arise either from a slow infiltration of population from the west combined with an equally gradual movement toward the periphery of the area by the older elements. Or a period of contact and assimilation by contiguous groups might also bring about a similar distribution after a relatively rapid and convulsive population replacement. The significant point, I believe, is the probability that Polynesia has been subjected to more than one settlement.

The certainty that some such phenomenon of continuous or discontinuous displacement as I have suggested did actually occur is materially strengthened by the consideration of the existing cranial data. When I first became interested in the Polynesian problem I was particularly struck by the discrepancies reported in the older literature[2] between cranial and living data for the same islands. The differences in the length-breadth proportions of the head were often considerable and far too great to be explained as the normal discrepancy arising from the presence of soft

[2] See Deniker, J., *The Races of Man: An Outline of Anthropology and Ethnography.* London, 1900 (p. 591).

parts on the living head. Moreover, these discrepancies between the two categories of material were confirmed by my own studies on various living populations when compared with observations made on crania. Since these comparisons were based upon cranial and living series derived from the same islands, the only obvious difference between them was a chronological one. Although it is obvious that the crania represent an earlier population than the living, the exact time differential is uncertain. The crania stored in various museums which have served as material for the craniological studies that have thus far appeared are generally without precise information as to date of origin, aside from the date of their collection. Generally, the coming of Europeans. For these reasons it is instructive to compare in Table 6 the cranial and cephalic indices of the same island groups.

The crania reveal at once a greater homogeneity than the present living population, especially if the extreme Easter Islanders are excluded. Furthermore the similarity between such marginal groups as the Maori and the Marquesas and the central archipelagoes represented by the Society and Cook Islands is distinctly evident. This suggests, although in the absence of exact chronology it does not prove, that formerly a population of similar length-breadth proportions was widespread in Polynesia, extending from the Societies to New Zealand. In passing, it is

TABLE 6

COMPARISON OF CRANIAL AND CEPHALIC INDICES

		Cranial Index[1]		Cephalic Index	
		Mean	No.	Mean	No.
Maori	M	74.5	125	77.7	421
Marquesas	M	75.9	38	79.4–79.9	167
	F	79.2	18	82.0	74
Hawaii	M	78.5	79	84.0	206
	F	79.5	60	84.69	175
Society Islands	M	75.0	35	83.6–85.0	150
	F	78.1	16	86.21–84.6	78
Cook Islands[2] (Mangaia)	M	73.3	12	80.6	204
	F	78.7	5	82.4	100
Tonga-Samoa	M	79.1	18	80.2–81.3	1069
	F	79.9	8	80.2–83.4	250
Easter	M	70.1	60	74.6	22
	F	72.3	37		

however, such specimens have been gathered from burial caves or other repositories for the dead and are most likely to represent a prehistoric epoch, since the post-European dead are interred in Christian cemeteries which are consecrated and inviolable ground in Polynesian communities. Beyond this probability, however, the exact dating of these crania is unknown. They may represent any period from the earliest settlement to the time of worth mentioning that the traditional origin of the Maori from central Polynesia nicely conforms with this picture.

When we turn to the living and consequently to a more recent population we find in the peripheral groups remarkably little difference between the cranial and cephalic index, after due allowance is made for the effect of soft parts. Among the central people, on the contrary, the change is remarkable. Here the index advances from a definite dolichocephaly to a pronounced brachycephaly increasing by as much as ten units. These data, then, indicate that at an earlier time a much greater homogeneity existed especially between

[1] Wagner, K., The Craniology of the Oceanic Races (*Skrifter utgitt av Det Norske Videnskaps-Akademi i Oslo. I. Mat.-Naturv. Klasse*, No. 2, Oslo, 1937).

[2] Wagner, from whom I borrow the cranial means, states that one skull in the series came from Rarotonga and all the others from Mangaia. I have, therefore, compared them with my means on the living Mangaians.

central and marginal Polynesia, which was later broken by the intrusion of a brachycephalic element into the central area. Since no known movements of people in historic times could have produced such a change, we are constrained to refer it to some relatively late prehistoric migration, perhaps the one traditionally responsible for the emigration of the ancestors of the Maori.

I have not considered the possibility that these modifications might have arisen from environmental factors because I know of no specific and local environmental alteration which could account for the change. Moreover such an assumption would not only beg the question, but it would also raise more incongruities than it would solve.

Nor can these alterations be explained, as some have attempted, by invoking the effect of admixture with Europeans. Such a solution demands an extremely improbable sequence of special circumstances. To bring about by miscegenation a brachycephalization to the degree now characteristic of central Polynesia would require the presence of a European stock or stocks genetically endowed with traits capable of this effect. Actually it is difficult to see how the English and Americans who account for most of the early admixture could have produced hybrids with cephalic dimensions and proportions that have so little genetically in common with their own. This, moreover, is not the only difficulty. We should also have to explain why the brachycephalization should have occurred only in central Polynesia when it is well known that contact with Europeans and Americans extended throughout Polynesia. Indeed, during the whaling period centers of contact existed even in remote areas no longer in free communication with Europeans or Americans. And finally it should be pointed out that all the subjects of these reports on the living were carefully selected as representing pure strains. It cannot, of course, be denied that now and then individuals of mixed origin have made their way into the series, but it is extremely probable that those few who did were of predominantly Polynesian appearance and represented highly attenuated mixtures. If this were not the case, evidence would certainly exist in a number of traits to indicate it.

Turning now to the western periphery of Polynesia, one cannot fit the Samoans and Tongans into this scheme without some qualification. Although marginal to central Polynesia, this region is not peripheral in the same sense as are the Marquesas, Mangareva, Easter Island, and New Zealand. It is contiguous to another (well-populated) ethnic area to which it is geographically closer than the central area of Polynesia. It is also the very portal to the Polynesian cul-de-sac rather than its terminus. Although, one might anticipate that the central brachycephaly with its reduced sagittal and expanded lateral dimensions would extend westward, marking the path of the invaders from their original settlement, actually the situation is not as simple as this. The cephalic index of the Samoans and Tongans stands in an intermediate position between the dolichocephaly characteristic of the peripheral islands and the pronounced brachycephaly of the recent central Polynesians. This relationship of the living populations alone might be taken to recommend either of the tentative hypotheses outlined above: the result of contact between the aboriginal dolichocephalic and invading brachycephalic types or the remnant of one of the intervening waves of intermediate cephalic make-up. But when the crania of western Polynesia also are considered it is apparent that they have the same length-breadth proportions as the living head. In other words, no change is evident here. Whether this means that when central and peripheral Polynesia were uniformly dolichocephalic western Polynesia had already been affected by brachycephalic elements, and that subsequent changes which profoundly affected the Societies and adjacent islands passed lightly, if at all, over Samoa and Tonga, is difficult to determine in the absence of adequate chronological evidence. It would be hazardous at this stage to be dogmatic on these aspects of the population history of Polynesia. With regard to western Polynesia all we can ascertain with respect to the present discussion is that the

overwhelming brachycephalic elements failed to affect Samoa and Tonga to the same degree as they did the central islands.

The question of where the Pukapukans fit into this geographic pattern now arises. From a scrutiny of Table 4 the cephalic diameters of this group are seen to fall fairly closely to the means of Samoans and Tongans, but with a slightly inexact fit suggestive of other influences. In head length the Pukapukans average 188.90 mms., with differences from the Samoans and Tongans that range from −1.30 mms. to −2.90 mms. These are of a magnitude that approaches significance. On the other hand, the Pukapukan mean could very well fit into the range of head lengths characteristic of the Society and its contiguous islands. The head width of the Pukapukans is slightly greater than that of Samoans and Tongans, ranging from +.20 mm. to +3.25 mms., although the latter figure based on Mrs. Keyes' Samoan data appears to be too high. Omitting the dubious average on which it is based, the range then becomes +.20 mm. to +.70 mm. These are statistically insignificant, but are opposite to those for head length. Thus the cephalic index is higher than those for Samoa and Tonga and occupies a position intermediate between them and the averages characteristic of central Polynesia. From these comparisons alone one might conclude that the Pukapukans have in some manner been influenced by the strongly brachycephalic stream of central Polynesia while retaining evidence of a close relationship with the western Polynesians of Samoa and Tonga. It should, however, be emphasized that this deviation in cephalic proportions from western Polynesian means may represent a local and specialized variation from a fundamentally western type. Such a relatively slight divergence might arise from the dominance of a family line in an isolated community.

Comparing the Pukapukans with the tiny, isolated outliers of Tongareva, Manihiki, and Rakahanga which lie just to the east of them, we find that Tongareva, the nearest of the three, shares with Pukapuka definite similarities in cephalic diameters, when statistical allowances are made for the inadequate size of the sample.

Unfortunately the remaining dimensions of the head and face do not readily lend themselves to this form of broad geographic analysis, either because the range of variation is too slight to offer a fruitful heterogeneity or because the effects of sampling and of personal equations interfere with interpretation. This latter difficulty is illustrated in the face width, the bigonial diameter, the face height and nose height. I have listed in Table 7 the actual differences between the means of pairs of independent samples drawn from the same populations and measured by different observers. It is at once apparent that some of these differences attain very considerable magnitudes and judged by their probable errors reach statistical significance. How much of these values may be assigned to the accidents of sampling and how much to the operation of a personal equation cannot, unfortunately, be determined in these instances since the samples compared are not identical. Nevertheless in the face of such deviations between samples of the same population the conclusion is inevitable that the means of series from different populations must to a greater or lesser degree be affected by the same variables inherent in the sampling and measuring processes. The above figures demonstrate that these variables are not always negligible as has been suggested. Indeed, in the case of face height and nose height, where the dimension is limited by nasion, it is almost axiomatic that the difference between two samples will be large. In the absence of any geographic pattern of variation I would, therefore, hesitate to assign to the existing differences between various Polynesian groups in these particular measurements any great significance, at least until more adequate check data are available by which their validity might be assessed.

These reasons are also, it seems to me, cogent in appraising the marked divergences which the Cook Island material displays in comparison with the rest of Polynesia. In view of the demonstrably large deviations possible as a result of personal

TABLE 7

DIFFERENCES BETWEEN INDEPENDENT SAMPLES OF THE SAME POPULATION

Samples	Face Width mms.	Bigonial mms.	Face Height mms.	Nose Height mms.
Marquesas I and II	0.30	1.40	2.20	2.50
Society I and II	0.62	1.84	1.08	1.79
Samoa I and II	3.20	0.60	6.15	3.20
Samoa I and III	0.50	2.20	7.40	6.20
Samoa II and III	2.70	1.60	1.25	3.00
Tonga I and II	1.70	1.20	5.90	4.60

and sampling equations it would be hazardous and indeed confusing to accept as reliable the Cook Island means that exceed ranges found elsewhere in Polynesia. Especially is this applicable to the bigonial diameter which in the Cook data everywhere far exceeds the average values found in the rest of Polynesia.

We are left, therefore, for the present with only a single complex of characters—the cephalic dimensions—that appears to vary according to a geographic pattern. Within this frame the Pukapukans fall between the Society Islands and the western Polynesians.

We may, therefore, sum up the position of the Pukapukans with regard to Polynesia in general by concluding that, stature excepted, they conform to the Polynesian physical type and that within this general relationship they reveal evidence of an intermediate position between its central and western varieties.

Although there can be little doubt that the Pukapukans are essentially a Polynesian folk, their definite deviation in stature from the rest of Polynesia, suggests that some degree of admixture with a foreign population has in the past affected the group. The magnitude of this deviation and its uniqueness in Polynesia argue strongly against the probability that it is merely a local variant as was suggested, among other possibilities, for the slight divergencies of cephalic proportion. It is, of course, not necessary to conceive of this reduction in stature as originating from direct contact with an extra-Polynesian population, even though such miscegenation might have occurred. An indirect influence, coming second-hand, by contact and admixture with a transitional and marginal group might as readily explain the exceptional stature of the Pukapukans. This possibility has in fact much to recommend it.

In seeking to discover the origin of Pukapuka's divergence in stature we turn naturally to contiguous areas and neighboring islands as possible sources. In Melanesia and Micronesia we immediately enter into regions of short-statured populations. The data for these two areas that are available to me I have already tabulated in a previous study on the Ontong Javanese.[1] In Melanesia, group averages for stature among males range from 159 cms. to 171 cms., excluding New Guinea where statures are in some instances even lower. The maximum here is the average of 133 Fijian males and is well above those most commonly found. Similarly the Micronesian means embracing groups from the Marshall, Gilbert, Caroline, and other islands fall generally between 160 cms. and 165 cms. Populations with statures of this low order might by admixture easily reduce the much greater Polynesian average. But to reduce the problem to stature alone is genetically unrealistic. Admixture affects the total organism. Miscegenation between two groups differing not only in stature but in other respects as well will produce in the hybrid population modifications in all these characters. Consequently any group of Melanesians or Micronesians offered as a candidate for the role of modifiers of the Pukapukan stature must also be appraised for other deviations than stature. In other words, a hypothetical modifying group must stand in all its traits in such relationship to Polynesia as to make it genetically possible to derive the known means of the Pukapukans. For this reason the various island populations of Melanesia, although possessing short stature are otherwise unacceptable. For the most part, they have head widths which are extremely narrow, whereas the Pukapukans approach the upper limit of broad-headedness in Polynesia. Other groups of Melanesians must be similarly eliminated by virtue of their possession of relatively short faces, narrow faces, or short and broad noses. In these traits, too, the Pukapukans do not deviate in these directions from Polynesian standards as might be expected had admixture with such groups occurred. The Tanna group of the New Hebrides, generally considered to be influenced by Polynesia,[2] alone of the available series from Melanesia approximates to some extent the position required.

The Micronesian data are unfortunately even less extensive than those for Melanesia but here, too, none of the published groups can be regarded as possible sources of a direct modifying influence upon the Pukapukans.

It is worth while, at this juncture, to examine the traditions of the Pukapukans for any clews pointing toward specific groups with which contact is ascribed. Beaglehole[3] has gathered together the traditional history of Pukapuka and I have leaned heavily upon his researches. It is estimated from genealogical records that Pukapuka was founded 550 years ago, and

[1] Shapiro, H. L., The Physical Characteristics of the Ontong Javanese (*This Series*, Vol. 33, Part 3, 1933).

[2] See Humphreys, C. B., *The Southern New Hebrides, An Ethnological Record*, Cambridge, 1926, and Speiser, F., Anthropologische Messungen aus Esperitu Santo (Neue Hebriden) (*Verhandlungen der Naturforschenden Gesellschaft in Basel*, Band 39, pp. 79–106, 1927–1928, Basel, 1929).

[3] *Op. cit.*

according to native belief, the island itself emerged from the sea bearing its first inhabitant. Such islands as Tonga, Tongaleleva, and Tokelau are mentioned in connection with the traditional origins of Pukapuka. Later in the history of the island references occur to immigrants coming from the Tokelau Islands, Yayaki, Manihiki, and Tongaleleva. Shortly before European contact an account survives of a drift canoe from Manihiki. In addition to these islands whence came immigrants or more transitory visitors, the traditions also speak of voyages from Pukapuka to neighboring islands. Among these we find Witi (Fiji?) Tonga, Niue, Yamoa (Samoa?), Niutao, the Tokelau Islands, and a number of unidentified islands. Assuming that when the present name and the traditional name agree, we are dealing with the same island it would appear that Pukapuka was in actual contact with the populations of western Polynesia as well as with the Tokelau and possibly the Ellice Islanders.

According to one interpretation the mysterious Yayaki refers to Tahiti, but this is uncertain. The more easterly Tongareva and Manihiki seem unquestionably to have formerly been in close contact with Pukapuka.

The indications of cultural relationships with Samoa and Tonga agree with our findings of a physical affinity with these islands. Furthermore, if Yayaki proves to refer to Tahiti the concordance with the physical findings would be even more greatly enhanced, for the Pukapukans, as I have already suggested, give indication of relationships with both western and central Polynesia.

There still remains, however, the identification of the source of the reduced stature of the Pukapukans. It seems definitely improbable that such a modifying influence emanated from Samoa, Tonga, the Society Islands, or from Tongareva, Rakahanga, and Manihiki to the east. On the northwest, however, the Tokelau and Ellice groups with which Pukapuka was in contact form a bridge head with Micronesia, an area of low stature. To derive the low stature of the Pukapukans secondhand from Micronesia via the agency of transitional populations in the Tokelau and Ellice groups is speculatively logical. Much may be said for such a view since only a people approximating the existing Polynesian type, but of low stature, could have affected the Pukapukans in stature without equally marked changes in other features. Theoretically the whereabouts of the Tokelau and Ellice Islands, by virtue of this geographic position, might fit such requirements. Unfortunately for our purposes this line of speculation cannot be corroborated, since the necessary data on the physical characteristics of these people are not available.

SUMMARY

The anthropometric data on 204 natives of Pukapuka, evenly divided as to sex are herein presented. On the basis of a comparative study of the means, the Pukapukan population appears to be intimately related to the western Polynesians, particularly those of Samoa and Tonga. Two deviations among the Pukapukans from the standards of western Polynesia create, however, a blemish on the purity of this kinship. The Pukapukans have noticeably shorter and slightly wider heads than the Samoans and Tongans. Such a divergence is possible simply as a consequence of isolation and the dominance of family lines in a relatively small population. Another explanation takes into account possible influences from the strongly brachycephalic populations of central Polynesia focusing in the Society Islands. The other significant departure among the Pukapukans from Polynesian characteristics is their significantly reduced stature. In view of the contiguity of Pukapuka to Micronesia which is sharply distinguished from Polynesia by a general decrease in stature it is probable that influences emanating from this region are responsible for the decline in the stature of Pukapuka. A direct contact, however, is quite improbable on genetic grounds. It is therefore suggested, since the Tokelau and Ellice groups are geographically transitional to Micronesia that their natives, with whom the Pukapukans have traditionally been in contact, might have served to transmit this effect. This is offered only tentatively and cannot be demonstrated in the absence of specific data for these archipelagoes.