DECIDUOUS TOOTH CROWN MORPHOLOGY

DECIDUOUS TOOTH CROWN MORPHOLOGY IN A TRIBE OF AUSTRALIAN ABORIGINES

A study of twelve non-metric traits

by

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SUMMARY

Dental casts of the deciduous and mixed dentitions of 139 male and 103 female Australian Aborigines belonging to the Wailbri tribe were examined in a study of twelve non-metric traits of deciduous tooth crown morphology. The casts were viewed under an illuminated magnifier and the presence or absence of each trait was determined by comparison with reference standards. The entire series of observations was repeated to ascertain the level of agreement on double determinations for each trait. The data were analysed for right and left side variation and for sex differences. As there were no significant side or sex differences the right teeth were used in calculations of the trait frequencies. The frequency occurrence was reported for the following twelve traits: shovel shape, lingual tubercle, double tubercle, double fold, Carabelli's trait, occlusal groove pattern, protostylid, sixth accessory cusp, seventh accessory cusp, deflecting wrinkle, distal trigonid crest and for the metaconid ridge. The six most frequently occurring traits were selected in order to examine the combination and the number of traits in each subject. The mean number of traits per subject was 2.5 and 94 per cent of subjects had between one and four traits. The relationships between the eight most frequently occurring traits were assessed to determine the degree of association occurring between paired combinations. Of 28 correlation coefficients calculated four were found to differ significantly from zero.

Examination of the variable inter-race deciduous dental characters revealed that the Wailbri could be clearly distinguished from all other populations by the high frequency occurrence of the double tubercle and the sixth accessory cusp. It was proposed that these two traits form the basis of the Wailbri dental character complex which could also represent the Australoid dental character complex.

Inter-population differences were analysed using a multivariate biologic distance statistic. The data relating to eight deciduous dental traits which were the same for each population were used to study the total morphological pattern and to derive estimates of the biological distance between pairs of populations. The Wailbri were found to differ significantly from the Japanese, American-Negro and from the American-White populations. In general the dental characteristics of the Wailbri showed a greater affinity towards the Caucasoid than to the Mongoloid population. The greatest affinity of the Wailbri was towards the American-Negro.

A limited genetic analysis was carried out for the double tubercle, sixth accessory cusp, seventh accessory cusp, protostylid and for Carabelli's trait. Individually the presence of each of these five traits was shown to occur at random. However, as a group the conclusion was that perhaps not all of the five traits occur at random. Evidence was also presented that the presence of the double tubercle, sixth accessory cusp, protostylid and Carabelli's trait could be under the control of a single gene. The presence of the seventh accessory cusp was shown not to be under the control of a single gene.

DECLARATION

This thesis is submitted in fulfilment of the requirements for the degree of Master of Dental Surgery in the University of Adelaide under 7(a) of the Regulations in force until 16th December, 1971.

I certify that this thesis is entirely my own work except where due acknowledgment is made and that no part of this thesis has been previously submitted for a degree in this or any other University.

The results of the investigation were presented in part to the meeting of the Australian and New Zealand Association for the Advancement of Science held in Adelaide, August 18-22, 1969.

SVEN KUUSK

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CHAPTER 1

INTRODUCTION

The possibility of using features of the dentition as indicators of racial affinity has followed recognition of the fact that many of the variations in dental morphology are genetically determined. However, almost all the inherited dental characters are continuous variables and they are considered to be polygenic in origin. For these reasons dental traits are more difficult to study than discrete variables such as blood types where the processes of inheritance are precisely determinable. Nevertheless there are indications that the dentition will provide criteria useful in helping to solve problems in human evolution.

LASKER (1951) has pointed out the difficulty of determining what constitutes a dental trait and the difficulty of specifying those which are meaningful as inherited variables. He referred to the problem of devising a simple morphological classification and emphasized the need for systematic studies of the genetics of dental characters. DAHLBERG (1963) suggested that the variations and origins of dental morphological structures have sufficient order and differences in degree of expression and frequency occurrence to make them useful features in identifying geographical or racial affinity.

MOORREES (1962) has drawn attention to the fact that the contribution of dental morphology to racial taxonomy has not kept pace with the contribution of other inherited traits, such as the blood types for example. He considered that the lag in dental anthropology was due to the following: first, the small number of studies that have been carried out have not produced an adequate sampling of dentitions from different racial stocks; second, the lack of standardization in evaluating different expressions of dental characters has complicated comparative genetic studies; and third, the modes of inheritance of dental characters have not been adequately established.

Studies of the deciduous dentition have not contributed to dental anthropology to the same extent as those of the permanent dentition. This is because they have been few in number and few populations have been sampled. JORGENSEN (1956) investigated the possible racial and evolutionary significance of anatomical structures in the deciduous dentition of Danish children. He could not arrive at a general conclusion since his work was the first extensive odontological study of recent deciduous teeth and because sufficient fossil material was not available. Accordingly, his conclusions were confined to: first, a survey of the structural features of individual teeth; second, compilation of a list of the structural elements considered valuable as evolutionary or racial criteria; and third, a listing of information of interest in phylogenetic studies of the anatomy of deciduous teeth.

HANIHARA (1955, 1956, 1961, 1963, 1965, 1966a, 1966b, 1967, 1968) investigated morphological variations in the deciduous dentition of various ethnic groups. His studies were principally concerned with the dental anthropology of Japanese-American hybrids, children born of Japanese mothers and American-White or American-Negro fathers. Recognizing the need for a common reference standard for the deciduous dentition, HANIHARA (1961) produced a set of the crown characters of the human deciduous dentition. These were modelled on the plaques for the permanent dentition developed by DAHLBERG (1956). The defining of these standards has provided a common basis for comparative studies.

When discussing racial differences in dental traits HANIHARA (1965) suggested that crown characters could be divided into two types. Those of the first type - variable inter-race characters - are distinguished by relatively clear differences in frequency occurrence from race to race. The well developed shovel shape trait, for example, has a high frequency in Mongoloids compared with a low frequency in Caucasoids. Characters of the second type - invariable inter-race characters - show little or no difference in frequency occurrence between races. The double fold in the deciduous mandibular canine, for example, varies in frequency among the various racial or population groups only by about five per cent. The variable inter-race characters are important for comparative population studies because they can be combined on the basis of their frequency occurrence to form an assembly of characters and frequencies descriptive of the population.

It is only after a population has been adequately described that it can be compared with other populations. CLARK (1964) emphasized that comparisons of populations should be made not on single characters one by one but on the total morphological pattern which the traits present in combination. This approach was followed by HANIHARA (1966b) in a study of the crown characters of the deciduous teeth of several Mongoloid population groups. In recognition of the importance of considering the total morphological pattern, HANIHARA (1966b) proposed the term 'Mongoloid dental complex' for the set of crown characters which had a high frequency in the deciduous dentition of Mongoloid populations but not in other populations. Although the set of dental traits used for the Mongoloid dental complex was restricted to those with high frequencies, dental traits of low frequency would also help to characterize a population. The important feature is that the population can be distinguished by the morphological pattern which the set of traits present in combination. The dental character complex of the total morphological pattern constitutes a basis for comparison of dental morphology in different populations.

A number of morphological variations in the deciduous dentition of the Australian Aboriginal have been reported by CAMPBELL (1925). However, these traits were only superficially studied.

AIMS OF THE INVESTIGATION

The aims of the present investigation were:

(1) to determine the extent of dental morphological variation in a tribe of Australian Aborigines for the following traits - shovel

shape, lingual tubercle, double tubercle, double fold, Carabelli's trait, mandibular second molar occlusal groove pattern, protostylid, sixth accessory cusp, seventh accessory cusp, deflecting wrinkle, distal trigonid crest and the metaconid ridge;

(2) to select a set of dental characters descriptive of the population;

(3) to compare the results with other studies;

(4) to conduct a limited genetic analysis for selected traits.

CHAPTER 2

NOMENCLATURE

Investigations of dental morphological variations are of limited value if the findings cannot be related in comparison with findings of other studies. Therefore it is important that standard nomenclature is used, that each of the characters or traits investigated is described in detail and that the criteria of classification constituting reference standards are clearly defined.

The symbolic notation used in the present investigation to specify individual deciduous teeth is outlined below and the tooth crown surfaces are designated. In addition, each tooth crown character investigated is described in general terms and illustrated. Methods of classification and more complete details of the reference standards for the observations are presented in Section 4 where each character is again dealt with in turn.

TOOTH NOTATION

Figure 1 presents a diagram showing the deciduous dentition as viewed from the occlusal aspect. Following the Federation Dentaire Internationale (FDI) System (DRUM, 1970), two digits are used to designate individual deciduous teeth. The first digit represents the quadrant of the dental arch: in the deciduous dentition 5 = maxillary right quadrant; 6 = maxillary left quadrant; 7 = mandibular left

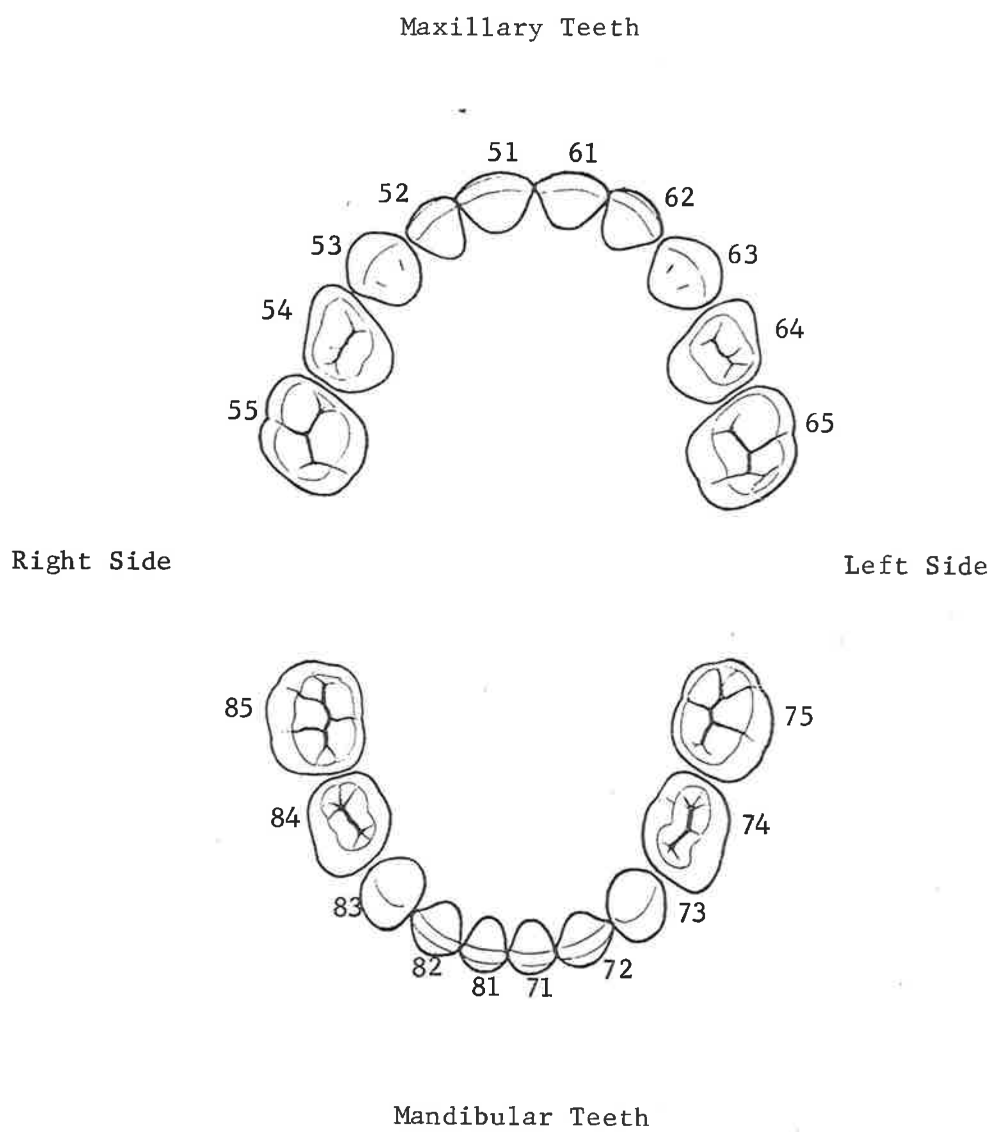


Figure 1. Deciduous tooth notation by the FDI system

quadrant; and 8 = mandibular right quadrant. The second digit signifies the position of the tooth in the dental arch quadrant: 1 = central incisor; 2 = lateral incisor; 3 = canine; 4 = first molar; and 5 = second molar. Thus, individual teeth may be simply denoted: for example, tooth 54 = right maxillary deciduous first molar; tooth 73 = left mandibular deciduous canine; and so on.

Where possible the illustrations of deciduous teeth or groups of teeth in this work are presented in the same orientation as Figure 1.

CROWN SURFACES

Following the method of BLACK (1902), tooth surfaces are named according to their relation to oral structures or to other teeth. Those of incisors and canines presenting towards the lips are termed labial surfaces; those of molars presenting towards the cheek, buccal surfaces; those presenting towards the tongue, lingual surfaces; those contacting opposing teeth when the mouth is closed, occlusal surfaces; and those presenting towards adjacent teeth, proximal surfaces. Proximal surfaces are more specifically defined either as mesial or distal surfaces, the former when they face towards and the latter when they face away from the median line, following the curve of the arch.

Figure 2 illustrates the nomenclature of the tooth crown surfaces of maxillary and mandibular deciduous molars.

Mesial Surface

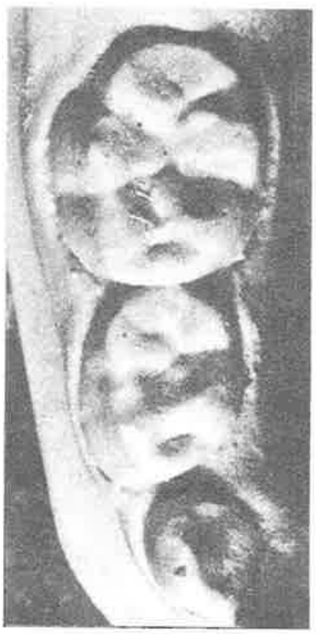
Buccal Surface

Lingual Surface

Maxillary Teeth

Distal Surface

Buccal Surface



Lingual Surface

Mandibular Teeth

Mesial Surface

Figure 2. Deciduous tooth crown surface nomenclature - teeth of the right side

CUSPS

Cusps of deciduous molar teeth are referred to by the nomenclature of OSBORN (1888) or by the numerical designation of GREGORY and HELLMAN (1926). The notation of BLACK (1902) is more widely used in clinical dentistry. Figure 3 collates and illustrates the three notations as applied to maxillary and mandibular deciduous second molars. Accessory or adventitious cusps on mandibular molars are designated by numbers: for example, the small cusps marked 6 and 7.

CROWN CHARACTERS

Shovel shape

The shovel shape trait occurs in incisors and canines. It is expressed as a prominence of the proximal marginal ridges in relation to the lingual fossa or concavity of the lingual surface between the marginal ridges and the linguo-gingival ridge or cingulum (see Figure 4).

Lingual tubercle and double tubercle

The lingual tubercle occurs in incisors and canines. It is expressed as a single, double or multiple protruberance arising from the cingulum (see Figure 5). The double tubercle most frequently occurs in maxillary canines.

Double fold

The double fold occurs in mandibular canines. It is formed by

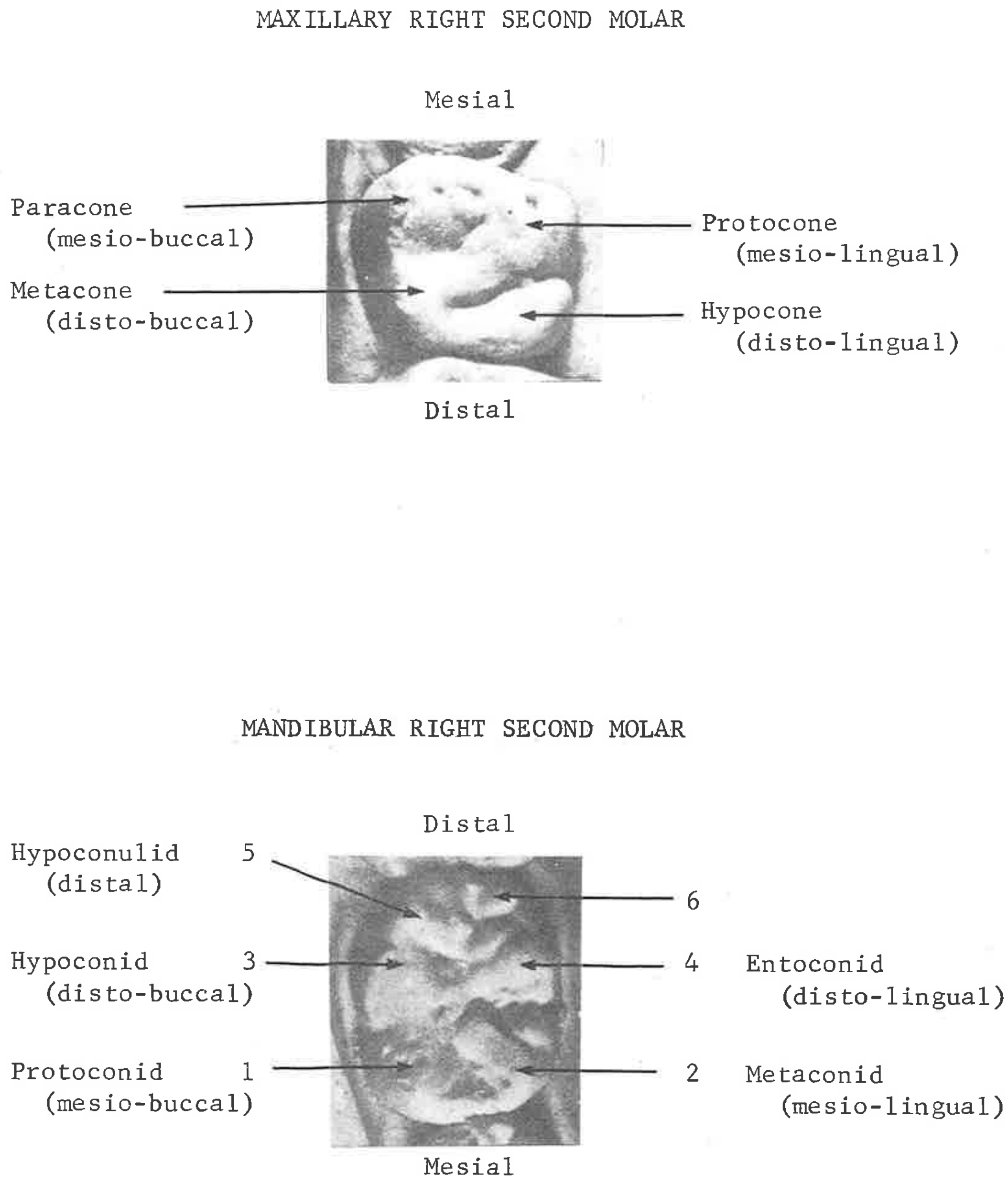


Figure 3. Cusp nomenclature for the deciduous maxillary and mandibular second molar

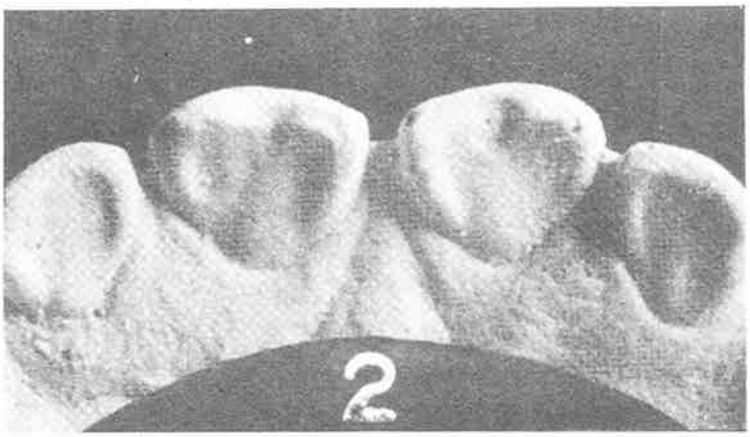


Figure 4. Shovel shape in deciduous maxillary incisors

Tooth 53 single tubercle

Tooth 53 double tubercle

Tooth 83 single tubercle

Figure 5. Lingual tubercle in the deciduous right canine

the groove separating the distal marginal ridge and an accessory ridge located between the median lingual ridge and the distal marginal ridge (see Figure 6).

Carabelli's trait

Carabelli's trait occurs in maxillary second molars. It is expressed as either a tubercle of varying size or as a groove or as a pit on the lingual surface of the protocone (see Figure 7).

Occlusal groove pattern

The Y occlusal groove pattern occurs in mandibular second molars. It is characterized by the Y shaped occlusal groove pattern formed when the metaconid is in basal line contact with the hypoconid. Modifications of the Y pattern include the + or X shaped groove pattern with basal point or line contact between the protoconid and entoconid (see Figure 8).

Protostylid

The protostylid occurs in mandibular second molars. It is the accessory cusp located on the buccal surface of the protoconid (see Figure 9).

Sixth accessory cusp

The sixth accessory cusp occurs in mandibular second molars. It is the accessory cusp located between the entoconid and the hypoconulid (see Figure 10).

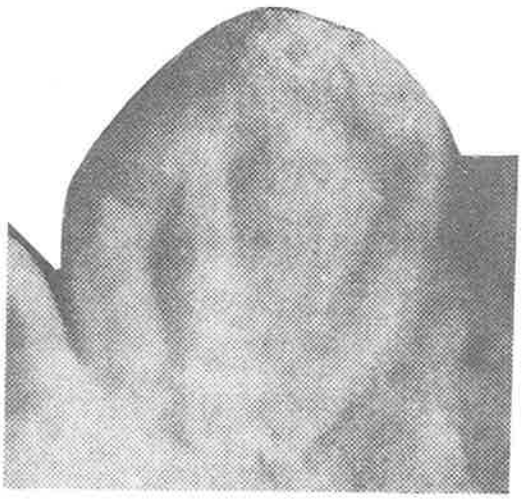
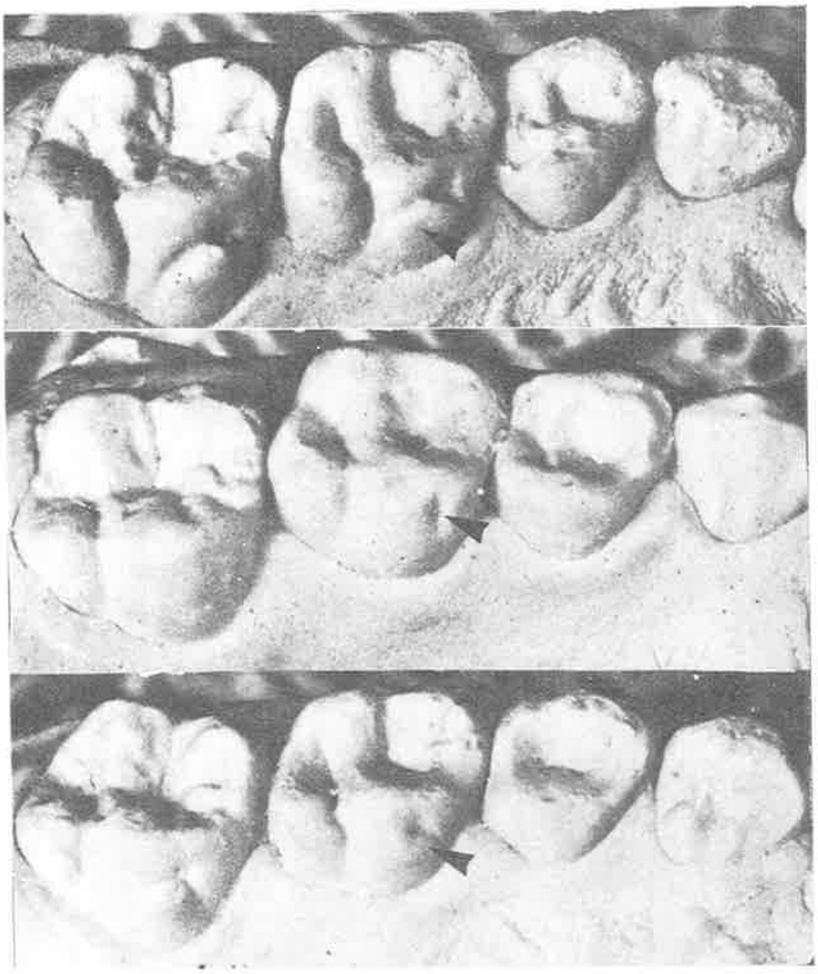


Figure 6. Double fold in the deciduous mandibular left canine - from HANIHARA (1965)



Tubercle

Groove

Pit

Figure 7. Carabelli's tubercle, groove and pit

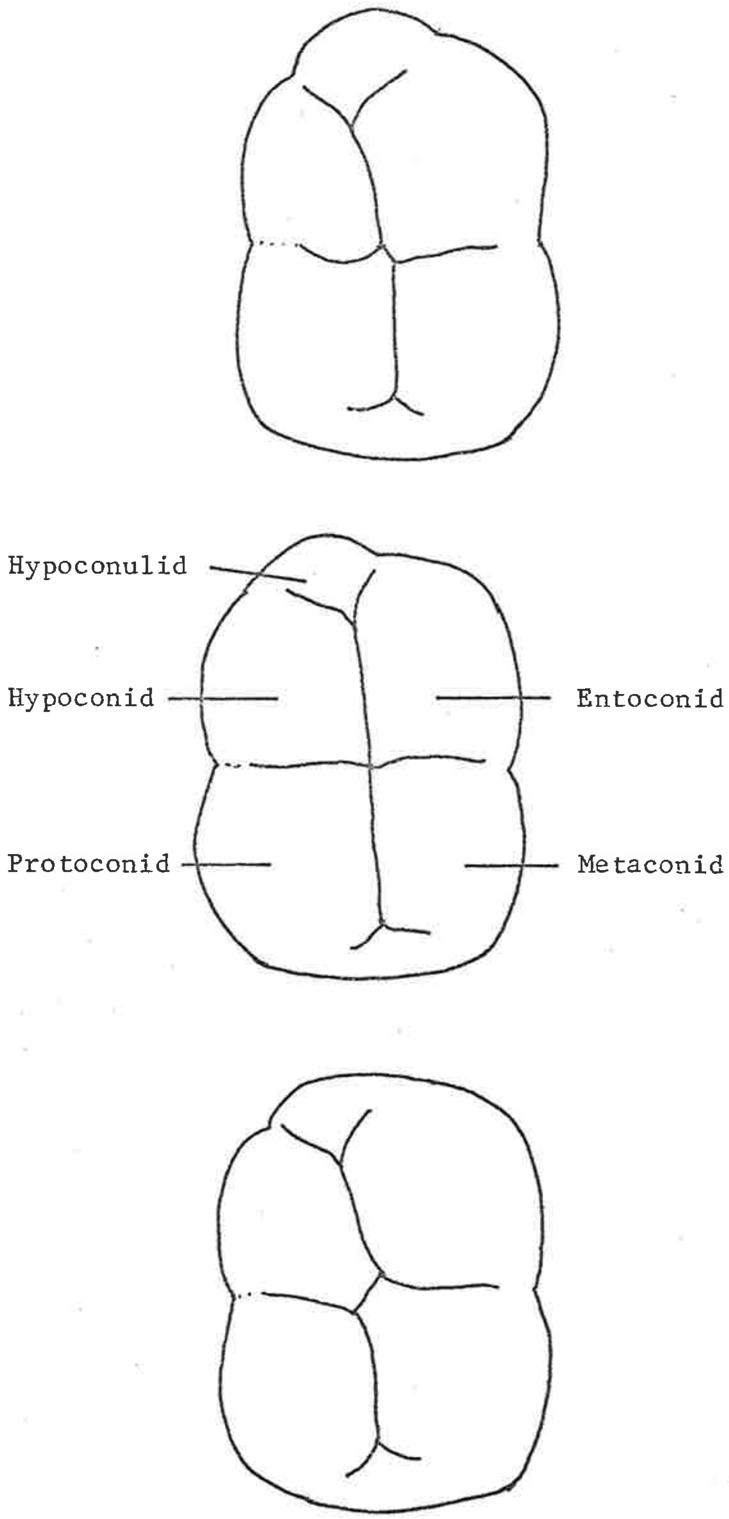


Figure 8. Variation of the occlusal groove pattern in the deciduous mandibular second molar

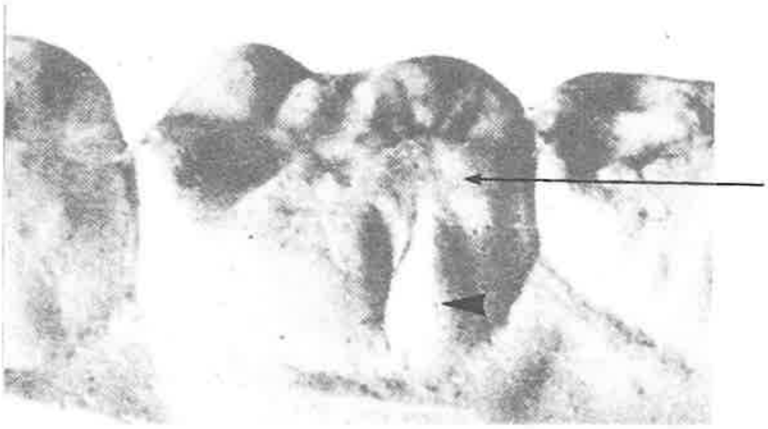


Figure 9. Protostylid in the deciduous mandibular molar - from HANIHARA (1961)

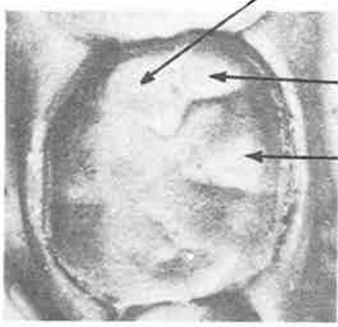


Figure 10. Sixth accessory cusp in the deciduous mandibular right second molar

Seventh accessory cusp

The seventh accessory cusp occurs in mandibular second molars. It is the accessory cusp located between the metaconid and the entoconid (see Figure 11).

Deflecting wrinkle

The deflecting wrinkle occurs in mandibular second molars. It is formed by the deflected configuration of the median ridge of the metaconid (see Figure 12).

Distal trigonid crest

The distal trigonid crest occurs in mandibular second molars. It is formed by the crest which connects the metaconid with the protoconid (see Figure 13).

Metaconid ridge

The metaconid ridge occurs in mandibular second molars. It is formed when the metaconid ridge is strongly developed in both length and breadth (see Figure 14).

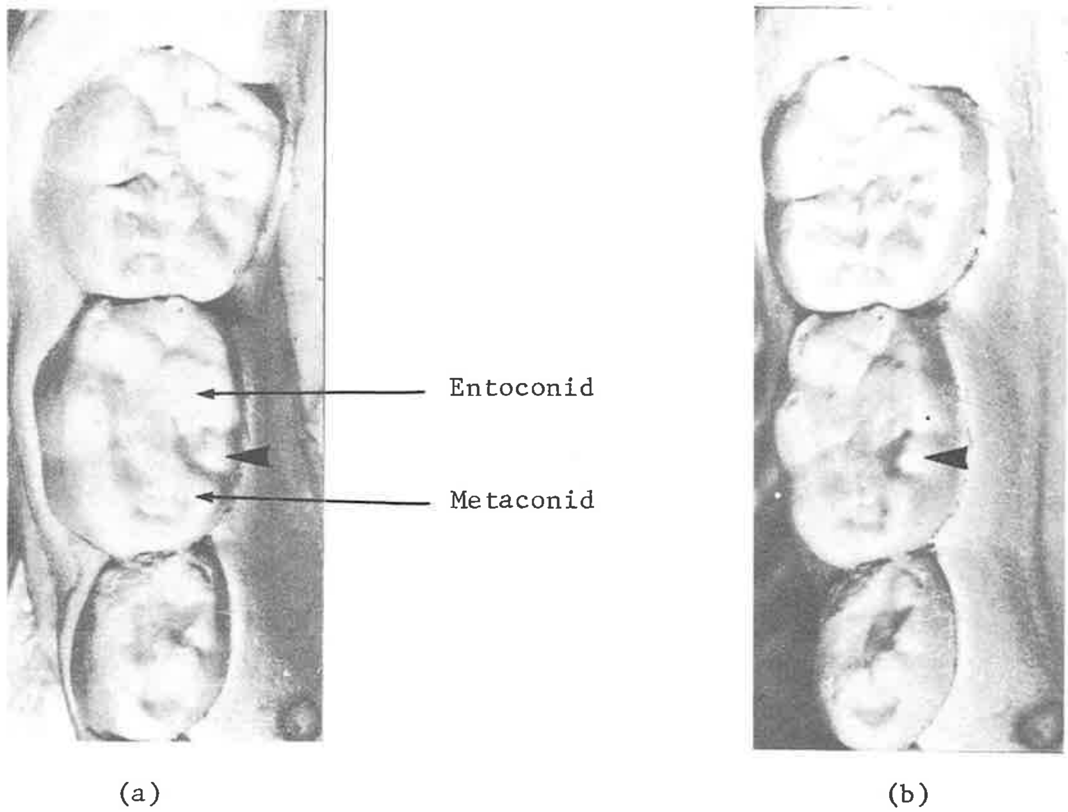


Figure 11. Seventh accessory cusp in the deciduous mandibular right second molar, views of the occlusal surfaces (a) and the lingual and occlusal surfaces (b)

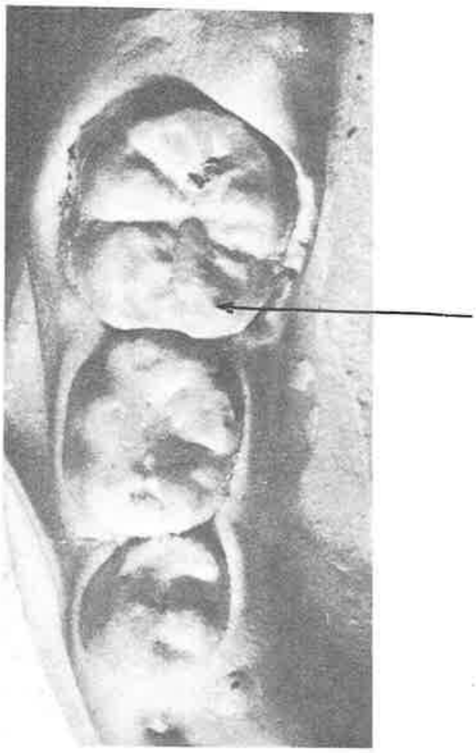


Figure 12. Deflecting wrinkle in the deciduous mandibular right second molar

Figure 13. Distal trigonid crest in the deciduous mandibular right second molar

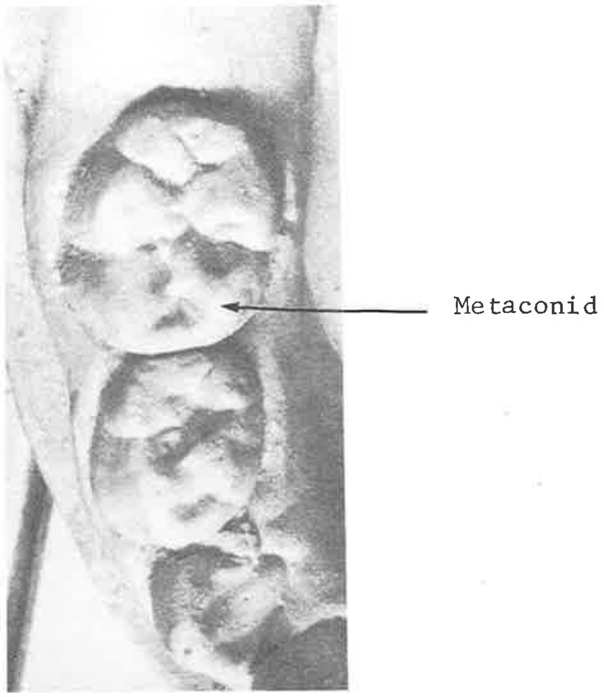


Figure 14. Metaconid ridge in the deciduous mandibular right second molar

MATERIAL AND METHODS

SUBJECTS STUDIED

Subjects providing data for study were Australian Aborigines belonging to the Wailbri tribal group living at Yuendumu in the Northern Territory of Australia who had been examined in a longitudinal investigation of dental and craniofacial characteristics (BARRETT, BROWN and FANNING, 1965).

Yuendumu was established in 1946 as a Commonwealth Government settlement for Aboriginal people. It is situated about 180 miles north-west of Alice Springs on a reserve of 850 square miles. The location of the settlement is shown in Figure 15. The present population of about 1,000 Aborigines is made up of Wailbri and Pintubi groups, predominantly the former, who have abandoned their tribal life in favour of a settlement existence in continuous contact with a plentiful supply of European foods and other amenities. Yuendumu is geographically isolated and most of the people never leave the settlement. Almost all the native people are of pure Aboriginal ancestry so far as this can be ascertained. The group is inbred because most marriages are arranged between couples from within the group.

CAMPBELL and BARRETT (1953) and BROWN and BARRETT (1971) have described the living conditions of the Aborigines at Yuendumu which

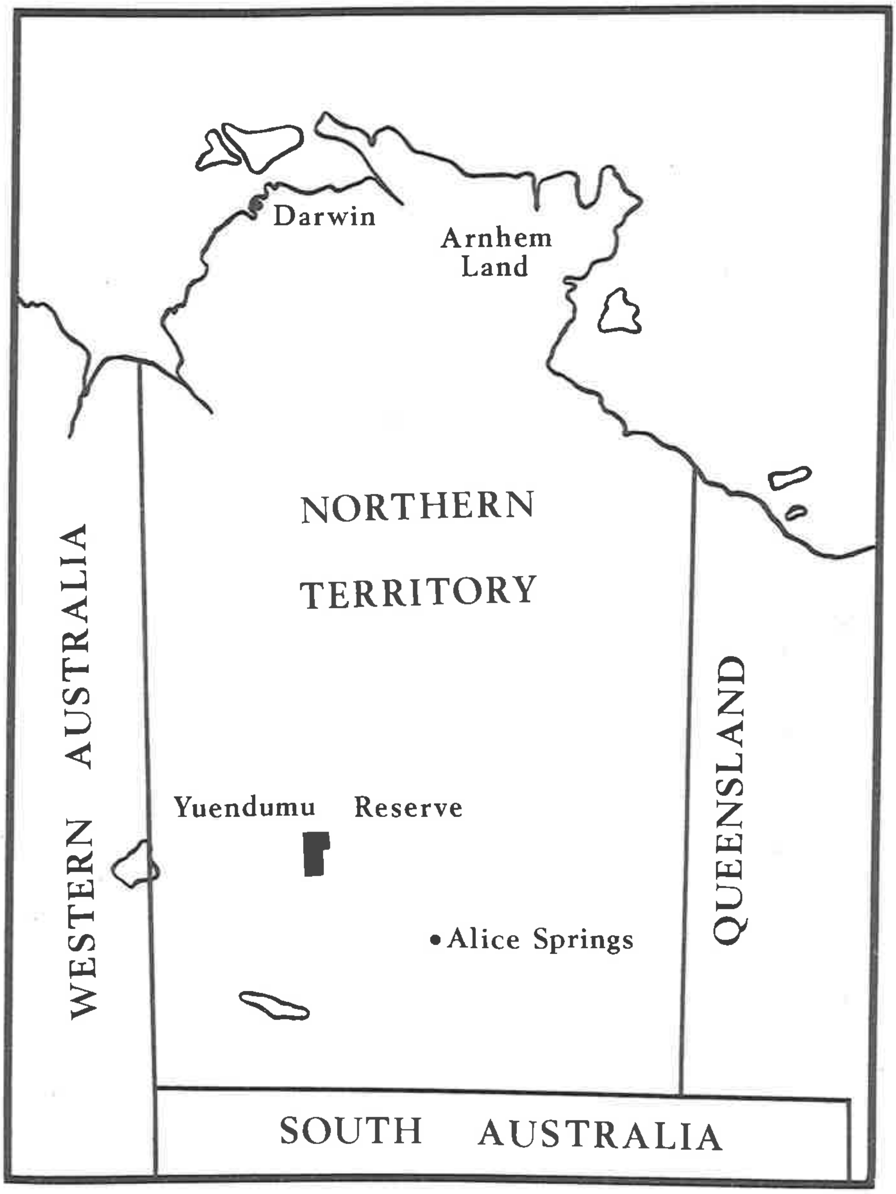


Figure 15. Map of Central Australia showing the location of Yuendumu

differ markedly from their previous hunting and food-gathering way of life. MEGGITT (1965) has given a detailed account of the kinship system and social organization of the Wailbri people. TINDALE (1953) and FLEMING, BARRETT and FLEMING (1971) have recorded genealogical data. BARRETT, BROWN and LUKE (1963) have reported mesiodistal crown diameters of deciduous teeth. BARRETT, BROWN, ARATO and OZOLS (1964) have reported buccolingual crown diameters.

MATERIAL STUDIED

The material for study of deciduous tooth crown morphology consisted of 242 sets of dental casts selected from a total of about 1,800 sets collected in the longitudinal study over a period of twenty years. Casts were chosen so that each subject was represented only once. Generally the earliest obtained set of casts was examined from the longitudinal series for each subject. If a tooth on the earliest cast exhibited an imperfection or had been damaged in any way then the corresponding tooth on the next cast in the series was examined.

Table 1 summarizes the distribution of dental casts examined with specified numbers of teeth present. Table 2 summarizes the distribution of teeth examined of specified types or classes.

REFERENCE STANDARDS

The criteria of classification were specified in a reference standard for each of the dental characters studied. Each standard

Table 1

Distribution of dental casts examined with specified number of deciduous teeth present.

Number of teeth present	Number of Subjects Males	Females	Total
20	22	10	32
19	3	2	5
18	12	7	19
17	1	0	1
16	4	5	9
15	2	1	3
14	17	11	28
13	7	5	12
12	31	20	51
11	6	3	9
10	8	8	16
9	2	2	4
8	4	3	7
7	5	0	5
6	4	4	8
5	4	0	4
4	4	9	13
3	1	4	5
2	2	4	6
1	0	5	5
Total	139	103	242

Table 2

Distribution of deciduous teeth examined of specific type or class.

Maxillary Teeth	Right Side					Left Side				
Tooth	55	54	53	52	51	61	62	63	64	65
Males	137	119	122	63	38	40	66	123	116	135
Females	95	75	79	38	21	22	41	84	77	95
Total	232	194	201	101	59	62	107	207	193	230

Mandibular Teeth	Right Side					Left Side				
Tooth	85	84	83	82	81	71	72	73	74	75
Males	137	119	107	42	28	24	43	109	117	138
Females	95	73	61	22	11	11	22	65	75	96
Total	232	191	168	64	39	35	65	174	192	234

consisted of a detailed description of the character and its variants, supplemented by one or more plaster plaques or illustrations. The classifications of crown characters closely followed those proposed by HANIHARA (1961) and his D Series plaques were used. The reference standards are set out in detail in Section 4.

METHOD OF OBSERVATION

A data sheet was raised for each subject studied (see Figure 16) and the following general information was recorded: identification number, sex, sibship number and tribe. The identification number was the general series number assigned in the longitudinal dental and craniofacial study by BARRETT (1953) and the sibship number was the index number assigned in the collection of family data by FLEMING, BARRETT and FLEMING (1971). The dental casts were examined under an illuminated magnifier. Deciduous teeth were noted as present or absent. The presence or absence of each trait was determined by comparison with reference standards. The observations were recorded on the data sheet and subsequently transcribed to punched cards.

REPEAT OBSERVATIONS

The entire series of observations was repeated, the second determination being made without reference to findings of the first. Pairs of observations for each subject were compared and counts made in terms of agreement and disagreement. Results of the repeat observations are shown in Table 3.

DENTGRO Form 6

DATA SHEET - DECIDUOUS TOOTH MORPHOLOGY

First Name | Kinship Group | Tr

TEETH PRESENT	1	R Maxilla L	R Mandible L	
DIASTEMATA	24	WINGING 28	OTHER TRAITS	30
SHOVEL SHAPE	Maxilla	32	Mandible	38
LINGUAL TUBERCLE	Maxilla	40	Mandible	44
CANINE TRAITS	Maxilla	46	Mandible	48
CROWN PATTERN	Maxilla	50	Mandible	54
MOLAR TRAITS	Carabelli	58	Protostylid	60
	Sixth Cusp	62	Seventh Cusp	64
	Deflecting Wrinkle	66	Trigonid Crest	68
	Metaconid Ridge	70		

IDENTIFICATION 72

△ No. Sex Sibship Tribe Card

REMARKS

Figure 16. Data sheet for recording observations of deciduous tooth morphology

Table 3

Results of the double determination expressed as percentages.

Trait	Tooth	Agreement °/₀	Disagreement °/₀ Pres/Abs *	Degree **	Doubtful ***
Shovel shape	51	98.3			1.7
Shovel shape	52	86.7	10.7		2.6
Shovel shape	53	100.0			
Shovel shape	83	94.3	5.7		
Lingual tubercle	51/52	100.0			
Lingual tubercle	53	92.2	7.8		
Lingual tubercle	83	98.2	1.8		
Double tubercle	53	89.0	9.3		1.7
Double fold	83	93.8	5.9		0.3
Carabelli's trait	55	84.3	6.1	7.6	2.0
Protostylid	85	78.5	12.5	3.9	5.1
Occlusal groove pattern	85	87.2		4.1	8.7
Sixth accessory cusp	85	90.0	1.9		8.1
Seventh accessory cusp	85	74.3	9.4	9.9	6.4
Deflecting wrinkle	85	86.0	8.4		5.6
Distal trigonid crest	85	88.4	4.9		6.7
Metaconid ridge	85	82.8	9.9		7.3

* Present/Absent - first and second determinations disagree with regard to the presence or absence.

** Degree - trait present on both determinations, discrepancy in degree of expression only.

*** Doubtful - trait not classified on first or second observation.

The results showed that the extent to which the first and second observation were identical varied among the different traits, and exhibited values between 74.3 to 100.0 per cent. The discrepancies which occurred were attributed to the following sources, the quantitative nature of the trait and loss of morphology due to tooth wear.

Discrepancies occurred among the quantitative characters which exhibited a continuous range of variability and where the demarcation between types were not clearly determinable. For example, in the seventh accessory cusp the level of agreement for the double determination was 74.3 per cent, this was also the lowest level. This discrepancy was accounted for as follows: 9.4 per cent due to the difficulty in deciding the amount of deflection of the buccal groove which constituted the initial presence of the trait. A further discrepancy of 9.9 per cent resulted from the trait being classified as present on both determinations but with a different degree of presence. Finally, a discrepancy of 6.4 per cent occurred because the trait was not classified on the first or second determination usually due to loss of tooth structure resulting in almost complete obliteration of the trait thus doubt existed as to whether the trait should have been classified.

Discrepancies which occurred among the discontinuous characters were generally smaller than those for the continuous characters. For example, the sixth accessory cusp was classified as either present or absent. The level of agreement for the double determination was 90.0 per cent. The discrepancy was accounted for as follows: 1.9 per cent where the trait was classified as present on one determination and as absent on the other determination, and 8.1 per cent because the trait was not classified on the first or second determination generally because the trait was almost obliterated due to tooth wear.

A third determination was made to correct the discrepancies detected by the double determination. The corrected data were used to determine the frequency occurrence of the traits.

STATISTICAL METHODS

Frequency count

The frequency occurrence of each trait was determined for the right and left side teeth. The data relating to males and females were treated separately. Each trait was allotted a number of Boolean relations depending upon the number of varying degrees of development of the trait. Where the trait was recorded as either present or absent four relations were assigned as follows: right side absent, right side present, left side absent, left side present. Where a trait presented in one of several forms, additional Boolean relations were assigned. For example, Carabelli's trait was allotted a total of ten Boolean relations, five for each side. Thus the trait on the right side was allotted to one of the following five relations; right side absent, right side pronounced tubercle, right side slight tubercle, right side groove or right side pit. Similarly there were five relations for the left side.

The numbers of subjects satisfying each specific Boolean relation were determined. The frequency data obtained were then arranged into tabular form for further analysis.

Where there was no significant difference between the right and left side, the presence or absence of each trait was determined from the tooth on the right side. Where the right tooth was absent the left tooth was used. The frequency occurrence of the trait in the population was determined for both males and females. If there was no significant sex difference the population frequency was determined from the pooled sample of males and females. The frequency occurrence (p) of each trait was calculated as:

$$p = \frac{a}{N} \times 100$$

where a = number of subjects with the trait;

N = total number of subjects;

p = percentage with trait present.

The error of the percentage ($\mathcal{E}$) was computed according to the usual procedure:

$$\mathcal{E} = \sqrt{\frac{p(100 - p)}{100.N}}$$

Right and left side analysis

The hypothesis that the trait occurred with the same frequency on the right and left side was investigated using a 2 by 2 or 2 by j contingency test. The data coded for males and females were analysed separately.

Where the data consisted of only two classes the 2 by 2 contingency test with Yates' correction for continuity was used. The data were arranged in a two-way table as follows:

	Right	Left	Total
Absent	a_1	a_2	$a_1 + a_2$
Present	a_3	a_4	$a_3 + a_4$
	$a_1 + a_3$	$a_2 + a_4$	N

Chi-square (χ^2) was determined by means of the formula:

$$\chi^2_1 = \frac{\left[\,\left|a_1 a_4 - a_2 a_3\right| - \tfrac{1}{2}N\,\right]^2 . N}{(a_1 + a_2)(a_3 + a_4)(a_1 + a_3)(a_2 + a_4)}$$

Where the data consisted of more than two classes the 2 by j contingency test was applied. The data were arranged in a 2 x j table as follows:

	Right	Left	Total
Absent	a_1	b_1	n_1
Present 1	a_2	b_2	n_2
Present 2	a_3	b_3	n_3
.	.	.	.
.	.	.	.
.	.	.	.
Present j	a_j	b_j	n_j
	A	B	N

The value of Chi-square was determined by means of the formula:

$$\chi^2_{j-1} = \frac{N^2}{A.B} \cdot \left[\sum^{j} \frac{a^2}{n} - \frac{A^2}{N} \right].$$

The computed value of chi square with the appropriate number of degrees of freedom was referred to the FISHER and YATES (1963) Scientific Table No. 4 to determine the level of probability. The probability level of 0.05 was used as the basis for accepting or rejecting the hypothesis.

Sex analysis

The hypothesis that the trait occurred with the same frequency in males and in females was investigated using a 2 by 2 or 2 by j contingency test.

Combination of traits

The frequency distribution of the combination of the presence or absence of the six most frequently occurring traits was investigated, using data from subjects in whom all six traits could be determined as being either present or absent. The computer was used to read for each subject a punched card indicating the absence (0) or presence (1) of each of six traits designated A, B, C, D, E and F. The following three frequency distributions were than calculated:

1. frequency occurrence of each trait;
2. frequency distribution of specified number of traits in each subject;
3. frequency distribution of specified combination of the traits ordered by a binary system.

Correlation of traits

The relationships between the eight most frequently occurring traits were assessed by correlation analysis using the coefficient of linear correlation to indicate the degree of association. To facilitate calculation of the correlation coefficients an arbitrary value of 2 was assigned in the case of a trait being present, a value of 1 when the trait was absent. Although the pre-assigned scores (1 and 2) are arbitrary, KENDALL and STUART (1961) suggest that when the number of categories is small the linear correlation coefficient is a close approximation to a coefficient of rank correlation.

The correlation coefficients were computed in the usual way:

$$r_{1,2} = \frac{\sum (a_{1i} - \bar{a}_1)(a_{2i} - \bar{a}_2)}{\sqrt{(a_{1i} - \bar{a}_1)^2 (a_{2i} - \bar{a}_2)^2}} \quad \text{for } i = 1,2....n$$

where $r_{1,2}$ is the coefficient of correlation between traits 1 and 2, a_{1i} and a_{2i} are the pre-assigned values given to traits 1 and 2, $\bar{a}_1$ and $\bar{a}_2$ are the means of the pre-assigned values, and n is the number of paired observations.

To test the significance of the coefficient, the hypotheses $r = 0$ was tested by means of the quotient:

$$t_{(n-2)} = \frac{r. \sqrt{(n-2)}}{\sqrt{1 - r^2}}$$

where n = number of subjects, $t_{(n-2)}$ is related to the Student's distribution and is distributed as t with n-2 degrees of freedom. Where $n-2 \geqq 200$ the significance limits for r were determined directly from the scientific table of DOCUMENTA GEIGY (1962). Where the value of r was smaller than the corresponding significance limit for the 0.01 level as shown in the table, then the correlation coefficient r did not differ significantly from zero, and the two traits were taken to be independent in their occurrence. Where r differed significantly from zero the coefficient of determination r^2 was calculated to indicate the proportion of variability that was common to both traits. The coefficient of determination was expressed as a percentage.

Inter-population analysis

To investigate the measure of divergence between any two populations a multivariate distance statistic was calculated. The method devised by C.A.B. Smith and used by BERRY and BERRY (1967) was used to calculate the mean measure of divergence and variance for any two populations.

The measure of divergence between two populations (1,2) of size n_1 and n_2 is taken as $(\theta_1 - \theta_2)^2 - (\frac{1}{n_1} + \frac{1}{n_2})$ for any character where θ is the angular transformation of the frequency occurrence (p) of the trait, measured in radians, such that $\theta = \sin^{-1}(1-2p)$.

In the absence of correlation between traits, individual measures of divergence may be summed. The mean "measure of divergence" for (N) number of traits is a quantitative expression of the separation of the populations. The mean divergence is calculated as:

Mean divergence

$$\sum^{N} \left[(\theta_1 - \theta_2)^2 - \left(\frac{1}{n_1} + \frac{1}{n_2}\right) \right] \Big/ N$$

Since θ_1 has the variance $\frac{1}{n_2}$, $\theta_1 - \theta_2$ has variance $\frac{1}{n_1} + \frac{1}{n_2} = V$, and where there is no real difference between the large populations from which the two samples are drawn, the observed $\theta_1 - \theta_2 = D$ will be a nearly normal deviate with mean zero and variance (V). Thus D^2/V will be approximately distributed as χ^2 with one degree of freedom; and will be significant at, for example, the 0.05 probability level if it is greater than 3V, and at the 0.01 level if greater than 6V.

The estimate of the variance of the mean measure of divergence between two populations classified for N traits is given by the formula:

$$\text{Variance} = 4\left(\frac{1}{n_1} + \frac{1}{n_2}\right) \sum^{N} \left[(\theta_1 - \theta_2)^2 - \left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right] \Big/ N .$$

The difference between two populations is considered to be significant at the 0.05 level where the mean divergence is greater than three times the variance.

CHAPTER 4

DECIDUOUS CROWN MORPHOLOGY

In this section the twelve dental characters studied will be dealt with in the sequence as they were described in Section 2. Each trait will be considered under the following headings: reference standard; previous investigations; the present investigation - results and discussion. In addition, combinations of traits will be reported and linear correlation coefficients calculated for paired combinations of traits.

SHOVEL SHAPE

REFERENCE STANDARD

The shovel shape trait occurs in incisors and canines. It is expressed as a prominence of the proximal marginal ridges in relation to the lingual fossa or concavity of the lingual surface between the marginal ridges and the linguo-gingival ridge or cingulum.

The reference standard for each of the maxillary incisors and for the maxillary and mandibular canines is defined separately.

a. Maxillary central incisor

The classification of HANIHARA (1961) in four types is followed (see Figure 17).

Type 0 - No shovel shape

This category includes teeth having only very slight marginal ridges or none at all. They may be manifested weakly on both the mesial and distal aspects or, as is occasionally seen, on the distal aspect alone. The latter two variants of this classification should not have a concavity between the ridges on the lingual surface.

Type 1 - Semi-shovel shape

The lingual ridges are present on both mesial and distal sides but they disappear mid-way in their course so that their length

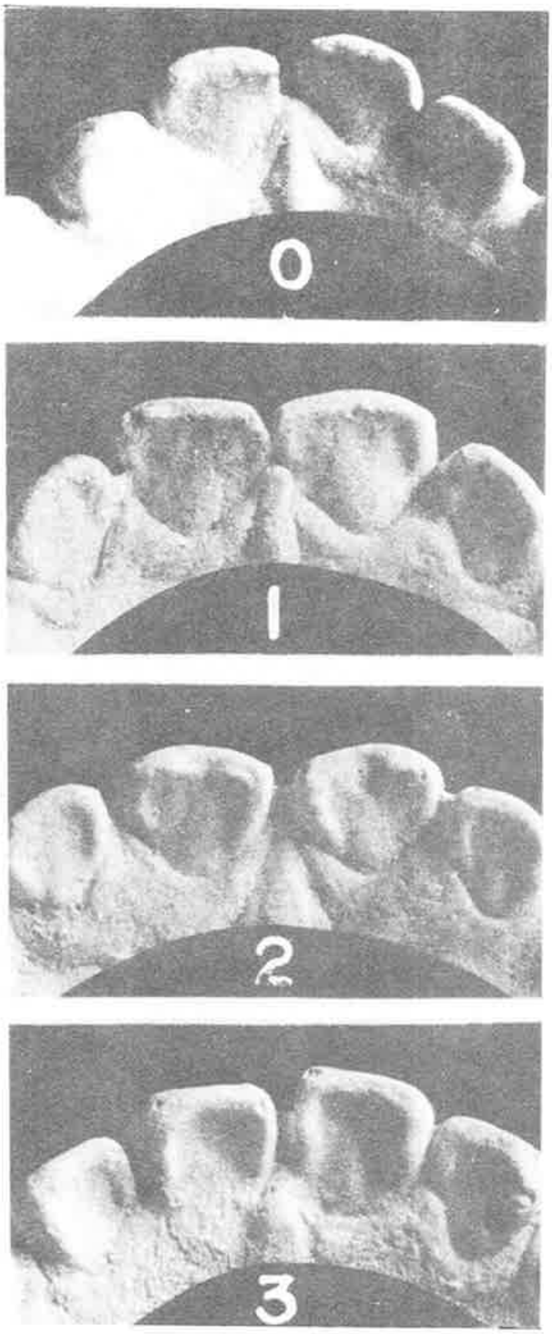


Figure 17. Variation of Shovel shape in the deciduous maxillary central incisors as illustrated on Plaque D1 from HANIHARA (1961)

is usually about one half of the crown height. The concavity of the lingual surface is slight.

Type 2 - Shovel shape

The lingual marginal ridges are well developed, clearly defined and reach closer to the lingual tubercle. The concavity on the lingual surface is distinct.

Type 3 - Shovel shape

The lingual marginal ridges as well as the concavity of the lingual surface are strongly developed.

b. Maxillary lateral incisor

The classification of HANIHARA (1961) in four types is followed (see Figure 18).

Type 0 - No shovel shape

The lingual marginal ridges are so slightly developed that the borders between the ridges and the lingual surface are not clear. The concavity of the lingual surface is also indistinct.

Type 1 - Semi-shovel shape

The lingual marginal ridges as well as the concavity of the lingual surface are not clear but, the ridge may not run all the way from the cutting edge to the lingual tubercle.

Type 2 - Shovel shape

The shovel shape is clearly defined by well developed lingual marginal ridges and the concave lingual surface. The ridges

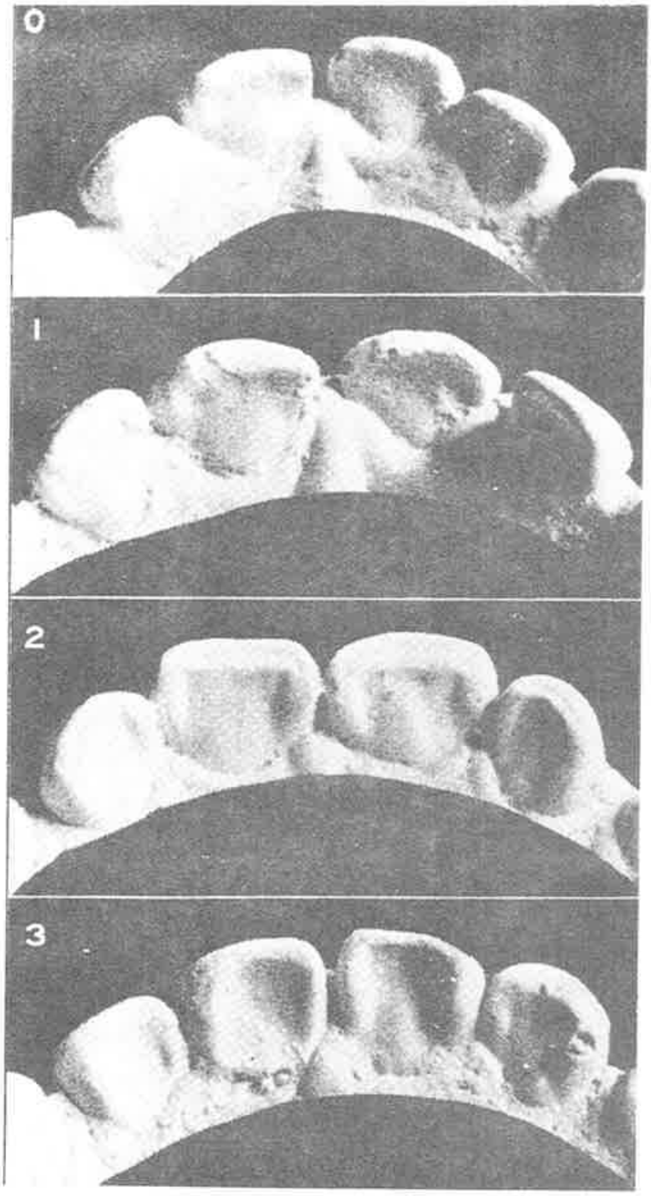


Figure 18. Variation of Shovel shape in the deciduous maxillary lateral incisors as illustrated on Plaque D2 from HANIHARA (1961)

are usually thicker than in the semi-shovel and no-shovel shape.

Type 3 - Shovel shape

The marginal ridges are thicker and the concavity of the lingual surface is greater than in the shovel shape.

c. Maxillary canine

The classification of HANIHARA (1961) in three types is followed (see Figure 19).

Type 0 - No shovel shape

Variations of this category include: (a) no trace of the lingual marginal ridges; (b) only one lingual marginal ridge; (c) three ridges, weak marginal ridges and a well developed central ridge; (d) any combination of the above.

Type 1 - Semi-shovel shape

The lingual ridges are distinctly developed, and the central ridge is weakly developed. The lingual surface has limited concavity.

Type 2 - Shovel shape

The lingual ridges are well developed and the central ridge is weakly developed. The lingual surface has a distinct concavity.

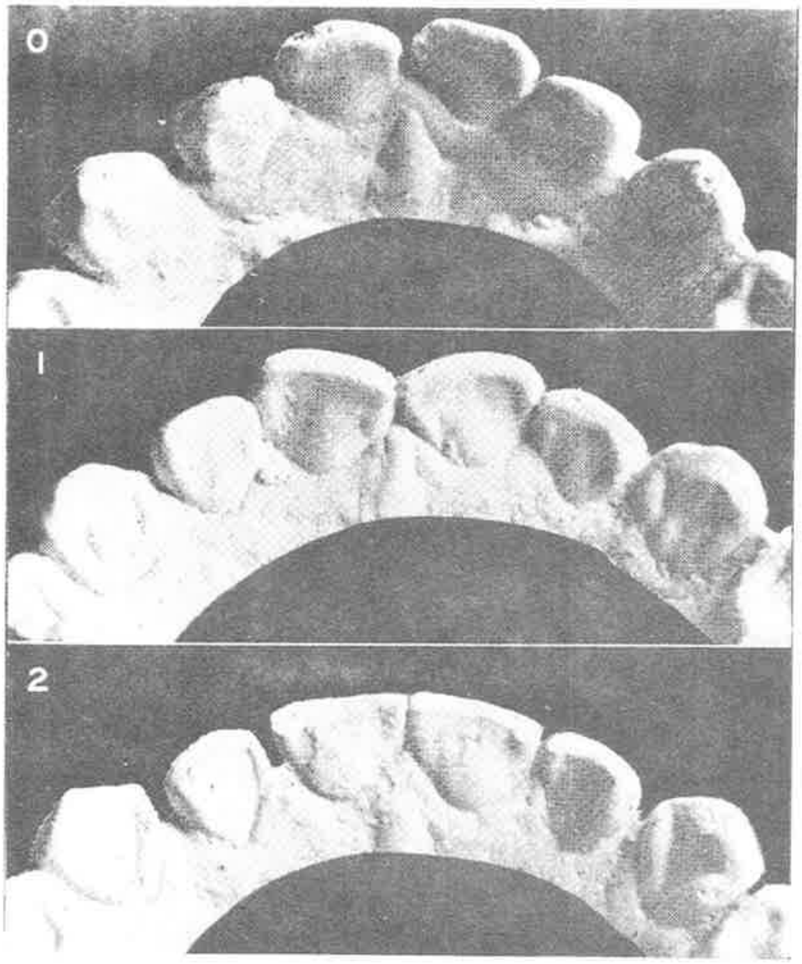


Figure 19. Variation of Shovel shape in the deciduous maxillary canine as illustrated on Plaque D3 from HANIHARA (1961)

d. Mandibular canine

The classification of HANIHARA (1961) in four types is followed (see Figure 20).

Type 0 - No shovel shape

The lingual marginal ridges if present are very slight.

Type 1 - Semi-shovel shape

The lingual marginal ridges are clearly developed but are interrupted by more or less well defined grooves or depressions. The concavity of the lingual surface is shallow.

Type 2 - Shovel shape

The lingual marginal ridges are clearer than in semi-shovel shape. The lingual surface is completely encircled by well defined marginal ridges. The depth of the inner part of the lingual surface is deeper than the semi-shovel shape.

Type 3 - Shovel shape

The development of the lingual ridges is that of shovel shape but the depression of the lingual surface is deeper.

PREVIOUS INVESTIGATIONS

Variations of the shovel shape trait were first classified by HRDLICKA (1920) into four types. This classification was followed for the deciduous dentition by HANIHARA (1961).

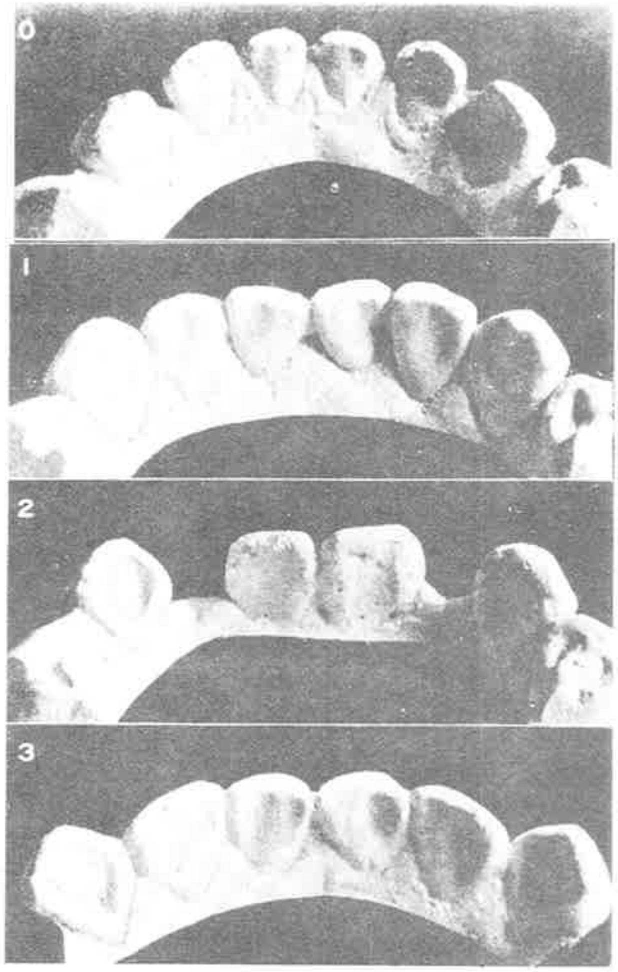


Figure 20. Variation of Shovel shape in the deciduous mandibular canine as illustrated on Plaque D4 from HANIHARA (1961)

The frequency occurrence of the shovel shape trait in maxillary deciduous central incisor, lateral incisor, canine and in the mandibular deciduous canine of five populations has been reported by HANIHARA (1963, 1965). His results are summarized in Table 4 for comparison with those of the present study. As there were no differences between the right and left side frequencies, his observations were made on the right teeth or where these were absent or damaged the left teeth were used. The data obtained from males and females were combined as there was no sex difference.

When considering the implications of his findings HANIHARA (1965) combined type 0 (absent) and type 1 (semi-shovel shape) because he considered that they represented non-carriers of the trait; and types 2 and 3 (shovel shape) which represented the carriers. His results showed that the shovel shape trait occurred frequently and was relatively well developed in the Japanese. The reverse situation was found both for American-Whites and American-Negroes. The Japanese-American-White and the Japanese-American-Negro hybrids both showed intermediate frequencies and development. Shovel shape was therefore considered to be a trait which varied between populations, Mongoloid populations being characterized by a high frequency.

Table 4

Frequency occurrence of the shovel shape trait in specified deciduous teeth - expressed as a percentage - for several population groups.

Population Group	Tooth	Number of Subjects	Shovel Shape Type *			
			0	1	2	3
Japanese +	51	124	0.0	23.4	76.6	0.0
	52	163	0.0	6.7	89.6	3.7
	53	197	5.6	85.8	8.6	-
	83	199	32.7	61.8	5.5	0.0
Japanese American White +	51	65	7.7	55.4	36.9	0.0
	52	50	2.0	38.0	60.0	0.0
	53	79	20.3	78.5	1.3	-
	83	78	52.6	44.9	2.6	0.0
American White +	51	20	50.0	50.0	0.0	0.0
	52	24	54.2	45.8	0.0	0.0
	53	52	90.4	9.6	0.0	-
	83	49	75.5	22.4	2.1	0.0
Japanese American Negro +	51	35	0.0	42.9	57.1	0.0
	52	40	0.0	30.0	70.0	0.0
	53	46	10.9	89.1	0.0	-
	83	45	48.9	46.7	4.4	0.0
American Negro +	51	10	80.0	10.0	10.0	0.0
	52	21	57.1	33.3	4.8	4.8
	53	51	76.5	23.5	0.0	-
	83	47	70.2	27.7	2.1	0.0
Australian Aboriginal ‡	51	58	100.0	0.0	0.0	0.0
	52	108	78.8	21.3	0.0	0.0
	53	206	100.0	0.0	0.0	0.0
	83	177	95.5	4.5	0.0	0.0

* See text for definitions of types.

\+ Data from HANIHARA (1963, 1965).

‡ Present study.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

Findings for the frequency occurrence of the shovel shape trait in the Wailbri deciduous maxillary incisors and canine and in the mandibular canine are summarized in Table 4.

Shovel shape was not detected in the maxillary central incisor or in the canine. Semi-shovel shape was found in 21.3 per cent of lateral incisors and in 4.5 per cent of mandibular canines.

Discussion

The present findings coincide with those of HANIHARA (1963, 1965) in that there was no significant sex difference in the occurrence of shovel shape nor was there a difference in the occurrence between right and left side teeth. The most striking findings were that the trait did not occur at all in two of the tooth classes studied and that no subjects were observed with the trait developed beyond the semi-shovel degree so far as the other two tooth classes were concerned. On this basis the Wailbri group is similar to non-Mongoloids in whom the shovel shape occurs with a low frequency.

LINGUAL TUBERCLE and DOUBLE TUBERCLE

REFERENCE STANDARDS

A lingual tubercle is a single, double or multiple protruberance arising from the cingulum on the lingual surface of the incisor or canine. The tubercle may have a long and narrow or short and stumpy appearance.

Variation of the lingual tubercle was classified in the present study as either present or absent. The type present is illustrated in Figure 5. When the tubercle was double and on the maxillary canine it was classified separately as a double tubercle.

The double tubercle consists of the two small tubercles found on the lingual surface in the cingulum region of the deciduous maxillary canine. The distal tubercle is usually slightly larger than the mesial tubercle. Variation of the double tubercle was classified as either present or absent. The type present is illustrated in Figure 5.

PREVIOUS INVESTIGATIONS

BLACK (1902) defined the tubercle as a slight rounded elevation on the linguo-gingival ridge of incisors and on various other parts of other teeth. Variations of lingual accessory cuspules were described by HRDLICKA (1921) as being either single, double or multiple. He reported that in 80 deciduous incisors of American Indians 5 per cent exhibited a single tubercle.

JORGENSEN (1956) reported that in the Danish deciduous canines the basal tubercle nearly always exhibited two short enamel projections, one on either side of the lingual ridge. He did not indicate the frequency for the double tubercle. He also stated that the mandibular canine practically never exhibited enamel elevations on the lingual surface.

The frequencies of single lingual tubercles in the deciduous maxillary canine were reported for three populations by HANIHARA (1955) and are summarized in Table 5 for comparison with those of the present study. He found the lingual tubercle to be more pronounced in canines than in incisors, especially in the maxillary canine where the trait is often expressed as two tubercles. Multiple tubercles, however, were found to be quite rare in incisors. In the mandibular canine lingual tubercles were generally weaker than in the maxillary canine and double tubercles did not occur. In the mandibular canine there were no remarkable differences in the frequency distributions for the populations investigated.

Frequencies of the double tubercle trait of five populations have been reported by HANIHARA (1965), and are summarized in Table 6 for comparison with those of the present study. The data obtained from males and from females were pooled as there was no significant sex difference. Statistical tests indicated that the population differences were not significant, and the trait was therefore considered to be an invariable population character.

Table 5

Frequency distribution of single lingual tubercles in the deciduous maxillary canine - expressed as a percentage - in several populations.

Population Group	Number	Single Tubercle Present	Single Tubercle Absent
Japanese +	117	52.1	47.9
Japanese-American-White +	59	35.6	64.4
Japanese-American-Negro +	31	25.8	74.2
Australian Aboriginal ‡	210	1.9	98.1

\+ Data from HANIHARA (1955).

‡ Present study.

Table 6

Frequency distribution of double lingual tubercles in the deciduous maxillary canine - expressed as a percentage - in several population groups.

Population Group	Number	Double Tubercle Present	Double Tubercle Absent
Japanese +	194	43.8	56.2
Japanese-American-White +	72	45.8	54.2
American-White +	50	48.0	52.0
Japanese-American-Negro +	46	45.7	54.3
American-Negro +	51	58.8	41.2
Australian Aboriginal ‡	205	75.1	24.9

+ Data from HANIHARA (1965).

‡ Present study.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the lingual tubercle in the maxillary canine is summarized in Table 5. Lingual tubercles were not found on the incisors. Single lingual tubercles were found on maxillary canines in 1.9 per cent and on the mandibular canines in 10.7 per cent of the subjects investigated.

The frequency occurrence of the double tubercle in the maxillary canine is summarized in Table 6, the trait was found in 75.1 per cent of the 205 subjects investigated.

Discussion

The occurrence of a lingual tubercle is rare in deciduous incisors. In the present study no tubercles were found on the incisors of 105 subjects.

The tubercle on the maxillary canine may be either single or double. The frequency of the single maxillary canine tubercle has been shown by HANIHARA (1955, 1965) to decrease as the frequency of the double tubercle increased in a population. This tendency also holds for the Wailbri in whom we find the highest frequency of double tubercles and the lowest frequency of single tubercles.

The absence of a sex difference for the double tubercle concurs with the findings of other investigators. The frequency occurrence of the double tubercle in the Wailbri is significantly higher than in any of the other populations summarized in Table 6. HANIHARA (1965) considered this character to be invariable among the different populations. The results of the present study show that the double tubercle can now be regarded as a trait which shows a variable population frequency, and as a racial trait of the Australian Aboriginal.

Comparable frequencies for the mandibular canine could not be found. However, Jorgensen stated that the mandibular canines investigated by him practically never exhibited enamel elevations on the lingual surface. In the present study 10 per cent of mandibular canines were found to have lingual tubercles. It would appear that the difference between practically never and 10 per cent constitutes a population difference. The need for further investigation of this trait in other populations is therefore indicated.

DOUBLE FOLD

REFERENCE STANDARD

The double fold trait is found on the deciduous mandibular canines. It is formed by the groove separating the distal marginal ridge and an accessory ridge. The accessory ridge is located between the median ridge and the distal marginal ridge. The groove commences at the basal junction of the accessory and distal marginal ridge and extends upwards to and terminates at the distal incisal edge. The general appearance is that of a folded and enlarged distal marginal ridge.

In the present investigation variation of the double fold was classified according to HANIHARA (1965) as either present or absent. The type present is illustrated in Figure 6 and was used as the reference standard.

PREVIOUS INVESTIGATIONS

Frequencies of the double fold in five populations have been reported by HANIHARA (1965) and are summarized in Table 7 for comparison with those of the present study. The data obtained from males and from females were pooled as there was no significant sex difference. Statistical tests indicated that the inter-population differences were not significant. The trait was considered to be an invariable inter-population character.

Table 7

Frequency occurrence of the double fold trait in the deciduous mandibular canine - expressed as a percentage - for several population groups.

Population Group	Number	Double Fold Present	Double Fold Absent
Japanese +	200	9.0	91.0
Japanese-American-White +	78	3.8	96.2
American-White +	48	4.2	95.8
Japanese-American-Negro +	45	8.9	91.1
American-Negro +	47	6.4	93.6
Australian Aboriginal ‡	175	5.7	94.3

\+ Data from HANIHARA (1965).

‡ Present study.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the double fold in the deciduous mandibular canine is summarized in Table 7. The trait was found in 5.7 per cent of the 175 subjects investigated.

Discussion

Previous investigations have not shown a sex difference for the frequency of the double fold and the results of the present investigation concur with these findings. The frequency of the double fold trait in five population groups was reported by HANIHARA (1965) to range from 3.8 to 9.0 per cent, this variation in frequency occurrence was found by Hanihara to be not significantly different. In the present investigation the double fold was present in 5.7 per cent of the subjects investigated, this frequency was not significantly different to those reported by Hanihara in Table 7. Based upon the results of the past and present investigations the double fold must still be considered as an invariable inter-population character.

CARABELLI'S TRAIT

REFERENCE STANDARD

Carabelli's trait is located on the lingual surface of the protocone of the deciduous maxillary second molar. The trait may take the form of a tubercle, or slight depression at the site where the Carabelli's trait would occur.

The classification of KRAUS (1951) in five types is followed for the reference standard. Variations of Carabelli's trait are illustrated in Figure 21.

Type 1 - Complete absence

There is no irregularity on the lingual surface of the protocone.

Type 2 - Pronounced tubercle

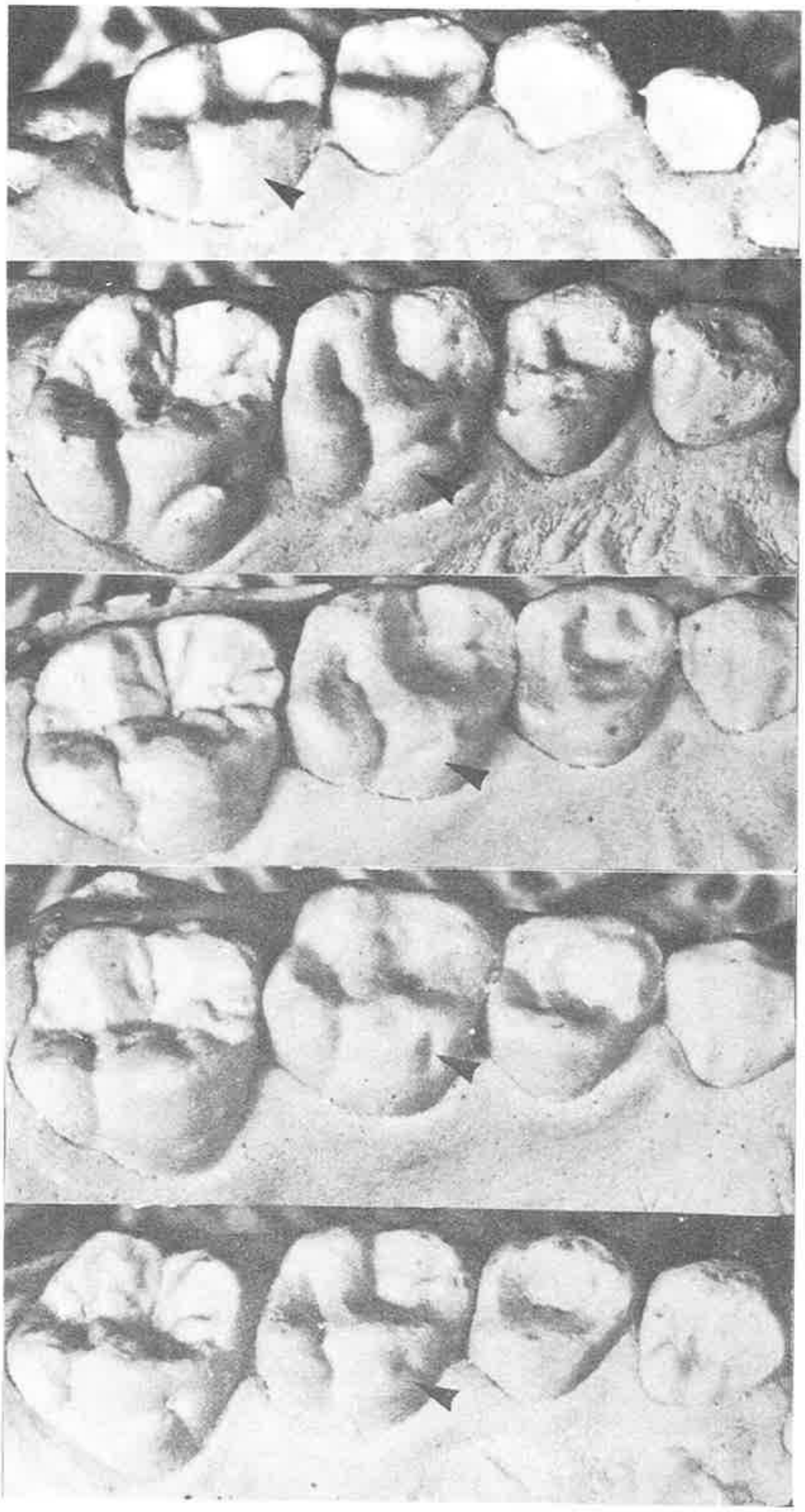
A strongly developed tubercle whose tip is encircled by a distinct groove. The apex of the tubercle is free.

Type 3 - Slight tubercle

A slight tubercle or bulge on the lingual surface of the protocone. The apex of the tubercle is not free.

Type 4 - Groove

A groove on the mesial side of the lingual surface. The single groove is straight and may have a pit at the base of the groove. The double groove is V shaped and there may or may not be a pit at the base.



Complete Absence

Pronounced Tubercle

Slight Tubercle

Groove

Pit

Figure 21. Variation of Carabelli's trait in the deciduous maxillary right second molar

Type 5 - Pit

A distinct pit or small circular depression at the site of the Carabelli's tubercle. There is no other evidence of groove or cusp formation.

PREVIOUS INVESTIGATIONS

The name "Carabelli's trait" is derived from George Carabelli Edlen von Lunkaszprie who over a century ago described it under the name of "tuberculus anomalus". Since then it has received considerable attention and is now universally known as the "tubercle of Carabelli". However, despite the considerable attention it has received, the classification of this trait is not yet universal, nor has its exact mode of inheritance been determined.

Variation of Carabelli's trait was classified by JORGENSEN (1956) into three types. The classification was based on the character and the degree of development of the 'convex furrow'. The three types distinguished were:-

a. cusp;

b. groove and / or pit;

c. no trace.

JORGENSEN (1956) also reviewed the literature relating to the Carabelli's tubercle in Recent Europeans, and found that the frequency of the trait was not always the same for the deciduous and permanent teeth of the same population. Table 8 summarizes the frequency of the

Table 8

Frequency distribution of Carabelli's trait - expressed as a percentage - for several Caucasoid population groups. Data from JORGENSEN (1956).

<table>
<tr><th>Population</th><th>Number</th><th>Cusp</th><th>Groove + Pit</th><th>No trace</th></tr>
<tr><td>Danes '55</td><td>696</td><td>9.3</td><td>77.6</td><td>13.1</td></tr>
<tr><td>Danes '65</td><td>650</td><td>10.5</td><td>77.4</td><td>12.2</td></tr>
<tr><td>Europeans</td><td>220</td><td>23.6</td><td>62.7</td><td>13.6</td></tr>
<tr><td>Europeans</td><td>106</td><td>34.0</td><td>46.2</td><td>19.8</td></tr>
<tr><td>Dutchmen</td><td>300</td><td>18.0</td><td>70.3</td><td>11.7</td></tr>
<tr><td>Finns</td><td>59</td><td>37.3</td><td>62.7</td><td>0.0</td></tr>
<tr><td>Italians</td><td>50</td><td colspan="2">74.0</td><td>26.0</td></tr>
<tr><td>Italians</td><td>791</td><td>39.6</td><td colspan="2">60.4</td></tr>
</table>

three types of Carabelli's trait in 1346 deciduous maxillary second molars of Recent Danes, and also summarizes the frequency of the trait in the deciduous teeth of Recent Europeans.

KRAUS (1951) classified variation of the Carabelli's trait into five types. These types are described in the reference standard. This classification was used because it provided a simple classification which could be easily related to the classifications used by other investigators.

HANIHARA (1961) classified Carabelli's trait into eight varieties, three types of pit and grooves and four types of cusps. These types were illustrated on Plaque D7 Figure 22. The frequencies for three populations and two hybrid populations were reported by HANIHARA (1963) and are summarized in Table 9 for comparison with those of the present study. From Table 9 it can be seen that the frequency of Carabelli's tubercle is high in Caucasoids and low in Mongoloids and in American Negroes. The frequency of Carabelli's pit and groove showed little inter-population variability among the five populations. The differences in the frequencies of cusps, pits and grooves was regarded by HANIHARA (1963) as evidence for demonstrating a different pattern of inheritance for Carabelli's cusp and pit.

Comparing the classification proposed by KRAUS (1951) with that of HANIHARA (1961) it would appear that the two classifications correspond as follows:-

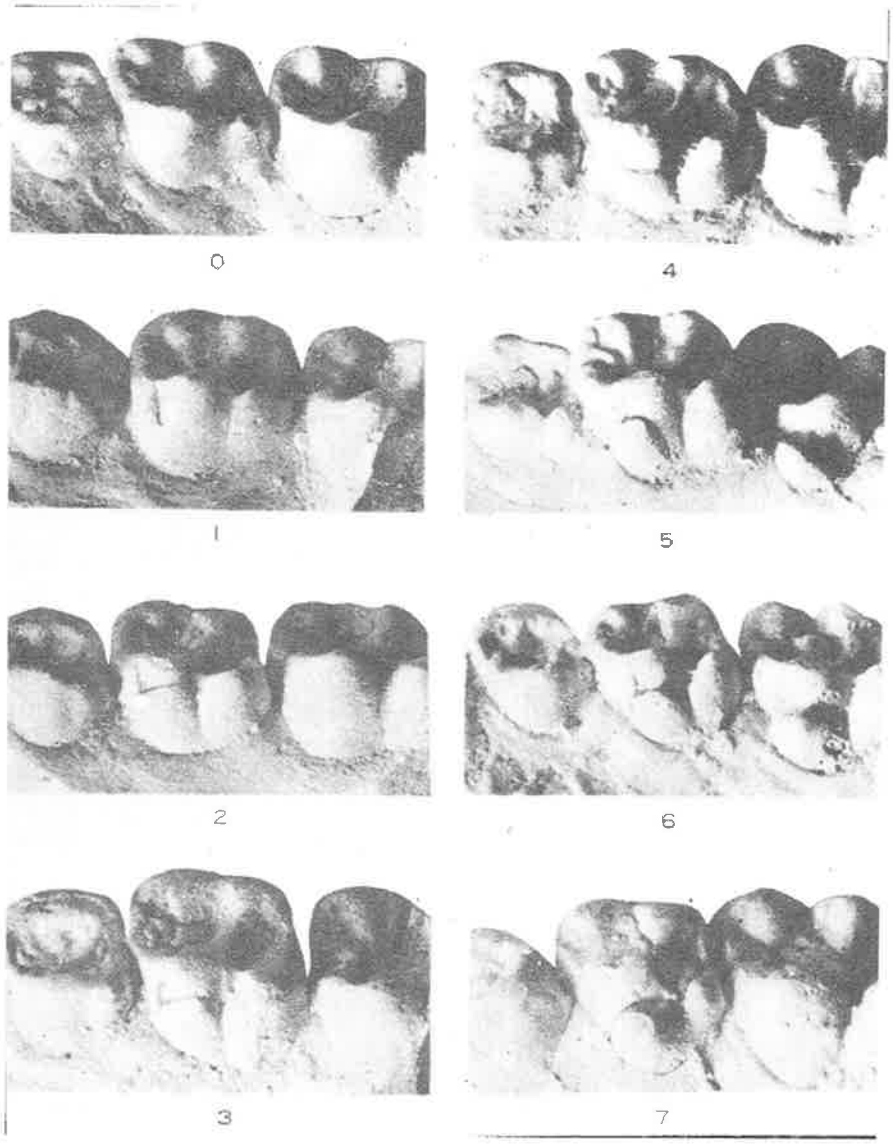


Figure 22. Variation of Carabelli's trait in the deciduous maxillary second molar as illustrated on Plaque D7 from HANIHARA (1961)

Table 9

Frequency of Carabelli's trait in the deciduous maxillary second molar - expressed as a percentage - for several population groups.

Population Group	Number	Absent	Groove + Pit		Cusp *	
		0	1	2+3	4+5	6+7
Japanese +	185	32.4	30.8	24.9	6.5	5.4
Japanese-American-White +	71	14.1	19.7	42.3	18.3	5.6
American-White +	56	5.4	19.6	39.3	14.3	21.2
Japanese-American-Negro +	41	17.1	19.5	43.9	17.1	2.4
American-Negro +	51	19.6	29.4	39.2	2.0	9.8
Australian Aboriginal ‡	226	20.8	66.4	4.4	5.8	2.6

* See text for definition of types - page 69.

\+ Data from HANIHARA (1963).

‡ Present study.

Kraus Type		Hanihara Type
Complete Absence	(CA)	0
Groove and Pit	(G + P)	1, 2 and 3
Slight Tubercle	(ST)	4 and 5
Pronounced Tubercle	(PT)	6 and 7

KRAUS and JORDAN (1965) studied the embrological development of Carabelli's tubercle, they also drew attention to the difficulty of obtaining comparable frequency data of the Carabelli's tubercle due to the great variation in terminology and in the methods of classification.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of Carabelli's trait is summarized in Table 9. The frequency of the cusp was 8.4 per cent, grooves were present in 66.4 per cent and pits were present in 4.4 per cent of the 226 subjects investigated.

Discussion

In the Wailbri the frequency of well developed cusps was low and within the non-Caucasoid frequency range. The frequency of pits was low but the frequency of grooves was very high. The combined frequency of pits and grooves, however, was similar to frequencies reported for other populations. It would appear then that the frequency of pits and grooves should still be regarded as an invariable character among the different populations. It has been suggested that the cusps and the pits and or grooves represent two different genetic entities. In view of this the pits and grooves should be reinvestigated to review the classification.

OCCLUSAL GROOVE PATTERN

REFERENCE STANDARD

The Dryopithecus occlusal groove pattern of the mandibular deciduous second molar is formed by the relationship of the basal contacts of the central ridges of the protoconid, metaconid, hypoconid and the entoconid.

In the present study variation of the Dryopithecus pattern was classified into three types. The classification of HELLMAN (1928) for types Y and + and of JORGENSEN (1955) for type X were followed (see Figure 8).

Type 1 - Y Pattern

The Y pattern is present when the metaconid is in basal line contact with the hypoconid.

Type 2 - + Pattern

The + pattern is formed by basal point shaped contact between the protoconid-entoconid and metaconid-hypoconid. The term point shaped contact as used here, means that it cannot be determined with certainty which of the two diagonal pairs of cusps has the most basal contact, or that this contact does not exceed 0.2 mm.

Type 3 - X Pattern

The X pattern is formed by basal linear contact between the protoconid and the entoconid.

PREVIOUS INVESTIGATIONS

The term Dryopithecus pattern was introduced by GREGORY (1916). The lower molar occlusal surface groove patterns were classified by HELLMAN (1928) into two types which were referred to by the letter Y and by the plus sign (+). The basic 5 cusped pattern was the Y5 type which was referred to as "dryopithecoid". JORGENSEN (1955) proposed an additional groove configuration which he termed the X pattern. He also considered that the cusp number and groove pattern should be treated separately.

HANIHARA (1956) investigated the Dryopithecus occlusal groove pattern in three populations. The frequencies reported are summarized in Table 10 for comparison with those of the present study. He also found that the frequency of the five cusped Y type of Dryopithecus pattern was greater in the deciduous than in the permanent dentition.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the Dryopithecus groove pattern is summarized in Table 10. The frequency of the Dryopithecus pattern Y5 was 96.9 per cent, the patterns +5 and X5 represented a frequency of

Table 10

Frequency distribution of the occlusal groove pattern in the deciduous mandibular second molar - expressed as a percentage - in several population groups.

Population Group	Number	Groove Pattern +5	Groove Pattern Y5
Japanese +	81	2.5	97.5
Japanese-American-White +	60	5.0	95.0
Japanese-American-Negro +	19	0.0	100.0
Australian Aboriginal ‡	194	3.1	96.9

+ Data from HANIHARA (1956).

‡ Present study.

3.1 per cent. All the mandibular deciduous second molars had five primary cusps.

Discussion

Previous investigations have shown that in three populations the frequency of the Y5 pattern ranges from 95 to 100 per cent, this difference was regarded by HANIHARA (1956) to be not significant and the trait was considered to be an invariable population character. The results of the present study do not differ significantly from other investigations. Because of this the Dryopithecus groove pattern remains an invariable population trait.

PROTOSTYLID

REFERENCE STANDARD

The protostylid is found on the buccal surface of the protoconid of the deciduous mandibular second molar. The classification of HANIHARA (1961) in seven types is followed for the reference standard (see Figure 23).

Type 0 - Absent

The buccal groove is straight and there is no trace of any irregularity.

Type 1 - Absent

No evidence of a protostylid, but the beginning of one is suggested by the curvature and branching of the buccal groove. There may be a very small but distinct pit at the lower terminal of the buccal groove separating the protoconid from the hypoconid. In such a case the buccal groove is slightly bent distalward at the point of the pit.

Type 2 - Present 1

The divergence of the buccal groove is evident.

Type 3 - Present 2

The two branches of the buccal groove are more strongly developed than in type 3. A small triangular area with its tip downward can be seen between the branches of the buccal groove.

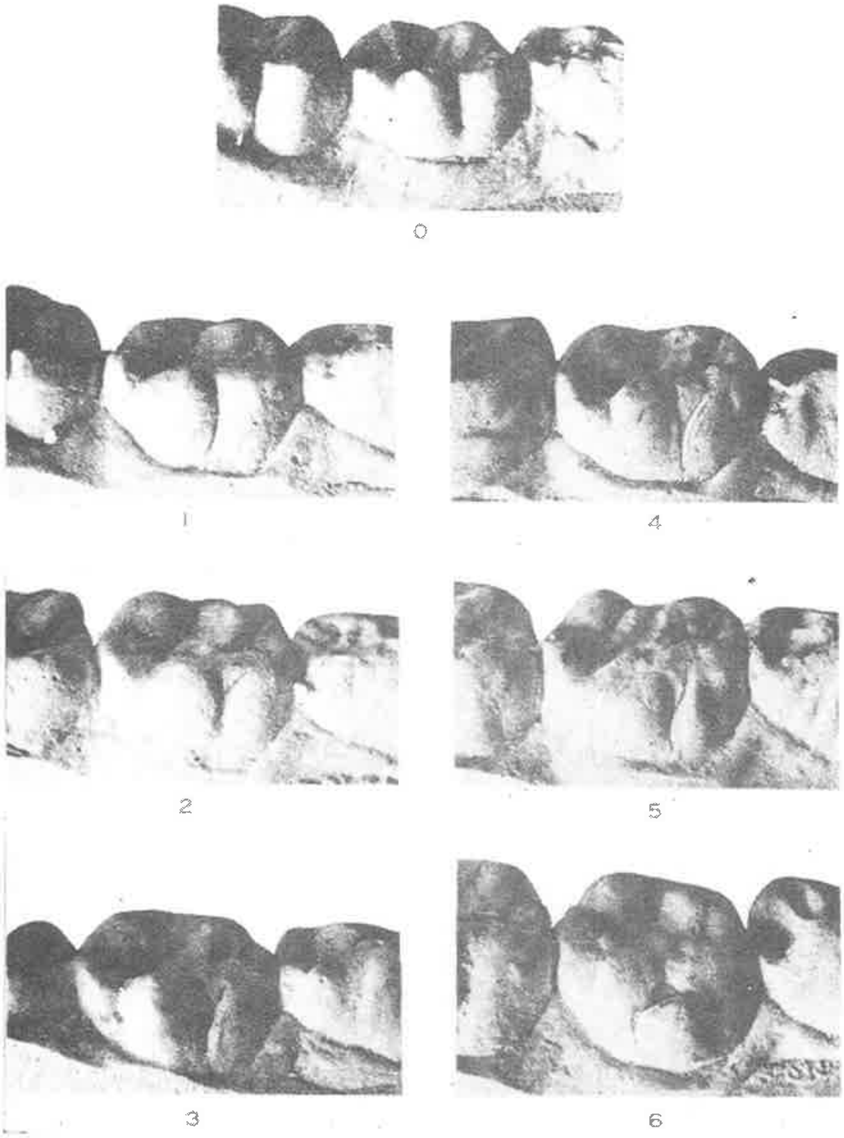


Figure 23. Variation of the Protostylid in the deciduous mandibular second molar as illustrated on Plaque D8 from HANIHARA (1961)

Type 4 - Present 3

A very shallow groove appears at the mesial corner of the buccal surface. The area between this groove and the mesial branch of the buccal groove bulges slightly and gives a triangular shape with its tip upward.

Type 5 - Present 4

The triangular area is more strongly developed than in type 5.

Type 6 - Present 5

The protostylid is strongly developed so that the tooth seems to have an extra cusp on the buccal surface.

PREVIOUS INVESTIGATIONS

DAHLBERG (1945) proposed that Bolk's paramolar cusp be referred to as the protostylid. This trait was classified by HANIHARA (1961) into seven categories. Since there was no evidence of cusp formation in the first two types these were considered to be non-carriers of the protostylid trait. The remaining five types were considered to represent carriers of the trait. For ease of comparison the seven types were grouped into four classes: absent or trace - types 0+1; weak - types 2+3; distinct - types 4+5; and strong - type 6. Individuals carrying the distinct protostylid were considered by HANIHARA (1963) to be rare. The main population differences were observed in the types 2+3 that is in the weak protostylid class. The frequency of the weak class was significantly higher in the Japanese than in American-Whites and American-Negroes.

In the deciduous mandibular second molars the frequency of the protostylid is usually greater than in permanent molars. DAHLBERG (1950) found that whenever the protostylid was present on the permanent molar then the trait was also present on the deciduous second molar, the reverse situation however did not always occur. This fact was also confirmed by HANIHARA (1961) for the mixed dentition of Japanese children. Hanihara also found that the protostylid occurred more frequently in the deciduous than in the permanent molars.

Frequency data published by HANIHARA (1968) indicated that Mongoloid populations exhibited the protostylid trait in excess of 40 per cent, while in non-Mongoloid populations the frequency occurrence was usually below 20 per cent. Therefore a high frequency occurrence of the protostylid trait was regarded as a Mongoloid racial dental character. The frequency occurrence of the protostylid trait in seven populations was reported by HANIHARA (1968) and is summarized in Table 11 for comparison with the present study. There was also no significant sex difference for the occurrence of the protostylid.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the

Table 11

Frequency occurrence of the protostylid trait in the deciduous mandibular second molar - expressed as a percentage - in several population groups.

Population Group	Number	Protostylid Present	Protostylid Absent
Japanese +	152	44.7	55.3
Pima Indian +	118	89.0	11.0
Eskimo +	52	67.3	32.7
American-White +	55	14.5	85.5
American-Negro +	47	17.0	83.0
Japanese-American-White +	70	28.6	71.4
Japanese-American-Negro +	42	31.0	69.0
Australian Aboriginal ‡	218	16.5	83.5

\+ Data from HANIHARA (1968).

‡ Present study.

left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the protostylid is summarized in Table 11. The trait was present in 16.5 per cent of the 218 subjects investigated.

Discussion

Previous investigations did not reveal a side or sex difference for the occurrence of the protostylid trait. Results of the present investigation concur.

The frequency occurrence of 16.5 per cent in the Wailbri was not significantly different to that of the American-Whites nor to that of the American-Negro. The frequency did however differ significantly from the Mongoloid populations and from the Japanese hybrid populations. The trait when present in the Wailbri was predominantly of the weakly developed type.

SIXTH ACCESSORY CUSP

REFERENCE STANDARD

The sixth accessory cusp is located on the distal surface between the entoconid and the hypoconulid of the deciduous mandibular second molar.

In the present investigation variations of the sixth accessory cusp were classified as either present or absent. The type present is illustrated in Figure 10.

PREVIOUS INVESTIGATIONS

The sixth accessory cusp has also been referred to by the following names:-

Tuberculum accessorium posteriore internum;

Tuberculum sextum; and as

Cusp 6 (C6).

JORGENSEN (1956) preferred the term "C6" and reported the frequency occurrence of this accessory cusp in 736 deciduous mandibular second molars, in three populations. His findings were summarized in Table 12. The average frequency of the total material was 2.5 per cent for the right side and 2.9 per cent for the left side.

Table 12

Frequency occurrence of the sixth accessory cusp in the deciduous mandibular second molar - expressed as a percentage - in several Caucasoid populations. Data from JORGENSEN (1956).

Population Group	Number	Sixth Accessory Cusp Present	Absent
Medieval Danish			
Right side	38	2.6	97.4
Left side	39	5.1	94.9
Modern Danish			
Right side	213	2.3	97.7
Left side	213	2.3	97.7
Modern Dutch			
Right side	102	2.0	98.0
Left side	131	2.3	97.7

The frequency of the sixth accessory cusp in Japanese was reported by HANIHARA (1965) to be greater in the deciduous than in permanent mandibular molars. The frequencies of the sixth accessory cusp in five populations were reported by HANIHARA (1966b) and are summarized in Table 13 for comparison with those of the present study. The right tooth of each subject was used or where this tooth was absent the left tooth was used. The data obtained from males and from females were combined as there was no significant sex difference. The results summarized in Table 13 indicated that Mongoloid populations had frequencies in the order of 36 per cent while non-Mongoloid populations had frequencies less than 15 per cent. The sixth accessory cusp was considered to be a trait which varied in its frequency occurrence between populations, and was included as a dental character belonging to the Mongoloid dental complex.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the sixth accessory cusp is summarized in Table 13. The trait was present in 65.0 per cent of the 177 subjects investigated.

Table 13

Frequency occurrence of the sixth accessory cusp in the deciduous mandibular second molar - frequency expressed as a percentage - in several populations.

Population Group	Number	Sixth Accessory Cusp Present	Sixth Accessory Cusp Absent
Japanese +	92	36.9	63.1
Pima Indian +	117	36.8	63.2
Eskimo +	53	37.7	62.3
American-White +	55	7.3	92.7
American-Negro +	50	14.0	86.0
Australian Aboriginal ‡	177	65.0	35.0

+ Data from HANIHARA (1966b).

‡ Present study.

Discussion

The absence of a sex difference for the sixth accessory cusp is in agreement with other observations. The frequency of the sixth accessory cusp in the Wailbri is at present the highest reported frequency and differs significantly from all the other populations reported in Tables 12 and 13. Since the difference in the frequency between the Mongoloids and the Wailbri Aboriginals is so large the sixth accessory cusp must be considered as a racial character of the Australian Aboriginal.

SEVENTH ACCESSORY CUSP

REFERENCE STANDARD

The seventh accessory cusp is located on the lingual surface between the metaconid and the entoconid of the deciduous mandibular second molar.

The classification of HANIHARA (1961) in four types was used for the reference standard (see Figure 24).

Type 1 - Absent

No trace of the seventh cusp is observed.

Type 2 - Present 1

A very weak and short groove extends downward from the lingual ridge of the metaconid.

Type 3 - Present 2

The groove on the metaconid is more definite. A small cusp-like formation is present.

Type 4 - Present 3

The seventh cusp is well developed and looks like an independent accessory cusp. It is small when compared with either the metaconid or with the entoconid.

PREVIOUS INVESTIGATIONS

The seventh accessory cusp has in the past also been referred to by the following names:-

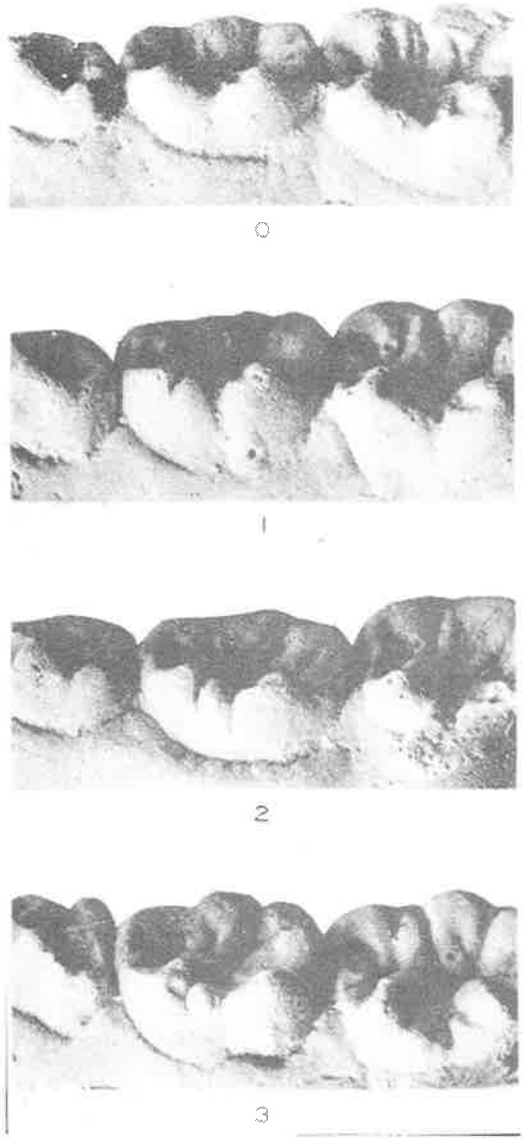


Figure 24. Variation of the Seventh accessory cusp in the deciduous mandibular second molar as illustrated on Plaque D9 from HANIHARA (1961)

median lingual accessory cusp;
tuberculum intermedium; and as
cusp 7 (C7).

The frequency of the seventh accessory cusp in 967 deciduous mandibular second molars was investigated by JORGENSEN (1956), his findings for three populations are summarized in Table 14. Jorgensen referred to the seventh accessory cusp as "C7" and stated that "the C7 was counted as a cusp only if its tip rose higher than the more or less pronounced secondary groove by which it was separated from the metaconid". It would appear that Jorgensen's data counted as present only types 3 and 4 of Hanihara's classification for the seventh accessory cusp.

The frequency of the seventh accessory cusp in five population groups has been reported by HANIHARA (1965, 1968). The frequencies for these five populations are summarized in Table 15 for comparison with those of the present study. The right tooth of each subject was used or where absent the left tooth was used. The data obtained from males and females were pooled as there was no significant sex difference. The occurrence of the seventh accessory cusp in Japanese deciduous mandibular second molars was found to be significantly correlated with the presence of the protostylid at the one per cent level, and at the five per cent level with the deflecting wrinkle.

No significant correlation was found between the occurrence of the seventh accessory cusp and the occurrence of the sixth accessory

Table 14

Frequency occurrence of the seventh accessory cusp in 967 deciduous mandibular second molars - expressed as a percentage - in several Caucasoid populations. Data from JORGENSEN (1956).

Population Group	Number	Seventh Accessory Cusp Present	Seventh Accessory Cusp Absent
Medieval Danish			
Right side	54	7.4	92.6
Left side	53	9.4	90.6
Modern Danish			
Right side	290	26.9	73.1
Left side	295	23.4	76.6
Modern Dutch			
Right side	120	13.3	86.7
Left side	155	13.5	86.5

cusp. In the Japanese the seventh accessory cusp appeared bilaterally with the same degree of development in most cases. The high degree of bilateral similarity was considered by HANIHARA (1965) as evidence for heritability of the seventh accessory cusp. Inter-population comparisons revealed that the frequency of the seventh accessory cusp was similar in the populations related to the Mongoloid race, but differed significantly from American-White and from the American-Negro. The trait was thus considered to be a variable inter-race character.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency occurrence of the seventh accessory cusp is summarized in Table 15. The frequency of the trait in 214 Wailbri subjects was 55.6 per cent.

Discussion

The absence of a sex difference for the seventh accessory cusp is in agreement with other studies. The frequency of the seventh accessory cusp in the Wailbri is significantly different from the

Table 15

Frequency distribution of the seventh accessory cusp in the deciduous mandibular second molar - expressed as a percentage - in several populations.

Population Group	Number	Seventh Accessory Cusp: Absent 1	Present 2	Present 3	Present 4	Present Total
Japanese +	156	26.3	49.4	23.1	1.3	73.7
Pima Indian +	118	27.1	46.6	21.2	5.1	72.9
Alaska Eskimo +	63	20.6	55.6	20.6	3.2	79.4
American-White +	54	59.3	33.3	7.4	0.0	40.7
American-Negro +	47	53.2	21.3	19.1	6.4	46.8
Australian Aboriginal ‡	214	44.4	30.4	18.2	7.0	55.6
		Absent	Present			
Japanese-American-White *	70	37.1	62.9			
Japanese-American-Negro *	41	29.3	70.7			

\+ Data from HANIHARA (1965).

* Data from HANIHARA (1968).

‡ Present study.

Japanese frequency, but is not significantly different from American Whites or American Negroes. The Wailbri frequency is closer to the American Negro frequency than to any of the other populations. Comparison with Jorgensen's data presents a problem because of the different classification used. If it is assumed that Types 3 and 4 of Harihara's classification are equivalent to Jorgensen's classification for the presence of a cusp then the frequency of Modern Danes would be within the Mongoloid frequency range. If however Type 2 were included then the Danish frequency would be well below that of American Whites. It is thus unwise to draw any final conclusions from the data of the Danish material relating to the seventh accessory cusp. The seventh accessory cusp should still be regarded as an inter-population variable character and a component dental character of the Mongoloid Dental Complex.

DEFLECTING WRINKLE

REFERENCE STANDARD

The deflecting wrinkle is the deflected configuration of the median ridge of the metaconid which shows a strong development in both length and breadth and curves distally at the central part of the occlusal surface to contact the hypoconid.

In the present investigation the classification of HANIHARA (1961) was used as the reference standard. The trait was classified as either present or absent. The type present is illustrated in Figure 12.

PREVIOUS INVESTIGATIONS

The frequency of the deflecting wrinkle in five populations was investigated by HANIHARA (1966). His findings are summarized in Table 16. The data obtained from males and females were pooled as there was no significant sex difference. The data contained in Table 16 showed that the Mongoloid populations had frequencies in excess of 70 per cent, whilst the American-Whites and the American-Negroes had frequencies below 20 per cent. The deflecting wrinkle was considered to be a variable inter-race character.

Table 16

Frequency distribution of the deflecting wrinkle in the deciduous mandibular second molar - expressed as a percentage - in several populations.

Population Group	Number	Deflecting Wrinkle Present	Deflecting Wrinkle Absent
Japanese +	201	71.6	28.4
Pima Indian +	115	84.3	15.7
Eskimo +	53	67.9	32.1
American-White +	54	13.0	87.0
American-Negro +	47	19.1	80.9
Japanese-American-White +	70	34.3	65.7
Japanese-American-Negro +	41	53.7	46.3
Australian Aboriginal ‡	176	27.3	72.7

+ Data from HANIHARA (1966b).

‡ Present study.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency distribution of the deflecting wrinkle is summarized in Table 16. The trait is present in 27.3 per cent of the 176 Wailbri subjects investigated.

Discussion

The absence of a sex difference in the deflecting wrinkle in the Wailbri was in agreement with other investigations. Compared with the values in Table 16 the Wailbri frequency was midway between that of the American-Negro and that of the Japanese American White hybrid population, the difference with each of these populations was not significant. The Wailbri frequency was however significantly higher than that of the American White and significantly lower than in the Mongoloid populations.

The close relationship between the metaconid ridge and the deflecting wrinkle indicates that further research of these traits is required. It would appear that a single classification for these two traits is required.

DISTAL TRIGONID CREST

REFERENCE STANDARD

The distal trigonid crest is found on the mandibular second molar. The distal trigonid crest is that structure which connects the tip of the metaconid with the protoconid without an interruption. This structure has also been referred to as "hintere Trigonidleiste".

The classification of HANIHARA (1961) in two types was used for the reference standard (see Figure 13).

Type Absent

There is no evidence of a crest connecting the tips of the metaconid with the protoconid.

Type Present

The distal trigonid crest is present, the occlusal surface is clearly divided into two parts, the trigonid and the talonid.

PREVIOUS INVESTIGATIONS

The frequency of the distal trigonid crest in five populations was reported by HANIHARA (1961), his findings are summarized in Table 17. Hanihara pointed out that the values showed a parallel relationship to the well developed central ridge of the metaconid. The trait was considered to be rare and variable within the Mongoloid race.

Table 17

Frequency distribution of the distal trigonid crest in the deciduous mandibular second molar - expressed as a percentage - in several populations.

Population Group	Number	Distal Trigonid Crest Present	Absent
Pima Indian +		17.8	82.2
Eskimo +		9.2	90.8
Japanese +		2.4	97.6
American-Negro +		0.0	100.0
American-White +		0.0	100.0
Australian Aboriginal ‡	172	13.4	86.6

\+ Data from HANIHARA (1961).

‡ Present study.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference.

The frequency distribution of the distal trigonid crest is summarized in Table 17. The trait was present in 13.4 per cent of the 172 Wailbri subjects investigated.

Discussion

Hanihara considered that the distal trigonid crest was a rare trait but he reported frequencies ranging from 2.4 to 17.8 per cent within the Mongoloid race. The trait was present in 13.4 per cent of the Wailbri. This frequency occurrence is therefore well within the Mongoloid range. The parallel relationship between the distal trigonid crest and the well developed metaconid ridge as found by Hanihara for the other Mongoloid populations does not hold true for the Wailbri. The results do however show that the trait can be considered a variable population character with an affinity towards the Mongoloids.

METACONID RIDGE

REFERENCE STANDARD

The metaconid ridge trait is formed by the well developed central ridge of the metaconid of the mandibular second molar.

In the present investigation the classification of HANIHARA (1961) in two types is followed for the reference standard, the type present is illustrated in Figure 15.

Type Absent

The central ridge of the metaconid is expressed similarly in size and prominence to that of the other cusp ridges.

Type Present

The central ridge of the metaconid is developed to a greater extent in both length and breadth than the cusp central ridges. The central ridge of the metaconid may be straight or it may exhibit a deflection distalward. Where the metaconid ridge is deflected the structure becomes homologous with the deflecting wrinkle.

PREVIOUS INVESTIGATIONS

The metaconid ridge and the deflecting wrinkle although classified as two traits do in fact occur on the same structure. The classifications for these two traits are based upon the size and shape of the metaconid ridge. The metaconid ridge must be strongly developed to be classified as the "metaconid ridge" trait, it may be either straight or deflected. The "deflecting wrinkle" trait occurs only when the metaconid ridge is deflected.

HANIHARA (1961) stated that the frequencies of the well developed metaconid ridge, or the so called deflecting wrinkle showed distinctive population differences. The frequencies of the metaconid ridge in five populations was reported by HANIHARA (1961), his findings are summarized in Table 18. The data in the table show a much higher frequency of the trait in Japanese than in American Whites or in American Negroes. The hybrid populations were reported by HANIHARA (1963) to show frequencies which were intermediate to the parental population.

PRESENT INVESTIGATION

Results

There was no significant difference between the right and the left side frequency. The frequency of the trait on the right side showed no significant sex difference. The frequency distribution of the metaconid ridge is summarized in Table 18. The trait was present in 27.6 per cent of the 181 Wailbri subjects investigated for this trait.

Table 18

Frequency distribution of the metaconid ridge in the deciduous mandibular second molar - expressed as an approximate percentage - in several populations.

Population Group	Number	Metaconid Ridge Present	Metaconid Ridge Absent
Pima Indian +		84	16
Eskimo +		73	27
Japanese +		58	42
American Negro +		20	80
American White +		11	89
Japanese-American-White *	70	34.3	65.7
Japanese-American-Negro *	41	53.7	46.3
Australian Aboriginal ‡	181	27.6	72.4

\+ Data from HANIHARA (1961).

* Data from HANIHARA (1963).

‡ Present study.

Discussion

In the present study there was no significant side or sex difference for the frequency of the metaconid ridge. Previous investigations did not explore for a side or sex difference. However, studies of the homologous structure the deflecting wrinkle showed that there was no frequency difference for side or sex. In view of this, the present results can be assumed to be in accord with the findings of other investigators. The frequency of the metaconid ridge in the Wailbri is higher than in American-Whites and American-Negroes, but is lower than in the Japanese. The frequency is however similar to that of the Japanese-American hybrids. However, accurate comparisons are difficult since the frequency data reported by HANIHARA (1961) are only approximate and since the data for the hybrid groups are treated together with the deflecting wrinkle data.

This trait can be regarded as a trait which varies significantly in its frequency occurrence between different populations. The frequency in the Wailbri is between that of Mongoloids and Caucasoids.

The relationship between the metaconid ridge and the deflecting wrinkle has already been dealt with previously.

COMBINATION OF TRAITS

Of the twelve dental characters studied in this section the six most frequently occurring were selected in order to examine the combination and the number of traits in each subject.

Results

Table 19 shows the combinations of the six most frequently occurring traits in 142 subjects of the total sample of 242. Only in the 142 subjects could all six traits be classified as either present or absent. Notwithstanding the smaller sample size the frequency occurrence of individual traits does not differ significantly from the population frequency. Table 19 also shows that thirty-three of a possible 64 combinations were observed.

Table 20 shows the distribution of subjects according to the number of traits observed to be present. The mean number of traits per subject was 2.5. Either two or three traits were found to be present in 58.5 per cent of the subjects and between one and four traits in 93.0 per cent.

Discussion

The results confirmed that the most frequent combination: double tubercle / sixth accessory cusp / seventh accessory cusp, was formed from the three most frequently occurring traits. Unfortunately the distribution of combinations could not be compared with other

Table 19

Combinations of the six most frequently occurring traits in 142 subjects in whom all six traits could be classified as either present or absent.

Combination	Number of Subjects	°/₀	Combination	Number of Subjects	°/₀
A	14	9.9	ACEF	2	1.4
AB	12	8.5	ABCDE	1	0.7
AC	10	7.0	ABCEF	2	1.4
AD	5	3.5	ABCDEF	1	0.7
AE	3	2.1	B	3	2.1
ABC	17	12.0	BC	8	5.6
ABD	4	2.8	BD	5	3.5
ABE	3	2.1	BCD	1	0.7
ABF	2	1.4	BCE	1	0.7
ACD	5	3.5	BDF	1	0.7
ACE	3	2.1	BCDE	3	2.1
ACF	1	0.7	C	1	0.7
ABCD	9	6.3	CD	1	0.7
ABCE	8	5.6	CDE	1	0.7
ABCF	5	3.5	D	2	1.4
ABDF	1	0.7	......	6	4.2
ACDE	1	0.7			

A, double tubercle; B, sixth accessory cusp; C, seventh accessory cusp; D, deflecting wrinkle; E, protostylid; F, Carabelli's cusp; ...... , all six traits absent.

Table 20

Distribution of subjects according to the number of traits observed to be present in Wailbri subjects.

Number of Traits	Number of Subjects	Total Number of Traits	°/₀
0	6	0	4.2
1	20	20	14.1
2	44	88	31.0
3	39	117	27.5
4	29	116	20.4
5	3	15	2.1
6	1	6	0.7
	142	362	100.0

populations since data were not available for comparison. It would have been interesting to allocate arbitrary values to the various combinations in order to quantify the combinations to produce a frequency distribution with a mean and standard deviation. The comparison of the mean and standard deviation between any two populations could then be applied to discriminate between any two populations.

Similarly it might be possible to determine the probability, based upon the dental traits, of an individual belonging to a specified population.

CORRELATION OF TRAITS

The relationships between the eight most frequently occurring traits were assessed to determine the degree of association occurring between paired combinations.

Results

Table 21 shows the coefficients of linear correlation computed between paired combinations of eight traits. The following four pairs of traits were found to be significantly correlated: Carabelli's tubercle - protostylid; protostylid - seventh accessory cusp; sixth accessory cusp - seventh accessory cusp; and the metaconid ridge - deflecting wrinkle.

Discussion

Of the 28 correlation coefficients calculated four were found to be significant. At the five per cent level of probability one significant correlation coefficient for every twenty calculated would be expected. Since four in 28 were observed it would appear that some factor other than chance was involved.

The significant correlation coefficient for the occurrence of Carabelli's tubercle and the protostylid is interesting as both of these traits occur on homologous cusps in opposing jaws. With a value of 2.6 per cent for the coefficient of determination the biological significance of the correlation coefficient must be considered as being of a low order.

Table 21

Results of Correlation Coefficients (r). A, double tubercle; B, sixth accessory cusp; C, seventh accessory cusp; D, deflecting wrinkle; E, protostylid; F, Carabelli's tubercle; G, metaconid ridge; H, double fold.

	A	B	C	D	E	F	G	H
A	-	-.07	.06	-.15	.10	.09	.00	.12
B		-	.18*	-.02	.05	.14	.03	.13
C			-	.00	.18**	.09	.04	.06
D				-	.01	-.04	.34**	-.01
E					-	.16*	.07	.00
F						-	.12	.09
G							-	-.01
H								-

* Significantly different from zero at 5 per cent level.

** Significantly different from zero at 1 per cent level.

The correlation coefficient between the protostylid and the seventh accessory cusp was statistically significant. However, the coefficient of determination with a value of 3.2 per cent implies that the biological significance is of a low order. A significant correlation coefficient for the occurrence of the protostylid and the seventh accessory cusp was also reported by HANIHARA (1965b) to exist in the Japanese. It would appear that there is a common factor influencing the occurrence of the protostylid and the seventh accessory cusp in both the Japanese and the Wailbri Aborigines of Australia, even though the protostylid is not as well developed in the Wailbri as in the Japanese.

The biological significance of the correlation coefficient between the sixth and seventh accessory cusps is difficult to evaluate because of the low value of the coefficient of determination, 3.2 per cent. However, the relationship is interesting since both of these traits are accessory cusps on the deciduous second molar, and both occur with a high frequency in the Wailbri. A genetic analysis of these two traits is therefore indicated to further explore their association.

Since the protostylid was significantly correlated with both the Carabelli's tubercle and the seventh accessory cusp it could be expected that the occurrence of Carabelli's tubercle and the seventh accessory cusp should also be correlated. Similarly since the seventh accessory cusp was significantly correlated with the protostylid and with the sixth accessory cusp it could be expected that the protostylid and the sixth accessory cusp should show a significant correlation coefficient. Such significant correlations were not detected, probably because the existing correlations were only of a low order.

The significant correlation coefficient between the well developed metaconid ridge and the deflecting wrinkle was not unexpected since both traits were directly related to the metaconid. In view of this, these two traits should be reinvestigated with a view to evaluating the current classifications. A single classification might, in fact, be more appropriate.

The significant correlation coefficients detected for the Wailbri although showing low coefficients of determination did have several features in common. Firstly, they were only found between traits occurring on the deciduous second molar. Secondly, the coefficients occurred between traits regarded as accessory cusps. It would appear that there is a common factor influencing the occurrence of accessory cusps in the deciduous second molar of the Wailbri.

CHAPTER 5

POPULATION DIFFERENCES

The tooth crown characters investigated in this study are found in all present-day human populations. However, the frequency occurrence varies because of genetic differences. Populations within a race show closer similarities than populations between races. Since it is unlikely that a specific dental trait will be found exclusively in a given race, to refer to a trait as "racial" merely implies that it occurs with a higher frequency in one race than another.

The objective of this section is to determine whether the Wailbri population can be distinguished from other populations on the basis of variation in deciduous tooth crown morphology.

PREVIOUS INVESTIGATIONS

There are two ways of interpreting population frequency data. The first method is to take each trait separately and compare its frequency in the different populations. This method has been used by many investigators and has resulted in traits being labelled as racial. For example, the shovel shape and protostylid characters are well known as Mongoloid racial characters. Similarly a high frequency occurrence of the well developed Carabelli's tubercle is regarded as a Caucasoid racial character. The disadvantage of this method is that an overall picture of the two populations under comparison is not always seen.

The second method is to look at the total morphological pattern of the population. HANIHARA (1966b) proposed the term "Mongoloid dental complex" for the combination of crown characters which show relatively high frequencies in Mongoloid populations but not so in other populations. The five deciduous crown characters included in the Mongoloid dental complex were: shovel shape, protostylid, deflecting wrinkle, sixth accessory cusp and the seventh accessory cusp. In formulating a "Caucasoid dental complex" HANIHARA (1966a, 1966b) included two characters, Carabelli's tubercle and a metric character which he named the "Canine breadth index". The value of this index was used as a dental character which showed distinct racial differences. Generally the value of the index remained at about 100 for non-Caucasoid populations and exceeded 105 for Caucasoid populations.

HANIHARA (1967) urged that further studies should be carried out on other racial or population groups, for example the Negroid dental complex has not been investigated.

Figure 25 is taken from HANIHARA (1968). It shows the frequency distribution of crown characters comprising the Mongoloid and Caucasoid dental complexes.

PRESENT INVESTIGATION

In order to compare the frequencies of the deciduous dental traits of the Wailbri Aboriginals with those of other populations the literature published by Hanihara was reviewed. The data for the Wailbri Aboriginals were obtained from the results of Section 4.

Differences in the frequency occurrence of traits in various populations reflect genetic differences. The differences in a pair of populations can be summed and used as a measure of the genetic distinctiveness or divergence between that pair of populations. In order to estimate the "measure of divergence" between any pair of populations a multivariate distance statistic based upon the frequency of eight traits was calculated. The formulae used for the calculations were described in Section 3.

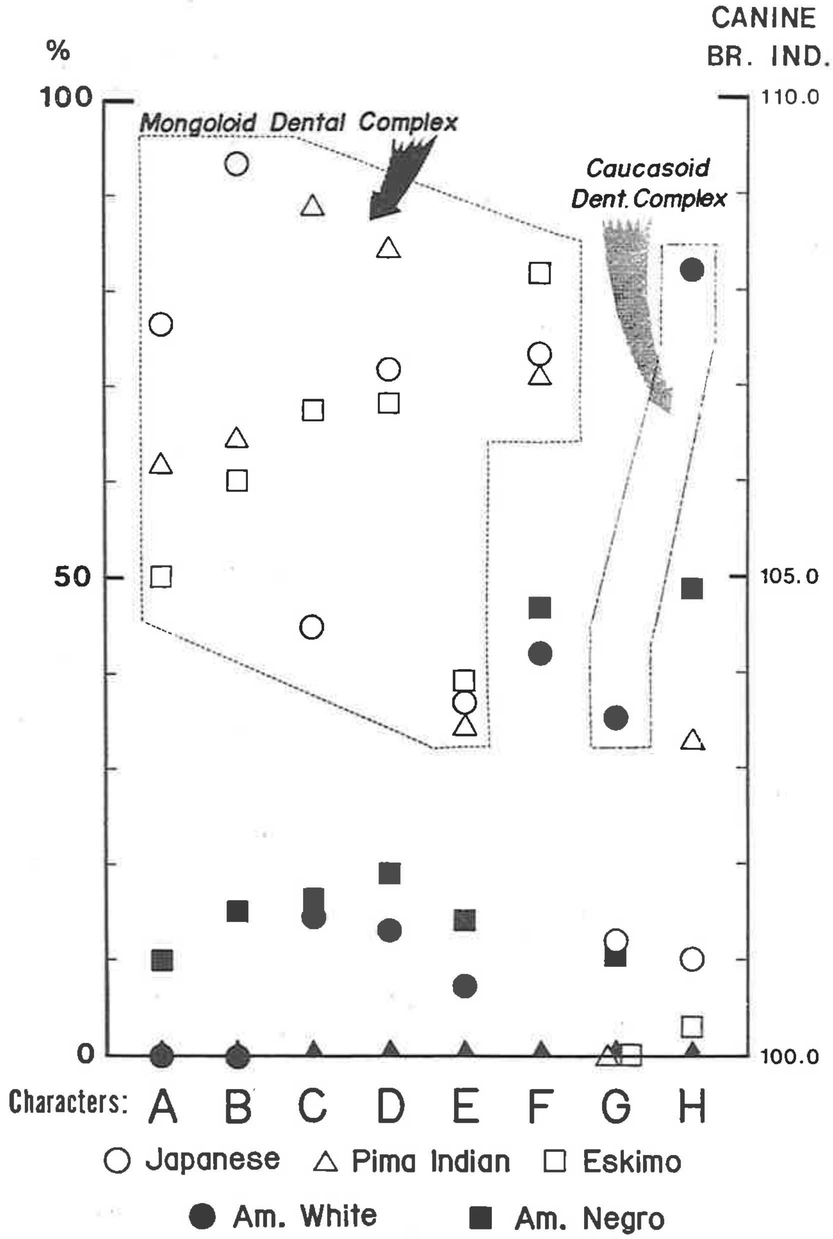


Figure 1. Frequency distributions of the crown characters composing Mongoloid and Caucasoid dental complexes.
(Characters: A, Shovel-shape in i^1; B, Shovel-shape in i^2; C, Protostylid in m_2; D, Deflecting wrinkle in m_2; E, 6th cusp in m_2; F, 7th cusp in m_2; G, CARABELLI's cusp in m^2; H, Canine breadth index in c^u.)

Figure 25. Frequency distribution of the crown characters comprising Mongoloid and Caucasoid dental complexes, as published by HANIHARA (1968)

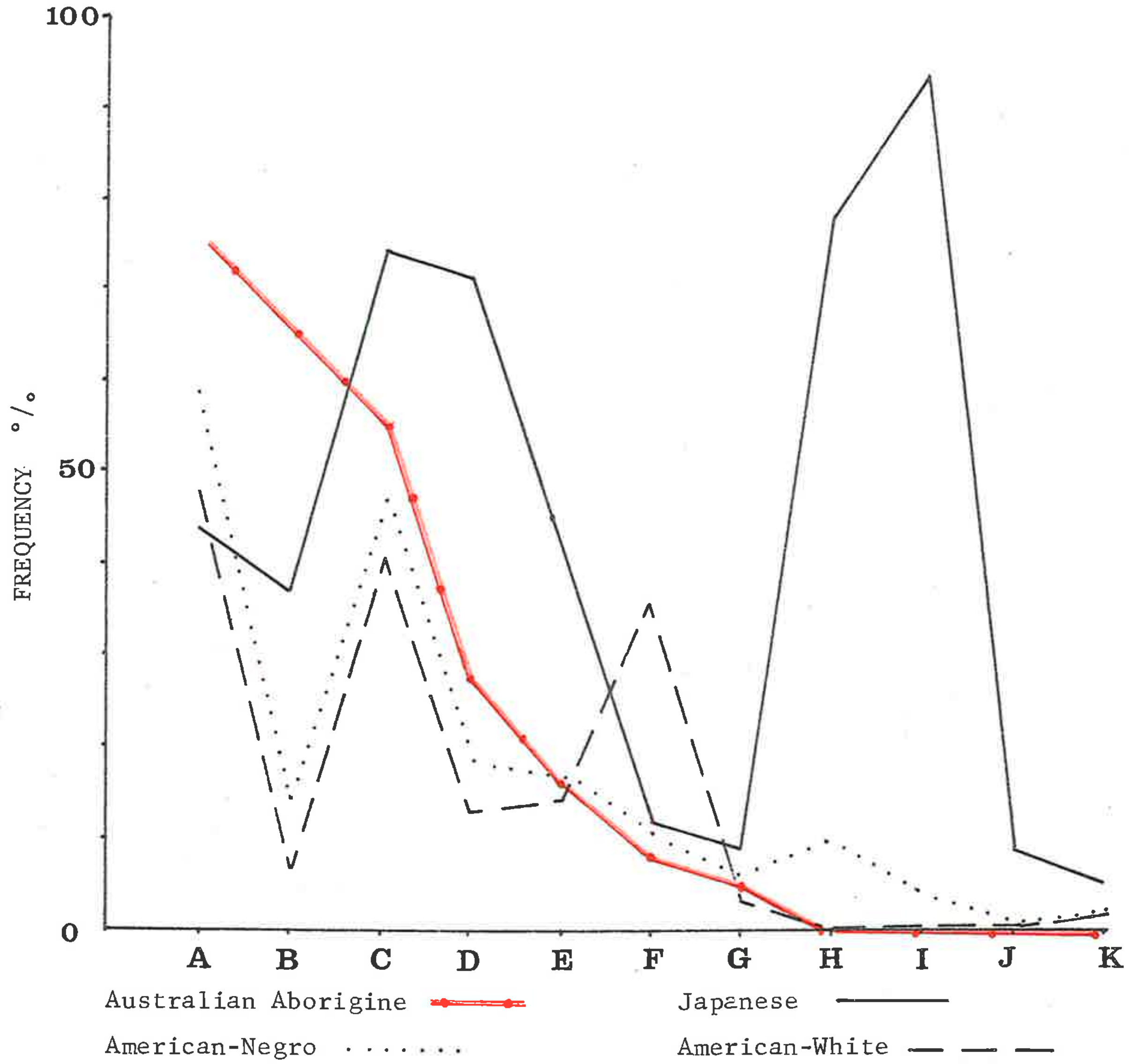


Figure 26. Profile curves illustrating the frequency distribution of deciduous crown characters in four populations. A , double tubercle; B , sixth accessory cusp; C , seventh accessory cusp; D , deflecting wrinkle; E , protostylid; F , Carabelli's cusp; G , double fold; H , shovel shape in tooth 51; I , shovel shape in tooth 52; J , shovel shape in tooth 53; K , shovel shape in tooth 83

Results

Table 22 shows the frequency data for three populations compared with findings for Australian Aborigines of the present study. In each of the populations - Japanese, American-Negro, American-White and Australian Aborigines - the same eight characters were compared: double tubercle, sixth accessory cusp, seventh accessory cusp, deflecting wrinkle, protostylid, Carabelli's tubercle, double fold, shovel shape in tooth 51, tooth 52, tooth 53 and in tooth 83. The data of Table 22 are also shown diagrammatically in Figure 26 which represents profile curves.

The Australian Aborigines are characterized by a high frequency occurrence of the double tubercle and of the sixth accessory cusp. The Japanese can be distinguished from the other three populations by the high frequency occurrence of the seventh accessory cusp, deflecting wrinkle, protostylid and the shovel shape trait in the maxillary central and lateral incisor. The frequencies for American-Negro and American-White populations are similar to each other except for the Carabelli's tubercle.

Table 23 shows the means and variances of divergence measures computed from the data of Table 22 by the method described in Section 3. The estimates of the biological distances recorded in Table 23 are also shown diagrammatically in Figure 27. The results indicated that the Wailbri could be distinguished from the Japanese, American-Negro

Table 22

Population frequency data used in the calculation of the biologic distance between pairs of populations.

Trait	Tooth Code	Population Frequency			
		Japanese	American Negro	American White	Australian
Double tubercle	53	.438	.588	.480	.751
Sixth accessory cusp	85	.369	.140	.073	.650
Seventh accessory cusp	85	.737	.468	.407	.556
Deflecting wrinkle	85	.716	.191	.130	.273
Protostylid	85	.447	.170	.145	.165
Carabelli's tubercle	55	.119	.118	.357	.084
Double fold	83	.090	.064	.042	.057
Shovel shape	51	.766	.100	.000	.000
Shovel shape	52	.933	.048	.000	.000
Shovel shape	53	.086	.000	.000	.000
Shovel shape	83	.055	.021	.020	.000

Table 23

Mean measure of divergence and variance between pairs of populations calculated by the C.A.B. Smith method.

Populations compared	Mean	Variance
Aust Abo - Japanese	1.237 *	.089
Aust Abo - Am White	.230 *	.020
Aust Abo - Am Negro	.156 **	.027
Am Negro - Japanese	.841 **	.198
Am Negro - Am White	.045 ns	.019
Am White - Japanese	1.361 **	.246

* Significantly different from zero (p = 0.01)

** Significantly different from zero (p = 0.05)

ns Not significantly different from zero

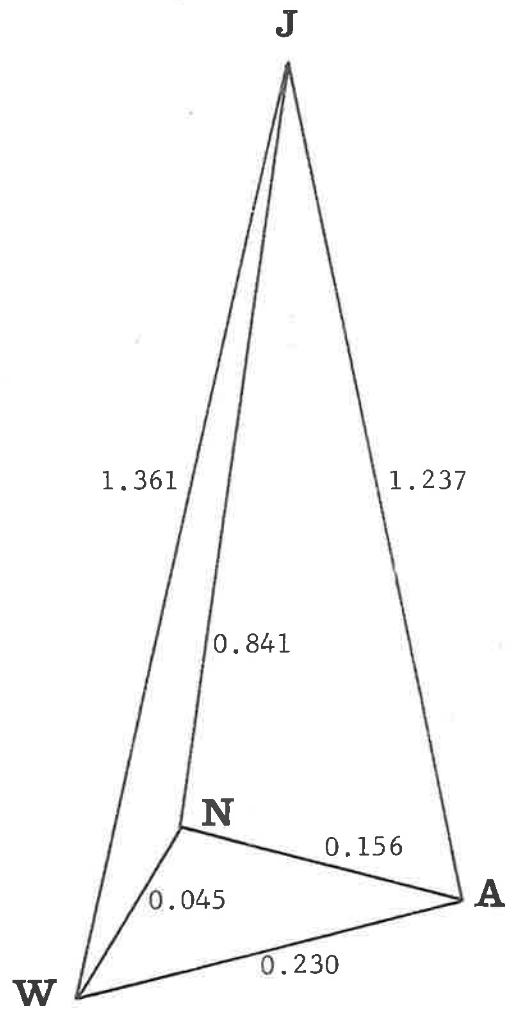


Figure 27. Diagram showing the estimates of biologic distance between Japanese (J), American-Negroes (N), American-Whites (W), and Australian Aborigines (A). Diagram not drawn to scale

and from the American-White populations. The greatest divergence was found to occur with the Japanese and the least with the American-Negro. The biological distance between the American-Negro and the American-White populations was not significantly different.

Discussion

In the Wailbri the frequency of the double tubercle is 75.1 per cent and the sixth accessory cusp is present in 65.0 per cent of subjects. These frequencies exceed by 16.3 and 28.1 per cent respectively the highest reported frequencies. The sixth accessory cusp was considered by Hanihara to be a Mongoloid racial trait. In view of the present findings this trait should be regarded as a racial trait of the Australian Aborigines, in addition this trait also shows a very high frequency occurrence in the permanent dentition. Therefore these two traits can be regarded as racial traits for the Wailbri and can be used to formulate a dental character complex for the Wailbri.

Physically the Australian Aborigines were considered by ABBIE (1966) to be an exceptionally homogeneous people. On this assumption the Wailbri dental complex could be used as the basis for the Australoid dental complex. However, KIRK (1965) reviewed the distribution of genetic markers in Australian Aborigines and found significant differences between populations of Aborigines and between geographical areas within the Australian continent. Therefore, before the Wailbri dental complex is accepted as representative of the

Australoid dental complex, other Australian aboriginal populations should be investigated to either confirm or modify the Australoid dental complex.

Of the eleven traits used to calculate the estimate of biologic distance only three pairs of traits were significantly correlated at the five per cent level and of these only one pair at the one per cent level. Since the coefficient of determination was very low a virtual absence of correlation could be accepted. Therefore, it was permissible to sum individual measures of divergence in order to calculate the mean measure of divergence.

The estimate of the biologic distance showed that the greatest divergence occurred between the Japanese and the Wailbri Aboriginals of Central Australia. This indicates that of the three populations which were compared with the Wailbri the Japanese showed the least similarity.

The least divergence occurred between the Wailbri and the American-Negro, and after the American-Negro the American-White population was the population closest to the Wailbri. Both of these populations were however significantly different to the Wailbri. The biologic distance between the American-Negro and the American-White was not significantly different. Thus with regard to the deciduous dental morphology the Wailbri show a greater affinity towards the American-Negro and to the Caucasoids than towards the Mongoloids.

The similarity between the American-White and the American-Negro can be explained by the fact that the American-Negro population has a proportion of American-White admixture. It would appear then that the African-Negro's dental characteristics might show an even closer similarity to the Wailbri Aborigines of Central Australia.

To test this hypothesis the African Negro's deciduous dentition should be investigated.

Conclusions

The frequency occurrence of the double tubercle and of the sixth accessory cusp were such as to allow the Wailbri to be distinguished from other populations. These two traits were used to formulate the Wailbri dental complex.

The Wailbri dental complex was proposed as the basis to estimate the Australoid dental complex.

The mean measure of divergence was calculated to express an estimate of the biological distance between the Wailbri and three other population groups. The results revealed that the Wailbri could be distinguished from the Japanese, American-Negro and from the American-White populations. The Wailbri showed the greatest affinity to the American-Negro and the least affinity with the Japanese. Since the biological distance between the American-Negro and American-White was not significantly different it was condluded that the Australian Aboriginal had a closer affinity to Caucasoids than to Mongoloids.

The true Negro racial deciduous dental characteristics are not known and thus require investigation.

CHAPTER 6

GENETIC ANALYSIS

Mendel's discovery of genes accounted for the sharply defined segregation of phenotypes in single factor inheritance. Traits inherited in this manner are referred to as qualitative. When two or more forms of the one trait occur frequently in a population, the trait is termed polymorphic. In man polymorphism has been detected by a variety of methods for studying the phenotype. For example, immunologic methods have revealed the ABO red cell blood groups and the gamma globulin groups of human serum. Enzymatic methods have demonstrated the difference in red cell glucose-6-phosphate dehydrogenase. Electrophoretic methods have been used to demonstrate polymorphism of haemoglobin and of the serum proteins.

Attempts to study genetically determined morphological characters have presented problems, since it has been difficult to find morphologic traits that occur with a high frequency and at the same time present in a clearly "discontinuous form". For example, at first sight morphological characters such as hair colour and eye colour in man, appear to show qualitative variation which is under simple genetic control. However, close investigation of these characters has shown that there is continuous variation of colour rather than clearly defined individual colours and that their inheritance is not under simple Mendelian control. It would seem that there are major genes determining colour but their effects are modified by those of a number of other genes.

In man a morphologic trait may be highly variable among individuals of a population. The reasons for this are that: first, a number of genes are involved. Second, genetic traits that are subject to considerable modification by the effects of genes other than the primary one, and also to environmental influences, may not be recognizable in some individuals despite the fact that they have the gene that "causes" the trait. In such cases the trait or gene is said to be non-penetrant. This phenomenon occurs at the mild end of the curve of expressivity. Penetrance and non-penetrance may however be a function of the accuracy of the method of determining the trait, since the threshold of penetrance may often be difficult to determine.

There is a large number of traits that are known to be inherited but do not manifest themselves as sharply defined pairs of phenotypes. Body height, weight and tooth size are examples of quantitative characters which show a continuous range of variation in a population. Multifactor, or polygenic, inheritance can explain the inheritance of these quantitatively-graded characters.

Knowledge of the inheritance of the morphological variation of tooth crown characters is limited, especially with regard to deciduous teeth. This lack of knowledge is primarily due to the shortage of suitable pedigree data, coupled with a disagreement between investigators regarding the criteria of dental traits. Due to the lack of pedigree data most of the evidence supporting inheritance of tooth crown characters has been based upon differences in population frequency, the high degree of concurrence between right and left side teeth, and the similarity of the expression of crown characters in monozygous twins.

The objective of the investigation detailed in this section was to carry out a genetic analysis on five selected tooth crown characters in ways permitted by the limited data available.

PREVIOUS INVESTIGATIONS

Of the crown characters investigated in this study only the presence of Carabelli's trait and of the seventh accessory cusp have previously been reported to be under simple Mendelian genetic control. Carabelli's trait was regarded to be under the control of two allelic autosomal genes without dominance and the seventh accessory cusp was regarded as a dominant character.

a. Carabelli's Trait

There is a general lack of concurrence regarding the morphological features which constitute Carabelli's trait. This trait may take the form of either a tubercle of varying size or a pit and or groove. This has produced obstacles to the study of its frequency distribution, comparison with other populations, and the mechanism if inheritance. There is however general agreement that a high frequency of Carabelli's tubercle is a racial characteristic of Caucasoids.

A hypothesis of two allelic autosomal genes without dominance has been advanced by KRAUS (1951) to account for the inheritance of Carabelli's trait in Caucasoids, but only if the slight tubercle, groove and pit are considered variable expressions of a heterozygous genotype. A persual of phenotypic frequencies in samples of the three major stocks of man suggests that this hypothesis is not adequate to explain all the observations.

The frequency of Carabelli's pit in deciduous teeth shows a different frequency distribution to that of the tubercle. Whereas the tubercle occurs with a high frequency in Caucasoids the frequency of Carabelli's pit was shown by HANIHARA (1963) to exhibit almost no racial difference. This evidence was regarded by HANIHARA (1963) as demonstrating a different pattern of inheritance of Carabelli's tubercle and pit. He held the opinion that Carabelli's tubercle was a dominant character under the control of a simple Mendelian gene with incomplete penetrance.

b. Seventh Accessory Cusp

A hypothesis that the seventh accessory cusp was a dominant character under single gene control was suggested by HANIHARA and MINAMIDATE (1965). Since pedigree data for the deciduous dentition were not available, the hypothesis was based upon the comparison of the population frequency of this trait in American-Whites, American-Negroes, Japanese, and in the Japanese-American-White and Japanese-American-Negro hybrid populations. In the populations observed the frequency of the trait was not inconsistent with the hypothesis. They also estimated the penetrance of the trait to be 99.7 per cent in the Japanese and accepted this as additional evidence of heritability.

PRESENT INVESTIGATION

The tooth crown characters: double tubercle, sixth accessory cusp, seventh accessory cusp, Carabelli's trait and protostylid were classified using the reference standards as specified in Section 4. The right tooth was used since the difference between the right and the left side frequency occurrence was not statistically significant. The frequency data for males and females were combined because the sex difference was not statistically significant. Since parent-child pedigree data were not available, all sibs were paired. Sibships of three were regarded as 1.5 sib-pairs and sibships of four as two sib-pairs. Table 24 summarizes the population frequency of each trait and the number of sib-pairs available for the sib analysis.

Method of Analysis

The sib-pairs were first analysed to determine whether the observed proportion of like sibs differed significantly from that expected. Designating the probability that the trait was present as 'p' and the absence as (1-p), the expected proportions of sib-pairs having 0, 1 and 2 members showing the trait was deduced by the application of the binomial distribution. Thus the expected number of sib-pairs belonging to each category was calculated as:-

Table 24

Summary of sib-ship data and population frequency data of selected traits used for the genetic analysis. N = number of subjects in the total sample.

Trait	Population Frequency		Sibship Size			Total Sib-pairs
	°/₀	N	2	3	4	
Double tubercle	75.1	205	31	9	2	48.5
Sixth accessory cusp	65.0	177	21	7	3	37.5
Seventh accessory cusp	55.7	214	29	9	5	52.5
Protostylid	16.5	218	31	8	5	53.0
Carabelli's trait	79.2	226	33	8	5	55.0

Both present = $p^2.n$

Present-Absent = $2.p(1-p).n$

Both absent = $(1-p)^2.n$

where p = population frequency of the trait

n = number of sib-pairs.

A trait which is inherited would be expected to occur more frequently in a family than in the general population. If the trait is not inherited then the presence or absence of the trait should occur at random among sib-pairs. The absence of a significant difference between the observed and expected number of like sib-pairs, under the hypothesis that the presence or absence of the trait occurred at random among the sib-pairs, was tested using the Chi square test of statistical significance. The five per cent level of probability was used to accept or reject the hypothesis.

In the second analysis the sib-pair data were tested to determine whether they were consistent with the hypothesis that the presence or absence of the trait was determined by a single Mendelian autosomal gene. The estimate of the gene frequency for each trait was obtained from the sibship frequency data.

Traits due to a single autosomal gene with dominance can be analysed on the basis of sib-pair data without knowing the parents, COTTERMAN (1937). The method is to compare the observed proportions of the three types of sib-pairs with their theoretical frequencies.

Thus a trait which could be classified as either present or absent in an individual could in a two child sibship produce one of three types of sib-pairings, for example - present-present, present-absent or absent-absent. The type and frequency of the sib-pair which could occur are determined by the type of parental mating, and are summarized in the table below.

Frequencies of sib-pairs in a random mating population where there is dominance.

Type of Mating	Frequency of Mating	Type of Sib-pair: Pres - Pres	Pres - Abs	Abs - Abs
PPxPP	p^4	p^4	...	...
PPxPp	$4p^3q$	$4p^3q$	...	...
PPxpp	$2p^2q^2$	$2p^2q^2$	...	...
PpxPp	$4p^2q^2$	$9/4p^2q^2$	$3/2p^2q^2$	p^2q^2
Ppxpp	$4pq^3$	pq^3	$2pq^3$	pq^3
ppxpp	q^4	...	...	q^4

The table shows that if 'P' (present was dominant to 'p' (absent), there would be only three phenotypic types of sib-pairs, disregarding the order of birth. The expected number of each type of sib-pair was obtained by summation:

$$\text{Present-Present} = (p^4 + 4p^3q + 2p^2q^2 + 9/4p^2q^2 + pq^3).n$$

$$\text{Present-Absent} = (3/2p^2q^2 + 2pq^3).n$$

$$\text{Absent-Absent} = (p^2q^2 + pq^3 + q^4).n$$

where p = gene frequency of the dominant trait

q = $(1-p)$

n = number of sib-pairs.

The method used to obtain an estimate of 'p' was to calculate the square root of the observed frequency of the double recessive, the value obtained was equal to (1-p).

The hypothesis that there was no significant difference between the observed and the expected number of the three types of sib-pairs based on the genetic assumption of a single gene with dominance was tested using the Chi square test of statistical significance. Since the sample of sib-pairs was small, it would be expected that the Chi square test in which the expected number of any type of sib-pair numbered less than five, would suffer considerable inaccuracy. Therefore, expected groups numbering less than five would be combined with one of the other groups. The number of degrees of freedom used in entering the probability table of Chi square values was one, because the expected values were adjusted so as to conform with the observations in two respects:- the total number of sib-pairs (n) and the parameter 'p'. The alternative hypothesis that the trait was inherited as a recessive character was tested in a similar way. The five per cent level of probability was applied to accept or reject the hypothesis. An important limitation of the 'Cotterman Method' is that, except for very extensive data, it is not always possible to distinguish whether the presence or absence of a trait is actually the dominant trait, even when the hypothesis of unit factor inheritance has been confidently established.

Results

Table 25 summarizes the results of the intra-familial variability analysis. The results indicate that the observed proportions of concordant sib-pairs did not differ significantly from expected values. But, in all cases, the number of sib-pairs which were alike for the character exceeded the expected number.

Table 26 summarizes the results of the sib-pair analysis. The observed distribution of the three types of sib-pairs for the double tubercle, sixth accessory cusp, protostylid and for Carabelli's trait did not differ significantly from that expected under the hypothesis that the presence of the trait is a dominant character controlled by a single gene. The observed distribution for the presence of the seventh accessory cusp does not fit the hypothesis.

Table 27 summarizes the results of the sib-pair analysis. The data for the double tubercle and for the seventh accessory cusp do not fit the hypothesis that the presence of the trait is a recessive character under single gene control. The data for the sixth accessory cusp, protostylid and for Carabelli's trait are not inconsistent with the hypothesis that the presence of the trait is a recessive character under the control of a single gene.

Discussion

A trait which occurs more frequently in a family than in the population from which the family was selected may indicate that the

Table 25

Results: Intra family variability analysis. Alike - both sibs are identical with regard to the presence or absence of the trait. Not alike - the trait is present in only one sib. Observed (O), expected (E) - on the hypothesis that the character shows random combination in sib-pairs.

Trait	O/E	Sib-pairs Alike	Sib-pairs Not alike	Total Sib-pairs	χ^2_1
Double tubercle	O	35.5	13.0	48.5	
	E	35.1	13.4		0.84*
Sixth accessory cusp	O	27.5	10.0	37.5	
	E	23.8	13.7		1.56*
Seventh accessory cusp	O	32.5	20.0	52.5	
	E	28.3	24.2		1.57*
Protostylid	O	42.0	11.0	53.0	
	E	38.0	15.0		1.49*
Carabelli's trait	O	43.0	12.0	55.0	
	E	40.0	15.0		0.83*

* Difference not significant at the p = 0.05 level

Table 26

Results: Sib analysis - distribution of the three types of sib-pairs, observed (O) and expected (E) with regard to the presence (P) and absence (A) of the trait. Trait present in both sibs (PP), trait present in only one sib (PA), trait absent in both sibs (AA). Hypothesis - trait is dominant, and under single gene control.

Trait	O/E	Sib-pair			Total	χ^2_1
		PP	PA	AA		
Double tubercle	O E	34.0 36.5	13.0 8.1	1.5 3.9	48.5	3.58*
Sixth accessory cusp	O E	23.5 24.5	10.0 8.0	4.0 5.0	37.5	0.74*
Seventh accessory cusp	O E	23.5 27.2	20.0 13.5	9.0 11.8	52.5	4.27**
Protostylid	O E	3.5 5.2	11.0 7.6	38.5 40.2	53.0	2.08*
Carabelli's trait ‡	O E	40.0 41.4	12.0 9.1	3.0 4.5	55.0	0.38*

* Difference not significant at the p = 0.05 level

** Difference significant at the p = 0.05 level

‡ Presence of trait = tubercles, grooves and pits

Table 27

Results: sib analysis - distribution of the three types of sib-pairs, observed (O) and expected (E) with regard to the presence (P) and absence (A) of the trait. Trait present in both sibs (PP), trait present in only one sib (PA), trait absent in both sibs (AA). Hypothesis - trait is recessive, and under single gene control.

Trait	O/E	Sib-pair			Total	χ^2_1
		PP	PA	AA		
Double tubercle	O	34.0	13.0	1.5	48.5	
	E	37.1	6.8	4.6		6.57**
Sixth accessory cusp	O	23.5	10.0	4.0	37.5	
	E	25.0	7.0	5.5		1.69*
Seventh accessory cusp	O	23.5	20.0	9.5	52.5	
	E	27.6	12.7	12.2		5.64**
Protostylid	O	3.5	11.0	38.5	53.0	
	E	4.5	9.0	39.5		1.35*
Carabelli's trait ‡	O	40.0	12.0	3.0	55.0	
	E	42.2	7.7	5.1		3.38*

* Difference not significant at the p = 0.05 level

** Difference significant at the p = 0.05 level

‡ Presence of trait = tubercles, grooves and pits

trait is inherited, or that there is a familial tendency. However, in a large population the frequency of sib-pairs having 0, 1 or 2 members showing an inherited trait can be deduced by application of the principle of random combination. The results of the intra-familial variability analysis showed that the observed proportion of alike sib-pairs for each of the five traits did not differ significantly from that expected on the basis of random combination. This finding indicates that the presence or absence of each of the five traits investigated occurred at random. But, in all cases, the number of sib-pairs which were alike for the character, or for absence of the character, exceeded the expected number. Under a random hypothesis it would be expected that either an excess, the expected number, or a deficiency of alike sib-pairs should occur among the five traits. However, in the present study all five traits showed an excess of alike sib-pairs, the chance of this occurring is $(\frac{1}{2})^5$ = 1 in 32. Since the sample size for each trait was about fifty sib-pairs a probability of 1 in 32 would indicate that not all of the five traits occur at random.

Since extensive pedigree data were not available the hypotheses that the traits were inherited as either dominant or recessive characters under the control of single genes were tested by the method advocated by COTTERMAN (1937). The estimate of the gene frequency for each trait was obtained by calculating the square root of the frequency of the double recessive. The data contained in Table 26 show that the observed number of the three types of sib-pairs for the double tubercle, sixth accessory cusp, protostylid and for Carabelli's trait did not differ significantly from that expected under the hypothesis that the trait was a dominant character under single gene control. The observations for the seventh accessory cusp did not fit the hypothesis.

The data in Table 27 show that the double tubercle and seventh accessory cusp cannot be regarded as recessive characters under single gene control. The data for the sixth accessory cusp, protostylid and for the Carabelli's trait are not inconsistent with a hypothesis of recessive inheritance under single gene control. From the results contained in Table 26 and Table 27, the inheritance of the sixth accessory cusp, protostylid and the Carabelli's trait are not inconsistent with both dominant and recessive inheritance. This can be explained by the fact that unless very extensive data are available the 'Cotterman Method' will not always distinguish whether the presence or absence of the trait is the dominant character. In addition the power of analysis to differentiate between dominance and recessiveness is limited and thus leads to indecision because of the high frequency occurrence of each trait. Although the results were unable to indicate whether presence of the trait is dominant or recessive they are consistent with the proposition that the traits are under single gene control. The presence of the double tubercle fits the dominant but not the recessive hypothesis. With regard to the seventh accessory cusp a previous investigation HANIHARA and MINAMIDATE (1965), based upon comparative population frequency data, concluded that the presence of this trait was a dominant character under single gene control. The results of the present investigation do not support this conclusion, but support the hypothesis that the trait occurs at random in the population.

Previous investigations concluded that the presence of Carabelli's tubercle was under the control of a single gene. The hypothesis of two allelic autosomal genes without dominance was advanced by KRAUS (1951) to account for the inheritance of Carabelli's trait, but only if the slight tubercle, groove and pit were considered as variable expressions of the heterozygous genotype. In the present investigation the number of pronounced tubercles was too small for an adequate analysis. Hence presence of Carabelli's trait was regarded as all types of tubercles, grooves and pits. The Cotterman analysis supported the single gene hypothesis but did not differentiate whether presence of Carabelli's trait was a dominant or recessive trait.

Summary

The presence of all of the five traits analysed was not inconsistent with the hypothesis that the characters occurred at random among the population, but in all of the five traits the observed number of concordant sib-pairs exceeded the expected values. It was concluded that not all of the five traits occur at random.

Evidence was also available that the double tubercle, sixth accessory cusp, protostylid and Carabelli's trait could be under the control of a single gene and that the presence of the double tubercle was a dominant trait. Evidence for the seventh accessory cusp indicated this character to occur at random in the sample investigated.

However it should be pointed out that the present sample was too small to be able to draw a precise conclusion. It is recommended that collection of dental morphological data continue in order to gain information relating to the second generation. This would enable comparisons to be made of parent-offspring relationships. For example, if both parents lack the trait then on a random occurrence hypothesis the offspring should show the trait with a frequency not significantly dissimilar to the population frequency. If on the other hand presence of the trait is a dominant character than parents without the trait should not produce offspring with the trait. It is also recommended that second generation data would be more useful than trying to obtain a larger sample size.

SUMMARY AND CONCLUSIONS

The aims of the present investigation were:

(1) to determine the extent of dental morphological variation in a tribe of Australian Aborigines for the following traits - shovel shape, lingual tubercle, double tubercle, double fold, Carabelli's trait, mandibular second molar occlusal groove pattern, protostylid, sixth accessory cusp, seventh accessory cusp, deflecting wrinkle, distal trigonid crest and the metaconid ridge;

(2) to select a set of dental characters descriptive of the population;

(3) to compare the results with other studies;

(4) to conduct a limited genetic analysis for selected traits.

The deciduous dental casts of 139 males and 103 females of pure aboriginal ancestry belonging to the Wailbri tribe were examined for the presence or absence of twelve deciduous dental traits. The dental casts were examined under an illuminated magnifier and each trait was compared with a reference standard. The observations were recorded and the data were stored on punched cards. A double determination was carried out. The second determination was made without reference to the recordings obtained in the first determination. A third determination was carried out to correct the errors detected by the double determination. The bulk of the data were analysed using a CDC 6400 electronic computer. Each trait was analysed for right and left side variation in males and females. As there was no significant difference between the right and left side frequency in males and in females the tooth on the right side was used to determine the frequency of the trait. Where the right tooth was absent or damaged the left tooth was used. As there was no significant sex difference, the data obtained from males and females were pooled.

The frequency occurrence of the deciduous dental traits are as follows:-

Trait	°/₀ Frequency
Shovel shape	
Maxillary central incisor	0.0
Maxillary lateral incisor	0.0
Maxillary canine	0.0
Mandibular canine	0.0
Lingual tubercle	
Maxillary incisors	0.0
Maxillary canine	1.9
Mandibular canine	10.7
Double tubercle	75.1
Double fold	5.7
Carabelli's trait	
Tubercles	8.4
Grooves	66.4
Pits	4.4

Trait	°/₀ Frequency
Occlusal groove pattern in tooth 85	
Y pattern	96.9
+ and X pattern	3.1
Protostylid	16.5
Sixth accessory cusp	65.0
Seventh accessory cusp	55.6
Deflecting wrinkle	27.3
Distal trigonid crest	13.4
Metaconid ridge	27.6

The combinations of the presence or absence of all six of the most frequently occurring traits were examined. A total of 142 subjects were available in whom all six traits could be recorded as either present or absent. The mean number of traits per subject was 2.5 and between one and four traits were present in 93.0 per cent of the subjects. The most frequent combination: double tubercle / sixth accessory cusp / seventh accessory cusp, was formed from the three most frequently occurring traits.

Coefficients of linear correlation were computed between paired combinations of eight traits. Four pairs of traits were found to be significantly correlated, these were: Carabelli's tubercle - protostylid, protostylid - seventh accessory cusp, seventh accessory cusp - sixth accessory cusp and the metaconid ridge - deflecting wrinkle. These four correlation coefficients although significant showed a low coefficient of determination. The interesting aspect of these correlation coefficients was that the first three were accessory cusp formations on the deciduous second molar. However, since all the coefficients of determination were of a low order the biological significance was difficult to assess. The last significant correlation coefficient was not unexpected since both traits occur on the central ridge of the metaconid. The classification of these two traits should be reviewed with a view to producing a single classification.

Examination of the variable inter-race deciduous dental characters revealed that the Wailbri could be distinguished from all other populations by the high frequency occurrence of two traits, the double tubercle and the sixth accessory cusp. It was proposed that these two traits be used to establish the Wailbri dental character complex which in turn could be used as the basis for the Australoid dental character complex.

Interpopulation differences were analysed using multivariate biological distance statistics. The frequency data relating to eight deciduous dental traits which were identical for each population were used to calculate the estimate of the biological distance between any two populations. The Wailbri were found to differ significantly from the Japanese, American-Negro and from the American-White populations. The largest biological distance was between the Wailbri and the Japanese and the smallest occurred with the American-Negro. Since the biological distance between the American-Negro and American-White population was not significantly different it was concluded that the Australian Aboriginal had a closer affinity to Caucasoids than to Mongoloids. An investigation of the African Negro's deciduous dentition is now required to determine the Negro dental complex thereby establishing the dental complexes for the four major racial groups.

Since extensive pedigree data for the deciduous dentition were not available, a limited genetic analysis was carried out using sib-pairs. The results indicated that individually the presence of the double tubercle, sixth accessory cusp, seventh accessory cusp, protostylid and Carabelli's trait occurred at random among the population. However, as a group of five traits the observed number of concordant sib-pairs exceeded expected values, indicating that perhaps not all of the five traits occur at random. The sib analysis indicated that the double tubercle, sixth accessory cusp, protostylid and Carabelli's trait could be under the control of a single gene and that the presence of the double tubercle was a dominant trait. The sib analysis for the seventh accessory cusp indicated this character to occur at random. It was pointed out that the present sample was too small to be able to draw a precise conclusion. A recommendation was made that collection of dental morphological data continue in order to gain information relating to the second generation, since this would enable parent-offspring comparisons to be studied. It was further recommended that second generation data would be more useful than trying to obtain a larger sample.

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