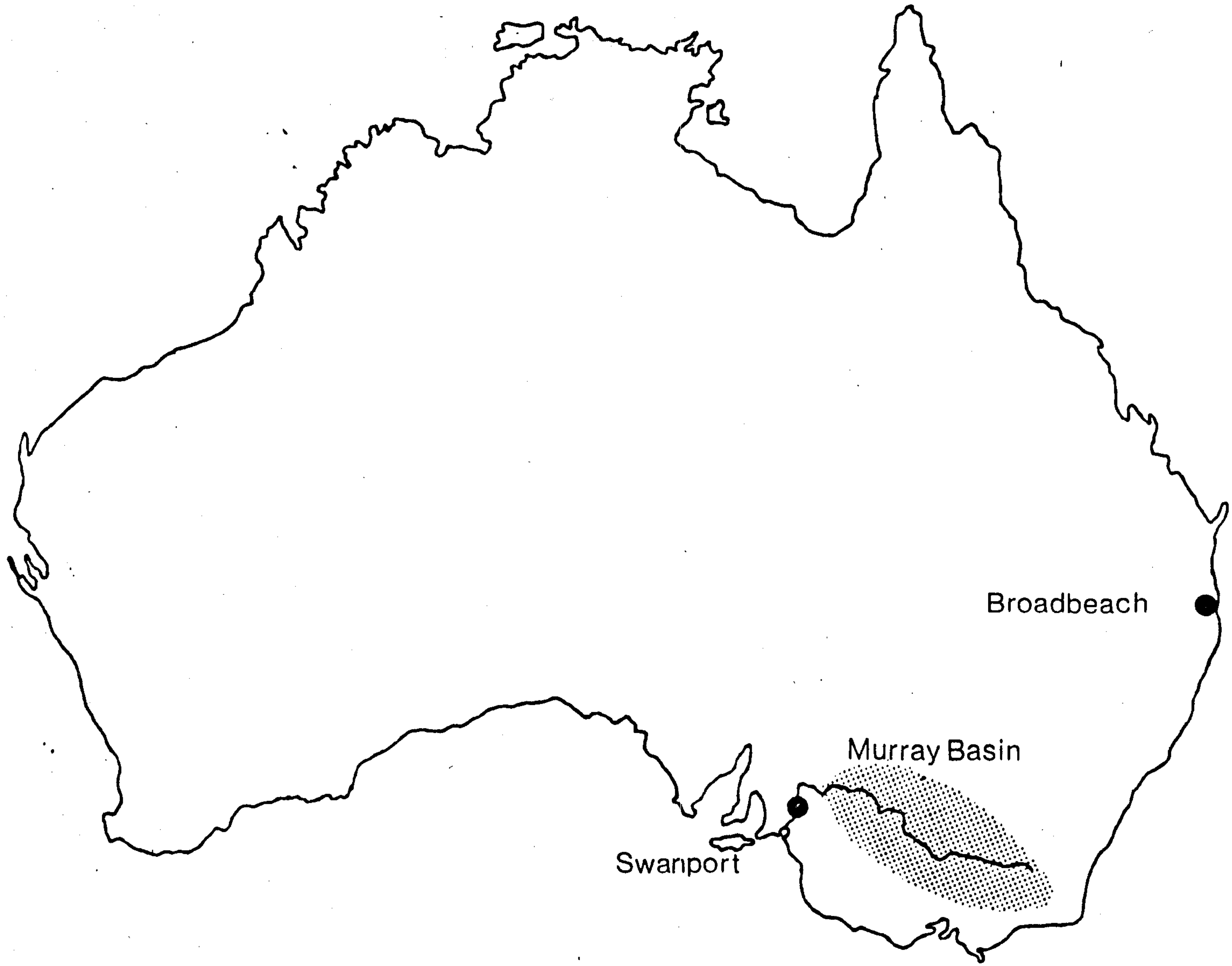

Australia Showing Locations of Populations Studied

AUSTRALIAN ABORIGINAL IMMATURE DENTITION

by

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A Thesis Submitted in Partial Fulfillment

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Australian Aboriginal Immature Dentition

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ABSTRACT

This is a study of the dentition of precontact Australian aborigines from three geographical areas -- Swanport, the Murray Basin, and Broadbeach. The individuals sampled from these areas include adults and juveniles.

The major questions examined are the relationships between environment, diet, tooth size, sex, age and possible industrial use of teeth, and the rate and degree of dental attrition. The methods used in the investigation of these questions were: 1. to use dental formation stages revealed by radiography to determine age at death of the juveniles; 2. to measure all teeth to calculate mean tooth sizes for each site; 3. to assess degree of dental attrition by the application of a 14 point ordinal scale of tooth wear stages.

Rates of tooth wear were determined by calculation of the gradient of wear of the deciduous and permanent molars (wear of first molar minus wear of second molar), and by regression analysis of wear against functional age of second deciduous molars, and permanent molars and incisors. Pattern of wear was determined by comparing anterior wear (first incisor) with posterior wear (first molar).

Deciduous teeth displayed the same rates of wear for all three sites when analysed by molar wear gradient, but regressive analysis showed Swanport to have the most rapid wear. In the permanent dentition the Broadbeach juveniles exceeded the Swanport juveniles in rate of molar wear, though Broadbeach teeth exceeded those of the other sites in length but not in width. There were no significant differences in the molar wear gradients for adults between the sites.

Anterior teeth were worn relative to posterior teeth very much more in Swanport males and adolescents, and Murray Basin males and females than in Broadbeach males and females and Swanport females. Environment and diet were examined and did not reveal a likely cause for this difference in attrition pattern.

Ethnographically observed industrial use of teeth, specifically in the preparation of fibre cord and manufacture of fishing nets, is proposed as the cause of this differential tooth wear between the Murray River sites and the Queensland coastal site of Broadbeach.

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INTRODUCTION

In the study of human evolution teeth have achieved an extraordinary anatomical priority. They are the hardest structures of the body, so they preserve well and sometimes constitute the whole of the fossil remains which anthropologists have to study.

The growth and ultimate form of teeth are under genetic control. Their morphology can be used to assess biological affinity between populations. They are also subject to environmental influences, to a degree exceeding that commonly believed (Brown and Townsend 1980), and that in two ways. Firstly, the developing teeth, both before and after birth, are subject to nutritional, chemical and disease influences (Bailit and Sung 1968; Schour 1938; Preston 1980; Townsend and Brown 1980; Barden 1980; Potter and Nance 1976).

Erupted teeth contact the environment directly. Consequently the dietary, cultural and industrial effects of this contact may be imprinted on the teeth. In this way they reflect behaviour of people who wear, extract, and utilize their teeth in different ways.

This is a study of the immature dentition of Australian aborigines from three geographical areas, which will be introduced in Chapter 1. It is primarily a study of dental attrition, that is, the wearing of teeth that results from the eating of abrasive or tough foods, utilisation of teeth as tools, and buxism, the non-masticatory grinding of teeth. Strictly speaking, attrition refers only to tooth wear occasioned by tooth to tooth contact, as in bruxism, and food to tooth contact is called abrasion. In this study, as the two forms of wear cannot be distinguished, all tooth wear is described by the word attrition.

The study of dental attrition is valid and useful for anthropologists as it reveals cultural information. It is applicable to living and fossil populations, and it can reveal behaviour of individuals and hence lead to a better understanding of the societies they form. These revelations result from observations on a number of levels. Overall degree of tooth wear can convey information on diet, and in a comparison between populations one may infer characteristics of the respective diets. In looking at differences in wear between adults and children it may be revealed that adults have patterns of tooth wear that probably result from use of teeth as tools. If children lack a characteristic pattern of wear, usually of the anterior teeth, it indicates that they have not adopted adult industrial/craft tasks. The same comparisons can be made between the sexes, and these may reveal sexual division of industrial/craft tasks or sexual differences in diet.

There is evidence for the use of anterior teeth as tools. Brace (1964) claimed that the heavy anterior tooth wear of Neanderthals resulted from their use of these teeth as tools. However, Wallace (1975) disagreed and claimed that examination of the teeth surfaces indicated wear caused by grit in food. Gould (1968) reported the aborigines of the interior of Australia to use their incisors to chip stone tools for sharpening. Merbs (1968) reported high anterior tooth loss in Eskimos due to accidental trauma occasioned by their use as tools in a variety of ways. Turner and Calien (1969) found frequent pressure chipping in teeth of high arctic Eskimos resulted from applying heavy crushing force, and while frequently found among adults, was rarely seen in children. Schultz (1977) provides evidence of industrially caused grooves on the anterior teeth of California Indians, and Hinton (1981) provides examples of Eskimos and Australian aborigines using anterior teeth as tools.

Dental attrition in Australian aborigines has been little studies, but there has been notable work. Campbell (1925, 1939) pioneered investigation of attrition, and he was followed by Begg (1954) and Heithersay (1960). All of these researchers used a four stage attrition scale devised by Broca. Campbell and Begg described attrition levels, but Heithersay calculated rates of attrition throughout life. He studied living people and was able to calculate an attrition index based upon the complete dentition. Richards and Brown (1981) calculated rates of attrition of first and second molars. They used dental casts of subjects of known age and an attrition scoring system which was not an ordinal stage scale.

This previous work, though of great value, has usually been limited to adults and to one part of the mouth, even to a single tooth. The present work extends the study of dental attrition to include juveniles and a systematic analysis of contributing variables.

A Systematic Approach to the Study of Dental Attrition

Many variables affect the degree, rate and pattern of dental attrition, the most important being tooth size, diet (which depends upon environment and economy), age, sex and industrial/craft utilisation of teeth. Tooth size: the size of teeth affects attrition. Larger teeth, given a constant work load of whatever kind, will wear less than smaller teeth because the work is spread over a greater area of tooth surface. The same amount of tooth mass may be removed, but the larger teeth will be less reduced as functioning structures. Tooth size depends upon two major dimensions, the mesio-distal or length, and the bucco-lingual or width. The ratio of length to width of teeth is not constant between populations or individuals. Tooth width is the more reliable dimension in assessing size as length is severely reduced by advanced attrition. Male teeth are on average larger than female teeth and given a constant work load would wear less. However, pattern of wear rather than degree of wear would reveal differences in industrial/craft tasks between the sexes. In this form of analysis variables that contribute to tooth wear can be controlled and a determination can be made of which variables are producing which wear.

Diet: the environment and the economic lifestyle of people determine their diet. Diet affects attrition in a fundamental way. The major function of teeth is to predigest food by mastication. The nature of food chewed -- its fibrous, coarse, tough or gritty qualities -- largely detemines degree of tooth wear.

Industrial/Craft Tasks: as already mentioned, the use of teeth as tools in industrial/craft activities causes tooth wear. This type of wear affects the anterior, or front, teeth as these are the ones which are accessible to such purposes. These activities may wear the teeth gradually, as in women chewing hides to soften them, or may chip and crack the teeth as in men sharpening stone tools.

Age: the effects of age upon attrition may come from two sources. Children may eat less, and different items of diet, especially 'prestige' foods. Children, especially young ones, would not engage in regular industrial/craft tasks.

Sex: attrition may or may not be affected by sex. There may be dietary differences between the sexes. Campbell (1939a) reports such differences in diet between aboriginal men and women. Sexual division of industrial/craft tasks which utilise teeth as tools also affects attrition patterns between the sexes.

Other variables, such as enamel thickness and hardness, affect dental attrition. It has not been possible in this study to control these factors.

The above variables may operate upon individuals within groups or populations, or they may follow patterns for whole populations which characterise them and distinguish them from other populations.

Observations upon these variables allow one to make certain predictions, and the analysis done in this research followed these predictions:

1. The different environments and resources of the populations studied would produce different diets and thus different degrees of dental attrition.
2. If differences in pattern of dental attrition occurred between the sexes they would result from industrial/craft task division.
3. If industrial/craft tasks affected dental attrition the adults would exhibit different patterns of wear than the juveniles. At a certain age, probably around adolesence, juveniles would adopt these adult tasks and begin to show the characteristic tooth wear associated with it. Possible adult/juvenile dietary differences would affect degree not pattern of attrition.
4. If the patterns of tooth wear differed between sites, that is, if one site had a characteristic type of tooth wear, it would be an industrial/craft activity producing that pattern. This would be evident if the young juveniles failed to exhibit the characteristic wear pattern.

To make this sort of analysis it was necessary to determine ages at death of juvenile individuals, determine the sizes of the teeth of the populations studied, and calculate the attrition levels of all the teeth. Chapter 2 deals with determination of age at death of juveniles, Chapter 3 deals with tooth size, and Chapter 4 deals with dental attrition.

The study reported here, because it considers many variables which contribute to dental attrition, and because it is one of very few studies to comprehend juveniles as well as adults, will lead to an increased understanding of dental attrition in general. It will particularly contribute to the understanding of dental attrition among Australian aborigines. The study of Australian aborigines facilitates the understanding of tooth wear generally. Aborigines are hunter-gatherers employing the same economy in vastly different environments in Australia. They thus provide a valuable opportunity to observe the effects of environment upon dental attrition. There are reasonably good samples of aboriginal remains from populations inhabiting wide-spread and diverese environments, and they include large numbers of juveniles. Australian aborigines are therefore ideal subjects for this type of research.

CHAPTER 1

BACKGROUND

Until the coming of British colonists to New South Wales in 1788, Australia was the only continent inhabited exclusively by hunter-gatherers. The aborigines afford a unique opportunity to study human adaptations to a wide range of environments; adaptations which were based upon an economy common to all human societies until the end of the Pleistocene.

Aborigines inhabited environments ranging from the central deserts to the lush river valleys of the South-east, from the tropical beaches and rainforests of Queensland to the cold, wet mountains of Tasmania. Their resources and population densities varied enormously, and so did their physical appearance. Aboriginies have been in Australia at least 30,000 and probably 50,000 years (Thorne 1980).

There is a consensus among modern writers that the original migrants came from South-east Asia, but there are different views on the dynamics of settlement. Basically there are two opposing views: modern aborigines are the descendants of a single settlement of a homogeneous population and observable physical variation is a result of adaptation to local environments and to random genetic effects (Abbie 1975, 1976); or, more than one migration of morphologically distinct peoples occurred at different times and this is evidenced by the high level of variability in modern aborigines.

This second view comprehends at least two opposing models. Birdsell (1977) continues to claim that three population waves -- Oceanic Negritos, Murrayians, and Carpentarians -- entered Australia sequentially and that these stocks are still discernible in modern aborigines. This model is largely discredited (Thorne 1980).

Thorne believes that in the Pleistocene two morphologically distinct peoples inhabited Australia: a gracile form represented by fossil human remains from Lake Mungo, and a robust form represented chiefly by fossils from Kow Swamp and Cohuna. These forms lie at the extreme ends of the gracile-robust range of variation of modern aborigines. They are seen as in some way blending at some time after 10,000 B.C. (Thorne and Wilson 1977; Thorne 1981).

It is also possible that small groups of people have been trickling into Australia over the millennia and have contributed to the cultural and genetic pool. This may be evidenced by the contact with Papuan melanesians in Cape York and along the Gulf of Carpenteria.

This study was not intended to contribute to these debates nor does it, but my own view is that two fossil populations are discernible, and it is reasonable to believe that at least small numbers of people entered Australia from time to time. Clearly the samples from the three areas studied represent modern aborigines.

The Sites

This study deals with skeletal samples from three geographical areas; two are from excavated burial sites. (see frontispiece map).

Swanport.

Swanport is on the lower Murray River about 60 km. from the sea and 20 km. from the river's entrance into Lake Alexandrina in South Australia. The site is just north of 36^{o} S. A large number of skeletons was exposed by workmen in 1911 (Sterling 1911) and the study sample is of ten adults (5 female, 5 male) and thirty-two juveniles. The graves were highly concentrated on the river bank adjacent to an area of swamp, but they were not excavated under scientific supervision (Stirling 1911). The people of this area were a component of a tribal nation known as the Ngarrindjeri, a confederation made up of eighteen tribes, each with its own territory (Jenkin 1979; Richards personal communication 1981).

The Ngarrindjeri area centered upon the Murray River and Lake Alexandrina, but it included more than a two hundred kilometer stretch of shore of the Southern Ocean, including all of the Coorong, an extensive area of coastal lakes and swamps. It was a very lush and productive habitat for hunter-gatherers.

The Ngarrindjeri were a distinct people with their own language which had no common words with that of the Kaurna, their northern neighbours (Jenkin 1979). They had distinct cultural and ritual practices which divided them from their neighbours. The mountains to the west were the eastern limit of the circumcision rite and this difference in a critical ritual practice reflected an enmity with the neighbouring Kaurna. Nor did they like the eastern neighbours, the Merkani who had a reputation for stealing and eating fat women. Their territory was geographically defined, to the north-west by mountains, to the north-east by a dry hinterland, and to the south by the ocean (Richards personal communication 1981).

It is believed that the excavated burials at Swanport are of people who died during a smallpox epidemic which came down the Murray River in 1830 (Richards pers. comm. 1981; Sterling 1911). Smallpox was possibly introduced in 1788 by

British settlers in Sydney. Certainly it ravaged widespread aboriginal populations in the early 1830's. This means the sample studied is of a people living together at a given time and is an ideal population for biological study. Epidemics may not usually kill proportional numbers of the age and sex classes in a society. Disease affects vulnerable individuals -- the aged, the sickly, the very young -- disproportionately. However, a very severe epidemic like smallpox contacting a population with no previous experience of it may have ravaged the whole group indiscriminately. The Swanport sample seems to represent all age and sex classes. The Ngarrindjeri nation as a whole is what Howells (1973) referred to as "a well-defined local population".

The juvenile sample was increased with individuals from other places within Ngarrindjeri territory, thus there are seventeen from Swanport and fifteen from elsewhere. It represents one overall population, but different local habitats.

The Murray Basin

There is a large amount of skeletal material collected in the area of the Murray River basin by Murray Black over several decades in the first half of this century. The material has no real provenience as Black merely recorded the general location of the specimen, and in the latter part of his collecting days he failed to do that much. The area from which this collection is taken is a large part of south-eastern Australia centered on the Murray River and its tributaries.

Brace (1980) and Giles (1976) whose studies comprehended samples of the Murray Black collection treated the Murray Basin group as a population. Brace, in discussing this material, says the following:

> Except for that which is obviously permineralized, the best that we can do is to guess that most of the specimens belong to a loose 'ethnographic present' extending back from the point of contact about 2,000 years" (Brace 1980 p. 160).

Certainly the Murray Basin people since contact have been looked upon as a biological unit. They are the heart of Birdsell's "Murrayians", one of the posited distinct founding populations that produced the tri-hybrid modern aborigines (Birdsell 1967, 1977).

My view is that the Murray Black samples can be looked upon as modern, south-eastern riverine aborigines who have a similar environment and economy. I treat them as a population though I am aware that this can only be valid in a loose sense. The sample consists of sixteen adults (9 female, 7 male) and forty juveniles.

Broadbeach

An aboriginal burial ground was located at Broadbeach, 1.5 km. inland from the present beach in extreme south-east Queensland precisely on the 29° S parallel.

Several burials were disturbed by soil contractors before the site could be excavated by Laila Haglund from 1965 to 1968. Overall 150 individuals were recovered of whom 60% are juvenile (Freedman & Wood 1977).

The site is described by Haglund as follows:

> The burial ground is located about 1.5 kilometers inland from the present-day coastline at Mermaid Beach, southeast Queensland. The coastal stretch in this area consists of a sandy beach, 60 meters wide in places, running almost due north from rocky outcrops at South Nobby and Burleigh Heads, terminating in a spit, formed by the northward drift of sand, which keeps turning the mouth of the Nerang River to the north. Behind the foredune is a well-developed series of parallel dunes with seams of mineral sands. Still further inland is the lower part of the coastal plain, consisting of broad sandy flats and swamps and

> narrow belts of swamp alternating with low sandy ridges. The latter curve in the same way as the parallel beach dunes. The almost flat top of one of these narrow ridges became the burial ground. The highest point of this is about 4 meters above sea level and only about 1-1.5 meters above the surrounding low-lying marshy area (Haglund 1976, p.1).

The burial ground was in use for about a thousand years ending last century (Haglund 1976, p. 55).

The Broadbeach site is in an area inhabited by the Nerang or Kombumerri clan. Clans in this area were comprised of fifty or sixty people (Haglund 1976). This territory extended back from the coast for about 30km. and occupied about 30km. of the coast from a line of hills in the south to include a narrow strait betwen the mainland and Stradbroke Island in the north.

Haglund (1976, p. 55) sees evidence for cultural continuity for the period during which the burial ground was used in the burial types and ritual details. There was very probably a society of people living in the area over that time with the late burials being the descendants of the early ones. This is a population sampled over time and is in contrast to Swanport which is a sample of a population living at one time. This means that any comparison is one of two sample types and this should be considered.

Broadbeach appears to be a selective sample of the population. Sixty percent of those represented are juvenile while adult males outnumber adult females by seven to one. Early Europeans in the area noted a preponderence of male aborigines, and Beveridge (1883) states that in southern New South Wales the preponderence of males was very considerable. This he ascribed to the early death of many women effected by very young maternity, their conversion into beasts of burden, their brutal ill-usage, and their husbands "very often killing them outright in their ungovernable periods of passion" (Beveridge 1883, p. 22).

It is unlikely, however, that so high a preponderence of males as represented at Broadbeach was actually to be found in the living society. Perhaps females were usually buried elsewhere, or were disposed of in a different manner. Beveridge indicates that in the Murray Basin females were buried with less care and ritual.

The sample of this study consists of fifteen adults (10 males; 5 females, the whole number of females for the site) and thirty-nine juveniles.

For the three populations all available juveniles were studied. Adults were studied for comparison and these represented a proportion of those available. As close as possible to equal numbers of males and females were selected, and the individuals were chosen randomly. See Appendix A for details of the site samples.

The next chapter discusses ageing of the juvenile individuals. The determination of individual age at death is necessary for the calculation of rates of attrition and relative degree of attrition between populations.

CHAPTER 2

Determination of Individual Age at Death: Tooth Eruption and Development

This chapter deals with determining the ages at death of the immature individuals of the samples. Tooth formation stages and eruption are used in this determination, and the difficulties in employment of these techniques are discussed. Determined ages are later used in assessing attrition rates and patterns.

Ageing of skeletal material is usually a first step in its analysis, but it is not an easy or certain procedure. The eruption of teeth has long been recognized as an age indicator in children but there are two considerations which militate against its direct application. Tooth eruption indicates a physiological age, a level of maturity of the dental system, and not an age in years since birth. A given dental physiological age can occur at different chronological ages, that is to say there is variability in the timing of dental events, including the eruption of teeth. One cannot say that when the deciduous first molar, for example, erupts at whatever age, the deciduous second molar will erupt ten months later, or that the permanent incisor will erupt two years after the permanent first molar. There is variability in the sequence of teeth erupting and in the length of time between eruptions of given teeth.

The deciduous dentition normally comprises twenty teeth erupting over a period of about thirty months. The permanent dentition normally comprises thirty-two teeth erupting over a period of about twelve years.

Tooth Nomenclature.

There are twenty deciduous teeth with five teeth in each quadrant: first incisors (i1), second incisors (i2), canines (c), first molars (m1), and second molars (m2). The incisor or molar type number is shown above the type initial in the upper jaw, for example m^1, and below the type initial in the lower jaw, for example i_2. Deciduous teeth initials are preceeded by a d, for example dc, to distinguish them from permanent teeth. There are thirty-two permanent teeth with eight teeth in each quadrant: first incisors (I1), second incisors (I2), canines (C), third premolars (P3), fourth premolars (P4), first molars (M1), second molars (M2) and third molars (M3). Permanent tooth initials are capitalised.

Teeth, including deciduous teeth, vary in morphology, size, eruption time and eruption order and these variations are influenced to some degree by sex, race and environment.

Some of this variability is predictable and general. Males in every population have larger teeth, on average, than females, while females erupt most teeth earlier than males. Variations in tooth size or morphology between populations are more patchy and are not readily predictable. These sources of dental variability are discussed in this and following chapters.

The Deciduous Teeth

A difference in the age at eruption of the deciduous teeth between the sexes is equivocal. Boys were found to erupt their teeth earlier than girls by Robinow (1942) for U.S. whites, by Ferguson (1957) for U.S. negroes and whites, and by Leighton (1968) for British whites. Conversely, no sex differences were found by Sandler (1944) for U.S. whites, by Nanda (1960) for U.S. whites, by Roche (1964) for Australian whites, by McGregor (1968) for Gambian negroes, by Friedlaender (1969) for Bougainville melanesians, by Bambach (1973) for Tunisian caucasoids, and by Billewicz (1973) for Chinese.

Most tables of eruption age given show the males slightly ahead of the females, but the difference is probably not biologically significant.

Table 1 shows average eruption times for males and females of nine studies including several races.

Table 1

Deciduous Tooth Eruption: Age in months

Study Number

	1	2	3	4	5	6	7	8	9
Males									
di^1	9.1	6-8	9.6	8.9	10.1	9.7	10.8	10-12	9.4
di^2	10.4	8-10	12.0	10.2	12.0	10.8	12.2	11-14	11.0
dc	18.9	16-20	21.0	17.5	19.9	19.0	17.3	19-24	18.4
dm^1	16.0	12-16	17.5	14.6	15.6	15.7	17.2	16-18	16.4
dm^2	27.6	20-30	31.0	26.3	29.0	28.3	28.5	29-32	27.1
di_1	7.3	---	7.2	6.9	6.7	7.6	9.3	10-12	8.8
di_2	13.0	---	13.1	11.1	13.6	12.7	13.7	14-18	12.4
dc	19.3	---	20.9	17.8	20.4	19.6	19.4	20-24	19.6
dm_1	16.2	---	16.6	14.7	16.3	15.9	18.0	16-18	15.9
dm_2	25.9	---	30.0	25.6	27.7	26.7	27.0	29-32	27.5
Females									
di^1	9.6	---	8.8	9.4	10.1	10.2	10.9	10-13	9.6
di^2	11.9	---	11.8	10.9	12.0	11.0	13.2	12-15	12.0
dc	20.1	---	20.8	18.7	20.0	18.8	18.9	19-24	19.2
dm^1	15.7	---	16.3	14.9	15.6	15.6	17.3	16-19	16.1
dm^2	28.4	---	31.4	26.3	29.0	28.7	28.8	29-32	27.5
di_1	7.8	---	7.8	7.7	6.7	8.0	9.4	10-13	9.4
di_2	13.8	---	13.3	12.0	13.6	12.6	14.0	15-20	13.0
dc	20.2	---	20.5	18.7	20.4	19.2	20.1	20-24	19.4
dm_1	15.6	---	16.4	15.0	16.3	15.7	17.8	16-18	16.6
dm_2	27.1	---	29.5	25.8	27.7	26.6	27.3	29-32	27.3

1. U.S. Whites 1. Robinow, Richards and Anderson 1942
2. U.S. Whites 2. Logan and Kronfeld 1934
3. U.S. Whites 3. Nanda 1960
4. British - Leighton 1968
5. Australian Whites -Roche, Barkla, and Maritz 1964
6. Swedish - Lysell, Magnuson, and Thilander 1964
7. Japanese - Sato and Ogiwara 1970
8. Bengal - Banerjee and Mukherjee 1967
9. Bougainville - Friedlaender and Bailit 1969

Table 2

Eruption Age (Months) of Deciduous Teeth
(average of seven studies)

Tooth	di^1	di^2	dc	dm^1	dm^2
Male	9.6	11.2	18.8	16.1	28.2
Female	9.8	11.8	19.5	15.9	28.6
Difference F-M	0.2	0.6	0.7	-0.2	0.4
Tooth	di_1	di_2	dc	dm_1	dm_2
Male	7.7	12.8	19.6	16.2	27.2
Female	8.1	13.2	19.8	16.2	27.3
Difference F-M	0.4	0.4	0.2	0.0	0.1

Table 2 shows the eruption times of seven of those studies averaged and the differences between the sexes. Boys are advanced in the eruption of all teeth except the dm1's and the advance is greatest in the upper dc's and dm2's, being about three weeks. The advances in other teeth amount to less than two weeks and cannot be seen as very significant.

Table 3

Average Number of Teeth Erupted (Deciduous) at Given Ages
(Males and females combined where necessary.)

Age in Months	Study Number 1	2	3	4	5	6	7	8
6	.1	.7	.7	--	.3	.5	1.6	.3
9	1.1	3.0	2.9	--	2.2	2.7	4.5	2.7
12	4.0	6.2	6.3	4.3	4.5	5.5	7.4	5.5
15	--	--	--	--	7.5	--	--	8.1
18	12.1	13.0	12.8	11.1	10.9	12.3	14.2	13.1
21	--	14.5	--	--	15.1	--	--	15.4
24	15.9	16.6	16.4	16.6	17.4	17.5	18.9	16.1
27	--	18.5	--	--	19.1	--	--	17.8
30	19.0	18.3	--	--	19.8	--	19.8	19.3
33	--	20.0	--	--	20.0	--	--	19.8
36	19.9	20.0	19.9	--	20.0	--	--	20.0

1. Aborigines - Barrett and Brown 1966
2. U.S. Whites - Sandler 1944
3. Swedes - Lysell 1962 (Barrett and Brown 1966)
4. Tunisia - Bambach 1973
5. Gambia - McGregor 1968
6. Africans - Falkner 1958 (Barrett and Brown 1966)
7. Bantus - MacKay 1952 (Barrett and Brown 1966)
8. Chinese H.K. - Billewicz 1973

Table 3 shows average numbers of deciduous teeth erupted at given ages in studies of eight social groups. Among very young children often living in remote localities these are easier data to collect than eruption times of given teeth and they are probably more reliable.

Tables 1 and 2 show variability between groups in eruption times, but some of it must be attributable to differences in study method. For example, Nanda's and Robinow's different findings for U.S. whites are more likely to result from their study methods than from real differences within that population.

There are differences between populations in Table 1 but they are not great and given populations have some teeth advanced against the average and some teeth retarded.

Revealing variability between populations is seen in Table 3. For the first twelve to eighteen months of life the aborigines lag significantly behind all other populations, but by eighteen months of age they catch up and from there exhibit no differences until the dentition is complete. There is almost a pattern during the first eighteen months of all the third world populations lagging behind the U.S. and Swedish whites, except that the Bantus are very advanced throughout the whole eruption period. It will be seen that this is true of their permanent dentition.

The question arises of whether eruption differences result from genetic or environmental effects. The evidence is equivocal. Barrett and Brown (1966, p. 49) quoting Falkner find evidence that disease in children under one year of age retards dental development but has no such effect after that age. Billewicz et al (1973) found that Hong Kong children with a heavier birth weight were advanced in dental development over the first twenty months but that post-natal growth and health made no difference. Ferguson et al (1957) found that healthy U.S. negro children erupted their first teeth before whites of similar or higher socio-economic levels.

If health in the first year does affect eruption age, this may well explain the lag of the aborigines from Yuendumu settlement in central Australia from where their data were taken. During the period of their investigation there were epidemics of measles, whooping cough and diphtheria, and respiratory and bowel infections were common causes of infant death (Barrett and Brown 1966, p. 50). This eruption schedule would not necessarily be seen in pre-contact times. Traditional aboriginal diet was nutritious and well balanced and they lived in small constantly moving groups (Campbell 1939b; Hamilton 1971). With the establishment of government or mission settlements the aborigines adapted their diet to store foods and with a preponderence of tea, sugar and flour the balance and much of the nutrition were lost. People were also congregated in large numbers in unsanitary camps and were thus prey to infectious diseases.

For these reasons it may not be appropriate to generalize the Yuendumu data to prehistoric aboriginal material. There are no direct data for the eruption ages of aboriginal deciduous teeth, so this study uses the table suggested by Lunt and Law (1974) as a general eruption schedule for deciduous teeth.

They reviewed the literature and modified the traditional table of Logan and Kronfeld by including the values of Lysell, Magnusson and Thilander (1962) who had the best survey methods of those reviewed.

Table 4 contrasts the Lunt and Law table of eruption ages with Table 2, the average eruption ages of seven studies:

Table 4

Average Eruption Ages of Deciduous Teeth from Several Studies

Lunt and Law (1974)		Average of 7 Studies (Table 2)	
Tooth	Age in Months	Age in Months	Difference
di^1	10	10	0
di^2	11	11	0
dc	19	19	0
dm^1	16	16	0
dm^2	29	28	1
di_1	8	8	0
di_2	13	13	0
dc	20	20	0
dm_1	16	16	0
dm_2	27	27	0

The tables are very close with only the upper dm^2 being different, and that only by thirty days. The Lunt and Law table is satisfactory for use for populations for which there are no data. For aborigines the values for the first eighteen months are likely to understate the true eruption times, but it is rare to get such young individuals in archaeological samples, and this study includes none.

The Permanent Teeth

The eruption ages of the permanent teeth vary considerably by sex and race while the deciduous teeth do not. There is obviously more time for variation to operate: the deciduous teeth erupt over a period of thirty months while the permanent teeth take twelve years to complete the same process. It is an adaptive advantage to the individual to erupt his deciduous teeth quickly. He needs a functional set of teeth by the time he is weaned onto solid foods at the age of two to three years. There is no such hurry for permanent teeth as most of them have deciduous precursors and there is almost no lag between the exfoliation of a deciduous tooth and the emergence of its permanent successor (Brown et al., 1979).

Table 5

Permanent Tooth Eruption Ages in Years for Several Populations

	Study Number							
Maxilla	1	2	3	4	5	6	7	8
				Males				
I^1	7.0	7.1	7.3	7.3	6.0	7.5	6.9	7.5
I^2	8.5	8.2	8.6	8.3	7.0	8.8	8.3	8.7
C	10.5	11.3	11.6	11.1	10.2	11.3	12.1	11.7
P^3	10.3	10.2	11.0	10.6	10.1	9.7	10.2	10.4
P^4	11.4	11.0	12.1	10.5	10.6	10.6	11.4	11.2
M^1	6.4	6.3	6.7	6.6	5.3	6.1	6.4	6.4
M^2	11.5	12.1	12.7	12.4	11.4	12.6	12.8	12.7
M^3					17.7			
Mandible								
I_1	6.6	6.2	6.6	7.1	5.5	6.4	6.3	6.5
I_2	7.2	7.3	7.7	7.8	6.0	7.6	7.3	7.7
C	10.0	10.5	10.8	11.2	9.6	10.4	10.4	10.8
P_3	10.5	10.8	11.0	10.8	10.1	10.0	10.3	10.8
P_4	11.5	11.6	11.9	11.7	10.7	10.9	11.1	11.5
M_1	6.4	6.1	6.7	6.6	5.2	5.8	6.3	6.2
M_2	11.2	11.7	12.4	12.1	11.0	11.8	12.2	12.1
M_3					16.8			

Table 5 Continued

	Study Number							
Maxilla	1	2	3	4	5	6	7	8
				Females				
I^1	7.3	6.8	7.1	7.3	6.2	7.2	6.7	7.2
I^2	8.1	7.8	8.2	7.5	7.1	8.5	7.8	8.2
C	10.1	10.7	11.1	10.9	9.7	10.9	10.6	11.0
P^3	9.8	9.8	10.7	10.5	9.7	9.4	9.6	10.0
P^4	11.0	10.7	11.8	11.5	10.1	10.3	10.2	10.9
M^1	5.7	6.1	6.6	6.9	5.8	6.3	6.4	6.2
M^2	11.0	11.8	12.4	11.9	10.9	12.4	12.4	12.3
M^3					17.7			
Mandible								
I_1	6.4	6.0	6.1	7.2	5.8	6.4	6.2	6.3
I_2	7.3	6.9	7.5	7.6	6.2	7.4	6.8	7.3
C	9.1	9.4	10.0	10.5	9.1	10.0	9.2	9.9
P_3	9.9	10.2	10.6	10.1	9.7	9.7	9.6	10.2
P_4	11.0	11.1	11.5	11.4	10.2	10.6	10.1	10.9
M_1	5.1	5.9	6.5	6.8	5.5	6.0	6.3	5.9
M_2	10.8	11.3	11.9	11.5	10.6	11.6	11.4	11.7
M_3					16.9			

1. Aborigines - Brown, Jenner, Barrett and Lees 1979
2. White Australians - Gates 1964. Median Values
3. American Whites - Nanda 1960
4. South Indians - Shourie 1946
5. Zulus - Hellman 1943
6. Chinese - Hellman 1943
7. Finns - Haavikko 1970. Median Values
8. White Northern Temperate Zone - Hurme 1949

Table 5 gives eruption ages of permanent teeth of males and females for eight populations.

There is considerable variability between the races with the Zulus being advanced for all teeth over all other populations. Aborigines show little difference from Europeans and other groups in the eruption of the first phase, that is, the incisors and first molars. However, the second phase (canines, premolars, second and third molars) begins earlier in Aborigines due to the advanced eruption of the canines, and the quiescent period between the phases is shorter (Brown 1978).

Aborigines erupt their third molars approximately 4.3 years earlier than caucasoids. This is because caucasoids relative to most other populations have retarded third molar eruption (Fanning and Moorrees 1969a, 1969b).

In a study of North American whites, Anderson and Popovich (1981) found a co-occurrence of delay in molar eruption timing with molars of reduced size. In light of this observation it may be suggested that caucasoid molar eruption retardation is associated with their relatively small size.

Table 6

Intervals in Years Between First and Second Phases of Permanent Tooth Emergence *

Group	Boys	Girls
Hong Kong (High socio-economic)	1.66	1.55
Hong Kong (Low socio-economic)	1.03	1.10
Hawaiian Chinese	0.93	0.91
England	2.23	1.59
New Zealand	2.46	1.88
U.S.A. European-descended	2.13	1.81
Australian European-descended	2.02	1.81
Australian Aboriginal	1.42	0.99
U.S.A. Negroes	2.39	2.04
Ugandan Negroes	1.70	1.20
New Guinea (Kaiapit)	2.60	1.60
New Guinea (Lae)	1.90	1.60

*Determined as the difference between the average ages at which the last incisor emerges and the first canine or premolar emerges.

In Table 6 Brown (1978) lists the intervals between the first and second eruption phases of twelve racial groups and only the low class Hong Kong Chinese have a shorter interval than the aborigines.

Figures 1 and 2 show the advanced second phase of aborigines compared to white Western Australians (Brown 1978).

Figure 1

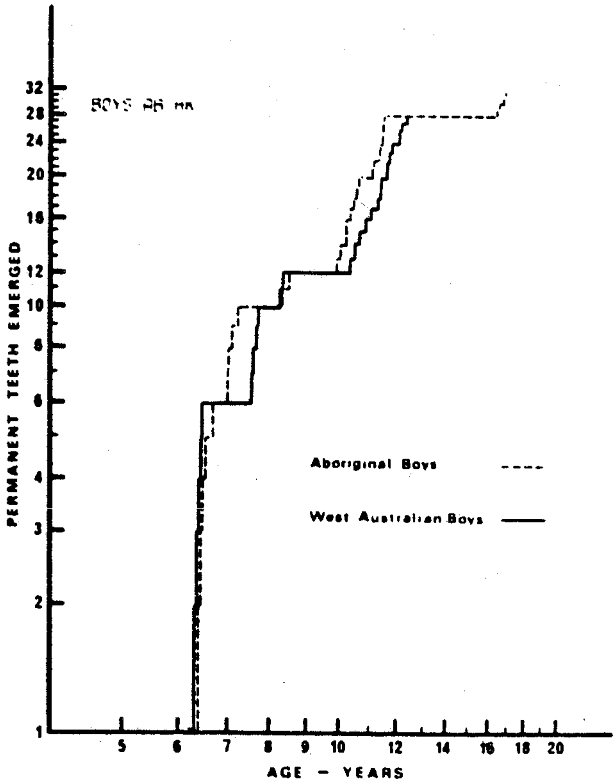


Figure 1 - Mean tooth emergence curves for Aboriginal boys and Western Australian boys.

Figure 2

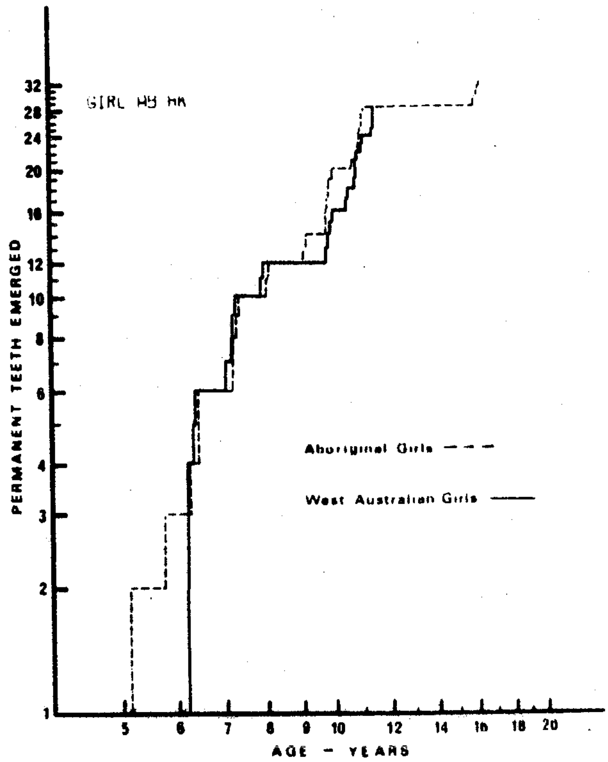


Figure 2 - Mean tooth emergence curves for Aboriginal girls and Western Australian girls.

Relative to Australian caucasoids aborigines tend to earlier eruption of most teeth, but aboriginal boys are delayed in the upper I^2, P^4 and lower I_1, while girls are delayed in the upper I^1, I^2, P^4 and lower I_1 and I_2 (Brown et at., 1979).

Females erupt their permanent teeth earlier than males. Gates (1964) found an average female advance for all teeth to be five months for white Australians. Brown et al (1979) found an average female advance for all teeth of six months but found the sex difference significant only for the lower C_1, P_3, P_4 and upper M^2.

Zulu boys differ from other populations in erupting the M1, I1 and I2 of both jaws earlier than girls, but they are later in the other teeth (Hellman 1943).

Bailit (1975) sees two basic reasons for the sex difference in eruption ages: girls develop earlier than boys sexually and skeletally and earlier tooth eruption is part of this advanced maturation; the smaller teeth of females may take less time to erupt once the process begins.

Eruption Sequence

Teeth erupt in many different sequences within given populations. Barrett, Brown and Cellier (1964) in a study of Yuendumu aborigines found the characteristic sequence for both sexes to be for the upper jaw M^1, I^1, I^2, P^3, C, (P^4, M^2) and for the lower jaw M_1, I_1, I_2, C, P_3, (M_2 P^4).

Figure 3

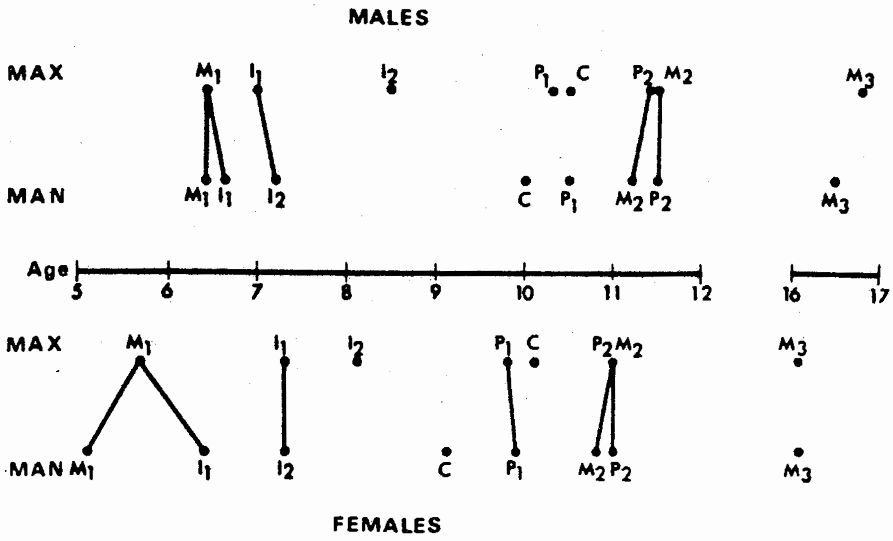


Figure 3 - Timing and sequence of permanent tooth emergence in Aborigines. Tooth pairs with close contest in eruption priority are linked by a solid line.

Ageing from Eruption:

Ageing skeletal specimens by tooth eruption presents many difficulties and sources of error. Firstly there are gaps in the process during which no reliable estimate can be made. From completion of the deciduous dentition to eruption of the first molar is a gap of about 3.5 years. There is usually a two to three year gap between the first and second phases of eruption, and a gap of five or more years between the second and third molars of some populations.

There are individual variations in sequence of eruption which are common enough to distort age estimation. Effects of disease may delay eruption schedules, and premature loss of deciduous teeth will cause advanced eruption of their permanent successors.

Sexual variation presents a real problem as it is significant and it is exceedingly difficult to sex juvenile skulls. One may be faced with having about half the sample under or over aged by up to a year because of sex variability.

Very importantly, one has the difficulty of the range of age during which a given tooth may erupt for one sex of one population. See Table 7 for standard deviations of eruption ages of aborigines. Many teeth can erupt over a four year age range and in ageing skeletal material with many missing teeth, one is often making an estimate based upon a single tooth. Significant inaccuracies obviously result.

Fortunately there are eruption age means available for many populations. This study uses those of Brown et al (1979) for central Australian aborigines. Different aboriginal populations probably vary in eruption schedule, but the Yuendumu group was close in emergence times to other aboriginal groups reported by Abbie (1975). Brown's figures are by far the best available for aborigines and any errors resulting from their application to the study samples will be of little importance overall.

Table 7 gives these eruption ages. Abbie's figures are taken from 266 males and 235 females from six areas of Australia from the central north coast down to the central south coast. The children had assigned ages rather than recorded ages and eruption was taken to mean full emergence of the tooth. In contrast eruption for Brown et al was first penetration of the gingiva, and the children had recorded ages.

Table 7

Timing of Permanent Tooth Eruption in Aborigines

Brown et al. (1979)

Timing of Permanent Tooth Emergence in Aborigines - 74 Boys and 51 Girls - with Recorded Birth Dates.
Yuendumu

Abbie (1975)

Median Eruption Ages of Permanent Teeth in 166 Aboriginal Boys and 235 Girls from 6 Months

	Male			Female			Male		Female	
Maxilla	N	Mean	St. Dev.	N	Mean	St. Dev.	Median	Range	Median	Range
I1	17	7.0	0.6	9	7.3	0.5	6.5	5-8	7.5	6-9
I2	28	8.5	0.8	19	8.1	0.8	8.5	5-12	9.0	6-12
C	49	10.5	0.9	32	10.1	0.9	10.0	7-13	9.5	7-12
P3	44	10.3	1.0	29	9.8	0.8	10.5	8-13	8.5	6-11
P4	56	11.4	1.1	37	11.0	1.0	10.5	8-13	9.5	6-13
M1	9	6.4	0.7	3	5.7	1.1	6.0	5-7	6.5	5-8
M2	57	11.5	1.0	37	11.0	1.1	11.5	9-14	13.0	10-16
M3	20	16.8	1.3	15	16.1	1.3	18.0	16-20	19.0	15-19
Mandible										
I1	11	6.6	0.6	3	6.4	0.8	6.5	5-8	6.0	5-7
I2	16	7.2	0.8	9	7.3	0.4	7.0	5-9	7.5	6-9
C	41	10.0	0.9	24	9.1	0.6	9.0	5-13	9.5	7-12
P3	47	10.5	1.0	28	9.9	0.8	10.5	8-13	9.0	6-12
P4	59	11.5	1.0	39	11.0	0.9	10.5	8-13	9.5	6-13
M1	7	6.4	0.7	2	5.1	---	6.0	5-7	6.0	5-7
M2	57	11.2	1.1	36	10.8	1.0	11.0	9-13	11.5	9-14
M3	24	16.5	1.3	12	16.1	1.0	17.5	16-19	19.0	13-19

Ageing by Tooth Formation Stages

Radiography has long been used to determine the developmental progress of teeth. Hess, Lewis and Roman (1932) did a radiographic study of the formation of teeth but did not develop age standards.

Hunt and Gleiser (1955) developed an ageing and sexing system based upon the greater difference between tooth development and skeletal development in girls than in boys. They (Gleiser and Hunt 1955) developed age standards for fifteen stages of tooth development.

Garn, Rohmann and Silverman (1967) used radiographs to develop age standards for three stages of development of four mandibular teeth.

Fanning (Fanning 1961; Moorrees, Fanning and Hunt 1963; Fanning and Brown 1971) has assembled age standards for ten permanent and three deciduous teeth.

Haavikko (1970) in a study of 1162 Helsinki children developed age standards for boys and girls for all permanent teeth and some deciduous teeth based upon twelve development stages.

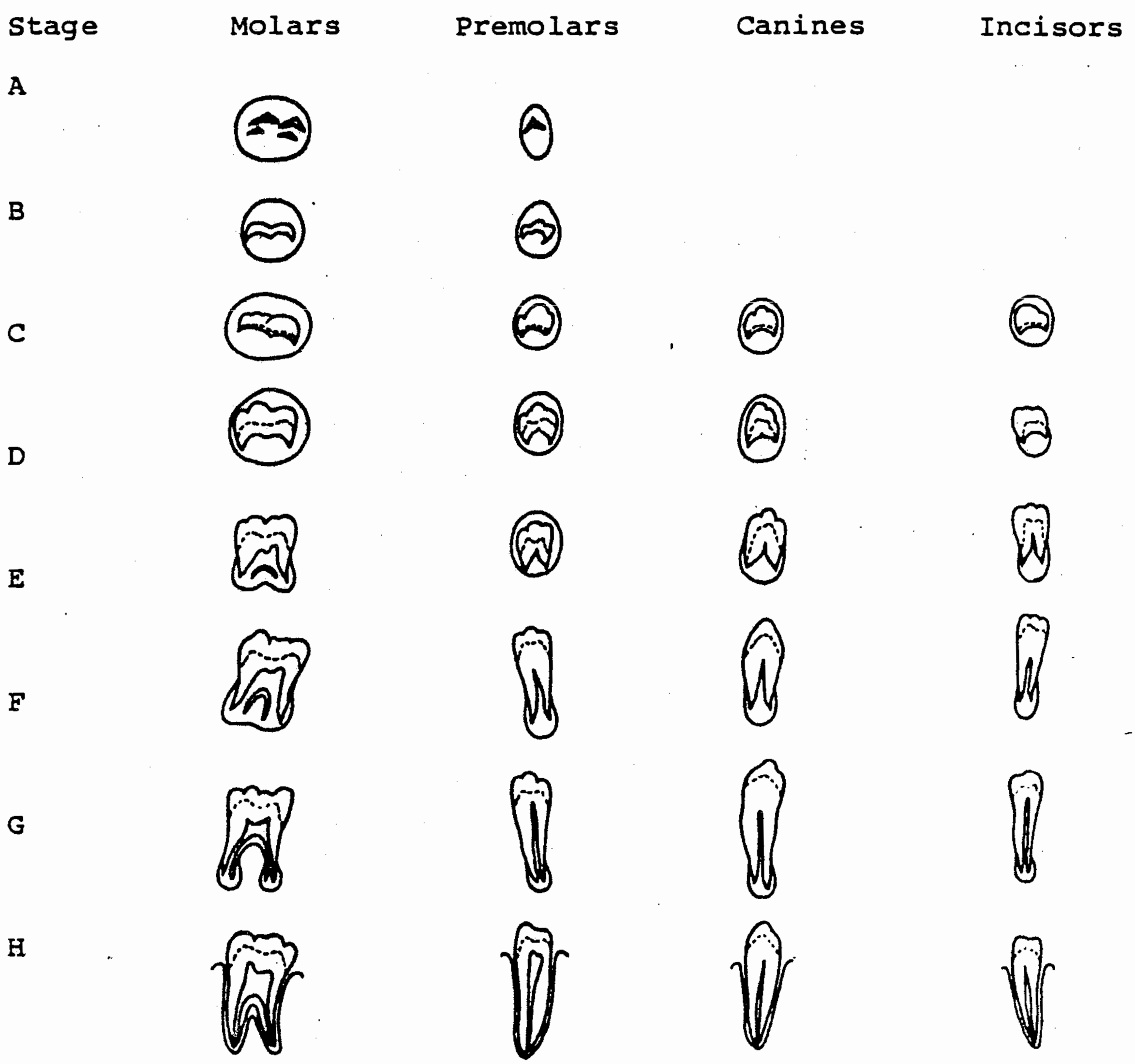
Demirjian, Goldstein and Tanner (1973) proposed a system of ageing based upon eight stages of development. Ageing an individual requires scoring all teeth, which makes the system inapplicable to most archaeological samples.

This study employs the system of Demirjian, Goldstein and Tanner in determining tooth development stages. Mark Skinner has adapted these stages to the age standards of Haavikko (1970), and these are the stages used.

Figure 4 illustrates the development stages of the various teeth.

Figure 4

Tooth Formation Stages



The following stage descriptions are taken directly from Demirjian, Goldstein and Tanner (1973 p. 221-226).

Stage Description:

A. In both uniradicular and multiradicular teeth, a beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.

B. Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.

C.a. Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen.

b. The beginning of dental deposition is seen.

c. The outline of the pulp chamber has a curved shape at the occlusal border.

D.a. The crown formation is completed down to the cemento-enamel junction.

b. The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region. The projection of the pulp horns, if present, gives an outline shaped like an umbrella top. In molars the pulp chamber has a trapezoidal form.

c. Beginning of root formation is seen in the form of a spicule.

E. Uniradicular teeth:

a. The walls of the pulp chamber now form straight lines whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage.

b. The root length is less than the crown height.

Molars:

a. Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape.

b. The root length is still less than the crown height.

F. Uniradicular Teeth:

a. The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape.

b. The root length is equal to or greater than the crown height.

Molars:

a. The calcified region of the bifurcation has developed further down from its semi-lunar stage to give the roots a more definite and distinct outline with funnel shaped endings.

b. The root length is equal to or greater than the crown height.

G. The walls of the root canal are now parallel and its apical end is still partially open (distal root in molars).

H.a. The apical end of the root canal is completely closed (Distal root in molars).

b. The periodontal membrane has a uniform width around the root and the apex.

Method of Ageing

Radiographs covering the full dentition of all the mandibles were taken. Each tooth was scored to one of the above stages and an age from the standard tables assigned to that tooth. The individual was then aged as a mean of the teeth ages, regardless of how many teeth were present, and even if only a single tooth was observed. Teeth which had completed formation were not included in the mean calculation.

This system allows for separate ages for girls and for boys. Because the samples for this study were unsexed all individuals were given ages for boys, which means that about half the individuals will be assigned an age exceeding their real age. This excess is usually less than six months, but can be up to one year.

There are difficulties with this system. Assignment of a tooth to a development stage is subjective. A sample of this material was scored by two observers and 31% of the teeth were scored with a difference of one stage. Levesque and Demirjian (1980) in testing inter-observer error in the same system found a 20-25% difference of one stage.

This level of error usually does not greatly effect the age assigned to the individual unless he has few teeth to score.

The age differences between some of the stages exceed two years and a tooth that is obviously between stages must be aged with a large error.

The standards provide mean ages for a given stage of development but there is a wide range of variation for each stage.

The standards used are based upon Finnish children and as Table 5 showed, they erupt their upper canines and both second molars from one year to one and a half years later than aborigines and their third molars are even more delayed. These differences cause an ill fit of the Finnish standards upon some aboriginal teeth. Given the luxury of a full dentition it would be advisable to leave these teeth out of the age calculation. It is difficult to estimate how much differences in eruption ages reflect differences in calcification ages. Brauer and Bahador (1942) found eruption and calcification to be two distinct processes. In one individual eruption could be retarded against the group mean while calcification could be at the mean, or vice versa. They state (p. 1386) that "In determining calcification of the teeth in terms of eruption without the use of the roentgenogram, the probable error in diagnosis is estimated as at least 50 percent".

Fanning and Moorrees (1969a) in studying Australian caucasoids and aborigines found that both groups had first and second molars developing in the same pattern relative to each other, but that for given stages of the first and second molars the third molars were delayed in the caucasoids. Yet from the tables one sees that aborigines have advanced eruption relative to caucasoids of both second and third molars.

Many of the sample individuals, especially from the Murray basin, lacked mandibles and as no radiographs of maxillae were taken they had to be aged by tooth eruption. In almost all cases an estimate was possible, based upon at least one tooth, but as there is an age range during which each tooth erupts there is built in error involved.

Eruption standards are based upon gingival emergence and this is not observable in skeletonized specimens.

Differences between alveolar and gingival eruption presented by Haavikko (1970) were used to estimate alveolar eruption ages.

The ageing of individuals in this study is by two methods, tooth eruption and tooth development. Because of the variability described above, it is likely that these methods give different results. Both methods assign a chronological age to a level (or more than one level) of physiological maturity and in almost every case there will be an error depending upon how far an individual varies from the age mean.

Differences resulting from the two ageing methods are unlikely to exceed the variations within each method.

See Appendix C for tooth formation stages of individuals' teeth.

CHAPTER 3

TOOTH SIZE

This chapter discusses the sizes of the teeth from the three populations. It is necessary to a study of dental attrition to consider tooth size as an important variable. Given a constant work load, whether it be food mastication or industrial manipulation, large teeth wear less and more slowly than small teeth. This is because the wearing agent, e.g. food, is spread over a greater tooth surface area. The purpose of this chapter is to discern any variations in tooth size between the samples so that the size variable can be accounted for in the next chapter on attrition.

The teeth were measured in two dimensions using Helios dial calipers with needle points which give a reading to .01 mm. The dimensions measured were mesio-distal, the length of the tooth, which is the greatest distance between the approximate surfaces of the tooth with the calipers parallel to the occlusal surface; and bucco-lingual, the greatest width of the tooth with the calipers parallel to the occlusal surface. For each individual the right and left sided teeth were averaged and that mean became one case for calculating a population mean. Where the tooth from one side was missing the present tooth measurements were used.

Teeth are difficult to measure, even from museum specimens and dental casts. The mesio-distal dimension is particularly difficult and unreliable because the points of maximum length often are firmly abutting the neighbouring teeth. It is thus not possible to bring the calipers to the points of maximum length. In addition, chewing stress causes the teeth surfaces in contiguity to wear upon each other. This is called interproximal attrition and in populations with high levels of dental attrition this very severely diminishes the lengths of the teeth, especially in mature people but even in children. For these reasons mesio-distal dimensions cannot be taken as the original lengths of teeth. They are a reading of original tooth size, interproximal attrition, and measurement error. These measurements therefore have a limited analytic applicability.

Bucco-lingual measurements do not suffer these limitations. The points of maximum width can be readily reached by the calipers and the width is not diminished by interproximal attrition. It is not reduced by occlusal attrition until the top half of the crown is worn away. Bucco-lingual measurements are affected by measurement error. They are the more reliable measurement and can usually be taken as original tooth size plus measurement error. They are a serviceable dimension for tooth size comparisons between individuals and groups.

Measurement errors are the random, unaccountable, and inevitable errors that occur in any measurement procedure however precise and rigorous. They include misreadings of the caliper dial.

The degree of measurement error in this study was tested by the complete dentition of an individual being measured in both dimensions ten times. The average standard error for the eight teeth is:

maxilla M-D 0.07 mm, maxilla B-L 0.09 mm
mandible M-D 0.10 mm, mandible B-L 0.14 mm

This error factor corresponds closely to that given by Townsend and Brown (1979) for central Australian aborigines. Their error average for combined maxilla and mandible was 0.11 mm in both mesio-distal and bucco-lingual dimensions. Errors at this level are insignificant, but much higher individual errors can occur.

Studies of Aboriginal Teeth

Aboriginal teeth have been measured and compared a number of times. Campbell (1925) measured the permanent and deciduous teeth of museum specimens from many areas of Australia, but he combined sexes and areas and did not give good provenience information.

Brace (1977, 1980) studied collections from eighteen areas of Australia and claims a cline in increasing tooth size from the northeast to the south. A cline is a directional biological variation in a structure through a geographical range. The only break in Brace's cline was at Broadbeach which had the largest teeth of all. Brace's argument is not convincing, but it is a unique study of teeth from many areas.

Hanihara (1976) took Barrett and Brown's data on central Australian aborigines and compared them to several populations around the world. He found the aborigines to have the largest deciduous teeth and the largest permanent teeth of all groups but the Pima Indians.

Freedman and Lofgren (1981) studied Western Australian aborigines from five broad regions of that state. The samples are from a museum collection which represents chance discoveries.

Smith, Brown and Wood (1981) measured the teeth of the Broadbeach collection and compared them to five other aboriginal samples including Yuendumu and Swanport. These tooth size comparisons will be discussed later, as will a comparison of Smith, Brown and Wood's results with the results of this study.

The Yuendumu Study

The best study of aboriginal teeth is that of the central Australian community of Yuendumu undertaken by the Dental Faculty of the University of Adelaide (Barrett, Brown and Luke 1963; Barrett, Brown, Arato and Ozols 1964; Margetts and Brown 1978; Townsend and Brown 1979; Brown, Margetts and Townsend 1980a, 1980b). They have done a growth study of 208 male and 194 female aborigines over a twenty year period. Dental casts have been taken at intervals so the developing dentition of many individuals from deciduous to permanent can be followed.

The Yuendumu population had deciduous dentition with mean mesio-distal measurements greater in males for all teeth except the mandibular incisors (Barrett, Brown and Luke 1963). The bucco-lingual means were greater in males than females for all teeth (Barrett, Brown, Arato and Ozols 1964). The sex differences were significant for 12 of the 20 dimensions measured. There was no significant sex difference in measurements for the mesio-distal diameter of the mandibular first molar and for all incisor dimensions except the bucco-lingual of the maxillary first incisor (Margetts and Brown 1978). Sexual dimorphism, the sexual difference in a biological structure, averaged 2.4 percent for mesio-distal measurements and 3.7 for bucco-lingual measurements. Except for two dimensions sexual dimorphism was greater in bucco-lingual than in mesio-distal measurements, which is the case in aborigines' permanent teeth and in those of other populations (Margetts and Brown 1978).

Table 8 gives Margetts and Brown's date for Yuendumu deciduous teeth.

Table 8

Size of Deciduous Teeth at Yuendumu
(Margetts and Brown 1978)

Mesio-Distal

	Males			Females		
Maxilla	n	Mean	S.D.	n	Mean	S.D.
di^1	29	7.35	0.45	18	7.20	0.49
di^2	54	6.00	0.44	36	5.93	0.43
dc	113	7.41	0.43	77	7.21	0.46
dm^1	112	7.55	0.52	74	7.28	0.44
dm^2	113	9.65	0.57	76	9.42	0.46
Mandible						
di_1	18	4.51	0.37	8	4.34	0.40
di_2	34	5.01	0.45	19	4.91	0.42
dc	109	6.31	0.37	62	6.16	0.41
dm_1	109	8.25	0.58	70	8.12	0.45
dm_2	115	10.89	0.61	69	10.64	0.49

Bucco-Lingual

Maxilla						
di^1	29	5.47	0.42	18	5.30	0.33
di^2	56	5.24	0.40	36	5.01	0.39
dc	113	6.61	0.45	77	6.34	0.40
dm^1	114	9.07	0.59	76	8.77	0.47
dm^2	14	10.65	0.55	76	10.27	0.44
Mandible						
di_1	18	4.33	0.29	8	4.19	0.44
di_2	33	4.75	0.35	18	4.65	0.37
dc	102	6.05	0.42	60	5.84	0.42
dm_1	112	7.92	0.51	73	7.49	0.51
dm_2	115	9.87	0.49	75	9.57	0.49

Table 9 gives Margetts and Brown's data for sexual dimorphism in the deciduous teeth.

Table 9

Sexual Dimorphism in the Size of Deciduous Teeth from Yuendumu (Margetts and Brown 1978)

	Mesio-Distal	Bucco-Lingual
Maxilla	Dimorphism Percent	Dimorphism Percent
di^1	1.97	3.34
di^2	1.11	4.59
dc	2.75	4.23
dm^1	3.71	3.37
dm^2	2.44	3.74
Mandible		
di_1	3.94	3.20
di_2	2.01	2.04
dc	2.53	3.74
dm_1	1.55	5.81
dm_2	2.37	3.05
Overall Mean	2.44	3.71

$$\text{*dimorphism percent} = \frac{\text{male mean} - \text{female mean}}{\text{female mean}} \times 100$$

Tooth sizes of the permanent dentition from Yuendumu are given in Table 10.

Table 10

Size of Permanent Teeth at Yuendumu (in mm.)
(Townsend and Brown 1979)

Mesio-Distal

	Males			Females		
Maxilla	n	Mean	S.D.	n	Mean	S.D.
I^1	206	9.36	.57	183	8.97	.53
I^2	203	7.54	.62	178	7.22	.66
C	192	8.25	.52	173	7.93	.43
P^3	200	7.63	.45	175	7.48	.40
P^4	191	7.13	.43	170	7.01	.40
M^1	208	11.20	.56	182	10.88	.50
M^2	156	10.83	.64	158	10.52	.60
M^3	57	10.05	.66	65	9.97	.70
Mandible						
I_1	206	5.83	.36	184	5.64	.42
I_2	106	6.56	.42	184	6.37	.39
C	198	7.44	.44	180	6.97	.35
P_3	196	7.46	.49	176	7.29	.42
P_4	185	7.55	.50	168	7.35	.43
M_1	205	12.05	.61	180	11.60	.51
M_2	176	11.44	.68	159	11.21	.62
M_3	54	11.74	1.03	73	11.54	.80

Table 10 Continued

Bucco-Lingual

	Males			Females		
Maxilla	n	Mean	S.D.	n	Mean	S.D.
I^1	205	7.87	.55	178	7.44	.46
I^2	194	6.92	.55	166	6.59	.51
C	186	9.00	.59	171	8.44	.51
P^3	199	10.25	.59	175	9.97	.55
P^4	191	10.23	.54	170	9.93	.55
M^1	208	12.55	.57	183	12.06	.54
M^2	154	12.77	.70	144	12.21	.61
M^3	48	12.28	.80	56	11.87	.75
Mandible						
I_1	206	6.60	.45	184	6.33	.39
I_2	196	6.82	.43	181	6.53	.39
C	183	8.23	.50	168	7.82	.39
P_3	196	8.82	.57	177	8.51	.53
P_4	183	9.25	.55	168	8.96	.55
M_1	206	11.81	.58	181	11.47	.53
M_2	169	11.53	.59	159	11.08	.56
M_3	59	11.53	.71	81	11.04	.66

All differences in the male and female means are significant ($p < .05$ or $p < .01$). Males exceed females in size in all tooth dimensions.

The Yuendumu publications provide population data that are very useful for comparison with other aboriginal samples. Compared to the Western Australian samples of Freedman and Lofgren (1981) the Yuendumu group has some teeth markedly larger and some teeth markedly smaller in the mesio-distal dimension, but very similar in sizes in the bucco-lingual dimension.

Table 11 gives the Western Australian tooth sizes.

Table 11

Permanent Tooth Measurements (in mm.) of Aborigines from Five Areas of Western Australia (Freedman and Lofgren 1981)

	Mesio-Distal						Bucco-Lingual					
	Male	n	S.D.	Female	n	S.D.	Male	n	S.D.	Female	n	S.D.
Maxilla												
I^1	9.33	12	.57	8.66	10	.69	7.92	18	.53	7.44	13	.44
I^2	7.24	26	.70	7.10	16	.94	7.03	30	.44	6.67	19	.50
C	8.01	35	.64	7.81	21	.32	9.18	39	.56	8.44	24	.45
P^3	7.38	40	.50	7.03	20	.50	10.32	42	.49	9.80	22	.66
P^4	7.03	43	.44	6.73	21	.48	10.29	44	.55	9.70	23	.68
M^1	11.62	48	.70	10.84	25	.86	12.78	48	.63	12.07	25	.52
M^2	11.61	48	.86	10.85	26	.82	12.95	48	.71	12.21	26	.60
M^3	10.42	47	.83	9.63	17	.85	12.22	47	.82	11.57	17	.62
Mandible												
I_1	5.55	11	.63	5.04	12	.40	6.65	12	.60	5.90	13	.27
I_2	5.86	14	.74	5.77	14	.48	6.69	19	.48	6.29	16	.45
C	7.28	22	.51	6.91	15	.44	8.67	24	.47	7.79	16	.42
P_3	7.15	23	.52	6.81	18	.58	8.87	24	.65	8.47	19	.50
P_4	7.17	25	.46	7.01	15	.62	9.00	25	.54	8.81	16	.52
M_1	11.62	27	.67	10.55	15	.94	11.99	27	.69	11.35	15	.73
M_2	11.75	28	.80	11.25	15	.61	11.65	29	.77	11.20	15	.69
M_3	11.72	30	.71	10.91	17	1.03	11.35	30	.72	10.95	17	.93

Direct comparison of the Yuendumu data with the three archaeological samples is conditional upon several factors which will be discussed later. The tooth size data for Swanport, Murray Basin, and Broadbeach will now be given, and followed by comparison and discussion.

Table 12 gives tooth dimensions of males, females and juveniles from Swanport, Murray Basin and Broadbeach.

Table 12

Permanent Tooth Dimensions in m m.

Mesio-Distal

Tooth	Swanport									Murray Basin									Broadbeach								
Maxilla	♂	N	S.D.	♀	N	S.D.	J	N	S.D.	♂	N	S.D.	♀	N	S.D.	J.	N	S.D.	♂	N	S.D.	♀	N	S.D.	J.	N	S.D.
I^1	9.10	2	.18	8.23	3	.36	9.23	6	.96	9.05	3	1.10	8.36	4	.68	8.95	7	.94	8.76	6	.93	8.79	2	.85	10.40	6	.70
I^2	7.02	5	1.10	6.77	4	.37	7.36	7	.59	6.91	4	.73	6.48	6	.76	7.27	6	.77	7.62	8	.70	7.17	4	.58	7.72	13	.64
C	8.32	6	.75	7.55	5	.53	8.15	4	.22	8.21	4	.96	7.34	8	.74	9.74	1	---	8.05	9	.72	8.70	4	.28	8.38	13	.57
P^3	7.62	5	.68	6.52	3	.37	7.40	5	.53	7.37	6	.81	6.71	8	.68	7.89	2	.50	7.38	9	.47	7.10	4	.53	7.79	12	.38
P^4	7.06	6	.69	6.67	5	.69	7.29	4	.63	7.13	6	.31	6.66	8	.57	---	-	---	6.91	9	.39	7.15	3	.48	7.63	5	.29
M^1	11.10	6	.55	9.81	5	.91	11.08	18	.84	10.58	6	.53	10.50	7	.44	11.21	23	.62	11.08	10	.75	10.33	5	1.24	11.62	26	.62
M^2	10.72	6	.52	10.09	4	.70	10.65	6	.40	10.48	6	.80	10.28	8	.75	---	-	---	11.11	10	.76	10.21	5	1.30	11.71	13	.92
M^3	9.78	6	.98	9.64	5	1.18	---.	-	---	9.61	6	.82	9.38	8	.88	---	-	---	9.70	10	1.10	9.84	6	.58	10.86	3	1.2
Mandible																											
I_1	4.95	4	.42	4.85	2	.40	5.78	9	.34	4.35	3	1.30	4.61	3	1.03	6.08	5	1.40	5.57	5	.24	5.40	5	.48	5.69	14	.43
I_2	5.34	5	.80	5.82	3	.59	6.68	7	.36	5.43	3	1.70	5.77	4	1.47	6.15	6	.46	6.59	7	.48	6.22	5	1.21	6.41	15	.38
C	7.06	6	.37	6.95	3	.45	7.30	2	---	8.27	1	---	6.60	6	.82	---	-	---	7.41	10	.41	7.13	5	.33	7.58	13	.29
P_3	6.83	5	.44	7.00	4	.17	7.15	3	.48	7.23	3	.61	6.60	5	1.00	---	-	---	7.45	10	.67	7.18	6	.78	7.63	9	.40
P_4	7.13	6	.92	7.11	3	.46	7.28	3	.64	7.74	3	.25	6.48	4	1.20	---	-	---	7.25	9	.54	7.15	6	.51	8.01	7	.54
M_1	12.17	5	.66	10.84	4	.82	12.11	15	1.05	11.24	2	1.40	11.37	6	1.11	12.13	10	.49	11.82	9	.84	11.29	6	1.06	12.50	20	.69
M_2	12.46	6	.79	11.83	4	.60	12.60	4	.66	11.96	3	.93	11.01	5	1.39	---	-	---	12.42	9	.99	11.42	6	1.51	12.89	8	.96
M_3	11.92	4	.40	11.10	4	.46	---	-	---	11.40	3	1.50	10.79	5	1.05	---	-	---	12.13	9	.76	11.59	6	.97	---	-	---

Table 12 Continued

Permanent Tooth Dimensions in m m.

Bucco-Lingual

	Swanport									Murray Basin									Broadbeach								
Tooth Maxilla	♂	N	S.D.	♀	N	S.D.	J	N	S.D.	♂	N	S.D.	♀	N	S.D.	J.	N	S.D.	♂	N	S.D.	♀	N	S.D.	J.	N	S.D.
I^1	7.80	2	.67	7.25	3	.32	7.52	6	.56	8.24	3	.66	7.49	4	.58	7.54	7	.62	7.70	6	.41	7.31	2	.21	7.89	6	.50
I^2	7.22	5	.75	6.54	4	.53	6.47	7	.39	7.09	4	.41	6.44	6	.45	6.77	6	.53	6.64	8	.41	6.61	4	.40	6.79	13	.79
C	9.03	6	.49	8.24	5	.28	8.85	4	.71	9.25	4	.50	8.53	8	.29	10.15	1	---	8.76	9	.84	8.64	4	.63	8.65	13	.67
P^3	10.51	5	.77	9.73	3	.37	9.95	5	.87	10.59	6	.62	9.87	8	.57	11.10	2	1.11	10.08	9	.64	9.22	4	.71	9.87	12	1.14
P^4	10.36	6	1.30	9.63	5	.79	9.85	4	.96	10.43	6	.67	9.97	8	.48	---	-	---	9.99	9	.59	9.26	3	.92	10.11	5	.79
M^1	13.07	6	.73	11.90	4	.76	12.15	18	.90	12.73	6	.46	12.17	7	.48	12.30	23	.61	12.56	10	.74	11.96	5	.77	12.26	26	.69
M^2	13.67	6	.84	12.41	4	.54	12.78	6	.50	13.57	6	.89	12.70	8	.63	---	-	---	13.14	10	.76	12.29	5	1.01	13.13	13	1.02
M^3	12.77	6	.98	11.78	5	.60	---	-	---	13.69	6	.97	12.30	8	1.06	---	-	---	12.43	10	.97	11.91	6	.72	12.87	3	1.36
Mandible																											
I_1	6.44	4	.56	5.89	2	.11	6.15	9	.51	6.08	3	.28	6.11	3	.17	6.17	5	.74	6.22	5	.40	5.91	5	.52	5.96	14	.42
I_2	6.45	5	.68	6.13	3	.17	6.45	7	.25	6.52	3	.59	6.45	4	.17	6.17	6	.33	6.44	7	.31	6.25	5	.41	6.21	15	.44
C	8.40	6	1.1	7.81	3	.24	7.39	2	---	9.11	1	---	7.74	6	.37	---	-	---	7.97	10	.50	7.57	5	.73	7.91	13	.75
P_3	9.11	6	.84	8.53	4	.55	8.13	3	.48	9.25	3	.32	8.41	5	.38	---	-	---	8.70	10	.51	7.96	6	.81	8.34	9	.81
P_4	8.46	6	1.0	8.16	3	.49	8.32	3	.36	9.77	3	.26	8.93	4	.62	---	-	---	9.04	9	.55	8.35	6	.91	9.07	7	.67
M_1	12.08	5	.68	11.36	4	.40	11.19	15	.43	12.79	2	.89	11.41	6	.97	11.22	10	.37	11.67	9	.51	10.95	6	.96	11.13	20	.88
M_2	11.64	6	.58	11.19	4	.69	11.30	4	1.00	12.00	3	1.00	10.82	5	.99	---	-	---	11.68	9	.74	10.53	6	.81	11.17	8	.73
M_3	11.67	4	.93	10.51	4	1.00	---	-	---	12.09	3	.53	11.19	5	1.03	---	-	---	11.26	9	.56	10.03	5	.49	---	-	---

Tooth Size Comparisons

When comparing sexed adult data one must consider age. Older individuals have more worn teeth than those younger, other factors being constant, so the dimensions of their teeth will be reduced. This is particularly true of the mesio-distal dimension. In comparing groups, particularly of small sample size, one cannot assume that the same age classes are represented with relative equality. The Yuendumu group has large sample sizes, but the three groups of this study have very small sample sizes.

The Yuendumu group represents the permanent teeth of juveniles which are very little worn while the archaeological groups' adults are mature with generally very worn teeth. A bucco-lingual comparison is appropriate given these circumstances, but wear must be considered as it is a factor in some individuals. This comparison does not reveal any patterns other than variability.

Comparing Yuendumu to Swanport it is found that male maxillae have anterior teeth (I1, I2 C) of about the same size but posterior teeth (P3, P4, M1, M2, M3) are larger. The male mandible has smaller anterior teeth except for C, but larger posterior teeth except for P4. For females the maxillae have smaller anterior teeth at Yuendumu and smaller posterior teeth except for M2. The mandibles have smaller anterior teeth except C and smaller posteriors except P3 and M2.

Comparing Yuendumu to Murray Basin, the male maxillae have larger anterior and posterior teeth. The mandibles have smaller anterior teeth except for C but larger posterior teeth except for P4. The females at Yuendumu have larger maxillary anterior teeth except that I2 is the same size, but in the posterior teeth the P's are the same size while the M's are larger. The mandibles at Yuendumu have smaller anterior and posterior teeth, except for M3.

Comparing Yuendumu to Broadbeach the male maxillae have larger anterior and posterior teeth except for the M's which are smaller. The mandibles have smaller anterior and posterior teeth except for M2 which is the same size and C is larger. In the posterior teeth the P's are much smaller at Yuendumu but the M's are the same size. The mandibles at Yuendumu have smaller anterior and posterior teeth. Because of the small sample sizes it is not possible to say whether there is any statistical significance in these mean differences.

Comparisons between Swanport, Murray Basin, and Broadbeach samples are difficult for a number of reasons. There are very small numbers of adults; at Swanport 5 males and 5 females, at Murray Basin 7 males and 9 females, at

Broadbeach 10 males and 5 females. The very frequent pre and post-mortem loss of teeth has reduced samples of some tooth classes to one or two specimens. This means it is not possible to calculate statistical significance of perceived mean size differences between the populations. The probable different ages of individuals within the populations introduces wear as a factor in tooth size, especially in mesio-distal dimensions. Researchers usually do not take measurements of badly worn teeth but there are differences in attitude to how worn a tooth must be to be excluded. Sometimes (Guagliardo 1982) any perceptible wear excludes a tooth. At Yuendumu the people measured were juveniles on a modern diet and exhibited very little attrition. The three samples in this study have heavily worn teeth, especially in the adults, and measurements were taken on teeth whose dimensions were much reduced by attrition. Some of the bucco-lingual measurements were probably reduced by extreme occlusal attrition. Therefore even in comparing males to males, say, one is measuring behaviour, age and original tooth size even though these various elements cannot be closely discriminated.

In comparing sex-combined adult populations the problem is that the different ratios of the sexes bias the mean sizes. For example, Swanport has even numbers of males and females but Broadbeach has only 33 percent females. As males have bigger teeth than females the Broadbeach excess males should increase the mean adult tooth size above that which would result from a sample of equal sex ratio. Given that objection it is not useful to make combined sex comparisons between these populations. Combined sex means were calculated for intrapopulation comparisons between adults and juveniles. The juveniles are of unknown sex. Any strong preponderence of one sex in a group will bias the mean tooth sizes, but one must initially assume that the sex ratios of the populations are the same.

Table 13 gives the combined-sex adult tooth means. One further complication must be revealed. The maxillary and mandibular samples are not necessarily contributed by the same individuals. Some individuals are represented only by a maxilla, some only by a mandible, and some by both jaws. This of course affects comparisons between upper and lower teeth. In addition, a tooth class may be missing from a mandible but present in the corresponding maxilla. This factor deepens the difficulty. The n in the tables refers not to number of individuals in the sample but to the number of individuals who have at least one tooth of that tooth class.

Table 13

Mean Tooth Dimensions
of Combined Male and Female Adults

Tooth		Swanport	n	Murray Basin	n	Broadbeach	n
Maxilla							
I^1	m-d	8.57	5	8.65	7	8.76	8
	b-l	7.47	5	7.81	7	7.60	8
I^2	m-d	6.90	9	6.65	10	7.47	12
	b-l	6.91	9	6.70	10	6.63	12
C	m-d	7.97	11	7.63	12	8.25	13
	b-l	8.67	11	8.77	12	8.72	13
P^3	m-d	7.20	8	6.99	14	7.29	13
	b-l	10.21	8	10.17	14	9.81	13
P^4	m-d	6.88	11	6.86	14	6.97	12
	b-l	10.02	11	10.16	14	9.80	12
M^1	m-d	10.51	11	10.53	13	10.83	15
	b-l	12.60	10	12.42	13	12.36	15
M^2	m-d	10.46	10	10.36	14	10.81	15
	b-l	13.16	10	13.07	14	12.85	15
M^3	m-d	9.71	11	13.07	14	9.75	16
	b-l	12.32	11	12.89	14	12.23	16
Mandible							
I_1	m-d	4.91	6	4.48	6	5.48	10
	b-l	6.25	6	6.09	6	6.06	10
I_2	m-d	5.52	8	5.62	7	6.43	12
	b-l	6.33	8	6.48	7	6.36	12
C	m-d	7.02	9	6.83	7	7.31	15
	b-l	8.20	9	7.93	7	7.83	15
P_3	m-d	6.90	9	6.83	8	7.34	16
	b-l	8.87	10	8.72	8	8.42	16
P_4	m-d	7.12	9	7.02	7	7.21	15
	b-l	8.36	9	9.29	7	8.26	15
M_1	m-d	11.57	9	11.33	8	11.60	15
	b-l	11.76	9	11.75	8	11.38	15
M_2	m-d	12.20	10	11.36	8	12.02	15
	b-l	11.46	10	11.26	8	11.22	15
M_3	m-d	11.51	8	11.02	8	11.93	14
	b-l	11.09	8	11.52	8	10.82	14

Table 12 of permanent tooth sizes reveals the following: Broadbeach compared to Swanport has mesio-distal measurements in males of about the same size in the maxilla and posterior mandible, but Broadbeach has larger anterior teeth. In females Broadbeach teeth are larger in the maxilla, especially in the anterior, and in the anterior mandible, but the same size in the posterior mandible.

For bucco-lingual measurements Broadbeach males have smaller teeth than Swanport males except for the posterior mandible which are the same size. In females Broadbeach has smaller teeth in the mandible and posterior maxilla, but slightly larger teeth in the anterior maxilla.

Broadbeach compared to Murray Basin has mesio-distal measurements in males of about the same size in the maxilla but larger teeth in the mandible, especially the anterior teeth. In females Broadbeach teeth are larger in both maxilla and mandible, especially in the anterior.

For bucco-lingual measurements Broadbeach has smaller teeth for males and females except for the female anterior maxilla which are about the same size.

Overall, Broadbeach generally has larger teeth than both Swanport and Murray Basin in mesio-distal measurements, especially in anterior teeth; but smaller teeth than both populations in bucco-lingual measurements. The bucco-lingual measurements give a truer report of tooth size. The implications for attrition patterns will be discussed in the next chapter.

Tables 14 - 16 give figures for these size comparisons.

Table 14

Tooth Row Length (One Side) of Adults by Sex

	Mesio-Distal			Bucco-Lingual		
	Swanport	Murray	Broadbeach	Swanport	Murray	Broadbeach
Maxilla	♂	♂	♂	♂	♂	♂
I^1 - C	24.44	24.17	24.43	24.05	24.58	23.10
P^3 - M^2	36.50	35.56	36.48	47.61	47.32	45.77
Whole Row	60.94	59.73	60.91	71.66	71.90	68.87
Mandible						
I_1 - C	17.35	18.05	19.57	21.29	21.71	20.63
P_3 - M_2	38.59	38.17	38.94	41.29	43.81	41.09
Whole Row	55.94	56.22	58.51	62.58	65.52	61.72
Maxilla	♀	♀	♀	♀	♀	♀
I^1 - C	22.55	22.18	24.66	22.03	22.46	22.56
P^3 - M^2	33.09	34.15	34.79	43.67	44.71	42.73
Whole Row	55.64	56.33	59.45	65.70	67.17	65.29
Mandible						
I_1 - C	17.62	16.98	18.85	19.83	20.30	19.73
P_3 - M_2	36.78	35.46	37.04	39.24	39.27	37.79
Whole Row	54.40	52.44	55.89	59.07	59.87	57.52

Table 15

Difference of Tooth Size:
Broadbeach Adults Compared to
Swanport and Murray Basin
(> = larger, < = smaller)

	Mesio-Distal		Bucco-Lingual	
Maxilla	BB:SP	BB:MB	BB:SP	BB:MB
I^1 - C	same	1.0 % >	4.1 % <	6.4 % <
P^3 - M^2	same	2.5 % >	4.0 % <	3.3 % <
Whole Row	same	1.9 % >	4.0 % <	4.4 % <
Mandible				
I_1 - C	12.8 % >	8.4 % >	3.2 % <	5.2 % <
P_3 - M_2	0.9 % >	2.0 % >	0.5 % <	6.6 % <
Whole Row	4.6 % >	4.0 % >	1.4 % <	6.1 % <
Maxilla				
I^1 - C	9.3 % >	11.1 % >	2.4 % >	0.4 % >
P^3 - M^2	5.1 % >	1.8 % >	2.1 % <	4.6 % <
Whole Row	6.8 % >	5.5 % >	0.6 % <	2.8 % <
Mandible				
I_1 - C	6.9 % >	11.0 % >	0.5 % <	2.8 % <
P_3 - M_2	0.7 % >	4.4 % >	3.8 % <	4.7 % <
Whole Row	2.7 % >	6.5 % >	2.7 % <	4.0 % <

Table 16

Permanent Tooth Sizes from Swanport and Broadbeach ("unworn" teeth from Smith, Brown and Wood 1981)

	Mesio-Distal			Bucco-Lingual		
Maxilla	SP ♂	BB ♂	BB ♀	SP ♂	BB ♂	BB ♀
I^1	9.2	9.8	9.5	7.9	7.9	7.4
I^2	7.6	7.8	7.2	7.1	7.0	6.3
C	8.3	8.6	8.3	9.2	---	---
P^3	7.6	7.9	7.6	10.4	10.5	9.7
P^4	7.3	7.5	7.3	10.4	10.5	10.2
M^1	11.4	1.9	10.4	13.0	12.9	12.9
M^2	10.8	11.6	10.9	13.5	13.5	13.0
M^3	9.8	10.1	9.7	12.7	12.4	11.6
Mandible						
I_1	6.1	5.9	6.0	6.4	6.5	6.1
I_2	6.5	7.0	6.8	6.6	6.8	7.4
C	7.4	7.7	7.3	8.2	---	---
P_3	7.5	8.1	7.2	9.1	9.0	8.4
P_4	7.7	8.0	7.6	8.9	9.3	8.9
M_1	12.5	12.3	12.0	11.9	11.6	11.4
M_2	12.5	12.8	11.9	11.8	11.8	11.2
M_3	11.7	12.1	11.3	11.4	11.5	10.4

Table 16 gives tooth sizes reported by Smith, Brown and Wood (1981) for Broadbeach males and females and Swanport males. They found Broadbeach to have the largest teeth of the six samples with the following teeth significantly ($P < 0.05$) larger in the mesio-distal dimension: maxillary P^3, M^1, M^2, mandibular I_2, C, P_3, P_4, M_2. However, as table 16 shows, the bucco-lingual measurements for Swanport and Broadbeach are almost identical. The average bucco-lingual measurement for the fourteen upper and lower teeth is 10.08 mm. at Broadbeach and 10.07 at Swanport. Five teeth are larger at Swanport and six teeth are larger at Broadbeach with the greatest difference being 0.4 mm for P_4. Smith, Brown and Wood state that only teeth with "little or no attrition" were measured. One wonders how adult teeth with little or no attrition were found in any numbers, but taken as given the data show Broadbeach to have larger teeth than Swanport mesio-distally, but equivalent sized teeth bucco-lingually.

Table 17

Sexual Dimorphism in Permanent Teeth (%)

	Swanport		Murray Basin		Broadbeach	
Maxilla	M-D	B-L	M-D	B-L	M-D	B-L
I^1	10.5	7.5	8.2	10.0	-0.3	5.3
I^2	3.7	10.4	6.6	10.0	6.2	0.4
C	10.2	9.6	11.8	8.4	-7.4	1.4
P^3	16.8	8.0	9.8	7.3	3.9	9.3
P^4	5.8	7.6	7.0	4.6	-3.3	7.8
M^1	13.1	9.8	0.7	4.6	7.2	5.0
M^2	6.2	10.1	1.9	6.8	8.8	6.9
M^3	1.4	8.4	2.4	11.3	-1.4	4.3
Mandible						
I_1	2.0	9.3	-5.6	-0.5	3.1	5.2
I_2	-8.2	5.2	-5.9	1.0	5.9	3.0
C	1.6	7.5	25.3 *	17.7 *	3.9	5.2
P_3	-2.4	6.8	9.5	9.9	3.7	9.3
P_4	0.3	3.6	19.4	9.4	1.4	8.2
M_1	12.2	6.3	-1.1	12.1	4.5	6.5
M_2	5.3	4.0	8.6	10.9	8.7	10.9
M_3	7.4	11.0	5.6	8.0	4.6	12.2
Average =	5.3%	7.8%	6.5%	8.2%	3.1%	6.3%

(Sexual Dimorphism = $\frac{\text{male mean} - \text{female mean}}{\text{female mean}} \times 100$)

*Male N = 1, female N = 6

Table 17 shows extremely high levels of sexual dimorphism for both mesio-distal and bucco-lingual measurements. At Broadbeach half the maxillary teeth were larger mesio-distally in females than in males, and this was true for two mandibular teeth at Swanport and three mandibular teeth at Murray Basin. Dimorphism is so extreme and female size excess is so unexpected that one must appeal to age differences, differential wear between the sexes and/or random effects for an explanation. As even bucco-lingual measurements give very high dimorphism levels for all teeth except maxillary I_2 and C and mandibular I_2 for Broadbeach, it appears very likely that these three populations truly have high levels of sexual dimorphism.

When sexual dimosphism is calculated from Smith, Brown and Wood's data levels almost as high as those above are found at Swanport and Broadbeach. Freedman and Lofgren (1981) report values for Western Australia a little lower than those above and similar to Smith et al. Townsend and Brown (1979) give sexual dimorphism percentages at Yuendumu. Their levels are much lower than those of this study and of the Western Australian group. Table 18 gives these percentages.

Table 18

Sexual Dimorphism Revealed in Three Studies of Aboriginal Tooth Size (%)

	Western Australia		Broadbeach		Yuendumu	
Maxilla	M-D	B-L	M-D	B-L	M-D	B-L
I^1	7.7	6.4	3.1	6.7	4.3	5.8
I^2	2.0	5.4	8.3	11.1	4.4	5.0
C	2.6	8.8	3.6	---	4.0	5.0
P^3	5.0	5.3	3.9	8.2	2.0	2.8
P^4	4.5	6.1	2.7	2.9	1.7	3.0
M^1	7.2	5.9	14.4	0	2.9	4.1
M^2	7.0	6.1	6.4	3.8	2.9	4.6
M^3	8.2	5.6	4.1	6.9	0.8	3.5
Mandible						
I_1	10.1	12.7	-1.6	6.2	3.4	4.3
I_2	1.6	6.4	2.9	-8.1	3.0	4.4
C	5.4	11.3	5.4	---	6.7	5.2
P_3	5.0	4.7	12.5	7.1	2.3	3.6
P_4	2.3	2.2	5.2	4.5	2.7	3.2
M_1	10.1	5.6	2.5	1.7	3.9	3.0
M_2	4.4	4.0	7.5	5.3	2.1	4.1
M_3	7.4	3.6	7.0	10.5	1.7	4.4
Average	5.6%	6.2%	5.5%	4.7%	3.1%	4.2%

Juveniles

In comparing sizes of juvenile teeth from Swanport, Murray Basin and Broadbeach one encounters the problem of potential differences in the relative ratios of sexes and age. The category of juvenile includes individuals up to eighteen years of age who have had first molars and incisors erupted for 12 years. The teeth of juveniles may be significantly worn with a concomitant diminution in length. Therefore if one group which randomly includes most individuals over age ten is compared to another group for which most individuals are under ten, the former group would average smaller teeth even if newly erupted crown size had been the same.

Similarly, as males have larger teeth than females a group with relatively more males would have larger mean tooth sizes than another group with relatively fewer males.

When the three study samples were divided into individuals of ages under 5, 5 to 10, and over 10 they had almost equal percentages of individuals in these three age categories. Age difference can thus be largely eliminated as affecting tooth size in the juveniles.

Table 19 gives size comparison between the juveniles from the three samples.

Table 19

Permanent Tooth Size of Broadbeach Juveniles
Compared to Swanport and Murray Basin (% difference)
(> = larger, < = smaller)

	Mesio-Distal		Bucco-Lingual	
Maxilla	BB:SP	BB:MB	BB:SP	BB:MB
I^1 - C	5.9%>	0.9%>	2.1%>	4.8%<
P^3 - M^2	2.4%>	----	1.4%>	----
Whole Row	5.4%>	----	1.6%>	----
Mandible				
I_1 - C	0.4%<	----	0.4%>	----
P_3 - M_2	4.8%>	----	2.2%>	----
Whole Row	3.0%>	----	1.6%>	----

Many teeth were not represented in the Murray Basin juveniles so a comparison was not possible.

Broadbeach compared to Swanport has greater mesio-distal mean dimensions especially in the maxilla. Broadbeach has very slightly greater bucco-lingual dimensions. Margetts and Brown (1978) for Yuendumu found extreme variability in the ratio of B-L dimension to M-D dimension in the maxilla. There was less, but some, variability of this ratio in the mandible. This effect may account for the M-D and B-L ratio differences in the Broadbeach:Swanport comparison. Alternatively, the closeness of the bucco-lingual means may indicate an equivalence of tooth size which reveals by the mesio-distal size difference more rapid wear at Swanport. If this were true the Swanport anterior teeth would be wearing more rapidly than the posterior in the maxilla, but in the mandible the posterior teeth would be wearing faster than the anterior - a curious situation.

Juveniles and Adults

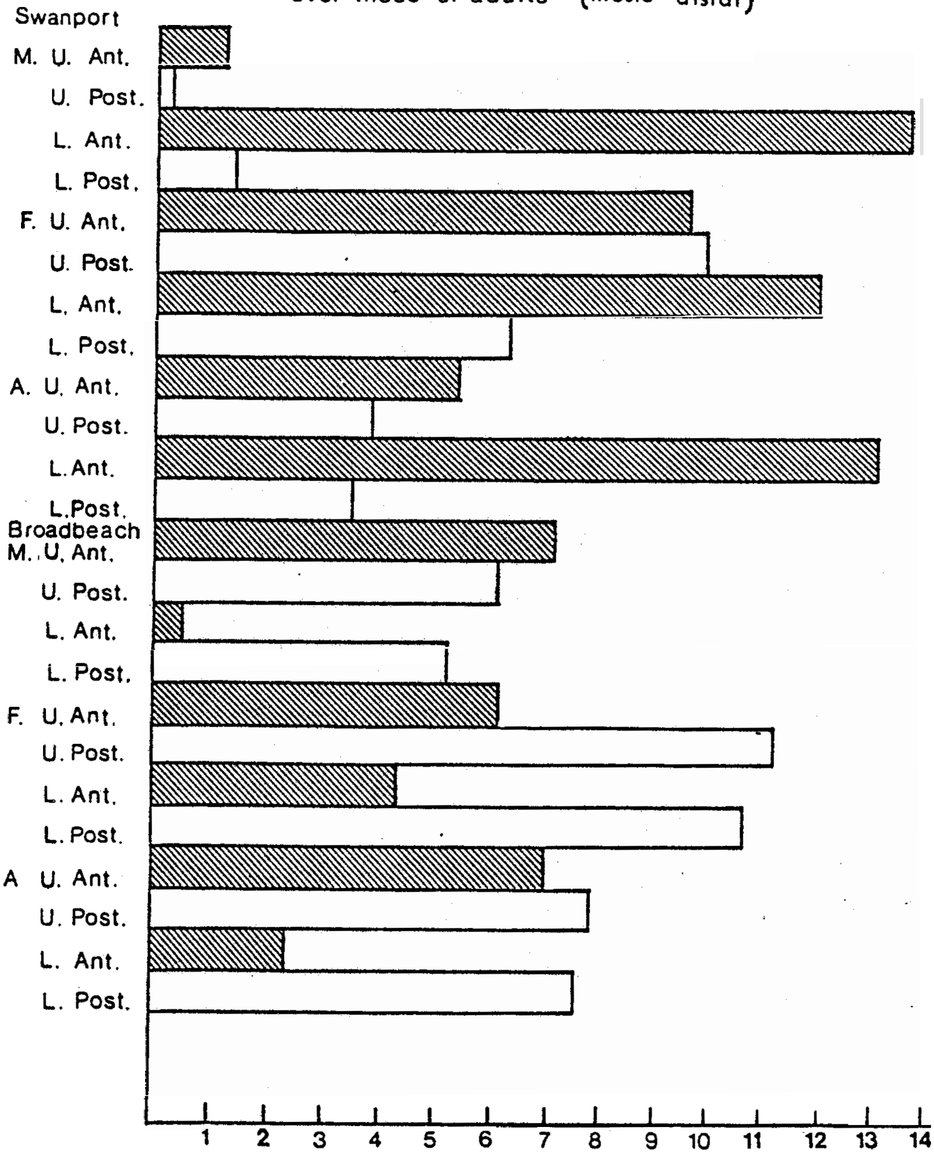
The difficulty of comparing juveniles to adults has been discussed. In making such a comparison one would expect one of two results. Because juveniles are comprised of males and females their tooth size means should fall between adult male means and female means. Alternatively, because adult teeth are much more worn juvenile tooth means should exceed even adult male means. Table 20 compares juvenile means from Table 12 with combined adult means from Table 13 and to male and female adults separately. The Murray Basin is excluded because of missing juvenile teeth. Figure 5 presents the same data graphically for the mesio-distal dimension.

Table 20

Relative Permanent Tooth Size in Juveniles and Adults
(% Difference) (> = larger, < = smaller)

	Mesio-Distal		Bucco-Lingual	
	Swanport	Broadbeach	Swanport	Broadbeach
J:Combined Adults				
Max. I^1 - C	5.5 % >	7.0 % >	0.9 % <	1.6 % >
P^3 - M^2	3.9 % >	7.9 % >	2.8 % <	1.2 % >
Whole Row	4.5 % >	7.5 % >	2.1 % <	1.3 % >
Man. I_1 -C	13.2 % >	2.4 % >	3.9 % <	0.8 % <
P_3 - M_3	3.5 % >	7.5 % >	4.1 % <	0.1 % <
Whole Row	6.6 % >	5.7 % >	4.0 % <	0.4 % <
J: Males				
Max. I^1 - C	1.2 % >	7.2 % >	5.3 % <	1.0 % >
P^3 - M^2	0.2 % >	6.2 % >	6.4 % <	0.8 % <
Whole Row	0.3 % >	6.6 % >	6.0 % <	0.2 % <
Man. I_1 - C	13.8 % >	0.5 % >	6.5 % >	2.7 % <
P_3 - M_2	1.4 % >	5.3 % >	6.3 % <	3.4 % <
Whole Row	5.3 % >	3.7 % >	6.4 % <	3.2 % <
J:Females				
Max. I^1 - C	9.7 % >	6.2 % >	3.6 % >	3.4 % >
P^3 - M^2	10.0 % >	11.3 % >	2.4 % >	6.1 % >
Whole Row	9.9 % >	9.2 % >	2.8 % >	5.2 % >
Man. I_1 - C	12.1 % >	4.4 % >	0.8 % >	1.7 % >
P_3 - M_2	6.4 % >	10.7 % >	1.0 % <	5.0 % >
Whole Row	8.2 % >	8.6 % >	0.4 % >	3.9 % >

Figure 5
Percent size excess of juvenile tooth groups over those of adults (mesio-distal)



M male F female A all adults
U maxilla L mandible Anterior Posterior

Table 20 is almost startling in its revelations. Take the bucco-lingual measurements first, that is, the dimension little affected by attrition. The comparison with the combined adults justified one of the alternative expectations, that juvenile tooth size should fall between adult male and adult female tooth size. There is little size difference at Swanport or Broadbeach, except for the Swanport mandibles which are a little smaller in juveniles. At Swanport the juveniles are quite smaller than the males in all teeth, a little larger than the females in the maxilla and almost the same size in the mandible. At Broadbeach the juveniles are a little smaller than the males and larger than the females.

The mesio-distal measurements are quite different. The Swanport and Broadbeach juveniles are larger in the mean size than both males and females in every tooth group except for the Swanport male posterior maxillary teeth which are the same size. This fulfills the alternative expectation that wear will reduce even male dimensions below those of juveniles.

The truly revealing thing is the pattern of juvenile excess over male and female tooth size. The Broadbeach juveniles exceed the adults in all tooth groups but the excess is very marked in the posterior teeth, except for the male maxilla. This indicates that the Broadbeach adults are wearing their posterior teeth relatively more than their anterior teeth.

The opposite is true at Swanport. Here the juveniles exceed the adults in size most markedly in the anterior teeth except for the female maxilla. This anterior excess is great in the mandibles. This indicates that the Swanport adults are wearing their anterior teeth, expecially in the mandible, much faster than they are wearing their posterior teeth.

The same pattern is found when worn adult teeth of this study are compared to "unworn" adult teeth reported by Smith, Brown and Wood (1981). For Swanport males the mesio-distal reduction, obtained by subtracting worn values from unworn values, is slightly greater in maxillary anterior teeth than posterior teeth, but is much greater in mandibular anterior teeth than posterior teeth.

For Broadbeach males both maxilla and mandible show much greater reduction in posterior teeth than anterior teeth. This is true in the female maxilla, but the mandible shows equivalent anterior and posterior reduction. Table 21 gives these figures.

Table 21

Reduction in Tooth Row Length Revealed by Subtraction of Worn Tooth Measurements (this study) from "Unworn" Tooth Measurements (Smith, Brown and Wood 1981)

		Smith et al		This Study		Difference
S.P. ♂	Max	$I^1 - C$	25.1	$I^1 - C$	24.44	0.66
		$P^3 - M^3$	46.9	$P^3 - M^3$	46.28	0.62
	Mand	$I_1 - C$	20.0	$I^1 - C$	17.35	2.65
		$P_3 - M_3$	51.9	$P_3 - M_3$	50.51	1.39
B.B. ♂	Max	$I^1 - C$	26.2	$I^1 - C$	24.43	1.77
		$P^3 - M^3$	49.0	$P^3 - M^3$	46.18	2.82
	Mand	$I^1 - C$	20.6	$I^1 - C$	19.57	1.03
		$P_3 - M_3$	53.3	$P_3 - M_3$	51.07	2.23
B.B. ♀	Max	$I^1 - C$	25.0	$I^1 - C$	24.66	0.34
		$P^3 - M^3$	45.9	$P^3 - M^3$	44.63	1.27
	Mand	$I_1 - C$	20.1	$I_1 - C$	18.75	1.35
		$P_3 - M_3$	50.0	$P_3 - M_3$	48.63	1.37

Effects of Physiological Stress on Tooth Size

In bucco-lingual dimensions the Swanport juveniles have teeth a little smaller than the combined adults of five males and five females. This may be merely random. Guagliardo (1982) studied an archaeological Indian population from Tennessee and found that adult teeth exceeded those of juveniles in size bucco-lingually. He concluded that the population was under physiological stress. Physical condition, especially prenatal, influences phenotypic tooth size, so sickly children should have smaller teeth than those healthy enough to live to adulthood. These sickly children would contribute much of the childhood mortality thus causing the teeth of the juvenile individuals from a burial site to be on average smaller than those of adults. In sites where juvenile teeth are smaller than adult teeth, Guagliardo would see evidence of stress.

If the Swanport sample resulted largely from a smallpox epidemic one would expect the disease to have carried off a disproportionately high number of children who were sickly. This could well fulfill the prediction of showing smaller teeth in juveniles than adults.

Deciduous Teeth

Table 22 gives the sizes of the deciduous teeth from Swanport, Murray Basin and Broadbeach.

Table 22

Deciduous Tooth Dimensions (*mm.*)

Tooth	Mesio-Distal									Bucco-Lingual								
	Mean	n	S.D.	Mean	n	S.D.	Mean	n	S.D.	Mean	n	S.D.	Mean	n	S.D.	Mean	n	S.D.
	Swanport			Murray			Broadbeach			Swanport			Murray			Broadbeach		
Maxilla																		
di^1	7.10	6	.52	6.96	3	.67	7.47	6	.44	5.51	6	.50	5.68	3	1.09	5.33	6	.27
di^2	5.71	7	.31	5.21	4	.37	5.78	5	.22	5.32	8	.39	4.80	4	.56	5.19	5	.36
dc	7.24	13	.65	7.04	7	.51	7.00	7	.81	6.36	14	.56	6.29	7	.40	6.08	7	.39
dm^1	7.46	20	.76	7.20	27	.59	7.65	23	.89	9.23	20	1.02	9.51	27	.62	9.03	23	.79
dm^2	9.79	21	.42	9.35	32	.82	9.62	23	.62	10.42	22	1.11	10.46	32	.60	10.46	23	.62
Mandible																		
di_1	4.35	3	.43	4.37	6	.48	4.49	4	.52	4.16	3	.41	4.03	6	.58	4.15	4	.54
di_2	5.14	7	.50	4.63	8	.30	5.32	7	.38	4.63	7	.32	4.18	8	.23	4.47	7	.37
dc	6.31	8	.41	6.09	12	.59	6.51	12	.68	5.98	9	.51	5.47	12	.35	5.86	12	.63
dm_1	8.76	20	.64	8.28	21	.88	8.68	28	.53	7.30	20	.75	7.34	21	.49	7.59	28	.70
dm_2	11.03	20	.76	10.63	19	.93	11.26	30	.62	9.33	20	.87	9.34	19	.50	9.45	30	.53

Table 23 gives the relative sizes of tooth groups.

Table 23

Deciduous Tooth Group Sizes (in mm.)

	Mesio-Distal			Bucco-Lingual		
	Swanport	Murray	Broadbeach	Swanport	Murray	Broadbeach
Maxilla						
di^1 - dc	20.05	19.21	20.25	17.19	16.77	16.60
dm^1 - dm^2	17.25	16.55	17.27	19.65	19.97	19.49
Whole Row	37.30	35.76	37.52	36.84	36.74	36.09
Mandible						
di_1 - dc	15.80	15.09	16.33	14.77	13.68	14.48
dm_1 - dm_2	19.79	18.91	19.94	16.63	16.68	17.04
Whole Row	35.59	34.00	36.27	31.40	30.36	31.52

In both mesio-distal and bucco-lingual dimensions the Swanport and Broadbeach deciduous teeth are virtually the same size, but both are slightly larger than Murray Basin.

Table 24 gives the deciduous teeth as a size percentage of their permanent successors in juveniles for each site.

Table 24

Deciduous Teeth as a Size Percentage of their Permanent Successors

	Mesio-Distal			Bucco-Lingual		
	Swanport	Murray	Broadbeach	Swanport	Murray	Broadbeach
Maxilla						
$di^1 : I^1$	79.6%	77.7%	73.9%	73.2%	75.3%	67.5%
$di^2 : I^2$	77.5%	71.6%	74.5%	82.2%	70.9%	76.4%
dc : C	88.8%	72.2%	83.5%	71.8%	61.9%	70.2%
$dm^1 : P^3$	100.8%	91.2%	98.2%	92.7%	85.6%	91.4%
$dm^2 : P^4$	123.3%	---	126.0%	105.7%	---	103.4%
Mandible						
$di_1 : I_1$	75.2%	71.8%	78.9%	67.6%	65.3%	69.6%
$di_2 : I_2$	76.9%	75.3%	82.9%	71.7%	67.7%	71.9%
dc : C	86.4%	---	86.0%	80.9%	---	74.0%
$dm_1 : P_3$	122.5%	---	113.7%	89.7%	---	91.0%
$dm_2 : P_4$	151.5%	---	140.5%	112.1%	---	104.2%

The table gives similar figures for all populations, and they are very close to the figures for Yuendumu given by Brown, Margetts and Townsend (1980a).

Mesio-distally in the maxilla the dm^1 approaches the size of the P^3, surpassing it at Swanport. The dm^2 is much larger than the P^4. In the mandible both dm_1 and dm_2 are much larger than their successors. This means that when the deciduous molars are exfoliated there is excess space for the emerging premolars and consequently little likelihood of anterior crowding or posterior malocclusion. Adult aborigines show a low incidence of these dental defects.

Discussion

The size of an erupting tooth crown is determined by genetic inheritance and environment. Townsend and Brown 1978a and 1978b; Townsend 1978; Townsend and Brown 1979a; and Townsend 1980 have studied sibling and half-sibling size correlations at Yuendumu and concluded that about 60% of the deciduous tooth size is due to genetic inheritance and a further 15% is due to common environmental factors. The remainder of size variation is due to environment. For permanent teeth genetic inheritance contributes 64% of tooth size and the common environmental determinant in tooth size is prenatal maternal environment. Garn, Osborne and McCabe 1979, in a study of North American whites concluded that maternal and fetal determinants accounted for half of crown size variability for both deciduous and permanent teeth.

According to Preston 1980, fluoride in drinking water produces smaller teeth while boron has the opposite effect. The drinking water at Yuendumu has the high fluoride level of up to 1.8 parts per million (Brown and Townsend 1980).

Given the strong environmental influence upon tooth size one misgives the use of tooth size as evidence for genetic affinity between populations. Certainly within an overall population like the Australian aborigines this approach must be used with caution and no fervent hopes of convincing success. The only way in which true tooth size or variability can be determined for populations such as those represented in this study, is to obtain large samples of unworn crowns from individuals of known sex. This would be asking a great amount and because of the paucity of juvenile specimens and the difficulty in sexing immature skeletons it is currently not possible.

The work in this chapter reveals tooth size variation but because of sample inadequacies it is not possible to determine if this variability is statistically significant.

The work of Smith, Brown and Wood (1981) suggests significantly longer teeth at Broadbeach than at Swanport and Murray Basin but the widths are the same. The picture is further obfuscated by uncertainties of sex ratio, age relativity, and attrition variability.

Nevertheless, revealing patterns have emerged, especially from bucco-lingual measurements, and by observing the relativity of the above confounding factors one can make useful and valid observations.

In summary, at both Swanport and Broadbeach juvenile bucco-lingual mean dimensions fall between those of adult males and adult females. However, in mesio-distal mean dimensions the juveniles from both sites exceed those of adult males as well as females. The pattern of juvenile excess is different between the sites. At Swanport juveniles exceed adults most markedly in the anterior teeth, while at Broadbeach the juveniles exceed the adults most markedly in the posterior teeth. This reveals a distinctly different pattern of attrition in adults between the sites.

CHAPTER 4

DENTAL ATTRITION

The wear of teeth in rate and degree depends upon genetic, environmental and cultural factors. Tooth size, morphology, occlusion and enamel hardness result from genetic and environmental interactions. Types of food eaten, food preparation techniques, and industrial or craft uses of the teeth depend upon culture and its environment.

The progressive wear of teeth with corresponding accommodations of the dental arch and occlusion patterns is a natural biological function and is general in pre-industrial revolution societies. Dental wear only becomes pathological when it reaches a degree of severity that exposes the pulp chamber (Begg 1954; Barrett 1958, 1969; Molnar 1971).

Many attempts have been made to develop a system of grading dental attrition for comparative purposes. Scales of wear stages of the occlusial tooth surface have been the commonest systems (Campbell 1925, 1938, 1939a; Murphy 1959a; Heithersay 1960; Molnar 1971; Scott 1979b; Hinton 1981, 1982).

The molar gradient of wear has been used (Murphy 1959b; Smith 1972; Walker 1978; Scott 1979a) to give a rate of wear independent of age. Because the M1 erupts about six years before the M2 in all populations the amount of wear by which M1 exceeds M2 represents six years of molar wear. For individuals of any age the rate of molar wear can thus be determined. It implies, of course, that M1 wears at the same rate as M2.

Tomenchuk and Mayhall (1979) used a system of measuring crown height reduction to assess attrition levels. This is suitable for assessing some types of wear.

A technique of photographing the occlusal surfaces of the teeth and measuring on the photograph the relative areas of enamel and exposed dentine has been used by Behrend (1977); Walker (1978); Richards and Brown (1981). Each of these systems has limitations. Scales of wear stages are subjective and however finely graded they are, one will always have teeth with perceptible wear differences in the same stage. As they are ordinal scales the results are not valid for sophisticated statistical analysis.

The molar gradient system finds fair numbers of individuals with M1 and M2 at the same level of wear, especially if the wear is graded on an ordinal scale. It ignores the anterior teeth which are important in understanding the overall pattern of attrition.

The photographic technique is promising in that it provides a true measure of tooth wear, but it only deals with teeth with exposed dentine. Those teeth with wear of the enamel but no dentine exposure, and those with no occlusal enamel left cannot be assessed by this system.

Attrition and Culture

Dental attrition has decreased in severity as human societies have evolved from hunting and gathering to agricultural and industrial economies (Barrett 1969; Molnar 1972, Wolpoff 1971). This is not so much because the foods eaten have changed, but because food preparation and cooking techniques have rendered food softer and less abrasive. The elaboration of material culture has lessened the use of teeth as tools, which practice in hunter-gatherer society contributed to tooth wear.

Smith (1972) in a study of three Natufian sites found less dental attrition and disease at the hunter-gatherer site than at the agricultural sites. She concluded that the highly abrasive quality of stone ground cereals was responsible for heavy wear among the agriculturalists. Other studies have found hunter-gatherers to have higher attrition than agriculturalists. Molnar (1971) in a study of three groups of south-western Indians found the Californian hunter-gatherers to have higher attrition than two agricultural groups. Sciulli (1977) in a study of Ohio Valley Indians found the agricultural group to have smaller teeth, less wear, but more enamel hypoplasia than hunter-gatherers. Hinton (1981) compared Australian aboriginal and Eskimo hunter-gatherers to Ohio and south-west Indian agriculturalists and found the hunter-gatherers to have relatively and absolutely greater wear of the anterior teeth but equivalent wear of the molars.

Different environments and cultural practices can produce differential tooth wear among hunter-gatherers. Hinton (1982) found Archaic Indians to have greater attrition than later Mississippian and Woodland Indians. This, he concluded, was because of pottery introduction and improvements in cooking. Walker (1978) in comparing Indians of the Santa Barbara Channel area found island Indians with a poor environment to have greater attrition than neighbours with wider resources. Richards and Brown (1981) on the other hand, in comparing north coast Australian aborigines from Kalumburu to central desert aborigines from Haasts' Bluff found no difference in molar attrition.

Sex differences in attrition levels are ambiguous. Molnar (1971) found no sex differences in two south-west Indian groups, but a slight anterior tooth difference in a California group. He (1972) found no difference in

Greenland Eskimos, even though females often chewed hides for clothing manufacture. Tomenchuk and Mayhall (1979) found males among North-West Territories Eskimos to have 30% greater wear of molars than females. They suggested bruxism as the cause of this difference. Campbell (1939a) states that for Australian aborigines attrition is more marked in females than in males. This, he says, is because females gather vegetable foods which are coarse and sandy, and they tend to eat more of these foods than do men. They also receive the tougher, more sinewy parts of animal carcasses provided by men. Heithersay (1960) also found Aboriginal females to have heavier attrition than males, even among children, but Richards and Brown (1981) found equivocal sex differences.

Scoring of Attrition

This study employed a 14 stage scale of dental attrition which was applied to all teeth. The stages are as follows:

0. No Wear.
1. Slight Facets. Slight facets of wear appear in enamel, usually on the cusps in molars.
2. Heavy Facets. Enamel facets are more developed.
3. Rounding. The cusps of molars and edges of incisors are rounded and smooth.

4. Flattening. The cusps of molars and edges of incisors are flattened.

5. Dentine Spots. Small spots of exposed dentine appear, usually in the cusp area of molars.

6. Light Dentine Exposure. In molars < 1/4 of the surface is exposed dentine. In incisors a thin dentine strip appears along the edge.

7. Moderate Dentine Exposure. In molars 1/4 - 1/2 of the surface is exposed dentine. In incisors the edge is worn down to reveal a dentine rectangle.

8. Heavy Dentine Exposure. In molars > 1/2 of the surface is exposed dentine. In incisors the edge is worn down to reveal a dentine rectangle.

9. Enamel Ring. In molars an enamel ring is left around the occlusal dentine. In incisors a large dentine circle appears.

10. Dentine Bowl. The dentine in molars is worn to a bowl contour with the enamel edges left higher.

11. Enamel Ring Partial, Steep Wear Slope. Enamel on one side is worn away so tooth surface assumes a steep slope to one side.

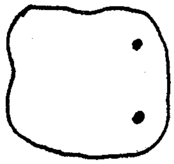
12. Root Wear One Side. The crown is worn away on one side and the root begins to wear.

13. Root Wear Both Sides. The crown is gone and the root is wearing.

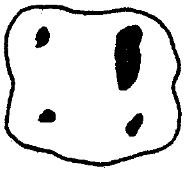
See Appendix B for photographic examples of tooth wear.

Figure 6 shows the middle stages of molar attrition.

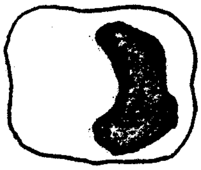
Middle Attrition Stages



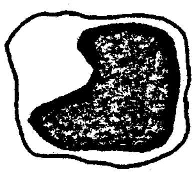
Stage 5 Dentine Spots



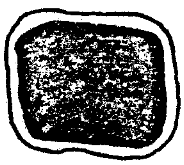
Stage 6 Light Dentine Exposure



Stage 7 Moderate Dentine Exposure



Stage 8 Heavy Dentine Exposure



Stage 9 Enamel Ring

The preceding scale is not ideal. Assigning a tooth to a stage is subjective, and sometimes two teeth with different wear have to be put in the same stage. The differences between stages are not necessarily equivalent. For example, it may take more attrition increment to proceed from stage 8 to 9 than to proceed from stage 4 to 5. This means that advanced statistical treatment of wear scores is not valid. Incisors and molars, because of their different size, shape and function will proceed through the stages at different rates. These difficulties are not critical in this study, as most comparisons are those of relative differences which are not compromised by the scale.

Attrition Comparisons

Deciduous Teeth

The teeth of juveniles were given a functional age, which is the age of the individual minus the eruption age for a given tooth. The four deciduous molars were the only teeth represented in reasonable numbers at the three sites (numbers ranged from 17 to 28). Their functional ages were compared to their wear scores and the two variables did not correlate very highly. The correlations ranged from .39 to .80. Table 25 gives these correlations.

Table 25

Correlations of Functional Age to Wear Score in Deciduous Molars

Tooth	Swanport	Murray Basin	Broadbeach
dm^1	.61	.71	.52
dm_1	.56	.68	.74
dm^2	.76	.72	.72
dm_2	.39	.80	.79

These correlations show great variability of wear rates for which no ready explanation is available. The range of error in the ageing technique and the variablity in eruption ages of teeth may be important factors, but they are unlikely to be complete answers. It seems that the teeth of individuals wear at quite different rates. All second deciduous molars were combined for each site and the correlation coefficients became higher: for Swanport .83; for Murray Basin .77; and for Broadbeach .82. The second deciduous molars were subjected to regression analysis. The results are presented later with those of permanent incisors and molars.

For each site juveniles were divided into three year age classes. It was hoped these classes would provide useful numbers of individuals and overcome error in ageing technique. The average wear for each age class for each tooth was calculated. Where an individual had both left and right teeth the mean attrition score was used if the scores varied. Left/right asymmetry in attrition was uncommon.

Table 26 gives these average wear scores for age classes.

Table 26

Average Attrition Scores of Teeth for Given Age Intervals

Tooth	Age Intervals in Years	Average Attrition Scores Swanport	n	Murray	n	Broadbeach	n
di^1	1 - 4	4.6	5	4.0	1	6.5	2
	>4 - 7	6.0	1	5.0	2	7.0	2
	>7 - 10	-		-		8.0	1
di_1	1 - 4	4.0	1	4.5	4	7.5	2
	>4 - 7	6.0	2	6.5	2	6.7	2
di^2	1 - 4	4.6	5	6.0	1	6.0	2
	>4 - 7	6.5	2	7.2	2	6.5	2
	>7 - 10	9.0	1	3.0	1	-	
di_2	1 - 4	4.5	4	4.3	3	6.0	4
	>4 - 7	6.0	2	6.6	3	6.0	2
	>7 - 10	7.0	1	6.0	1	-	
dc	1 - 4	5.5	2	3.5	1	0.5	2
	>4 - 7	6.2	4	8.0	1	6.3	3
	>7 - 10	8.0	6	6.5	4	7.0	1
dc	1 - 4	5.8	3	2.6	5	5.2	5
	>4 - 7	5.8	3	6.7	4	6.0	2
	>7 - 10	7.1	4	6.5	2	6.0	4
dm^1	1 - 4	4.1	7	3.7	4	3.6	6
	>4 - 7	5.9	4	5.8	10	7.1	5
	>7 - 10	7.5	9	7.7	11	7.5	10
	>10 - 13	-		7.5	2	-	
dm_1	1 - 4	3.4	7	2.6	7	4.1	8
	>4 - 7	4.9	5	4.8	5	6.1	6
	>7 - 10	6.7	8	6.4	7	6.5	13
	>10 - 13	-		7.0	1	-	-

Table 26 Continued

Tooth	Age Intervals in Years	Average Attrition Scores Swanport	n	Murray	n	Broadbeach	n
dm^2	1 - 4	2.2	5	1.8	4	2.4	5
	>4 - 7	4.1	5	4.7	11	5.3	3
	>7 - 10	6.8	10	6.3	12	6.8	12
	>10 - 13	---		6.7	5	7.0	1
dm_2	1 - 4	2.0	5	2.0	5	3.0	7
	>4 - 7	3.8	5	4.6	5	5.7	6
	>7 - 10	6.3	10	6.6	7	6.9	13
	>10 - 13	---		6.0	1	7.0	2
I^1	7 - 10	2.2	4	2.5	4	1.0	2
	10 - 13	---		3.7	3	6.0	1
	13 - 16	6.0	2	---		---	
	16 - 19	6.5	2	---		6.2	
I_1	7 - 10	3.7	6	1.5	4	3.4	7
	>10 - 13	6.0	1	---		5.0	3
	>13 - 16	6.5	2	---		---	
	>16 - 19	6.5	2	---		6.2	4
I^2	7 - 10	2.3	3	0.3	3	1.5	2
	>10 - 13	2.0	2	2.3	3	5.0	3
	>13 - 16	4.0	2	---		---	
	>16 - 19	4.5	2	---		5.2	4
I_2	7 - 10	4.0	3	0.8	6	1.0	5
	>10 - 13	3.0	1	---		5.0	3
	>13 - 16	6.5	2	---		---	
	>16 - 19	6.5	2	---		6.0	4

Table 26 Continued

Tooth	Age Intervals in Years	Average Attrition Scores Swanport	n	Murray	n	Broadbeach	n
$\underline{C}$	10 - 13	1.5	2	0	1	1.6	3
	>13 - 16	5.0	2	---		3.0	1
	>16 - 19	3.5	2	---		4.5	4
$\overline{C}$	10 - 13	1.5	1	---		2.2	5
	>13 - 16	2.0	1	---		3.0	1
	>16 - 19	4.5	2	---		3.7	3
P^3	10 - 13	0.5	2	0	2	2.0	4
	>13 - 16	2.5	3	---		3.0	1
	>16 - 19	3.0	1	---		3.7	3
P_3	10 - 13	1.0	1	---		1.7	4
	>13 - 16	3.5	2	---		3.0	1
	>16 - 19	4.0	2	---		3.5	4
P^4	10 - 13	0.5	2	---		2.6	3
	>13 - 16	3.2	2	---		---	
	>16 - 19	3.0	2	---		3.5	4
P_4	10 - 13	1.0	1	---		3.0	2
	>13 - 16	2.7	2	---		3.0	1
	>16 - 19	3.7	2	---		4.0	4
M^1	4 - 7	1.0	1	1.6	6	1.5	2
	>7 - 10	2.7	10	2.2	12	2.5	12
	>10 - 13	3.0	2	3.3	5	4.7	4
	>13 - 16	4.0	4	---		6.0	1
	>16 - 19	5.5	2	---		6.5	4

Table 26 Continued

Tooth	Age Intervals in Years	Average Attrition Scores Swanport	n	Murray	n	Broadbeach	n
M_1	4 - 7	---		1.0	3	1.5	2
	> 7 - 10	3.5	9	3.1	6	3.3	9
	>10 - 13	4.5	1	3.0	1	4.5	6
	>13 - 16	4.6	4	---		6.0	1
	>16 - 19	6.0	2	---		6.1	4
M^2	10 - 13	1.0	2	---		0.7	3
	>13 - 16	2.7	4	---		3.0	1
	>16 - 19	3.5	2	---		3.5	4
M_2	10 - 13	1.0	1	---		1.7	3
	>13 - 16	3.0	3	---		2.0	1
	>16 - 19	3.7	2	---		4.2	4
M^3	16 - 19	1.2	2	---		1.5	4
M_3	16 - 19	2.0	1	---		2.0	2

Unfortunately the sample sizes remain very small even when combined into age classes. Variability can be seen in the odd diminution of mean score with an increase in age. The deciduous teeth show a general similarity between the sites, especially in the later ages for each tooth. The anterior teeth have high scores at the earliest age class which indicates that the deciduous teeth begin to wear as soon as they become functional. This supports Campbell (1938, 1939a) and Begg (1954) who found deciduous teeth to begin wearing immediately upon coming into occlusion, even though aboriginal children were generally breast fed until three and even five years of age.

The permanent teeth are represented by such small numbers that nothing can be safely said. No site differences are indicated.

The deciduous molar wear gradient was calculated by subtracting dm2 wear scores from dm1 wear scores in jaws that had both teeth. Where there was a difference between right and left sides the average was taken. Table 27 gives these gradients.

Table 27

Deciduous Molar Mean Wear Gradients

	Swanport			Murray Basin			Broadbeach		
	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.
Maxilla $dm^1 - dm^2$	16	1.66	1.36	14	1.54	1.37	17	1.38	1.07
Mandible $dm_1 - dm_2$	16	1.09	1.36	14	0.32	1.03	17	0.53	0.96

In each site the maxillary teeth are wearing faster than the mandibular teeth. At Swanport the inter-jaw difference is not significant, but at Murray Basin and Broadbeach it is significant at the $P < .05$ level. The differences between sites are not significant. Indeed, the means are very close except for the Swanport mandible.

These data suggest a similarity in the rate of wear of deciduous teeth at the three sites.

Juvenile Permanent Teeth

The molar gradient was calculated for juveniles with permanent M1 and M2 by subtracting M2 wear score from M1 wear score. Murray Basin had no individuals in this age group. Table 28 gives these gradients.

Table 28

Permanent Molar Mean Wear Gradients in Juveniles

	Swanport			Broadbeach		
	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.
Maxilla $M^1 - M^2$	6	1.58	.74	6	3.58	1.43
Mandible $M_1 - M_2$	5	2.75	1.57	5	3.00	1.58
Both Jaws M1 - M2	11	1.91	1.02	11	3.32	1.45

As the maxillae and mandibles showed no significant differences they were combined. The result was that Broadbeach exceeded Swanport in rate of molar wear and the difference was significant at $P < .05$ level. With such small numbers it is not possible to be confident of patterns. The numbers are suggestive that at Swanport mandibles exceed maxillae in molar wear rate, while at Broadbeach the opposite is true. Greater sample sizes would be revealing.

Anterior and Posterior Teeth

Anterior and posterior teeth were compared by analysis of I1 and M1 wear scores. These teeth make a useful comparison. They are the earliest permanent teeth to erupt, which occurs at approximately the same time. They therefore have equivalent functional ages. They are the key teeth in the anterior and posterior dentition.

Juvenile individuals were divided into two age groups: younger than 12.5 years and 12.5 years and over. This divides young children from adolescent children and is probably close to the onset of puberty, at least in girls. Mean M1 - I1 wear scores were calculated to give relative posterior to anterior wear rates. Table 29 gives the figures.

Table 29

M1 Minus I1 Mean Wear Scores : Posterior Minus Anterior Tooth Wear in Juveniles

	Swanport			Murray Basin			Broadbeach		
< 12.5	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.	n	$\bar{x}$	S.D.
Maxilla	4	0.75	0.96	6	-0.08	1.63	2	1.50	2.12
Mandible	5	-0.90	1.60	4	1.13	.85	8	0.13	1.96
Combined	9	-0.17	1.54	10	0.40	1.45	10	0.40	1.96
≥ 12.5									
Maxilla	2	-1.75	1.06		----		2	-0.25	1.06
Mandible	5	-1.30	0.91		----		2	-1.00	1.41
Combined	7	-1.43	0.89		----		4	-0.63	1.11

The mandible and maxilla results look quite different but with samples so small the differences are not significant. When the jaws are combined a pattern seems to emerge. In the younger age group at Swanport the incisors are slightly more worn than the molars. After age 12.5 the incisors are much more worn than the molars.

At Broadbeach the younger age group has molars a little more worn than incisors, but after age 12.5 the incisors are more worn than the molars, though not by as much as at Swanport.

The number of jaws for which M1 wear was greater than or equal to I1 wear was calculated for both age groups and all sites. Table 30 gives the numbers of jaws.

Table 30

M1 Wear Relative to I1 Wear in Two Juvenile Age Groups

	< 12.5 years		≥ 12.5 years	
Swanport	I1 ≥ M1	4	I1 ≥ M1	7
	I1 < M1	6	I1 < M1	0
Murray Basin	I1 ≥ M1	5	---	
	I1 < M1	5		
Broadbeach	I1 ≥ M1	6	I1 ≥ M1	3
	I1 < M1	5	I1 < M1	1

A pattern exists at all three sites. Before age 12.5 the molars are more worn than the incisors about as often as the incisors are more worn than the molars. However, after age 12.5 the incisors are usually more worn than the molars. This is true at Swanport and Broadbeach, but especially so at Swanport. Chi square tests were done for both sites to test the difference in incisor relative to molar wear for the age groups < 12.5 years and ≥ 12.5 years. At Swanport there was a significant difference ($P < .01$) between the two age classes. This reveals an increase of incisor wear relative to molar wear after age 12.5 years. At Broadbeach the chi square test did not reveal a significant difference between the age classes. These tests indicate a different attrition pattern between Swanport and Broadbeach. At both sites for ages below 12.5 years the incisors are about as worn as the molars. After 12.5 years at Swanport the incisors are significantly often more worn than the molars, but this is not true at Broadbeach.

These figures strengthen those of Table 29. After age 12.5 that is, close to the onset of puberty, incisor wear increases relative to molar wear and at Swanport greatly exceeds it. This indicates more than a greater consumption of food to fuel the adolescent growth spurt. In that case absolute attrition rate should increase but not the relative wear of anterior teeth to posterior teeth. It is more likely, if the pattern is not a random effect of small sample sizes, to indicate a behavioural change. It could well indicate the assumption of adult industrial tasks that wear anterior teeth more than posterior teeth. This possibility will be discussed further when adults' teeth have been examined.

Regression of Attrition Against Functional Age.

In order to determine rates of wear of various teeth least squares regression was computed using the MIDAS program. Attrition score was regressed against functional age to give a rate at which attrition increases with an increasing functional age of the tooth. The teeth tested were deciduous second molars, permanent first and second molars, and first and second incisors. In order to attain high sample numbers the teeth were promiscuously lumped into categories. Molars included first and second upper and lower molars regardless of the individual from whom they came. Teeth from only one side of the dental arch were used. Incisors were lumped in the same way as molars. There are problems of lack of variable independence in using this technique, and also in the fact that ordinal attrition stages are probably not equivalently spaced. However, the test was done to gain a strong indication of attrition rates. Table 31 gives the results. See Appendix D for graphs of regression lines.

Table 31

Least squares Regression of Attrition Score Against Functional Age. Juvenile Teeth

Site	Age Group	Tooth	r	r.Sq.	Slope	n	Significance
Swanport	< 12.5	Molar	.13	.019	.11	23	not signif.
	≥ 12.5	Molar	.85	.73	.40	26	p < .01
	< 12.5	Incisor	.19	.03	.30	18	not signif.
	≥ 12.5	Incisor	.62	.38	.42	17	p < .01
	All Ages	Molar	.71	.50	.29	49	p < .01
	All Ages	Incisor	.72	.52	.40	35	p < .01
	All Ages	dm2	.83	.69	.83	40	p < .01
Murray Basin	< 12.5	Molar	.56	.31	.45	33	p < .01
	< 12.5	Incisor	.76	.35	.76	22	p < .01
	All Ages	dm2	.77	.60	.67	51	p < .01
Broadbeach	< 12.5	Molar	.54	.29	.47	28	p < .01
	≥ 12.5	Molar	.86	.75	.52	23	p < .01
	< 12.5	Incisor	.56	.32	1.07	19	p < .01
	≥ 12.5	Incisor	.41	.17	.21	16	not signif.
	All Ages	Molar	.81	.66	.48	51	p < .01
	All Ages	Incisor	.65	.43	.45	35	p < .01
	All Ages	dm2	.82	.67	.70	46	p < .01
Combined Sites	All Ages	Molar	.74	.55	.39	133	p < .01
	All Ages	Incisor	.71	.50	.47	92	p < .01
	All Ages	dm2	.80	.63	.72	137	p < .01
	< 12.5	Molar	.45	.20	.38	84	p < .01
	≥ 12.5	Molar	.83	.69	.45	49	p < .01
	< 12.5	Incisor	.47	.22	.77	59	p < .01
	≥ 12.5	Incisor	.50	.25	.29	33	p < .01

The headings of the table have the following meanings: r is the correlation coefficient which gives the strength of relationship between the two variables. It ranges from -1 to 1; r.Sq. is the square of r. It tells what percentage of the score of one variable (attrition) depends upon the other variable (functional age). For example, .42 indicates 42% of attrition depends upon age; Slope gives the steepness of the regression line and the rate at which attrition rises per unit rise in functional age. The higher the slope number the more rapid the rate of attrition; n is the number of teeth; Significance tells whether the regresson test had a mathematically significant result.

Unfortunately some tests gave non-significant results making any overall patterns difficult to detect. At Swanport the I for < 12.5 result was not significant. For ≥ 12.5 the M attrition rate and I rate were about the same. For all-ages the M rate was much lower than the I rate.

At Murray Basin, which only had < 12.5, the M rate was much lower than the I rate.

At Broadbeach for < 12.5 the M rate was much lower than the I rate. The ≥ 12.5 I test result was not significant. For all-ages the M rate was about the same as the I rate.

For M < 12.5 the Broadbeach attrition rate was close to Murray Basin rate, (.47 : .45). The test for Swanport was not significant. For M ≥ 12.5 the Broadbeach rate exceeded the Swanport rate, (.52 : .40). For all-ages M Broadbeach greatly exceeded Swanport in attrition rate, (.48 : .29).

For I < 12.5 Broadbeach rate greatly exceeded Murray Basin rate, (1.07 : .76). The test result for Swanport was not significant. For I ≥ 12.5 the test result for Broadbeach was not significant. For all-ages I Broadbeach exceeded Swanport slightly, (.45 : .40) The slopes from the non-significant tests indicate that for I < 12.5 Broadbeach greatly exceeds Swanport in attrition rate, (1.07 : .30), while for I ≥ 12.5 Swanport greatly exceeds Broadbeach in attrition rate, (.42 : .21).

All sites were combined to give results for Australian aborigines. M of all-ages was exceeded in attrition rate by I, (.47 : .39). This was also true for age < 12.5, (M .38 : I .77); but for age ≥ 12.5 M exceeded I in attrition rate, (M .45 : I .29)

In summary, for all ages combined the M attrition rate at Broadbeach and the I attrition rate at Swanport and Broadbeach are about the same. The M rate at Broadbeach exceeds that at Swanport, and is very slightly greater than at Murray Basin. The I rate at Broadbeach for < 12.5 greatly exceeds that at Murray Basin. The I rate for combined ages at Broadbeach very slightly exceeds that at Swanport, (.45 : .40).

There is an indication (partly from non-significant test results) that at Swanport the I attrition rate increases after age 12.5 years while at Broadbeach it decreases after 12.5 years. At Broadbeach the M increase their attrition rate slightly after age 12.5 years.

The clearest result is the low attrition rate for Swanport all-ages M, evidently due to the rate of < 12.5 M. The M rates for Swanport ≥ 12.5, Murray, and all Broadbeach age groups are fairly close. Broadbeach does exceed Swanport in molar wear rate, but the difference is probably not great.

Deciduous Molars

The dm2 attrition rate is greatest at Swanport, followed by Broadbeach, then Murray Basin (SP .83, BB .70, MB .67). This reverses the pattern for the permanent molars. The dm2 tests have high correlations and high sample numbers and can be taken as reliable indicators of relative attrition rates between the sites.

Discussion of Regression Results

The results of the regression tests are limited by some non-significant results. There are several low correlation and R.Sq. results that reflect great variability in attrition relative to age. The very high attrition rate slopes of the incisors for the < 12.5 age group probably do reflect rapid wear, but they are more likely to be an artefact of the attrition scale. The incisors of the young children are worn at the low end of the scale where the wear describes enamel facetting, rounding, and flattening. Progress through these stages is probably much more rapid than through the later stages of exposed dentine, where the children ≥ 12.5 are mostly to be found. One would therefore expect a higher rate of incisor wear in young than in old children when the rate is calculated upon this scale.

Adult Teeth

Molar wear gradient.

The molar wear gradient was calculated for all adult jaws that had both M1 and M2. Differences between upper and lower jaw gradients were not significant so they were combined. The gradients are given in Table 32.

Table 32

Mean Molar Wear Gradients in Adults (M1 Minus M2 Wear)

		Male				Female			
		$\bar{x}$	n	S.D.		$\bar{x}$	n	S.D.	
Swanport	Max.	1.20	5	.84		2.13	4	1.25	
	Mand.	1.60	5	.55		1.20	5	.57	
Combined Jaws		1.40	10	.70		1.61	9	.99	
Murray Basin	Max.	1.50	6	1.42		1.71	7	1.63	
	Mand.	1.83	3	1.76		1.60	5	1.52	
Combined Jaws		1.61	9	.99		1.67	12	1.51	
Broadbeach	Max.	2.05	10	1.42		2.40	5	.42	
	Mand.	1.17	9	1.22		2.00	4	1.35	
Combined Jaws		1.63	19	1.37		2.22	9	.91	

Gradient differences between sexes and between sites were not statistically significant, nor were differences between upper and lower jaws. The figures for combined jaws are very close with the greatest difference, Broadbeach females to Swanport males, being .82 of one wear stage. The figures strongly indicate a very similar rate of molar wear at each of the three sites and for each sex.

The juvenile permanent molar gradient, (Table 28) was compared to male and female adult wear gradient (Table 32). At Broadbeach the Juvenile gradient exceeded the male gradient with a difference significant at $P < .01$ level. The juvenile gradient exceeded the female gradient but not significantly.

At Swanport the juvenile gradient exceeded both male and female gradients, but not significantly.

These comparisons indicate a higher rate of molar wear in juveniles than adult males at Broadbeach. It is difficult to say why this may be when it is not so for females or the Swanport adults. Perhaps with higher sample numbers the apparent juvenile excess over all adult groups would be statistically significant.

One would expect adolescents to have a higher M1 - M2 score than mature adults. The M2's are recently erupted and have had little chance to wear while M1's have been bearing the brunt of attrition forces for over six years and are usually worn to several stages. For an adult whose M2 has been in wear for twenty years the M1 is unlikely to maintain the same excess of attrition. The M1 now has the M2 and M3 to share the stress, and the loss of the childhood deciduous molars has been largely compensated by the eruption of the premolars. In adulthood the M2 should close the wear gap with the M1, and one would expect juvenile molar gradients to exceed those of adults, just as is seen above.

Anterior and Posterior Tooth Wear

Comparisons were made between anterior and posterior tooth wear by subtracting I1 wear from M1 wear in jaws that had both teeth. Unfortunately incisors are commonly lost in excavated specimens, but sufficient numbers were obtained to reveal a pattern. The results are given in Table 33, upper and lower jaws are combined.

Table 33

M1 Minus I1 Mean Wear in Adults

Swanport	♂	$\bar{x}$	-0.75	n	6	S.D.	2.32
Swanport	♀	$\bar{x}$	0.60	n	5	S.D.	1.47
Murray Basin	♂	$\bar{x}$	-0.60	n	5	S.D.	.55
Murray Basin	♀	$\bar{x}$	-0.71	n	7	S.D.	.76
Broadbeach	♂	$\bar{x}$	2.05	n	11	S.D.	1.39
Broadbeach	♀	$\bar{x}$	1.00	n	6	S.D.	1.52

Comparisons

SP : BB	Significant $P < .01$
SP : BB	Not significant
MB : BB	Significant $P < .01$
MB : BB	Significant $P < .05$
SP : MB	Not significant
SP : MB	Not significant
SP ♂ : ♀	Not significant
MB ♂ : ♀	Not significant
BB ♂ : ♀	Not significant

These results reinforce the pattern revealed in Table 29. The incisor wear of Swanport males is so much stronger than at Broadbeach that the combined sexes show a significant difference between sites even though Swanport females follow the Broadbeach pattern.

Of the three sites the Murray Basin shows the greatest prominence of incisor wear.

When adolescent M1 : I1 wear (Table 30) is contributed the pattern in adults is strengthened. There is a marked difference in anterior relative to posterior tooth wear between the Murray River sites of Swanport and Murray Basin and the Queensland coastal site of Broadbeach. Incisor wear exceeds molar wear in Murray Basin females and males, and Swanport males and adolescents. Molar wear exceeds incisor wear in Broadbeach males and females and Swanport females.

The juvenile to adult comparisons of tooth row lengths given in Table 20 support the above pattern. Swanport adult anterior teeth were reduced far more than were posterior teeth, and the opposite was true at Broadbeach.

Table 34 gives anterior wear relative to posterior wear in adults from the three sites:

Table 34

M1 Wear Relative to I1 Wear in Adults

		I1 ≥ M1	I1 < M1
Swanport		7	4
Murray Basin		12	0
Broadbeach		3	14
Adults + Juveniles ≥ 12.5 years			
Broadbeach		6	15
Swanport + Murray Basin		26	4
Swanport:	Males	5	1
	Females	2	3
Murray Basin:	Males	5	0
	Females	7	0
Broadbeach:	Males	2	9
	Females	1	5
All Sites:	Males	12	10
	Females	10	8

Chi square tests were done on these figures. Patterns of relative M1 wear to I1 wear were tested. The comparison of Swanport to Broadbeach gave a significant difference ($P < .01$). Swanport shared the pattern with Murray Basin but it was not as strong and the sites were significantly different ($P < .01$).

Juveniles $\geq$ 12.5 years old were added to the adults and the two Murray River sites (Murray Basin and Swanport) were combined for a comparison with Broadbeach. The difference was highly significant ($P \ll .01$)

Sexes from all sites and from sites separately were compared and there was no significant difference.

The analysis of Table 34 supports the other analysis given above. A consistent pattern is clear: adults from the Murray River sites show anterior tooth wear in excess of posterior tooth wear while at Broadbeach the opposite is true. An explanation for this difference in pattern of tooth wear between the Murray River sites and Broadbeach will be discussed in the next chapter.

CHAPTER 5

Environment and Economy

The Murray River

The Aborigines of the Murray River and its mouth, which include the areas of the Swanport and Murray Basin samples, inhabited a bountiful environment with plentiful and diverse food resources (Krefft 1862; Beveridge 1883, Lawrence 1968; Jenkin 1979). Fish, shellfish, birds, small mammals, kangaroos and emus, and vegetable foods were eaten.

Krefft (1862) observed that the people of the Murray ate fish, principally Murray Cod, Silver Perch (*Lates colonorum*), Catfish (*Copidoglanis tandanus*), and Manor (*Chatoessus come*); large crayfish (*Potamobius serratus*); mussel shells (*Unio*); six or more species of duck; emus and possums (*Phalangista vulpina*) which were plentiful and easy to catch in the mallee; and kangaroos and wallabies. The only vegetables he saw eaten were Quandong and a type of root the size of a radish.

Beveridge (1883) observed on the Murray that fish are the principal food which for eight months of the year are available in superabundance. Mammals such as kangaroos, wallabies and possums; emus; and aquatic wildfowl, living in great profusion and diversity in the lakes, were also eaten. During fowl breeding season great numbers of eggs were eaten. Water lily roots and reed shoots were much eaten. In the winter when food was less abundant the people resorted to any living thing including frogs and dogs.

Lawrence (1968) lists several species of plants of which the roots, fruits, seeds or leaves and flowers were eaten. Archaeological evidence from the Murray River sites of Devon Downs, Tantanga and Fromm's Landing revealed food remains of large numbers of mussel shells (Unio), crayfish, fish, tortoises, snakes, lizards, bandicoots, possums, wallabies, kangaroos, wombats, rats and dingoes (Lawrence 1968 : p. 95). A wide variety of food resources seems to have been exploited with a concentration for most of the year upon fish.

Jenkin (1979) and Campbell (1939) refer to the steaming of plant and animal foods in earth ovens by the Ngarrindjeri of the Swanport area. According to Jenkin these aborigines were well known among Europeans for their culinary ability and for the efficacy of their steaming oven. These earth ovens are to be found throughout the Murray River area.

Broadbeach

Lawrence (1968) in his study of the economy of the New South Wales and north Queensland coast found a general specialization of marine food exploitation. The coastal aborigines lived largely on fish and shellfish, but they also ate land mammals, birds, plant foods, and the occasional sea mammal. Coastal midden excavations at Gymea Bay near Sydney revealed that 92 percent of the food remains were of estuarine shellfish, while fish and animal bones were represented. At Curacurrang on the south coast of New South Wales shellfish comprised a smaller percentage of food remains while land mammals, whale, seal, birds and fish was represented (Lawrence 1968 : P 140).

Early settlers observed the hunting of land mammals and the collection of berries, yams and fern roots (Lawrence 1968). On the north Queensland coast marine resources were similarly important.

Broadbeach burial site is situated back from a sandy coastal beach in an area of lagoons and swamps. A full range of marine and estuarine fish and shellfish were available for exploitation. The site excavation yielded food remains of mussel shells as well as a range of small land mammals. These mammals included the bandicoot

(Isoodon), the long-nosed bandicoot (Erameles nasuta), the brush-tailed possum (Trichosurus vulpecula), the pademelon (Thylogale), the red-necked wallaby (Macropus rufogrisea), and rats and mice. Snake and lizard remains were found (Haglund 1976).

The Broadbeach diet can be generalized as primarily of fish and shellfish with some land mammals, reptiles and vegetable foods.

Though Broadbeach is far from Swanport and the Murray Basin and the environments are quite different, the overall complex of foods eaten is similar. Broadbeach people probably exploited relatively more shellfish, and Murray people probably exploited relatively more fish and large land animals like the kangaroo and emu.

One would not expect these similar dietary complexes to result in major differences in the rate and degree of dental attrition. Shellfish contaminated with sand and with sand in the gut of the animal are abrasive on teeth, and their probable higher consumption at Broadbeach may have led to higher levels of attrition. However, attrition from such a source would primarily affect the molars and as demonstrated in Chapter 4, Broadbeach molar wear exceeded that of Swanport in juveniles, but for Murray Basin and Swanport adults very little if at all. The markedly different patterns of tooth wear between Broadbeach and Swanport and Murray Basin cannot be explained by dietary differences due to environment. The cause must be sought in the material culture.

Nets and Netting

According to Jenkin the Ngarrindjeri of the Swanport area "were outstanding craftsmen in wood and leather, but their forte was their basketry, netting and matting". (Jenkin 1979 : P 14). His book includes a photograph of beautiful and sophisticated examples of these crafts.

The Murray River tribes used Giant Mallow fibre to manufacture coarse cords from which they made large nets 100 yards long, for catching emus (Beveridge 1883). According to Beveridge these large nets were made by men while small nets and waist bands were made by women.

Krefft (1862) recorded the manufacture and use of nets along the Murray. Netting was used for fishing and for domestic utensils such as carrying bags. Krefft described the operation of producing fibre from the roots of the reed, _Typha_ _shuttleworthii_:

> "when enough 'wongal' is roasted the whole tribe sit around the fire and chew most vigorously; lumps of rejected fibre are afterwards collected by the women and spun into threads" (Krefft 1962 : P 361).

The root contains a small amount of saccharine matter and considerable fibre, but it appears to be the latter which is in chief demand.

> "If we take into consideration the large nets for catching water-fowl in use, it is indeed astonishing how great the perseverence of these people (and how sound their teeth) must have been, and it is not to be wondered at that the possession of one of these nets has always been considered to be a sort of fortune to its owner" (Krefft 1862 : p. 361).

Lawrence (1968) noted that while the eastern coastal people generally knew of nets they used them little and usually restricted their use to providing carrying bags. The use of hunting nets was not recorded.

DISCUSSION AND CONCLUSIONS

The preceding discussion of the importance of nets in the material culture of the Murray River peoples and their absence on the east coast provides an answer to the different patterns of tooth wear between Broadbeach and the Murray River sites.

The heavy anterior tooth wear seen in the Murray Basin and at Swanport is almost certainly the result of chewing roots to produce fibre and the use of that fibre in the manufacture of cords and nets. Net manufacture probably required knotting and nipping cords with the incisors. Strong anterior tooth wear is general to both sexes in the Murray Basin, and is seen among adult males and adolescents at Swanport. The adolescents appear to have adopted the adult task of net or cord manufacture. Why the Swanport females do not show higher anterior relative to posterior tooth wear is not apparent. Perhaps Beveridge's observation that men manufacture large, coarse nets while women make small nets provides an answer or part of an answer. Perhaps the sex difference is merely the result of the small sample sizes.

Clearly the Broadbeach people lack the pattern of very heavy anterior tooth wear, and just as clearly they did not manufacture large nets. This is strong evidence to support the claim of an industrial source for a heavy anterior tooth wear. Schulz (1977) provides evidence of industrially caused grooves on the anterior teeth of California Indians, and Hinton (1981) provides examples of Eskimos and Aborigines using anterior teeth as tools.

The posterior deciduous teeth like the posterior permanent teeth of juveniles reveal differences in wear between the sites, but the differences are not consistent. The deciduous molar wear gradient shows no difference between sites, but the regression analysis shows the Swanport dm2's wearing faster than the other sites. Both the molar wear gradient and the regression analysis show Broadbeach juveniles with a higher rate of permanent molar wear than at Swanport. It is a pity that too few deciduous incisors exist to reveal a pattern of anterior wear relative to posterior wear. It is not assumed that industrial task activities would be revealed in deciduous tooth wear as nothing such is revealed in the permanent teeth of pre-pubescent children from Swanport.

Sex difference in attrition pattern and degree seems to be limited to Swanport as previously discussed. This may be a result of sexual division of labour, but the case for this is not strong.

Tooth size differences do not appear to result in attrition rate differences in the way expected. Smith, Brown and Wood (1981) show that the Broadbeach population has the longest (but not wider) teeth of the three groups. These larger teeth do not experience a slower rate of attrition. In fact, the Broadbeach juveniles experience a faster rate of wear of permanent molars than those of Swanport. There appears to be no difference in molar wear rate of adults, but small samples may obscure a difference.

Environment as such, and such dietary differences as exist between the three sites do not find a strong reflection in tooth attrition rates or degrees. Broadbeach juveniles have a higher rate of molar wear than at Swanport. These differences probably reflect dietary differences, but if so it is difficult to explain why the comparison between sites is not consistent throughout childhood. No such difference in molar wear in adults is found between sites. Richards and Brown (1981) found this to be true for the diverse northern Australian environments of Haast's Bluff and Kalumburu. Industrial/craft activity is presented as the cause of the different dental attrition patterns revealed in this study.

APPENDIX A

Individuals from the Sites
Attrition Scores and Functional Ages

Individual number includes the number for this study and the identification number assigned by the institutions holding the collections.

Age is the assigned age of the individual.

Where both right and left side teeth are present only one is given, unless the two scores differ. The tooth is given followed by the functional age and attrition score, for example, dm2 - 3.0 - 2; dml - 4.0 - 4; U = upper jaw, L = lower jaw.

Individual	Age		Teeth, Functional Ages, and Attrition Scores
Swanport			
1. A48	5.3	U.	dm2 - 2.9 - 4; dml - 4.0 - 5; dc - 3.7 - 6
		L.	dm2 - 3.0 - 2; dml - 4.0 - 4;
2. A52	7.5	U.	dm2 - 5.1 -6,5; dml - 6.2 - 7,5; M1 - 1.1 - 2;
3. A56	7.5	U.	dm2 - 4.9 - 8; dml - 6.0 - 8, 10; dc - 5.7 - 9; di2 - 6.4 - 9; M1 - 0.9 - 3; I1 - 0.3 - 1;
		L.	dm2 - 5.0 - 6; dml - 6.0 - 7,8; dc - 5.7 - 7; M1 - 0.9 - 2; I2 - 0.1 - 0; I1 - 0.7 - 1;
4. A71	4.4	U.	dm2 - 2.0 - 3; dml - 3.1 - 6; dc - 2.8 - 6; di2 - 3.5 - 6;
		L.	dm2 - 2.1 - 2; dml - 3.1 - 5; dc - 2.8 - 2,6;
5. A75	13.5	U.	M2 - 2.0 - 3; M1 - 7.1 - 5;
6. A80	9.8	U.	dm2 - 7.4 - 8; M1 3.4 - 2; I2 - 1.3 - 1;
		L.	dm2 - 7.5 - 7; M1 - 3.4 - 5;
7. A82	3.0	U.	dm2 - 0.6 - 1; dml - 1.7 - 3,5; di2 - 1.9 - 6; dil - 2.4 - 6;
		L.	dm2 - 0.7 - 1; dml - 1.7 - 2; di2 - 1.9 - 6;

Individual	Age	Teeth, Functional Ages, and Attrition Scores	
8. A88	6.6	U.	dm2 - 4.2 - 4; dm1 - 5.3 - 6; dc - 5.0 - 7; di2 - 5.7 - 7; di1 - 5.8 - 6;
		L.	dm2 - 4.3 - 4; dm1 - 5.3 - 4; dc - 5.0 - 7, di2 - 5.5 - 6; di1 - 6.0 - 6;
9. A93	12.6	U.	M2 - 1.1 - 2; M1 - 6.2 - 4; P4 - 1.2 - 1; P3 - 2.3 - 3; C - 2.1 - 2; I2 - 4.1 - 3;
		L.	M2 - 1.4 - 1; M1 - 6.2 - 5,4; P4 - 1.1 - 1; P3 - 2.1 - 1; C - 2.6 - 2; I2 - 5.4 - 2; I1 - 6.0 - 6;
10. A94	7.4	U.	dm2 - 5.0 - 6; dm1 - 6.1 - 7; M1 - 1.0 - 2;
		L.	dm2 - 5.1 - 7; dm1 - 6.1 - 7; M1 - 1.0 - 4; I2 - 0.2 - 5; I1 - 0.8 - 6;
11. A95	9.8	U.	dm2 - 7.4 - 7; dm1 - 8.5 - 9; dc - 8.2 - 8; M1 - 3.4 - 3; I2 - 1.3 - 3; I1 - 2.8 - 3;
		L.	dm2 - 7.4 - 7; dm1 - 8.5 - 8; M1 - 3.4 - 4; I2 - 2.6 - 3,2; I1 - 3.2 - 3;
12. A111	7.3	U.	dm2 - 4.9 - 8; dm1 - 6.0 - 8; M1 - 0.9 - 4,5;
		L.	dm2 - 5.0 - 5,7; dm1 - 6.0 - 6,7; m1 - 0.9 - 3;
13. A118	2.5	U.	dm2 - 0.1 - 0; dm1 - 1.2 - 5; dc - 1.6 - 6; di2 - 1.6 - 6; di1 - 1.7 - 2;
		L.	dm2 - 0.2 - 1; dm1 - 1.2 - 5;
14. A121	13.2	U.	M2 - 1.7 - 1,2; M1 - 6.8 - 3; P3 - 2.9 - 1;
		L.	M2 - 2.0 - 2; M1 - 6.8 - 5;
15. A128	7.5	U.	dm2 - 5.1 - 6; dm1 - 6.2 - 7; dc - 5.9 - 8; M1 - 1.1 - 3;
16. A116	7.5	U.	dm2 - 5.1 - 6; M1 - 1.1 - 4;
17. A232	2.3	U.	dm1 - 1.0 - 1; di1 - 1.5 - 2;
		L.	dm1 - 1.0 - 1; di1 - 1.2 - 4; di1 - 1.7 - 4;
18. A235	7.3	U.	dm2 - 4.9 - 6; dm1 - 6.0 - 6; M1 - 0.9 - 2;

Individual	Age		Teeth, Functional Ages and Attrition Ages
19. A106 ♂	Adult	U.	M3 - 4,6; M2 - 7; M1 - 7; P4 - 6; P3 - 6; C - 8; I2 - 8;
		L.	M3 - 6; M2 - 10, 12; P4 - 8,9; P3 - 7,9; C - 8,9; I2 - 9; I1 - 9;
20. A42 ♂	Adult	U.	M3 - 1; M2 - 7; M1 - 8; P4 - 6; P3 - 8,9; C - 9; I2 - 10;
21. A481 ♂	Adult	U.	M3 - 2; M2 - 5; M1 - 7; P4 - 6; C - 5;
		L.	M3 - 4; M2 - 6; M1 - 8; P4 - 6; P3 - 6; C - 8;
22. A38 ♂	Adult 17.0	U.	M3 - 0.4 - 0,1; M2 - 5.5 - 2; M1 - 10.6 - 4,5; P4 - 5.6 - 3; P3 - 6.7 - 3; C - 6.5 - 2; I2 - 8.5 - 3;
		L.	M2 - 5.8 - 2; M1 - 10.6 - 5; P4 - 5.5 - 3; P3 - 6.5 - 3; C - 7.0 - 2; I2 - 9.8 - 6; I1 - 10.4 - 6;
23. A40 ♂	Adult	U.	M3 - 4,9; M2 - 6,7; M1 - 7,8; P4 - 6; C - 5; I2 - 6; I1 - 8;
		L.	M3 - 6; M2 - 7; M1 - 8; P4 - 4; P3 - 6; C - 9; I2 - 9; I1 - 13;
24. A99 ♂	Adult	U.	M3 - 4; M2 - 4; M1 - 6; P4 - 4,5; P3 - 5; C - 7; I2 - 4; I1 - 7;
		L.	M3 - 4; M2 - 5; M1 - 7; P4 - 6; P3 - 6; C - 7; I2 - 7; I1 - 7;
25. A55 ♀	Adult	U.	M3 - 0; M1 - 7; P4 - 6; P3 - 6; C - 9; I2 - 8; I1 - 8;
		L.	M2 - 9; M1 - 9,10; P4 - 8; P3 - 9; C - 9; I2 - 9; I1 - 9;
26. A100 ♀	Adult	U.	M2 - 2.0 - 2; M2 - 7.1 - 5; M1 - 12.4 - 6,7; P4 - 7.1 - 3; C - 8.0 -5;
	18.4		I2 - 10.0 - 6;
		L.	M3 - 2.0 - 2; M2 - 7.3 - 5,6; M1 - 13.0 - 7; P4 - 7.1 - 4,5; P3 - 8.2 - 5; C - 9.0 - 7; I2 - 10.8 - 7; I1 - 11.7 - 7;
27. A63 ♀	Adult	U.	M3 - 8; M2 - 8; M1 - 12; P4 - 8,9; P3 - 9; C - 9; I2 - 9; I1 - 9;
		L.	M3 - 8; M2 - 12; P4 - 13; C - 13;

Individual	Age	Teeth, Functional Ages and Attrition Scores
28. A304 ♀	Adult	U. M3 - 4; M2 - 6; M1 - 7,8; P4 - 6; C - 8;
		L. M3 - 4; M2 - 7; M1 - 8; P4 - 7; P3 - 7;
29. A57 ♀	Adult	U. M3 - 6; M2 - 7; M1 - 9; P3 - 9; C - 8,9; I2 - 7,8; I1 - 8,9;
		L. M3 - 4; M2 - 8; M1 - 10; P3 - 9; C - 9; I2 - 8;
30. A248	7.0	U. dm2 - 4.6 - 3; M1 - 0.6 - 1;
31. A13143	3.6	U. dm2 - 1.2 - 4; dm1 - 2.3 - 6; dc - 2.0 - 5; di2 - 2.7 - 7; di1 - 2.8 - 7;
		L. dm2 - 1.3 - 4; dm1 - 2.3 - 6; dc - 2.0 - 6,7; di2 - 2.5 - 7;
32. A16510	7.3	U. dm2 - 4.9 - 6; dm1 - 6.0 - 6; dc - 5.7 - 5,7; M1 - 0.9 - 3; I1 - 0.3 - 2;
		L. dm2 - 5.0 - 6; dm1 - 6.0 - 6; dc - 5.7 - 6; M1 - 0.9 - 4; I1 - 0.7 - 3,6;
33. A20621	13.5	U. M2 - 2.0 - 3; M1 - 7.1 - 3,4; P4 - 2.1 - 3; P3 - 3.2 - 3; C - 3.0 - 4; I2 - 5.0 - 3,4; I1 - 6.5 - 6;
34. A20630	16.0	U. M2 - 4.5 - 2,5; M1 - 9.6 - 5,5; P4 - 4.6 - 3,4; P3 - 5.7 - 3,4; C - 5.5 - 6; I2 - 7.5 - 3,6; I1 - 9.0 - 6;
		L. M2 - 4.8 - 4; M1 - 9.6 - 5,6; P4 - 4.5 - 4; P3 - 5.5 - 4; I2 - 8.8 - 7; I1 - 9.4 - 7;
35. A25448	12.0	U. M2 - 0.5 - 0; M1 - 5.6 - 2; P4 - 0.6 - 0; P3 - 1.7 - 0; C - 1.5 - 1; I2 - 3.5 - 1;
36. A38454	3.0	U. dm2 - 0.6 - 3,5; dm1 - 1.7 - 5;
		L. dm2 - 0.7 - 2; dm1 - 1.7 - 2;
37. A38588	3.6	U. dm2 - 1.2 - 2; dm1 - 2.3 - 5;
		L. dm2 - 0.7 - 3; di2 - 1.1 - 2; di1 - 1.2 - 6;
38. A38632	2.0	U. dm1 - 0.7 - 3; di2 - 1.1 - 2; di1 - 1.2 - 6;
		L. dm1 - 0.7 - 3; di2 - 0.9 - 1;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
39. A38798	7.5	U. dm2 - 5.1 - 5; dm1 - 6.2 - 5,6; dc - 5.9 - 7; M1 - 1.1 - 2;
		L. dm2 - 5.2 - 5; dm1 - 6.2 - 5; dc - 5.9 - 6,7; di2 - 6.4 - 7; M1 - 1.1 - 3; I1 - 0.9 - 1;
40. A57621	4.6	U. dm2 - 2.2 - 6; dm1 - 3.2 - 6,7; dc - 3.0 - 6;
		L. dm2 - 2.3 - 6; dm1 - 3.3 - 5; dc - 3.0 - 7; di2 - 3.5 - 6; di1 - 4.0 - 6;
41. A577758	9.0	U. dm2 - 6.6 - 6; dm1 - 7.7 - 10; dc - 7.4 - 10; M1 - 2.6 - 3; I2 - 0.5 - 3; I1 - 2.0 - 3;
		L. dm2 - 6.7 - 8; dm2 - 7.7 - 8; dc - 7.4 - 9; M1 - 2.6 - 3; I2 - 1.8 - 3,6; I1 - 2.4 - 6;
42. A57824	4.8	L. dm2 - 2.5 - 5; dm1 - 3.5 - 5;
Murray Basin		
43. 4102	7.0	U. dm2 - 4.6 - 6; dm1 - 5.7 - 6; M1 - 0.6 - 2;
44. 3466	10.0	U. dm2 - 7.6 - 6; dm1 - 8.7 - 8; M1 - 3.6 - 3;
45. 4098	4.3	U. dm2 - 1.8 - 3; dm1 - 2.9 - 5;
		L. dm2 - 2.0 - 5; dm1 - 3.0 - 5; dc - 2.7 - 6;
46. 3661	4.3	U. dm2 - 1.8 - 3; dm1 - 2.9 - 3;
47. 3926	6.0	U. dm2 - 3.6 - 6; dm1 - 4.7 - 6,7;
48. 4103	3.9	U. dm2 - 1.5 - 6; dm1 - 2.6 - 6;
		L. dm2 - 1.6 - 5; dm1 - 2.6 - 4,5;
49. 4100	6.0	U. dm2 - 3.6 - 5; dm1 - 4.7 - 6; di2 - 5.1 - 7; di1 - 5.2 - 7;
50. 3870	7.9	L. dm2 - 5.6 - 7; dm1 - 6.6 - 6,7; M1 - 1.5 - 4; I2 - 0.7 - 0;
51. 3870	8.5	U. dm2 - 6.1 - 6; dm1 - 7.2 - 8; M1 - 2.1 - 2; I1 - 1.5 - 0;

Individual	Age	Teeth, Functional Ages and Attrition Scores
52. 4095	6.5	U. dm2 - 4.1 - 5; dml - 5.2 - 7; dc 4.9 - 8; di2 - 5.6 - 7,8;
		L. dm2 - 4.2 - 6; dml - 5.2 - 6; dc - 4.9 - 8; di2 - 5.4 - 7; M1 - 0.1 - 1;
53. 4101	3.8	U. dm2 - 1.5 - 0,1; dml - 2.6 - 3; dc - 2.2 - 2,5;
		L. dm2 - 1.6 - 1; dml - 2.5 - 1; dc - 2.2 - 1; di2 - 2.7 - 2; dil - 3.2 - 4;
54. 4097	10.0	U. dm2 - 7.6 - 8; dml - 8.7 - 9; M1 - 3.6 - 5;
55. 3922	8.2	U. dm2 - 5.8 - 6; dml - 6.9 - 6; dc - 6.6 - 5; M1 - 1.8 - 2; I1 - 1.2 - 3;
		L. dm2 - 5.9 - 6; dml - 6.9 - 7; M1 - 1.8 - 3;
56. 4093	2.8	U. dm2 - 0.4 - 1; dml - 1.5 - 5; di2 - 1.9 - 6; dil - 2.0 - 4;
		L. dm2 - 0.5 - 1; dml - 1.5 - 3; dc - 1.2 - 5;
57. 161	8.0	U. dm2 - 5.6 - 6; dml - 6.7 - 9; M1 - 1.6 - 3,4;
		L. dm2 - 5.7 - 7; dml - 6.7 - 7; dc - 6.4 - 6; M1 - 1.6 - 2,3; I2 - 0.8 - 0; I1 - 1.4 - 1;
58. 1936	12.0	U. dm2 - 9.6 - 7; M1 - 5.6 - 3,4; P3 - 1.7 - 0; C - 1.5 - 0; I2 - 3.5 - 1; I1 - 5.0 - 4;
59. L40	9.0	U. dm2 - 6.6 - 6; dml - 7.7 - 7,8; dc - 7.4 - 8; M1 - 2.6 - 1; I2 - 0.5 - 0;
60. A33	2.7	U. dm2 - 0.3 - 0; dml - 1.4 - 1;
61. L38	10.5	U. dm2 - 8.1 - 8; M1 - 4.1 - 4; P3 - 0.2 - 0; I1 - 2.0 - 2;
62. 244	7.5	U. dm2 - 5.1 - 5; dml - 6.2 - 6; dc - 5.9 - 6; M1 - 1.1 - 0;
63. L46	6.5	U. dml - 4.1 - 2; dml - 5.2 - 3; M1 - 0.1 - 1;
		L. dm2 - 4.2 - 2; dml - 5.2 - 2; M1 - 0.1 - 1;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
64. 3653	10.3	U. dm2 - 7.9 - 3; dml - 9.0 - 8; M1 - 3.9 - 3;
		L. dm2 - 8.0 - 6; dml - 9.0 - 7; M1 - 3.9 - 3,
65. 3790	6.8	U. dm2 - 4.4 - 6; dml - 5.5 - 8; dil - 6.0 - 3; M1 - 0.4 - 3,4;
66. 3448	8.1	U. dm2 - 5.7 - 6; dml - 6.8 - 7; di2 - 7.2 - 3; M1 - 1.7 - 2; I1 - 1.1 - 4
		L. dm2 - 5.8 - 7; dml - 6.8 - 7; M1 - 1.7 - 4; I2 - 0.9 - 3; I1 - 1.5 - 4;
67. 3529	11.0	U. dm2 - 8.6 - 6; M1 - 4.6 - 3; I2 - 2.5 - 3; I1 - 4.0 - 4;
68. 3520	7.4	U. dm2 - 5.0 - 6; dml - 6.1 - 7; M1 - 1.0 - 3; I1 - 0.4 - 3;
		L. dm2 - 5.1 - 6; dml - 6.1 - 7; M1 - 1.0 - 3; I2 - 0.2 - 1; I1 - 0.8 - 1;
69. 3540	11.0	U. dm2 - 8.6 - 6; dml - 9.7 - 7; dc - 9.4 - 7; M1 - 4.6 - 3; I2 - 2.5 - 3;
70. 3470	6.5	U. dm2 - 4.1 - 3; M1 - 0.1 - 0;
71. 764	5.0	L. dm2 - 2.7 - 5; dml - 3.7 - 6; dc - 3.4 - 7; di2 - 3.9 - 7; dil - 4.4 - 7;
72. 3563	6.5	U. dm2 - 4.1 - 6; dml - 5.2 - 6;
73. 3644	6.5	U. dm2 - 4.1 - 6; dml - 5.2 - 7; M1 - 0.1 - 2;
74. 3651	9.5	U. dm2 - 7.1 - 7,10; M1 - 3.1 - 3;
75. L10	7.5	U. dm2 - 5.1 - 6,7; dml - 6.2 - 10; M1 - 1.1 - 2;
		L. dm2 - 5.2 - 7; dml - 6.2 - 7; di2 - 6.4 - 6; I2 - 0.3 - 0; I1 - 0.9 - 0;
76. 3570	8.0	U. dm2 - 5.6 - 5; dml - 6.7 - 6; dc - 6.4 - 7;
		L. dm2 - 5.7 - 6; dml - 6.7 - 4; dc - 6.4 - 7; M1 - 1.6 - 2; I2 - 0.8 - 1;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
77. 3376	2.0	L. dm1 - 0.7 - 2; di1 - 1.4 - 3;
78. 2669	6.8	L. dm2 - 4.5 - 5; dm1 - 5.5 - 5; dc - 5.2 - 6; di1 - 5.7 - 6; di1 - 6.2 - 6;
79. 3514	2.8	L. dm2 - 0.5 - 2; dm1 - 1.5 - 5; dc - 1.2 - 5; di2 - 1.7 - 6;
80. 2667	2.5	L. dm2 - 0.2 - 1; dm1 - 1.2 - 2; dc - 0.9 - 2; di2 - 1.4 - 5; di1 - 1.9 - 5;
81. 3511	3.3	L. dm2 - 1.0 - 2; dm1 - 2.0 - 4,6; dc - 1.7 - 5; di2 - 2.2 - 6; di1 - 2.4 - 6;
82.	2.0	L. dm1 - 0.7 - 1; dc - 0.4 - 0;
83. 3848 ♂	Adult	U. M3 - 1; M2 - 4; M1 - 6; P4 - 5; P3 - 6; C - 6; I2 - 6; I1 - 7;
		L. M3 - 3; M2 - 4; M1 - 6; P4 - 5; P3 - 5; C - 6; I2 - 6; I1 - 7;
88. R47 ♂	Adult	U. M3 - 4; M2 - 5; M1 - 7; P4 - 6; P3 - 5,6; C - 7; I2 - 7; I1 - 7;
89. R13 ♂	Adult	U. M3 - 8; M2 - 8; M1 - 9; P4 - 8; P3 - 11; C - 9,11; I2 - 9; I1 - 9;
90. 3640 ♂	Adult	U. M3 - 4; M2 - 5; M1 - 6; P4 - 6; P3 - 6;
91. 344 ♂	Adult	L. M3 - 8; M2 - 8,11; M1 - 13; P4 - 12; P3 - 11;
93. 3700 ♂	Adult	U. M3 - 9; M2 - 9; M1 - 10; P4 - 7; P3 - 8;
		L. M3 - 10; M2 - 12; M1 - 12; P4 - 9; I1 - 12; I1 - 13;
98. 3544 ♂	Adult	U. M3 - 6; M2 - 7; M1 - 9; P4 - 8; P3 - 9; C - 8,9; I2 - 9;
		L. M3 - 8; M2 - 9; C - 12, I2 - 12; I1 - 12;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
84. 3813♀	Adult	U. M3 - 4; M2 - 6,7; M1 - 6,8; P4 - 7; P3 - 9; C - 9; I2 - 9;
85. 3868♀	Adult	U. M3 - 6; M2 - 7,8; M1 - 9; P4 - 11; C - 11; I2 - 8; I1 - 11;
86. 102 ♀	Adult	L. M3 - 5; M2 - 6; M1 - 7; P3 - 7; C - 7;
87. L47 ♀	Adult	U. M3 - 7,8; M2 - 7,9; M1 - 8; P4 - 8; P3 - 11; C - 11;
		L. M1 - 12; P4 - 9; P3 - 9; C - 9; I2 - 11;
92. 3688♀	Adult	U. M3 - 6; M2 - 8; P4 - 11; P3 - 11; C - 11; I2 - 11;
		L. M3 - 6; M2 - 6; M1 - 7; C - 8;
94. 3719♀	Adult	U. M3 - 8; M2 - 8; M1 - 8; P4 - 8; P3 - 11; C - 11; I2 - 9; I1 - 9;
		L. M3 - 9; M2 - 12; P4 - 12; P3 - 12; C - 12; I2 - 12; I1 - 12;
95. 3769♀	Adult	U. M3 - 3; M2 - 3; M1 - 7; P4 - 5; P3 - 6; C - 6; I2 - 6; I1 - 7;
		L. M3 - 3; M2 - 4; M1 - 8; P4 - 7; P3 - 7; C - 7; I2 - 7; I1 - 8;
96. 3784♀	Adult	U. M3 - 2; M2 - 5; M1 - 8; P4 - 7; P3 - 7; C - 7;
97. 3278♀	Adult	U. M3 - 2; M2 - 3; M1 - 6; P4 - 4; P3 - 5; C - 5; I2 - 6; I1 - 7;
		L. M3 - 3; M2 - 4; M1 - 6; P4 - 5,6; P3 - 5; C - 5; I2 - 6; I1 - 7;
Broadbeach		
99. B1	8.0	U. dm2 - 5.6 - 8; dm1 - 6.7 - 8; M1 - 1.6 - 1;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
100. B2	12.5	U. M2 - 1.0 - 1; M1 - 6.1 - 5; P3 - 2.2 - 1; C - 2.0 - 1; I2 - 4.0 - 3;
		L. M2 - 1.3 - 2; M1 - 6.1 - 5; P4 - 1.0 - 3; P3 - 2.0 - 3; C - 2.5 - 3; I2 - 5.3 - 6 I1 - 5.9 - 6;
101. B7	11.5	U. M2 - 0 - 0; M1 - 5.1 - 3; P3 - 1.2 - 0; C - 1.0 - 0; dm2 - 9.1 - 7;
		L. M1 - 5.1 - 5; P3 - 1.0 - 0; C - 1.5 - 0; I1 - 4.9 - 6; dm2 - 9.2 - 7;
102. B9	8.0	U. M1 - 1.6 - 3; dm2 - 5.6 - 6; dm1 - 6.7 - 8;
		L. M1 - 1.6 - 3; I1 - 1.4 - 6; dm2 - 5.7 - 7; dm1 - 6.7 - 8;
103. B14	11.3	U. M1 - 4.9 - 3;
		L. M1 - 4.9 - 4; C - 1.3 - 0; I2 - 4.1 - 6;
104. B16	3.1	U. dc - 1.5 - 5; di1 - 2.3 - 6;
		L. dm2 - 0.8 - 3; dm1 - 1.8 - 5; dc - 1.5 - 6;
105. B19	4.7	U. dm1 - 3.4 - 6; dc - 3.1 - 7; di2 - 3.8 - 7; di1 - 3.9 - 7;
		L. dm2 - 2.4 - 6; dm1 - 3.4 - 6; di1 - 4.1 - 7;
106. B23	7.5	U. M1 - 1.1 - 2; I2 - 0.3 - 2; I1 - 0.9 - 2; dm2 - 5.1 - 6; dm1 - 6.2 - 7;
		L. dm2 - 5.2 - 6; dm1 - 6.2 - 6,7; M1 - 1.1 - 3; I2 - 0.3 - 0; I1 - 0.9 - 0;
107. B26	5.6	U. di2 - 4.5 - 6; di1 - 5.0 - 7;
		L. dm2 - 3.3 - 5,6; dm1 - 4.3 - 5; dc - 4.0 - 6;
108. B27	2.5	U. dm2 - 0.1 - 0; dm1 - 1.2 - 0; dc - 0.9 - 0;
		L. dm2 - 0.2 - 0; dm1 - 1.2 - 1;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
109. B31	2.8	U. dm2 - 0.4 - 0; dm1 - 1.5 - 1; dc - 1.2 - 1;
		L. dm2 - 0.5 - 3,5; dm1 - 1.5 - 5; dc - 1.2 - 3; di2 - 1.7 - 6;
110. B32	7.4	U. dm2 - 5.0 - 7; dm1 - 6.1 - 8; M1 - 1.0 - 3;
		L. dm2 - 5.1 - 8; dm1 - 6.2 - 7;
111. B40	7.0	U. dm2 - 4.6 - 7; dm1 - 5,7 - 8; M1 - 0.6 - 1; dc - 5.4 - 7; di1 - 6.2 - 8;
		L. dm2 - 4.7 - 6; dm1 - 5.7 - 6; dc - 5.4 - 7; M1 - 0.6 - 2;
113. B66	3.4	U. dm2 - 1.0 - 2; dm1 - 2.1 - 5; di2 - 2.5 - 6;
		L. dm2 - 1.1 - 2; dm1 - 2.1 - 5; dc - 1.8 - 6;
114. B71	1.6	L. dm1 - 0.3 - 1; di1 - 1.0 - 6;
115. B78	12.5	U. M2 - 1.0 - 0; M1 - 6.1 - 6; P4 - 1.1 - 2; P3 - 2.2 - 2; C - 2.0 - 2; I2 - 4.0 - 3;
		L. M2 - 1.3 - 0; M1 - 6.1 - 5; P4 - 1.0 - 3; P3 - 2.0 - 3; C - 2.5 - 5; I1 - 5.9 - 7;
116. B81	9.0	L. dm2 - 6.7 - 9; dc - 7.4 - 4; M1 - 2.6 - 3;
117. B83	8.5	U. dm2 - 6.1 - 5; dm1 - 7.1 - 6; M1 - 2.1 - 1;
		L. dm2 - 6.2 - 6; dm1 - 7.2 - 6; I2 - 1.3 - 0;
118. B86	8.6	U. dm2 - 6.2 - 8; dm1 - 7.3 - 9; M1 - 2.2 - 5;
		L. dm2 - 6.3 - 8,9; dm1 - 7.3 - 7,8; M1 - 2.2 - 5; I2 - 1.4 - 1; I1 - 2.0 - 6;
119. B87	6.6	U. dm1 - 5.3 - 7; dc - 5.0 - 7;
		L. dm2 - 4.3 - 6; dm1 - 5.3 - 6; M1 - 0.2 - 0;
120. B72	8.0	U. dm2 - 5.6 - 6; dm1 - 6.7 - 7; M1 - 1.6 - 3;
		L. dm2 - 5.7 - 7; dm1 - 6.8 - 7; M1 - 1.6 - 4; I2 - 0.8 - 4; I1 - 1.4 - 5;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
121. B93	6.8	U. dm2 - 4.4 - 5; dml - 5.5 - 6; M1 - 0.4 - 1;
		L. dm2 - 4.5 - 6; dml - 5.5 - 6;
122. B97B	5.3	U. dm2 - 2.9 - 6; dml - 4.0 - 8;
		L. dm2 - 3.0 - 6; dml - 4.0 - 7; di2 - 4.2 - 6; dil - 4.7 - 6,7;
123. B103	9.5	U. dm2 - 7.1 - 6,8; M1 - 3.1 - 3;
		L. dm2 - 7.2 - 8;
124. B104	3.7	U. dm2 - 1,3 - 5; dml - 2.4 - 8,10; di2 - 2.8 - 6; dil - 2.9 - 6;
		L. dm2 - 1.4 - 6; dml - 2.4 - 6; dc - 2.1 - 6; di2 9 2.6 - 6;
125. B105A	5.3	U. dm2 - 2.9 - 5; dml - 4.0 - 8; dc - 3.7 - 5;
		L. dm2 - 3.0 - 5; dml - 4.0 - 6;
126. B112	12.8	U. M1 - 6.4 - 5; P4 - 1.4 - 3; P3 - 2.5 - 3; I2 - 4.3 - 6;
		L. M2 - 1.6 - 4; M1 - 6.4 - 5; P4 - 1.3 - 3; P3 - 2.3 - 3; C - 2.8 - 5,6; I2 - 5.3 - 6;
127. B114	17.0	U. M3 - 02 - 0; M2 - 5.5 - 3; M1 - 10.6 - 7,8; P4 - 5.6 - 3; P3 - 6.7 - 3; C - 6.5 - 5; I2 - 8.5 - 6; I1 - 10.0 - 7;
		L. M2 - 5.8 - 4; M1 10.6 - 6; P4 - 5.5 - 3; P3 - 6.5 - 3; C - 7.0 - 3; I2 - 9.8 - 6; I1 - 10.4 - 6;
128. B118	9.5	L. dm2 - 7.2 - 8; dml - 8.2 - 7; M1 - 3.1 - 5; I1 - 2.9 - 6;
129. B119	5.9	L. dc - 4.3 - 6; di2 - 4.8 - 6;

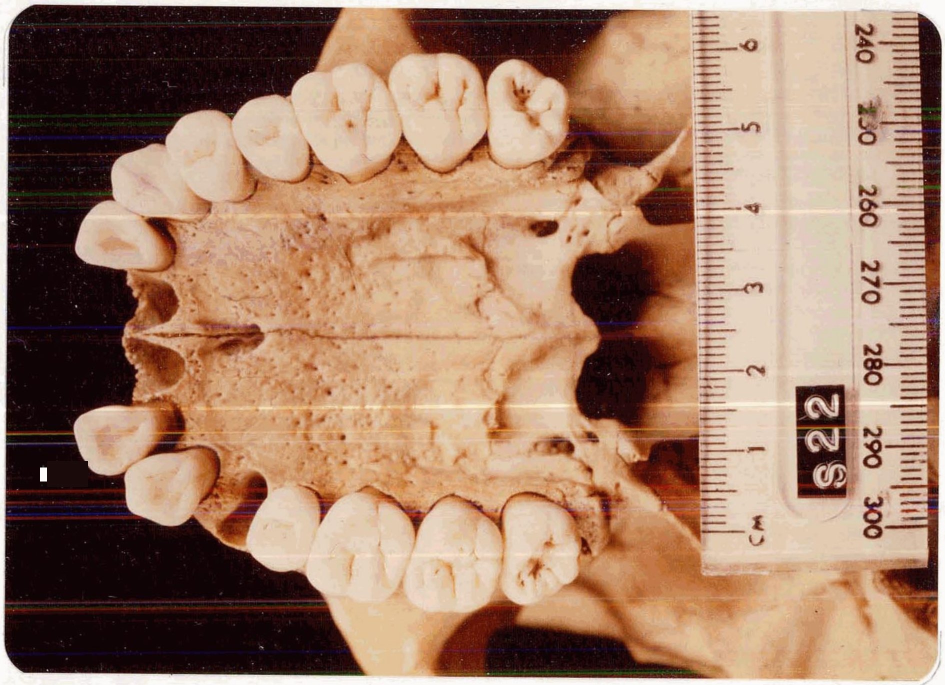
Individual	Age	Teeth, Functional Ages, and Attrition Scores
130. B123	7.4	U. dm2 - 5.0 - 7; dml - 6.1 - 7; M1 - 1.0 - 3; I1 - 0.4 - 0;
		L. dm2 - 5.1 - 7; dml - 6.1 - 7; dc - 5.8 - 7; M1 - 1.0 - 2; I1 - 0.8 - 1;
131. B125	7.5	U. dm2 - 5.1 - 6; dm2 - 6.2 - 7; M1 - 1.1 - 2;
		L. dm2 - 5.2 - 6; dml - 6.2 - 6; dc - 5.9 - 6;
132. B128B	13.6	U. M2 - 2.1 - 3; M1 - 7.2 - 6; P3 - 3.3 - 3; C - 3.1 - 3; I2 - 5.1 - 3;
		L. M2 - 2.4 - 3; M1 - 7.2 - 6; P4 - 2.1 - 3; P3 - 3.1 - 3; C - 3.6 - 3;
133. B132	9.8	U. dm2 - 7.4 - 8; M1 - 3.4 - 3; I2 - 1.3 - 3;
		L. dm2 - 7.5 - 7; dml - 8.5 - 7; M1 - 3.4 - 3;
134. B133	10.2	L. dm2 - 7.9 - 7; dml - 8.9 - 7; M1 - 3.8 - 3; C - 0.2 - 0; I2 - 3.0 - 0; I1 - 3.6 - 2;
135. B134	3.2	L. dm2 - 0.9 - 3; dml - 1.9 - 5; di2 - 2.1 - 6;
136. B137	3.0	U. dm2 - 0.6 - 5; dml - 1.7 - 5,6; dil - 2.2 - 7;
		L. dm2 - 0.7 - 3; dml - 1.7 - 5; dc - 1.4 - 5; di2 - 1.9 - 6,8; dil - 2.4 - 9;
137. B139	7.2	L. dm2 - 4.9 - 6; dml - 5.9 - 6;
138. B4	♂Adult 18.4	U. M3 - 1.6 - 3; M2 - 6.9 - 4; M1 - 12.0 - 7; P4 - 7.0 - 4; C - 7.9 - 5; I2 - 9.9 - 3; I1 - 11.4 - 7;
		L. M3 - 1.9 - 3; M2 - 7.2 - 5; M1 - 12.0 - 6; P4 - 6.9 - 4; P3 - 7.9 - 3; C - 8.4 - 3; I2 - 11.2 - 6; I1 - 11.8 - 6;

Individual	Age	Teeth, Functional Ages, and Attrition Scores
139. B37	Adult ♂	U. M3 - 3; M2 - 6; M1 - 9; P4 - 5; P3 - 5; C - 5; I2 - 6; I1 - 7;
		L. M3 - 4; M2 - 8; M1 - 9; P4 - 7; P3 - 6,7; C - 7; I2 - 6; I1 - 7;
140. B43	Adult ♂	U. M3 - 3,4; M2 - 6; M1 - 8; P4 - 5; P3 - 5; C - 6; I2 - 6;
		L. M3 - 4; M2 - 7; M1 - 8; P4 - 6; P3 - 5; C - 6; I2 - 6; I1 - 6;
143. B52	Adult ♂	U. M3 - 6; M2 - 7; M1 - 9; P4 - 7; P3 - 7; C - 8; I2 - 7; I1 - 7;
		L. M3 - 7; M2 - 8; M1 - 9; P4 - 7,8; P3 - 7; C - 7; I2 - 6,7; I1 - 7;
145. B73	Adult ♂	U. M3 - 7; M2 - 12,13; M1 - 13; P4 - 13; P3 - 12; C - 9; I2 - 9; I1 - 9;
		L. P4 - 13; C - 13; I2 - 13;
147. B79	Adult ♂	U. M3 - 4; M2 - 6; M1 - 6; P4 - 5; P3 - 5,6; C - 5,7;
		L. M3 - 5; M2 - 6; M1 - 6; P4 - 5; C - 5;
148. B98	Adult ♂	U. M3 - 3; M2 - 5; M1 - 6,7; P3 - 5;
		L. M3 - 4; M2 - 6; M1 - 8; P4 - 4; P3 - 4; C - 5; I2 - 7;
150. B109	Adult ♂	U. M3 - 4; M2 - 7,8; M1 - 8,9; P4 - 5; P3 - 5; C - 5; I2 - 5;
		L. M3 - 4; M2 - 8; M1 - 8; P4 - 4; P3 - 5; C - 5;
152. B138	Adult ♂	U. M3 - 6; M2 - 7; M1 - 12; P4 - 6; C - 7; I2 - 6,7; I1 - 8;
		L. M3 - 5; M2 - 7; M1 - 11; P4 - 6; C - 8; I2 - 7,8; I1 - 7,8;

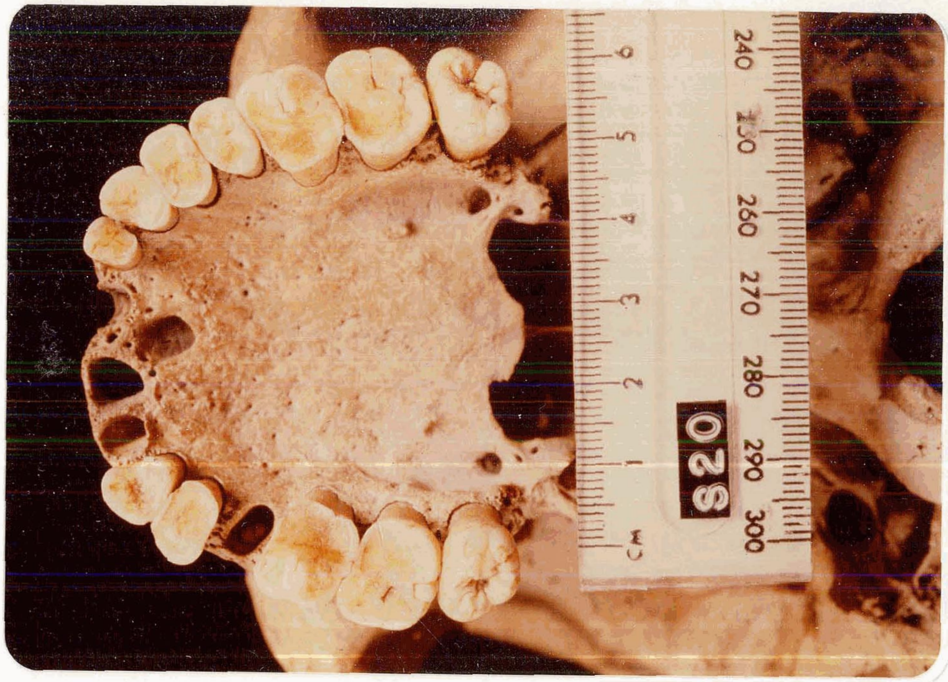
Individual	Age	Teeth, Functional Ages, and Attrition Scores
153. B139	Adult♂	U. M3 - 4; M2 - 6; M1 - 8; P4 - 5; P3 - 5; C - 5; I2 - 6; I1 - 7;
		L. M3 - 5; M2 - 7; M1 - 7,8; P3 - 5; C - 5;
141. B45	Adult♀ 18.0	U. M3 - 1.9 - 3; M2 - 7.0 - 5; M1 - 12.3 - 7,8; P4 - 7.0 - 4; P3 - 8.2 - 5; C - 7.9 - 5; I2 - 9.9 - 6; I1 - 10.7 - 7;
		L. M3 - 1.9 - 1; M2 - 7.2 - 6; M1 - 12.9 - 8; P4 - 7.0 - 6; P3 - 8.1 - 5; C - 8.9 - 6; I2 - 10.7 - 6; I1 - 11.6 - 6;
142. B50	Adult♀	U. M3 - 7; M2 - 6; M1 - 8,10; P3 - 5; I2 - 8;
		L. M3 - 6; M2 - 6; M1 - 6,8; P4 - 5, P3 - 6;
144. B69	Adult♀	U. M3 - 4; M2 - 6,7; M1 - 8,9; P4 - 7,9; P3 - 8; C - 8; I2 - 8; I1 - 8;
		L. M3 - 7; M2 - 13; P4 - 13; P3 - 13; C - 13; I2 - 13, I1 - 13;
146. B76	Adult♀	U. M3 - 4; M2 - 6; M1 - 8; C - 6; I2 - 5;
		L. M3 - 4; M2 - 4,5; M1 - 8,9; P4 - 6,7; P3 - 5,6; C - 5,8; I2 - 7; I1 - 6;
151. B116	Adult♀	U. M3 - 4; M2 - 8; M1 - 9,12; P4 - 8; P3 - 8; C - 8,9; I2 - 11,12; I1 - 12;
		L. M3 - 5; M2 - 9; M1 - 9,12; P4 - 4; P3 - 9; C - 9; I2 - 11; I1 - 8;

APPENDIX B

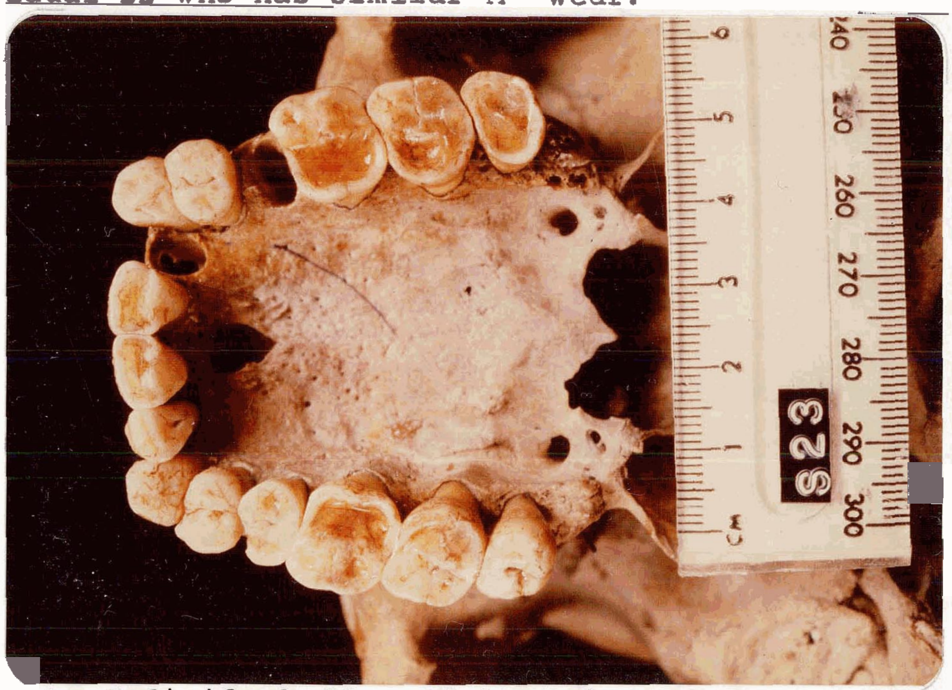
Photographs of Tooth Wear



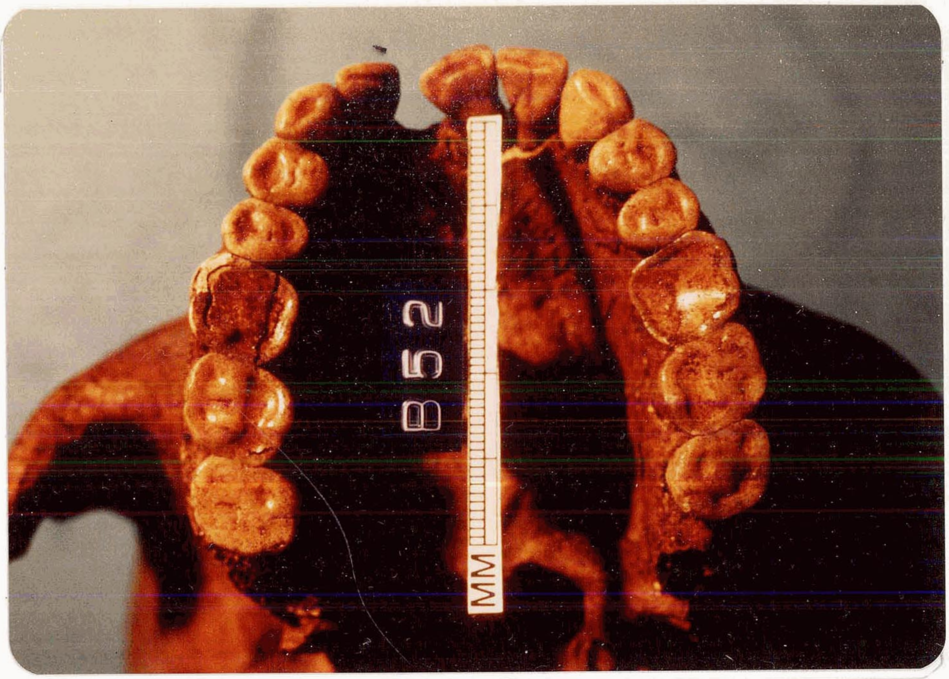
Swanport Individual 22. 17 years old. This individual shows very little tooth wear. Male. Attrition stages: RM^3 - 1, M^2 - 2, M^1 - 5, P^4 - 3, C - 2, I^2 - 3, L I^2 - 3, C - 2, P^3 - 3, M^1 - 4, M^2 - 2, M^3 - O.



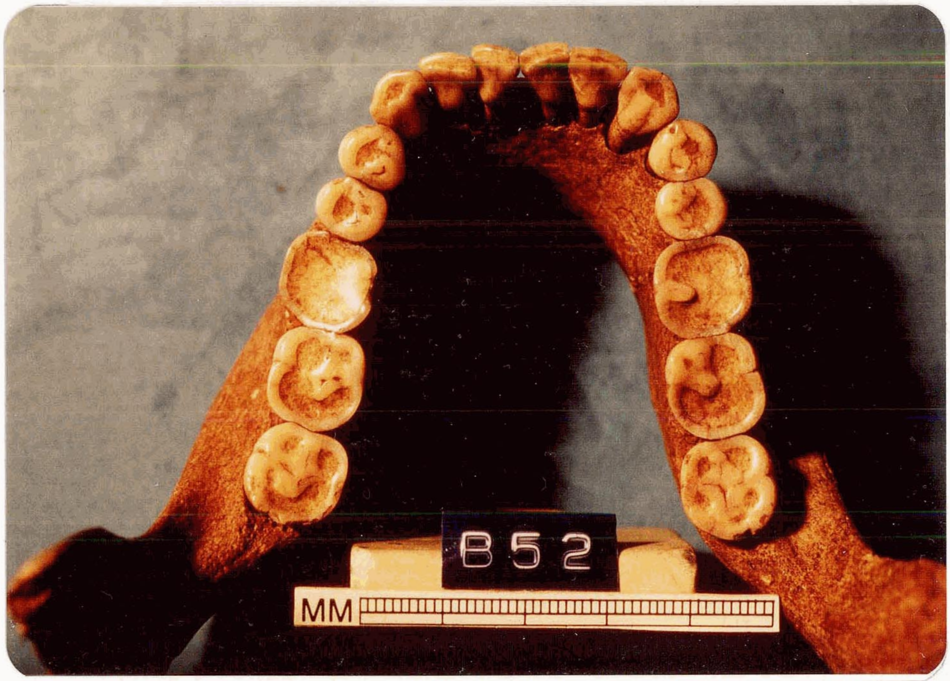
Swanport. Individual 20. Adult male. Swanport pattern of heavy anterior wear. Attrition stages: R M^3 - 1, M^2 - 7, M^1 - 8, P^3 - 9, C - 9, L I^2 - 10, C - 9, P^3 - 8, P^4 - 6, M^1 - 8, M^2 - 7, M^3 - 1.
Note variability in wear between this individual and Individual 22 who has similar M^3 wear.



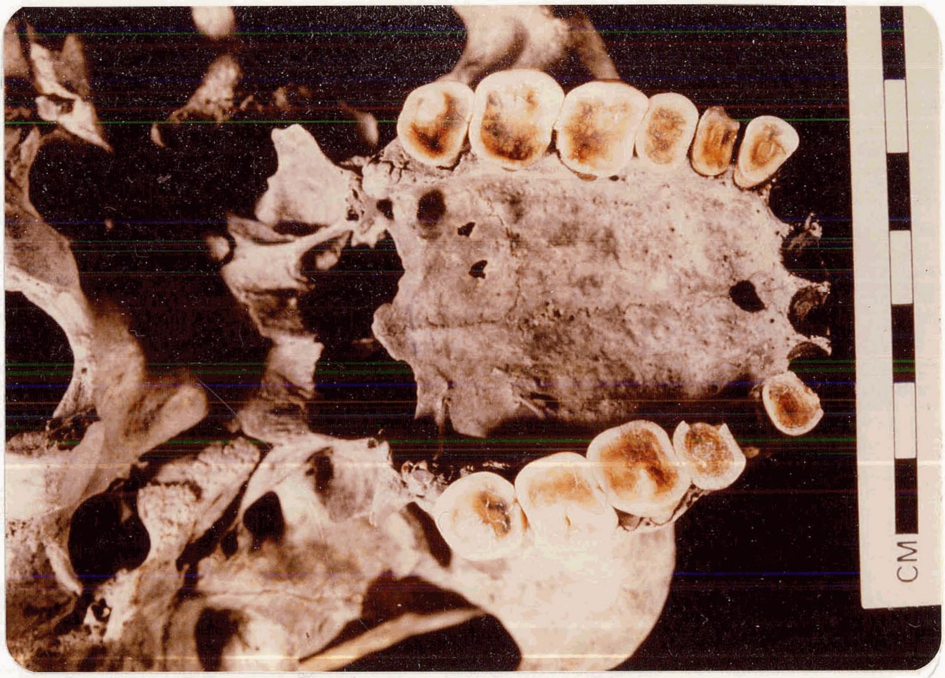
Swanport. Individual 23. Adult male. Swanport pattern of heavy anterior wear. Attrition stages: R M^3 - 4, M^2 - 6, M^1 - 7, P^4 - 6, P^3 - 5, C - 5, I^2 - 6, I^1 - 8, L I^1 - 8, C - 5, P^3 - 4, M^1 - 8, M^2 - 7, M^3 - 9.
Note difference in left and right M^3 wear.



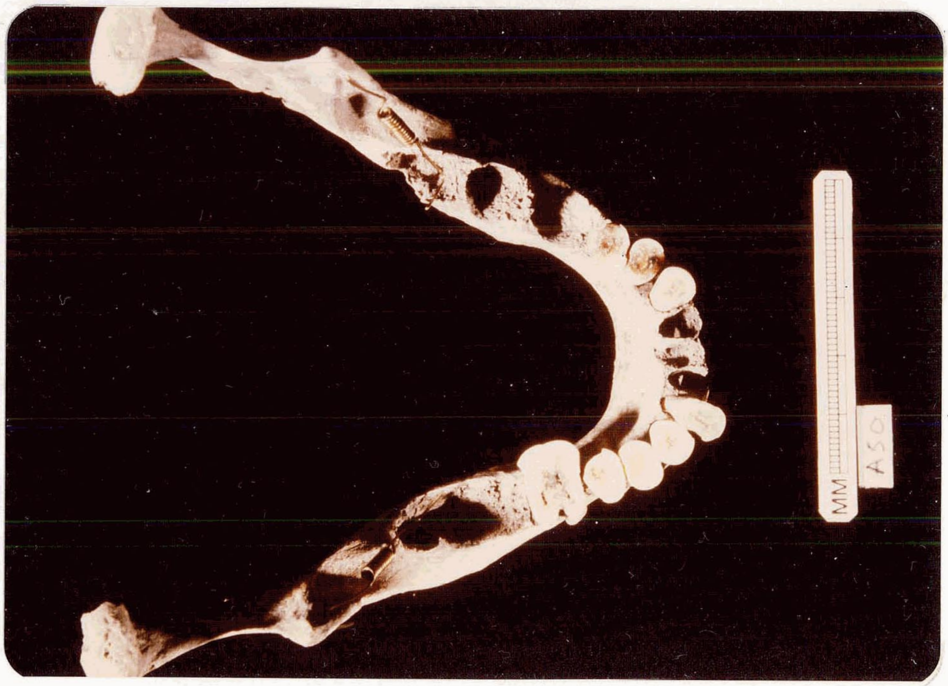
Broadbeach. Individual 143. Adult male. Broadbeach pattern of light anterior wear. Attrition stages: R M^3 - 6, M^2 - 7, M^1 - 9, P^4 - 7, P^3 - 7, C - 7, I^2 - 7, I^1 - 7, L I^1 - 7, I^2 - 7, C - 7, P^3 - 7, P^4 - 7, M^1 - 9, M^2 - 7, M^3 - 6.



Broadbeach. Individual 143. Attrition stages: R M_3 - 7, M_2 - 8, M_1 - 9, P_4 - 8, P_3 - 7, C - 7, I_2 - 6, I_1 - 7, L I_1 - 7, I_2 - 7, C - 7, P_3 - 7, P_4 - 8, M_1 - 9, M_2 - 8, M_3 - 7.

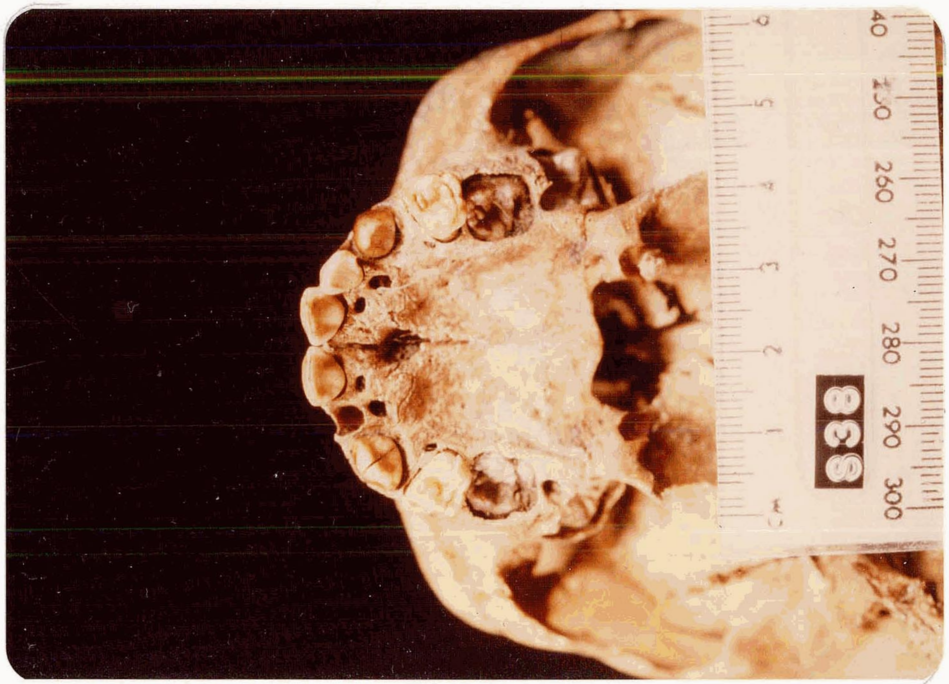


Murray Basin. Individual 87. Adult female with severe attrition. Attrition stages: R M^3 - 8, M^2 - 9, M^1 - 8, P^4 - 8, P^3 - 11, L C - 11, P^4 - 8, M^1 - 8, M^2 - 7, M^3 - 7.

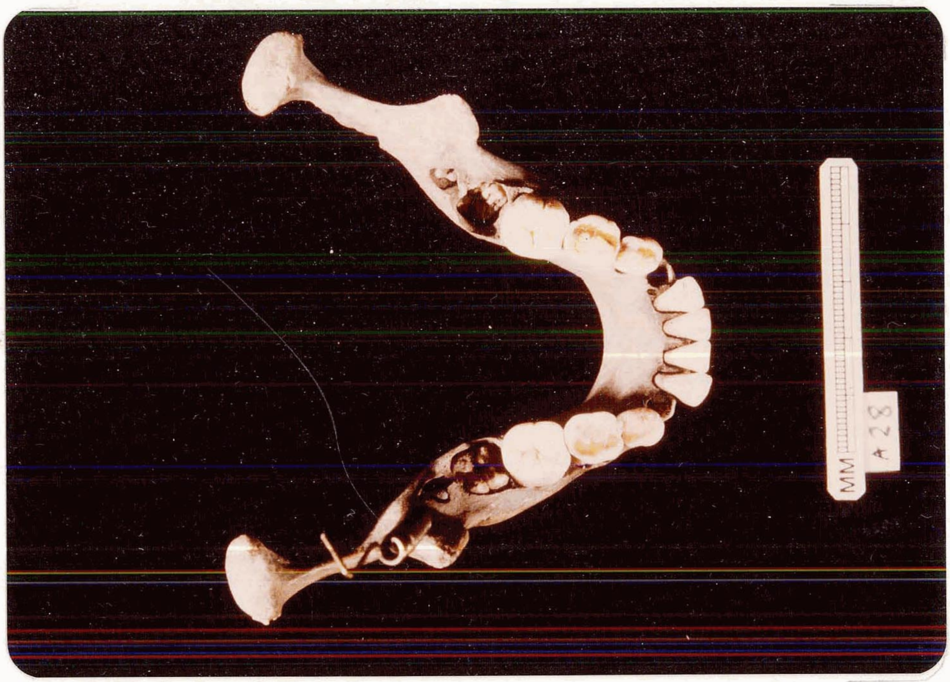


Murray Basin. Individual 87. Attrition Stages: R M_1 - 12, P_4 - 9, P_3 - 9, C - 9, I_2 - 11, L C - 9, P_3 - 9, P_4 - 9.

Swanport. Individual 15. Age 7.5. Deciduous tooth wear. Attrition stages: R M^1 - 3, dm^2 - 6, dm^1 - 7, dc - 7, L dc - 7, dm^1 - 7, dm^2 - 6, M^1 - 3.



Swanport. Individual 38. Age 2. Dentine exposure on deciduous incisor. Attrition stages: R dm^1 - 3, di^1 - 6, L di^1 - 6, di^2 - 2, dm^1 - 3.



Murray Basin. Individual 66. Age 8.1. Deciduous molar wear. Attrition stages: R M_1 - 4, dm_2 - 7, I_2 - 3, I_1 - 4, L I_1 - 4, I_2 - 3, dm_1 - 7, dm_2 - 7, M_1 - 4.

APPENDIX C

Tooth Formation Age Standards, and Stages Scored for Individuals

Mean Ages for Formation Stages of Teeth. Skinner's adaptation of Haavikko (1970) Ages for males, in years.

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
di1	A. Calcification in crypt				
	B. Initial Crown formation				
	C. Crown One Half				
	D. Crown Complete	.08		.08	
	E. Root Initiation	.50		.50	
	F. Root Advanced				
	G. Apical Canal Open	1.00		1.00	
	H. Apical Canal Closed	1.17		1.15	
di2	A.				
	B.				
	C.				
	D.	.08		.08	
	E.	.50		.50	
	F.			.75	
	G.	1.00			
	H.	1.17		1.50	

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
dc	A.				
	B.				
	C.			.34	.25 - .51
	D.	.17		.68	.49 - .92
	E.	.58		.88	.65 - 1.14
	F.	1.17		1.56	.89 - 1.94
	G.			2.59	1.79 - 3.80
	H.	2.17		3.24	2.69 - 3.89
dm1	A.				
	B.				
	C.				
	D.	.50		.62	.36 - .90
	E.	1.00			
	F.			1.06	.63 - 1.75
	G.	1.50		1.88	1.27 - 2.42
	H.	2.50		1.98	1.89 - 2.50

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
dm2	A.				
	B.			.38	.31 - .54
	C.				
	D.	.58		.88	.68 - 1.11
	E.	1.17		1.16	.93 - 1.44
	F.			2.04	1.41 - 2.44
	G.	2.00		2.79	1.92 - 3.29
	H.	3.00		3.11	2.63 - 4.19
I1	A.				
	B.				
	C.				
	D.	3.3	- 4.1		
	E.	5.7	4.9 - 6.4	4.3	3.7 - 4.9
	F.	7.3	5.4 - 8.3	6.3	4.7 - 7.4
	G.	8.7	7.7 - 10.0	7.2	6.0 - 6.8
	H.	9.8	8.8 - 11.4	8.0	7.1 - 9.8

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
I2	A.				
	B.				
	C.	3.3	- 4.2		
	D.	4.6	3.7 - 5.4	3.3	2.5 - 3.9
	E.	6.8	5.7 - 7.4	5.4	4.6 - 6.3
	F.	8.6	7.0 - 9.9	7.3	4.9 - 8.0
	G.	9.6	8.3 - 10.0	8.1	7.8 - 9.9
	H.	10.8	9.7 - 11.6	9.6	8.0 - 10.1
C	A.			0.7	0.4
	B.			1.2	0.4 - 1.7
	C.	3.3	? - 4.3	2.8	1.6 - 3.6
	D.	4.6	4.1 - 5.4	4.3	3.5 - 5.1
	E.	7.0	6.3 - 8.2	6.9	5.7 - 7.5
	F.	9.8	7.9 - 1.7	9.6	7.3 - 11.8
	G.	12.3	11.3 - 13.9	11.6	9.2 - 13.0
	H.	13.6	12.4 - 16.3	13.2	12.0 - 13.9

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
P3	A.			2.0	1.9 - 3.0
	B.			2.9	1.8 - 3.7
	C.	6.0	3.4 - 6.5	5.5	3.1 - 6.3
	D.	6.8	5.6 - 7.6	5.9	5.0 - 6.5
	E.	8.4	7.3 - 9.2	8.0	7.5 - 9.6
	F.	10.7	8.0 - 11.6	10.4	7.9 - 12.5
	G.	11.5	10.4 - 13.6	11.8	10.8 - 13.5
	H.	13.3	12.1 - 15.1	12.8	11.4 - 14.1
P4	A.			3.4	2.9 - 6.9
	B.	4.6	4.0 - 5.8	4.4	3.2 - 5.5
	C.	6.7	4.8 - 7.3	6.1	4.3 - 7.0
	D.	7.1	5.7 - 7.7	7.0	5.6 - 8.1
	E.	8.6	7.7 - 9.9	8.5	7.6 - 10.2
	F.	7.2	4.7 - 8.1	6.6	5.1 - 7.4
	G.	8.1	7.2 - 9.1	7.3	6.9 - 8.8
	H.	9.8	8.0 - 10.9	9.8	8.1 - 11.1

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
M1	A.			0.1	0.8 - .26
	B.			0.7	0.1 - 0.8
	C.			1.6	0.9 - 2.0
	D.	3.6	2.9 - 4.4	3.5	2.9 - 3.8
	E.	5.8	4.6 - 6.2	5.1	4.2 - 5.8
	F.	7.2	4.7 - 8.1	6.6	5.1 - 7.4
	G.	8.1	7.2 - 9.1	7.3	6.9 - 8.8
	H.	9.8	8.0 - 10.9	9.8	8.1 - 11.1
M2	A.	3.7	3.1 - 4.5	3.9	3.2 - 5.3
	B.	4.7	3.2 - 5.4	4.5	3.7 - 5.9
	C.	6.4	4.3 - 7.7	6.7	4.4 - 7.3
	D.	7.3	6.7 - 8.1	7.4	6.7 - 8.2
	E.	10.2	8.2 - 11.4	9.7	8.2 - 11.3
	F.	12.3	9.9 - 13.8	12.1	9.5 - 13.9
	G.	13.6	12.9 - 15.8	13.4	12.2 - 14.7
	H.	16.2	13.7 - 17.1	15.7	13.5 - 17.0

Tooth	Formation Stage	Maxilla: Mean	Dispersion	Mandible: Mean	Dispersion
M3	A.	9.0	7.9 - 12.3	9.8	7.6 - 14.2
	B.	9.6	8.2 - 13.4	10.5	8.6 - 14.4
	C.	12.7	8.5 - 17.3	13.0	9.0 - 14.9
	D.	13.2	12.0 - 17.6	13.7	10.8 - 15.8
	E.	15.9	15.4 - 19.2	16.0	14.4 - 18.9
	F.	17.0	15.9 - 19.0	18.2	15.3 - 19.0
	G.	18.1	16.5 - 19.7	18.4	16.2 - 19.4
	H.	19.5	17.8 - 21.0	20.4	17.1 - 20.4

Tooth Formation Stages Scored for Individuals

Individual	Assigned Age	Teeth and Formation Stages. Left and Right Sides							
Swanport									
1	5.3		M2-C,	M1-E,	P4-C,	P3-C,	C-D,	I2-E,	I1-E
			M2-C,	M1-E,	P4-C,	P3-C,	C-D,	I2-E,	I1-E
3	7.3		M2-D,	M1-F,	P4-D,	P3-E,	C-E,	I2-F,	I1-G
			M2-D,	M1-F,	P4-D,	P3-E,	C-E,	I2-F,	I1-G
4	4.4		M2-B,	M1-E,		P3-C,	C-D,	I2-E,	I1-E
			M2-B,	M1-E,		P3-C,	C-D,	I2-E,	I1-E
6	9.8			M1-E,		P3-O			
				M1-E,		P3-O			
7	3.0			M1-D,		P3-B.,	C-C,	I2-D,	I1-D
				M1-D,		P3,B,	C-C,	I2-D,	I1-D
8	6.6		M2-C,	M1-E,	P4-B,	P3-C,	C-D,	I2-E,	I1-F
			M2-C,	M1-E,	P4-B,	P3-C,	C-D,	I2-E,	I1-F
9	12.6		M2-G,	M1-H,	P4-G,	P3-H,	C-G,	I2-H,	I1-H
				M1-H,	P4-G,	P3-H,	C-G,	I2-H,	I1-H
10	7.4		M2-D,	M1-G,	P4-D,	P3-E			I1-G
			M2-D,	M1-G,	P4-D,		C-E,	I2-G	
11	9.8	M3-B,	M2-E,	M1-G,				I2-G,	I1-G
		M3-B,	M2-E,	M1-G,	P4-E,	P3-F,	C-F,	I2-G,	I1-G
12	7.3		M2-D,	M1-G,	P4-D,	P3-E,	C-E		
			M2-D,	M1-G,	P4-D,	P3-E,	C-E		
13	2.5			M1-C,			C-C,	I2-C,	I1-D
				M1-C,			C-C,	I2-C,	I1-D
14	13.2	M3-C,	M2-G,	M1-H					
		M3-C,	M2-G,	M1-H					

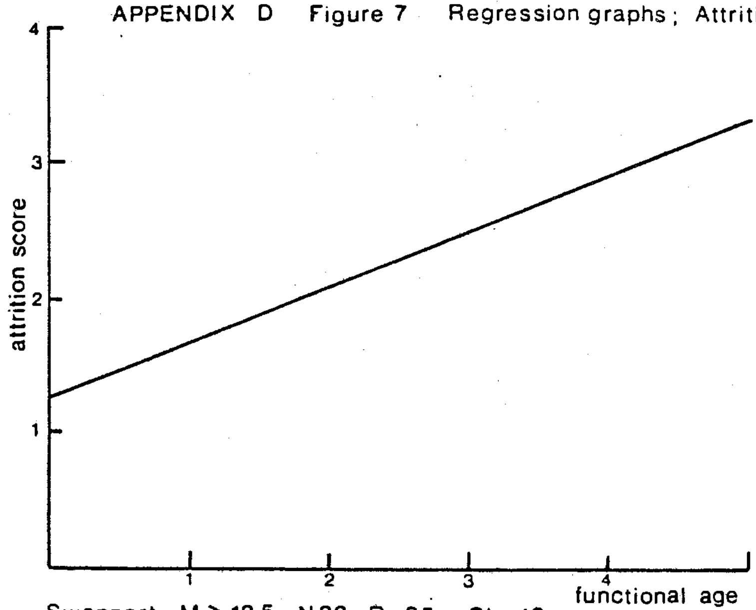
Individual	Assigned Age	Teeth and Formation Stages Left and Right Sides							
17	2.3			M1-C,			C-B,	I2-C,	I1-C
				M1-C,			C-B,	I2-C,	I1-C
31	3.6			M1-D,		P3-C,	C-C,	I2-D,	I1-D
				M1-D,		P3-C,	C-C,	I2-D,	I1-D
32	7.3		M2-D,	M1ØG,	P4-D,	P3-E,	C-F,	I2-F,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-F,	I1-G
33	13.5	M3-D,	M2-G						
		M3-D,	M2-G						
36	3.0			M1-D,		P3-B,	C-C,	I2-D,	I1-D
				M1-D,		P3-B,	C-C,	I2-D,	I1-D
37	3.6			M1-D,	P4-A,	P3-C,	C-C,	I2-D,	I1-E
				M1-D,	P4-A,	P3-C,	C-C,	I2-D,	I1-E
38	2.0			M1-C,			C-B,	I2-C,	I1-C
				M1-C			C-B,	I2-C,	I1-C
39	7.5		M2-D,	M1-F,	P4=C,	P3-D,		I2-E,	I1-F
			M2-D,	M1-F,	P4-C,	P3-D,		I2-E,	I1-F
40	4.6			M1-D,		P3-C,	C-D,	I2-E,	I1-E
				M1-D,		P3-C,	C-D,	I2-E,	I1-E
41	9.0		M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-F,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-F,	I1-G
42	4.8		M2-B,	M1-E,	P4-B,	P3-C,	C-D,	I2-E,	I1-E
			M2-B,	M1-E,	P4-B,	P3-C,	C-D,	I2-E,	I1-E

Individual	Assigned Age	Teeth and Formation Stages Left and Right Sides							
Murray Basin									
A4	4.2		M2-B,	M1-D,	P4-B,	P3-C,	C-D,	I2-D,	I1-E
			M2-B,	M1-D,	P4-B,	P3-C,	C-D,	I2-D,	I1-E
A8	3.9	dm2-G,	M2-B,	M1-D,	P4-A,	P3-C,	C-D,	I2-D,	I1-D
		dm2-G,	M2-B,	M1-D,		P3-C,	C-D,	I2-D,	I1-D
A10	7.9		M2-D,	M1-G,	P4-D,	P3-E,	C-F		
			M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-G	
A12	6.4		M2-D,	M1-F,	P4-C,	P3-D,	C-E,	I2-E,	I1-F
			M2-D,	M1-F,	P4-C,	P3-D,	C-E,	I2-E,	I1-F
A13	3.9						C-D,	I2-D,	I1-E
				M1-D,			C-D,	I2-D,	I1-E
A15	8.2		M2-D,	M1-G,	P4-E,	P3-E,	C-F		
			M2-D,	M1-G,	P4-E,	P3-E,	C-F		
A16	1.8	dm2-F,	dm1-G,	M1-C					
		dm2-F,	dm1-G,	M1-C					
A24	6.3		M2-C,			P3-D,	C-E,		I1-F
			M2-C,	M1-F,	P4-C,	P3-D,	C-E,	I2-F,	I1-F
A25	10.3		M2-E,	M1-H,	P4-E,	P3-F,	C-F		
		M3-D,	M2-E,	M1-H,	P4-E,	P3-F			
A28	8.1		M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-G,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-G,	I1-G
A30	7.4		M2-D,	M1-G,	P4-D,	P3-E,	C-E,	I2-G,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-E,	I2-G,	91-G
A33	5.0		M2-B,	M1-D,	P4-B,	P3-C,	C-D,	I2-E,	I1-E
			M2-B,		P4-B,	P3-C,	C-D,	I2-E,	I1-E
A39	8.0		M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-G,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-F,	I2-G,	I1-G

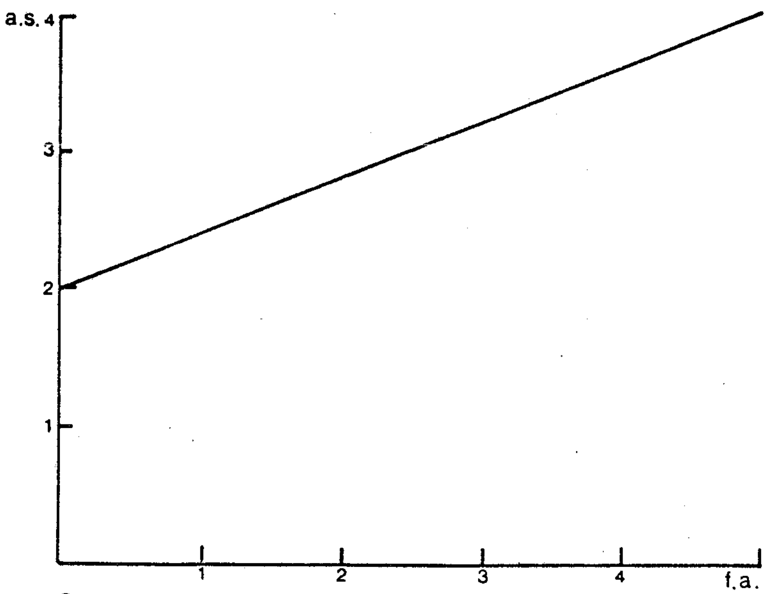
Individual	Assigned Age	Teeth and Formation Stages Left and Right Sides							
A40	1.4	dm2-E,	dm1-G,	M1-C,			C-B,	I2-C,	I1-C
		dm2-E,	dm1-G,	M1-C,			C-B,	I2-C,	I1-C
A41	6.8		M2-C,	M1-E,	P4-C,	P3-D,	C-D,	I2-E,	I1-F
			M2-C,	M1-E,	P4-C,	P3-D,	C-D,	I2-E,	I1-F
A42	2.0	dm2-F,	dm1-G,	M1-C,		P3-A,	C-B,	I2-D,	I1-D
		dm2-F,	dm1-G,	M1-C,		P3-A,	C-B,	I2-D,	I1-D
A43	2.2	dm2-F,	dm1-G,	M1-C,		P3-A,	C-B,		I1-D
		dm2-F,	dm1-G,	M1-C,		P3-A,	C-B,	I2-D,	I1-D
A44	3.3	dm2-G,	dm1-H,	M1-D,			C-C,	I2-D,	I1-E
				M1-D,			C-C,	I2-D,	I1-E
Broadbeach									
B2	12.5	M3-C,	M2-G,	M1-H,			C-G,	I2-H,	I1-H
		M3-C,	M2-G,	M1-H,	P4-H		C-G,	I2-H,	I1-H
B9	8.0		M2-D,	M1-G,	P4-E,	P3-E,	C-F,		I1-G
			M2-D,	M1-G,	P4-E,	P3-E,	C-F		
B14	11.3	M3-C,					C-F		
		M3-C,					C-F		
B16				M1-D,			C-C,		I1-D
B19	4.8		M2-B,	M1-E,	P4-B,	P3-C,	C-D,	I2-C,	I1-D
B23	7.5		M2-D,	M1-G,	P4-D,	P3-E,	C-E,	I2-G,	I1-G
			M2-D,	M1-G,	P4-D,	P3-E,	C-E,		I1-G
B26	5.6		M2-C,	M1-E,			C-D,	I2-E	
B27	1.3	dm2-E,	dm1-F,	M1-C,			C-B,	I2-C	
B31	2.8	dm2-G,	dm1-H,	M1-D,					I1-D
		dm2-G,	dm1-H,	M1-C,		P3-A,	C-C,	I2-C,	I1-D
B40	6.3		M2-C,	M1-F,	P4-C,	P3-D,	C-E,	I2-E	
			M2-C,	M1-F,		P3-D			

Individual	Assigned Age	Teeth and Formation Stages. Left and Right Sides							
B45	18.4	M3-G,	M2-H,	M1-H					
B51	1.1	dm2-D,	dc-E,	di2-G,	M1-C				I1-C
B71	1.2	dm2-E,	dm1-F,		M1-C				I1-C
B86	8.6	M3-B,	M2-E,		P4-E,	P3-E,	C-E,		
B87	4.8		M2-B,	M1-E,		P3-C,	C-C,	I2-D,	I1-D
B92	8.0		M2-E,	M1-G,	P4-E,	P3-E,	C-E,	I2-G,	I1-G
B104	3.7	dc-G,					C-C,	I2-D	
B112	12.8	M3-C,	M2-G,	M1-H,					I1-H
			M2-G,	M1-H,	P4-G,	P3-H,	C-H,	I2-H	
B123	7.4		M2-D,	M1-G,	P4-D,	P3-E			
			M2-D,	M1-G,	P4-D,	P3-E			
B125	7.5		M2-D,	M1-F,		P3-D,		I2-E	
B128	13.6	M3-D,	M2-G,	M1-H,	P4-H,				
B134	3.2			M1-D			C-C,	I2-D	
B137	3.0	dm2-G,	dm1-H,	M1-D,		P3-B,		I2-D,	I1-D
		dm2-G,	dm1-H,	M1-D,		P3-B,	C-C,	I2-D,	I1-D
B139	7.2		M2-D,		P4-D				

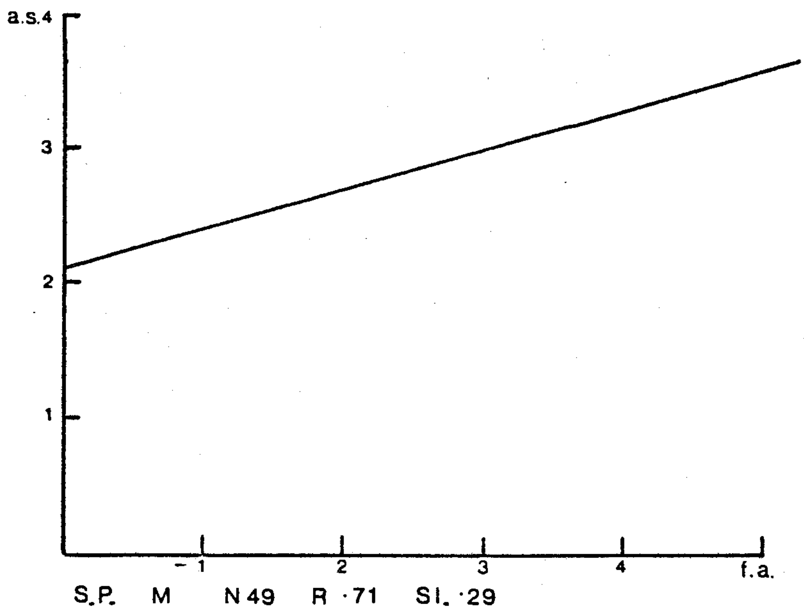
APPENDIX D Figure 7 Regression graphs ; Attrition : F. Age

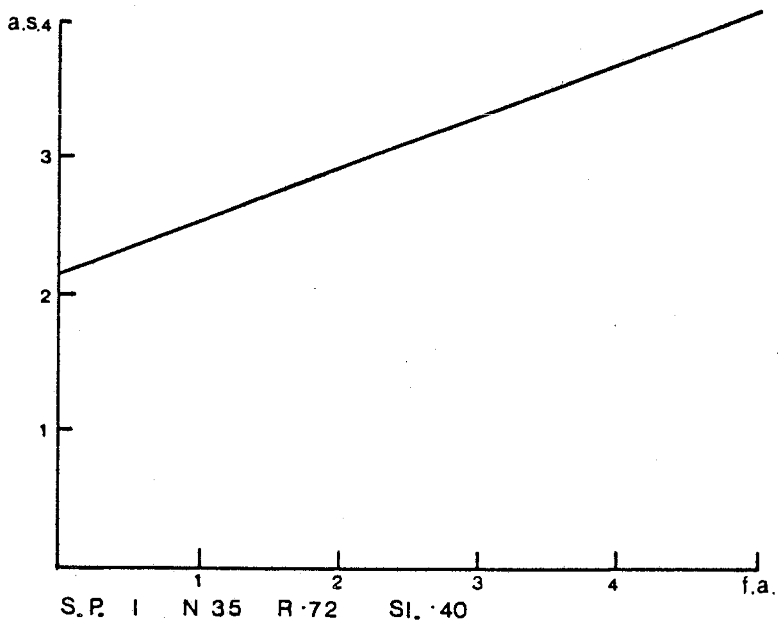


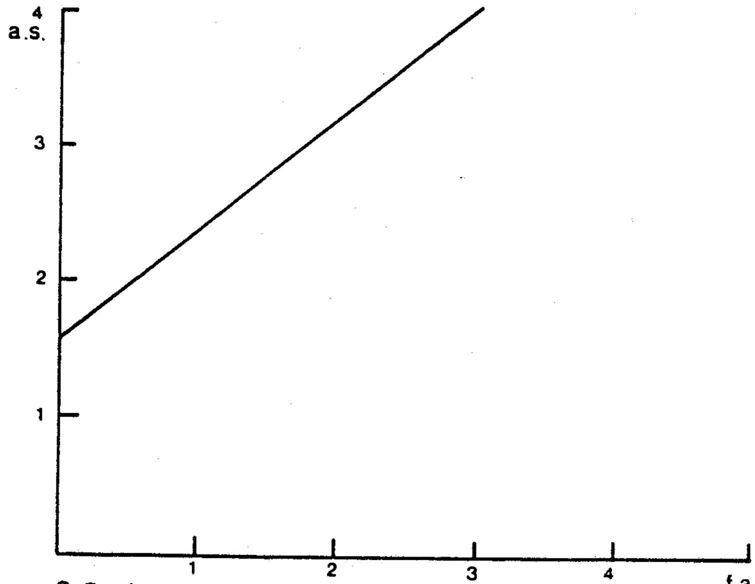
Swanport M ≥ 12·5 N 26 R · 85 Sl. ·40



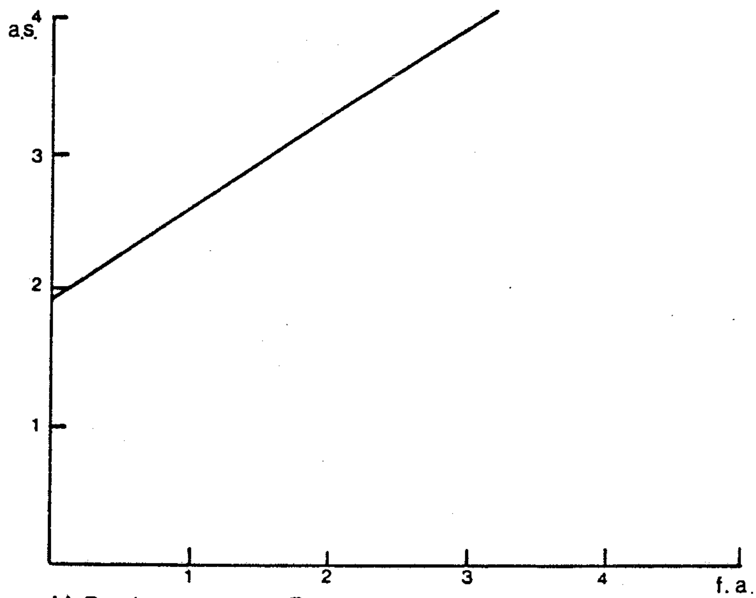
S.P. I ≥ 12·5 N 17 R · 62 Sl. ·42


a.s.4
3
2
1
1
2
3
4
f.a.
S.P. M N 49 R ·71 SI. ·29

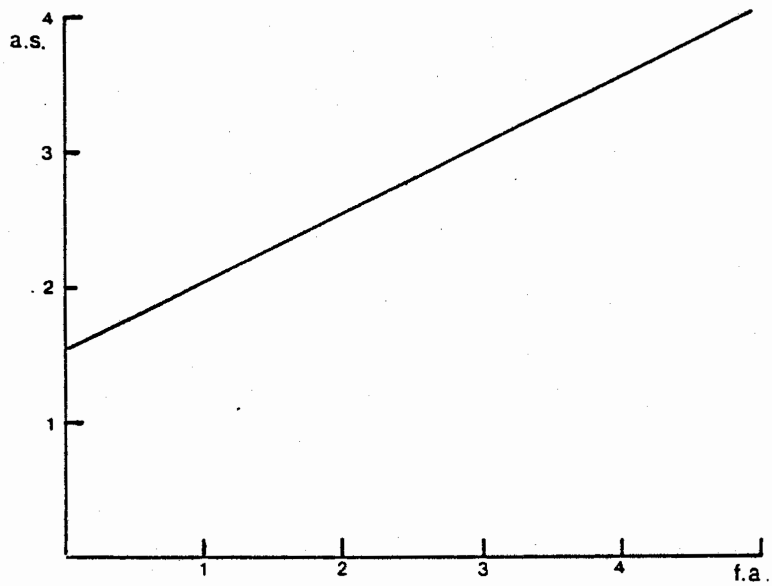

a.s.4
3
2
1
1
2
3
4
f.a.
S.P. I N 35 R ·72 SI. ·40



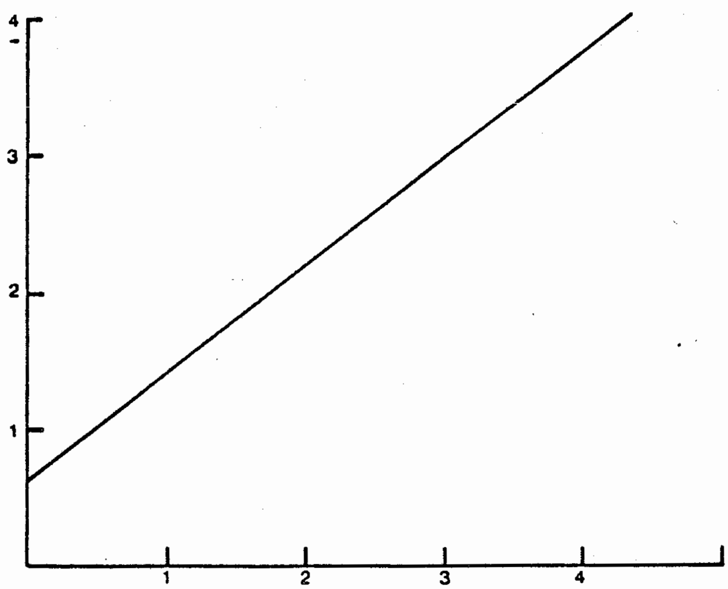
S.P. dm2 N 40 R ·83 SI. ·83



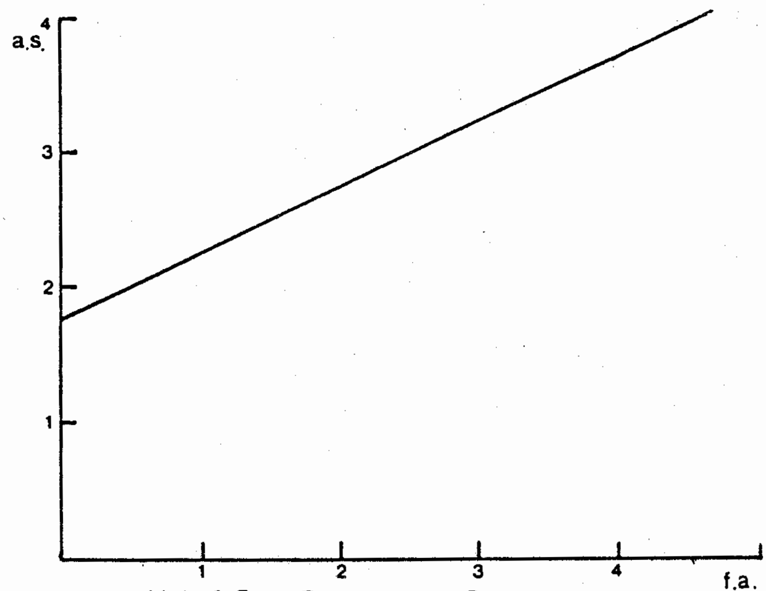
M.B. dm2 N51 R ·77 SI. ·67



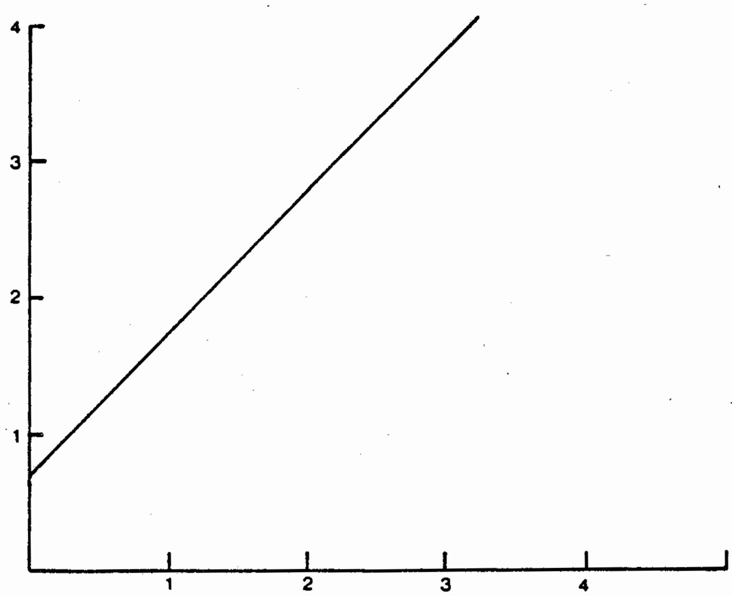
M.B. M< 12·5 N 33 R · 56 SI. ·45



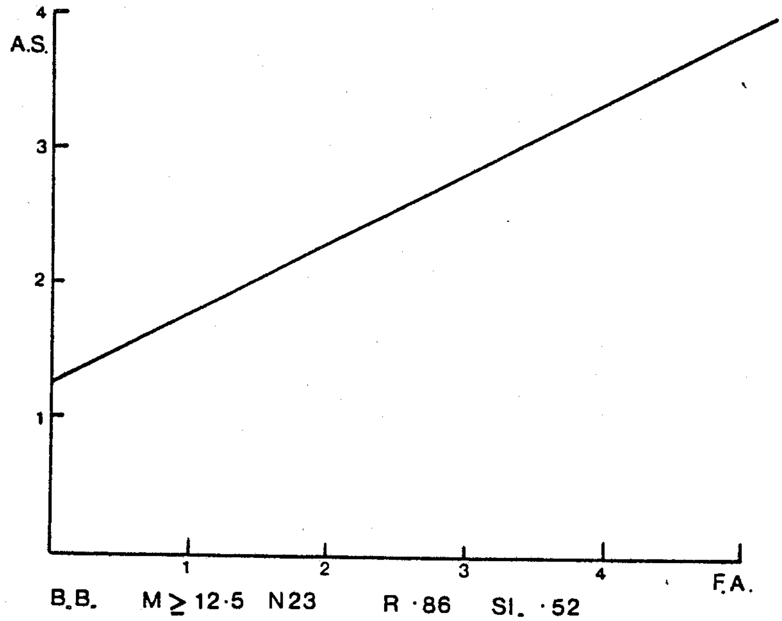
M.B. I < 12·5 R · 59 SI. ·76

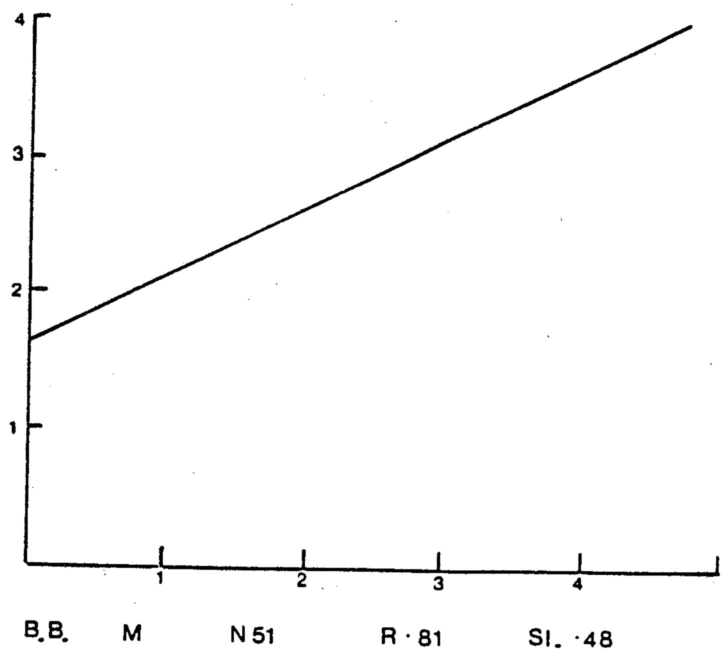


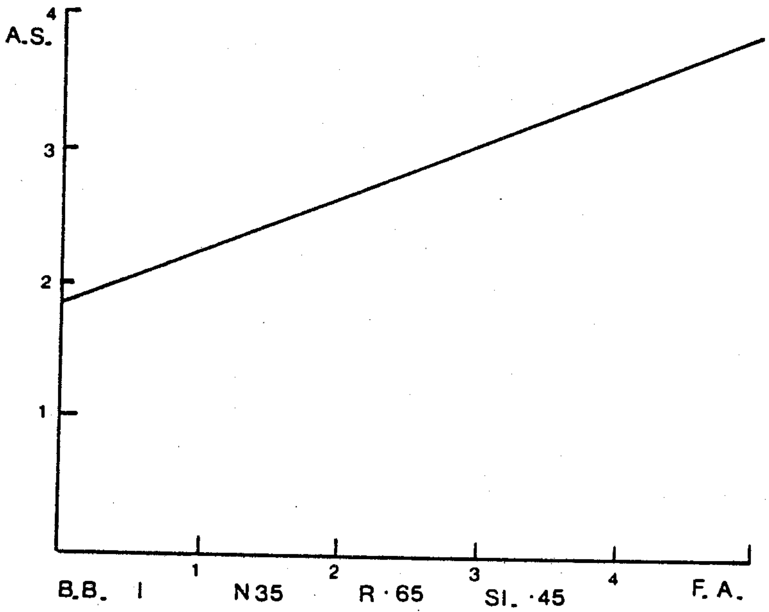
B.B. M< 12·5 R·54 SI. ·47 N 28

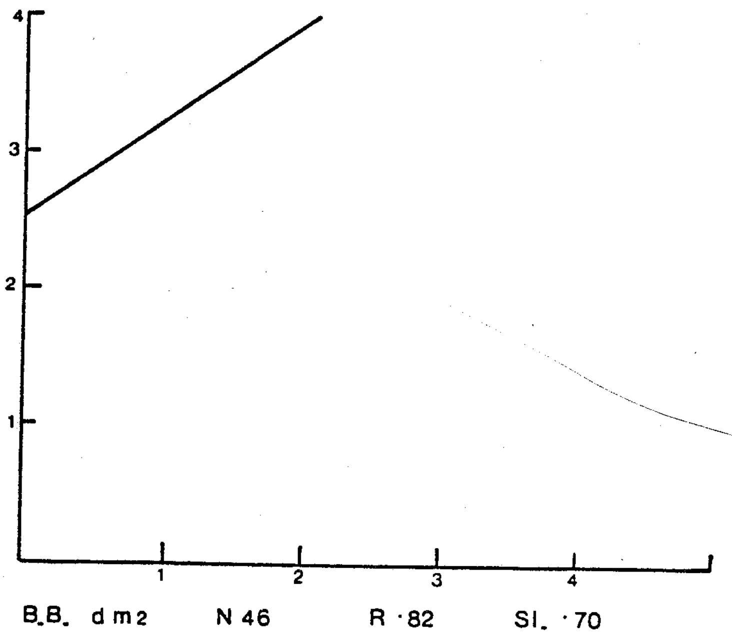


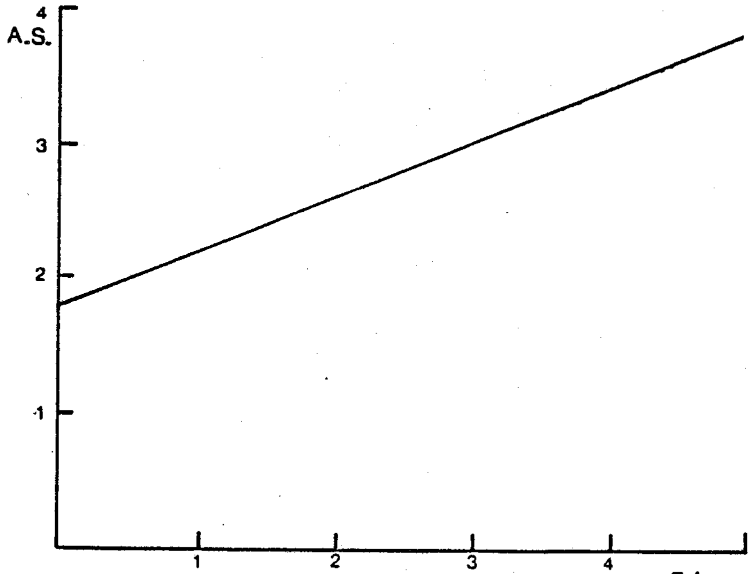
B.B. I < 12·5 N19 R·56 SI.1·07


4
A.S.
3
2
1
1
2
3
4
F.A.
B.B.   M ≥ 12·5   N23   R ·86   SI. ·52

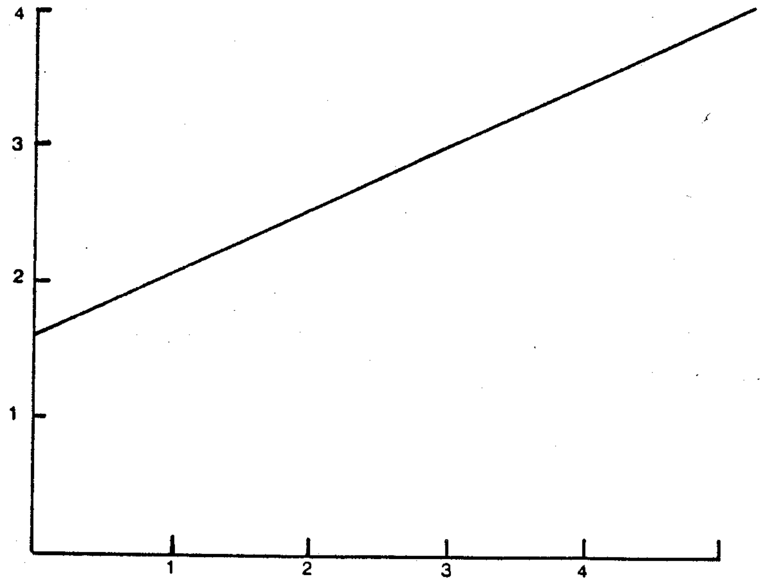

4
3
2
1
1
2
3
4
B.B.   M   N51   R · 81   SI. ·48


A.S.
4
3
2
1
1
2
3
4
B.B. I
N35
R ·65
SI. ·45
F. A.

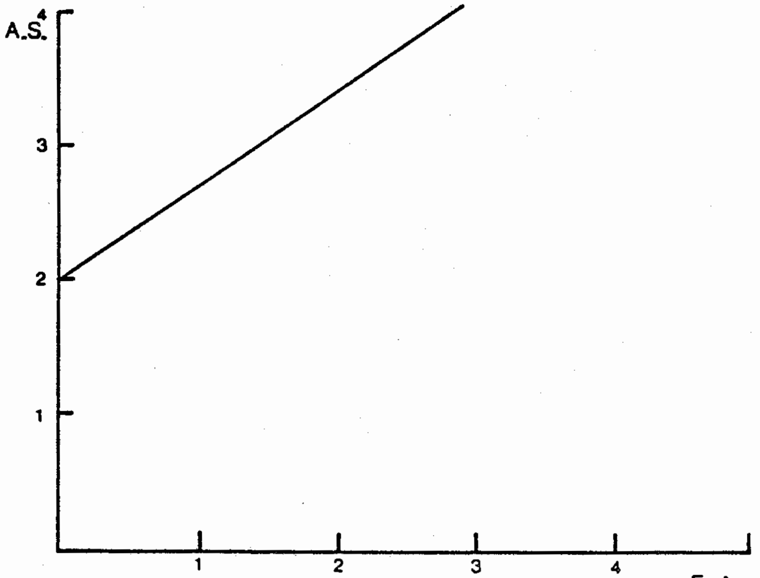

4
3
2
1
1
2
3
4
B.B. dm2
N 46
R ·82
SI. ·70



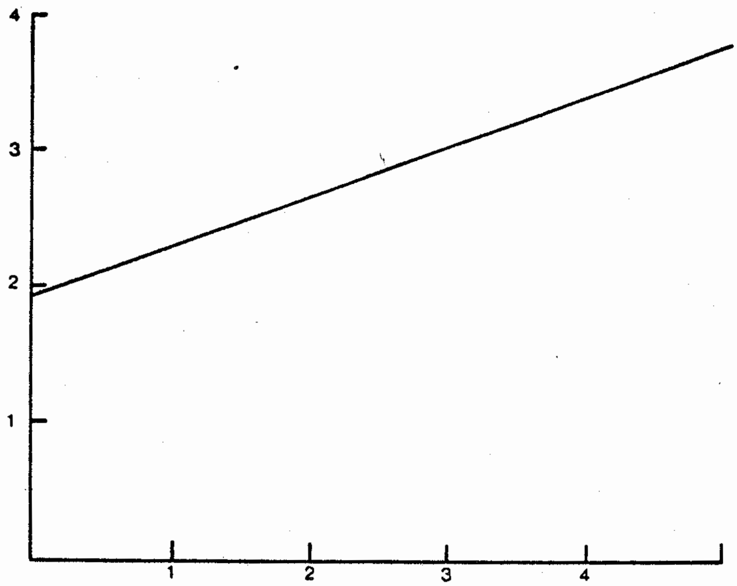
All Sites M N133 R·74 Sl. ·39



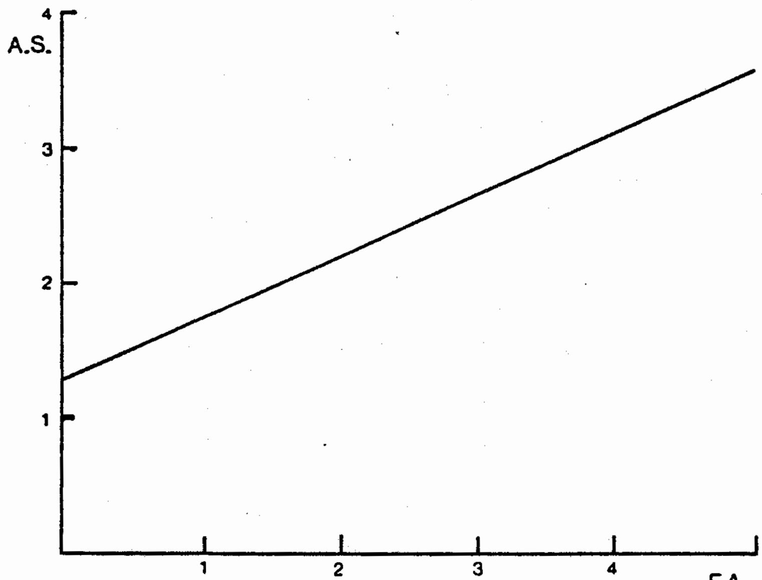
All Sites I N 92 R ·71 Sl. ·47



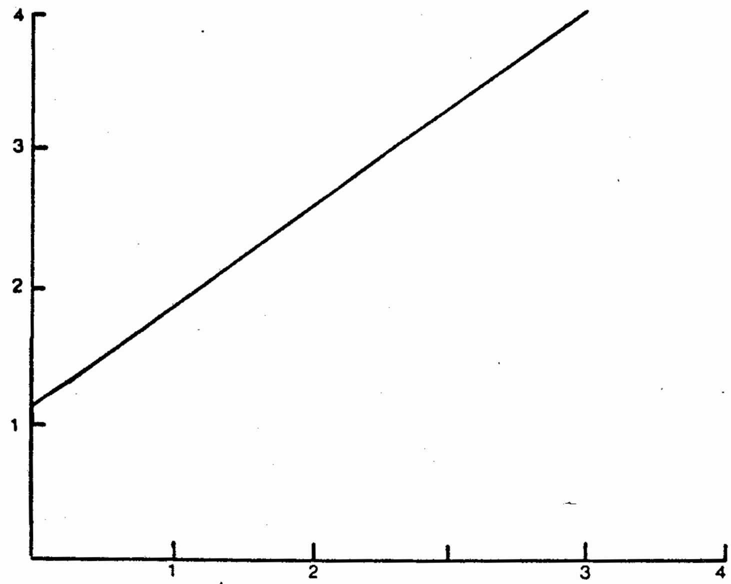
All Sites dm2 N 137 R ·80 Sl. ·72



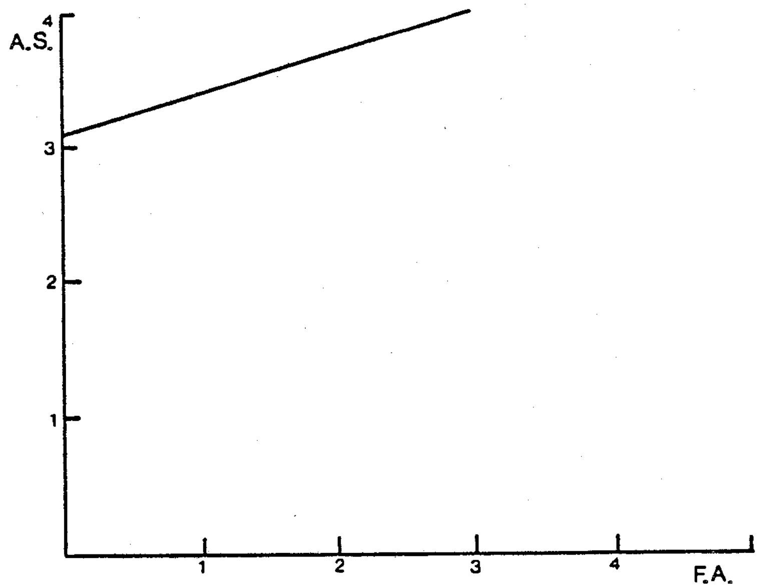
All Sites M<12·5 N 84 R ·45 Sl. ·38



All Sites M ≥ 12·5 N 49 R ·83 Sl. ·45



All Sites I < 12·5 N 59 R ·47 Sl. ·77



All Sites I ≥ 12·5 N33 R ·50 SL ·29

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