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SAYING SO DOESN'T MAKE IT SO

PAPERS IN HONOUR OF B. FOSS LEACH

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The Incidence of Dental Caries in Some Prehistoric Pacific Groups

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INTRODUCTION

This paper outlines a study of comparative dental conditions undertaken for a master's thesis (Evans 1987). Three basic factors cause changes to the teeth of living individuals which can be observed in skeletal material. These are attrition, periodontal disease and caries. This study concentrates on the incidence of caries.

There have been numerous studies of the physical anthropology of prehistoric Pacific peoples, some of which have concentrated on the state of the dentition (Chappel 1927; Keene 1986; Klatsky and Klatell 1943; Leigh 1929; Owsley *et al.* 1985; Sinclair *et al.* 1950). The results have varied from groups where caries was nearly absent, to those with a caries incidence of 27%. Some of these results may be explained by a sampling bias of the kind that occurs in some early museum collections, where perfect, or near perfect skulls and teeth were retained preferentially. Alternatively, bias may have been introduced by differing methods employed by researchers, these in turn depending upon their research aims.

Problems with many of these early studies include accurate dating of the skeletal material, to rule out any European influence, and the composition of the groups, whether they are a representative sample of what was actually excavated. It can be seen that even within a single island group (Hawaii), the percentage of carious teeth found can vary from 0.0 to 27% (see Table 1).

In a recent paper, Walker and Erlandson (1986) report the analysis of skeletal material from the Channel Islands, off the coast of Southern California. This material dated from 4000 to 400 B.P. The dentition was studied for evidence of carious lesions. The general trend found was a decrease in caries in all tooth types over time.

Briefly, the situation on the Channel Islands is that there are many marine animal remains in the middens but milling stones, which would indicate agricultural practices, are rare. The authors postulate a change in diet from a dependence on "carbohydrate-rich plant foods" to an increasing dependence on marine foods. This agrees with the dental evidence of a decrease in the incidence of caries. This trend is explained by the effects of marine diet upon the dentition.

The present study considers some possible effects of diet on the incidence of caries in Pacific populations.

TABLE 1
THE INCIDENCE OF CARIES ON A PER TOOTH BASIS IN SEVERAL PACIFIC POPULATIONS

Population	Location	Number of teeth	Percentage carious	Source
Melanesian	Lakeba	22	31.82 ± 16.8	(8)
Polynesian	Hawaii	1860	27.26 ± 1.5	(1)
Polynesian	Hawaii	12429	10.93 ±0.4	(7)
Polynesian	Hawaii	188	0.00	(3)
Polynesian	Easter Island	1019	27.10 ± 2.0	(6)
Polynesian	Easter Island	235	3.83 ± 2.0	(3)
Micronesian	Guam	227	18.50 ± 3.8	(2)
Melanesian	Eriama	27	14.81 ± 11.6	(8)
Melanesian	Nebira	675	6.52 ± 1.41	(8)
Melanesian	Papua New Guinea	6142	3.81 ± 0.4	(4)
Melanesian	Papua New Guinea	281	0.36 ± 0.7	(3)
Polynesian	Tonga	779	11.04 ± 1.6	(8)
Polynesian	Pukapuka	11072	9.30 ± 0.4	(5)
Polynesian	New Zealand	399	2.26 ± 1.2	(3)
Polynesian	Wairau Bar	564	1.06 ± 0.7	(8)
Polynesian	Castlepoint	24	0.00	(8)
Polynesian	Tahiti	145	1.38 ± 1.7	(3)
Melanesian	Solomon I	139	0.72 ± 1.4	(3)
Melanesian	Namu	1928	0.57 ± 0.3	(8)
Polynesian	Chatham Islands	783	0.64 ± 0.5	(8)
Polynesian	Chatham Islands	199	0.00	(3)
Melanesian	New Britain	1859	0.43 ± 0.2	(3)
Melanesian	Watom	24	0.00	(8)
Melanesian	Vanuatu	52	0.00	(8)

Age more than 16, sexes pooled, upper and lower teeth, after Owsley *et al.* [1985: 419], Turner [1979: 625], and Klatsky and Klatell [1943: 268]), compared to the populations in the present study. Geographically similar studies are grouped together.
Source: (1) Chappel (1927), (2) Leigh (1929), (3) Klatsky and Klatell (1943), (4) Sinclair *et al.* (1950), (5) Davies (1956), (6) Owsley *et al.* (1985), (7) Keene (1986) and (8) Evans (1987).

MATERIALS

Ten Pacific groups were chosen for study, the main criteria being that of availability. These groups were Nebira and Eriama in Papua New Guinea (Bulmer 1978); Watom off the coast of New Britain (Specht 1968; R. C. Green, pers. comm.); Namu in the Southeast Solomon Islands (B. F. Leach, pers. comm.); Vanuatu (Ward 1979); Wairau Bar (Duff 1977) and Castlepoint in New Zealand; Lakeba in Fiji (Best 1984); the Chatham Islands, and Tonga (Davidson 1969). The Tongan material has been studied by Pietrusewsky (1969) and the Wairau material by Houghton (1975); the populations of Castlepoint, Nebira and Eriama, Namu and Vanuatu are the subjects of unpublished studies by Houghton. The Tongan material was examined at the Auckland Institute and Museum, the Chathams and Wairau Bar material at the Canterbury Museum, and the remainder at the Anatomy Department, Otago Medical School.

Four hundred individuals with a total of 5351 teeth were studied. However, only the permanent dentitions (360) are discussed here. Table 2 shows the numbers of individuals and teeth in each study group.

TABLE 2
THE INCIDENCE OF CARIES ON A PER TOOTH AND PER INDIVIDUAL BASIS, AND AVERAGE NUMBER OF CARIOUS TEETH PER INDIVIDUAL FOR EACH OF THE TEN GROUPS

1	2	3	4	5	6	7	8
Nebira	34	725	44	6.07%	7	20.59%	6.3
Eriama	6	27	4	14.81%	2	33.33%	2.0
Watom	2	24	0		0		0.0
Namu	163	2084	12	0.59%	6	3.68%	2.0
Vanuatu	7	52	0		0		0.0
Wairau Bar	37	562	6	1.06%	2	5.41%	2.0
Castlepoint	7	24	0		0		0.0
Lakeba	5	22	7	31.82%	3	60.0%	2.3
Chathams	64	846	5	0.59%	5	7.81%	1.0
Tonga	75	985	86	8.73%	20	26.67%	4.3
Total	400	5351	164	3.06%	45	11.25%	3.6

KEY: 1. group; 2. total number of individuals; 3. total number of teeth; 4. number of carious teeth; 5. percentage of carious teeth; 6. number of individuals with caries; 7. percentage of individuals with caries; 8. average number of carious teeth per individual.

With the exception of the material from Eriama rockshelter and the Chatham Islands, these collections were excavated under controlled archaeological procedures, so that provenance can be ascertained. In most cases, radiocarbon estimates produced some reliable dates, which place each group in the correct position in the relevant archaeological sequence.

METHODS

Once the sample populations had been selected, suitable methods had to be devised for analysing the information they contained. Information was to be collected about various features of each tooth, as well as general information regarding the total dentition of the individual. Numerical scoring was chosen as being easy to apply and comprehend, as well as being suitable for computer analysis. The methods used in this study are based on those used by other researchers in the field of dental anthropology.

Where possible the original number assigned to an individual by the excavator or the principal examiner was retained. These were mainly burial numbers. Where no number of this sort was available, the registration number of the institution where the individual was stored was used. Where possible, the age and sex assigned by the principal examiner were adhered to. A complete list of individuals studied can be found in Evans (1987).

Powell (1985) analysed wear and caries in relation to dietary reconstruction, and also reviewed some of the methods used previously for recording such features. The method of recording the location of caries in the present study is an adaptation of Powell's, which is in turn an adaptation of Moore and Corbett's (1971) scheme. The importance of defining the location of carious lesions is that some areas are more susceptible to caries, depending on other factors of the dental or dietary condition. This is because where there is a sticky, high carbohydrate diet, the location of any carious lesions is more likely to be in the pit and fissure or smooth surface areas, as in most modern populations. This is due to the consistency of the food, the lack of cleansing effect from fibrous food and the resulting increase in salivary flow. A diet with a significant quantity of very fibrous foods should not, theoretically, be very cariogenic. A situation where there is some factor causing sufficient alveolar erosion to expose the roots might make the cementum susceptible to root caries. The location of carious lesions is as important as the fact that there are lesions, when considering the implications for dietary reconstruction.

The scheme for recording the location of caries was as follows (after Powell 1985: 327):

1) = normal, no caries;
2) = pit and fissure, located on the occlusal surfaces of the premolars and the molars, as well as in the molar buccal and lingual pits and grooves;
3) = interproximal, located at the point of contact between two adjacent teeth;
4) = cervical, located at the cemento-enamel junction;
5) = smooth surface, located on smooth buccal or lingual surfaces;
6) = root, located on the root below the cemento-enamel junction.

Koritzer's (1977: 297) classification of the degree of caries was used. This scale was adequate to cover all the variations found in the study material. It is as follows:

1) = normal, no caries;
2) = small pit or fissure lesion;
3) = moderate size pit or fissure;
4) = includes any lesion endangering the pulp;
5) = exposure of the dental pulp.

In the category of small pit or fissure lesion, a tooth was defined as carious if it had visible cavitation; no other criteria were used.

RESULTS AND INTERPRETATION

Tables 3 and 4 summarise the distribution of carious teeth on a per tooth and per individual basis respectively. No carious lesions were found in the teeth from Watom, Vanuatu and Castlepoint.

TABLE 3
THE DISTRIBUTION OF CARIOUS TEETH BY AGE ON A PER TOOTH BASIS IN THE STUDY GROUPS WITH CARIES

Group	12–17	18–25	26–39	40–50	Unknown
Nebira	0	10	34	0	0
Eriama	0	0	0	0	4
Namu	1	3	8	0	0
Wairau Bar	0	4	0	0	2
Lakeba	0	0	4	0	3
Chathams	0	0	1	0	4
Tonga	0	1	40	20	25
TOTAL	1	18	87	20	38

The data show, for example, that although there are 20 carious teeth in individuals aged 40–50, they belong to only three individuals. There is one individual with caries in the

TABLE 4
THE DISTRIBUTION OF CARIOUS TEETH BY AGE ON A PER INDIVIDUAL BASIS IN THE STUDY GROUPS WITH CARIES

Group	12–17	18–25	26–39	40–50	Unknown
Total in age group	16	104	101	27	101
Nebira	0	1	6	0	0
Eriama	0	0	0	0	2
Namu	1	2	3	0	0
Wairau Bar	0	1	0	0	1
Lakeba	0	0	2	0	1
Chathams	0	0	1	0	4
Tonga	0	1	9	3	7
TOTAL	1	5	21	3	15

12–17 age group, from Namu, but there are no carious lesions in any deciduous teeth. Approximately half of the carious teeth (53.0%) belong to individuals between the ages of 26 and 39, who make up only 24.1% of the total population (all groups pooled). The individuals between the ages of 40 and 50, who make up 7.1% of the population, have 12.2% of the total carious lesions.

The incidence of caries on a per tooth and a per individual basis was shown in Table 2. Both Eriama and Lakeba have small samples of 27 and 22 teeth and 6 and 4 adult individuals respectively, and this may affect these results. The highest number of carious teeth per individual is 6.3% at Nebira, followed by Tonga, Lakeba and Namu. The location of caries was predominantly at the cemento-enamel junction. Of the 163 carious lesions, 134 (82.2%) occurred there. Root caries was not common, there being 22 (13.5%) carious lesions in the root area in the whole sample of carious teeth.

The position of the carious lesions in the mouth was noted. Molars, which comprise 12 (37.5%) of the 32 teeth in the mouth, and 1977 of the 4973 permanent teeth in the study ($39.8\% \pm 0.98, p = 0.05$) make up 93 of the 164 carious teeth ($57.1\% \pm 5.72, p = 0.05$). It appears that the molars may be the most likely site for the presence of carious lesions. In this study, however, there were very few cases of occlusal surface caries (4 out of 164 carious lesions). Most of the carious lesions occur in the cervical area. The reason the molars are the most likely site for caries could be, in the case of the first molars, the length of time they have been erupted and exposed to the oral environment. Also, food is masticated primarily by molars, and the compacted food tends to stick near the back of the mouth, where it can settle and decay.

According to Walker and Erlandson (1986: 378)

> Due to their greater surface area and rugosity, molars and premolars are generally more susceptible to caries attack than canines or incisors.

In effect, then, the surfaces of molars and premolars have more pits and fissures, locations in which carious lesions are more likely to form, because of the entrapment of food particles. Powell (1985: 315) agrees with this view, and reiterates the fact that molars and premolars tend to show a higher rate of caries than the other teeth.

> The explanation for this difference lies in the efficiency with which the pits and fissures on the posterior occlusal surfaces trap particles of soft foods, whose decay may promote cariogenic bacterial activity. Deep narrow fissures are more caries-prone than are

> wide, shallow ones. The original configuration of these surface features is genetically determined, but is subject to continual modification from dental wear throughout the lifetime of the individual.

In Table 1, showing the incidence of caries on a per tooth and per individual basis, the populations in this study with the highest incidence of caries are in descending order Lakeba, Eriama, Tonga and Nebira.

Turner (1979) uses the incidence of crown caries to infer the prehistoric diet of Jomon people. He states that a high incidence of crown caries is consistent with a high carbohydrate intake. He then infers that Jomon people with this high incidence practised agriculture (or horticulture). This statement may need more evidence before it can be readily accepted. It may be true that the incidence of caries in agricultural people is higher than that in hunter-gatherer groups, but there are many factors which must be taken into account. Firstly, there is the environment. Within the Pacific there are differences in the crops grown in different areas, and even when the same crops are grown, cultural influence can affect which ones are the dietary staples. Horticulturalists in New Zealand could in most places only rely on the kumara, unlike the Pacific horticulturalists who also grew plants such as taro, yams, breadfruit, bananas and coconut.

However, when comparing groups which have been studied in the same manner, as here, it is reasonable to assume that the diets of groups with higher incidences of caries probably contained a higher proportion of carbohydrate, most of which could be derived from starchy tubers, the basis of much Pacific horticulture.

So one factor in the incidence of caries in relation to diet is the level of carbohydrate intake. Another factor could be the amount of protein.

> While artifacts can provide information on the types of plants collected, they yield little quantative information on the contribution of plant foods to a population's total caloric intake. Dental caries rates, in contrast, can provide an index of the ratio of protein to carbohydrates in the diet. (Walker and Erlandson 1986: 376)

A diet, then, which is rich in carbohydrates rather than protein, could be considered more cariogenic than a diet which is rich in protein. This is particularly applicable to the Pacific area, where many populations depend on the sea for much of their food.

Turner (1979: 622) states, on the basis of a study of caries incidence, "... that caries seldom exceed a 1–2% rate without the addition of agriculture or agricultural products". The Pacific examples (in Table 1, after Turner 1979) are characterised as having 'mixed economies', these being economies combining the activities of horticulture, hunting, gathering and fishing. Turner gives an average rate of caries on a per tooth basis in these mixed economies as 4.37%. Hunters and gatherers have a rate of 1.72% and agriculturalists have a rate of 8.56%. The lowest values in Table 1 are from the populations of Watom, Vanuatu, and Castlepoint (all 0.0%), then Namu (0.57%), Chathams (0.64%) and Wairau Bar (1.06%). These are all lower than the value given for hunter-gatherers (1.72%). However, the group called 'Pacific Islands' by Turner pooled samples from Tahiti, Hawaii, Easter Island, New Zealand, and the Chatham Islands to give an average value of 1.7% carious teeth. The samples from the Solomon Islands, New Britain and Papua New Guinea were grouped together under 'New Britain', and gave an average value of 0.44% carious teeth. In Table 1 the original data from Klatsky and Klatell (1943) are given, as the usefulness of grouping together such widely diverse groups as Hawaii and the Chatham Islands under a 'Pacific Island' heading, as Turner did, is questionable. Therefore, the original articles and data were used, in order to obtain a more accurate picture.

The samples from Easter Island reported by Owsley *et al.* (1985: 416) are dated to the proto-historic period (A.D. 1600 to 1800) on the basis of radiocarbon dates and obsidian hydration dates. Klatsky and Klatell give no date for their Easter Island material, so it is not known whether it is contemporary with the material studied by Owsley *et al.* (1985). Turner classified Easter Island as having an agricultural economy. Keene's data from the island of Oahu are prehistoric, although no firm date is given.

Dental caries is caused by bacterial plaque, which rapidly ferments sucrose, glucose and fructose, causing a drop in the pH of the plaque to "... a level at which microscopic demineralisation of enamel can occur; a pH of 5.5 is usually considered as the critical threshold for demineralisation" (Mandel 1979: 683). Continued periods of demineralisation can eventually lead to opaque brown or white spots beneath the plaque layer, and these in turn lead to carious lesions (Mandel 1979: 683). Essentially, the cariogenic organisms present in bacterial plaque produce an acid environment, which then leads to demineralisation of the enamel at the tooth's surface.

The change from a carbohydrate-rich diet to a diet rich in marine fauna has an effect on the incidence of caries because of some of the properties of a high-protein diet. This type of diet can deny cariogenic bacteria the carbohydrates they need to survive. Also, a high protein content in the diet can reduce the acidity of the saliva, which then neutralises the decalcifying acids which cariogenic bacteria produce. Lastly, marine resources, especially fish-bone, are rich in fluoride. Although the role of fluoride in caries prevention is still somewhat controversial, especially in relation to its addition to drinking water, there appears to be sufficient evidence to suggest that the presence of fluoride can reduce the incidence of carious lesions. Therefore a diet rich in marine foods might influence the caries incidence.

Owsley *et al.* (1985) obtained a caries incidence of 27.1% for late prehistoric Easter Islanders, which is very high. Their diet appears to have been dependent upon cultivated foods. The authors cite the limited fresh water on Easter Island as a possible reason for this high rate of caries. They suggest that the people used sugar cane to relieve their thirst, especially when travelling around the island. There is ethnographic evidence in support of this (Metraux 1940). Owsley *et al.* (1985) use this consumption of sugar cane to account for the high incidence of caries. They state of this high incidence of caries, when compared to European populations, "... no other groups had rates higher than those with sources of natural sugar in their diets" (p. 420).

It might be a case not so much of sugar consumption, which occurs in many Pacific islands, but of lack of marine food consumption with its prophylactic effects that leads to the high caries incidence on Easter Island in the presence of sugar cane.

> Lying just outside the tropics, and swept by cold water currents from the Antarctic region, the island has no fringing reef (although some limited coral growth is present), and most of the coastline consists of sea cliffs. Consequently, fishing cannot provide the same range and quantity of protein as on other Polynesian islands. (Kirch 1984: 265)

So in the case of the dentition of the people of Easter Island, the relatively high rate of caries may have been caused, not by what they were eating (sugar cane), but by what they may not have been eating (marine foods). In the interpretation of dietary factors from the study of dental conditions, both presence and absence of certain foods can affect the state of the teeth, so careful consideration must be given not only to which foods the people were eating, but also to those which were not part of the regular diet.

The results of this study show varying rates in the incidence of caries in some Oceanic groups. Some of the results could be explained as anomalous because of the very small sample size (for example Eriama, Watom, Vanuatu, Castlepoint and Lakeba). The variations in past results of the incidence of caries may be explainable by small sample sizes, sampling error, or variation in examination technique, but only further studies in this same area will help to clarify the true situation.

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