



NEW ZEALAND JOURNAL OF ARCHAEOLOGY



This document is made available by The New Zealand Archaeological Association under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

To view a copy of this license, visit
<http://creativecommons.org/licenses/by-nc-sa/4.0/>.

An Estimation of Fertility in Prehistoric New Zealanders.

M.A.L. Phillipps.

Canterbury Museum, Christchurch.

ABSTRACT

The limited contribution of physical anthropology to the discipline of archaeology in New Zealand prompted a study of fifty-nine female pelvic bones obtained from prehistoric sites throughout the country and including the Chatham Islands. Estimations of age by symphyseal changes and pregnancy/birth numbers by bony alterations to the pelvis were undertaken. On analysis, they suggested not only a relatively small family size but also a long span of time between births. A theory of fertility for New Zealand's prehistoric people is presented to explain these trends. It consists of three hypotheses based on current medical and anthropological knowledge of the age of onset of menarche, adolescent infertility and lactational amenorrhoea.

Keywords NEW ZEALAND, PREHISTORIC, PREGNANCY/BIRTH ESTIMATIONS, FAMILY SIZE, BIRTH INTERVAL.

INTRODUCTION

The contribution of physical anthropology to the discipline of archaeology in New Zealand has been limited. Sutton (1976, 1977) attributed the lack of attention to human skeletal evidence to the small and seemingly unapproachable samples typical of New Zealand sites, and the work on material recovered from the Washpool site, Eastern Palliser Bay (Sutton 1976), represents the first major attempt to come to terms with this.

The problem now appears twofold. While on the one hand there has been a restricted application by archaeologists of information gleaned from skeletal remains, on the other there is still a large amount of primary data to be collected and analyses to be made. A number of recent publications by Houghton (1975a, 1976, 1977a, 1977b) illustrate the important and extensive data relating to diet, health and longevity that can be obtained from analyses of prehistoric human burials. Sutton (1976) concentrated on the biological and social conditions of life for a group of people living at a known period, thus demonstrating the possibility of a more anthropological approach to the study of skeletal material.

In view of the immediate difficulties with obtaining further samples for regional work, it is suggested that a return to existing collections is warranted to determine what other contributions they might make. The study of pelvic morphology is a relatively new aspect of physical anthropology in New Zealand, although its importance in sexing and aging skeletal remains has been discussed (Houghton 1976, 1977a, 1977b). Baker has studied the male pelvis from an anatomical view point (Baker 1975). Preliminary attempts have also been made to estimate the number of births from an examination of alterations to the female pelvis (Sutton 1976), and the validity of the technique investigated (Houghton 1974, 1975b).

The information already published has been utilised mostly in a descriptive and regional manner, whereas it is capable of contributing to a picture of fecundity and fertility of the Polynesian population living in New Zealand prior to European settlement. When compared to what is known of populations in the nineteenth and twentieth century the results may be relevant to problems of demography, now an important branch of anthropology in its own right.

A step in this direction was made by Sutton (1976) when he estimated the fecundity

or "yield per adult woman of surviving children" for the Washpool specimens. The kind of study attempted in this paper is anticipated in Sutton's work, which includes an examination and explanation of the evidence of fertility and parity left on the margins of the pubic symphysis and on the grooves of the sacro-iliac ligaments, on the basis of what was then known of the process (Angel 1969, Stewart 1970, Houghton 1974). As described below this has since been further refined and new information disclosed. Therefore, categories given for this sample which correlate markings and the number of children borne have been modified.

The first record of the fact that macro-anatomical alterations may occur at the pelvic bone as a consequence of pregnancy and childbirth appeared in 1931 (Putschar 1931), but this failed to attract any immediate attention in osteological research. Stewart (1957) connected the irregularity of the dorsal edge of the symphyseal surface in females with the formation of pits during childbirth, though the concern was more with their effect on age determination by symphyseal changes. Research did not become directed towards fecundity estimates and palaeodemography for at least another decade, when Angel (1969) produced a two-stage sequence of development for pitting on the anterior surface of the pubic symphysis. This sequence consisted of, (a) the appearance of spiral fossae below the pubic tubercle after one to two births, (b) a series of small fossae next to the lip exostoses which may coalesce into a deep groove at the back edge of the symphyseal face. This occurs only after a "sufficient number of births", here given as four to eight.

Angel's suggestions were tentative, as documentation on parity was restricted to the study of a small number of Eskimo pelvises and an examination of only four female pubic bones from United States autopsies. Therefore, a further 35 Eskimo pelvises were examined by Stewart (1970), who categorized the changes at the pubic symphysis as: (i) "trace-to-small", or a variety of shallow depressions, usually not sharply limited and sometimes taking the form of a groove closely parallel to the articular margin, (ii) "medium-to-large" or very definite scarring ranging from more or less distinct depressions to unmistakable cavities. Only the latter were seen to clearly indicate parturition. As mentioned earlier this scheme was utilized by Sutton (1976).

Nemeskeri (1972) noted a number of differences between the Putschar (1931) and Stewart (1970) publications in their association of numbers of pregnancies/births with their respective stages and devised instead a five stage scheme. This formed the basis of further fertility studies (Ullrich 1975) although it is now recognized that alterations can be diagnosed better at the facies posterior of the pubis than the facies anterior.

The physiological and pathological changes which occur during pregnancy and childbirth have been found to produce markings not only at the pubic symphysis but also on the iliac bone (Houghton 1974, Ullrich 1975). Houghton (1974) identified markings which occur in the form of a groove and resemble those on the posterior aspect of the pubic symphysis. Although the groove is seen in both males and females, being the site of ligament attachment, it takes on a different form in the female, with more extensive pitting. These alterations were apparently known by the forensic pathologist Sir Sydney Smith, as they are illustrated in his autobiography, yet in his book of forensic medicine (Smith 1959) no mention is made of the features.

A detailed investigation into fertility by means of a study of pregnancy/childbirth alterations to the pelvis was provided by Ullrich (1975). An examination of 63 pubes, 70 ilia and 49 sacra enabled stage sequences for each area to be constructed. These provided, except for those at the sacrum, the basis of the present study. Clearly the different degrees of formation, classified in fertility stages of I – IV, correspond to an increasing number of childbirths. Although the allocation of a certain number of childbirths to each stage must be considered to be largely hypothetical, alterations can be diagnosed with near-certainty and this is important for palaeodemographical studies.

Ullrich (1975) presented an analysis of the women represented in the skeletal material from the late Slavonic cemetery of Sanzkow, showing that pregnancy/childbirth markings were already evident at the age of seventeen to eighteen years. The average age at death (31 years) and the latest beginning of reproductive age (16 years) were correlated to give the average reproductive period (15 years) and the average birth interval (four to five years). Ullrich was also able to calculate the proportion of childless women (2-6%). His low figure contrasts markedly to that of 29% given by Houghton (1974). However, Houghton's estimate was not drawn from a representative population but merely from a medical school series, making a comparison invalid.

A review of the study of pregnancy/birth alterations is given by Houghton (1975b). He describes the evidence as, (a) smooth-walled pits or craters on the posterior surface of the pubic bone, and (b) a modification of the preauricular groove of the ilium. The following points were considered when assessing the fertility of a prehistoric population from skeletal evidence alone. Pits became shallower after pregnancy due to the replacement of bone, though they may still be evident fifty years later, and this renders the estimate more difficult. Arthritis at the symphysis may obscure pitting, and ankylosis at the sacro-iliac joint obliterates evidence at an early stage. These processes are, however, recognisable. Differences between studies of modern western populations represented by forensic evidence and prehistoric populations represented by archaeological evidence are also discussed. The former tend to reveal less conspicuous pitting at the posterior pubic symphysis at least, probably due to better obstetrical care and less physical activity.

A recent study by Holt (1978) must also be mentioned. Holt found from the medical records of 68 female pelvises that 1.5% of females who had not given birth exhibited "trace-to-small" markings at the pubic symphysis and 23.4% exhibited "medium-to-large" markings. He concluded that bony changes could not be assigned solely to parturition. However, Holt used a series collected by Todd in the early 1920s. The obstetrical records of these individuals were determined from autopsy examinations as well as information given by the patients themselves. Both procedures are unreliable. In addition, a substantial number of women, who had not borne children yet showed a marked "imprint of pregnancy", suffered from an advanced pathology of the pelvis or the lower limb.

Recently, Dunlap (1978) has published results from a continuing study of pelvis from recent autopsy specimens of known obstetrical history. To date, 40 female and 19 male pelvis have been examined. He confirms the distinctiveness of the female pregnancy sulcus: "No male ilia in the sample exhibit anything remotely similar to the female pregnancy sulcus". His data, however, do not yet show a correlation between number of pregnancies and extent of sulcus erosion. This study of Dunlap's must be considered, in statistical terms, the most authoritative to date.

Finally, certain unpublished data from Basset (Houghton: pers.comm.) gives a histological basis for the changes which are clearly related to pregnancy and childbirth. Unfortunately this data was not available for further discussion.

MATERIALS AND METHODS

In order to investigate the fertility of Polynesians living in New Zealand prior to European settlement, an examination of the pelvic bones of 59 female individuals at present stored in the four main museums and the Otago Medical School, Dunedin, was undertaken. These bones were obtained either from excavations or from surface finds made throughout the country and including the Chatham Islands.

As outlined above, previous studies have suggested that it is possible to allocate specific numbers of births/pregnancies to females by examining the appearance of pits on the posterior pubic symphysis and grooves on the sacro-iliac joints, thereby

assessing their stage of development. This stage or phase is then equated with the number of children borne, the assumption being that the increasing extent of pitting corresponds to an increasing number of births/pregnancies. The positions of the features on the pelvis considered in this study are illustrated in Figure 1. Although alterations are also evident at the sacrum here the signs are less constant and less reliable (Houghton 1976). Furthermore the sacrum was usually either very fragmented or absent from skeletal remains, making analysis impossible. These have been excluded therefore.

Estimations of births/pregnancies were made independently at the two areas of the pelvis selected for study, firstly at the posterior pubic symphysis, which has been found to be more reliable for diagnosis than the anterior pubic symphysis (Ullrich 1975), and then at the ilium, noting the extent and depth of the preauricular groove (Houghton 1974, 1975b; Ullrich 1975). As Houghton has indicated, the male form of the preauricular groove is similar to nullipara and quite different from that of the female who has had children. The criteria or standards for estimates of the number of children borne are shown in Figures 2 and 3.

The aging of the specimens was the second step in the analysis and comprised an examination of growth changes in the symphyseal face of the female os pubis, following the method of Gilbert and McKern (1973). This method specifically attempts to account for any alteration caused by childbirth and should be independent of any such changes. In addition, wherever possible, age was estimated by other means, such as epiphyseal fusion or tooth wear.

The photographs (Figs. 5-11) illustrate the progressive stages of development in pitting at the posterior pubic symphysis and the preauricular groove of the ilium as seen in prehistoric New Zealand women. Particularly important was the identification of extreme alterations representing the upper stages in the process. Doubts have been expressed as to the ability to recognize "Stage IV" or the pitting evident from as many as six to eight births/pregnancies. An example of this evidence is therefore included.

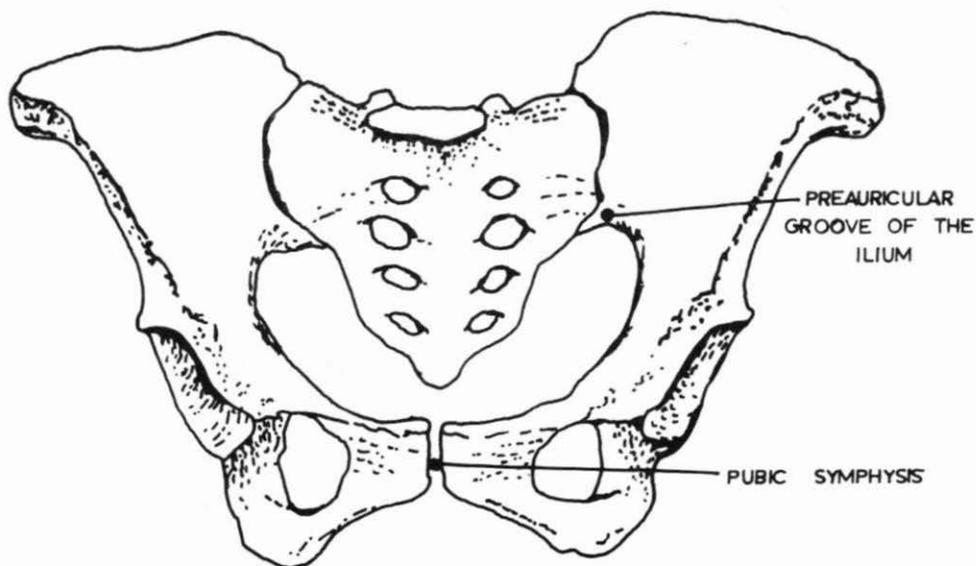


Figure 1: Female pelvis viewed from front.

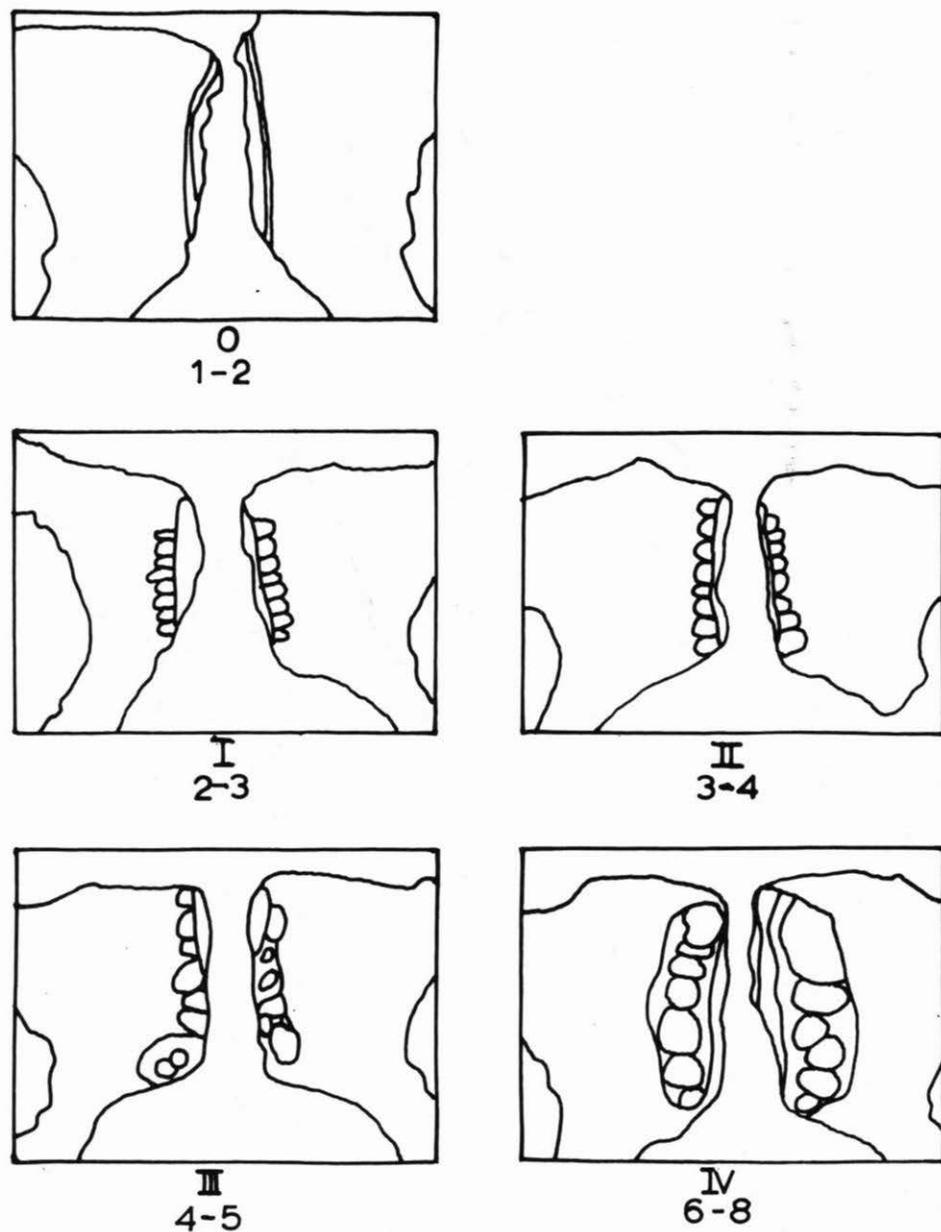
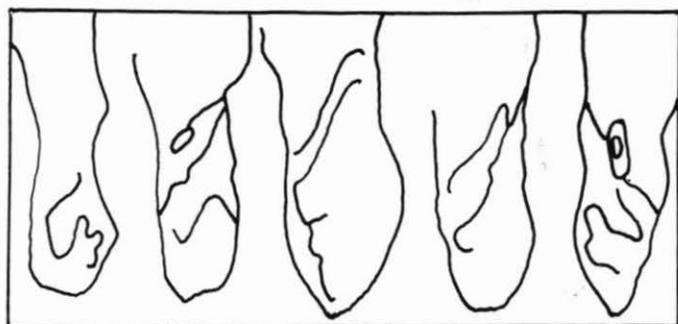


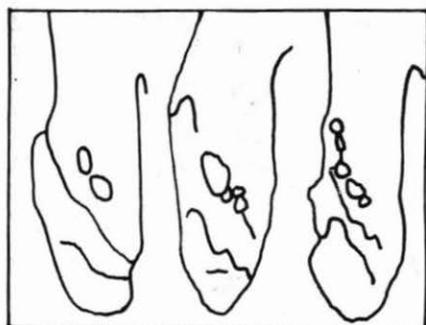
Figure 2: Scheme for diagnosing the fertility stages at the facies posterior of the pubis.

RESULTS

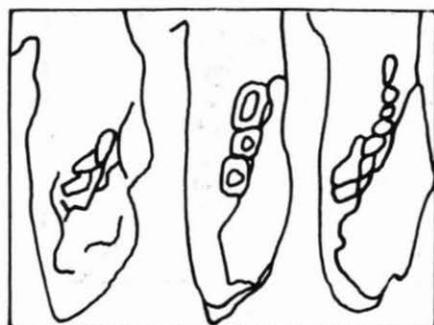
The results are presented below in Table 1 and Figure 4. The estimations of pregnancies/births are generally slightly higher at the preauricular groove of the ilium, which is in agreement with recent work (Houghton 1974). Figure 4 shows clearly two important points concerning the fertility of prehistoric New Zealand women. The first



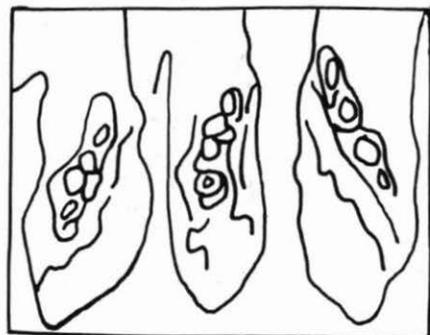
0 Males and Nullipara



I
1-2



II
2-3



III
4-5



IV
6-8

Figure 3: Scheme for diagnosing the fertility stages at the ilium.

TABLE 1
SUMMARY

Specification	Age from symphysis with supportive evidence in parenthesis	Number of pregnancies/births.	
		Posterior pubic symphysis	Preauricular groove of ilium
PAn284	20 (epiphyses)	0	0
PAn221	21	0	1
22367	21 (epiphyses)	0-1	2
24273	26	1	1
E74	26	1-2	2
E88	26	2	3
PAn302	27 (toothwear)	0	1
45505	32	2	2
E27	32	2-3	3-4
E45	33 (toothwear)	1	1
E24	34	3	4-5
E125	35 (toothwear)	3	3-4
E42	36	1	1
E87	36	1	2
unknown (c)	36	1-2	2-3
D40	36	4-5	4
D24	36	5	4-5
D16	39	3	2-3
PAn166	39 (toothwear)	3	3
E28	39	4	4
38764	39	4-5	4-5
D23	43	2-3	3-4
PAn35	43	3-4	3-4
16273	43	4	4-5
Woodend	47	3	0
PAn31	47	3	3
D7	47	4	3-4
E48	47	4-5	3
13708	47	4	4
unknown (a)	47	3	4-5
D14	47	5	4
SK387	47+	5	5
D34	50	3-4	4

is an increase in the number of births/pregnancies from one to five until about the age of 35 years. This represents an expected trend towards increasing family size. The second important feature is that after the age of 35 years a 'plateau' is apparent. Related to this is the fact that many specimens over the age of 35 years exhibited repair to the bone in the area of pitting, especially at the posterior pubic symphysis. The maximum number of pregnancies/births was only five and the average number borne was about three.

DISCUSSION

These figures are remarkably low, as it was theoretically possible for the women to have had many more pregnancies during this span of time. The physiological factors of age at onset of menarche, adolescent infertility, lactation and the birth interval will now be discussed in relation to these results. The theory of fertility for prehistoric New Zealanders maintained in this paper rests on a number of hypotheses derived from current medical and anthropological knowledge of these factors.

The mean age at menarche, or the onset of puberty, has been extensively studied and shown to vary from one population to another as well as between different groups

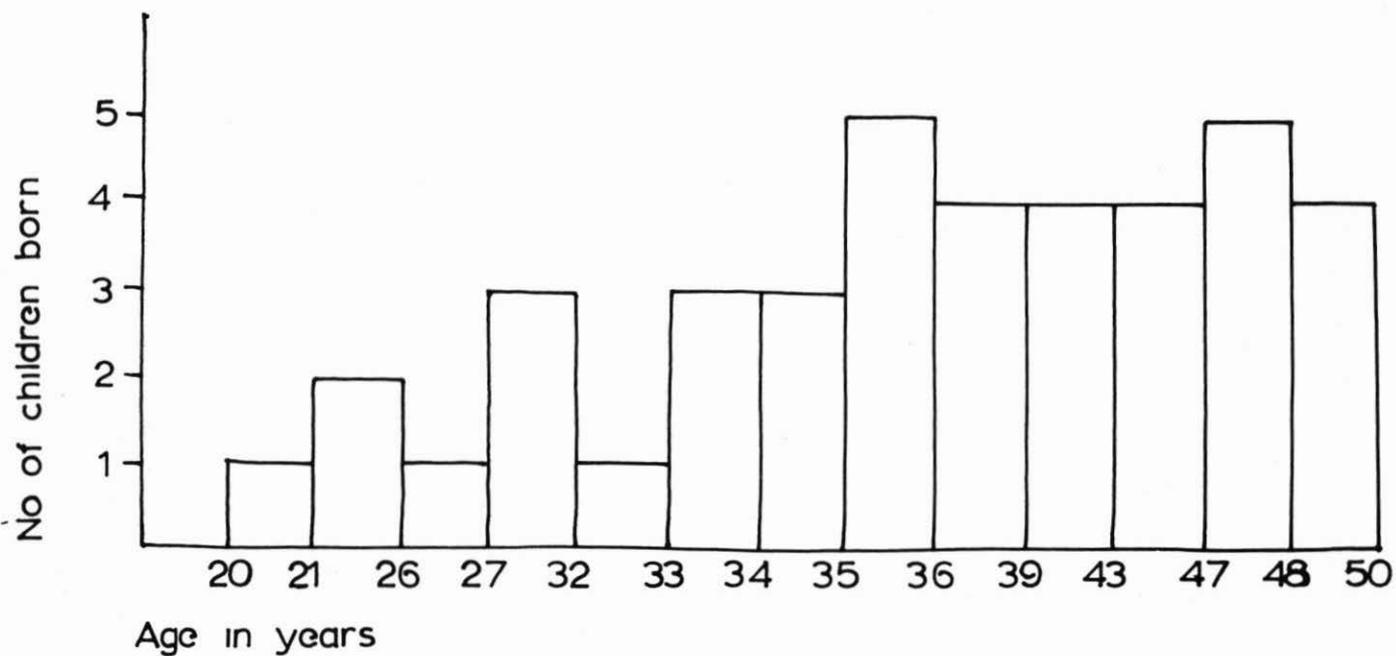


Figure 4: Histogram showing the estimated birth numbers increasing from 1-5 between ages 20-50 in prehistoric New Zealanders.

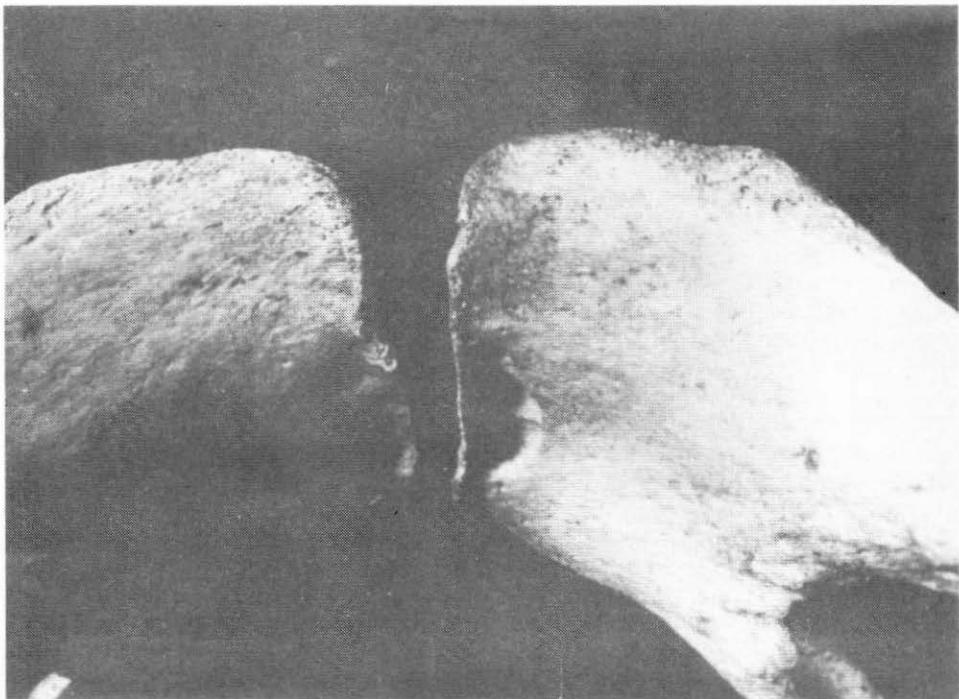
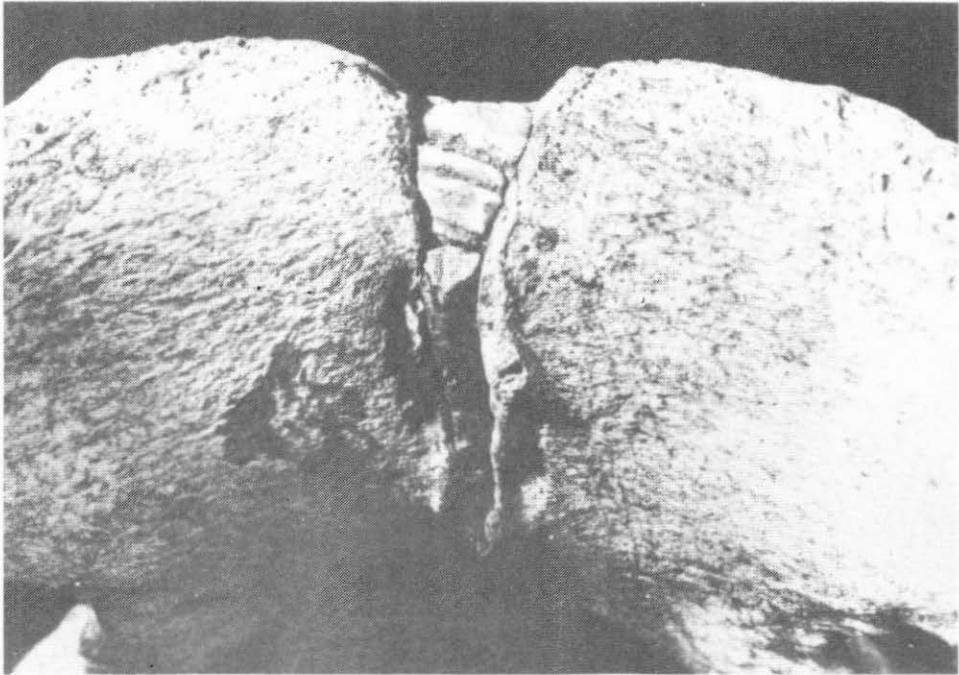


Figure 5: Bony alterations at the posterior pubic symphysis, stage two (upper) and stage three (lower).

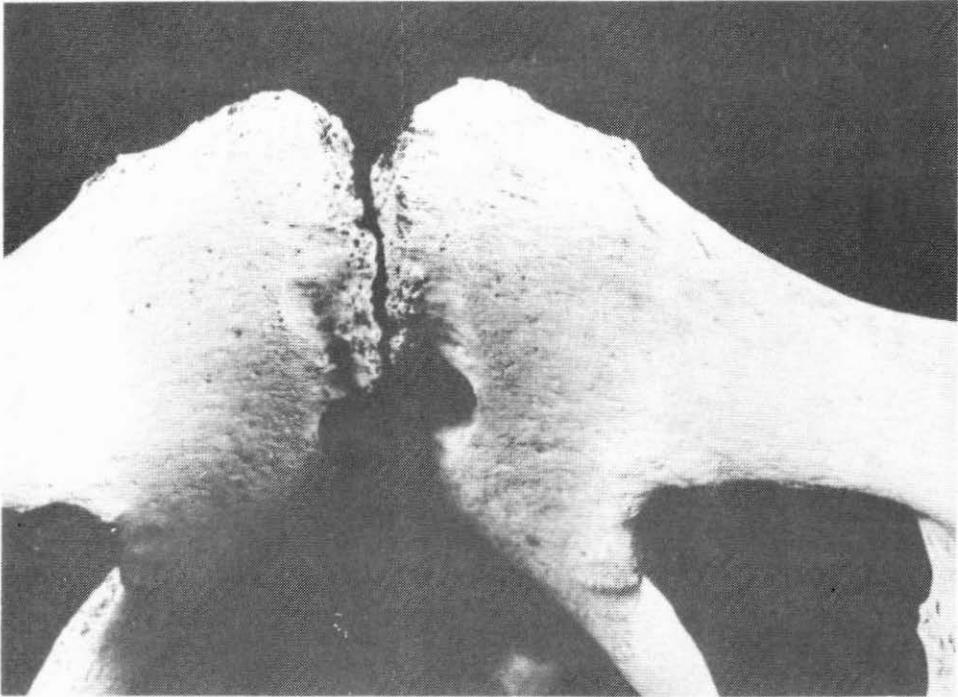


Figure 6: Bony alterations at the posterior pubic symphysis, stage four.

within the same geographic area (Magnusson 1978). There has been little progress, however, in clarifying the exact physiological mechanisms that trigger the onset of puberty (May 1978). The hypothesis that menarche occurs at a critical mean body weight has been criticised on the basis of marked individual differences in the weight at menarche (Magnusson 1978). Nonetheless it is likely that nutrition is a relevant factor, especially in view of the change in age at first menstruation through time on a world scale. There has been a spectacular decline in the age at first menstruation in the western world over the past century which has reached a limit at a mean age in developed countries of 12.4 to 13.5 years (May 1978). Magnusson (1978) suggests that the low figures are the effect of better general living conditions and smaller family size.

The first hypothesis is based on these findings. The nutritional situation in prehistory according to present evidence is such that diet was generally adequate (Houghton 1978), although periods of malnutrition were not uncommon (Houghton 1977a). Therefore one would neither expect the age at menarche to be as low as the figures for a modern society nor higher than about sixteen years of age. There is some evidence that prehistoric Polynesian women living in New Zealand were bearing children at about eighteen to nineteen years of age. This comes from one individual which was not included in the final analysis because only one hip bone remains.

A discrepancy between suggested age at onset of menarche and age of first conception of about three years is apparent. A second hypothesis is proposed which accounts

for this by a period of "adolescent infertility" (Short 1975, May 1978), given the absence of contraception. Social anthropological studies of 'primitive' societies have led to the suggestion that ovulation does not typically commence until a few years after the onset of menstruation. Kolata (1974) found that for the !Kung hunters and gatherers of the Kalahari Desert, menarche and marriage occur at 15½ years of age but women do not bear the first child until about 19½ years. This study cannot be entirely relied upon because of the limitations of anthropological research on modern hunting and

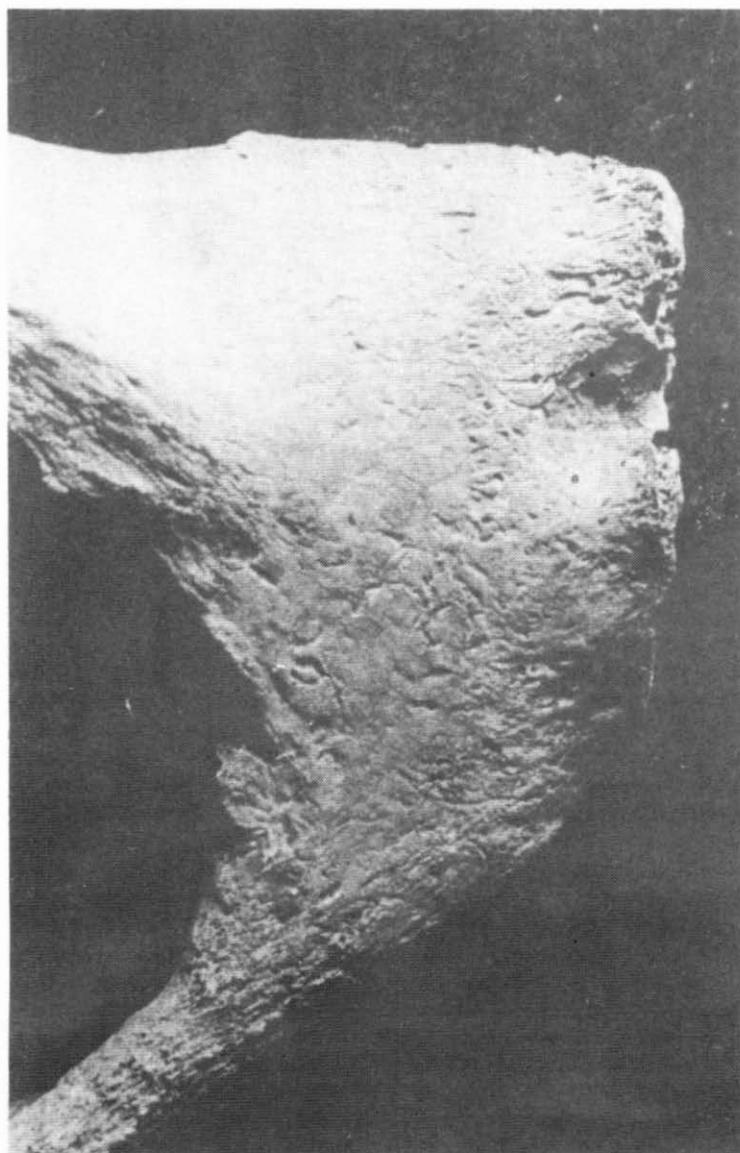


Figure 7: Bony alterations at the posterior pubic symphysis showing repair work to the bone.

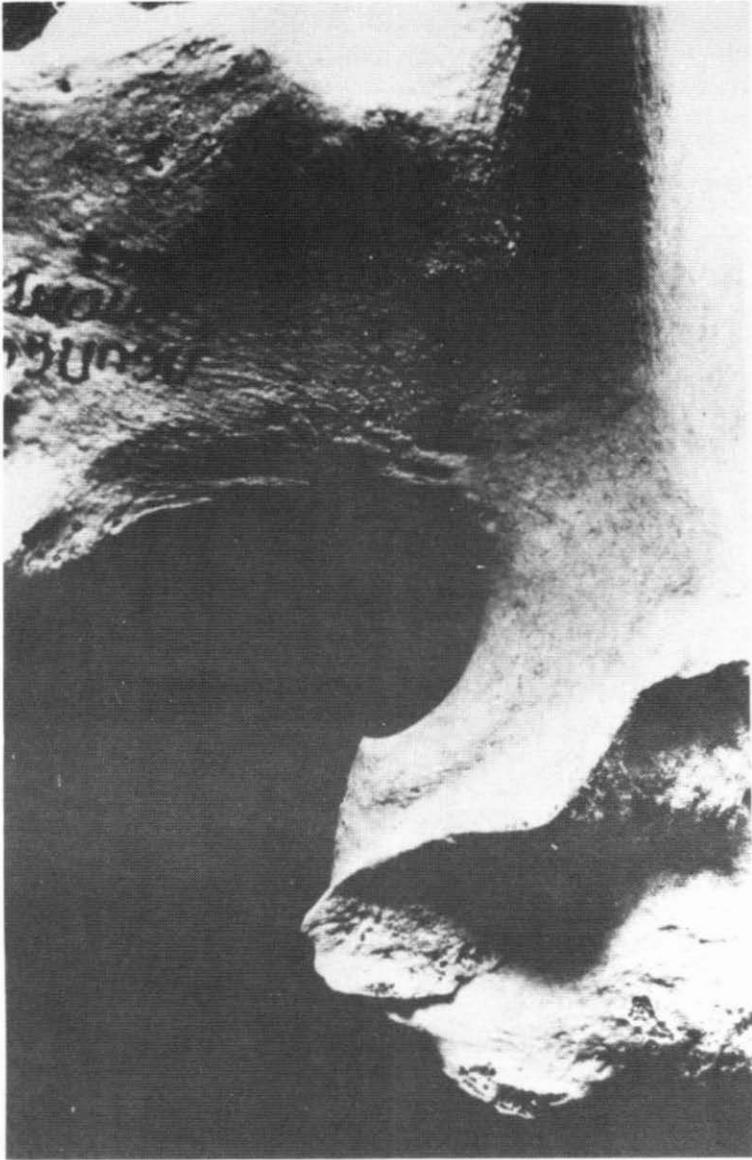


Figure 8: Male form of the preauricular groove of the ilium.

gathering groups but the suggestion is supported by current medical research (Doring 1969; Reiter, Kulin and Hamwood 1974; Short 1975). "Anovulatory" cycles are well recognized in modern medicine.

The age of onset of menstruation (16) and the age at first conception (18-19) having been thus proposed, it is now possible to estimate the birth interval given the average age at death and the average number of births. These figures, 37 and three to four

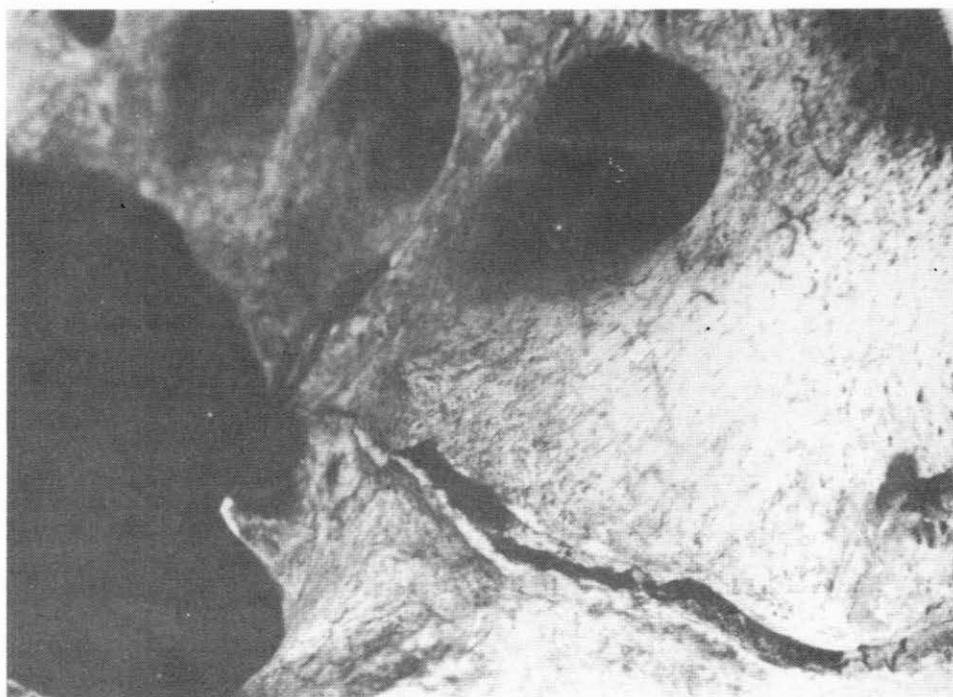
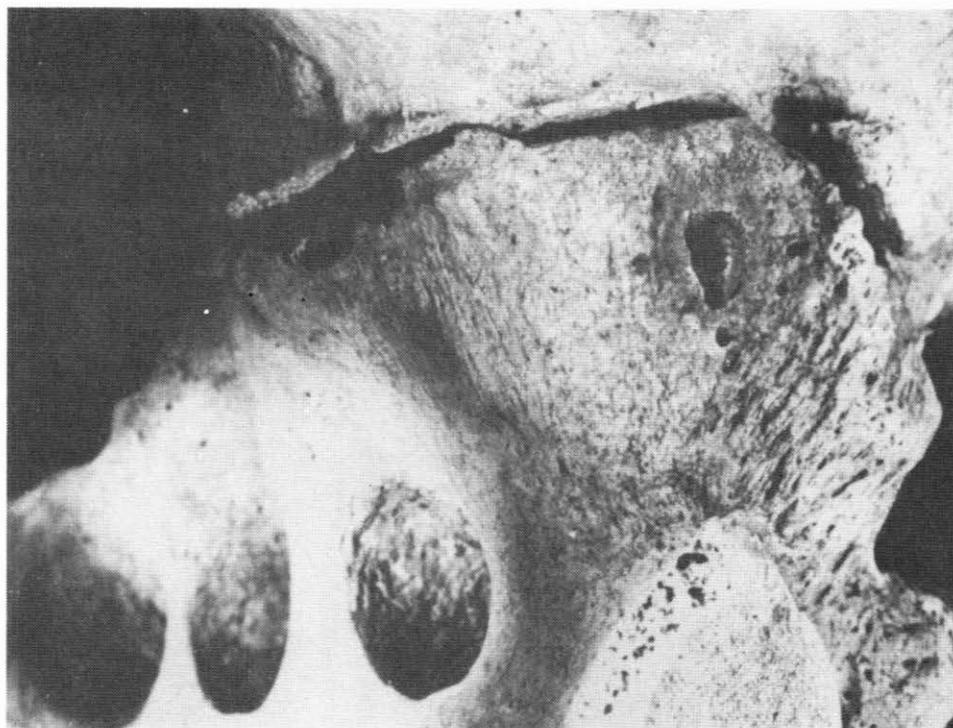


Figure 9: Bony alterations at the preauricular groove of the ilium, stage one. Right (upper) and left (lower) views.

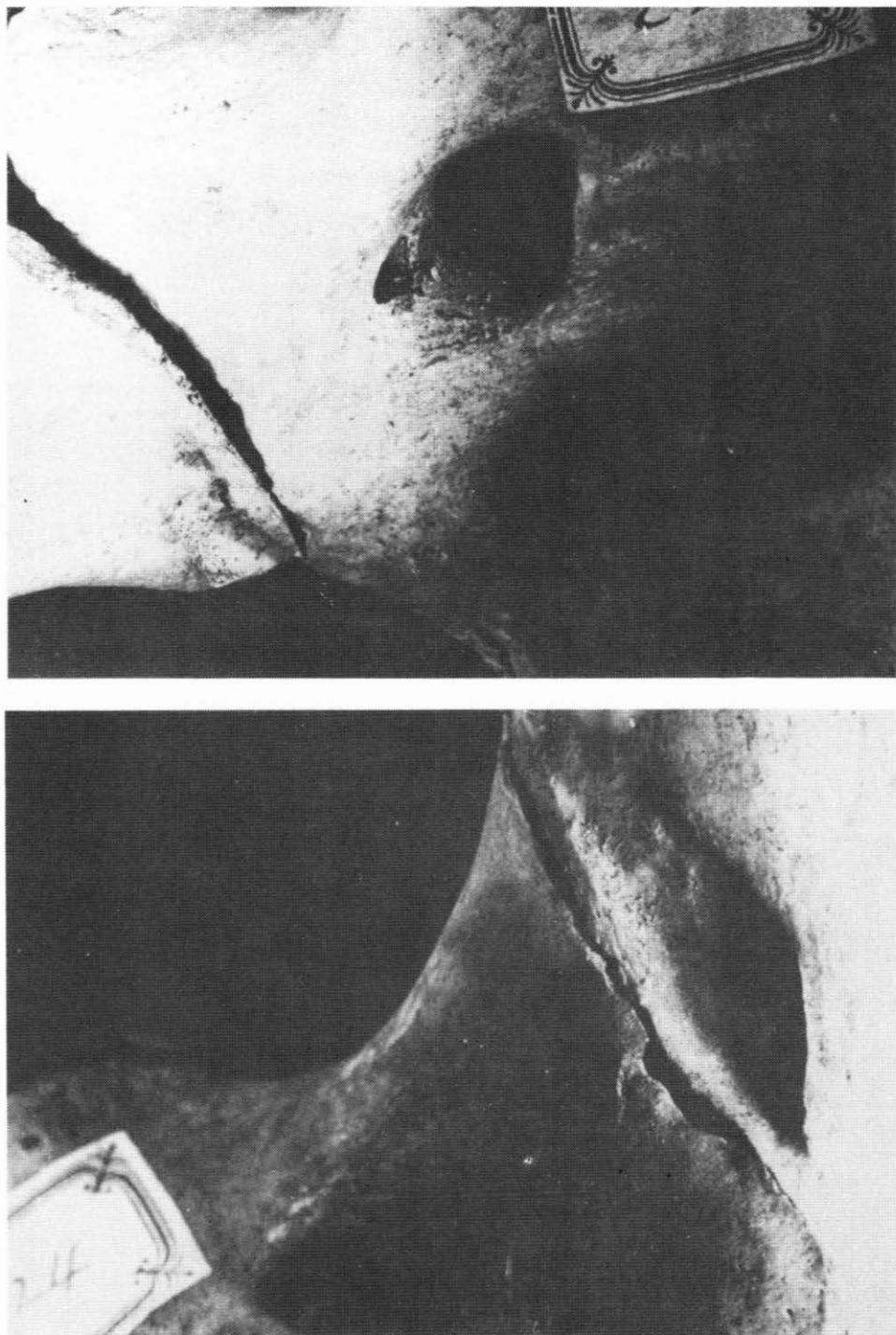


Figure 10: Bony alterations at the preauricular groove of the ilium, stage two. Right (upper) and left (lower) views.

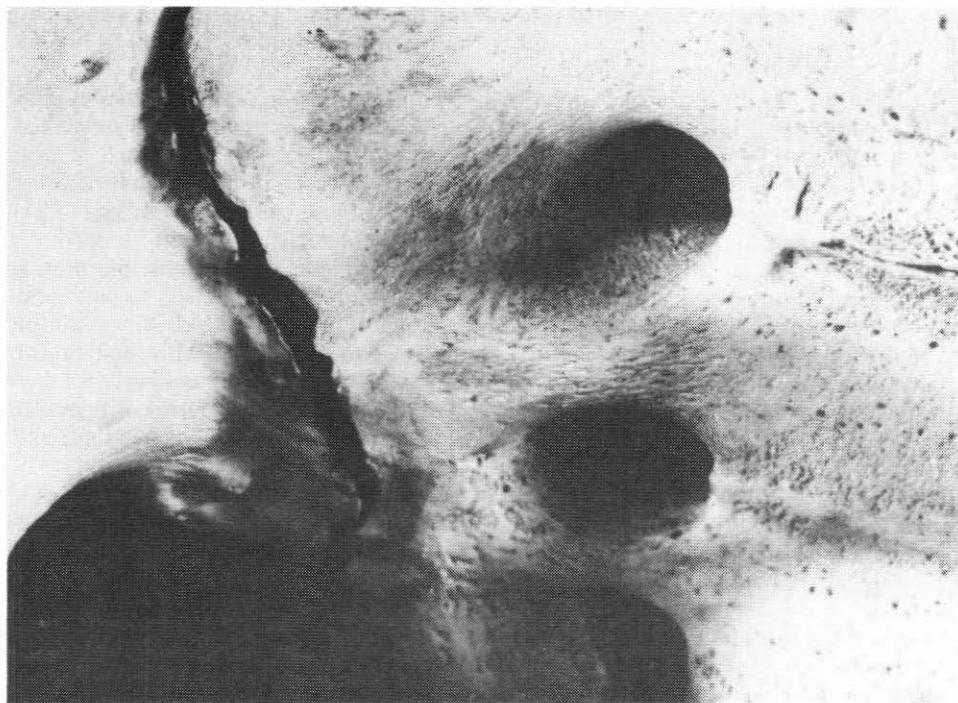


Figure 11: Bony alterations at the preauricular groove of the ilium, stage four. Right (upper) and left (lower) views.

respectively, suggest that the birth interval would be about three to four years. The average age at death given here is higher than that suggested by Houghton (1975a, 1978). Further evidence may bear on this.

To explain the birth interval and the low number of pregnancies/births evident in the histogram, a third hypothesis concerning lactational amenorrhoea is suggested. The suppression of ovulation and menstruation while the mother is breast feeding is not reliable as a means of contraception in modern society but there have been studies which suggest that it operated more successfully in prehistory (Kolata 1974). Evidence on diet and health for prehistoric New Zealand women will be pertinent to the question of lactational amenorrhoea but not conclusive. It is possible that, as with other hunting and gathering societies, where there was no access to soft foods as a supplement to breast feeding and food was not as abundant or as readily available as today, the young were breast fed for about three to four years. Although Maoris were also partly horticultural (Leach 1976) soft kumara was only available for part of the year when it was used in feasting. For the rest of the time fernroot provided the mainstay of the diet (Shawcross 1967), and this would not have been suitable as a supplementary food for children.

It is also possible that during the time of breast feeding lactation suppressed ovulation due to a mixture of nutritional and hormonal factors (May 1978). These ideas correspond very closely to those given by Short (1975) who believes that for the world as a whole more births are prevented by lactation than all other forms of contraception put together. While the suppressive effect of lactation is cited in this paper, it would not have been completely effective. Individual exceptions would have been as relevant in prehistory as they are today and in order to gain a more realistic picture of the reasons for long birth intervals socio-cultural factors must also be considered. There can be no single explanatory mechanism for the interpretation of fertility levels, the case in New Zealand prehistory being no exception.

Cross-cultural studies of factors affecting human fertility have sought to explain the low fertility levels generally seen in primitive societies (Lee and deVore 1968, Nag 1962), invoking postpartum abstinence, sterility and venereal diseases as significant factors. Dumond (1975) stated that it is possible social factors are more important in the control of population. The total population of modern hunting and gathering societies is well within the limits of available reserves, yet there is a margin of fecundity above the level of surviving births which is controlled by conscious and personally applied mechanisms adopted to effect birth spacing.

While there is no conclusive evidence to confirm Dumond's opinion, Devereux (1955) considers that abortion is a universal phenomenon and Hunton (1977) showed from his research that abortion and infanticide were relatively common among Maoris in pre- and early European New Zealand. Gluckman (1976) mentions that though many people doubt that the Maori practiced infanticide, historical evidence points to the contrary, and the naturalist-physician Hooker in 1869 noted that abortions were not uncommon among Maoris.

In summary, it is proposed that, (a) the average number of children borne by prehistoric New Zealand women was only three, (b) since the age at first conception was approximately 19 years and the average age at death was 37 years, the birth interval is thus estimated to be about three to four years, and (c) this relatively long span of time between births and the small family size inferred can be related to a combination of nutritional, hormonal, and socio-cultural factors, although the way in which these factors affect fertility and reproductive levels is still incompletely understood.

There are a number of variables which may influence the extent of bony changes of the pelvis caused by pregnancies/births. Diseases cited by Holt (1978) such as chronic inflammatory pelvic conditions, femoral hernia and oedema of the legs, would not have been common in prehistoric New Zealanders. Joint diseases, however, did

occur (Houghton 1975a). Arthritis obscures pitting and its effect must be considered when estimating fertility by pregnancy and childbirth changes alone. The size of the infant, the size of the pelvis, labour difficulties connected with the musculatory power of the uterus and arthritic changes are some of the variables for which statistical validity could not be achieved in this study. Sutton (1976) suggested that pelvic size would be a measurable variable in the estimation of pregnancy and childbirth alterations. A small number of pelvises of the present study were measured across the inlet, and while the numbers were statistically insignificant they did not support the idea that the degree of marking is closely related to pelvic size.

SUMMARY AND CONCLUSIONS

The significance of the results is twofold. Firstly they lend support to the idea that the bony imprints visible at the posterior pubic symphysis and the preauricular groove of the ilium are a consequence of pregnancy and childbirth alterations. This was anticipated by Houghton (1974, 1975b) and supported by Dunlap's (1978) study. Secondly they enable a theory of fertility to be constructed on the basis of an estimation of the actual numbers of children borne. When taken together with a number of hypotheses concerning age at onset of menarche, adolescent infertility and lactational amenorrhoea, an anthropological approach to the problem of fertility in New Zealand's prehistoric population is possible.

There is a contrast between the fertility of pre- and post-European Maori women. It was as common for the Maori in historic times as it was for the European to have large families, often of ten or more children. Indeed this high birth rate continued for the Maori to the present day, unlike the rest of the population (Metge 1976). The results of this study clearly show that the high fertility in post-European Maori women cannot be projected back into prehistory.

This paper looks toward narrowing the gap now existing between the skeletal remains of our prehistoric people and their possible contribution to the disciplines of archaeology and anthropology. It is hoped that this study may give further indication of the value of human skeletal material to the anthropologist. An examination and assessment of pelvic bones alone provides a remarkable amount of information regarding health and fertility in prehistory.

ACKNOWLEDGEMENTS

My thanks extend especially to Dr Philip Houghton for his assistance with this paper. I am grateful for the continued advice and encouragement of Dr Houghton and Dr Helen Leach, supervisors of the thesis written for the completion of the degree of Bachelor of Arts with Honours on which this paper is based. Financial assistance from the Royal Society of New Zealand is gratefully acknowledged. Thanks are also due to Martin Fisher and Cyril Schollum for photographs and diagrams, to John Dennison of the Otago Medical School and those members of the Auckland, Wellington, Christchurch and Dunedin Museums who so willingly assisted with research.

REFERENCES

- Angel, J.L. 1969. The bases of palaeodemography. *American Journal of Physical Anthropology* 30:427-437.
- Baker, R. 1975. A discriminant analysis of Maori and non-Maori innominate bones. M.A. thesis, University of Auckland.
- Devereux, G. 1955. *A study of abortion in primitive societies*. International Universities Press Inc. New York.
- Doring, J. 1969. The incidence of anovular cycles in women. *Journal of Reproduction and Fertility*, Supplement No. 6:77-81.

- Dumond, D.E. 1975. The limitation of human population: a natural history. *Science* 187:713-721.
- Dunlap, R. 1978. The preauricular sulcus in pregnancy. *American Journal of Physical Anthropology* 50:434-435.
- Gilbert, B.M. and McKern, T.W. 1973. A method for aging the female os pubis. *American Journal of Physical Anthropology* 38:31-38.
- Gluckman, L.K. 1976. *Tangiwai, a medical history of nineteenth century New Zealand*. Whitcoulls Ltd, Christchurch.
- Holt, C.A. 1978. A re-examination of parturition scars on the human female pelvis. *American Journal of Physical Anthropology* 49(1):91-94.
- Houghton, P. 1974. The relationship of the pre-auricular groove of the ilium to pregnancy. *American Journal of Physical Anthropology* 41:381-390.
- Houghton, P. 1975a. The people of Wairau Bar. *Records of the Canterbury Museum* 9:231-246.
- Houghton, P. 1975b. The bony imprint of pregnancy. *Bulletin of the New York Academy of Medicine* 51(5):655-661.
- Houghton, P. 1976. The human skeletal material from the Waihora Site, Chatham Islands. *Working paper in Chatham Islands Archaeology* 4. Anthropology Department, University of Otago.
- Houghton, P. 1977a. Prehistoric burials from recent excavations on Motutapu Island. *Records of the Auckland Institute and Museum* 14:37-43.
- Houghton, P. 1977b. Human skeletal material from excavations in Eastern Coromandel. *Records of the Auckland Institute and Museum* 14:45-56.
- Houghton, P. 1978. Prehistoric New Zealanders. *New Zealand Medical Journal* 87:213-216.
- Hunton, R.B. 1977. Maori abortion practices in pre- and early European New Zealand. *New Zealand Medical Journal* 86:567-570.
- Kolata, C.B. 1974. !Kung hunter-gatherers : feminism, diet and birth control. *Science* 185:932-934.
- Lee, R.B. and deVore, I. 1968. *Man the hunter*. Aldine, Chicago.
- Leach, H.M. 1976. Horticulture in prehistoric New Zealand. Ph.D. thesis, Otago University, New Zealand.
- Magnusson, M. 1978. Age at menarche in Iceland. *American Journal of Physical Anthropology* 48(4):511-514.
- May, R.M. 1978. Human reproduction reconsidered. *Nature* 272:491-495.
- Metge, J. 1976. *The Maoris of New Zealand*. Routledge and Kegan Paul Ltd, London.
- Nag, M. 1962. *Factors affecting human fertility in non-industrial societies : a cross cultural study*. Department of Anthropology, Yale University.
- Nemeskeri, J. 1972. Die archaologischen und arthropologischen voraussetzungen palaodemographischer forschungen. *Praehistorische Zeitschrift* 47:5-46.
- Putschar, W. 1931. *Entwicklung, Wachstum und Pathologie der Beckenverbindungen des Menschen mit besonderer Berücksichtigung von Schwangerschaft, Geburt und ihren Folger*. Jena.
- Reiter, E.O., Kulin, H.E. and Hamwood, S.M. 1974. The absence of positive feedback between estrogen and luteinising hormone in sexually immature girls. *Pediatric Research* 8:740-745.

- Shawcross, K.A. 1967. Fernroot and the total scheme of eighteenth century Maori food production in agricultural areas. *Journal of the Polynesian Society* 76:330-352.
- Short, R.V. 1975. Definition of the problem. The evolution of human reproduction. *Proceedings of the Royal Society London, B* 195:3-24.
- Stewart, T.L. 1957. Distortion of the pubic symphyseal surface in females and its effect on age determination. *American Journal of Physical Anthropology* 15:9-18.
- Stewart, T.L. 1970. *Personal Identification in mass disasters*. National Museum of Natural History. Smithsonian Institution, City of Washington.
- Sutton, D.G. 1976. Resurrection of the prehistoric dead. M.A. thesis, Otago University, New Zealand.
- Sutton, D.G. 1977. An alternative research strategy for the study of prehistoric human remains. *New Zealand Archaeological Association Newsletter*. 20:176-187.
- Smith, Sir Sydney A. 1959. *Mostly Murder*. Harrap, London.
- Ullrich, H. 1975. Estimation of Fertility by means of pregnancy and childbirth alterations at the pubis, the ilium and the sacrum. *OSSA: International Journal of Skeletal Research* 2(1):23-39.

Received 13 September 1979