



NEW ZEALAND
ARCHAEOLOGICAL
ASSOCIATION

**NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION MONOGRAPH 17:
Douglas Sutton (ed.), *Saying So Doesn't Make It So: Essays in Honour of
B. Foss Leach***



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/>

SAYING SO DOESN'T MAKE IT SO

PAPERS IN HONOUR OF B. FOSS LEACH

Edited by
Douglas G. Sutton

**New Zealand Archaeological Association
Monograph 17**

First Record of Medullary Bone from an Archaeological Context in New Zealand

Rick McGovern-Wilson

Department of Anthropology, University of Otago

INTRODUCTION

The question of site seasonality is of much interest to archaeozoologists involved in reconstructing the economic way of life of prehistoric populations. Seasonality is an important settlement pattern parameter, related to and determining the duration of site occupancy to a large extent.

In the past the determination of seasonality has been based mainly on the presence of migratory or seasonally abundant species, tooth eruption and microstructure, and the analysis of various types of growth rings in scales and shells. These methods have a number of flaws because they cannot take into account factors such as preservation of food for later consumption (and the appearance of this preserved food in archaeological sites), and climatic changes which may affect the length of the seasons and so cause interruptions in the deposition of growth rings.

A secondary area of interpretation which concerns archaeozoologists is the identification of sex in groups of bones. Determination of the sex of the remains is necessary to understand population dynamics and to facilitate the interpretation of measurements. Few non-metric osteological features positively identify the sex of a bone (Carey 1982; West 1982). The identification of medullary bone provides a valuable indication.

This paper describes the formation and recognition of medullary bone, and discusses how its presence can be used in the interpretation of seasonality and sex of archaeological remains.

MEDULLARY BONE

Birds bones have a thin wall of cortical bone, made of a lamellar type of bone, surrounding a relatively narrow marrow cavity (Driver 1982: 251). Although this marrow cavity is usually hollow, it is sometimes partially or completely filled with a system of bone spicules which grow out from the endosteal surfaces (Simkiss 1967: 168).

This granular deposit of bone, known as medullary bone, develops only in females and only during the egg-laying part of the reproductive cycle (Wing and Brown 1979: 117). It is a calcium source for developing eggshells. The bone has no mechanical function and

serves merely as a temporary store for calcium which is built up during the laying cycle and can then be quickly reserved to provide calcium for the egg-laying process (Hancox 1972: 31; Rick 1975: 183). Taylor (1970: 92) believes the bone evolved "in direct relation to the laying of eggs with thick, calcified shells". Medullary bone was first described by Kyes and Potter (1934) in relation to feral pigeons (*Columbia livia*). They described

the range of ossification observed, from a case where fine spicules of bone extended a short distance into the marrow, to having trabeculae [sic] extending well into the marrow, to the case where ossification is complete with anastomosing trabeculae [sic] of bone extending in all directions throughout the medulla with the marrow, as a result, being dry, gray and chalky. (1934: 378)

They found that the changes in the bone marrow of female pigeons were cyclic and paralleled functional changes of the ovary. They concluded, therefore, that

there is a cyclical ossification of the red marrow of the long bones of the leg and that the ossification is coincident with the maturation of the ovarian follicule. (1934: 378)

Furthermore, medullary bone only occurred in females.

From the initial description of this bone in pigeon, and an earlier reference by Foote in 1916 to medullary bone in yellow hammer (*Emberiza citrinella*) and white pelican (*Pelecanus erythrorhynchus*) (Simkiss 1967: 166), it has now been described from a number of species. Taylor and Moore (1953: 504) note its presence in four species, while Simkiss (1967: 168, Table 12.7) describes its occurrence in eleven species belonging to different families. Archaeologically, medullary bone has been identified in six species (Driver 1982: 251; Rick 1975: 188) of which the most common is the domestic chicken (*Gallus gallus*).

While it is most clearly seen in long bones, medullary bone has been recorded as forming in most parts of the skeleton (Simkiss 1967: 168, Table 12.6). The highly pneumatic elements, such as the humerus, contain less medullary bone than non-pneumatic bones of a comparable size (Rick 1975: 184). It is best seen in bones with extensive, open medullary cavities such as the ulna, femur and tibiotarsus. Depending on the stage reached when the bird died, medullary bone can appear as a thin coating on the inner face of cortical bone, or it may fill the marrow cavity (except for the channels occupied by the blood vessels) to varying degrees. In the latter case, the medullary bone can be clearly differentiated from the outer shell of compact cortical bone, although the bone appears solid. In an experiment with eight laying pullets, Taylor and Moore (1953) identified medullary bone in all bones, although the skull, humeri, wing and leg extremities only contained small amounts.

The sequence of the medullary bone cycle in wild birds has not been fully studied, but a generalised description of the sequence as recorded for domestic chicken and pigeons will give an idea of the process involved (Simkiss 1967: 168-9, Taylor 1970: 92-3). In males and nonbreeding females the marrow cavities of most bones are filled with red marrow tissue, which is involved in the production of blood cells.

Medullary bone forms after mating under the control of the sex hormones. During the period of approximately 1-2 weeks before laying, calcium is rapidly accumulated in the marrow cavity until it fills most of the available space. Medullary bone differs from other types of bone in that it is composed of collagen but it also contains a nitrogen fraction not found in cortical bone (Rick 1975: 184). When the medullary bone is examined histologically, it can be seen that the period of bone deposition coincides with a phase of osteoblastic

activity. By the time the egg is due to receive its shell, the marrow cavities are almost filled with the bony spicules. About four hours after the egg enters the shell gland the medullary bone undergoes dramatic changes. Through the action of osteoclasts the medullary bone is broken down, calcium is liberated into the blood stream and used in the formation of the eggshell (Rick 1975: 194; Simkiss 1967: 168; Taylor 1970: 92-3). When the shell is completely calcified and the egg is laid, osteoclastic activity falls and the osteoblasts dominate (Simkiss 1967: 168).

The eggshell is composed of calcite, one of the crystalline forms of calcium carbonate, with a sparse matrix of protein running through the crystals (Taylor 1970: 89). Hancox (1972: 113) records that

in the domestic hen, an average eggshell contains about 2 g of calcium, most of which is laid down in the final 16 h of calcification; this correspond to a rate of 125 mg/h. The total calcium circulating in the blood of the hen at any time is 25 mg; hence an amount of calcium equal to the weight of calcium in the circulation is removed from the blood every 12 min.

In extreme cases as much as 10% of the total bone substance is mobilized for eggshell formation in less than a day (Taylor 1970: 89). After the egg is laid more medullary bone builds up in the marrow cavity in preparation for the next eggshell. It is present throughout the laying period (Rick 1975: 185). The bone exists in wild species which lay small clutches, for three to four weeks, but will persist for longer in those species which have bigger clutches. Because of their artificially lengthened laying periods, domestic chickens can maintain medullary bone for many months (Rick 1975: 185; Simkiss 1967: 170; Taylor 1970: 92). Medullary bone acts as a temporary store of calcium and phosphate ions, but in small quantities in comparison with the rest of the skeleton. The calcium is stored when the opportunity arises and is subsequently utilised in the formation of eggshell (Simkiss 1967: 170). The actual withdrawal and deposition are mediated respectively by the resorption and deposition of bone (Hancox 1972: 43). The great advantage that medullary bone has for the storage of calcium ions is its lability. Because of its large surface area and vascularity, it can be broken down much more quickly than cortical bone when calcium is required for the calcification of eggshell (Simkiss 1967: 170).

An interesting fact which has emerged from experimental work is that a bird which continues to lay on a calcium-deficient diet depletes the structural bone rather than the medullary bone (Simkiss 1967: 174; Taylor 1970: 92). The percentage of medullary bone present increased during egg-laying on a calcium-deficient diet because the rest of the skeleton was depleted in order to maintain it.

What mechanisms might account for this rapid change from bone formation to bone destruction or vice versa? Both Kyes and Potter (1934) and Simkiss (1967: 171-2) suggest that it is related directly to the reproductive cycle and that variations in the level of oestrogen control the cyclic changes in the medullary bone. Taylor (1970: 94), however, considers that the control is mediated by the parathyroid gland which regulates the level of calcium ions in the blood. Subsequent bone resorption under the influence of parathyroid hormone is largely due to an increase in the number and activity of osteoclasts. Therefore, the hormone is directly responsible for the induction of bone resorption associated with shell formation.

The method of detection of medullary bone in faunal remains can range from the simple to the more complex and more expensive. A visual examination of the interior of long

bones will reveal its presence as it is clearly visible to the naked eye. In the case of unbroken bones it is more difficult, assuming that one does not wish to break the bones deliberately. X-rays may faintly define its presence but this is a costly and time-consuming method. Both Driver (1982: 252) and Rick (1975: 186) suggest that if slight damage to the bone is permissible, a small hand drill can be used to drill a hole in the long bone shaft. This will reveal any medullary bone accumulation. Although this type of bone is not as compact as cortical bone, Driver (1982: 251) feels there is not evidence to suggest that it will leach from a specimen of complete bone buried in an archaeological site. It was found that medullary bone was retained close to the break in broken specimens from a variety of conditions.

ARCHAEOLOGICAL MATERIAL

The material which is the subject of this paper, was recovered during the excavations of the Halfway House Hotel site in the Cromwell Gorge, Central Otago. During November and December 1984 excavations were undertaken on the site and associated dumps of this former hotel (Bedford 1985). The hotel was built in 1864 and served initially as a stopping place for people travelling through the Cromwell Gorge, while in later years it was primarily a refreshment stop. The hotel was in existence for over fifty years until it was destroyed by fire in 1917 (Bedford 1985: 227).

The excavation, on the upstream side of "No. 5 Creek", revealed the remains of the hotel and three outbuildings. A large midden comprising general hotel refuse (ash, broken tableware, bottles, food scraps, etc.), was recovered on the riverside. Analysis of the excavated bird bone showed that the majority of the birds consumed were domestic species—chicken, goose (*Anser domesticus*), turkey (*Meleagris gallopavo*), and possibly duck (*Anas platyrhynchos*) (McGovern-Wilson 1986). The majority of the chicken remains were of adult birds, but there were also a high number of subadult and immature specimens present. The fowls and geese would have been kept at the hotel but the turkey were most probably bought in Cromwell as prepared birds.

As in many other historic sites in the Central Otago area, the diet was supplemented by a number of wild species, of which the most common were the weka (*Gallirallus australis*), paradise shelducks (*Tadorna variegata*) and grey ducks (*Anas superciliosa*). The feral pigeon is also represented and this early introduction to New Zealand was possibly caught for its food value.

The most common remains recovered during the excavation were those of the domestic chicken. A closer analysis of them not only revealed a range of age classes but enabled a definitive statement to be made regarding the sex of a number of the birds present. Two roosters are represented in the midden, as evidenced by the spurs on the tarso-metatarsi. This is the only method by which roosters can be identified with any certainty, although West (1982) in examining the remains of caponized birds, found that there were some other distinguishing characteristics.

Of more importance, however, are the two bones which contain medullary bone in their marrow cavity. This first archaeological identification of medullary bone in New Zealand was found in two tibiotarsi which exhibit differing degrees of medullary bone storage. The medullary bone appears as a granular substance on the inner surface of the cortical bone (Figure 1a-c) filling much of the marrow cavity. In thin section (Figure 2) the medullary bone is plainly evident. The fact that both of these bones are broken and the medullary

bone exists right up to the break, attests to its durability under considerable environmental stress.

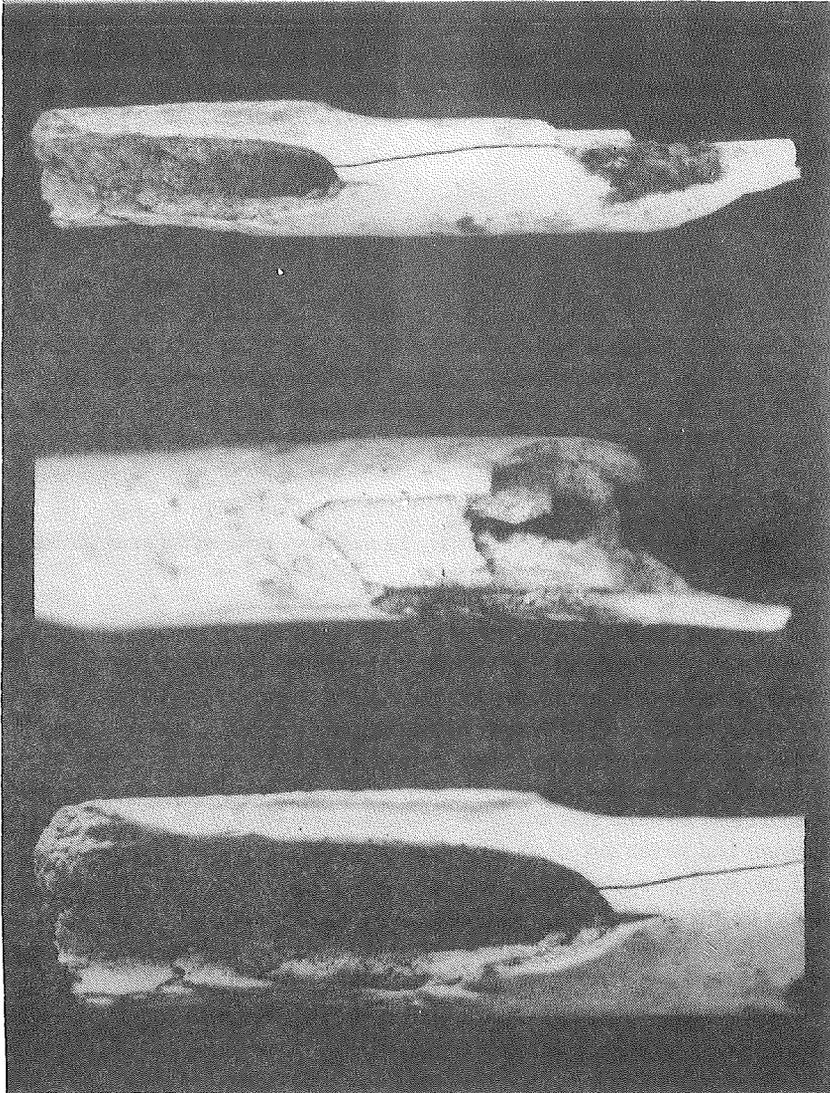


Figure 1: Above. Shaft fragment of right tibiotarsus showing medullary bone. Centre and below. Close-ups of the ends showing the bone in more detail.

APPLICATION TO NEW ZEALAND ARCHAEOLOGY

The major application that the study of medullary bone can have for New Zealand archaeology is its use in the study of seasonality. To date the use of bird species as seasonal

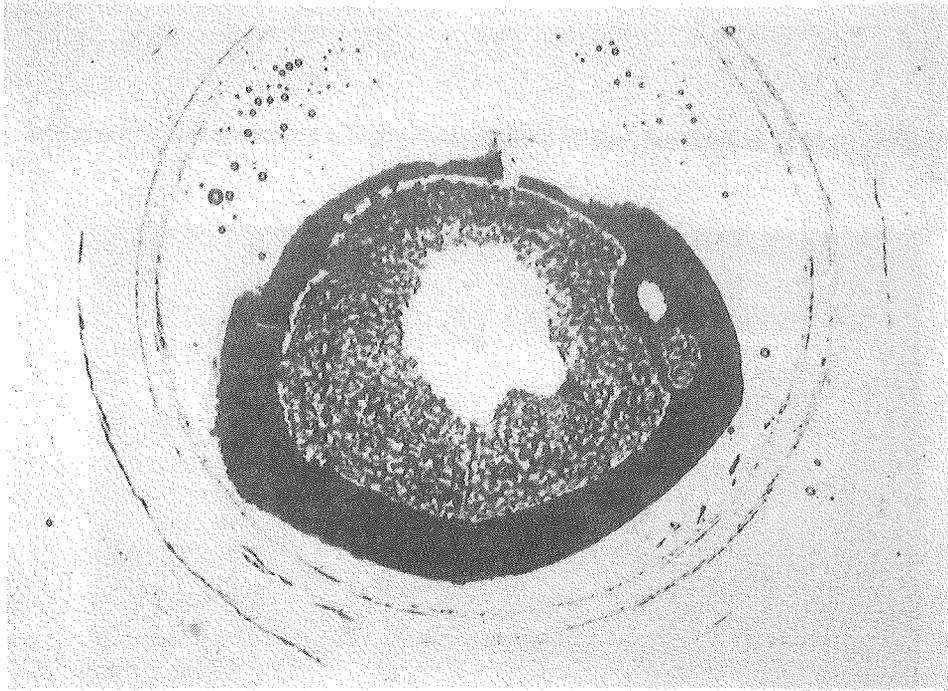


Figure 2: Thin section of the bone ($\times 15$) showing the medullary bone on the inner surface of the cortical bone.

indicators has been confined mainly to the Procellariiformes, the petrels and shearwaters, which breed in vast numbers in the Hauraki Gulf and Foveaux Strait areas during the summer and autumn months. The main difficulty with this method is that it does not take account of the preservation of specimens for subsequent consumption and for trade.

Because medullary bone occurs only in adult female birds, the time of year at which they were taken can be more precisely pin-pointed. Adult birds were typically not taken for preservation and so the use of medullary bone as a seasonal marker overcomes this problem. If the span of medullary bone occurrence and breeding dates are known for a species, it may be possible to state, within a month, when a bird was taken (Rick 1975: 186). The problem with this, however, is that the medullary bone cycle of most wild birds is not fully known. There are several other disadvantages to seasonal dating with this method (Rick 1975: 188–9), but these can be overcome. Because it only occurs in females, not all of which breed in any one year, and has a short interval of occurrence, the chance that medullary bone will occur in faunal remains is small. The method cannot be used to show occupation at a site in more than one season. As well, many birds will produce a second clutch of eggs if the first is destroyed, and this will affect the period that the medullary bone is in existence. Finally, the bone is easily distinguished in medium to large species, but it is very difficult to see in small species.

It is important to investigate medullary bone in the New Zealand ratites. Given the size of the egg, in relation to the body size, laid by the kiwi, it is highly probable that medullary bone is produced for the large amount of calcium required for the shell. By extension, it is possible that moa also produced medullary bone, although the sheer size of the adult birds means that there may have been enough available calcium within the cortical bone

system to provide the mineral needed for calcification. If medullary bone was produced by moa, its recognition would be an important step in defining the reproductive cycle, and determining the sex, of individuals from archaeological and natural remains.

CONCLUSION

The observation of medullary bone, a fine granular type of bone deposited in the marrow cavity of female birds during reproduction, provides a means for the seasonal dating of archaeologically derived faunal remains. It also defines the sex of the individual from which the bone comes. This type of bone is here described for domestic chicken bones recovered from excavations of the Halfway House Hotel, Cromwell Gorge. Although this method has limitations, it is a valuable addition to the means of seasonal determination available to faunal analysts. The possibility that medullary bone was deposited in moa as a store for the large amount of calcium required for the egg needs further investigation.

REFERENCES

- Bedford, S. H. 1985. A preliminary report on the excavation of the Halfway House Hotel site, Cromwell Gorge. *New Zealand Archaeological Association Newsletter* 28: 227–34.
- Carey, G. 1982. Aging and sexing domestic bird bones from some Late Medieval deposits at Baynard's Castle, City of London. In B. Wilson, C. Grigson and S. Payne (eds), *Aging and Sexing Animal Bone From Archaeological Sites*, pp. 263–8. *British Archaeological Reports (British Series)* 109.
- Driver, J. C. 1982. Medullary bone as an indicator of sex in bird remains from archaeological sites. In B. Wilson, C. Grigson and S. Payne (eds), *Aging and Sexing Animal Bone From Archaeological Sites*, pp. 251–4. *British Archaeological Reports (British Series)* 109.
- Hancox, N. M. 1972. *Biology of Bone*. Cambridge, Cambridge University Press.
- Kyes, P. and T. S. Potter 1934. Physiological marrow ossification in female pigeons. *The Anatomical Record* 60: 377–9.
- McGovern-Wilson, R. J. 1986. Report on the bird bones from the Halfway House Hotel, Cromwell Gorge. Report to the Ministry of Works, Cromwell. 4 pp.
- Rick, A. M. 1975. Bird medullary bone: a seasonal dating technique for faunal analysis. *Bulletin of the Canadian Archaeological Association* 7: 183–90.
- Simkiss, K. 1967. *Calcium in Reproductive Physiology: a Comparative Study of Vertebrates*. London, Chapman and Hall.
- Taylor, T. G. 1970. How an eggshell is made. *Scientific American* 222: 89–95.
- Taylor, T. G. and J. H. Moore 1953. Avian medullary bone. *Nature* 172: 504–5.
- West, B. 1982. Spur development: recognizing caponized fowl in archaeological material. In B. Wilson, C. Grigson and S. Payne (eds), *Aging and Sexing Animal Bone From Archaeological Sites*, pp. 155–61. *British Archaeological Reports (British Series)* 109.
- Wing, E. S. and A. B. Brown 1979. *Paleonutrition: Method and Theory in Prehistoric Foodways*. New York, Academic Press.