NEW ZEALAND JOURNAL OF ARCHAEOLOGY

Moa Utilisation at Owens Ferry, Otago, New Zealand

Brian Kooyman

University of Otago

ABSTRACT

This paper analyses faunal and lithic remains from an Archaic site in the South Island. The faunal analysis concentrates on cut mark location and bone fragmentation patterns as these relate to butchering practices. The lithic analysis employs microchipping usewear as an indicator of tool function. The results indicate that Owens Ferry was a secondary processing site related to moa hunting.

Keywords: MOA, BUTCHERING PATTERNS, HUNTING, LITHICS, SOUTH ISLAND.

INTRODUCTION

Owens Ferry (S132/4) is an Archaic site located on the Kawarau River in the interior of the southern South Island, New Zealand (Fig. 1). The site consists of two prehistoric cultural horizons containing a variety of lithic and faunal remains. The faunal material is dominated by moa bone and the site has been interpreted as a short term camp related to the hunting of these large, flightless birds (Ritchie and Harrison 1981:97-100).

There is a noticeable lack of literature discussing moa hunting strategies and butchering techniques. Usually statements are restricted to cursory remarks, such as Duff's (1977:70) suggestion that moa could have been trapped on spits of land surrounded by water and Scarlett's (1974:1) comment that the highly fragmented nature of moa bone was presumably the result of breaking the bones to extract marrow. Butchering and hunting have been considered in more detail recently (Anderson 1983a, 1983b), but a systematic analysis of cut mark and bone fragmentation patterns has yet to be undertaken. This paper incorporates such an approach.

The present analysis utilises the location of cut marks on bones as an indicator of how the animal was segmented in butchering and how the meat was removed from the bone. The types of cut marks also provide basic information about the types of tools used in butchering. A microchipping usewear analysis of the porcellanite tools from the site is employed to provide further insight into the butchering procedure and its importance as an activity at Owens Ferry. The role of bone marrow extraction at the site is assessed by an examination of the bone breakage patterns. The relative representation of the various bone elements is used to define the positon of Owens Ferry in the general moa procurement strategy, and the number and species of moa are used to suggest a probable hunting technique. Together, these lines of evidence define the nature of moa procurement and utilisation at Owens Ferry.

MOA SPECIES

Altogether, 1469 bone fragments from Owens Ferry were positively identified as moa, 1419 from the upper Archaic horizon (Layer 8) and 50 from the lower (Layer 10). Thirty-eight fragments from the two layers had anatomical features preserved on them that allowed species identification to some degree. Fifteen of these could be identified to actual species. This information is summarised in Table 1. The species identifications follow Cracraft (1976) as revised by Millener (1982) (for a discussion of the method used to derive the minimum number of individuals, MNI, see section on element representation).

New Zealand Journal of Archaeology, 1984, Vol. 6, pp. 47-57.

Figure 1: Owens Ferry location map.

Lack of information about moa habitat and the ongoing debate about the validity of the various moa species makes comment on these results difficult. It is obvious that a wide spectrum of moa species, both larger and smaller, were hunted at Owens Ferry. As only one or two individuals of any particular species are present, stalking individual birds seems to have been the hunting strategy employed. As will be seen in the following section, the number of birds taken as calculated by the species MNI coincides with that derived from the element representation analysis.

It is noteworthy that two *Dinornis struthoides* individuals were identified in the remains. Few bones of this species have been recorded from the South Island. Cracraft (1976:202) questioned its South Island range, but left the possibility open pending further work. Recent research I have completed at the Otago Museum has revealed

TABLE 1
MOA SPECIES IDENTIFICATIONS

Species	Number of Identified Fragments Positive	Probable	MNI
LAYER 8			
Dinornis giganteus	1	–	1
Dinornis novaezealandiae	1	1	1
Dinornis torosus	–	1	1
Dinornis struthoides	1	–	1
Euryapteryx geranoides	1	1	1
Pachyornis elephantopus	1	3	2
Anomalopteryx didiformis	2	–	2
TOTAL LAYER 8	7	6	9
LAYER 10			
Dinornis struthoides	1	1	1

additional South Island material. The existence of *Dinornis struthoides* in the South Island appears confirmed.

ELEMENT REPRESENTATION

The relative frequency of the various bone elements in a site is an important indicator of butchering strategy, the role food procurement had in the site, and the general type of occupation represented. This type of analysis has been used in New Zealand (e.g. Smith 1979:220) and elsewhere (e.g. Wheat 1972:79-83), although the problem of differential bone destruction due to non-cultural factors such as soil acids complicates the observed frequencies (e.g. Binford and Bertram 1977). Each element of the prey species is assessed to determine its value for products such as meat and marrow and the elements are then ranked on a relative scale or "utility index" (Binford 1978:15-38). This purely economic ranking is then compared to the relative frequencies of the elements in the archaeological site and the differences are evaluated in terms of possible human behaviour. Only 382 of the Layer 8 fragments and 20 of those from Layer 10 could be identified to specific element (totals include unspecified vertebral fragments). Some of the details of these identifications are given in Table 2. Figure 2 shows the anatomical positions of the various bones in the moa skeleton.

In the present analysis, unique anatomical landmarks provided the basis for determining the number of specimens of each element present in the sample, grouped into lefts and rights where appropriate. The minimum number of individual birds (MNI) represented by each element was defined by the largest number of left or right anatomical landmarks present in the remains, or by the largest number of elements where the landmark had no side distinction (such as many of those on the vertebrae). These were then standardised by dividing all the values by the largest value and then multiplying by 100; this essentially converts the values to percentages and makes direct comparison between layers possible regardless of the actual MNI values. Some elements are difficult to distinguish one from another (e.g. the various cervical vertebrae), hence a minimum number of elements (MNE) was calculated for these bones and the MNI was derived by dividing the MNE by the number of these elements in each bird. The MNE value for other elements was determined by adding the number of left and right specimens.

No attempt was made to maximise the MNI counts by pairing bones (Krantz 1968) or by taking account of species differences. This is often impossible when dealing with small anatomical landmarks, relative size and species being difficult to determine.

TABLE 2
ELEMENT REPRESENTATION

Element	Number of Fragments		MNE		MNI		Standardised MNI	
	L.8	L.10	L.8	L.10	L.8	L.10	L.8	L.10
Skull	7	0	2	0	2	0	22	0
Mandible	1	0	1	0	1	0	11	0
Quadrate	3	0	4	0	2	0	22	0
Tracheal Rings	0	0	0	0	0	0	0	0
Cervicals	38	0	19	0	1	0	11	0
Thoracics	7	0	4	0	1	0	11	0
Vertebrae	35	1	1	1	1	1	11	100
Ribs	42	1	21	1	3	1	33	100
Sternal Ribs	7	0	5	0	2	0	22	0
Sternum	4	1	1	1	1	1	11	100
Pelvis	47	0	6	0	6	0	67	0
Femur	43	5	13	2	9	1	100	100
Tibiotarsus	96	6	11	1	6	1	67	100
Fibula	10	1	4	1	3	1	33	100
Tarsometatarsus	7	2	4	1	3	1	33	100
First Phalanges	5	0	5	0	1	0	11	0
Middle Phalanges	21	3	19	1	2	1	22	100
Terminal Phalanges	9	0	8	0	2	0	22	0
Long Bone, Shaft Frags.	229	27	–	–	–	–	–	–
Long Bone, End Frags.	3	0	–	–	–	–	–	–
Axial Frags.	101	3	–	–	–	–	–	–
Unidentified Frags.	704	0	–	–	–	–	–	–
Total	1419	50	–	–	9	1	–	–

Using such small bone portions is in itself a maximising technique. Additionally, it is the *relative* frequencies that are most important in this analysis and hence there is no need to maximise the values.

It is difficult to define an "economic" index for extinct species such as the various moa so that archaeological distributions can be evaluated. What follows is an approximation based on initial research. The National Museum in Wellington kindly provided me with a kiwi, the closest living relative of the moa and hence a reasonable species to use as a model for the moa. The kiwi was dissected and the meat on each bone was weighed. The following meat values were thus obtained for each element, standardised for comparative purposes (defined for the complete bird unless otherwise indicated): skull 5, cervical vertebrae 100, thoracic vertebrae 15, sternum (including wings) 5, ribs/sternal ribs 35, pelvis 40, femur (one side) 100, tibiotarsus/fibula (one side) 60, tarsometatarsus (one side) 1, phalanges 0. The thoracic vertebrae total includes the meat from the proximal ribs. The cervical vertebrae total is based on an estimate; the complex, interlocking structure of these vertebrae made complete removal of the meat impossible. The difficulty of removal may be a factor in their importance in archaeological sites.

The value of the various bones for marrow is solely based on my observations on marrow cavity volume. The rank order of value seems to be: high value, tibiotarsus; some value, femur and tarsometatarsus; limited value, pelvis, fibula, phalanges. The others have little or no apparent value.

At this stage I have not yet attempted to assess the elements for their value for other products.

Comparing the standardised MNI values for Layer 8 from Table 2 with the meat values derived from the kiwi dissection shows a generalised similarity between the two.

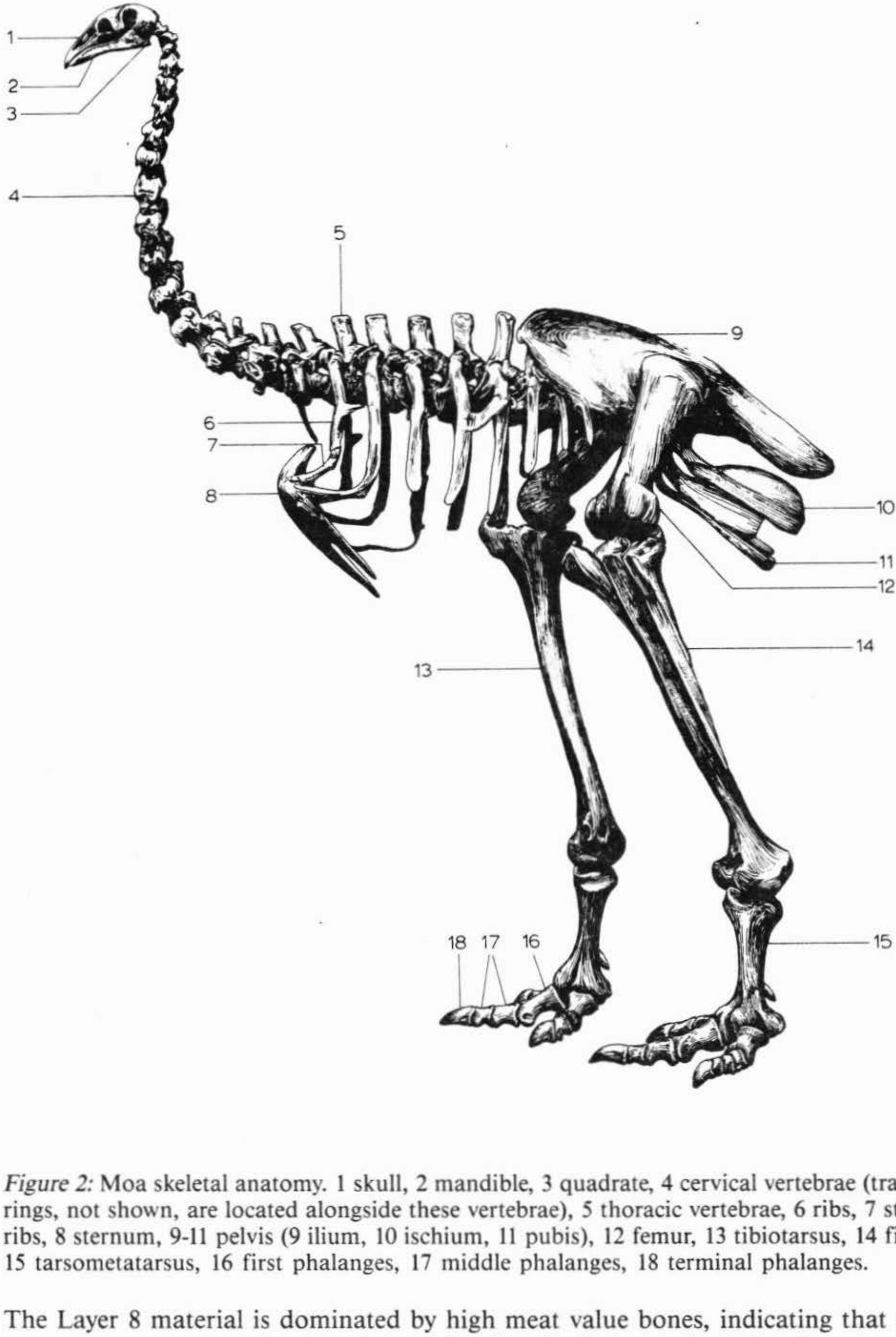

Figure 2: Moa skeletal anatomy. 1 skull, 2 mandible, 3 quadrate, 4 cervical vertebrae (tracheal rings, not shown, are located alongside these vertebrae), 5 thoracic vertebrae, 6 ribs, 7 sternal ribs, 8 sternum, 9-11 pelvis (9 ilium, 10 ischium, 11 pubis), 12 femur, 13 tibiotarsus, 14 fibula, 15 tarsometatarsus, 16 first phalanges, 17 middle phalanges, 18 terminal phalanges.

The Layer 8 material is dominated by high meat value bones, indicating that meat procurement was a major function of the site. At the same time, the absence of the generally low value elements indicates that the site was not the kill site itself. Some of the low value carcass portions have been discarded or culled at another site or sites. The very low representation of cervical vertebrae suggests that the difficulty associated with removing the meat from the bone imposes a severe limitation on the usefulness of this portion. The phalanges, tarsometatarsus, and pelvis are overrepresented in the archaeological material relative to their meat index values. This may be partially due to their value for marrow, an aspect that will be examined in the next section. An equally plausible explanation is that to some extent these lower value elements are "riding along" with higher value portions because together they constitute a convenient butchering unit (Binford 1978:74). It may be that the pelvis and leg comprised a convenient field butchering unit.

Obviously the number of fragments recovered from Layer 10 are too few to analyse in detail. The same pattern is apparent, however, with the bulk of the material coming from the meaty leg elements.

It is possible that large and small moa were differentially processed during butchering, a well known phenomenon for other animal species (Kooyman 1981:30-31). Small sample size made it impossible to evaluate this realistically at Owens Ferry.

The relatively recent age of this site compared to others in other areas of the world suggests that differential bone destruction due to *in situ* soil environment processes is unlikely to be a problem. The slight overrepresentation of fragile elements such as the skull seems to corroborate this. The fact that some fairly substantial elements, such as the tarsometatarsus, are present in low frequency also argues for a cultural factor as the cause. Only 33 of the fragments from the two layers evidence any animal gnawing (all carnivore, presumably dog), hence significant destruction by these agents was not an important factor in the site formation process at Owens Ferry.

To evaluate further whether or not one of the above two factors caused differential loss of the moa remains, the elements were classified according to their general resistance to destruction. The following groups are ranked in order of greatest to least resistance, with individual elements within each group also arranged in this order: tibiotarsus and femur; tarsometatarsus and fibula; phalanges; pelvis; ribs; vertebrae and sternal ribs; sternum; quadrate, mandible, skull, and tracheal rings. If dog gnawing or soil environment had been important factors in preservation, the MNI values in Table 2 would correspond with the above ranking. Leaving aside the small Layer 10 sample, the femur is much more evident in the remains than it should be relative to the tibiotarsus. The fibula, tarsometatarsus, and phalanges are very poorly represented based upon their relative strengths, as are the vertebrae. The sternum is underrepresented when compared with the final grouping, and within this last group the skull is overrepresented. In short, there is little correspondence between element frequency and susceptibility to destruction. The differential element representation can be viewed as being due to human behaviour.

CUT MARK AND FRAGMENTATION PATTERNS

It is obviously necessary to break a bone before the marrow in it can be extracted, and the greater the exposed extent of the marrow cavity, the easier is the task. This processing strategy has been observed ethnographically among various groups that are widely separated geographically, and before the use of metal tools the task was usually accomplished by breaking the bone so as to produce long spiral fractures. At least one ethnographic bone sample has also shown this feature, and together with various archaeological material, it indicates that a long spiral fracture incidence of 35 percent or more can be taken as a good indication that marrow processing was occurring at a site (Kooyman 1981:13, 17-18, 217). With this in mind, the long spiral fracture incidence was calculated for the Owens Ferry material (a long spiral fracture was defined as being of 6 cm or more in length, following Kooyman (1981)). As can be seen from Table 3, only the pelvis, femur, and tibiotarsus had any long spiral fractures at all. The tibiotarsus remains from Layer 8 are the only ones that meet the 35 percent minimum requirement and hence can be confidently proposed as evidencing marrow extraction on a regular basis. The femur remains from Layer 8 and the tibiotarsus remains from Layer 10 may have been occasionally or casually processed for marrow, but this cannot be confirmed from the evidence available here.

TABLE 3
ELEMENTS DISPLAYING TRACES OF BUTCHERING

Element	% Long Spiral Fracture	Number of Breaking Blows	Breaking Blows Per MNE	Cut Marks (No. of Fragments)		
				Fine	Heavy	Blunt
LAYER 8						
Cervicals	–	–	–	2(1)	–	–
Pelvis	2.1	1	0.2	22(2)	3(3)	–
Femur	14.0	2	0.2	4(1)	2(2)	2(2)
Tibiotarsus	47.9	10	0.9	5(1)	2(2)	11(9)
Tarsometatarsus	–	1	0.2	–	1(1)	–
Middle Phalanges	–	–	–	–	1(1)	–
Long Bone, Shaft Frags.	4.8	2	–	6(1)	–	2(2)
LAYER 10						
Femur	–	–	–	2(2)	–	–
Tibiotarsus	16.7	–	–	–	–	–

Breaking bones during carcass processing can serve to isolate meaty portions from low meat value units, to extract marrow, or to prepare bones for grease or stock extraction. Breakage related to meat removal appears to be rare in traditional hunting societies (e.g. Wheat 1972:98-100, 103; Binford 1978:50), but should not be dismissed outright. Kooyman (1981:89) suggested, and to some extent substantiated, a procedure for distinguishing among these processing procedures based on determining the number of break-causing blows or cut marks per MNE for each element considered. For stone tool using people, the following patterns were proposed: severance for meat removal, one to three breaks per MNE; breakage for marrow extraction, one to about ten; and for grease extraction a very large number, perhaps as many as twenty or thirty. Once again, examination of Table 3 shows that breaking blows were rare in the assemblage and that only the tibiotarsus fragments from Layer 8 indicate any regular breaking procedure. The Layer 8 tibiotarsus frequency falls at the low end of both the meat and marrow processing distributions. Which of these two procedures is involved cannot be defined.

Based on the evidence of the long spiral fracture frequency and the breaking blow/MNE ratio, it is highly unlikely that the overrepresentation of the pelvis, tarsometatarsus, and phalanges in the element-representation tabulations is due to their marrow value. The "riding" hypothesis is more tenable. This probably represents one or two carcasses being returned to the site complete.

The presence of fragmentary bone in the site remains could also be the result of bone tool manufacture. However, at Owens Ferry there were no bone tools, no bone tabs or blanks, no obviously sawn bone, and no attrition saws. Preparation of bone for use in tools was not an activity at the site.

Three types of cut marks were distinguished in this analysis: fine cuts, as would have been due to unmodified flakes and fine flake tools; heavy cuts, as might have resulted from larger "choppers" or perhaps adzes; and blunt object blows, as shown by circular impact scars, cones of percussion, etc. Very few cut marks were preserved on the remains. These are summarised in Table 3.

Beginning with the Layer 8 material, the two fine cuts on the cervical vertebra fragment are on the ventral surface of the centrum and probably relate to meat stripping. With so few cuts, little else can be said about this area.

All 22 of the fine cuts on the pelvis are on the pubis and ischium shafts, and the three heavy cuts are at or near the juncture of the ischium and acetabulum. This suggests meat removal from the posterior portion of the pelvis. Since only one of the three heavy cuts actually caused a break, the procedure seems to have been to strip the meat from this area rather than to obtain it by breaking the pelvis.

The femur cuts are too few and scattered to indicate any general processing strategy; they probably indicate occasional alternative patterns. All the fine cuts are on the proximal end of a single femur, suggesting in this instance that at some stage in the processing the femoral head was removed from the acetabulum. All the heavier cuts were struck on the shaft, and three of the four on the posterior shaft. It may be that severing the femur was sometimes desirable, especially since it is the two chopper-like blows that caused breaks and not the blunt object blows.

The five fine cuts on the tibiotarsus fragment are located in two groups, one on the distal end and one on the distal shaft. These could relate either to the cutting away of the non-meaty distal end of the leg, or to stripping of meat from the bone. The fine cuts on the long bone shaft fragment might also relate to either of these procedures. As with the femur, this does not appear to have been a common process. The large number of breaking blows on tibiotarsus fragments is proof that the tibiotarsus was broken for some purpose, a point which has already been discussed. The two non-breaking blunt object blows in the sample are evenly spaced at 2 cm intervals in a line along with another blunt object blow which caused a break. This is exactly the type of procedure that Sadek-Kooros used to obtain long spiral fractures in her experimental work (1972:371). The work of Sadek-Kooros and other lines of evidence have been used to suggest that multiple blows on an element, in conjunction with a breaking blow, are an indicator of marrow processing (Kooyman 1981:15-17). The particular fragment in question here is positive evidence for marrow processing. All the heavy cuts and blunt object blows are on the shaft. They are distributed along the entire shaft length (six distal, two middle, and five proximal), as would be the case to promote long spiral fracturing. Nine are on the posterior shaft, further suggesting a defined processing procedure rather than haphazard breakage. Particularly when combined with the other evidence for marrow processing, there can be no doubt that this was an important aspect of tibiotarsus utilisation. The long bone shaft fragments with blunt object breaking blows may also relate to this procedure.

Little can be said about the two blows on tarsometatarsus and phalanx fragments, except that since both are heavy blows and one caused a break, they may relate to severing the low value distal portion of the limb from the remainder of the carcass.

The only Layer 10 cut marks were two fine cuts on the femur shaft. The significance of these is impossible to determine, although they might be the result of stripping meat from the femur.

The overall cut mark patterning indicates that the tibiotarsus material from Layer 8 was processed for marrow and that the Layer 8 pelvis material had had the meat stripped from the posterior portion. There is little evidence for butchering, and whatever procedure was used resulted in little contact between the tools and the bone elements.

STONE TOOL EVIDENCE

A detailed analysis of the Owens Ferry lithic remains is currently under way, and although it is not yet complete, some of the initial results have important implications for the present analysis. One aspect of the work is a microchipping usewear analysis of the porcellanite material from the site. The criteria employed are the result of an experimental programme which was used to evaluate the appropriateness to porcellanite of the usewear features proposed by other analysts (Vaughan 1981, Odell and Odell-Vereecken 1980, and Tringham *et al.* 1974). Some of the Owens Ferry results are presented in Table 4.

TABLE 4
STONE TOOL ANALYSIS

		Layer 8 (% of Total)	Layer 10 (% of Total)
Number of Used Edges		144	2
Worked Material:	Bone	5(3%)	0
	Hardwood	40(28%)	1(50%)
	Hide	3(2%)	0
	Meat	11(8%)	1(50%)
	Probable Vegetable	1(1%)	0
	Not Bone (includes above hardwood, hide, meat, and vegetable)	114(79%)	2(100%)
	Not classifiable	25(17%)	0

Although a specific worked material could not be determined for just over half of the used edges, even these provided some information concerning what materials they were not used on. Particularly important in this regard is that 79 percent of the Layer 8 edges and 100 percent of those from Layer 10 were *not* used on bone. This corroborates the cut mark evidence, *i.e.*, that if butchering was engaged in at the site there was little bone contact involved in the process. Only five of the Layer 8 edges (3 percent of the Layer 8 sample) were used on bone. Four of these edges were used in a transverse shaving/scraping motion which would be consistent with a meat stripping function which might involve some limited bone contact. At the same time it is obvious that butchering or carcass processing was an important activity in both layers at the site, since 11 of the Layer 8 edges (8 percent) and one of the Layer 10 edges (50 percent) were used on meat. An additional three (2 percent) Layer 8 edges had been used on hide. Together, 13 percent of the Layer 8 stone tools were used in some aspect of butchering (as already noted, there is no evidence for bone tool manufacture at the site); this also represents 32 percent of the tools which could have their worked material identified.

Despite the importance of butchering at the site, the most important activity seems to have been working hardwood. These pieces constitute 67 percent of the identified worked material edges from Layer 8 (28 percent of the total assemblage) and 50 percent of the Layer 10 assemblage. Thirty of the 40 Layer 8 edges and the one Layer 10 edge were used in a transverse shaving/scraping motion and they are generally quite small in size (average 2.9 cm). This suggests working smaller objects, perhaps weapon shafts or poles for drying or cooking racks. Ovens are present at the site.

Procuring vegetable products (fern root, *ti* (cabbage tree), flax fibre, etc.) was not an important function of the site as only one tool edge was diagnosed as having been used on such materials.

These preliminary stone tool results indicate that Owens Ferry is a secondary processing camp related to moa hunting. Butchering was an important activity, but not the major one *per se*, and plant processing did not feature in the site activities.

SUMMARY

The faunal remains indicate that Owens Ferry is a secondary processing site related to moa hunting. It is somewhat removed from the actual kill site or sites, yet close enough to justify returning some low value portions of the carcass to the site. The specialised nature of the remains rules out the possibility of this being a permanent or long term habitation site. The hunting strategy sought a broad spectrum of moa species rather than specialising on a particular one. Hunting of solitary birds appears probable.

ACKNOWLEDGEMENTS

I wish to thank Neville Ritchie, Project Archaeologist for the Clutha Valley Development, Cromwell, for making the Owens Ferry material available to me. I also wish to thank John Darby for his assistance with the Otago Museum moa material and Richard Newell for the illustrations.

REFERENCES

Anderson, Atholl J. 1983a. The prehistoric hunting of Moa (Aves: Dinornithidae) in the high country of southern New Zealand. *In* Grigson, Caroline and Clutton-Brock, Juliet (Eds), *Animals and Archaeology: 2. Shell Middens, Fishes and Birds*, pp.33-52. British Archaeological Reports International Series 183.

Anderson, Atholl J. 1983b. *When All the Moa-ovens Grew Cold: Nine Centuries of Changing Fortune for the Southern Maori.* Otago Heritage Books, Dunedin.

Binford, Lewis R. 1978. *Nunamiut Ethnoarchaeology*. Academic Press, New York.

Binford, Lewis R. and Bertram, Jack B. 1977. Bone frequencies—and attritional processes. *In* Binford, Lewis R. (Ed.), *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, pp.77-153. Academic Press, New York.

Cracraft, Joel. 1976. The species of Moa (Aves: Dinornithidae). *In* Olsen, Storris L. (Ed.), *Collected Papers in Avian Paleontology Honoring the 90th Birthday of Alexander Wetmore*, pp.189-205. Smithsonian Contributions to Paleobiology 27.

Duff, Roger. 1977. *The Moa-hunter Period of Maori Culture*. Government Printer, Wellington (3rd edn.).

Kooyman, Brian P. 1981. Métis Faunal Remains and Variables in Archaeological Butchering Pattern Analysis. Unpublished M.A. thesis, University of Calgary.

Krantz, Grover S. 1968. A new method of counting mammal bones. *American Journal of Archaeology* 72:286-288.

Millener, P. R. 1982. And then there were twelve: the taxonomic status of *Anomalopteryx owenii* (Aves: Dinornithidae). *Notornis* 29:165-170.

Odell, G. and Odell-Vereecken, F. 1980. Verifying the reliability of lithic use-wear assessments by 'blind tests': the low-power approach. *Journal of Field Archaeology* 7:87-120.

Ritchie, Neville A. and Harrison, Anna. 1981. Clutha Valley Archaeology 1980-1981: an interim report. *New Zealand Archaeological Association Newsletter* 24:97-105.

Sadek-Kooros, Hind. 1972. Primitive bone fracturing: a method of research. *American Antiquity* 37:369-382.

Scarlett, R. J. 1974. Moa and Man in New Zealand. *Notornis* 21:1-12.

Smith, Ian W. G. 1979. Prehistoric sea mammal hunting in Palliser Bay. *In* Leach,

B. Foss and Leach, H. M. (Eds), *Prehistoric Man in Palliser Bay*, pp.215-224. National Museum of New Zealand Bulletin 21.

Tringham, R., Cooper, G., Odell, G., Voytek, B., and Whitman, A. 1974. Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of Field Archaeology* 1:171-196.

Vaughan, Patrick Clemente. 1981. Lithic Microwear Experimentation and the Functional Analysis of a Lower Magdalenian Stone Tool Assemblage. Unpublished Ph.D. thesis, University of Pennsylvania.

Wheat, Joe Ben. 1972. *The Olsen-Chubbuck Site: A Paleo-Indian Bison Kill.* Society for American Archaeology Memoir 26.

Received 3 April 1984