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TAIRUA - RESULTS OF MIDDEN ANALYSIS

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Abstract

Various methods of midden analyses used at different times to analysis material from Tairua are investigated and compared. The investigation of the smaller or less obvious constituents of faunal assemblages is shown to be important in increasing our knowledge of environmental and behavioural aspects of a site.

INTRODUCTION

The Tairua site (N44/2) Coromandel Peninsula, is composed of 2 cultural layers. The lower layer (2) is an Archaic campsite containing moa bone, a variety of other bird remains and a range of shellfish species. The later layer (6) contained mainly pipi and cockle shells. The Archaic layer is probably well-known to most New Zealand archaeologists as being one of the first truly areal excavations in the North Island, where all material was recorded in situ, and where emphasis was placed on environmental rather than artifactual interpretations (Smart & Green 1962). Midden material from the 1959 excavation of the Archaic layer has been discussed (Smart & Green 1962: 234-256) and midden material from the upper layer 6 analysed as part of a general study of midden structures (Davidson 1964). The Archaic layer was again excavated in 1964 but midden material from this excavation was not discussed is a subsequent paper which dealt only with a 'pearl-shell lure' and its possible derivation in Polynesia (Green 1967).

Analysis of further published and unpublished material from the site has recently been completed (Rowland 1975). This study included a re-analysis of midden material from layer 6 collected in 1963 and reported by Davidson (1964) and material collected by Green in 1964 from layer 2, but not previously analysed.

Results of theoretical and methodological interest, relevant to midden analysis in general, arose from the comparative nature of the study. For example, it was possible; to compare results based on different methods of quantification (by minimum numbers and by percentage weights); to compare the effects of retaining various sizes of unsorted 'residual' categories, and, given material from two major phases of excavation of layer 2, to compare sample sizes and discuss the total site composition. The importance of analysing the smaller or less obvious constituents of faunal assemblages was also realised. These points are elaborated in this paper.

MIDDEN ANALYSIS

Shell from layer 2 & layer 6

Layer 6: A major criticism of midden analyses has been the tendency to underestimate shellfish numbers. In California shell-mound studies underestimation has been calculated to vary from 30 to 300% if standard analysis is carried out (see Koloseike 1968: 372-373 for the standard analysis, which is the procedure generally followed in New Zealand). The primary cause of underestimation was the retention of residue categories of 50% or greater (Koloseike see 1968: 372-373 for the standard analysis, which is the procedure generally followed in New Zealand). The primary cause of underestimation was the retention of residue categories of 50% or greater (Koloseike 1968: 373).

Davidson's analysis of material from layer 6 included a residue category of about 75% of the total weight of samples from the upper lens and 60% from the lower lens (Davidson 1964: 99-100: Tables 111A and 111B).

In the present analysis of this material the residual category was reduced as much as possible. Some smaller shell fragments were viewed microscopically. An average residual category of 16% for layer 6 and 22% for layer 2 was achieved. The effects of this on each midden component can be seen when my results for layer 6 (with a residual of 16%) are compared with Davidson's (with a residual of about 75%).

Fig. 1. Comparison of Percentage of shell species and other components for the upper layer (6), Tairua.

	Sample No					
Chione stutchburyi	2	3	8	9	10	AV
Davidson (1964)	16	22	11	13	14	15.2
My analysis	63	57	41	42	49	50.4
Amphidesma australe						
Davidson (1964)	12	12	9	8	7	9.6
My analysis	28	32	38	22	26	29.2
Other shell						
Davidson (1964)	>1	1	>1	>1	>1	>1
My analysis	1	2	1	1	7	2.4
Residue						
Davidson (1964)	71	66	80	78	78	74.6
My analysis	5	8	17	35	14	15.8
Bone						
My analysis	1	>1	>1	>1	1	>1
Stone						
My analysis	2	-	1	1	1	1
Charcoal						
My analysis	>1	1	1	>1	1	1

The effect of reducing the residual category by around 60% was to increase considerably the percentage weights of Chione and Amphidesma. In other words, Davidson's residual category included a high percentage of Chione and Amphidesma. The bone, stone and charcoal categories comprised only about 2% of Davidson's residual category.

Category weight percentages, like those produced above, have often been uncritically extended to the general midden composition and total shell weights estimated using empirical density or volume measurements, which are then used as the basis for estimating meat weights (Koloseike 1968: 372-373). Had meat-weights been estimated using Davidson's figures a considerable underestimation of both Amphidesma (by 20%) and Chione (by 35%) would have resulted. Davidson at no time indicated an intention to estimate meat-weights, her research was concerned with the structure and composition of middens. The composition of layer 6 midden, is however, not well illustrated by her figures of 15% for Chione and 9% for Amphidesma when compared with those presented here of 50% and 29%. When shell categories as percentages of the total shell weight only were compared, thus excluding the residual category from estimations, the basic ratio of Amphidesma to Chione was found to be similar in both studies.

In conclusion one must agree with Koloseike that considerable underestimation of shell quantities will result from leaving large unsorted residual categories. When these are used to calculate further absolute quantities, such as meat weights, error is more seriously magnified. In sum, absolute estimates of shell quantities, meat weights etc. will be invalid if large amounts of unanalysed residue remain. While the retention of large amounts of residue does not appear to alter the estimation of ratios of different species it is the absolute figures which archaeologists require for most kinds of study.

Davidson did not elaborate on her 'other shell' category but this more detailed analysis revealed the presence of sea egg (Evechinus chloroticus), Paua (Haliotis iris), mussel (Perna sp.) and Cats' eye (Lunella smaragda). Quantities were small and they are obviously not of major importance but do indicate at least some exploitation of the rocky-shore habitat.

Layer 2: Estimation of shell numbers by Smart and Green (1962: 245) from layer 2 involved a 'count' made of each type of shell as it was uncovered while in some squares only the presence or absence of species was noted (Smart and Green 1962: 256). Minimum numbers of bivalves in layer 2 were estimated by halving the original total number of these shells (Smart and Green 1962: 257 Table 2). Such an approach must affect a true estimate of minimum numbers since oddly there is seldom equal representation of left to right valves. Also counts of shells as they are recovered would be affected by the experience in identification of individual excavators. Small shells and shell fragments would undoubtedly be overlooked. These methods of estimation would in effect result in a large but uncollected residual category.

My results for layer 2 are compared (Fig. 2) with Smart and Green's (1962) and Davidson's (1964: 123). The criteria for comparison is not the same as with layer 6. The samples are not the same, although all are from layer 2. Neither Smart and Green (1962) nor Davidson (1964) include a residue category or weights for midden components other than shell so that the relative importance of the total shell and each shell type to the other midden components cannot be established.

Fig. 2. Shell types as Percentages of total Shell Layer 2, Tairua.
My analysis by weight.

Square Number	C4	C6	C7 No1	C7 No2	B9	Av	Davidson '64 by weight	Smart & Green '62 by number
Cellana denticulata	32.7	50.5	21.9	17.8	20.7	28.7	35.6	28.7
Lunella smaragda	19.2	20.7	54.8	39.1	27.2	32.2	27.8	32.0
Haliotis iris	32.8	1.7	2.0	3.7	x	9.9	6.8	12.8
Perna sp.	3.9	13.5	7.8	5.7	10.6	8.3	0.8	22.0
Evechinus chloroticus	-	x	0.7	2.5	4.2	1.4	-	-
Crassostrea glomerata	3.4	-	-	x	-	0.6	26.2	0.6
Chione stutchburyi	7.4.	12.7	8.1	27.0	30.7	17.1	2.5	1.6
Amphidesma australe	0.2	-	0.9	0.8	0.7	0.5	0.3	0.3
Other Shell		0.5	2.5	3.0	5.5	2.3	-	6.1

x = less than 1 gm.

There is a remarkable degree of correlation in the results considering the differences in the extent to whicn the material was sorted, the way in which numbers were calculated by Smart and Green and the different methods of presentation. Where results are different these could be attributed to the same spatial variation noted by Jones (1973) for the deposition of other site components. Relatively minor differences occur between the three studies in the average quantities of Cellana denticulata, Lunella smaragda, Haliotis iris and Amphidesma australe. Only Perna sp. varies considerably among the three (Smart and Green 22%, Davidson 0.8%, mine 7.5%). The different methods of presentation might account for some differences. For example, estimation by number would favour mussel with its diagnostic hinge, while its importance by weight would be underestimate due to its fragile shell. However, spatial variation is more likely to account for the differences. Only one species, sea egg (Evechinus chloroticus) was not recognised by either Smart and Green or Davidson. A total of 69gms (1% of the total shell weight) were recorded in the present study, identified by spines and small fragments. Since it is present in all but one of the layer 2 samples, local variation is unlikely to account for its absence from Smart and Green's study and its identification here is probably a result of the more detailed analysis.

There appears to be considerable agreement between the results despite the different methods used. However while there is consistency in the ratios of different shell types (as there was for results from layer 6) there is no way of estimating the shell component in relation to the total midden sample. As with layer 6 it would be expected that the proportion of shell in the total midden sample was underestimated, given the similar degrees of analysis.

CONCLUSION AND DISCUSSION

Shell weights or minimum numbers: From her study of midden analysis procedures Davidson concluded that presentation by weight rather than by minimum numbers was likely to be most accurate (Davidson 1964: 147-166). On the other hand it has been suggested that percentage of species by weight alone is insufficient and that counts of individuals by minimum numbers is essential (Ambrose 1963: 156-158). Both methods of presentation are now generally standard practice in midden analysis. Estimation by minimum numbers has been attempted where possible in this study (see Appendix A) but the results were not used in percentage estimations. Nor were minimum numbers of different shellfish species compared as estimation by minimum numbers was not regarded as very precise. For example, while minimum numbers of bivalves could simply be estimated by counting left and right valves and numbers of rocky-shore types like cats-eye estimated from operculum, in general, the fragmentary nature of shell middens (especially rocky shore middens) does not facilitate such estimations. To take an example, Cellana denticulata specimens in square C4 were reasonably well intact and 57 individuals could be identified, weighing 440gms. In contrast Cellana denticulata shell from square C7 sample No 1 was extremely fragmented and no single individual could be recognised. On the basis of shell weight (371 gms) as many as 50 individuals could be represented. However, for this to be acceptable a number of assumptions about size of individuals and degrees of fragmentation would have to be made, and we are not in a position to make these. Furthermore, comparison of minimum numbers between layers with a number of whole shells (layer 6) and a layer with very fragmentary shells (layer 2) would not be of much value. Results expressed both by percentage numbers and weights are to be preferred as at least then they provide independent checks. Different results are inevitable as the two methods measure different things. Davidson estimated both weights and minimum numbers for layer 6 (Davidson 1964: 99-100 Table 111A) and this reflected the differences inherent in using the two methods.

Sample size and sieve size: Other aspects of midden analysis which have been much debated are sample size and sieve size (Cook and Heizer 1951: Heizer 1960; Greenwood 1961: 419; Smart 1962: 167; Davidson 1964: 166; Chartkoff 1966: 131; Terrell 1967: 53). No sieves were used at Tairua, but the degree of analysis undertaken in this study enable some comments to be made concerning sieve size. It has been argued that to estimate meat values an ⅛ inch mesh is essential (Koloseike 1968: 377-378). Estimating meat weights should not however be the only reason for analysing small material and it will be shown below that important information can be got from the smallest of midden components. Nevertheless, it is probably not worth spending the considerable amount of time that was spent in this study in sorting all such material, but rather to sort a few randomly selected samples (Koloseike 1968).

All except one sample in layer 6 were over 500gms and those in layer 2 generally over 1000gms. The structure of the midden must be important in determining sample size. A sample of 500gms was sufficient to determine the predominance of pipi and cockle in layer 6 and 1000gms enough to detect the variation in layer 2, where this was coupled with analysis of the small finds.

Estimation of meat weights: Davidson concluded from her study that it should be possible to estimate the amount of meat consumed at a small camping site such as represented by layer 2, Tairua (Davidson 1964: 174).

There are however a number of problems with such estimations. Firstly, we do not know how representative the samples are of the total site, nor the proportion of shellfish eaten but not deposited in the site. Also some resources may have been dried or preserved for future consumption, rather than at the period of occupation. Site densities calculated on samples which include shells of unnoticed utilitarian or ornamental use (Feldman 1972: 90) would produce deceptive results. Estimation of shell quantities for Layer 2 was made by weight only as attempts to estimate minimum numbers was considered unsatisfactory. But estimation by weight may seriously underestimate shell quantities due to etching and dissolving of shell over time (Koloseike 1968: 375-376).

Biological changes in the life of shells also present problems in estimating meat weights. The meat content of cockles, for example, can vary as much as 50% between winter and summer catches (Hancock and Simpson 1962: 38) and fast-growing cockles have lower flesh weights (Larcombe 1971: 19). Comparisons between archaeological shell remains and modern shellfish populations may produce unknown discrepancies since one cannot know the long-term and cumulative affects of man and other factors on the modern populations. When the results of palaeontological studies (Boucot 1953; Olson 1957: Ager 1953) of naturally occurring fossil populations are considered, it is obvious that a number of factors select out certain classes of a population prior to any of the selective abilities of man. Exploitation of shellfish and fish do have cumulative effects which may be beneficial (Hancock 1971: 433-436; Gulland 1971: 452) or non-beneficial (Swadling 1972: 61; Larcombe 1971: 31) in the general sense of either increasing or decreasing the locally available meat supply. Such effects will be difficult if not impossible to detect archaeologically.

In estimating population sizes associated with a midden it is also necessary to estimate archaeologically the contribution of plant remains to the site. General estimations for the respective dependence on gathering and fishing have been made (Coutts 1971: 190) but the varying importance of vegetable plants indicated by the ethnographic record (Colenso 1880) and the regional importance of forest resources (Best 1902) would suggest such estimations vary for largely unknown and untestable reasons.

Only about a quarter of the lower layer at Tairua has been excavated and activity areas are sharply differentiated (Jones 1973: 149) so it would be unwise to make assumptions for the site as a whole.

Population estimations from shell middens have produced orders of magnitude of populations (Shawcross 1967) and the relative importance of different foods in a diet (Shawcross 1972) and sources of error have been recognised and made explicit (Shawcross 1970: 282). Nevertheless, Shawcross's 692 ± 699 man days is "an affective indicator of our inability to define with any precision the magnitude of many of the variables introduced into the calculations" (Coutts 1971: 185). Estimation of meat weights from the Tairua evidence was not attempted because of the lack of control over many of the important variables.

<u>Bone material from layer 2</u>: The fish and bird bone material from the layer 2 midden samples was not identified in detail but Denis Bryne was able to identify Tarakihi (<u>Nemodactylus macropterus</u>), kingfish (<u>Seriola grandis</u>) and also snapper (<u>Chrysophrys auratus</u>). Of these three, snapper is the only one previously recorded from the site.

The major bird and mammal bones from the 1959 excavation have been identified and discussed by Ron Scarlett and John Yaldwyn (in Smart and Green 1962: 256-263). Similar bone material from the 1964 excavation was also identified by Scarlett and Yaldwyn but has not previously been published and thus is included here as an Appendix (b).

Minimum numbers of species were estimated by counting recurring bones and immature bones. Due to the very fragmented nature of the bone, underestimation of numbers can be expected. When identified species of birds and mammals are grouped from each period of excavation (Fig. 3), the comparison reveals some interesting results in terms of the representativeness of samples from each period.

Fig. 3. Birds and Mammals identified from the various phases of excavation at Tairua.

1959 only	Min. No	1964 only	Min. No	Both excavations	Min. No
Kakapo	1	Pigeon	4	Oystercatcher	2
Caspian Tern	1	Albatross	1	Tui	5
Paradise Duck	1	Black-fronted Tern	1	North Island Weka	2
Pied Stilt	1	Prion	1	North Island Kaka	2
Smaller Petrel	1	Grey faced Petrel	1	Pied shag	1
		Extinct crow	1	Shag	1
		Spotted shag	1	Grey Duck	2
		Mollymawk	1	N.Z. Kokako	1
		Southern Crested Grebe	1	Black-backed gull	1
		Redfronted Parakeet	1	Giant Petrel	1
		Falcon	1	<u>Puffinus</u> sp.	1
		Southern Fur Seal	1	Little Blue Penguin	2
		Rat	1	North Island Wattled Crow	1
		Dog	1		

Neither the bone from the 1959 nor the 1964 excavation are representative of the total site composition and spatial variation in deposition of bone material is marked. With such differences in a quarter of the site, further, perhaps marked, variability could be expected in the total site. Total excavation would reveal the remaining variability, however this would not be feasible or ethical.

<u>Other Results:</u> The shell weight of samples from layer 6 is in most cases greater than 95% of the total sample weight. Layer 6, is clearly a shell dump with only very minor 'other components'. In contrast layer 2 midden samples indicate it is not simply a 'shell dump' and there is also variation in the spatial distribution of midden components (Jones 1973). In this plan of the site Jones (1973: 144) notes a shell midden,

an oven base and a firepit in Square B9. The midden sample from this square contained a stone category of 23.6% of the total sample weight, largely fragments of oven-stones thus confirming the presence of the firepit. No features are noted by Jones in squares C4 and C5 but the midden samples from these squares contained large quantities of shell (86.9% and 85.6%) so that an extension of the midden from square C3 is likely. On Jones' plan square C7 contains a shell midden. The two midden samples from this square included high percentages of bone (8.1% and 13.5%), stone (11.9% and 9.8%) and charcoal (4.5% and 3.2%). Thus while these deposits are middens they differ from material in square C3, C4 and C5 which are cleaner shell middens. Material from the midden in square C7 was more fragmented than in squares C4 and C6. Perhaps material was dumped in the area of C7 and then some activity took place on it, such as the activities associated with the adze debris and firepit indicated by Jones in C8. The midden analysis thus confirms the spatial specialisation noted by Jones but also reveals differences in the nature and composition of the various middens. These differences may have resulted from isolated hunting/gathering episodes but a very fine-grain excavation procedure would have been required to determine these.

UNECONOMIC SHELLS

As a result of reducing the size of residual categories a large number of small shells were identified. These have been classified 'uneconomic shells', being too small to be considered sources of food. They must have entered the midden attached to major edible shellfish, in sand, or attached to sea plants.

The 'uneconomic shells' (see Appendix C) reveal that at both periods of collection, represented by layer 2 and layer 6, both mudflat, rocky-shore and sandy-shore habitats, and in addition in layer 2, the reef fringe zone, were being exploited. The separation of middens into 'rocky-shore' and 'pipi-cockle' types is not as clear-cut as the general division implies when the 'uneconomic shells' are considered. The 'uneconomic-shells' and the relatively high percentage of cockle shell (17.1%) in layer 2 shell samples suggest that while a high percentage of shellfish were coming from the rocky-shore habitat, other habitats were certainly not being overlooked. Smart and Green (1962: 255-256) emphasise the difference between the earlier predominately rocky-shore midden and the later pipi-cockle midden and argue a case for dietary change. Since the samples analysed in this study reveal that cockles are the third most common species by shell weight their arguements are not well substantiated.

Layer 2 contained five shellfish species from the reef fringe zone which together with the evidence for sea-egg Evechinus chloroticus might indicate diving for shell-fish as indicated in ethnographies. In layer 2 and 6 the small top shell Cantharidella tessellata, and from layer 2 the Tiger shell Maurea punctulata were identified. These species are often associated with sub-tidal kelp. Ethnographic evidence suggests that kelp was used for potting birds and seal blubber and these activities are clearly an intriguing possibility (no more than that) in view of the number of birds butchered on the site.

Habitat Demands: One aim of the more detailed midden analysis was to investigate the 'habitat demands' of major shellfish species, the 'uneconomic shellfish', and landsnails with the view that they might reflect aspects of the local environment and changes in that environment (Morrison 1942: 382-383; Willey and McGimsey 1954: 126; Matteson 1960: 118-119).

Unfortunately, few of the species represented at Tairua, proved to be habitat diagnostic. Among the more common shellfish at Tairua, Chione stutchburyi, for example occurs in coarse, low-tidal sands of entrance areas, in fine sands and muds of estuarine areas, from sublittoral regions in channels to inter-tidal areas, and on flats high on the shore, being in general unaffected by substrate grades (Larcombe 1971: 27). One important shellfish species from layer 2 which did however prove significant when its habitat was investigated, was Cellana denticulata. This has been the subject of a separate paper (Rowland 1976) and need not be discussed here.

Among the small finds of importance were 3 specimens of the landsnail Austrosuccinea archeyi and a species of Charopa from layer 6 (identified by Richard Willan). Landsnails have only been reported infrequently from archaeological sites in New Zealand (Foxton (B. McFagdean pers. com.); Hotwater Beach (Leahy 1974: 68); South Bay Midden, Slipper Island (Willan 1974)) yet they must be considered important in discussing local environmental and anthropogenic influences (Evans 1972).

Species like Austrosuccinea archeyi are particularly important because of their restricted habitat range (Powell 1950). Living and extinct colonies and the chronological sequence of this species have been studied in a number of localities in New Zealand (Powell 1950: 67-69). It is difficult to interpret the significance of so few specimens of Austrosuccinea and other landsnails from Tairua. If landsnails typical of coastal forest, such as Delos jeffreysiana and Rhytida greenwoodi were present in layer 2 then it might be possible to suggest that coastal forest was maintained during this period through to the deposition of Layer 6 at which point the presence of Austrosuccinea suggests that a sand-grass community was or had been established in the immediate area. At present all that can be inferred is that either climatic change prior to the layer 6 occupation or human induced changes at the period of occupation removed an unknown vegetation type replacing it with a sand-grass community.

SUMMARY

This paper has been critical of midden analyses which ignore, by way of leaving a large unsorted residual category, the smaller or less obvious constituents of faunal assemblages (Casteel 1972). Hopefully, it has demonstrated that it is possible to extract a considerable amount of ecological and behavioural information from such material.

A negative attitude to the estimation of population numbers from midden samples was also expressed. This attitude developed in part because of the nature of the Tairua evidence which would have made such estimations of dubious value. However, in the case of Tairua and other such sites, estimating population numbers overlooks the more important problem of defining the sites function. Inevitably, with population estimations one is faced in the final analysis with the logical problem of '1 person for 200 days' or '200 people for 1 day'. One of a range of population estimations might become more realistic when the function of a site both internally, in respect to the activities represented and externally, in relationship to other sites in the annual economy is more clearly understood. This argument has been developed more fully elsewhere (Rowland 1977).

Appendix A. Tairua Midden Analysis Layer 6

	Sample 2			Sample 3			Sample 8			Sample 9			Sample 10		
	Min.No.	Wt.gms.	% total sample weight												
Chione stutchburyi	310	928	62.78	61	175	56.81	76	220	41.5	53	240	42.03	93	350	49.01
Amphidesma australe	246	410	27.74	61	99	32.14	97	202	38.11	62	124	21.71	70	185	25.91
Lunella smaragda		X			X		-	-	-	-	-	-		X	
Haliotis iris		X			X		-	-	-	-	-	-		X	
Perna sp.		X		-	-	-	-	-	-	-	-	-		X	
Evechinus chloroticus		X			X			X			X			X	
Other Shell		20	1.35		5	1.62		5	0.94		3	0.52		50	7.00
Bone		18	1.21		1	0.32		2	0.34			0.20		10	1.40
Stone		23	1.55	-	-	-		6	1.13		4	0.70		10	1.40
Charcoal		3	0.20		4	1.29		4	0.75		2	0.35		9	1.25
Residue		76	5.14		24	7.79		91	17.16		198	34.57		100	14.00
		1478			308			530			571			714	

x = less than 1 gm.

Appendix A   Tairua Midden Analysis Layer 2

	Sq. C. 4			Sq. C. 6			Sq C. 7 No.1			Sq C. 7 No.2			Sq B. 9			Average
	Min.No.	Wt.gms.	% of total weight													
Cellana denticulata	57	440	28.46	55	422	43.32		371	10.87	9	235	8.53	10	111	7.80	19.79
Lunella smaragda		259	16.75		173	17.76	307	927	27.16		516	18.75		145	10.26	18.13
Haliotis iris		442	28.58		15	1.54		35	1.02		50	1.81		X		6.59
Perna sp.		53	3.42		113	11.60	35	133	3.89		76	2.76		57	4.00	5.13
Evechinus chloroticus	-	-	-		X			12	0.35		34	1.23		23	1.61	0.63
Crassostrea glomerata		47	3.04		X			X			X			X		
Amphidesma australe		4	0.25	-	-	-	6	15	0.43	8	11	0.39		4	0.28	0.27
Chione stutchburyi	9	100	6.46	11	106	10.88	20	137	4.01		356	12.93		165	11.60	9.17
Other shells					5	0.51		60	1.75		40	1.45		30	2.10	1.16
Bone		3	.19		10	1.02		280	8.20		149	5.41		107	7.62	4.48
Stone		13	0.84		10	1.02		407	11.92		291	10.57		335	23.55	9.58
Charcoal	-	-	-		4	0.41		152	4.45		96	3.48		41	2.88	2.24
Residue		185	11.96		116	11.90		883	25.87		898	32.63		403	28.34	22.14
		1546			974			3412			2752			1422		

Appendix B Identified Bone Material from Tairua

Includes material excavated in 1959, identified by John Yaldwyn and Ron Scarlett and described in Smart and Green 1962 by Yaldwyn and material excavated in 1962 identified by Yaldwyn and Scarlett but not previously published.

Layer 2	Identified from 1958 excavation	Identified from 1962 excavation
Moa		
Pachyornis septentrionalis (Oliver)	R. ischium (frag.)	L. femur distal L. femur Proximal L. femur ?Proximal shaft L. femur distal R. tibia ?distal part L. tibia shaft L. tibio-tarsus distal shaft tibio-tarsus
Dinornis novaezealandiae (Owen)	distal L. femur proximal R. femur shaft frag. R. fibula Distal frag. fibula Distal end fibula Immature distal L tarso-metatarsal 3 frag. R. tarso-metatarsus Distal R. tibio-tarsus Shaft frag. tibio-tarsus 20 frag. tibio-tarsus	
Pachyornis mappini (Archery)	proximal and part shaft L. femur proximal L. femur shaft L. femur sub-adult shaft R. femur distal R. femur Articulatory head R. femur proximal and part shaft L. tibia proximal L tibia shaft frag. L. tibia proximal shaft frag. R. tibia distal frag. R. tibio-tarsus frag. R tibio-tarsus	
Dinornis? struthoides (Owen)	2 tracheal rings worn cervical vertebrae 4 worn vertebrae	distal R. tarso-metatarsus 2 associated phalanges

Dinornis? giganetus	sub-adult distal L. tibia	
Moa (small)	sacral frag.	L. fibula
Moa (bigger than above)	R. ischium pelvis	shaft L. fibula
Dinornis sp.	pelvic rib frag. vert. frag. vert. + rib.	Distal L. femur distal frag. R. tibio-tarsus proximal shaft R. tibio-tarsus shaft and frag. of tibio-tarsus 3 shaft frag. tarso-metatarsus
Birds Layer 2	1958	1962
Oceanic		
Diomedea sp. Albatross		10 frag. R. humerus 8 frag. humerus proximal frag. R. coracoid
Thalassarche cauta sub.sp Mollymawk		worn sub-adult R. femur
Eudytula minor iredalei Little Blue Penguin	R. femur Distal and shaft of tibia	2 L. humeri distal R. femur R. acetabular frag.pelvis Distal and shaft L. tibio-tarsus shaft L. tibio-tarsi R. coracoid part R. coracoid part L. coracoid
Sea-Coastal		
Haematopus sp. Oystercatcher	proximal and shaft R. humerus Distal R. humerus R. scapula L. ulna distal and shaft L. radius R. coracoid	slightly sub-adult distal R. humerus part L. humerus worn L. ulna sternum sacrum coracoids distal L tarso-metatarsus ?frag. of furcula

Phalacrocorax varius varius Black Shag	Distal R. femur R. radius R. tibia R + part L. ulna R coracoid L. anterior ramus cranium Forepart cranium posterior pro-maxilla	Proximal & shaft R. femur distal shaft frag. R. humerus shaft L. tibio-tarsus
Stictocarbo punctatus p. Spotted shag		shaft L. ulna
Phalacrocorax sp White throated or Little Black Shag	R. femur Distal L. femur proximal L. humerus L. tibio-tarsus part R. coracoid	Distal & shaft R. femur shaft femur proximal R. carpo-metacarpus frags. L. carpo-metacarpus sternal frags.
Larus dominicanus Black-backed gull	proximal & frag. L. humerus part shaft R. ulna distal R. tarso-metatarsus distal L. tarso-metatersus	proximal R. humerus
Hydroprogne caspia Caspian Tern	L. coracoid	
Puffinus sp.	distal R. humerus	

? probably shearwater distal and shaft R. tarso-metatarsus

Macronectes giganetus halli Giant petrel	section worked humerus	distal end of diseased R. humerus distal frag. R. tarso-metatarsus
Pachyptila sp Prion		part shaft distal L + frag. shaft R. humerus
Pterodroma macroptera gouldi Grey-faced petrel		Distal end R. humerus

Shore lagoon and swamp

Gullirallus australis greyi North Island Weka	L. femur	R. tibio-tarsus L. proximal and 2 L. tibio-tarsus

Anas superciliosa Grey Duck	proximal and distal R. humerus	R. part of R. femur L. humerus proximal + shaft L. humerus R. part 2 ulna part L. radius Distal shaft R. tibio-tarsus shaft R. tibio-tarsus frag. R. carpo-metacarpus part L. proximal R.coracoid frag. coracoid
Tadorna variegata Paradise Duck	R humerus	
Large Duck	2 R. femur	
Chlidonias hybrida albostriatus Black fronted Tern		distal and shaft R. humerus frag. L. humerus
Podiceps cristatus australis Southern Crested Grebe		distal end & shaft R. femur distal end & shaft L. tibio-tarsus
Forest		
Prosthemadera novaeseelandiae Tui	R. humerus R. coracoid	proximal L. humerus R & 2 L. coracoid R. tarso-metatarsus distal R. tibio-tarsus shaft frag. R. tibio-tarsus 5R + 2L tarso-metatarsi (min.No. 5 individuals)
Hemiphaga n. novaeseelandiae Pigeon		immature L. cor coid L. ulna parts R + L ulna shaft R. ulna L. radius distal end, part shaft L. radius shaft 2 L. ulna shaft R. tarso-metatarsus distal L. carpo-metatcarpus distal R. tibio-tarsus distal + shaft L. tibo-tarsus proximal R. coracoid

Strigops habroptilus Kakapo	shaft R. tibia	
Nestor meridionalis septentrionalis North Island Kaka	L. femur L. ulna Upper mandible R + L palatines shaft frag. R tibio-tarsus	R. ulna Distal R. Humerus shaft frags. R. + L. humerus part L. radius R carpo-metacarpus proximal frag. R. carpo-metacarpus distal frag. L coracoid R. palatines forepart of cranium premaxilla shaft 2 R ulna shaft 2 R. humerus shaft L. tibio-tarsus distal L cor coid distal frag. L humerus proximal L humerus proximal frag. R scapula proximal frag.R carpo-metacarpus worn R ulna part mandible L coracoid 2 part pre-maxilla L palatine 3 frag. mandible R + L carpo-metatcarpus part palatine L scapula R tibio-tarsus Anterior frag. sternum
Callaeus cinerea North Island Wattled Crow	Distal R. tibia	L humerus R coracoid part shaft R tibio-tarsus shaft R tarso-metatarsus proximal frag. L tarso-metatarsus
Cyanoromphus n. novaezelandiae Red-fronted Parakeet		L coracoid
Falco novaezeelandiae Falcon		Anterior sternum

Palaeocorax moriorum Extinct Crow		Distal end and shaft of L. tibio-tarsus
Mammal		
Arctocephalus fosteri Southern Fur Seal	2 R humerus 2 L humerus 2 L femur 2 R ulna part L + R humerus parts L + R ulna	cranial frags. frags mandible R ramus mandible frag. R. maxilla rib frags. frags. inter-vertebrate plates 2 cavidal vertebrate acetabular portion pelvis part L scapula metatarsals and metacarpals
Macrorhinus leoninus Southern Elephant Seal		sub-adult lower jaw other frags.
Rattus exulans Kiore	R humerus R proximal L femur	
Canis familiaris Dog	atlas veretebrate shaft R radius part R frag. of L maxilla	

Appendix C. 'Uneconomic Shells' identified from Tairua

	Mudflat	Sandy Shore	Rocky Shore	Reef Fringe
From layer 6 only	Zediloma atrovirens	Cominella adspera Cominella glandiformis Macomona liliana	Eliminus plicatus Sigapatella novaezelandiae Zeacumantus subcarinatus Modiolus neozelandius	
From layer 2 only	Notoacema helmsi	Zethalia zelandica Zeacolpus padogus Siphonia zelandia Baryspira australi Cominella virgata Taron dubius	Maoricryta costata Tetraclita purpurascens Chamaesipho brunnea Ophicardelus costellaris Penion adusta	Maurea puntulata Parantrophon stangeri Chlamys zelandiae Pecten novaezelandiae Haliotis australis
Both layers	Zeacumantus lutulentus Zediloma subrostrata	Dosinia anus	Notoaema parvicnoidea Amaurochiton glaucus Maoricryta monoxyla Nerita melanotragus Radiacema inconspicua Melagraphia aethiops Cantharidella tessellata Haustrum haustorium	

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