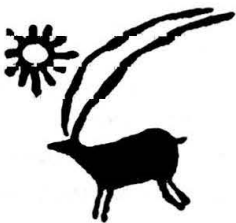


The Role of Zooarchaeology in Archaeological Interpretation: A view from Australia

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ABSTRACT: The foundations of Australian zooarchaeology are to be found in early paleontological studies concerned with extinct fauna and their association with humans. It was not until the 1960s that interest in faunal research was rekindled. In this paper we explore the evolution of zooarchaeological research in Australia and Tasmania by reviewing the contents of over 350 papers, books and theses that, over the past 35 years, have been devoted in some way to the study of faunal remains. This study shows that most of this research has been in three categories, namely, taphonomy, subsistence and extinction studies. Some 20% of these studies reside in unpublished undergraduate theses while another 55% have been published in journals, both national and international. It is also evident that periods of highest output are often associated with individual researchers and that since 1992 there has occurred a steady decline in both the published and unpublished material.

KEY WORDS: AUSTRALIA, FAUNA, ARCHAEOLOGY, ZOOARCHAEOLOGY, BIBLIOGRAPHY, TRENDS

RESUMEN: Los orígenes de la arqueozoología australiana han de buscarse en estudios clásicos de paleontología referidos a faunas extinguidas y su asociación con el hombre. Desde entonces, no es sino hasta la década de los sesenta que resurge el interés por los análisis de fauna. En este trabajo se revisa la trayectoria de la investigación arqueozoológica en Australia y Tasmania a través de una revisión de contenidos de más de 350 artículos, libros y tesis universitarias dedicadas al tema a lo largo de los últimos 35 años. El estudio muestra como gran parte de estas investigaciones pueden encuadrarse dentro de tres categorías, a saber, tafonomía y análisis de extinciones y de subsistencia. Aproximadamente un 20% de esta producción científica está compuesta por tesis de licenciatura inéditas en tanto que un 55% ha sido publicada en revistas nacionales o internacionales. Resulta también evidente como los periodos de máxima productividad coinciden con la actividad de ciertos investigadores y como, desde 1992, se detecta una progresiva disminución en la producción científica en este campo, tanto en lo referente a trabajos inéditos como publicados.

PALABRAS CLAVE: AUSTRALIA, FAUNA, ARQUEOLOGÍA, ARQUEOZOOLOGÍA, BIBLIOGRAFÍA, TENDENCIAS

INTRODUCTION

The Australian continent has been isolated from the placental faunas of Eurasia for about 65 million years from the Late Palaeocene to the present. During the late Pleistocene New Guinea, Tas-

mania and Australia were connected by land bridges that had a combined area of well over 11 million square kilometres. Because of these earlier connections they share many endemic faunas that include monotremes, marsupials and reptiles. Humans reached the continent of Sahul at least

40,000 radiocarbon years ago from Southeast Asia. They made and used watercraft sophisticated enough to cross 100 km of ocean (Irwin, 1993). The only other placental mammals to make this crossing were rats and bats (Heatwole, 1987: 121). These people were anatomically modern, biologically viable (Webb, 1989; O'Connell & Allen, 1998) and their entry into Australia marked the beginning of one of the most successful long-term, continuous continental occupations by hunter-gatherers anywhere in the world. Fundamental questions concerning the earliest human occupation of Australia are still debated (e.g. Roberts *et al.*, 1990; Allen & Holdaway, 1995; O'Connell & Allen, 1998; Thorne *et al.*, 1999; Allen, 2000; Turney *et al.*, 2001) as is the role of humans in the demise of large marsupial fauna (megafauna) (Field & Dodson, 1999; Flannery & Roberts, 1999) and their effect on the Australian environment (Head, 2000). The interaction between animals and humans has a long history and specific studies have appeared that document these relationships over time and space (e.g. Tindale, 1955; Megaw, 1966, 1969b; Merrilees, 1968; Meehan, 1977a, 1982; Jones, 1978; Kimber, 1983; Marshall, 1992; Balme, 1995; Bryden *et al.*, 1999; Field, 1999a; Cosgrove & Allen, 2001).

In Australia human/animal interaction was unique because on passing through the biogeographical transitional zone of Wallacea that separates the Oriental and Australian Zoogeographic Regions, people entered a world of marsupials, monotremes, giant flightless birds and large reptiles (Heatwole, 1987). These were to become their companions and terrestrial prey, along with molluscs, birds, marine mammals, fish, insects, megafauna and later the dingo (Thomson *et al.*, 1987: 227-228). The endemic Australian fauna had never coexisted with hominids before nor had they shared their environment with large carnivorous pack animals like hyena or wolves. Large felids and bears were absent as were smaller carnivores like the fox, wolverine and lynx. Only three marsupial carnivores were present, the thylacine (*Thylacinus cynocephalus*), Tasmanian devil (*Sarcophilus harrisii*) and the marsupial lion (*Thylacoleo* sp.) (Murray, 1991), the former two surviving across the continent until about 3,000 BP and in Tasmania into modern times. Although it has been suggested that the introduction of the dingo about 3,000 BP to the Australian mainland drove the marsupial carnivores to extinction, Thomson *et al.* (1987: 228) argue that the effect was more subtle.

They believe environmental change played a more important part in their demise in the last 4,000 years. Animals also became part of the Aboriginal Dreamtime mythology and were both symbolically and realistically represented in paintings and petroglyphs (Brandl, 1973; Stanbury, 1987: 203-205). Aboriginal people depicted several extinct species in their art including the thylacine (*Thylacinus cynocephalus*), long beaked echidna (*Zaglossus* sp.), marsupial lion (*Thylacoleo* sp.) and marsupial tapir (*Palorchestes* sp.) (Chaloupka, 1984; Murray & Chaloupka, 1984). At least another 25-30 species of mammal, bird, reptile, fish, amphibians and invertebrates were also painted (Thomson *et al.*, 1987: 204).

HISTORY

The foundations of zooarchaeology in Australia lie in vertebrate palaeontology (Wilkinson, 1885; Anderson, 1890a, b; Etheridge *et al.*, 1896; De Vis, 1899, 1900; Stirling, 1900a, b; Etheridge, 1905; Doak & Macaulay-Doyle, 1927; Anderson & Fletcher, 1934; Tedford, 1955; Wakefield, 1960a, b; Vickers-Rich & Archold, 1991). Early experimental studies by Spencer & Walcott (1911) showed that marks on extinct animal bones were made by marsupial carnivores not humans and the possibility of associations of humans and extinct fauna were discussed (Barrett, 1927). After initial attempts at discovering the antiquity of humans through their stratigraphic relationships with extinct fauna interest waned when it became apparent that many associations were equivocal in what they could reveal. Australia was not blessed by deep sedimentary sequences like those of the Somme River valley nor were there clear associations of extinct fauna and stone technology like those found in Brixham cave and Kent's Cavern (Trigger, 1989). Nearly 60 years were to pass before there was a renewed interest in fossil remains (Horton, 1982: 188). Nevertheless, issues of taphonomy, site formation processes and extinction as well as a determination of the antiquity of humans have provided on-going themes for the archaeological debate in Australia that intensified after the 1960s.

During this period archaeologists applied paleontological concepts in zooarchaeological studies largely within an ethnographic milieu. Ethnography offered an effective method for deriving

explanations from the archaeological evidence of human/animal interaction because it provided highly detailed accounts of Aboriginal economic and social life (e.g. Brough-Smyth, 1878; Roth, 1901b; Spencer, 1928; Altman, 1987) that were, and still are woven into archaeological narratives. However, the inherent danger in its overuse is the creation of an Aboriginal culture that is ahistorical. In this case, the past becomes like the present characterised by 19th century ethnographic descriptions of Aboriginal hunting and gathering (Murray, 1992). This has been a common practice in Australian archaeology, some arguing that this is effectively ethnography with a shovel that denies Aborigines a varied history (Murray, 1992). Allen (1972) showed how seductive the use of ethnography becomes when interpreting the zooarchaeological record. The analyses of Aboriginal sites located on lakes and rivers in western New South Wales dating to between 30,000 and 13,000 BP showed exploitation of local resources. Allen's initial conclusions were that sites were occupied on a short-term seasonal basis because the terrestrial fauna was found to be almost identical to that documented for 19th century Aboriginal peoples from the same region. In this case, the historical behavioural observations and the archaeological evidence were seamlessly meshed to produce a descriptive narrative about life in the late Pleistocene. Later, a revision of this explanation was made, perhaps in response to the fact that it reflected a changeless society and Allen proposed a more dynamic scenario that took into account more recent evidence and the limitations of ethnographic analogy (Allen, 1990). Alternative views of this process, its consequences and the use of appropriate time scales to investigate the past, have also been advanced both in Australia and elsewhere (Bailey, 1983; Cosgrove & Allen, 1996: 24-25; Murray, 1997, 1999; McGlade, 1999).

Human behaviour during late Pleistocene was also seen as less complex and relatively homogeneous across the continent for at least the first 30,000 years or more and argued to represent an economic system characterised as an 'immediate-return type system' (White & O'Connell, 1982: 72; Lourandos, 1997: 252, 325). As early as 1928 Aborigines were pronounced as 'an unchanging people living in an unchanging environment' suggesting that Aboriginal society was static and that there was nothing that could be learnt from archaeological excavation (Mulvaney & Kamminga, 1999: 12). Even the influence of artefact collectors

and anthropologists as recently as the 1950's largely stifled the study of temporal change in Aboriginal culture (Griffiths, 1996: 76-85). Mulvaney has argued that early academic pioneers of anthropology in Australia thought that no useful insights would come from studies of the past and that it was better to promote the study of living Aboriginal societies instead (Mulvaney & Kamminga, 1999: 12-14). It was not until the establishment of academic archaeology departments in the late 1960's and early 1970's (Mulvaney, 1993; Spriggs & Jones, 1993), the advent of radiocarbon dating and systematic archaeological excavation that finally put the question of the human/animal interactions squarely back on the agenda. This time it was taken seriously within a temporal and spatial framework that has established Aboriginal culture as one of the oldest surviving in the world.

Over the past 35 years limestone cave sites with exceptionally rich faunal records covering the last 35,000 years have been found in various parts of the continent, particularly in southwest Tasmania and southwest Western Australia (eg. Balme *et al.*, 1978; Merrilees & Porter, 1979; Kiernan *et al.*, 1983; Lilley, 1993; Cosgrove, 1995; Dortch, 1996, 1997). In addition, coastal midden sites of the eastern seaboard, inland waterways and Tasmania's west coast provide some of the very best conditions for faunal preservation that have played an important role in the interpretation of archaeological sites (Jones, 1971; Meehan, 1977b; Sullivan, 1982a; Johnstone, 1993). Inland, open sites with good faunal preservation are rare, but megafaunal sites like Cuddie Springs in western New South Wales are offering up new and tantalising evidence of the extinction process in Australia (Furby *et al.*, 1993; Field & Boles, 1998; Field & Dodson, 1999). Systematic general archaeological research on these highly productive sites has taken place repeatedly over the last 30 years (Tindale, 1955; Horton, 1976; Gillespie *et al.*, 1978; Horton & Murray, 1980; Horton & Connah, 1981; Hope *et al.*, 1983; van Huet *et al.*, 1998). In the following discussion several trends in the Australian zooarchaeological literature are examined and are discussed below.

ZOOARCHAEOLOGICAL LITERATURE

Although a range of specialised faunal studies have been undertaken since 1965, coverage has

been patchy because of the relatively small number of full time academic/research archaeologists specialising in zooarchaeology. Zooarchaeologists in Europe and America have centred their discussions on a wider range of topics, particularly those concerned with identifying the attributes of Middle and Upper Palaeolithic behaviour (Speth & Tchernov, 1998; Boyle, 2000; Burke, 2000; Stiner *et al.*, 2000), domestication (Clutton-Brock, 1989), the role of large carnivores in bone accumulation (Brain, 1981; Stiner, 1994), ageing/sexing (Wilson *et al.*, 1982) and seasonality (Legge & Rowley-Conwy, 1987; Lieberman *et al.*, 1990; Lieberman, 1994; Pike-Tay *et al.*, 1999).

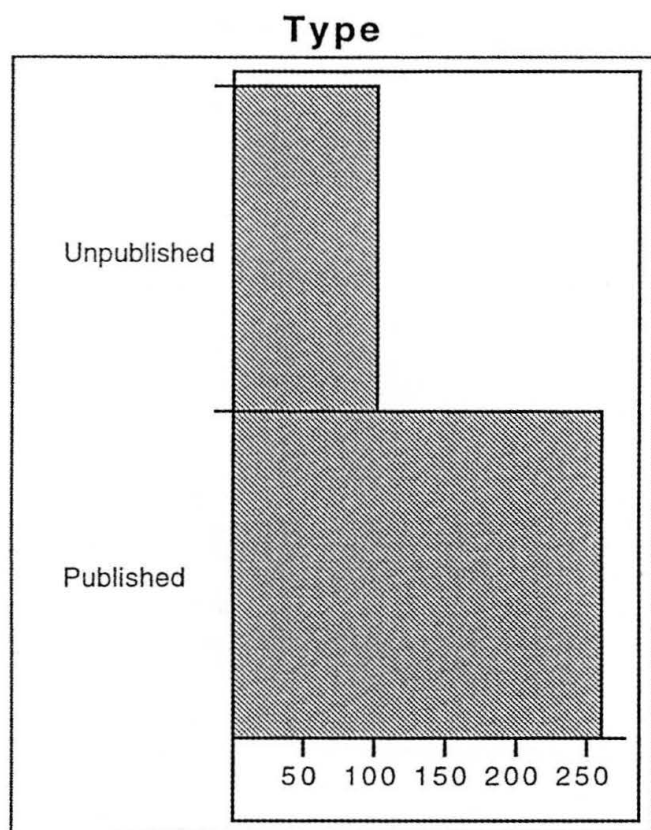
Australian archaeology has focussed on a narrower set of zooarchaeological topics and a review of the Australian literature of the past 35 years shows that over 350 papers, books and theses have been devoted in some way to the study of faunal remains. In compiling the database for this review, unpublished reports were excluded but the variety and scope of this 'grey literature' can be appreciated by an examination of the Australian Heritage Commission's bibliographic databases as well as other specific publications (eg Australian Heritage Commission, 1993). Many that are identified here are concerned with general archaeological studies where faunal analyses are of a secondary concern and include articles where faunal studies compose a small proportion of site reports. This has the effect of inflating to some extent the number of articles but allows an examination of the overall Australian trends. Although faunal studies have been carried out in New Guinea (Mountain, 1990, 1991; Marshall & Allen, 1991; Mountain, 1993) the focus of this paper will be on the Australian and Tasmanian literature.

The literature can be divided into (i) that data obtained from general archaeological excavations, (ii) those from palaeontological investigations with zooarchaeological application and (iii) those that address specific zooarchaeological practical, methodological and theoretical issues. This paper will firstly discuss the utilisation and adoption of zooarchaeological data in Australian archaeological research, and secondly how the data is disseminated in the literature. The bibliography contains examples of the range of zooarchaeological research in Australia over the past 35 years. This list is possibly incomplete although every care has been taken to survey the available literature that in some way discusses zooarchaeological practice, methods and/or theory. Some limitations also exist

especially where there is an overlap of categories within one article, particularly in doctoral theses, where papers or reports have been missed and/or incorrectly classified. Where there are joint and multiple authors the first is cited for database analysis. In this review where there are several faunal topics dealt with in one article, the major issue has been taken as the defining element for inclusion in the database and its classification.

Type and Status

Figure 1 presents the frequency and proportion of published and unpublished work while Figure 2 displays the data on their status. Seventy-two percent are published and 28% are unpublished works. The latter are primarily made up of university theses, particularly Bachelor of Arts 4th year honours theses (20%) while the former are mainly distributed across a variety of national journals such as *Archaeology in Oceania* and *Australian Archaeology*. Fifty one (14%) are published in edited books usually as a collection of papers among other archaeological topics with a related interest (eg. Solomon *et al.*, 1990) while a number of zooarchaeological studies are embedded within larger archaeological reports. This is particularly true of doctoral theses where the data have been gathered initially with other questions and problems in mind (eg. Jones, 1971; Allen, 1972; Bowdler, 1979; Lourandos, 1980; Schrire, 1982; McNiven, 1990b; Cosgrove, 1991; Mountain, 1991; Sim, 1998). However relatively few doctoral dissertations have actually addressed specific zooarchaeological issues. Between 1975 and 1995 a total of 9 out of 53 doctoral dissertations (White, 1994) specifically addressed faunal analysis (Bailey, 1975b; Meehan, 1977c; Luebbers, 1978; Gollam, 1982; Sullivan, 1982a; Walters, 1986; Balme, 1990; Walshe, 1994a; Furby, 1995a). In addition, a relatively large number of unpublished undergraduate theses have been completed, many analyses based on material originally dug by archaeologists with broad zooarchaeological questions (eg. Geering, 1980; O'Connor, 1980; Goodwin, 1981; Johnstone, 1982; Zobel, 1982; David, 1983; Newland, 1984; Walshe, 1987; Izard, 1988; Mowart, 1989; Yap, 1992; Gale, 1994; Mebberson, 1998; Cockbill, 1999; Garvey, 1999). These are chiefly investigations of taphonomy, subsistence, seasonality, biogeography and/or climatic change although biochemical and isotope studies have been under-



Frequencies

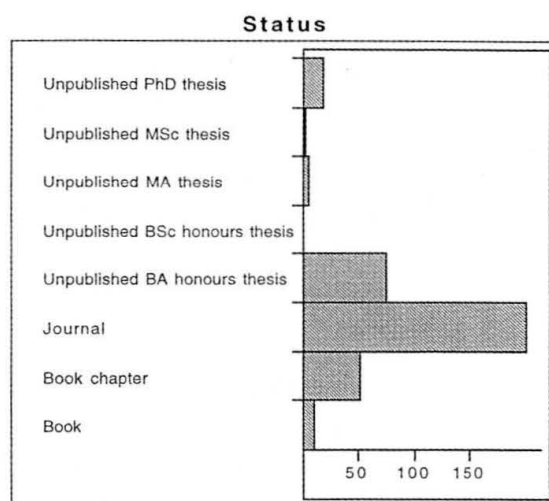
Type	Count	%
Published	261	71.7
Unpublished	103	28.3
Total	364	100.00

FIGURE 1

Frequency and proportion of published and unpublished zooarchaeological research.

taken more recently (Murphy, 1988; Garling, 1994; Anson, 1997; Jellinek, 1998; Roberts & Pate, 1999).

As argued above, the role of ethnography has been important in the interpretation of zooarchaeological data and the consequent characterisation of the archaeological record. It has played a significant part in setting the interpretive agenda and frameworks for zooarchaeological interpretation, particularly in midden analysis in Australia (eg. Bowdler, 1976; Meehan, 1982; Walters, 1984, 1988a; Gould, 1996). Others have argued however, that when dealing with the deep past, particularly when there is no known ethnographic analogue, archaeological interpretation needs to develop its own analytical and theoretical frameworks



Frequencies

Status	Count	%
Book	11	3.02
Book chapter	51	14.01
Journal	199	54.67
Unpublished BA honours thesis	76	20.88
Unpublished BSc honours thesis	1	0.28
Unpublished MA thesis	6	1.65
Unpublished MSc thesis	2	0.55
Unpublished PhD thesis	18	4.94
Total	364	100.00

FIGURE 2

Frequency and proportion of status of zooarchaeological research.

(Murray, 1997). Issues of time scale and resolution are important but are rarely discussed in the archaeological, let alone the zooarchaeological literature in Australia (Frankel, 1993; Cosgrove & Allen, 1996: 27; Murray, 1999) although topics such as site formation and taphonomy have come closest to addressing these concerns. Where actualistic studies have established frameworks of analyses, conflation of deposits, over-printing and time averaging confound the identification of the one to one correlations of physical forces responsible for bone patterns and these problems need to be accounted for in the reconstructions of past human behaviours.

Temporal change and zooarchaeological field

The majority of studies have focussed on mollusc (40.66%, n=148), extant mammals (33%, n=120) and extinct mammals (17%, n=62) while fish, marine mammals and birds make up 7%, 1% and 1% respectively (Figure 3). Although limited, studies of marine mammals and birds have been

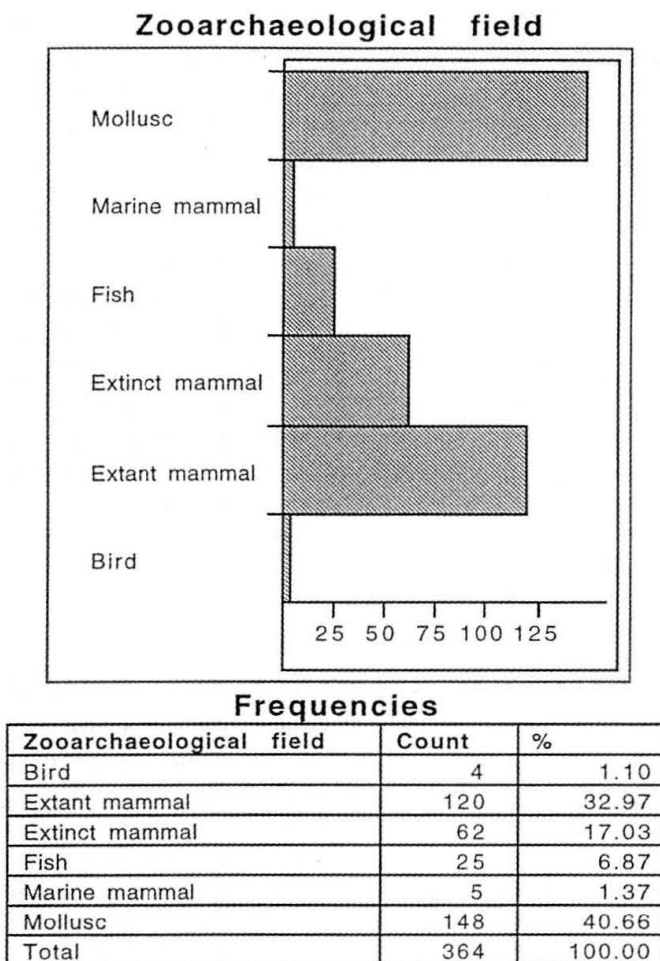


FIGURE 3

Frequency and proportion of zooarchaeological field by animal class.

undertaken that demonstrates the potential of these classes of animals for study (Jones, 1971: 525-554; Van Tets, 1978; Stockton, 1981; Minnegal, 1982, 1984; West & Sim, 1995; Bryden *et al.*, 1999).

In Figure 4 the profile of the zooarchaeology literature over time reveals an interesting pattern. This can be divided up into four periods; the 9 years covering 1966-1975, the 10 years covering 1976-1985, the 9 years covering 1986-1994 and 7 years between 1995-2001. During this time, a total of 364 articles with zooarchaeological content were identified and while faunal analyses were slow to appear before 1970s, the advent of new archaeology teaching and research departments gave research impetus after the 1970s.

During 1966 to 1975, 53 articles made up 14.5% of the total; during 1976 to 1985 150 articles make up 41.2% whereas between 1986 and

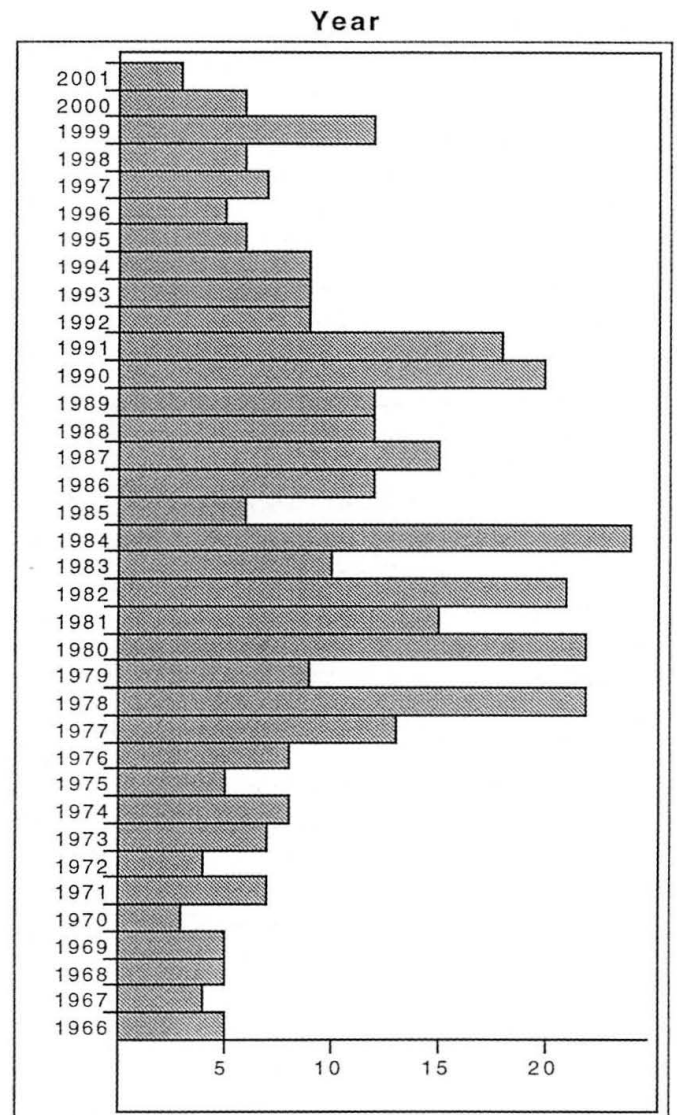


FIGURE 4

Frequency graph of zooarchaeological research output as measured by published and unpublished data by year.

1994 116 articles made up 31.8% of the total and between 1995-2001 45 or 12.3%.

There are a number of peak years, resulting from the flow-on effects of early research by individuals undertaking doctoral work and regional surveys focussing primarily on shell midden analysis (Luebbers, 1978; Bowdler, 1979; Lourandos, 1980; McBryde, 1982; Meehan, 1984). More particularly 1977, 1978, 1980 and 1982 were years where midden analyses and the megafaunal extinction where a major point of debate (Bailey, 1977; Hope *et al.*, 1977; Meehan, 1977a, c; Balme, 1978, 1980a; Balme *et al.*, 1978; Gillespie *et al.*, 1978; Goede *et al.*, 1978; Hope, 1978; Horton, 1978a, b,

1980; Murray, 1978; Archer *et al.*, 1980; Murray *et al.*, 1980; Blackwell, 1982; Sullivan, 1982a). In 1982 conference proceedings and two books concerned with mollusc analysis and methodology were published (Bowdler, 1982; McBryde, 1982; Meehan, 1982) as well as two doctoral dissertations on the dingo and molluscs were completed (Gollam, 1982; Sullivan, 1982b).

After 1983 we see an increase in the diversity of topics, a move away from midden description to analyses of extant mammals and related topics (O'Connor, 1980; Horton, 1981, 1984a, b; David, 1983, 1984a, b, 1987; Geering, 1983, 1990; Allen & Guy, 1984; Newland, 1984; Walters, 1984, 1988a; Birkett, 1985; Marshall, 1985, 1986; Solomon, 1985, 1986; Barker, 1987; Stokes, 1987; Walshe, 1987; Webb, 1987; Allen *et al.*, 1988; Burke, 1988; Pocock, 1988; Mowart, 1989; Nove-llo, 1989; O'Connell & Marshall, 1989; English, 1990; Hall & Jones, 1990; Marshall & Cosgrove, 1990; Northwood, 1990; Solomon & David, 1990; Webb & Allen, 1990), fish (Dyall, 1982; Balme, 1983, 1995; Owen, 1984; Walters, 1986, 1992; Colley, 1987; Colley & Jones, 1987; McJann, 1991) and a limited interest in marine mammals (Minnegal, 1984; Cribb & Minnegal, 1989). In 1984 two books were published that dealt in part with faunal analysis (Dortch, 1984; Vanderwal & Horton, 1984) along with the completion of several graduate theses and journal articles.

After 1991, diversity in zooarchaeological topics is relatively steady but there is a decrease in research publication until 1998 and 2000. In this period 17% were on taphonomy (Field, 1999b; Walshe, 1999; Walshe, 2000), 41% were on extinction (Field & Boles, 1998; van Huet *et al.*, 1998; Field, 1999a, 2000; Field & Dodson, 1999; Flannery & Roberts, 1999; Miller *et al.*, 1999; Horton, 2000) and the rest evenly divided between subsistence (Knuckely, 1999), biochemical analyses (Roberts & Pate, 1999), ageing/sexing (Bryden *et al.*, 1999), butchery and ethnoarchaeology (Piper, 1992; Pickering, 1995; Cosgrove, 1999a; Hall, 2000; Cosgrove & Allen, 2001). Explanations for this trend are: (1) aspects of larger programs of research being farmed off to undergraduates as thesis topics that remain unpublished, (2) fewer large research programs funded for Aboriginal archaeology, (3) the closure of the Department of Prehistory, Research School of Pacific Studies in Canberra, (4) a perception of the growing influence of Aboriginal politics on academic research and the need of funding institutions to have clear evidence of Aboriginal project support.

This last issue is of some importance. Clearly Aboriginal involvement in all archaeological research is crucial but this has led to some changes in research trends. Post-graduate researchers are less likely to start projects on their own because of the time spent in Aboriginal negotiation and consultation, sometimes taking up to a year out of their 3 year scholarship funded research. This unpredictability has led to post-graduate researchers moving under the umbrella of fewer, much larger research projects, involving multidisciplinary teams and Aboriginal communities (eg Allen, 1996; Field & Dodson, 1999; Lilley *et al.*, 1999) or into historical archaeology (eg English, 1990, 1991; Piper, 1992; Lawrence, 1998; Tucker, 1999; Lawrence & Tucker, in press).

Gender

Males appear to dominate (59.7%) the total contributions made by archaeologists over the last 35 years (Figure 5). Females are under-represented in the first 10 years from 1966 to 1976 but they become more prominent contributors from this time on. In all categories apart from environment, contributions are similar or lower than males (Table 1). Forty-eight percent of males are published while 27% of females are published (Table 2). This is particularly true of contributions made to journals where females make up 15% and males make up nearly 40% of the published papers (Table 3). Conversely females write 12% of unpublished 4th honours theses whereas males write only 7% of these (Table 2). In all zooarchaeological fields except fish research, males outnumber females by up to 8%, for example in studies on extant mammals (Table 4). Explanations for these trends are not immediately apparent given the relatively equitable gender balance in Australian archaeology. Reviews of gender participation in Australian archaeology have put forward a number of explanations for similar patterns found elsewhere such as the influence of power structures in academic institutions, employment opportunities and family commitments (Beck & Head, 1990; du Cros & Smith, 1993; Balme & Beck, 1995).

CATEGORIES OF RESEARCH

In Figure 6 categories of zooarchaeological research are shown. As discussed above, classification in each was determined by a number of fac-

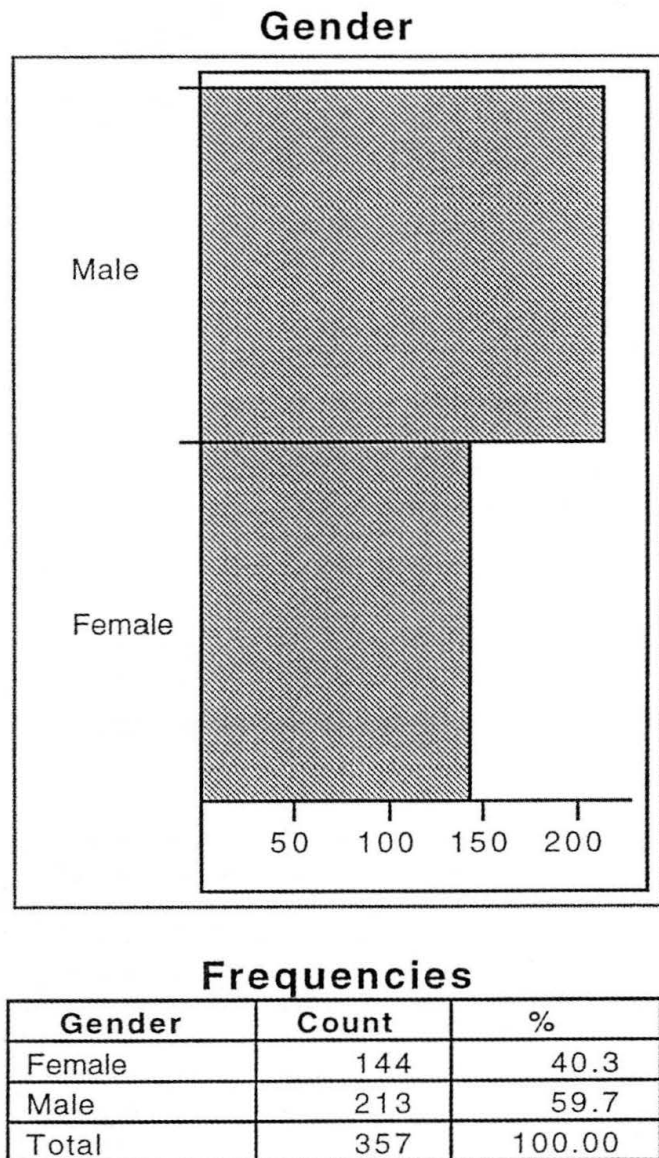


FIGURE 5

Frequency and proportion of male and female archaeologists as measured by published and unpublished data.

tors. Where the article discussed a specific faunal topic it was assigned a category. Where several faunal topics were discussed together or where it formed part of a larger section including general archaeological issues the most dominant faunal theme was chosen to classify the article. Although a further review of the articles by others may reveal different frequency distributions, it is felt that any variation is likely to be small.

Taphonomy

Seventy-two articles, or 20%, were identified discussing the role of taphonomy in structuring the

Category name	Female	Male	Total
Ageing/sexing	1	0	1
Biochemical	1	5	6
Biodiversity	1	16	17
Bone modification	3	8	11
Butchery studies	2	3	5
Catchment	1	2	3
Economic analysis	8	8	16
Environment	4	1	5
Ethnoarchaeology	6	6	12
Extinction	13	33	46
Quantification	5	9	14
Seasonality	7	6	13
Social analysis	1	4	5
Subsistence	58	73	131
Taphonomy	33	39	72
	144	213	357

TABLE 1

Frequency of zooarchaeological categories by gender as measured by published and unpublished data.

Status	Female	Male	Total
Book	3	8	11
Book chapter	28	23	51
Journal	55	141	196
Unpublished BA honours thesis	45	27	72
Unpublished BSc honours thesis	0	1	1
Unpublished MA thesis	3	3	6
Unpublished MSc thesis	1	1	2
Unpublished PhD thesis	9	9	18
	144	213	357

TABLE 2

Frequency of zooarchaeological status by gender as measured by published and unpublished data.

Type	Female	Male	Total
Published	86	172	258
Unpublished	58	41	99
	144	213	357

TABLE 3

Frequency of zooarchaeological type by gender as measured by published and unpublished data.

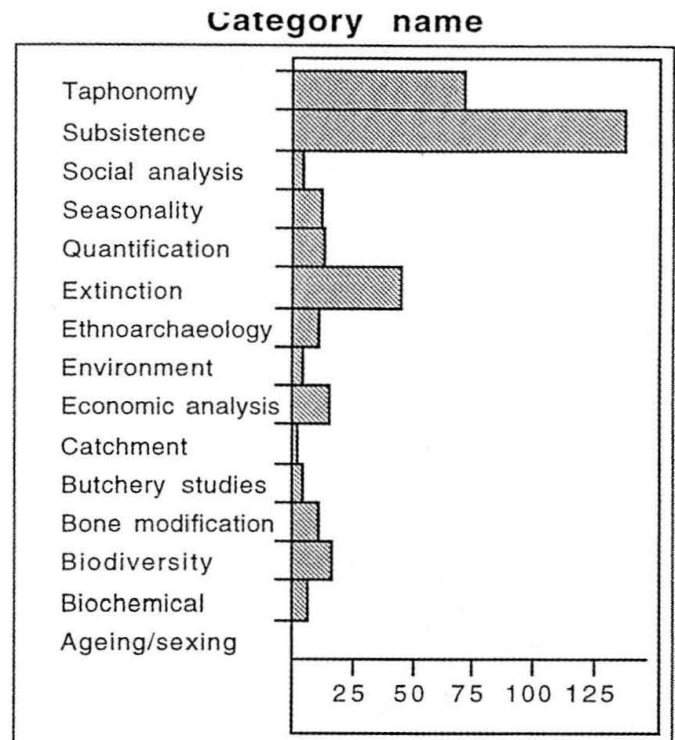
archaeological record. The earliest taphonomic and site formation research centred on issues dealing with accumulating agents, identifying signature criteria for marsupial carnivores and their effect on bone properties (Wakefield, 1960a, b, 1982; Douglas *et al.*, 1966; Lundelius, 1966). These laid the foundations for later work that

Zooarchaeological field	Female	Male	Total
Bird	1	3	4
Extant mammal	46	73	119
Extinct mammal	18	43	61
Fish	15	10	25
Marine mammal	2	3	5
Mollusc	62	81	143
	144	213	357

TABLE 4

Frequency of zooarchaeological field by gender as measured by published and unpublished data.

focussed on taphonomic agents such as owls (eg Morton, 1975; Seebeck, 1976; Marshall, 1985; Geering, 1990; Garvey, 1999), carnivores (eg Ewer, 1969; Hope, 1973; Archer *et al.*, 1980; David, 1983; Bowdler, 1984; Walters, 1984; Hall & Jones, 1990; Marshall & Cosgrove, 1990; Northwood, 1990; Walshe, 1994b; Gould, 1996; Oakley, 2000; Walshe, 2000;), seals and sea birds (Horton, 1978b; Jones & Allen, 1978) and megafauna (Mebberson, 1998; Field, 1999b). The latter zooarchaeological studies have concerned themselves with identifying the role played by humans in the extinction process and establishing the direct association of people with megafauna. The debate continues on the length of that association and the human role in the extinction process and is further discussed below (Field, 1999a; Miller *et al.*, 1999). Shell midden research focussed mainly on identifying their origin and formation particularly along the Australian east and north coasts (Hughes & Sullivan, 1974; Jones & Allen, 1978; Stone, 1989; Bailey, 1991, 1993, 1994; Attenbrow, 1992; Bird, 1992; Bailey *et al.*, 1994; O'Connor & Sullivan, 1994; Rowland, 1994). As a proportion of the overall zooarchaeological literature, taphonomic analysis has increased steadily since the mid-1970s. It peaked at the beginning of the 1990s with the publication of a book (Solomon *et al.*, 1990), several articles (Balme & Hope, 1990; English, 1990; Huchet, 1990; McNiven, 1990a; Weaver, 1990; Cribb, 1991; David & Stanisic, 1991), a doctoral (Walshe, 1994a), a masters (van Huet, 1994) and four honours theses (Edwards, 1990; Northwood, 1990; English, 1991; McJann, 1991). Gould's (1996) work in central Australia attempted to link high levels of macropod bone fragmentation with the notion of human dietary stress using ethnoarchaeological comparisons. Recently this has been challenged by Walshe



Frequencies

Categories	Count	%
Ageing/sexing	1	0.28
Biochemical	7	1.92
Biodiversity	17	4.67
Bone modification	11	3.02
Butchery studies	5	1.37
Catchment	3	0.82
Economic analysis	16	4.40
Environment	5	1.37
Ethnoarchaeology	12	3.30
Extinction	46	12.64
Quantification	14	3.85
Seasonality	13	3.57
Social analysis	5	1.37
Subsistence	137	37.64
Taphonomy	72	19.78
Total	364	100.00

FIGURE 6

Frequency and proportion of zooarchaeological categories as measured by published and unpublished data.

(2000) who has argued that in fact Tasmanian devils and dingos were the primary agents for bone breakage and that the pattern does not represent human subsistence behaviour. The basis for these studies had been made earlier by a number of researchers (Baynes *et al.*, 1976b; Horton, 1976; Hope *et al.*, 1977; Balme, 1978, 1979, 1980a; Archer *et al.*, 1980; Horton & Wright, 1981).

Subsistence

One hundred and thirty-seven articles or 38% are devoted to subsistence studies, in some cases using ethnographic observations to support interpretations of the zooarchaeological data. Sixty-one percent ($n=84$) of subsistence studies focus on the role of molluscs in the Aboriginal economy (eg. Jones, 1967, 1971; Lampert, 1971; Bailey, 1975a, b; Dortch *et al.*, 1984; Sullivan, 1982b, c; Sullivan, 1984b; Vanderwal & Horton, 1984; Sullivan, 1987; McNiven, 1989; Weaver, 1990; Balme, 1995; Morse, 1996). Some of the literature show clear links between the interpretative process and the use of early historical literature to provide a narrative (eg Coleman, 1982; Hall, 1982). These narratives have come out of and are based upon the ethnographic observations made during the contact period. While this is no bad thing, there are few explicit concerns with using zooarchaeological evidence from the deep past, early Holocene and more particularly the late Pleistocene, which are then pasted onto what is known in ethnographic descriptions. This is not to deny that ethnographically observed behaviours were present in past communities but demonstrating that the archaeological patterns reflect such behaviour is difficult. Although this may be the case, use of the historical records to provide an explanation for the changes in the zooarchaeological record have been attempted, particularly in social analyses (Jones, 1971, 1978; Bowdler, 1976; Satterthwait, 1987; Walters, 1988b; Hall, 2000).

Twenty-four percent of subsistence studies are based on terrestrial mammals. These studies have focussed on the faunal remains and associated technology used to interpret regional subsistence patterns (eg Lourandos, 1968; McBryde, 1976; Dortch, 1984). Other work has investigated the way in which extant animals were utilised in the food quest and how their modern behavioural ecology can be investigated to inform on palaeoecological structure and land use patterns (Cosgrove, 1995; Cosgrove & Allen, 2001). The presence of some terrestrial animals such as emu and macropod at late Pleistocene inland archaeological sites have also challenged earlier coastal models of continental colonisation (Kiernan *et al.*, 1983; Bowdler, 1990; Cosgrove *et al.*, 1990). The evidence would suggest adaptations to inland and upland areas much earlier than has been argued (Bowdler, 1981). The presence of people in the interior Tas-

manian mountain valleys between 35,000 to 13,000 BP is a good example where people were already hunting macropods in cold and rugged uplands 25,000 years earlier than suggested (Figure 7) (Cosgrove, 1995: 117; 1999a). Prey choice in these regions and at these times focussed primarily on Bennett's wallaby (*Macropus rufogriseus*). Body parts most commonly selected were the lower limb bones particularly the tibia and femur (Figure 8). Bone concentrations in most sites reach over 250,000 in less than a cubic metre of excavated deposit (Figure 9).

Social Analyses

Considering the wealth of ethnography and its widespread use, it is interesting that so few social analyses have been attempted with faunal data. This trend may be explained by the fact that the theoretical frameworks needed in linking the zooarchaeological data to the past ideological realm are very underdeveloped. There is a far greater theoretical distance between the linking arguments of say, ideological and zooarchaeological data than with subsistence and faunal evidence. This is particularly true of the connection between gender roles seen in the ethnography and their correlates in the archaeological record. Bowdler's (1976) study on the changing role of women in Aboriginal society at Bass Point, New South Wales, was an attempt to tie the 19th century ethnographic observations to the appearance of fishhooks. The sexual division of labour had been observed ethnographically in Aboriginal societies where the women carried out much of the work and provisioning. Shellfish, the "low key dependable resources" were the economic mainstay. These animals were found in abundance along with fish hooks and bone points and Bowdler argued that a change from point to hook technology reflected the changing roles of men and women in the coastal economy of Aboriginal society. Shell fishhooks were obviously an important technological innovation appearing in the archaeological record less than 1,000 BP (Sullivan, 1987). Their role in a shift in women's subsistence activities has continued to be debated. MacKay and White have suggested that increases in mussel shellfish in middens along the south coast of New South Wales were due to ecological changes rather than changing gender roles (MacKay & White, 1987).

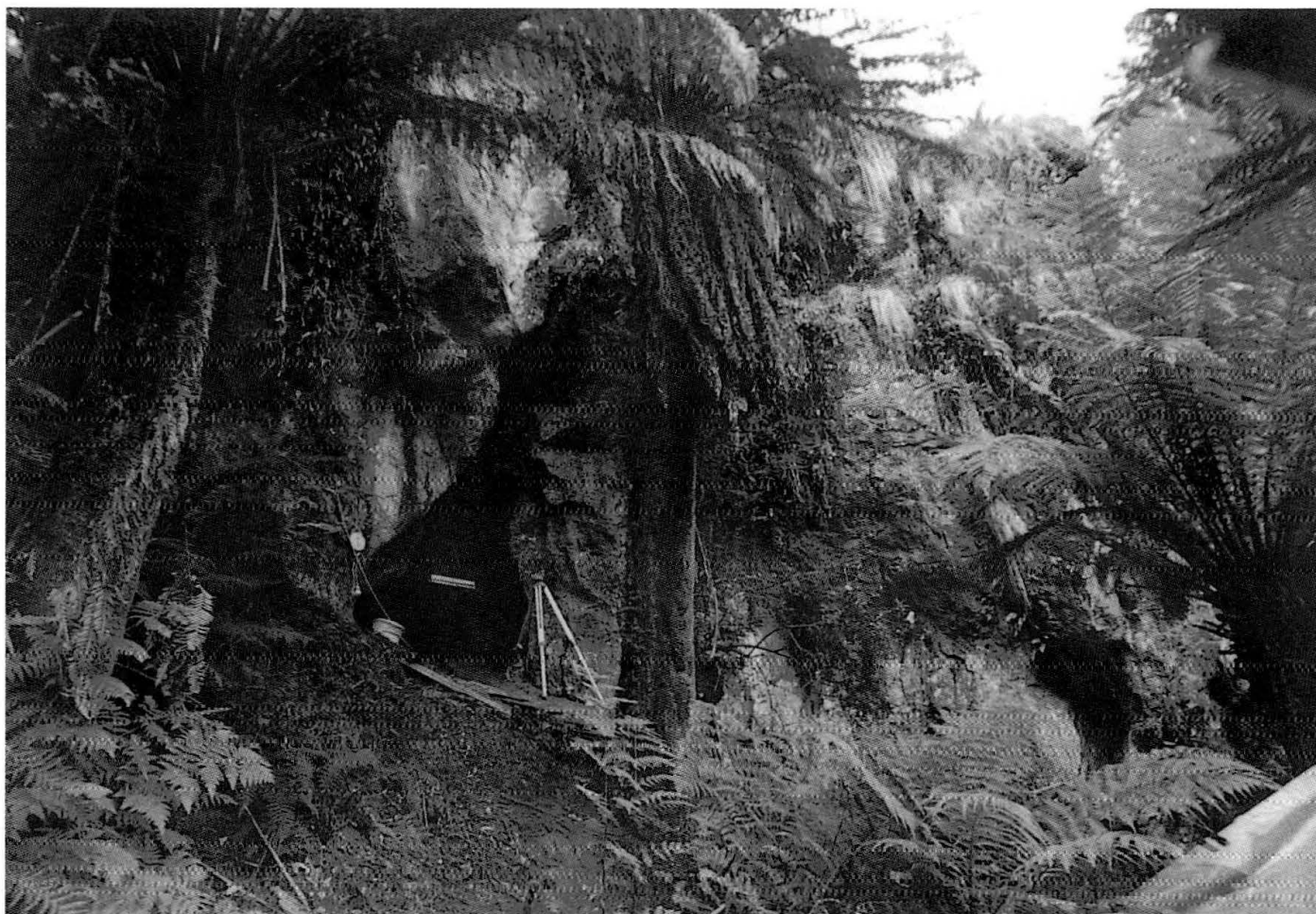


FIGURE 7

Bone Cave is located within a dolomite bluff in the Weld River valley, Southwest Tasmania. The tripod and bucket mark the entrance to this small cave. Large tree ferns (*Dicksonia antarctica*) grow on the moist soils while *poa* grass survive as refugia on the rocky cliff face. (Photo R. Cosgrove).

Jones (1971, 1978) also used the fact that no Tasmanian Aborigines were reported to have eaten scale fish at European contact although fish were found in archaeological deposits dated prior to ca. 3,500 BP but not after (Colley & Jones, 1987). This led to the question why the Tasmanians stopped eating fish and began a brief and feisty debate in the literature with no clear winners (Jones, 1978; Allen, 1979; Horton, 1979; Bowdler, 1980; Thomas, 1981; Vanderwal & Horton, 1984:108-113). More recently, a post-processual 'model' has been put forward as a way of explaining this archaeological pattern (Collett, 1994). In this 'model' discreet middens found on the Tasmanian coasts were interpreted as the result of women's gathering from the sea while nearby artefact scatters were the result of men's hunting on land. This is not surprising in itself and based mainly on observations recorded in the limited Tasmanian ethno-

graphy. This dichotomy was further assumed to reflect the 'ideological' domain of women to the sea and men to the land (Collett, 1994: 353). Two more assumptions were then made about the role of men and women in Tasmanian Aboriginal society (Collett, 1994: 353). The first was that because Aboriginal men at European contact caught scale fish elsewhere in Australia, the absence of scale fish in middens in Tasmania after 3,500 BP implied that role of men had changed in Tasmanian society. The second assumption was that the dropping of scale fish from the diet was a 'prohibition' following on from Jones' idea (1978). With this 'prohibition' in place 'men could no longer 'hunt' in the sea' and it was argued that the dropping of scale fish from the diet heralded changed 'exchange gender relationships' after 3,500 BP. The archaeological evidence suggests that fish were not speared but caught in basket traps (Colley

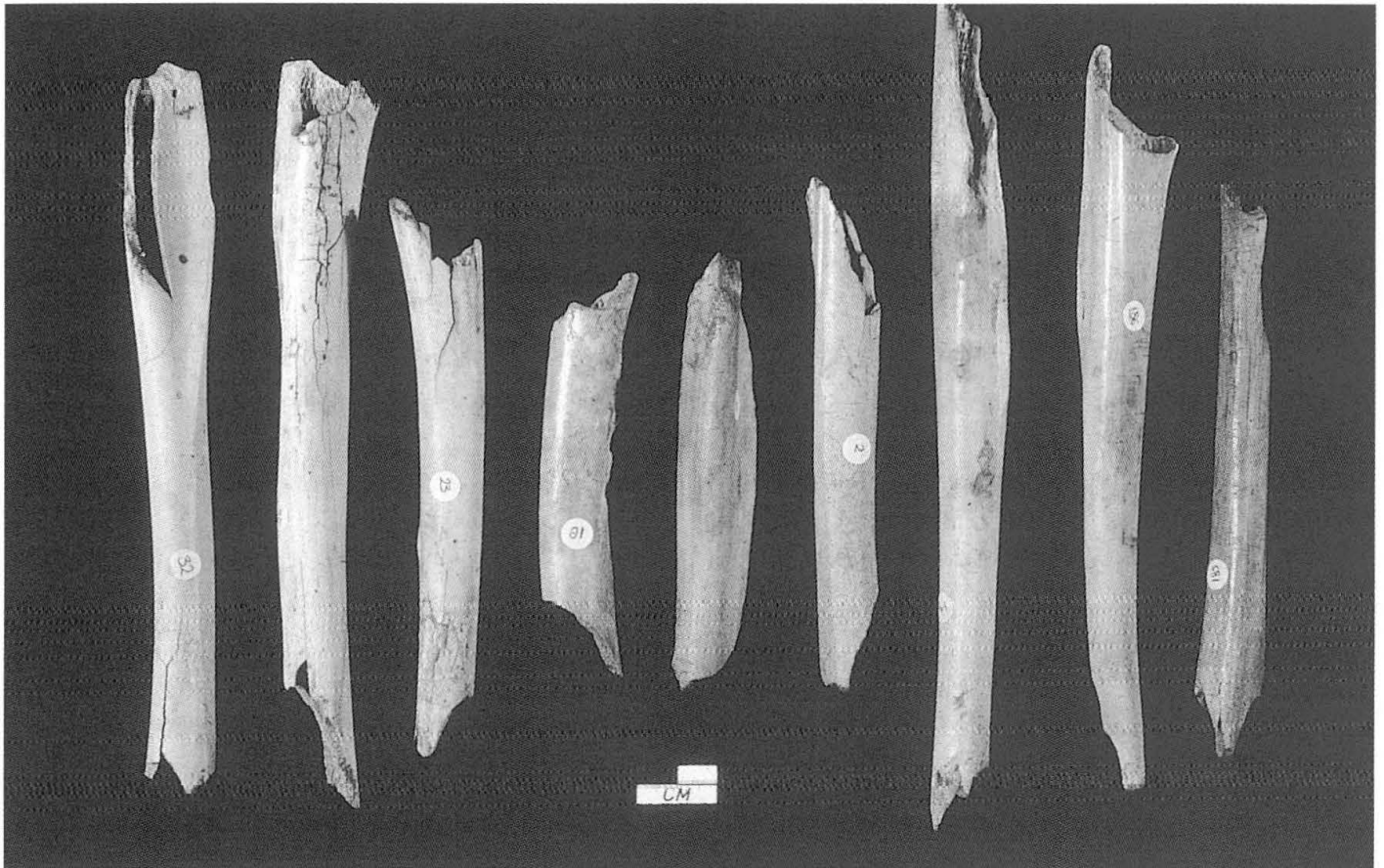


FIGURE 8

Systematically broken tibia of Bennett's wallaby, the major prey animal of late Pleistocene humans in Southwest Tasmania. (Photo R. Frank).

& Jones, 1987), an activity that is 'low key' like possum 'gathering' and identified as women's 'work' where spears were said not to be used either (Collett, 1994: 353). Why women did not take up fishing themselves given their argued 'strengthened association' with 'marine resources after 3,500 BP' is not explained beyond the assumed 'prohibition'. The obvious answer to this question produces a rather circular argument.

In assessing the usefulness of any archaeological model to explain patterning, it must be testable and subject to refutation. A model without such conditions is flawed. The failure to provide any clear substantive archaeological correlates of the enigmatic 'new exchange relationships' between men and women in Tasmanian coastal society beyond the spatial relationships of middens and stone artefacts indicate that it is not a model but rather a narrative pasted onto the archaeology. Indeed, there is no clear evidence at present to indicate whether the midden/artefact dichotomy is related in time, a Tasmania wide coastal phenomenon or the result of taphonomic patterning. In the

end, the question of 'why the Tasmanians stopped eating fish' is perhaps the wrong question to ask, as there have been few ways to judge the veracity of competing explanations.

Nevertheless, one outcome of the debate was the question of how and to what extent the effect of 10,000 years of isolation had on a human community and how a society totally cut off from outside contact may eventually develop. In addition, bone points were dropped from the technological assemblage about 3,500 BP although Bowdler's (1984: 126) suggestion that they were used principally as needles to make fishing nets cannot be supported given their common occurrence in late Pleistocene inland sites. The first appearance of bone points in the uplands of Tasmania is dated to between $31,610 \pm 370$ and $27,160 \pm 250$ (Webb & Allen, 1990; Cosgrove, 1999a; Cosgrove & Allen, 2001).

Stylistic changes in fish hook manufacture were also used to argue for changing social make-up on the south east Queensland coast (Walters, 1989, 1992). In addition, Walters suggested that differen-



FIGURE 9

Excavated trench at Bone Cave revealing density of in situ faunal remains. (Photo R. Frank).

ces in fishhook styles reflected the different Aboriginal social affiliations along the Queensland coast.

Seasonality

The majority of these studies occurred in the 1980s and 1990s mainly using fish (Kefous, 1977; Walters, 1992), shellfish (Feary, 1981; Godfrey, 1984), emu eggshell (Cosgrove, 1995: 76-77), marine mammals (O'Connor, 1980; Bryden *et al.*, 1999) and in a few cases, terrestrial mammals (Geering, 1982). Often, seasonal occupation has been assumed rather than demonstrated through detailed faunal analyses. Studies of terrestrial animals have focussed on wallaby jaw material obtained from excavations in Tasmania. Annuli in wallaby teeth are being investigated to determine season and age of death of modern wallaby populations as a way of assessing seasonal occupation and human landscape use during the late Pleisto-

cene (Pike-Tay *et al.*, 2001). Macropod teeth advance throughout their life, erupting from the ramus, pushing the in situ teeth forward (Figure 10). Macropods are limited to four molars and their eruption depends on rates of chewing, type of food and sexual dimorphism (Lentle *et al.*, 1998). Eruption is therefore not directly related to true age but zoological studies have refined the correlations between age, molar eruption and molar progression (Kirkpatrick, 1964; Dudzinski *et al.*, 1977; Newsome *et al.*, 1977). Molar progression and eruption studies of contemporary Bennett's wallaby populations have aided in identifying relationships between molar age and age class of archaeological specimens (Geering, 1983; Driesen, 1993; Hartzell *et al.*, 1999). Other studies have used oxygen isotope of shellfish as a means of determining seasonal occupation (Godfrey, 1988). These have been undertaken as specialist studies on mollusc material in south eastern Australia. Other studies on microfauna have been undertaken as undergraduate honours theses but remain unpublished (Cockbill, 1999).

Quantification

Fourteen articles make up this category, or 4% of the total number of zooarchaeological literature. These studies are focussed on questions of faunal sampling (Baynes *et al.*, 1976a; Barz, 1977; Walters, 1979, 1981; Horton, 1984a), their characterisation (Horton, 1978b; Bowdler, 1983) and measurement (Allen & Guy, 1984). They deal mainly with the zooarchaeological fields of mollusc remains and modern mammals. It is interesting to note that such studies were popular in the early 1980s and late 1970s but have waned, particularly over the last 10 years. This may have occurred in response to, and the increased awareness of, the problems of taphonomic vectors, the desire to understand the attritional processes before dealing with the problems of counting. The papers also appear before and at a time of international debates about quantification in the zooarchaeological record, particularly the book publications of Binford (1981), Grayson (1984), Klein & Uribe (1984), Lyman (1994) and later Reitz & Wing (1999).

Extinction

Forty-two articles, or 13% of the total, are devoted to issues of extinction. A number of very

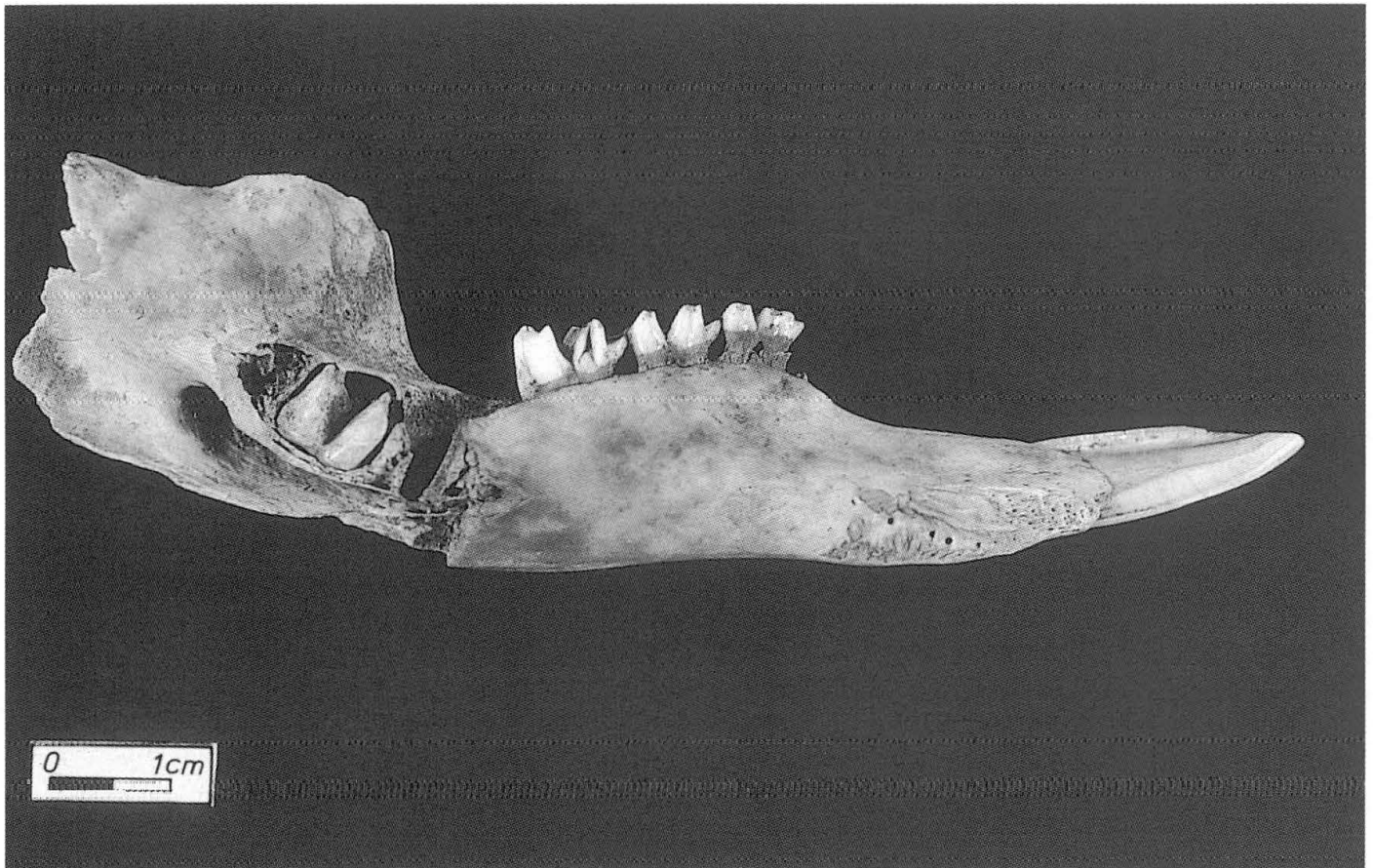


FIGURE 10

Bennett's wallaby mandible showing process of molar progression. Teeth erupt from the mandibular ramus pushing the teeth forward throughout the animal's life. The number of partly and fully erupted molars can determine relative age. (Photo R. Frank).

early papers going back to 19th and early 20th century were written by paleontologists (Wilkinson, 1885; De Vis, 1899, 1900; Stirling, 1900b; Spencer & Walcott, 1911). Some material was sent back to Richard Owen in England who was the first to describe the large *Diprotodon* and other extinct species (Horton, 1991). The zooarchaeological evidence for extinctions comes mainly from the fossil bearing cave and lake deposits of Western Australia, Victoria, New South Wales, and Tasmania. In many instances the initial research was carried out by paleontologists being followed by archaeologists. Principal among these are David Horton (Victoria, Tasmania, NSW) (Horton, 1976, 1977, 1978a, 1980; Horton & Samuel, 1978; Horton & Murray, 1980; Horton & Connah, 1981; Horton & Wright, 1981), Jeanette Hope (western New South Wales, Kangaroo Island) (Hope, 1973, 1978, 1980; Hope *et al.*, 1977; Hope *et al.*, 1983), Albert Goede and Peter Murray (Tasmania) (Goede & Murray, 1977, 1979; Goede *et al.*,

1978), Jane Balme, Alex Baynes, Duncan Merri-
llees (Western Australia) (Merrilees, 1968, 1973; Baynes *et al.*, 1976b; Balme, 1978, 1979, 1980a, b; Balme *et al.*, 1978; Merrilees & Porter, 1979) and Judith Field and John Dodson (northeastern NSW) (Dodson *et al.*, 1993; Furby, 1995b; Field, 1999a, 2000; Field & Dodson, 1999).

Many of the publications appear in the early 1980s with a hiatus from the mid-80s to the early 1990s. In the late 1990s, major research on the question of the role of climate, humans or a combination of variables was again undertaken. Many Australian dating specialists and zoologists have preferred to view humans as the primary cause of extinction (Flannery, 1990; Flannery & Roberts, 1999; Miller *et al.*, 1999) while many archaeologists see the extinction process as more complex involving climate, humans and regional differences (Goede & Murray, 1979; Goede & Bada, 1985; Dodson, 1989; Field & Dodson, 1999; Cosgrove & Allen, 2001: 424-425). The published evidence



FIGURE 11

Cuddie Springs, New South Wales during excavation. The site is located on the bed of an ephemeral lake that attracted humans and megafauna between 19,000 and 32,000 radiocarbon years ago. (Photo R. Cosgrove).

however has failed to identify any one prime mover nor is there unequivocal evidence about the overlap of humans and megafauna (Gillespie *et al.*, 1978; Gorecki *et al.*, 1984), although some more recent evidence does suggest an association (Dodson *et al.*, 1993; van Huet *et al.*, 1998). Important work by Judith Field, John Dodson and Richard Fullagar at Cuddie Springs has advanced our understanding of this association (Figure 11). It remains one of the best sites for untangling the question of the reasons for the demise of Australia's giant marsupials. Analysis on the range of taxa, body part distribution, the presence of cut marks and impact marks, as well as their association with flaked stone artefacts and 30,000 year old seed grinding technology demonstrates clear megafauna/human association (Field, 1999a, 2000). The orientations of bones in vertical, horizontal and semi-articulated positions in the lower levels suggest trampling and/or in situ deaths of the large flightless bird *Genyornis* (Figure 12).

One interesting feature of zooarchaeological data is that in sediments dated to before 35,000 BP radiocarbon years a wider, but steadily decreasing number of animal species is found before human presence at the site (Field & Dodson, 1999). After 30,000 BP, the range of taxa diminish further until some of the biggest animals disappear from the record entirely. Field and Dodson have argued that this steadily decreasing range of animals reflects a drying of the continent, particularly at the beginning of the Late Glacial Maximum. The earliest dated human occupation is about 32,000 BP radiocarbon years. With their arrival, it is suggested that the combination of deteriorating climatic regime and human predation tipped the balance for a range of both large and small animals. From about 19,000 to 14,000 BP almost all of the big animals have disappeared from the archaeological record. The largest marsupial to survive this process was the red kangaroo, still extant on the Australian continent (Horton, 1984b).



FIGURE 12

Genyornis newtoni long bones exposed at the base of Cuddie Springs excavations. Note their horizontal semi-articulated orientation. A tibiotarsus seen in the lower right of the figure is in a vertical orientation suggestive that this *Genyornis* became bogged. (Photo R. Cosgrove).

The picture has become more complex since Merrelies first suggested that 'man' was the prime reason for the disappearance of megafauna (1968). More sophisticated modelling of the interaction between Australian megafauna and humans has been attempted (Choquernot & Bowman, 1998) following the methods of Mithen for mammoth extinctions in Eurasia (1993). O'Connell has made the point that these approaches are likely to address more interesting questions about how people were involved in the extinction process rather than just whether there were involved (O'Connell, 2000).

Ethnoarchaeology

Eleven articles are devoted to ethnoarchaeology or 3% of the total. These studies come mainly

from Betty Meehan who in the late 70s and early 80s published the results of her year long field work with the Aboriginal people of the Blythe River region in northern Australia (Meehan, 1977a, b, c, 1982, 1983, 1988). She made extensive studies of the shellfish gathering carried out by the Aboriginal women over the seasonal cycle. This led to a reassessment of the contribution of women's activities in Aboriginal societies and highlighted the important role shellfish played in the coastal economy. Other work on subsistence strategies of Aboriginal groups of central and northern Australia were published in the 1980s and 1990s, with the view to collect data that could be used in optimal foraging studies, butchering and modelling human/megafauna interactions (Gould, 1967; O'Connell & Hawkes, 1984; Altman, 1987; O'Connell & Marshall, 1989; Pickering, 1995; O'Connell, 2000).

Economic Analysis

This category contains a majority of analyses focussed on molluscs and a small percentage on terrestrial fauna. Major trends in the 1970s were towards quantifying meat weight contributions from shellfish as an indicator of population numbers (Bailey, 1975a). Although these studies suffered from a relatively short half-life, they did demonstrate the many difficulties in this sort of approach. They also highlighted the problems of the equifinality in the interpretative and explanatory process.

Bone Modification

Eleven papers, or 3% of the total, have investigated the modification of bones by humans (Megaw, 1969a; Jones, 1971: 518-524; Dortch, 1979a; Dortch, 1979b; McIntyre, 1981; Webb, 1987; Vanderwal & Fullagar, 1989; Webb & Allen, 1990). Bone points have been described in various archaeological and ethnographic contexts (eg Roth, 1901a; Bird & Beck, 1980; Pickering, 1980; Mulvaney & Kamminga, 1999: 198, 212, 277, 288). Points found in coastal sites were argued to be for the manufacture of fishing nets (Bowdler & Lourandos, 1982) but Jones argued that there was no connection between the technology and the fish caught (Jones, 1971: 510). Later work (Colley & Jones, 1987, 1988) suggested the use of basket fish



FIGURE 13

Bone points from Bone Cave, Southwest Tasmania. (Photo R. Frank).

traps. The application of use wear analysis to bone tools has provided an insight into the functions of these implements. The recovery of over 20 bone points and spatulas from southwest Tasmanian cave sites dated to between 30,000 and 13,000 years old has indicated selection of favoured body parts for their manufacture. Almost exclusively these were made on the proximal ends of the fibula of the Bennett's wallaby, *Macropus rufogriseus*. Webb and Allen's use-wear study indicates that many functioned as awls for punching holes in wallaby skins presumably for clothing and some probably as spear tips (Figure 13). Other shorter, stouter varieties, has been suggested functioned as toggles for clothing. No engraved bone or mobiliary art has been discovered from the Southern Forests Archaeological Project's analysis of 636,351 bones (McWilliams *et al.*, 1999; Cosgrove & Allen, 2001: 411) although hand stencil art is present in the Tasmanian caves (Cosgrove & Jones, 1989).

Work by Dortch (1984) at the Western Australian site of Devil's Lair has provided evidence of body adornment in the form of hollowed and rounded beads made on the fibula of small macropods (Figure 14). These were attached by twine and probably served as a necklace of some sort. Descriptions of the use of various faunal remains for decoration has also been undertaken including those dating to the late Pleistocene (Morse, 1993; Akerman, 1995).

Biodiversity

These studies make up 6% of the total, or 19 articles. The interesting thing about this is that the survey revealed that all of these studies occurred in the early 70s and 80s; all but two were written by males and most concentrated on extinct marsupial faunas (Calaby, 1971; Archer & Baynes, 1972; Archer, 1974, 1977; Baynes *et al.*, 1976b; Hope *et*

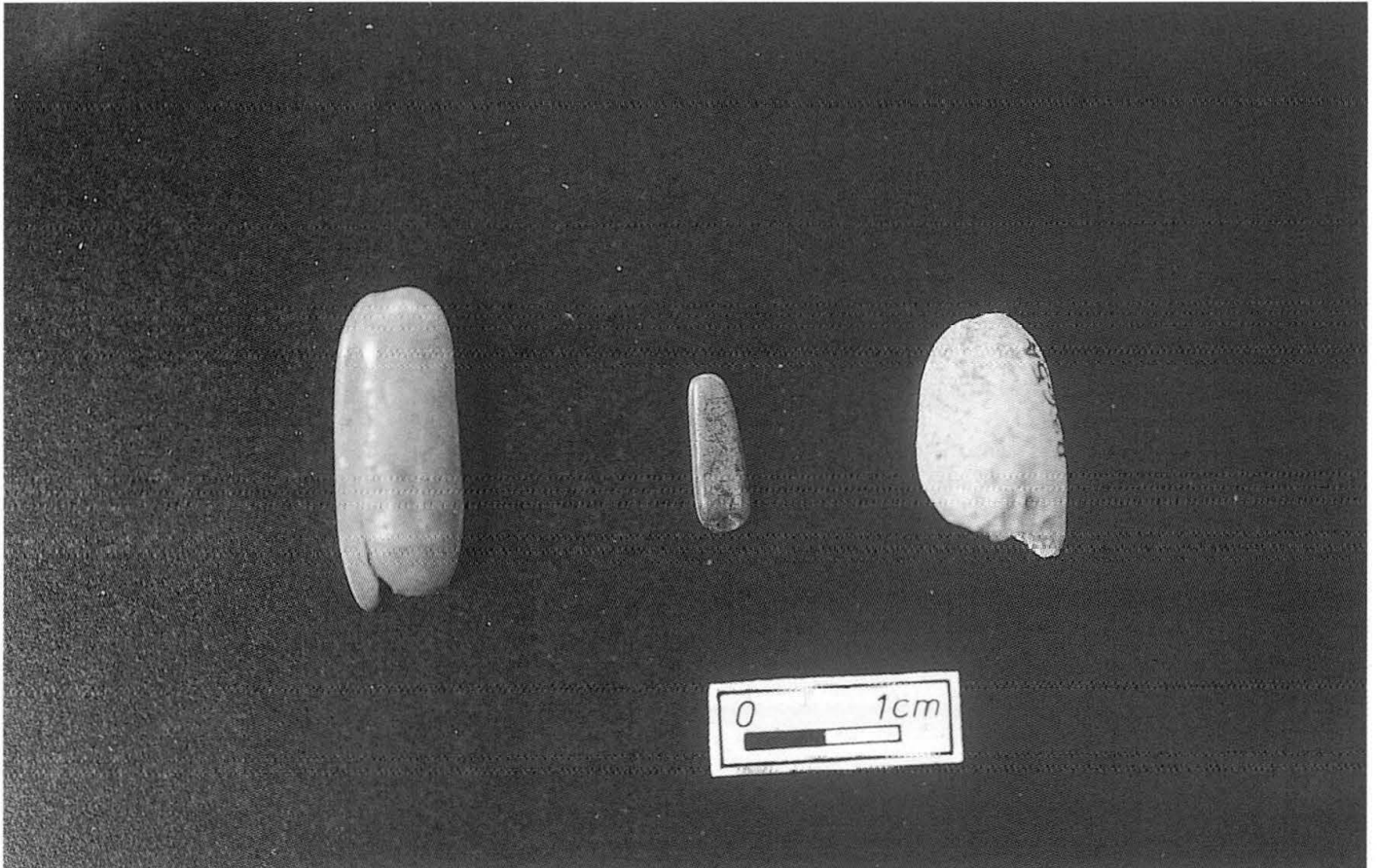


FIGURE 14

Bone beads from Devil's Lair, Western Australia made on the fibula of a macropod. (Photo J. Allen).

al., 1977; Archer & Brayshaw, 1978; Merrilees & Porter, 1979; Aplin, 1981a; Aplin, 1981b; Horton, 1981; Winter, 1981; Webster, 1982; Corbett, 1985). It may reflect the research opportunities of archaeologists during this period and the desire to describe the community ecology of these faunas.

The other categories play a minor role in the published and unpublished literature.

CONCLUSION

Zooarchaeological studies have had an uneven history in Australia and a rather narrower range of study than elsewhere. The foundations of zooarchaeological research are to be found in early paleontological studies concerned with extinct fauna and their association with humans. It was not until the 1960s that interest in faunal research was rekindled. The majority of zooarchaeological literature

appeared between 1970s and 1990s with a steady decline in both the published and unpublished material since 1992. Several reasons were advanced to explain this along with the limited opportunity of formal training in zooarchaeology at a tertiary level that would have otherwise allowed an increase in output. Periods of highest activity are associated with individual researchers and their projects designed to address questions of faunal remains or related topics. These have, in many instances, been as an adjunct to larger research projects. Most of the faunal research has been in three categories; taphonomy, subsistence and extinction studies. A significant number (20%) of faunal studies reside in unpublished undergraduate theses while another 55% have been published in national and international journals. Ethnography and its use in explanations for patterns in the faunal record have remained a strong influence over the last 35 years. Unlike earlier periods where functionalist explanations were common, after the 1970s, and particularly into the 1980s, structuralist

explanations have been used in zooarchaeological explanations although they lack interpretative power because much of the theory used to underpin the interpretation remains underdeveloped. The main fields of zooarchaeological investigation are in studies of shellfish remains, extant and extinct mammals. Fruitful areas of future zooarchaeological research include the application of DNA profiling to unidentified archaeological bones to assist in their identification, seasonality studies and ageing/sexing of marsupials and the broader use of isotope studies to non-human remains as a way of investigating palaeoclimates and palaeodiets. There is also a need to develop more detailed archaeological reference collections of Australian animals either in electronic format (Cosgrove, 1999b; Chrisfield *et al.*, 2000) or as printed manuals like those produced for the Northern Hemisphere (eg. Hillson, 1995). The study of birds, reptiles, amphibians and marine mammals in Aboriginal and historic sites is also an area of high priority. These areas of research are common elsewhere but are only now being applied to Australia's unique archaeofauna.

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