

Bone fragmentation patterns in Australian sites

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Abstract

There is broad recognition that faunal assemblages within Australian archaeological and palaeontological sites show high levels of fragmentation. However, a paucity of published data about the quantities (weight, total number of specimens (NSP), number of identified specimens (NISP)) of bone from Australian sites makes it difficult to confirm this beyond anecdotal accounts. This limits our potential to determine the most likely causative factors such as humans, carnivores, weathering or other taphonomic factors. Here we seek to begin a conversation about Australian bone fragmentation patterns by reviewing the available data and discussing opportunities for minimum reporting measures that could improve our understanding of fragmentation trends across Australian sites. We found that the limited quantitative data available makes it difficult to properly characterise fragmentation; however, where data are available, high fragmentation levels are generally supported. In order to properly consider the factors that may make Australian faunal assemblages particularly vulnerable to fragmentation when compared other continents, it is important for more quantitative data to be shared so that the breadth and consistency can be fully understood.

Background

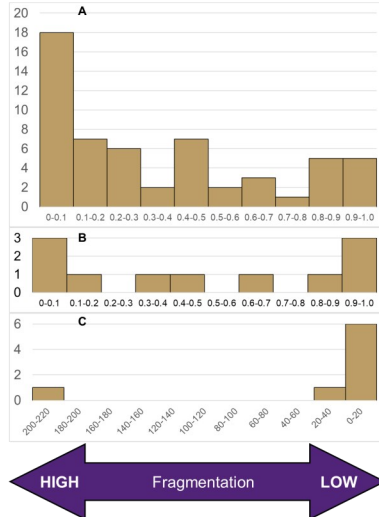
While many authors have referred to the high levels of fragmentation in Australian faunal assemblages¹⁻³, there is wide variability in the types of data reported about vertebrate fauna from Australian archaeological sites^{4,5}. As different taphonomic causes of fragmentation or bone loss can skew common measures used to answer zooarchaeological questions about resource use, species choices and foodways⁶⁻⁹, limited or inconsistent data hinders meta-analyses aimed at understanding taphonomic factors in Australian contexts. This has implications for our ability to address questions of past human-environment interactions.

Methods

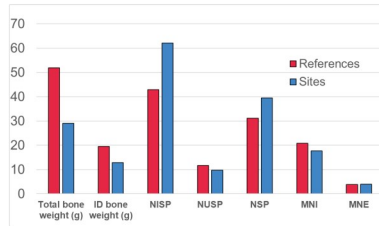
Mein and Manne⁴ identified journal articles discussing primarily native fauna from Australian sites; this list was used as the starting point for this work. To provide more data relating to introduced domesticates, articles from the journals *Australasian Historical Archaeology* and the *Journal of Island and Coastal Archaeology* were also incorporated. These articles were reviewed to determine whether they reported, for vertebrate fauna:

- Total bone weight
- Weight of identified bone
- Number of identified specimens (NISP)
- Total number of specimens (NSP)
- Number of unidentified specimens (NUSP)
- Minimum number of individuals (MNI)
- Minimum number of elements (MNE)
- Any discussion of bone fragmentation.

Where sufficient data were available, we calculated three measures that indicate fragmentation: NISP:NSP, NISP:MW, and weight of identified bone:total weight of bone (IDW:TW)^{7,10}. None of these measures perfectly address factors such as differential weight and size between species or skeletal elements, and interpretations can be distorted by the fact that low to moderate levels of fragmentation typically increase the NISP of an assemblage^{7,8,10}. However, they can all provide a useful indication of fragmentation based on commonly reported data.



Figures, clockwise from top: Figure 1. Histograms of fragmentation indexes for sampled papers. A) NISP:NSP (n=56); B) IDW:TW (n=11); C) NISP:MNI (n=8). X axis has been reversed for figure 1C to align fragmentation across figures. Figure 2. Proportion of identified and unidentified fragments (NISP:NSP) mapped to site locations. Figure 3. Frequency of different forms of quantitative faunal data for references and sites that included at least one category of datum.



Results

We reviewed 217 papers, discussing 272 sites. Papers included site reports, methodological and theoretical studies, review papers, and papers which focussed on analyses of non-faunal materials. Many only briefly mentioned faunal remains as part of broader contextualisation of results. In total, 77 references contained quantitative data on vertebrate fauna from 124 sites.

For sites, NISP was the most provided figure (62 percent; n=77), while NSP was the second most common (40 percent; n=49) (Figure 3). However, 35 of the 56 sites for which NISP and NSP were both provided were from a single meta-analysis¹¹. Removing this single paper reduces the sites with data on NISP to 30 percent (n=37) and NSP to 11 percent (n=14). Sites with quantitative data were predominantly open coastal sites containing mostly marine vertebrates (n=38). Quantitative data for closed sites with mostly terrestrial fauna were more rare (n=6).

NISP:NSP could be calculated for 56 sites. For 32 percent (n=18) of these, less than 10 percent of faunal remains could be identified (Figures 1A, 2). IDW:TW was calculated for 11 sites; 27 percent (n=3) had less than 10 percent of total bone (by weight) identified (Figure 1B). NISP:MNI could be calculated for 8 sites; 75 percent (n=6) had fewer than 20 fragments identified per calculated individual (Figure 1C).

When discussing the cause of fragmentation or bone loss in assemblages, likely causes suggested by authors were soil acidity¹²⁻¹⁴, carnivores^{15,16}, trampling¹⁷⁻¹⁹, or bone processing²⁰.

Discussion

Measures of NISP:NPW and IDW:TW support the anecdotal evidence for Australian faunal assemblages being highly fragmented. Accounts from overseas suggest sites in which only 10 percent of bone can be identified may be considered unusually fragmented^{1,22}. However, our results suggest this may be quite common in Australian sites. Several potential causes for this were cited by authors, such as bone processing, carnivore action, trampling and soil acidity. Other environmental factors should also be considered, such as exposure to ultraviolet light²³ or significant wet-dry cycles²⁴. As our current sample is dominated by open coastal sites with marine vertebrates, this may be impacting on the rate of fragmentation (NISP:NSP) observed in this study. The inclusion of more data from closed sites with terrestrial vertebrate remains may reveal different patterns of fragmentation. Consistent reporting of measures is a key step in allowing broader comparisons of fragmentation across Australian assemblages. To this end, we would encourage all analysts to publish NISP, NSP, total weight and identified weight for faunal assemblages at a minimum.

It is also worth noting that, like any aspect of archaeological analyses, expertise, resources and time constraints can all have significant impacts on identifications of faunal remains²⁵⁻³⁴. These measures of fragmentation all assume any material that could be identified has been. In practice, calculating the NSP of a large assemblage may not be practical or add value to the specific research questions being asked. It also neglects the fact that new techniques for identifying fragmented remains exist^{35,36}. That is why we strongly encourage the reporting of as much detail about quantification and identification protocols as possible, maximising the potential for assemblages to be compared within broader regional syntheses and meta-analyses.

Developing a clear understanding of the processes leading to fragmentation and differential survival of faunal remains informs interpretations of identified fauna, but can also support the use of taxonomically unidentified bone in other ways. Understanding these processes can help inform sample selection for ZooMS and aDNA testing^{22,37,38}. However, even bone fragments that can't be identified can have value for zooarchaeological interpretations. Studies have begun to show the way in which these fragments can help identify the role of carnivores in Australian assemblages^{3,39,40}. Beyond this, developing a better understanding of bone fragmentation in Australian sites can inform us about marrow extraction or other methods humans may use to process animal remains. Outram^{41,42} has shown the potential of fragmentation patterns to identify bone processing in sites from Europe. While ethnographic accounts discuss Aboriginal and Torres Strait Islander butchery practices involving bone breakage^{43,44}, few have investigated evidence of marrow or grease processing from Australian sites^{16,45}, and there has been limited attribution of fragmentation of faunal assemblages outside of Tasmania to intentional human action^{46,47}.

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