Chapter 9
Identification: Sorting Decisions and Analytic Consequences

Zoologists traditionally have focused on complete skeletons, and even paleontologists show a preference for more or less complete osteological elements when distinguishing species. Zooarchaeologists, by contrast, expect that most of their specimens will be fragmented due to human handling and other taphonomic processes. They also expect that valuable information about human handling and site formation is recoverable even from less identifiable specimens. Thus, from the initial sorts of an archaeofaunal sample, specimen identifiability is assessed, and the balance of one's analysis can follow upon the decisions made at this point. Because analysts make this distinction differently, how one decides to exclude specimens from further analysis can ultimately determine the structure of one's data on element frequencies and even taxonomic abundances, possibly affecting inter-analyst comparability. This major, albeit seldom discussed, methodological issue merits treatment in some detail in this chapter.

9.1 Levels of Identifiability: A Multidimensional Issue

The analyst's first task is to sort through archaeofaunal materials from a unit and level. If one empties out a typical level bag containing only fauna, one may see a few whole bones, bone fragments, teeth whole or broken, and, depending on the area sampled perhaps some molluscan shell. Some specimens, such as rodent incisors, are immediately recognizable as belonging to a certain taxonomic order. Depending on one's familiarity with the regional fauna, certain elements of some species, like a warthog tooth, are immediately identifiable to species level. Other fragments may be attributable to element on the spot but require comparative specimens for species attribution. One may recognize a distal radius of a medium-sized artiodactyl, or the third phalanx of a raptorial bird, but these will require further checking against morphologically similar and like-sized species known to inhabit the region studied. Other bits of bone are recognizable according to their body

© Springer International Publishing AG, part of Springer Nature 2018

D. Gifford-Gonzalez, *An Introduction to Zooarchaeology*,
https://doi.org/10.1007/978-3-319-65682-3_9

Table 9.1 Some examples of the interaction of differing levels of taxonomic versus osteological identifiability (ID)

Osteological ID	High Taxonomic ID	Medium Taxonomic ID	Low Taxonomic ID
High *Example*	Cervical 3 Thomson's gazelle	Cervical 3 Small bovid	Cervical 3 Medium mammal
Somewhat lower *Example*	Cervical fragment Thomson's gazelle	Cervical fragment Small bovid	Cervical fragment Medium mammal
Considerably lower *Example*	Vertebra fragment Small bovid	Vertebra fragment Small artiodactyl	Vertebra fragment Medium mammal
Lowest *Example*	Cancellous fragment Medium mammal	Cancellous fragment Medium mammal	Cancellous fragment Mammal size indeterminate

region, for example a fragment of vertebra or a 2-cm length of long bone shaft. Still other fragments, however, are simply recognizable as bones of mammals, of birds, of reptiles, amphibians, or fishes. Finally, some fragments are so ambiguous that one might resort to microscopic examination (or the notorious touch-it-to-the-tongue test – bone usually sticks) to determine if it even is bone. The foregoing descriptions distill the two intersecting continua of identifiability: osteological identifiability, on the one hand, and taxonomic identifiability, on the other. This can be represented in tabular form, showing how high-to-low levels of osteological and taxonomic identifiability interact to produce different identification outcomes (Table 9.1).

Remarkably few methodological articles or zooarchaeological reports have discussed the criteria involved in distinguishing an identifiable from a nonidentifiable specimen. An exception is Driver's (1992) excellent piece, republished with comments by other zooarchaeologists, as well has his own reflections 20 years later (Driver 2011). The issue was explicitly addressed by Klein and Cruz-Uribe (1984), Morales Muñiz (1988), Reitz and Wing (2008), and Zeder (1991), demonstrating that a diversity of opinion exists among zooarchaeologists regarding criteria for cutoffs between these categories. One zooarchaeologist's "unidentifiable fragment," excluded from further examination early in analysis, may include diaphyseal fragments recorded as "Medium bovid tibia" in another's analysis. Marean et al.'s (2004) discussion of diaphyseal fragments in palaeolithic assemblages presents a good overview of these divergences' analytical implications.

9.1.1 Factors Influencing Identifiability

Binford and Bertram (1977) asserted that there is no such thing as an unidentifiable bone. From the viewpoint that any bone fragment does ultimately derive from a specific bone in a specific animal of a specific taxon, it is theoretically possible that any specimen could be identified. However, in practice, most analysts are more than willing to put a proportion of fragments in a "nonidentifiable" category.

Preliminary sorting and analysis into potentially identifiable and nonidentifiable is influenced by a variety of factors. These include:

1. The abilities of the analyst;
2. the extent of specimen fragmentation by human action or other processes;
3. the screen size or other recovery methods used in obtaining the sample;
4. the likelihood of encountering two or species of similar size and morphology in the region sampled;
5. whether identification of minimally identifiable specimens to grosser taxonomic levels is deemed to be a useful part of one's overall analytical strategy;
6. whether identifications of minimally identifiable specimens to body region is deemed to be a useful part of one's overall analytical strategy;
7. the amount of time and other essential resources one has for analyzing the assemblage.

The next sections examine each of these determinants of identifiability in more detail. I will refer to examples from my own experiences because I have a better grasp of the underlying issues and decisions relevant to this discussion.

9.1.1.1 Analysts' Abilities

Researchers' abilities to identify fragmentary specimens vary. White (1992) notes that inter-analyst differences in what is considered identifiable are a concern when comparing assemblages. The longer one works with the same range of species, the more likely one is to become more knowledgeable. All other factors being equal, sites analyzed earlier in one's career are likely to have proportionately more non-identifiable or minimally identifiable materials than sites analyzed later, at least at the level of element identification. However, Driver (2011) observed a countervailing tendency, especially at the taxonomic attributions, toward what could be called "over-specific identification." He notes this is many times more characteristic of new students in the field, an observation I would support, but Gobalet's (2001) study (see below) indicates it may be more pervasive.

To give an example of experience-based increments in osteological and taxonomic identifications, I can look back at the effects of 20 years of practice in my career. In 1970–1971, I was a graduate student at the University of California, Berkeley and joined a team of relatively unskilled student sorters of the 165,000 bone specimens from Prolonged Drift. A skilled zooarchaeological supervisor was lacking because such individuals were then very rare, but one team member had paleontological experience, and I had studied human osteology. Our goal was to sort the very large assemblage into potentially identifiable, individually bagged specimens, and to place the less identifiable and completely nonidentifiable specimens into bag lots, weighing and counting as we went. In 1974, I went on to analyze several thousand potentially identifiable specimens isolated in the earlier sorts at the National Museum of Kenya, Nairobi, my first experience using comparative specimens to identify an East African archaeofauna. Through the late 1970s and 1980s, I analyzed about 30 more such African archaeofaunas.

In 1990, while working in the Kenya National Museum collections again, I decided to review the Prolonged Drift specimens that I had in 1974 put into a carton labeled the "Saint Jude Box," after the Catholic patron saint of hopeless cases. These were specimens with distinctive landmarks that I nonetheless had been unable to identify to element or taxon. I cleared the box completely in 2 days, identifying fragmentary bovid and equid metapodials, carpals, and tarsals to species and identifying all the "long bone shaft fragments" to elements. With these diaphyseal specimens, I could determine element, side, and taxon (species or Large Bovid, etc.) of about half of them without using comparative specimens, and I identified the balance to element and higher taxonomic levels (e.g. medium bovid) with the aid of the rich reference collections at the Museum. Going through these specimens, I reflected on my gains in knowledge of the morphology of East African ruminant and equid bones over those intervening 16 years.

When an analyst shifts regions and taxa, such benefits of long experience are largely lost. My ability to distinguish like-sized African bovids did not offer much traction when, in the late 1990s, I shifted to working with closely related members of the Otariidae, or eared seals. The only thing that I believe carried over was having "learned how to learn" minor differences in morphology: where to look (bone form, joint surface shape, muscle attachments) and why (feeding and locomotor anatomy).

Given these factors, most zooarchaeologists would probably agree that different analysts working with the same assemblage would probably sort identifiable to non-identifiable bone differently. The question is, by how much? This was not, to my knowledge, tested with mammal taxonomic identifications until recently, although ichthyologist Kenneth Gobalet (2001) undertook blind tests with zooarchaeological fish identifications. Gobalet's results were less than assuring, with five fish analysts identifying between four and 18 species from the same samples and varying considerably in rates at which were assigned to family or higher taxonomic grouping (Gobalet 2001: Table 2). He notes there were more problems of over-specific, erroneous identifications than with the opposite, opining that it might be natural for someone trained on species in one area to attribute the same species to roughly similar from another region.

Morin et al. (2017a) experimentally assessed inter-analyst concordance, mainly focusing on mammal skeletal element identification and a restricted range of taxa, using 506 elements, allocated in about equal proportions to be the "input" to two separate fragmentation processes: marrow extraction (5354 specimens ≥1 cm) and bone grease production (10,522 specimens ≥1 cm), respectively. Red deer (*Cervus elaphus*) specimens dominated each sample, with over 500 complete skeletal elements of the 506. Each specimen ≥1 cm was assigned a random number linking it to its original element and species identification. Test volunteers had moderate to significant experience with identification of animal remains, including the species in the sample and were given an instruction guide that requested estimates of commonly used quantitative measures (Chap. 10). Details of the analysis of inter-analyst results are to be found in Morin et al. (2016:902–910). Two aspects of inter-analyst agreement were examined: percentage of specimens identified to skeletal element and error rates of these identifications. A high level of inter-analyst concordance characterized the element identification percentages with the bone marrow sample, whereas the bone grease sample was more highly variable, as might be expected, given the comminution of the assemblage and variations in experience among analysts. Error rates were compared, and these were more variable, in terms of *how* analysts erred, and some differences were statistically significant. Breaking this down by categories of elements, Morin et al. (2016:908–910) noted that, for given types of elements, inter-analyst error rates differed by less than 10%. Accuracy varied with which zone of the skeleton was analyzed. Long bones, especially shaft fragments, represented the least accurately identified class of elements, a topic that will be taken up in Chaps.10 and 18.

The Morin et al. experiment demonstrates that identification accuracy can be affected by involving sorters with different skill levels. With large assemblages, I routinely assigned the most experienced graduate students to make definitive element and taxonomic identifications, with ongoing spot-checks by me. However, experts can only work with what less skilled sorters select out as potentially identifiable and pass on to them. In my Santa Cruz lab, each grad student usually worked with a few undergraduate interns whom they tasked with preliminary sorts of a specific type (e.g. fish bone vs. lagomorph bone vs. bird bone). This allowed one-to-one feedback between the more and less expert members of any given team, as well as opportunities for the undergrads to acquire specialized skills.

When I worked in a field lab on the Gol Kopjes Site (SAES coordinate site number HcJe1) on the Serengeti Plains, Tanzania in 1983, a National Science Foundation funded field project headed by the late John Bower (Bower and Chadderdon 1986), a five-person lab team sorted over 50,000 specimens in about six weeks. I was fortunate to have as initial sort supervisor Kathlyn Stewart (Canadian Museum of Nature), then a doctoral student with fine zooarchaeological skills in identifying North American mammals and fishes. Several Tanzanian novice assistants had good natural abilities and high motivation. Stewart provided enough training and supervision to the primary sorters that, when I later made spot-checks of the "nonidentifiable" bone fraction they had sorted, I could not find any potentially identifiable specimens (unlike, I regret to say, the Prolonged Drift "nonidentifiable" fraction). This reassurance freed me to focus on the most identifiable assemblage component for several weeks in the field lab with the assurance that we'd overlooked very little. These anecdotes illustrate that the standards of a given analysis are only as strong as its weakest links, but that, with guidance and oversight, preliminary sorting by novices can produce acceptable results.

At home in my own laboratory, I used a "production chain" approach. Novices who had done well in my vertebrate osteology lab course made preliminary sorts under my own or my graduate students' supervision. Grads made taxonomic identifications for taxa with which they were very familiar and recorded bone surface modifications. I worked at the end of the chain for taxa I know best, definitively identifying terrestrial carnivores and pinnipeds, while initially spot-checking everyone's work. I checked grads' ascriptions until I could not find errors. A team leader stopping to check a proportion of identifications by somewhat less skilled sorters does slow the rate of progress, but it makes the output more consistent. I could sometimes say that the buck literally stopped at my workstation before being entered in the database.

While analyzing her doctoral dissertation materials, Laura Scheiber (Indiana University), took an alternative approach to using skills levels of students. To analyze the predominantly bison specimens from the Donovan Site (Scheiber and Reher 2007), she organized teams of undergraduates who had completed my comparative osteology class, each team specializing in specific body segments: a cranium/mandible team, a vertebrae team, one team working with scapula and innominate fragments (because of possible conflation of these in preliminary sorts), fore limb and hind limb teams, and a team dealing with rare other species. Within a few weeks, the five bison teams had developed an excellent familiarity with "their" body segments, as well as a camaraderie that helped move the analysis forward. Team members checked one other's work and further reduced errors by flagging specimens that needed Scheiber's expert opinion.

9.1.1.2 Degree of Element Fragmentation

The extent to which osteological elements have been fragmented influences the ratio of identifiable to unidentifiable specimens in an assemblage. The more fragmented an assemblage, the less likely it is that all small pieces can be assigned to taxon, or even to element, as indicated by the Morin et al. study described above. Larger fragments of an element are more likely to have distinctive anatomical features than are smaller fragments of the same element. These differences can complicate comparing estimates of relative abundances from one site to another. However, such differences in intensity of fragmentation can be a rich source of information on human subsistence behavior.

From a half-century of ethnoarchaeological research, we know that the same forager group can produce variable proportions of identifiable to unidentifiable fragments at different locales and times of the year, according to their goals in handling carcasses. Binford's (1978, 1981) ethnoarchaeological case studies among the Nunamiut people of Anaktuvuk Pass, Alaska showed this well. At the caribou mass kill and butchery locale of Anavik, quite a few bones were discarded nearly whole after meat was stripped from them. Some long bones were discarded after being broken to extract marrow, overall resulting in few unidentifiable specimens at Anavik. By contrast, at Anaktuvuk, the village where families of the same group over-wintered, women manufactured bone grease by smashing up stockpiled caribou bones into small pieces and simmering them (Binford 1978), this produced many very small bone fragments which, had one not seen the bones entering the process, would have been difficult to identify to body region.

Both Anavik and Anaktuvuk incorporated mainly one species, caribou, so the proportions of identifiable to unidentifiable specimens in the two sites might not affect estimates of taxonomic composition. However, if the compositions of species processed at the kill-butchery versus residential sites were to differ from one

Fig. 9.1 Longitudinal section of a cow (*Bos taurus*) humerus, showing internal features of the diaphysis that aid in identification. Specimen from a dairy herd in Swarzedz, western Poland. Long bone specimens were donated to author by Professor Arkadiucz Marciniak, University of Poznan. Sectioning courtesy Richard Baldwin, University of California, Santa Cruz. (Photo by author)

another, then the divergent fragmentation intensities could pose problems for comparing taxonomic composition. The more fragmented state of one species could conceivably "conceal" it in the sample.

Identifying fragmentary long bone diaphyses, I have found that longitudinally sectioned long bones of species common in archaeofaunas with which I work, such as deer for my California analyses, and cattle for my East African research, facilitate identifications (Fig. 9.1). The sections permit matching diagnostic features of the medullary cavity wall with analogous ones on a fragment that lack distinctive features on their outer walls.

9.1.1.3 Recovery Techniques

Screen size and general recovery methods have been discussed Chap. 8 in terms of their influence on taxonomic representation, and they can also influence the proportion of identifiable to nonidentifiable bones. Very fine mesh or flotation may recover very small bits of the elements of larger animals, thus increasing specimen counts in the minimally identifiable and nonidentifiable assemblage categories. We saw this in my lab with the flotation samples that yielded the many very small fish elements identified by Dr. Boone: mixed in with these largely complete specimens were tiny "bone crumbs" of cancellous tissue from much larger mammals. If one wishes to compare ratios of identifiable specimens between or among sites, or relative abundances of very small to large animal species, one should begin with comparing sample recovery methods.

9.1.1.4 Levels of Taxonomic Identifiability

Another problem with identifiability has also been alluded to above. This occurs when more than one species of overall similar morphology and morphology might exist in an archaeofaunal sample. If the only medium-large sized artiodactyl ever documented in a region is the mule deer (*Odocoileus hemionus*), and if a specimen actually had no morphological traits distinctive of *Odocoileus*, some analysts would feel reasonably secure in assigning even fragmentary artiodactyl specimens in the mule deer size range, to that species.

Klein and Cruz-Uribe (1984:17–20) discuss the assumptions underlying taxonomic ascriptions in such situations, noting that analysts rely on their background knowledge of the species expected to occur in a given temporal and geographical context. In Africa, where many wild bovid species and three domestic species of the family Bovidae can coexist, zooarchaeologists and paleontologists routinely diagnose species on the basis of teeth, horn cores, and less fragmentary postcranial remains (e.g. Peters 1986a, 1986b). They place more fragmentary and taxonomically ambiguous bovid specimens into standardized size classes (Brain 1981; Klein 1976), for example, "medium bovid."

Zooarchaeologists working with central coastal California archaeofaunas face such issues, as both mule deer and pronghorn are historically or archaeologically attested. These two species are not even members of the same zoological family; mule deer are in the Cervidae, and pronghorns are in the Antilocapridae. However, they are of similar body size, and a very fragmentary specimen may not be taxonomically distinguishable. In this case, a wise zooarchaeologist would refer it to some more general classification, for example, "medium ruminant (or artiodactyl)."[1]

Driver (2011) cogently argued against such "identification by association," stating that each specimen should be identified based upon its own traits, rather than its likelihood of being derived by a species identified from other specimens. Discussions of Driver's point by Butler (2011) and Lyman (2011) are of interest. Butler (2011: 31) contended that Driver's recommendation against taxonomic "identification by association" can be modified under some circumstances. She points out that only one member of the family Catostomidae (suckers), *Catostomus macrocheilus*, the largescale sucker, is represented among identifiable specimens in some fish archaeofaunas with which she has worked. She argues that, based upon a thorough analysis of an assemblage, she is willing to assign less identifiable catostomid specimens to this species.

Lyman (2011) argued that zooarchaeologists would benefit from following paleontological practices in describing species, which involve detailed descriptions with

[1] I prefer "Ruminant" because it reflects a more precise level of identification. The zoological suborder Ruminantia is one of three suborders within the order Artiodactyla, the other two being Suiformes (including pigs) and Tylopoda (including modern Asian camels and South American camelids). The Ruminantia includes all even-toed hoofed animals with ruminating stomachs, which genomic analysis shows to be a longstanding divergence in the order (Fernández and Vrba 2005). When referring to members of two zoological families within the suborder, as the Cervidae and Antilocapridae, Ruminantia or "ruminant" is more precise than is the name of the order.

illustrations of diagnostic features as well as blind tests of taxonomic identifications. This is excellent advice for rigorously describing archaeofaunal evidence for rare or first occurrences of a taxon in a region. However, zooarchaeologists have not yet worked through challenges of executing this protocol with archaeofaunal materials:

1. how we deal with differences in collection size;
2. how we define commonly encountered species not needing such treatment (Butler and Lyman 1996);
3. how we publish previously unpublished diagnostic postcranial elements that have not been addressed in paleontological works.

One method for advancing common zooarchaeological knowledge, along these lines as exemplified by paleontologically or zoologically trained researchers such as Guilday, Lawrence, and Peters (Chap. 4), is alternating between publishing on archaeofaunas and publishing identification guides to closely related species encountered in the archaeofaunas.

I counsel my students to take Driver's advice and be conservative in their taxonomic attributions, referring specimens to a more general, but solidly defensible, level of identification. This advice may seem to contradict the experience I recounted with the "St. Jude Box" in Nairobi. However, most of the mysteries there were resolved by identifying the *osteological element*, and then assessing whether enough other, species-specific osteological features existed on individual specimens to make a more definite *taxonomic* ascription than "large bovid," "small bovid," etc.

Practically speaking, when working with central coastal Californian archaeofaunas, I have maintained the separation between *Odocoileus* and medium ruminants in archaeofaunal report main table, even when no *Antilocapra* specimens had been found by evaluating specimens with comparative materials of both taxa. However, I have also noted in methods sections that, when no *Antilocapra* were identified among the most identifiable specimens, it is highly likely that the medium ruminant component in the sample were from *Odocoileus.* Moreover, for some types of analysis, such as processing effects, I combine these two categories, again noting that I am doing so and why.

Analysts working with Holocene archaeofaunas may begin by consulting reports on previously excavated sites of similar age and contexts, augmented by historical accounts and guides to modern regional faunas. However, as zooarchaeologists' reports have shown, even in the Holocene, the species we expect from historical records may not tell the whole story, as some species previously inhabiting a region disappeared before European colonization and record-keeping (Hildebrandt 1984; Lyman 1983). For those working with very old archaeological sites from Pleistocene or even Pliocene epochs, zooarchaeologists refer to species lists from previously analyzed paleontological and archaeofaunal assemblages of similar age and geographic context to assess the likelihood of encountering certain ancient species in their samples.

Assigning fragmentary specimens to species is further complicated by sexual dimorphism as well as by intraspecific geographic and temporal size variation.

For example, the closely related eared seal species of the north Pacific are so sexually dimorphic that females of the largest species, the Steller sea lion (*Eumetopias jubatus*) overlap in size with males the smaller California sea lion (*Zalophus californianus*) and large male northern fur seals (*Callorhinus ursinus*), all of which have been known to breed or haul out on the same isolated stretches of coastline or islands in historic or pre-European contact times. Analysts must be aware of such potential problems in their species samples, and of the need to use comparative specimens to resolve ambiguous cases.

Geographical differences in body size are known for regional populations of a single species. Analysts should be alert to the possibility that comparative specimens collected from regions other than those from which their archaeofaunal samples derive may differ in modal size, as Zeder (2005) showed was the case for *Capra aegagrus*, the ancestor of domestic goats. Early Holocene bison in North America display larger modal body size than historically documented populations (Lyman 2004; Wilson 1978), as is also noted for bear (Wolverton and Lyman 1998). Factors underlying such diachronic size changes are similar to those conditioning synchronic geographic variability in size: variations in the quality of forage and other essential resources, as well as interspecific relationships. All these factors call for considerable circumspection on the part of analysts making identifications of older archaeofaunas using modern comparative collections.

In sum, depending on the vertebrate species richness in a region and the intensity of fragmentation of a sample, the most prudent identifications of fragmentary specimens may be at higher levels of classification (e.g. genus, family, suborder) than the species level. Such taxonomic "demotions" will result in species abundance statistics to be based on fewer species-diagnostic specimens. These levels of identifiability nonetheless can work well for grosser assessments of taxonomic abundance, such as comparisons of ruminants vs. pinnipeds in regional archaeofaunas, and they certainly are functionally appropriate for studying butchery and processing activities, as will be discussed in the next section.

9.1.1.5 Uses of Less Taxonomically Identifiable Elements

Although they are of limited use in addressing research questions concerning regional paleoenvironment and species dynamics, less taxonomically and osteologically identifiable specimens can be used to investigate carcass handling (Table 9.1). Because humans will likely follow similar processing strategies with anatomically similar species, less identifiable specimens can be aggregated with species-identifiable ones to enlarge the sample size for studying butchery and culinary processing. Even in cases where the presence of two or more very similar taxa prevents definitive species identification, aggregating all specimens attributable to the same size class produces useful datasets. With these, I explored whether people at the Prolonged Drift site handled different-sized prey in a divergent manner, comparing element frequencies, locations and rates of cut marks, and other damage in this aggregate to a similar aggregate of larger bovid specimens (Gifford et al. 1980).

Marshall (1990) followed a similar strategy when comparing the handling of sheep and goats (which in fragmentary states, generally could not be differentiated) with handling of cattle at the central Kenyan pastoralist site of Ngamuriak.

Size-grouping specimens identified to varied taxonomic specificity is especially useful when certain body segments are consistently less likely to be species-identifiable. Vertebrae, for example, are relatively fragile (Kreutzer 1992; Lyman 1984, 1992). They are also likely to be broken down during primary and secondary butchery and in culinary processing by boiling (O'Connell et al. 1990; Oliver 1993; Yellen 1977). Their fragmentation renders vertebrae less likely to be assigned to genus or species than are more durable carpal and tarsal bones. To obtain a comprehensive view of carcass processing strategies, including transport decisions, one's sample must include less taxonomically identifiable specimens along with those that have been identified to genus or species.

However, lumping similarly sized taxa is less useful for other research questions. Putting all wild specimens in a single pool would not be productive for investigating hunting. Closely related wild species have divergent ecological niches and behaviors, hunting tactics for each may vary, and pooling might obscure these. Likewise, the processing of domestic versus wild animals of similar sizes may differ, and grouping these together will obscure this.

9.1.1.6 Uses of Less Osteologically Identifiable Elements

As with specimens of varying levels of taxonomic identifiability, it may be worthwhile to place minimally identifiable elements into general body region categories and use them for taphonomic and butchery analyses. These specimens are often the same fragile or heavily processed elements that cannot be identified to species. Fragments of crania, vertebrae, ribs, and long bone diaphyses can be assigned to "minimally identifiable" categories. As noted regarding taxonomic identification, the decision whether to use minimally identifiable element categories stems in part from the research questions zooarchaeological practitioners want to ask. If one is mainly interested in what taxonomic abundances can reveal about changes in climate, ecology, or species over time, these specimens are not useful. However, if one is interested in teasing out information on human handling of animals or the archaeofauna's taphonomic history, they merit attention (Ziegler 1973).

This sometimes reveals the presence of body segments that may be underrepresented by better-preserved specimens. Ethnoarchaeological research has highlighted that hunters handle limbs of large prey differently than axial elements, especially vertebrae, when transporting larger mammals' body segments (Chap. 19). These findings and those on differing carnivore impacts on various body segments (Chap. 12) make it critical to assess the presence or absence of vertebrae in archaeofaunas. Here, the minimally identifiable component can shed important light on whether, for example, vertebral segments are present, albeit in fragmentary form, in an assemblage.

In my East African research, I analyzed archaeofaunal samples from Ele Bor A, a stratified rock shelter site near the Kenya-Ethiopia border (Phillipson 1984; Gifford-Gonzalez 2003), which demonstrated the survival of vertebral fragments, even in a highly comminuted archaeofauna. The modal maximum dimension of specimens from the site was 2 cm, with very few pieces greater than 5 cm. In one stratigraphic unit, 57% of 1404 taxonomically identifiable bovid specimens were isolated teeth, carpals, tarsals, sesamoids, first and second phalanges, all relatively dense elements that typically withstand attritional processes. However, cervical vertebrae accounted for 7% of bovid specimens. In another layer with 978 bovid specimens, cervical vertebrae comprised 4% of bovid specimens, ranking immediately below teeth, carpals, tarsals, and sesamoids in frequency. Dense segments of fragile vertebral elements can survive even in assemblages subject to heavy attrition, and testify to transport of these body segments to the site. This illustrates the risks of assuming certain body segments were not transported, simply because they do not fall into the most osteologically and taxonomically identifiable categories (Table 9.1).

Careful study and enumeration of minimally identifiable or nonidentifiable specimens can directly shed light on the economics of animal processing. Outram (2001, 2003; Outram and Mulville 2005) made the case for study of nonidentifiable specimens to assess rates of bone grease extraction, a labor-intensive activity, which in turn reflects a strong motivation on the part of the processors to recover fat. Working with archaeofaunas from the Neolithic Anatolian site of Çatalhöyük, Martin and Russell (Martin 2001; Russell and Martin 2005), were able to use the ratios of nonidentifiable specimens as one of several indices to determine whether samples derived from feasting or everyday animal processing, which at certain seasons included bone grease production. This topic will be taken up in more detail in Chap. 15.

9.1.1.7 Identifiability Decisions Based on Logistical Constraints

The proportions of identifiable to nonidentifiable specimens in an assemblage also may depend upon the amount of time and essential resources an analyst has at their disposal. I can give an example from my own research. In 1983, when I worked as zooarchaeologist on the Gol Kopjes excavation project in the Serengeti National Park, the Tanzanian economy was at a very low ebb. Gasoline was in severely rationed, and supplies of all sorts were hard to find. The Tanzanian government was also discouraging temporary exportation of archaeological samples to neighboring Kenya for a more detailed analysis in the Kenya National Museum, despite lacking comparable collections in Tanzania. As a result, I needed to sort and identify nearly all recovered specimens in a lab at the Serengeti Wildlife Research Institute (SWRI) at Seronera, using supplies at hand and comparative specimens of the most common bovids in the Park, plus whatever we could collect within walking distance of SWRI. A further complication was that SWRI's electricity was cut, and we had the

12-hour equatorial day for work. We were in the lab an hour after first light and stayed until dusk. As noted in earlier, a fine crew of sorters isolated thousands of potentially identifiable bones in six weeks.

I arrived 2 weeks into the excavation, with 4 weeks to do the work and the chance to export only a few hundred specimens to Kenya for further examination. Bones from deeper levels of the main, Gol Kopjes site were often covered with calcium carbonate concretions. This did not hinder element or taxon identification but did obscure surface modifications. We quickly exhausted our supply of dilute acetic acid for removing concretions from specimens, and no more could be obtained.

Given these limitations, I decided to depart significantly from my usual analytic tactics. Previous radiocarbon dates and ceramic evidence indicated the Gol Kopjes cultural sequence spanned about 4000 years, encompassing the time when pastoralism appeared in East Africa, and the excavator wanted to monitor these developments in the Serengeti. This could be assessed by the presence or absence of domestic fauna in successive levels. I decided to process as many highly diagnostic (more complete) specimens as possible in the time allotted. I opted not to spend time further identifying minimally identifiable fragments but instead to focus on taxonomically diagnostic elements: teeth, carpals, tarsals, long bone joint surfaces, and bovid anterior cervical vertebrae, which are often species-diagnostic.

These choices affected the categories of identifiability into which bones were placed. Although I had satisfied myself that the "nonidentifiable" category did not contain potentially identifiable elements, I believe that the general taxonomic categories (e.g. small bovid, medium bovid) and minimally osteologically identifiable body segment categories in the Gol Kopjes archaeofauna are proportionately larger than they would have been, if I had worked with them for a longer time with good comparative specimens – in which case, a good percentage of these would have been "promoted" to a species identification. This is a stark example of the influence of time and resource limitations on proportionate levels of identifiability and recording of other distinctive traces. I believe that significant and reliable information was gathered from the elements we processed. Nonetheless, I recognize that the analytical "triage" created a different database than those generated by my analyses in more leisurely, better-equipped contexts.

Zooarchaeologists who work with in foreign countries from which collections cannot be exported may look with undue envy at colleagues who work with collections in their home countries, imagining the luxury of being able to check identifications over months or even years. In reality, many zooarchaeologists working on home country archaeofaunas also face deadlines for project funding and reporting, permit and resource crunches, coping with some of the same problems as overseas workers. In some situations, analysts can't do much about the root causes of logistical problems that force them to streamline their analyses in ways they'd rather not. The important step is to be as specific as they can about the corners they had to cut in the strategy they in fact did follow as the best way to meet their project's goals.

References

Binford, L. R. (1978). *Nunamiut ethnoarchaeology*. New York: Academic Press.

Binford, L. R. (1981). *Bones: Ancient men and modern myths*. New York: Academic Press.

Binford, L. R., & Bertram, J. (1977). Bone frequencies – and attritional processes. In L. R. Binford (Ed.), *For theory building in archaeology: Essays on faunal remains, aquatic resources, spatial analysis, and systemic modeling* (pp. 77–153). New York: Academic Press.

Bower, J. R. F., & Chadderdon, T. J. (1986). Further excavations of Pastoral Neolithic sites in Serengeti. *Azania, 21*(1), 129–133.

Brain, C. K. (1981). *The hunters or the hunted? An introduction to South African cave taphonomy*. Chicago: University of Chicago Press.

Butler, V. L. (2011). Comments on “identification, classification and zooarchaeology.” *Ethnobiology Letters, 9*(1), 31.

Butler, V. L., & Lyman, R. L. (1996). Taxonomic identifications and faunal summaries: What should we be including in our faunal reports? *Society for American Archaeology Bulletin, 14*(1), 22.

Driver, J. C. (1992). Identification, classification and zooarchaeology. *Circæa, 9*(1), 35–47.

Driver, J. C. (2011). Identification, classification and zooarchaeology. *Ethnobiology Letters, 2*, 19–39.

Fernández, M. H., & Vrba, E. S. (2005). A complete estimate of the phylogenetic relationships in Ruminantia: A dated species-level supertree of the extant ruminants. *Biological Reviews, 80*(2), 269–302.

Gifford, D. P., Isaac, G. L., & Nelson, C. M. (1980). Evidence for predation and pastoralism at Prolonged Drift, a Pastoral Neolithic site in Kenya. *Azania, 15*, 57–108.

Gifford-Gonzalez, D. (2003). The fauna from Ele Bor: Evidence for the persistence of foragers into the later Holocene of arid north Kenya. *African Archaeological Review, 20*(2), 81–119.

Gobalet, K. W. (2001). A critique of faunal analysis: Inconsistency among experts in blind tests. *Journal of Archaeological Science, 28*(4), 377–386.

Hildebrandt, W. R. (1984). Archaeological presence of the northern fur seal (*Callorhinus ursinus*) along the coast of northern California. *The Murrelet, 65*(1), 28–29.

Klein, R. G. (1976). The mammalian fauna of the Klasies River Mouth Site, southern Cape Province. *South African Archaeological Bulletin, 31*(123/124), 75–98.

Klein, R. G., & Cruz-Uribe, K. (1984). *The analysis of animal bones from archaeological sites*. Chicago: University of Chicago Press.

Kreutzer, L. A. (1992). Bison and deer bone mineral densities: Comparisons and implications for the interpretation of archaeological faunas. *Journal of Archaeological Science, 19*(3), 271–294.

Lyman, R. L. (1983). Prehistoric extralimital records for *Pappogeomys castanops* (Geomyidae) in northwestern New Mexico. *Journal of Mammalogy, 64*(3), 502–505.

Lyman, R. L. (1984). Bone density and differential survivorship in fossil classes. *Journal of Anthropological Archaeology, 3*(4), 259–299.

Lyman, R. L. (1992). Anatomical considerations of utility curves in zooarchaeology. *Journal of Archaeological Science, 19*(1), 7–22.

Lyman, R. L. (2004). Aboriginal overkill in the intermountain west of North America: Zooarchaeological tests and implications. *Human Nature, 15*(2), 169–208.

Lyman, R. L. (2011). Comments on "identification, classification and zooarchaeology." *Ethnobiology Letters, 2*, 33–34.

Marean, C. W., Domínguez-Rodrigo, M., & Pickering, T. R. (2004). Skeletal element equifinality in zooarchaeology begins with method: The evolution and status of the “shaft critique.” *Journal of Taphonomy, 2*(2), 69–98.

Marshall, F. B. (1990). Cattle herds and caprine flocks. In P. T. Robertshaw (Ed.), *Early pastoralists of South-western Kenya* (pp. 205–260). Nairobi: British Institute in Eastern Africa.

Martin, L. (2001). Hunting, herding, feasting: Animal use at Neolithic Çatalhöyük, Turkey. *Archaeology International, 4*, 39–42.

Morales Muñiz, A. (1988). Identificación e identificabilidad: Cuestiones básicas de metodología zooarqueológica. *Espacio, tiempo y forma. Serie I, Prehistoria y arqueología,* (1), 455–470.
Morin, E., Ready, E., Boileau, A., Beauval, C., & Coumont, M.-P. (2017). Problems of identification and quantification in archaeozoological analysis, Part I: Insights from a blind test. *Journal of Archaeological Method and Theory, 24*, 886–937. https://doi.org/10.1007/s10816-016-9300-4.
O'Connell, J. F., Hawkes, K., & Blurton-Jones, N. (1990). Reanalysis of large mammal body part transport among the Hadza. *Journal of Archaeological Science, 17*(3), 301–316.
Oliver, J. S. (1993). Carcass processing by the Hadza: Bone breakage from butchery to consumption. In J. Hudson (Ed.), *From bones to behavior: Ethnoarchaeological and experimental contributions to the interpretation of faunal remains* (pp. 200–227, Occasional Paper, Vol. 21). Carbondale, IL: Center for Archaeological Investigations, Southern Illinois University Press.
Outram, A. K. (2001). A new approach to identifying bone marrow and grease exploitation: Why the "indeterminate" fragments should not be ignored. *Journal of Archaeological Science, 28*(4), 401–410.
Outram, A. K. (2003). Comparing levels of subsistence stress amongst Norse settlers in Iceland and Greenland using levels of bone fat exploitation as an indicator. *Environmental Archaeology, 8*(2), 119–128.
Outram, A. K., & Mulville, J. (2005). The zooarchaeology of fats, oils, milk, and dairying: An introduction and overview. In J. Mulville, & A. Outram (Eds.), *The zooarchaeology of fats, oils, milk and dairying* (pp. 1–6). Oxford: Oxbow Books.
Peters, J. (1986a). *Osteomorphology and osteometry of the appendicular skeleton of African Buffalo,* Syncerus caffer *(Spaarman, 1779) and cattle, Bos* primigenius *f.* taurus *(Bojanus, 1827)* (Vol. 1, Occasional Papers, Laboratory of Paleontology). Ghent: Rijksuniversiteit Gent.
Peters, J. (1986b). *Osteomorphology and osteometry of the appendicular skeleton of Grant's Gazelle,* Gazella granti *(Brooke, 1872), Bohor Reedbuck,* Redunca redunca *(Pallas, 1767), and Bushbuck* Tragelaphus scriptus *(Pallas, 1766)* (Vol. 2, Occasional Papers, Laboratory of Paleontology). Ghent: Rijksuniversiteit Gent.
Phillipson, D. W. (1984). Aspects of early food production in northern Kenya. In L. Kryzyzaniak & M. Kobusiewicz (Eds.), *Origins and early development of food-producing cultures in north-eastern Africa* (pp. 489–495). Poznan: Polish Academy of Sciences.
Reitz, E. J., & Wing, E. S. (2008). Zooarchaeology (2nd Ed.). Cambridge: Cambridge University Press.
Russell, N., & Martin, L. (2005). Çatalhöyük mammal remains. In I. Hodder (Ed.), *Inhabiting Çatalhöyük: Reports from the 1995–1999 Seasons* (pp. 33–98, Çatalhöyük Research Project Volume 4, BIAA Monograph No. 38). Cambridge: McDonald Institute for Archaeological Research and the British Institute of Archaeology at Ankara.
Scheiber, L. L., & Reher, C. A. (2007). The Donovan site (5LO204): An Upper Republican animal processing camp on the High Plains. *Plains Anthropologist, 52*(203), 337–364.
White, T. D. (1992). *Prehistoric cannibalism at Mancos 5MTUMR-2346*. Princeton: Princeton University Press.
Wilson, M. (1978). Archaeological kill site populations and the Holocene evolution of the genus *Bison*. *Plains Anthropologist, 23*(82), 9–22.
Wolverton, S., & Lyman, R. L. (1998). Measuring late Quaternary ursid diminution in the Midwest. *Quaternary Research, 49*(3), 322–329.
Yellen, J. E. (1977). Cultural patterning in faunal remains: Evidence from the !Kung Bushmen. In J. E. Yellen, D. Ingersoll, & W. Macdonald (Eds.), *Experimental archaeology* (pp. 271–331). New York: Columbia University Press.
Zeder, M. A. (1991). *Feeding cities: Specialized animal economy in the Ancient Near East*. Washington, DC: Smithsonian Institution Press.
Zeder, M. A. (2005). A view from the Zagros: New perspective on livestock domestication in the Fertile Crescent. In J.-D. Vigne, J. Peters, & D. Helmer (Eds.), *The first steps of animal domestication: New Archaeozoological approaches* (pp. 125–146). Oxford: Oxbow Books.
Ziegler, A. C. (1973). *Inference from prehistoric faunal remains*. Reading, MA: Addison-Wesley Module in Anthropology 43.