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On the Paramount Importance of Adequate Comparative Collections and Recovery Techniques in the Identification and Interpretation of Vertebrate Archaeofaunas: A Reply to Vale & Gargett (2002)

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ABSTRACT: Neotropical zooarchaeology has slowly developed as a defined area of study over the last few decades of the 20th century. Two primary issues have retarded this development, the lack of fine-grained recovery methods and the virtual absence of suitable comparative collections. This paper examines these issues and suggests ways to improve the identification and interpretation of tropical archaeofaunas, especially archaeological ichthyofaunas. Several problematic issues concerning comparative collection development and use, assemblage interpretation, and screen size bias raised by Vale & Gargett (2002) are discussed. Several suggestions concerning cooperative collection development and rigorous analysis of tropical archaeofaunas are proposed.

KEYWORDS: ZOOARCHAEOLOGY, MORPHOLOGY, COMPARATIVE COLLECTIONS, NEOTROPICS

RESUMEN: La Zooarqueología neotropical se ha desarrollado lentamente como un campo de estudio específico durante las últimas décadas del siglo XX. Dos cuestiones principales han retrasado este desarrollo, a saber, la ausencia de metodologías de recuperación meticulosas y la casi total ausencia de adecuadas colecciones comparativas. Este trabajo examina estas cuestiones y sugiere modos de mejorar la identificación e interpretación de las arqueofaunas tropicales, especialmente las colecciones arqueológicas de peces. Se discuten aquí otras cuestiones problemáticas relativas al desarrollo y uso de colecciones comparativas, la interpretación de las muestras y los sesgos introducidos por el uso de distintas luces de malla de los tamices que fueron en su día avanzadas por Vale & Gargett (2002). Se proponen, por último, una serie de sugerencias relativas al desarrollo cooperativo de estas colecciones y al análisis riguroso de las arqueofaunas tropicales en general.

PALABRAS CLAVE: ZOOARQUEOLOGÍA, MORFOLOGÍA, COLECCIONES DE REFERENCIA, NEOTRÓPICO

INTRODUCTION

The study of archaeological faunal remains from the humid neotropics has gained greater importance as research in the region has moved beyond chronology building and a focus on monumental architecture and cemeteries. Over the past 20 years the combination of more focused research designs, a holistic multidisciplinary approach to the interpretation of past societies, household archaeology, and improved recovery techniques has resulted in the collection of numerous rich archaeofaunal assemblages. Vertebrate archaeofaunas have been recovered from many different regions of the neotropics, ranging from deep within rainforests throughout the Maya realm (Wing & Steadman, 1980; Wing, 1981; Teeter, 2001), to households in Ecuador (Stahl & Ziedler, 1990), the Amazon basin (Roosevelt *et al.*, 1991, 1996) and Pacific coastal sites (Cooke, 1993; Voorhies *et al.*, 2002; Wake, 2002, 2004; Wake & Harrington, 2002).

Some of the richest and best-preserved humid neotropical archaeofaunal collections have been recovered from Atlantic and Pacific coastal contexts (Marcus, 1987a, 1987b; Reitz, 1988a, 1988b, 2001; Marcus *et al*., 1999; Wake *et al*., 1999; Reitz & Sandweiss, 2001; Wing, 2001; Voorhies *et al*., 2002; Wake, 2004). The diversity of these coastal collections can best be ascribed to their accumulation within a species-rich environment - essentially the ultimate ecotone, where aquatic and terrestrial habitats meet - consisting of a combination of species-rich, humid, neotropical terrestrial and marine environments. The preservation of archaeofaunal remains in these contexts is most likely due to the presence of high concentrations of invertebrate shell (both mollusks and crustaceans) which as they fragment and dissolve may actually serve to mitigate the negative effects of the generally highly acidic neotropical soils and the leeching effects of high rainfall environments on vertebrate bone. The bony constituents of these assemblages must be identified prior to their analysis and interpretation. Accurate identification of such assemblages requires consulting the available literature and representative comparative osteological collections.

COMPARATIVE OSTEOLOGICAL COLLECTIONS

Vertebrate collections from the neotropics have generally followed traditional natural historical standards, with collections generally focusing on study skins of the higher vertebrates (birds and mammals), mammal skulls, and herpetological and ichthyological wet specimens (for example, see http://elib.cs.berkeley.edu/mvz). Because of these collection practices, osteological specimens of humid neotropical species are underrepresented.

Osteological specimens of neotropical vertebrates are certainly available in various museum and laboratory collections but they are not common, with the higher vertebrates often the best represented. Osteological collections of the lower vertebrates are comparatively rare, especially given their greater overall diversity in neotropical environments. Fish collections exist in many of the larger U.S. natural history museums, although representation can be quite spotty. Representative neotropical fish skeleton collections are available at places like the UCLA Department of Biology, the Los Angeles County Museum of Natural History (LACM), the Smithsonian Tropical Research Institute (STRI) in Panama, Museo Salango in Ecuador, Museo Chan Chan in Trujillo, and various locations in Mexico (Polaco & Guzmán, 1997) and elsewhere.

The UCLA Department of Biology curates an important comparative collection that has not been added to since the late 1960s; the same is true at LACM. The development of osteological collections has generally languished, especially since the advent of DNA studies in organismal biology. Much of the development of representative comparative osteological collections has shifted to zooarchaeologists.

ARCHAEOICHTHYOLOGY AS AN EXAMPLE

Fish remains are arguably the most difficult archaeofaunal remains to identify for a variety of reasons. The first and foremost reason concerns adequate recovery methods: a 3 mm mesh or smaller must be used in order to capture remains of the smaller vertebrate species (Gobalet, 1989; Shaffer, 1992; Shaffer & Sánchez, 1994; James, 1997). Fish communities, whether fresh water or marine, are diverse and speciose (Miller & Lea, 1972; Fischer, 1978; Eschmeyer *et al*., 1983; Fischer *et al*., 1995a, 1995b; Bussing, 2000). Fish skeletons, and vertebrates in general, contain many bones, not all of which are readily identifiable or preserve well. Perhaps most importantly, adequate comparative collections are few and far between. Well-trained and experienced analysts are relatively rare and do not always produce the same results in blind tests on the same collections (Gobalet, 2001).

A suite of issues relevant to the analysis of neotropical and pan-tropical archaeofaunas are raised by the suspect research of Vale & Gargett (2002) on a northern New South Wales, Australia, coastal midden fish assemblage, including recovery techniques, identifiability of the specimens, collections development and use, and identification techniques. The authors counted over 60,000 bone specimens, identifying only 435 to 10 families and two genera and species. They claim throughout that samples captured in 3 mm mesh do not add any diversity to their results. The authors then discuss the Alawarra I fishery based on their findings.

My experience in Pacific West Mexico, northern Peru, and California calls the findings of Vale & Gargett (2002) into question at several levels. In identifying two genera and species from 10 families, Vale & Gargett (2002) appear to assume that identification to the family level is sufficient to allow interpretations to be made concerning the fishery at the site. This idea is fundamentally flawed in that it ignores the fact that the families identified at this site are all polytypic, having multiple genera and species within them. Species even within a genus often have radically different life histories and fill different ecological niches. Identification to at least the genus level is more appropriate and provides a more suitable means for interpreting the assemblage in terms of catchment areas and procurement techniques. Identification to species or even genus allows assessment of evidence concerning specialization, microhabitat focus, seasonality, potential fishing techniques (hook versus net versus trap versus poison) that cannot be teased out of family-based studies.

I compared the Vale & Gargett (2002) results with analyses of archaeological fish bone assemblages from around the Pacific rim (Table 1) (Follett, 1963, 1965, 1967; Salls, 1985; Marcus, 1987a, 1987b; Reitz, 1988a, 1988b, 2001; Gobalet, 1990; Sandweiss, 1992; Gobalet & Jones, 1995; Broughton, 1999; Wake & Gobalet 2000; Butler, 2001; Colten, 2001; Gobalet & Hardin, personal communication, 2002; Voorhies *et al*., 2002; Wake, 2002, 2004; Wake & Harrington, 2002; Wake *et al*., in press). In order to compare these assemblages I developed a simple identification index by dividing the number of identified genera and/or species by the number of identified families. The Vale & Gargett (2002) index of genera to families is significantly lower (GI = 0.20) than the average for the 21 comparative sites (GI = 1.20). The Vale & Gargett (2002) index of species to families is also low (SI = 0.20) compared with the average of the 23 sites (SI = 0.92) in Table 1. The low values of their identification indices suggest that the Alawarra I archaeological fish bone assemblage has not been thoroughly evaluated for some reason.

Vale & Gargett (2002: 59) state that their identifications were dependent primarily on five mouthparts inaccurately described as the dentition (tooth bearing bones): the maxilla, premaxilla, dentary, quadrate, and articular. Only two of these elements are tooth bearing - the premaxilla and dentary. The authors appear to have ignored the tooth bearing pharyngeal (5^{th} ceratobranchial) bones. They also state that some vertebrae were distinctive but do not mention that many vertebrae are diagnostic to genus. The focus on so few elements suggests unfamiliarity with overall fish skeletal anatomy, and it undoubtedly negatively biased their identifications, greatly reducing the diversity of their assemblage by ignoring other highly diagnostic skeletal elements.

Vale & Gargett (2002: 59) state, “identifications were made using a comparative collection Vale prepared for the project.” They add that by agreement all materials had to be analyzed at the local community center, “which precluded the use of larger museum collections of comparative specimens” (Vale & Gargett, 2002: 59). Any gaps in the Vale collection could have been filled with specimens on temporary loan from the larger museum collections, a common practice in zooarchaeological analysis throughout the world. The statement that “The Garby Elders of the Gumbaingirr Nation and local anglers provided insights as to which species to include in the collection” reveals yet another potential bias, that of modern fishing preference and propriety. Some archaeological fish assemblages contain high frequencies of certain species considered undesirable by modern fishers - for example, ocean sunfish (*Mola mola*) in southern California (Porcasi & Andrews, 2001) and toadfish (*Batrachoides waltersi*) in Chiapas, Mexico (Voorhies *et al*., 2002).

As is all too common in archaeoichthyology, the species represented in this collection remain unknown and unpublished. Standards suggested by Gobalet (2001) and presented in Gobalet & Wake (2000) allow readers to determine the extent of the collections and specimens used, and encourage potential replication of results, a process fundamental to modern scientific method. It remains to be determined whether this collection was “adequate” for the purpose at hand. By “adequate” I mean at least representative of the most prevalent fish species expected in the region, if not comprehensive - that is, a collection that would allow identification well beyond the family level.

Vale & Gargett (2002) state unequivocally that the use of 3 mm mesh does not increase diversity or relative representation in their assemblage of over 60,000 fish bones from a species-rich marine environment in northwest New South Wales. The implications of this assertion are potentially dangerous. This paper can now be cited to support the notion that fine-mesh screening of archaeological

Site	Families	Genera	GI	Species	SI	NISP	Total
Alawarra I, Aus (Vale & Gargett, 2002)	10	2	0.20	2	0.20	432	60000
Tangatatau, Mangaia, CI (Butler, 2001)	22	30	1.36	3	0.14	1472	1475
Salinas la Blanca, Gu (Follett, 1967)	10	11	1.10	12	1.20	211	211
La Blanca, Gu (Wake & Harrington, 2002)	7	4	0.57	1	0.14	55	67
Ujuxte, Gu (Wake, 1999)	6	7	1.17	7	1.17	5871	6822
Los Cerritos, Mx (Wake, 2002)	13	15	1.15	12	0.92	241	573
Cerro de las Conchas, Mx (Voorhies *et al*. 2002)	17	24	1.41	13	0.76	5540	8785
Paso de la Amada, Mx (Wake, 2004)	13	12	0.92	5	0.38	1479	1790
Cerro Mayal, Pe (Wake *et al*., In Press)	11	12	1.09	6	0.55	942	969
Lo Demas, Pe (Sandweiss, 1992)	8	10	1.25	7	0.88	7102	7706
Cerro Azul, Pe (Marcus, 1987a)	14	18	1.29	20	1.43	17241	17241
Ostra, Pe (Reitz & Sandweiss, 2001)	15	17	1.13	4	0.27	880	2391
La Paloma, Pe (Reitz, 1987a,b)	6	9	1.50	4	0.67	3903	5068
CA-ALA-309 (Gobalet & Hardin, 2002)	22	28	1.27	27	1.23	49920	67039
CA-ALA-309 (Broughton, 1999)	8	8	1.00	3	0.38	2004	2004
CA-CCO-269 (Gobalet, 1990)	12	12	1.00	8	0.67	3215	3215
CA-CCO-297 (Gobalet, 1990)	18	18	1.00	13	0.72	2413	2413
CA-LAN-61 (Salls, 1985)	25	43	1.72	49	1.96	4828	6034
CA-LAN-227 (Follett, 1963)	12	17	1.42	16	1.33	176	268
CA-MNT-234 (Gobalet & Jones 1995)	22	33	1.50	29	1.32	17107	25913
CA-SCRI-240 (Colten, 2001)	34	40	1.18	38	1.12	3424	3424
CA-SFR-129 (Wake & Gobalet, 2001)	13	14	1.08	12	0.92	6889	10367
CA-VEN-69 (Follett, 1965)	13	14	1.08	14	1.08	116	156
Average	14.39	17.30	1.20	13.26	0.92	6507	8452
GI = *n*Genera/*n*Families, SI = *n*Species/*n*Families							

TABLE 1

Summary of Selected Fish Assemblages from Various Localities around the Pacific Rim, Including Numbers of Families, Genera, and Species Identified.

sediments is not necessary. It is always necessary at some level. For example, the practice was necessary to support Vale & Gargett's (2002) contentions in this single isolated and debatable case. It is clear that the use of 3 mm mesh screens, in concert with adequate comparative collections and anatomical expertise, is imperative to the identification and interpretation of archaeofaunal collections throughout the world. Profound differences in species representation, diversity, consumption patterns, and dietary contribution are often evident when comparing animal remains recovered from different mesh sizes (Casteel, 1972; Schaffer, 1992; Gordon, 1993; Schaffer & Sánchez, 1994; James, 1997; Quitmyer, 2004).

A large sample of fish remains recovered from recent (1999) excavation at the Emeryville Shellmound and identified by Gobalet & Hardin (2002) provides an excellent diversity example based on screen size. Small fish such as Atherinopsidae (jacksmelt - *Atherinopsis californiensis*) and Clupeidae (Pacific sardine - *Clupea pallasii*) and Engrualidae (northern anchovy - *Engraulis mordax*) were caught primarily in samples sieved through 3 mm mesh in recently excavated (1999) samples. Their presence in relatively large numbers raises these families of small fish to a greater level of importance in the subsistence regime at the site. Atherinopsids and clupeids are underreported in Broughton (1999) in samples that were not screened at all (Table 2). Their underrepresentation is simply due to the lack of finer screening in his samples from 1903, 1909, and 1924. Virtually all of the 1999 sampled bones of these smaller species passed through 6 mm mesh as opposed to 3 mm mesh.

In Peru, at sites such as Ostra, Lo Demas, Cerro Azul, La Paloma, and Cerro Mayal, the numerically dominant fish species simply would not be represented without the use of fine mesh (3 mm and

Scientific Name	**ALA-309 (2002)**	**ALA-309 (1999)**
Carcharodon carcharias	1	
Carcharhinidae	2010	281
Raja sp.	1	
Rajiformes	9237	
Platyrhinoidis triseriata (?)	1	
Myliobatis californica	11561	403
Elasmobranchiomorphi	414	
Acipenser medirostris	72	
Acipenser transmontanus	883	
Acipenser sp.	6802	1193
Archoplites interruptus	11	
Atherinopsis californiensis	1	
Atherinidae	4782	2
Atractoscion nobilis	5	2
Ptychocheilus grandis	1	
Orthodon microlepidotus	1	
Gila crassicauda	3	
Lavinia exilicauda	1	
Cyprinidae	20	
Catostomus occidentalis	4	
Engraulis mordax	111	
Sardinops sagax	18	
Clupea pallasi	137	
Clupeidae	5985	7
Cymatogaster aggregata	3	
Rhacochilus vacca	3	
Amphisticus sp.	55	
Embiotoca sp.	3	
Embiotocidae	457	1
Gasterosteus aculeatus	4	
Gillichthys mirabilis	322	
Leptocottus armatus	16	
Cottidae	1	
Notorynchus cepedianus	7	
Oncorhynchus kisutch	6	
Oncorhynchus mykiss	15	
Oncorhynchus sp.	4722	113
Oncorhynchus tshawytscha	2090	2
Pleuronectiformes	87	
Porichthys notatus	34	
Porichthys sp.	6	
Sebastes sp.	26	
Thunnus alalunga (?)	1	
Total NISP	49920	2004
Actinopterygii	17119	
Grand Total	67039	2004

TABLE 2

Fish Remains from the Emeryville Shellmound (Gobalet & Hardin, Personal Communication, 2002).

less) screens. Virtually all anchovy bones (especially vertebrae) can pass through a 6 mm mesh. It is irresponsible to state, in the absence of fine-mesh samples, that small fish that can potentially make a profound dietary difference are not present in rich coastal middens.

Recently an isolated Mexican caecilian vertebra was identified from within a collection of fish bones from Paso de la Amada, Chiapas, Mexico (Wake *et al*., 1999). The faunal assemblage from this site was sieved through a 3 mm mesh. A 6 mm mesh would not have collected the specimen, the only known Quaternary paleontological record for the entire order. The specimen might have remained with the fish sub-assemblage if the UCLA Zooarchaeology Laboratory had not had caecilian skeletal specimens in its collection.

For all their rhetoric concerning variability in identifiability of representative individuals of divergent fish communities on opposite sides of the Pacific Ocean, Vale & Gargett's (2002) arguments fail simply because they discuss and identify these assemblages at the family level. Vale & Gargett (2002) cannot and do not provide evidence that diversity at the generic and specific levels does not differ between the 6 mm and 3 mm mesh samples they studied, because their level of analysis simply precludes it.

Within all of the fish families Vale & Gargett (2002: 59) identify, smaller, larger, and morphologically different species are present in northern New South Wales (Kuiter, 1993). It does not matter that Vale & Gargett (2002: 60) point out Butler's (1994: 85) findings that family level diversity changes little across screen mesh fractions in her Mangaia samples. Greater diversity, niche partitioning, and the potential for differential resource acquisition techniques and effects are seen at the generic and even specific levels. I use two fish families common to southern California, the Sciaenidae (croakers) and the Serranidae (sea bass), as examples.

California croakers include eight monotypic genera: *Atractoscion*, *Cheilotrema*, *Cynoscion*, *Genyonemus*, *Menticirrhus*, *Roncador*, *Seriphus*, and *Umbrina*. Habitat, food preferences, and skeletal morphology differentiate all of these genera (Miller & Lea, 1972; Eschmeyer *et al*., 1983: 218-223). *Atractoscion* and *Cynoscion* are streamlined open-water predators with large terminal mouths, sharp teeth, and simple pharyngeal plates. *Menticirrhus* and *Umbrina* both feed on bottom-dwelling invertebrates and have sub-terminal mouths with chin barbels, tiny small-toothed jaws, and well-developed pharyngeal plates. *Cheilotrema*, *Genyonemus*, *Roncador*, and *Seriphus* are more generalist predators, consuming small crustaceans and fish, and having small sub-terminal mouths with no barbels, larger jaws, and well-developed pharyngeal plates. Identification of archaeological California sciaenids to family alone would mask a great deal of information concerning resource focus, capture techniques, and even general habitat exploitation.

California sea basses include five genera; *Epinephelus*, *Hemanthias*, *Mycteroperca*, *Paralabrax*, and *Pronotogrammus*. Three of these genera are polytypic: *Epinephelus* with two species, *Mycteroperca* with two species, and *Paralabrax* with four species. California *Epinephelus* and *Mycteroperca* species are both large predators that exploit various habitats, prefer some structure, and travel from deep to shallow waters (Eschmeyer *et al*., 1983: 197-199). The *Paralabrax* species can be divided by habitat preference, with three species associated with sandy bottoms and one with kelp forests. Clearly, with *Paralabrax*, even genus level identification is insufficient to determine where people were fishing - in kelp forests or over unstructured sandy-bottomed habitats.

It is at the generic and specific taxonomic levels that a real understanding of fishing techniques, resource focus, scheduling, and resource degredation can be most accurately gauged. Species-level identifications are imperative in fine-grained interpretation of past fishing practices and human adaptations (see Cooke, 2004).

CONCLUSIONS

The point of this paper concerns recovery and identification methods and their effects on subsequent interpretive efforts. The methods used by Vale & Gargett (2002) are improper and severely affect their interpretations. That Vale & Gargett (2002: 59) focus on only a few specific skeletal elements in their identification efforts, failing to note the utility of other bones, suggests that the Alawarra I collection remains under-identified, and reveals an underlying lack of comprehensive knowledge of fish skeletal anatomy. A comprehensive identification effort might change their results.

Comprehensive vertebrate archaeofaunal analysis begins with proper, fine-grained recovery techniques. It is not always practical to have all excavated soils screened through 3 mm mesh. It is, however, imperative that representative samples be sieved through such mesh to assess what the larger meshes are missing - because they always miss something (Casteel, 1972; Schaffer, 1992; Gordon, 1993; Schaffer & Sánchez, 1994; James, 1997; Quitmyer, 2004). More importantly, many excavation projects in the neotropics and elsewhere still do not employ adequate recovery techniques where archaeofaunas are concerned. Archaeological project leaders need to be reminded of the importance of fine-mesh screening of representative samples to provide fine-grained subsistence-related data.

Of course, diverse archaeofaunas cannot be accurately identified without equally diverse comparative collections. Such collections, especially those geared toward zooarchaeological analysis, are relatively few and far between, but they do exist. These collections can be visited if the time and money to do so are available. Where these collections are lacking, they can be developed in the field. Where they are available, they can be presented on the Internet to facilitate evaluation of the collection's "adequacy" and to facilitate potential loans and collections development through specimen exchange. The collection begun by Vale (Vale & Gargett, 2002: 59) is nowhere near comprehensive for the region (Kuiter, 1993) and is of questionable utility for a comprehensive identification effort. Furthermore, reliance on modern anglers and Gumbaingirr Nation elders for insight into which fish to include in the comparative collection (Vale & Gargett, 2002: 59) introduces an obvious modern preference bias that may differ greatly from past consumption patterns.

I have had considerable success in producing comparative osteological collections in Peru and Panama - all with the proper permissions in a cooperative fashion where equal numbers of prepared specimens per species are curated in the country of origin and deposited in U.S. collections. I have attempted to develop these growing collections with reference to published regional archaeofaunal studies and fisheries publications concerning ranges of local species. As a primary goal where fish are concerned I attempt to obtain a greater diversity than that represented in the available literature. Key activities in developing these collections include fishing, market purchases, and visits to different local areas. It is important to remember to get the "trash fish," and to collect during different seasons.

Any specimens collected must be properly identified in the field to be of any use. Identification guides, such as Emmons (1990), Iverson (1992), Howell & Webb (1995), Linares (1996), Reid (1998), and natural histories, such as Alvarez del Toro (1983) and Jantzen (1983), are quite useful. Bone anatomy and nomenclature references, such as Rojo (1991) and taxonomic guides similar to Robins *et al*. (1991), are important for standardizing terms and systematics. Guides with dichotomous keys, such as the FAO identification guides for fish from the eastern Pacific rim (Fischer *et al*., 1995a, 1995b), the Caribbean (Fischer, 1978), Peru (Chirichigno, 1974), and California (Miller & Lea, 1972; Eschmeyer *et al*., 1983), are excellent resources to use for field or laboratory identification. Similar guides exist for most regions where ichthyologists have been active. It is also imperative to know how to use such resources by becoming familiar with fish anatomical vocabulary (for example, Rojo, 1991).

Cooperative collections development should be stressed (see Cooke, 2004). Multiple specimens must be collected to allow the host country or agency to retain one set while the other set goes to an extra-national facility. Multiple specimens of different size, age, and sex also allow for consideration of individual and ontogenetic variation within and across species. This strategy also leaves nuclei of collections in two places. Ideally future investigators can add to these collections, making them more comprehensive and useful. With diverse comparative collections available for consultation, more accurate assessments of past fisheries and vertebrate exploitation and subsistence practices can be made.

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