

Differential identifiability between chosen North American gallinaceous skeletons and the effect of differential survivorship

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Abstract. Differential identifiability – the variation in the ease with which skeletal parts can be identified in samples of their bones – affects the presence and abundance of gallinaceous birds reported in the zooarchaeological record. In this paper, I examined how the distinctiveness of morphological characters among 27 fossil classes of the gallinaceous birds: Bobwhite *Colinus virginianus*; Ruffed Grouse *Bonasa umbellus*; Prairie Hen *Tympanuchus cupido*; and Wild Turkey *Meleagris gallopavo* may limit the researcher's ability to identify an archaeological bird bone specimen. The results and discussion: 1) demonstrate that the morphology of bird bones may limit taxonomic distinctions even at the high taxonomic levels of order and subfamily; and 2) present three patterns relating the differential identifiability of fossil classes to their differential survivorship. Awareness of the effects of these two factors potentially increases researchers' ability to explain the occurrence and abundance of "rare" bird taxa in the archaeofaunal record.

Key words: gallinaceous birds, differential survivorship, skeletal identification.

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I. INTRODUCTION

Identification is, of course, the foundation on which all subsequent analysis rest (LAWRENCE 1973, as cited by PARMALEE 1977).

Differential identifiability – the variation in the ease with which skeletal parts can be identified in samples of their bones – affects the presence and abundance of gallinaceous birds reported in the zooarchaeological record. The differential identifiability of bone elements (e.g., femur) or portions (e.g., distal end or epiphysis) is dependent on the existence of intrinsic characters or the "attributes which are inherent to the organisms themselves" (WILEY 1981: 115). Archaeologists too recognize that although a bone element and portion is "recognizable" the lack of diagnostic characteristics often prevents an identification to taxon (WHITE 1952; HARGRAVE 1972; LYMAN 1979; HARGRAVE & EMSLIE 1979; SHIPMAN 1981; EMSLIE 1984; PARMALEE 1985; REA 1986). Archaeological reports of animal remains tend to neglect detailing how identifications are made (DRIVER 1992; BUTLER & LYMAN 1995). JONES & LEONARD (1989) and BOBROWSKY & BALL (1989) warn that classification schemes and methods of identification must be defined, clearly standardized, and recognized by all

researchers; otherwise quantitative measures will misrepresent the archaeological material under study. Moreover, it is equally important for analysts to recognize their own limitations in identifying different taxa, to be humble enough to ask other specialists for assistance, and to be conservative when differential identifiability occurs in their samples.

When comparing archaeofaunas, researchers compensate for this bias by distinguishing different levels of identifiability (LYMAN 1979) (Table I). Recognizing how misidentifications can result in the misinterpretation of animal use by Native Americans, I adopt a “conservative approach” to identifying remains (DIRRIGL 1991). This approach considers only positive identifications. I transpose any questionable identification based on the concept of closest or next higher taxonomic category. If an animal is identified as possible or ? or cf. at a given level (e.g., *Meleagris gallopavo*?), I change the animal’s identification to the closest or next higher taxonomic category (i.e., a Massachusetts, USA specimen of *M. gallopavo* could be transposed to Subfamily: Meleagridinae. However, because only a single species of *Meleagris* is extant, I would record the next higher taxonomic category of Order: Galliformes).

Table I

Levels of identifiability for animals (modified after LYMAN 1979)

Level	Description
1A	Unidentifiable
1B	Unidentifiable (identifiable to taxonomic kingdom)
2A	Approximately identifiable to size
2B	Approximately identifiable to size and skeletal element
2C	Approximately identifiable to size, skeletal element, and side
3A	Identifiable to taxonomic phylum
3B	Identifiable to taxonomic subphylum
3C	Identifiable to taxonomic class
3D	Identifiable to taxonomic subclass
3E	Identifiable to taxonomic order
3F	Identifiable to taxonomic tribe
3G	Identifiable to taxonomic family
3H	Identifiable to taxonomic subfamily
3I	Identifiable to taxonomic genus
3J	Identifiable to taxonomic species
3K	Identifiable to taxonomic subspecies

For birds, the similarity of appearance of skeletons hinders taxonomic identifications of species. Thus, archaeologists may resort wrongly to assuming that large bird bones are of Wild Turkey *Meleagris gallopavo*, even when analysts caution that the bones of Wild Turkey and other birds appear similar (HARGRAVE & EMSLIE 1979). This practice leads to specimens being misidentified in museum collections, reports, and publications.

My recent reexamination of remains identified as Wild Turkey *Meleagris gallopavo* for the Calf Island Site, Massachusetts (LEUDTKE 1980) demonstrates this problem. In a sample of bones recognizable as diaphysis long bone fragments, the previous identification of numerous small fragments to Wild Turkey is questionable because the specimens lack diagnostic characteristics for identification at the levels of family, genus, or species. In my conservative approach, I would not assume that

the fragments “must belong” to a turkey because other bones were identified to this species. The resulting published number of identified specimens (LEUDTKE 1980) is therefore misrepresented not by the fault of the author, but perhaps by the analysts of the animal remains not recognizing the problems caused by differential identifiability. As part of my research program, I have worked toward awakening the archaeological community of the Northeast United States to similar case studies involving problems of identification among both invertebrate and vertebrate remains (DIRRIGL 1993a, 1993b).

The absence of comparative studies of bird osteology and the lack of skeletal specimens in scientific collections is problematic for zooarchaeologists who identify animal remains from archaeological contexts and study prehistoric bird hunting by Native Americans. In the Northeast, as well as other areas, archaeofaunal samples differ in their preservation and representation of bird remains (DIRRIGL 1991). The high fragmentation of remains and few recognizable skeletal elements commonly associated with northeastern samples often limits making identifications using diagnostic osteological characters (cf. ZIEGLER 1973; WATSON 1979; LYMAN 1979, 1987).

Current state of research in the Northeast United States

Gallinaceous birds are no exception. Archaeological evidence indicates that Wild Turkey *M. gallopavo* and Ruffed Grouse *Bonasa umbellus* comprise a major part of the northeastern avian archaeofaunal record (STEADMAN 1988; DIRRIGL 1991; FUNK 1993) although the survival of body parts varies among samples. Based on its frequency, archaeologists suggest that wild turkey played important role in the prehistoric diet of Northeast Native Americans (RITCHIE 1965; RITCHIE & FUNK 1973; GRAYSON 1974; FUNK 1976, 1993; NEUMMAN 1989).

I agree with these researchers, having found similar animal use patterns (DIRRIGL 1991). However, the under-representation of other gallinaceous bird species (e.g., Bobwhite *Colinus virginianus* and Heath Hen *Tympanuchus cupido cupido*) in the archaeological record does not suggest that other gallinaceous bird species were any less important. For example, in my database of over 100 archaeofaunal samples from New England and New York, only three Massachusetts sites contain the bones of the extinct Heath Hen. It is incorrect to use this information to assume that the Heath Hen was less important to diet and bird use than Wild Turkey. Clearly, cultural and non-cultural factors (SCHIFFER 1987; LYMAN 1995) may account for the absence.

I propose that research reports about the presence of different types and abundance of gallinaceous birds are dependent upon “differential identifiability” – the variation in the ease with which skeletal parts can be identified in samples of their bones. This ease may, therefore, be one bias accounting for the commonality of some species and the rarity of others. LYMAN (1995) provides the best discussion of the complex determination of why a specific animal is absent in the archaeological record. He reports that the misidentification of animal remains is potentially a sixth reason that evidence of a particular taxon is absent in reports and museum collections.

Differential identifiability is also dependent on the differential loss of specimens (GRAYSON 1991) that results from taphonomic biases such as density-mediated attrition (LYMAN et al. 1992). Whereas other studies of density-mediated attrition include similar comments, the assessment of the potential effects is lacking (LYMAN 1984; KREUTZER 1992). DIRRIGL (1998, 2001) demonstrated that the skeletal elements and portions of gallinaceous birds differ in their bone mineral density (BMDa and BMDv). My examination of paleontological and archaeological samples of gallinaceous bird remains demonstrated that density-mediated attrition accounted at least, in part, for the differential survivorship of skeletal parts.

With this project, I examine how the differential identification of bird bone potentially affects the reports of gallinaceous birds in samples of their bones. Clearly, the inherent problems of identifying bird bones indicate that an examination of differential identifiability among gallinaceous birds is warranted. I also examine the relationship between the identification/representation of fossil classes and density-mediated attrition using DIRRIGL (1998, 2001). Until these biases are consid-

ered, it may be premature to develop cultural criteria to distinguish birds hunted by the prehistoric peoples of the Northeast United States similar to those proposed for the Southwest (SENIOR & PIERCE 1989).

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II. MATERIALS AND METHODS

Zooarchaeologists should identify to a particular taxon only those bones which can unquestionably be assigned to it (DRIVER 1992: 43).

Bird identification and phylogenetic study relies on combining relationships derived from genetic sequence data, observable external characters (e.g., feather pattern and color), ecological characters (e.g., territory), vocalization, and lastly osteological or myological characteristics (BLEDSOE 1988; HUGHES 1996; ELLSWORTH et al. 1996). Studies of bird osteology focus on the comparative material from museum specimens to identify macroscopic diagnostic characters. Interested analysts of gallinaceous bird bones should consult the references listed in DIRRIGL (1998: Table 4.2) or Zooarchaeology Home Page (www.zooarchaeology.com).

This study examines the differential identifiability among the appendicular skeletal elements of Bobwhite *Colinus virginianus* LINNAEUS, 1758, Ruffed Grouse *Bonasa umbellus* (LINNAEUS, 1766), Prairie Hen *Tympanuchus cupido* (LINNAEUS, 1758), and Wild Turkey *Meleagris gallopavo* LINNAEUS, 1758 using annotated descriptions presented in DIRRIGL (1998). The development of this study is based on WOOLFENDEN (1961) for waterfowl and GILBERT et al. (1981), HARGRAVE (1972), HARGRAVE and EMSLIE (1979), HOLMAN (1961, 1964), and MACDONALD (1992) for gallinaceous birds. In DIRRIGL (1998), I limited my presentation to the characteristics and fossil classes most useful to identification rather than the development of full zoological diagnoses. My results annotated the skeletal characteristics reported by GILBERT et al. (1981) for Anseriformes (*A. platyrhynchos*) and Galliformes (*C. virginianus*, *B. umbellus*, *M. gallopavo* and *T. cupido*). The descriptions in DIRRIGL (1998) are provided to assist archaeologists, many who use this classic reference regularly, with identifying bird remains.

Importantly, my treatment is not meant to be a definitive resource for identification. Only through examining and comparison with several well-prepared museum specimens, should identifications be determined. This practice will also allow the archaeologist to become familiar with the variation in skeletal morphology that is present intraspecifically and interspecifically. For example, I found variation among the proximal femur, proximal ulna, and proximal scapula between specimens of *T. cupido* not previously reported by ALLEN (in GROSS 1928). A future project will review these findings for the subspecies of *T. c. cupido*.

My descriptions do not include size differences similar to GILBERT et al. (1981). Whether size is used to identify one gallinaceous bird from another is a matter of choice by the faunal analyst. Although I do not report size differences, in some circumstances taxonomic separation is appropriate. For example, the proximal radii of Galliformes are indistinguishable morphologically, but the recovery of a large, broad gallinaceous specimen would most likely be *M. gallopavo*. In making such a decision, the faunal analyst must heed the cautionary notes provided by avian osteologists (HARGRAVE 1972; HARGRAVE & EMSLIE 1979; STEADMAN 1980).

Thus, similar to MACDONALD (1992:315), I focused on identifying “non-metric traits” or qualitative structural differences rather than morphometric data (cf. MCKUSICK 1986). I chose not to study morphometric differences for several reasons. First, the lack of complete skeletons and the availability of specimens for loan (e.g., Prairie Hen) hindered any morphometric study. Second, although bird morphometric studies (e.g., CRACRAFT 1968, 1976) are useful in assessing the size and shape of skeletal elements among taxa, LOUGHEED et al. (1991: 436) caution about measurement errors and the “problem variables” existing among them. Third, morphometric data may not always provide dependable criteria for making taxonomic distinctions between bird species (cf., Podicipediformes (grebes) examined by BOCHENSKI 1994 and LIVEZEY & STORER 1992). Lastly, the utility of skeletal measurements, such as those presented by GILBERT et al. (1981), is limited in the North-east United States where bird remains are recovered most often as fragmented pieces.

I utilized the osteological terminology presented by BAUMEL et al. (1993) and GILBERT et al. (1981) to compare intrinsic, morphological characters (i.e., structural attributes sensu WILEY (1981: 319-322)) exhibited by birds. I adopted WILEY’s (1981: 115-119) view of characters as features that exhibit systematic relationships among organisms. Characters that are useful to identification are those that: (1) vary between taxa; (2) vary in a correlated, coherent manner; and (3) do not vary environmentally (WILEY 1981: 319). I examined macroscopic morphological characters among the appendicular skeletons of dried museum specimens lacking muscle or ligaments. Additionally, I used the glossary of anatomical terminology presented in BORROR et al. (1976) and SCHWARTZ (1995) based on the references presented therein.

My study only considered the osteological characters of males for several reasons. DIRRIGL’s (1998, 2001) study of mineral bone content and density necessitated examining males because of the presence of medullary bone in females, which is lost and gained with egg laying (TAYLOR et al. 1971; SIMKISS 1975; DACKE et al. 1993). JOHNSGARD (1973: 87, Table 18) reports that adult males comprise over half of the present populations of gallinaceous birds, and it is likely that males would be well represented in prehistoric cultural deposits. Whenever possible, several specimens of each taxa were examined following the recommendations of BOCHENSKI & TOMEK (1995) and STEADMAN (1980). A skeletal element is a discrete anatomical unit that includes portions and features. I studied the appendicular elements commonly found in northeastern archaeofaunal samples based on DIRRIGL (1998) and considered by researchers to be most useful taxonomically: humerus, carpometacarpus, coracoid, tarsometatarsus, femur, tibiotarsus, and scapula (BLEDSOE 1988). Although the ulna and radius may be considered less useful (BLEDSOE 1988), I also examined these elements. Because the fibula of gallinaceous birds is fused with the tibiotarsus and is found regularly broken on both museum and archaeological specimens, I avoided its description.

For each element, I noted the differences in osteological characters for the proximal, medial, and distal portions. Following HOLMAN (1961, 1964), osteological characters exhibiting no differences were not included in the descriptions. Comparing gallinaceous bird bones to mallard (Anseriformes: *Anas platyrhynchos*), I examined the differential identifiability among the two bird orders: Galliformes to Anseriformes. The decision to compare these two orders is based on the common ancestry reported by DZERZHINSKY (1995), although debate about this relationship continues (ERICSON 1996). Using the information from DIRRIGL (1998, 2001) for areal and volumetric bone mineral density (BMDa and BMDv), I also discuss the effect of differential survivorship on the reporting of the skeletal parts relating to their differential identifiability.

III. RESULTS AND DISCUSSION

If the major goal of zooarchaeological analysis is calculation of relative frequency of species, some species will be more abundant simply because their skeletons are more easily identified (DRIVER 1992: 41).

Identification biases of archaeological artifacts and ecofacts (see review by SCHIFFER 1987: 362) can be attributed to the ability, training, and experience of analysts and the condition of the specimens they examine. Interanalyst biases toward identifying zooarchaeological specimens demands attention (LYMAN & O'BRIEN 1987; DRIVER 1992). To demonstrate the differential identifiability of diaphysis long bone fragments, I recommend that the beginning analyst smash specimens of gray squirrel *Sciurus carolinensis* and Mallard *A. platyrhynchos*, mix them in a box, and attempt to sort among the two species. The problem encountered for a basic interclass determination of mammals from birds becomes apparent.

HILLSON (1992: 5-6) describes the basic steps for identification: (1) "Decide which bone in the body it is from, and which fragment of that bone it is"; (2) "Decide which side of the body it is from"; (3) "Assess its size and robustness"; and (4) "Look for detailed points of anatomy to amend finer distinctions that are possible." This is similar to DRIVER's (1992) notion that the identification of vertebrates relies on descriptions of species, element, and part of element (i.e., portion). Furthermore, the characteristics of size, shape, structure or combinations thereof for skeletal remains recovered from archaeological sites can limit identification (SHIPMAN 1981). Those "distinctive skeletal elements" (SHIPMAN 1981: 126), which allow for identification beyond the class level, can be ranked in order of identification utility to zooarchaeologists (LYMAN 1979).

The annotated osteological descriptions for gallinaceous birds in the Northeastern United States are presented fully in DIRRIGL (1998). Using this information, Table II presents the identifiability of the fossil classes described. A pattern of differential identifiability is apparent. The proximal humerus (PHU) followed by the proximal femur (PFE) and proximal coracoid (PCO) offer the highest levels of identifiability (Table III). Those fossil classes providing moderate identifiability include the distal femur (DFE), tibiotarsus (DTI), humerus (DHU), and ulna (DUL) and the proximal scapula (PSC). Although the medial tarsometatarsus (MTA) provides identifiability to the species level, this is only possible when a specimen of adult male with a spur cone is preserved. Several fossil classes are indistinguishable even at the taxonomic level of order, medial tibiotarsus (MTI), ulna (MUL), radius (MRA), and scapula (MSC) and distal scapula (DSC). The preservation of these less distinguishable bones would inhibit a faunal analyst to identify them as Anseriformes or Galliformes.

The results of this study demonstrate that the morphology of bird bones may limit taxonomic distinctions even at the higher levels of order and subfamily. For several fossil classes, only identification among Anseriformes and Galliformes may be possible. Of the twenty-seven fossil classes between one species of Anseriformes (*A. platyrhynchos*) and four species of Galliformes, I found forty-four percent to be in this category. When these fossil classes preserve, the zooarchaeologist is unable to distinguish between the gallinaceous species, except for the larger specimens representing *M. gallopavo*.

The survivorship of gallinaceous bones depends on their aerial (BMDa) and volumetric (BMDv) bone mineral density (DIRRIGL 1998; 2001). When the potential effect of differential survivorship is related to the differential identifiability of fossil classes, the zooarchaeologist's ability to discriminate bone specimens between different native gallinaceous birds occurring in the North-east to species is limited.

Three patterns for the fossil classes examined emerge; the second and third patterns are more common than the first.

1. A fossil class having a high level of identifiability tended to have a high potential for survival

For example, the proximal coracoid provides identifiability among the orders Anseriformes and Galliformes and between Galliformes. This fossil class contained high levels of bone mineral density for *C. virginianus* (ranking 16 BMDa and 19 BMDV of 20 fossil classes). Additionally, the bone mineral density of the proximal coracoid ranked high for *B. umbellus* (ranking 26 BMDa and 25 BMDv of 26 fossil classes), and *T. cupido* (ranking 25 BMDa and 24 BMDv of 26 fossil classes). Although the proximal coracoid of *M. gallopavo* tended to rank lower than the other gallinaceous birds (15 BMDa and 14 BMDv of 28 fossil classes), this element falls within those considered most dense (DIRRIGL 1998: 81).

2. A fossil class having the highest level of identifiability tended to have a low potential for survival

This proposition is based on the assumption that bones with the highest bone mineral density levels are most likely to survive the non-cultural taphonomic or attritional processes described by SCHIFFER (1987), BEHRENSMEYER (1991, 1993), and LYMAN (1994). For example, the proximal humerus exhibited a high level of identifiability, but differs in its potential survivorship between Galliformes. Of the twenty fossil classes measured in DIRRIGL (1998, 2001), the proximal humerus of *C. virginianus* is low ranking (6.5 BMDa and 5 BMDv). For *B. umbellus* and *T. cupido*, it ranks similarly (12.5, 11 BMDa and 5, 5 BMDv respectively) for 26 fossil classes. However, the proximal humerus of *M. gallopavo* is also low ranking for BMDa (8) and low for BMDv (1) out of 28 fossil classes. A similar pattern emerges for the proximal femur, which has high identifiability but low ranking survivorship, except that for the BMDa of *C. virginianus* and *M. gallopavo* it ranks moderately or higher (10 and 19 respectively). A plausible explanation for this exception is that the proximal femur for these two gallinaceous birds is not pneumatic, therefore measuring high in bone mineral density.

3. A fossil class having a low identifiability tended to have a high potential for survival

For example, the medial portions of the tibiotarsus and ulna do not provide identifiability among the orders Anseriformes and Galliformes. Yet, these fossil classes contain high levels of bone mineral density, except for the medial ulna of *C. virginianus* (BMDa low ranking = 8.5). The medial radii of Galliformes are also indistinct, however, this fossil classes is low ranking in BMDa (9.5 for *B. umbellus*; 5.5 for *T. cupido* and 7 for *M. gallopavo*) and high ranking in BMDv (21 for *B. umbellus*; 25 for *T. cupido* and 24.5 for *M. gallopavo*). Whether the medial radius is considered similar to the medial tibiotarsus and ulna in its identifiability and survivorship depends on which measure of bone mineral density is considered the best predictor for survivorship (DIRRIGL 1998, 2001).

Table III

Overall order of identifiability by element. "Best" elements for identification in bold face. Abbreviations as in Table II

Element	Portion Ranked by Identifiability
Femur	PFE > DFE >MFE
Tibiotarsus	DTI >PTI>MTI
Humerus	PHU >DHU>MHU
Coracoid	PCO > DCO≈MCO
Tarsometatarsus	PTA>DTA>MTA
Ulna	DUL≈PUL>MUL
Radius	PRA≈DRA>MRA
Carpometacarpus	PCA>DCA≈MCA
Scapula	PSC>MSC≈DSA

IV. CONCLUSION

The ability of a researcher to identify a particular archaeological bone specimen to a taxon is dependent on both taphonomy and the osteology of animals. This study expands on earlier concepts of differential identifiability (c.f., LYMAN 1979; LYMAN & O'BRIEN 1987) by examining how the distinctiveness of avian macro-osteological characters among 27 fossil classes may limit the identification of Bobwhite *C. virginianus*; Ruffed Grouse *B. umbellus*; Prairie Hen *T. cupido*; and Wild Turkey *M. gallopavo*. The results suggest that the morphology of bird bones may limit taxonomic distinctions even at the high taxonomic levels of order and subfamily. Finally, my research demonstrates how the rarity of an identified species is considered to be a function of the fossil classes surviving density-mediated attrition (DIRRIGL 1998).

REFERENCES

- AMERICAN ORNITHOLOGIST'S UNION. 1983. A.O.U. Check-list of North American birds, 6th edition. American Ornithologists' Union.
- BAUMEL J. J., KING A. S., BREAZILE J. E., EVANS H. E., VANDEN BERGE J. C. (eds). 1993. Handbook of avian anatomy: nomina anatomica avium, second edition. Publications of The Nuttall Ornithological Club 23. The Nuttall Ornithological Club, Cambridge, Massachusetts.
- BEHRENSMEYER A. K. 1991. Terrestrial vertebrate accumulations. [In:] P. A. BRIGGS, D. E. G. BRIGGS (eds) – Taphonomy: Releasing the data locked in the fossil record. Plenum Press, New York. Pp: 291-335.
- BEHRENSMEYER A. K. 1993. Discussion: noncultural processes. [In:] J. HUDSON (ed.) – From bones to behavior: Ethnoarchaeological and experimental contributions to the interpretation of faunal remains. Southern Illinois University, Carbondale, Illinois. Pp: 342-348.
- BLEDISOE A. H. 1988. A phylogenetic analysis of postcranial skeletal characteristics of the ratite birds. *Annals of the Carnegie Museum*, **57**: 73-90.
- BOBROWSKY P. T., BALL B. F. 1989. The theory and mechanics of ecological diversity in archaeology. [In:] R. D. LEONARD, G. T. JONES (eds) – Quantifying diversity in archaeology. Cambridge University Press, Cambridge, United Kingdom. Pp: 4-12.
- BOCHEŃSKI Z. M. 1994. The comparative osteology of grebes (Aves: Podicipediformes) and its systematic implications. *Acta zoologica cracoviensia*, **37**: 191-346.
- BOCHEŃSKI Z. M., TOMEK T. 1995. How many comparative skeletons do we need to identify a bird bone? [In:] D. S. PETERS (ed.) – Acta paleornithologica. *Courier Forschungsinstitut Senckenberg*, **181**: 357-361.
- BOCK W. J. 1962. The pneumatic fossa of the humerus in the Passeres. *The Auk*, **79**: 425-443.
- BORROR D. J., DELONG D. M., TRIPLEHORN C. A. 1976. An introduction to the study of insects, 4th edition. Holt, Rinehart, and Winston, New York.
- BUTLER V. L., LYMAN R. L. 1995. Taxonomic identifications and faunal summaries: What should we include in our faunal reports? Society for American Archaeology, 60th Annual Meeting, Forum, Minneapolis, Minnesota.
- CRACRAFT J. 1968. The lacrimal-ectethmoid bone complex in birds: a single character analysis. *American Midland Naturalist*, **80**: 316-359.
- CRACRAFT J. 1976. The hindlimb elements of the moas (Aves, Dinornithidae): a multivariate assessment of size and shape. *Journal of Morphology*, **150**: 495-526.
- DACKE C. G., ARKLE S., COOK D. J., WORMSTONE I. M., JONES S., ZAIDI M., BASCAL Z. A. 1993. Medullary bone and avian calcium regulation. *Journal of Experimental Biology*, **184**: 63-88.
- DIRRIGL Jr. F. J. 1991. The archaeozoology of Connecticut tetrapod vertebrates. Master's Thesis. Department of Anthropology, University of Connecticut, Storrs.
- DIRRIGL Jr. F. J. 1993a. Qualification and taphonomic analysis of bone fragments recovered from archaeological sites. Eastern States Archaeological Federation, 60th Annual Meeting, Bangor, Maine.
- DIRRIGL Jr. F. J. 1993b. Zooarchaeological assemblages in Connecticut. Annual Meeting, Archaeological Society of Connecticut, Westport, CT.
- DIRRIGL Jr. F. J. 1998. Zooarchaeology and taphonomy of gallinaceous birds in the Northeastern United States. Ph.D. Dissertation. Department of Anthropology, University of Connecticut, Storrs.
- DIRRIGL Jr. F. J. 2001. Bone mineral density of wild turkey (*Meleagris gallopavo*) skeletal elements and its effect of differential survivorship. *Journal of Archaeological Science*, **28**: 817-832.
- DRIVER J. C. 1992. Identification, classification, and zooarchaeology. *Circaea*, **9**: 35-47.
- DZERZHINSKY F. Y. 1995. Evidence for the common ancestry of Galliformes and Anseriformes. [In:] D. S. PETERS (ed.) – Acta paleornithologica. *Courier Forschungsinstitut Senckenberg*: 325-336.

- ELLSWORTH D. L., HONEYCUTT R. L., SILVY N. J. 1996. Systematics of grouse and ptarmigan determined by nucleotide sequences of the mitochondrial cytochrome-b gene. *The Auk*, **113**: 811-822.
- EMSLIE S. D. 1984. Faunal remains and archaeological research designs: a need for consistency. *American Archaeology*, **4**: 132-139.
- ERICSON P. G. P. 1996. The skeletal evidence for a sister-group relationship of anseriform and galliform birds: a critical evaluation. *Journal of Avian Biology*, **27**: 195-202.
- FUNK R. E. 1976. Recent contribution to Hudson Valley prehistory. *New York State Museum Memoir* **22**, Albany, New York:
- FUNK R. E. 1993. Archaeological investigation in the Upper Susquehanna Valley, New York State. Volume 1. Persimmon Press, Monographs in Archaeology, Buffalo, New York.
- GILBERT B. M., MARTIN L. D., SAVAGE H. 1981. Avian osteology. B. Miles Gilbert. Laramie, Wyoming.
- GRAYSON D. K. 1974. The Riverhaven No. 2 vertebrate fauna: comments on methods in faunal analysis and on aspects of the subsistence potential of prehistoric New York. *Man in the Northeast*, **8**: 23-39.
- GRAYSON D. K. 1991. Alpine faunas from the White Mountains, California: Adaptive change in the Late Prehistoric Great Basin? *Journal of Archaeological Science*, **18**: 483-506.
- GROSS A. O. 1928. The heath hen. *Memoirs Boston Society of Natural History* **6**.
- HARGRAVE L. L. 1972. Comparative osteology of the chicken and American grouse. *Prescott College Studies in Biology*, **1**: vii-94.
- HARGRAVE L. L., EMSLIE S. D. 1979. Osteological identification of sandhill crane versus turkey. *American Antiquity*, **44**: 295-299.
- HARVEY E. D., KAISER H. E., ROSENBERG L. E. 1968. Atlas of the domestic turkey (*Meleagris gallopavo*): myology and osteology. U.S. Atomic Energy Commission, Division of Biology and Medicine, Germantown, Maryland.
- HILLSON S. W. 1992. Mammal bones and teeth: an introductory guide to methods of identification. Institute of Archaeology, University College London, U.K.
- HOLMAN J. A. 1961. Osteology of living and fossil New World quails (Aves, Galliformes). *Bulletin of the Florida State Museum (Biological Sciences)*, **6**: 131-233.
- HOLMAN J. A. 1964. Osteology of gallinaceous birds. *Quarterly Journal of the Florida Academy of Science* **27**.
- HUGHES J. M. 1996. Phylogenetic analysis of the Cuculidae (Aves, Cuculiformes) using behavioral and ecological characteristics. *The Auk*, **113**: 10-22.
- JOHNSGARD P. A. 1973. Grouse and quail of the world. University of Nebraska Press, Lincoln, Nebraska.
- JONES G. T., LEONARD R. D. 1989. The concept of diversity: an introduction. [In:] R. D. LEONARD, G. T. JONES (eds) – Quantifying diversity in archaeology. Cambridge University Press, Cambridge, United Kingdom. Pp: 1-3.
- KREUTZER L. A. 1992. Bison and deer bone mineral densities: comparisons and implications for the interpretation of archaeological faunas. *Journal of Archaeological Science*, **19**: 271-294.
- LIVEZEY B. C., STORER R. W. 1992. Morphometric comparisons of skeletons of the western grebe complex *Aechmophorus* of the United States and Canada. *The Condor*, **94**: 668-679.
- LOUGHEED S. C., ARNOLD T. W., BAILEY R. C. 1991. Measurement error of external and skeletal variables in birds and its effect on principal components. *The Auk*, **108**: 432-436.
- LEUDTKE B. 1980. The Calf Island Site and the Late Prehistoric Period in Boston Harbor. *Man in the Northeast*, **20**: 25-76.
- LYMAN R. L. 1979. Faunal analysis: an outline of method and theory with some suggestion. *Northwest Anthropological Research Notes*, **13**: 22-35.
- LYMAN R. L. 1984. Bone density and differential survivorship of fossil classes. *Journal of Anthropological Archaeology*, **3**: 259-299.
- LYMAN R. L. 1987. Archaeofaunas and butchery studies: A taphonomic perspective. [In:] M.B. SCHIFFER (ed.) – Advances in Archaeological Method and Theory, Vol 10. Academic Press, New York. Pp: 249-337.
- LYMAN R. L. 1994. Vertebrate taphonomy. Cambridge University Press, Cambridge, U.K.
- LYMAN R. L. 1995. Determining when rare (zoo-) archaeological phenomena are truly absent. *Journal of Archaeological Method and Theory*, **2**: 269-424.
- LYMAN R. L., O'BRIEN J. 1987. Plow zone zooarchaeology: fragmentation and identifiability. *Journal of Field Archaeology*, **14**: 493-498.
- MACDONALD K. C. 1992. The domestic chicken (*Gallus gallus*) in sub-saharan Africa: a background to its introduction and its osteological differentiation from indigenous fowls (Numidinae and *Francolinus* sp.). *Journal of Archaeological Science*, **19**: 303-318.
- MCKUSICK C. R. 1986. Southwest Indian turkeys: prehistory and comparative osteology. Southwest Bird Laboratory, Globe, Arizona.
- NEUMMAN T. W. 1989. Human-wildlife competition and prehistoric subsistence: the case of the eastern United States. *Journal of Middle Atlantic Archaeology*, **5**: 29-58.

- PARMALEE P. W. 1977. The avifauna from prehistoric Arikara sites in South Dakota. *Plains Anthropologist*, **22**: 189-222.
- PARMALEE P. W. 1985. Identification and interpretation of archaeologically derived animal remains. [In:] R. I. GILBERT Jr., J. H. MIELKE (eds) – The analysis of prehistoric diets. Academic Press, Orlando, Florida. Pp: 61-95.
- REA A. M. 1986. Verification and reverification: problems in archaeofaunal studies. *Journal of Ethnobiology*, **6**: 9-18.
- RITCHIE W. A. 1965. The archaeology of New York state. Natural History Press, Garden City, New York.
- RITCHIE W. A., FUNK R. E. 1973. Aboriginal settlement patterns in the northeast. New York State Museum and Science Service, Albany.
- SCHIFFER M. B. 1987. Formation processes of the archaeological record. University of New Mexico Press, Albuquerque.
- SCHWARTZ J. H. 1995. Skeleton keys: an introduction to human skeletal morphology, development, and analysis. New York: Oxford University Press.
- SENIOR L. M., PIERCE L. J. 1989. Turkeys and domestication in the Southwest: implications from Homol'ovi III. *Kiva*, **54**, 245-259.
- SHIPMAN P. 1981. Life history of a fossil. Harvard University Press, Cambridge, Massachusetts.
- SIMKISS K. 1975. Calcium and avian reproduction. *Symposia of the Zoological Society of London*, **35**: 307-337.
- STEADMAN D. W. 1980. A review of the osteology and paleontology of turkeys (Aves: Meleagrinae). *Contributions in Science, Natural History Museum of Los Angeles County*, **330**: 131-207.
- STEADMAN D. W. 1988. Prehistoric birds of New York State. [In:] R. F. ANDRLE, J. R. CARROLL (eds) – The atlas of breeding birds in the New York State. Cornell University Press, Ithaca, New York. Pp: 19-24.
- TAYLOR T. G., SIMKISS K., STINGER D. A. 1971. The skeleton: its structure and metabolism. [In:] B. M. FREEMAN (ed.) – Physiology and biochemistry of the domestic fowl. Academic Press, New York. Pp: 125-70.
- WATSON J. P. N. 1979. The estimation of the relative frequencies of mammalian species: Khirokitia 1972. *Journal of Archaeological Science*, **6**: 127-137.
- WHITE T. E. 1952. Suggestions for facilitating the identification of animal bones from archaeological sites. *Plains Anthropological Conference Newsletter*, **5**: 3-4.
- WILEY E. O. 1981. Phylogenetics: the theory and practice of phylogenetic systematics. John Wiley & Sons, New York.
- WOOLFENDEN G. E. 1961. Postcranial osteology of the waterfowl. *Bulletin of the Florida State Museum, Biological Sciences*, **6**: 1-129.
- ZIEGLER A. C. 1973. Inference from prehistoric faunal remains. Addison-Wesley Module in Anthropology 43. Addison-Wesley, Reading, Massachusetts.