Avifauna Discard Packages and Bone Damage Resulting from Human Consumption Processes

Caroline Funk PHD*, Emily Holt PHD, Ariel Taivalkoski MA, Joshua Howard MA, and Darren Poltorak
All University at Buffalo | *Corresponding Author

Abstract

Few actualistic studies of the patterns resulting from human preparation and consumption of birds inform interpretations of archaeological avifauna assemblages. This study focuses on developing new and adding to existing interpretive models. We examine differences in bone modifications produced by a culturally homogeneous group of eaters consuming medium-sized birds cooked using three cross-culturally common methods. We use the analytical concept of discard packages to capture variability in how groups of skeletal elements might be deposited into the archaeological record. We also examine chop/cut marks, burn marks, and chew marks as these are variables that archaeologists frequently use to identify and interpret anthropogenic avifaunal assemblages. We find that the creation of discard packages appears to be culturally motivated and varies little within our group of eaters, but the degree to which the associated elements are disaggregated during consumption is highly variable and depends on individual preference. Additionally, we find that while the presence and locations of chop marks are consistent across cooking methods and individual consumption preferences, the presence and locations of cut marks, burn marks, and chew marks are affected by cooking methods, individual preferences, or both.

Keywords: avifauna archaeology, consumption, food preparation, zooarchaeology, experimental archaeology, discard packages

1.0 Introduction

1.1 Purpose of the Study

Bird bones are common in archaeological sites and understanding the causes of patterns present in archaeological avifauna is critical because patterns of skeletal part representation and bone modification signal different human interactions with birds. Ratios of bird bones in the archaeological record typically vary from the natural occurrence of skeletal elements in whole birds. The cause of these differences is difficult to interpret (Weisler and Gargett 1993). Many previous approaches to this problem focus on taphonomic issues, addressing differential preservation due to bone density, but differences in bone density have not been sufficient to explain all the observed variation (Bickart 1984; Bovy 2002, 2012; Ericson 1987; Livingston 1989; Weisler and Gargett 1993). The possible impacts of human hunting, processing, and consumption behaviors on skeletal part representation are often the subject of speculation in these studies, but few actualistic studies of bird consumption documenting these processes and their results have been undertaken (Laroulandie 2001, 2005b; Serjeantson 2009).

The present study builds on previous work by providing an actualistic analysis of avifaunal skeletal element damage and disaggregation resulting from consumption after three different cooking processes. The goals of the study are to identify patterns in damage to bones and disaggregation into animal unit packages. We cooked six avian specimens (chicken, *Gallus* spp.) using three cooking methods, ate them, and defleshed the skeletal remains using a dermestid colony. Then, we analyzed the skeletal remains using a uniform set of variables. Our study provides insight into how preparing, cooking, and consuming processes damage bones and impact the formation of discard packages.

1.2 Limited Interpretive Models Available

We have few models for understanding the complex social mechanisms by which bird bones were deposited. Descriptions of avifaunal preparation and consumption infrequently are included in ethnographic or historic texts. A search of the eHRAF World Cultures database (search terms “bird”, “cooking”, and “Food Consumption”) resulted in only 34 references to preparing birds for consumption. The disposal of bird remains also is little mentioned in ethnographic and archaeological literature outside of disposal related to religious practices (exceptions Andrews 1980; Gotferdsen 1996). Generally, bird bones as archaeological artifacts have been less studied than mammal bones, the result being taphonomic studies of bird bones are limited in scope and number (Bickart 1984; Bovy 2012; Ericson 1987; Livingston 1989; Serjeantson 2009; Weisler and Gargett 1993).

1.3 Previous Actualistic Studies

We know only of two previous actualistic studies of bird consumption. Weisler and Gargett (1993) conducted an actualistic study to determine whether observed patterns of bird bone modification from nine archaeological sites in west Moloka’i, Hawai’ian Islands were the result of human predation. They steamed and roasted nine galliform birds: four quail, two partridges, two squabs, and a pheasant. They then ate the birds, chewed the epiphyses off half the long bones, and snapped the other half through the midshaft using bare hands. Overall, their experimental specimens strongly resembled the archaeological materials that prompted the study, though they acknowledged that natural processes might also produce similar modifications.

Laroulandie (2001, 2005a, 2005b) focused on understanding modified bird bone from Paleolithic sites in France. She butchered, cooked, and defleshed ten gray partridges as proxies for all medium-sized birds. She butchered the carcasses using unretouched flint flakes, disarticulating the raw birds primarily by cutting through their joints with the flakes. She twisted and overextended some of the joints, in particular the joint between the humerus and the radius/ulna. She cooked the individual carcass segments on hot rocks by a fire, defleshed the cooked meat from the bones using flint flakes, and ate some of the meat off the bones with her teeth. She recorded the resulting cut, burn, and chew marks.

1.4 Descriptive Study

Our study is intended to be descriptive and to contribute to model building, rather than serve as a hypothetico-deductive test. Inspired by the repeated observation that archaeological bird bones often vary from the natural occurrence of skeletal elements, we wondered if consumption patterns might produce sets of skeletal elements that are frequently discarded together. Additionally, following Serjeantson (2009:138), we suspected that different cooking techniques would have different effects on muscle and connective tissue, resulting in more or less “attached” elements. For example, Serjeantson (2009) indicates that stewing animals leaves flesh tender and more likely to disarticulate easily. Particular cooking practices might affect the makeup of discard packages, because skeletal elements that disaggregate easily may be discarded separately, while skeletal elements that do not disaggregate easily may be discarded as a group.

The two previous actualistic studies set an important foundation for this type of work while leaving many avenues open for further research (Laroulandie 2005b: 174). Our study contributes additional, complementary data in important ways. We are not trying to replicate the bone modifications seen in a particular assemblage, but instead are attempting to capture the range of variation that may be produced within a group of eaters. Both previous actualistic studies were inspired by the characteristics of particular archaeological assemblages, which the authors then tried to reproduce. We started from the assumption that a range of eating practices and resulting bone modifications could occur even within a culturally fairly homogenous group. We avoided making assumptions about how we should eat or how bones would likely be modified, allowing eaters to follow personal inclinations.

The patterns identified in a cooking and consumption context should be distinct from those resulting from skinning for down (Esser 2010) or symbolic/ritual use (Serjeantson 1997), for example. We were influenced by Storey et al's (2008) suggestion that for chickens, bird preparation, consumption, and disposal strategies impact their survivorship and subsequent identifiability. We took the position that this is true for all birds, though we chose to use chickens as proxies for medium-sized birds. The impacts of depositional and post-depositional processes are beyond the scope of this study.

2.0 Materials and Methods

2.1 Chickens as Proxies for Medium-sized Avifauna

We used chickens as proxies for all medium-sized birds, as Laroulandie (2001) similarly employed gray partridges. The study is intended to provide useful information about cooking and consumption impacts on bird bone in general, although the impacts of cooking techniques on chicken bone and the disarticulation patterns recorded here may be of particular use in regions where the use of chickens is the focus (as in Storey et al 2008).

We used free range, pastured chickens in the study as they were the most appropriate option available. Our experience gained from using and producing skeletal reference collections indicated that the bones of factory-farmed chickens are poor analogs of prehistoric avifauna; they have greater porosity and are less ossified than free-range chicken bones. The chickens used in this study were purchased from a local co-operative market. They were whole, cleaned carcasses missing skulls, cervical vertebrae, and lower limb bones below the tibiotarsus. The lack of internal organs may not accurately reflect all possible cultural practices of cooking birds, but we judged it unlikely to alter the effects of cooking and consumption practices on the formation of discard packages, which is the focus of this study. The lack of lower limb and foot bones does mean that the ways in which these bones disaggregate during cooking and consumption cannot be addressed by this study.

2.2 Cooking Techniques

We selected cooking techniques that represent three cross-culturally widespread cooking methods. Using eHRAF and traditional literature search methods, we learned that boiling, roasting, and grilling both whole and parted carcasses were and are commonly used techniques for cooking birds. The technique of preparing avifauna by boiling has not significantly changed over time and varies little across cultures (Aresty 1964; Bayard 1991; Bohannan and Bohannan 1958; de Bry 1972; Fletcher 1911; Hollander 2010; Irimoto 1981; Kaufman 2006; La Barre 1948; Lin and Pan 1947; Messing 1985; Musters 1872; Reichel-Dolmatoff 1971; Reynolds 1968; Sass 1975; Stöeffler 1969; Vennum 1988; Wagley 1941). Dry or oven roasting (Batdorf 1990, Byock 1999, diMessisbugo 1960, Fletcher 1911, Gifford 1965, Gusinde and Schütze 1937; Kniffen 1939; Lin and Pan 1947; Musters 1872, 1873; Sass 1975; Thoms 2009; Wallace and Hoebel 1952; Wagley 1941) and open fire grilling (Basden and Willis 1966; Breton 1955; de Bry 1972; diMessisbugo 1960; Irimoto 1981) are two other common preparation techniques. Across cultural contexts, birds and other smaller fauna are cooked whole or are "hewn" into portions prior to cooking (as in Medieval cookery as presented in Basden and Willis 1966; Bohannan and Bohannan 1958; Sass 1975).

2.3 Study Variables

The primary purpose of this study was to identify potential discard packages of avian skeletal elements that might consistently be produced during preparation and consumption processes. We also recorded three common types of bone modification that are central to the interpretation of bird remains by zooarchaeologists: burning, cut and chop marks, and chewing marks.

2.3.1 Skeletal Part Representation/Disaggregation

Our study complements past works by approaching the problem of differential representation of avifauna elements from the beginning of the process. We analyzed our post-consumption chicken bones to learn what "packages" of skeletal elements with what types of damage were present. In this we followed Bovy (2002, 2012), who posited that human processes are more likely than taphonomic processes to cause the patterns of skeletal disaggregation present at archaeological sites. She suggested that other explanations like differential selection by humans, scavenging by animals, processing techniques, or consumption practices should be used to interpret avifauna skeletal part patterns (2002, 2012). Other studies that approach the problem of differential representation in the archaeological record also ask what cultural and taphonomic processes could account for the observed assemblages (as in Roberts et al 2002). Ericson (1987) hypothesized that the ratios of bird bones found at archaeological sites could be indicative of human activity and postulated that the decomposition process might be different for bones that were consumed as food than for naturally deposited bones. Livingston (1989) postulated that avian element survivorship was related to taphonomic differences in the structural properties of bones, but her work was countered by Higgins' (1999) conclusion that there was no relationship between bone survivorship and the taphonomic characteristics of the species to which they belonged.

2.3.2 Bone Modification: Burning, Cutting, and Chewing

We suspected that our three cooking techniques would result in differential bone discoloration and charring. Changes in bone color due to heating have been found to occur at temperatures as low as 20° C (McCutcheon 1992; Shipman et al. 1984). These color changes are affected by the temperature to which bones are heated, the length of time for which they are heated, the shapes of the bones, and whether the bones are fleshed or defleshed when heated (McCutcheon 1992; Pfeiffer 1977; Shipman et al. 1984). We controlled the temperatures to which bones were heated only as an indirect result of controlling the cooking temperatures of our chickens. Experimental studies of burned bone have shown that bones do not reach the maximum temperature of the heating element unless exposed to it for at least two hours (Buikstra and Swegle n.d.). This length of time is longer than the cooking times for any of the chickens in this experiment and, by analogy, probably longer than most cooking times of chicken-sized birds in the past. Given this, cooking activities alone probably would produce only minimal color change of chicken bones. Because the chicken bones were wet and predominantly fleshed when cooked, it was not possible to record colors of unheated bones for use as controls.

Experimental studies and archaeological analyses of cut and chop marks on bird elements have not been extensive, but some commonalities across time, space, and cultures have been identified (Serjeantson 2009:132-144). Chop marks, which tend to be short and deep, result from the use of heavy knives during dismemberment in primary butchery; often near significant points of articulation (Serjeantson 2009:132). Cut marks are made during eating as secondary butchery. Bone pressure damage can result from manually pulling apart articulated elements. Cut marks are believed by many to be less common on bird bones, yet some studies do find a high frequency of cut marks (Blasco and Peris 2009; Bovy 2012; deFrance 2005; Steadman et al 2002). Since we intended to identify cut and chop marks made by modern metal cleavers and knives on fresh, un-aged bone, typical concerns about distinguishing between type of bone damage and origin are not relevant to our study (as in Fisher 1995; Greenfield 1999; Noe-Nygaard 1989; Olsen 1988; Shipman 1981; Walker and Long 1977).

We gathered data about the location and frequency of chew marks in the interest of contributing to the broader literature. Human chewing of bone is often difficult to distinguish from other tooth marks in archaeological contexts (Andrews and Fernández-Jalvo 1997; Fernández-Jalvo and Andrews 2011; Steadman 2006), although this was not a concern here. As only humans consumed the meat on the bird bones in this study, we were more interested in understanding how the location of chewing marks might correspond to cooking techniques and/or consumption behaviors.

2.4 Methods

We established and followed standardized protocols for the three experiments and subsequent analyses. Each time, we recorded the size and weight of the uncooked chicken carcasses. Each of the three experiments included two chickens: one remained whole and the other was "hewn" into portions using an 8-inch cleaver. For each experiment, dismemberment followed the same general pattern. Each wing (proximal humerus to distal phalanges) was removed from the axial portion as a package. Each leg was parted into two discreet packages, femur and tibiotarsus, by separating the distal femur joint, then the proximal femur joint. After the limbs were removed, the ribs were disarticulated from the spine with the cleaver, from posterior to anterior. Finally, the breast was separated at the sternum. In total, each "hewn" chicken was parted into 9-11 units: two wings, two thighs, two legs, two breasts, the sides (ribs, pelvic girdle, and pectoral girdle) and the back. In Experiment 3, the spine of the hewn chicken was split, causing a slight modification in the composition of the butchered packages. Also in Experiment 3, the whole chicken was spatchcocked so that it could cook to food-safe temperatures on an open grill: the spine was cut out of the bird and the limb joints were manually loosened. After preparing the birds, we recorded the cooking technique, cooking duration, and post-cooking weight. All phases of the preparation were photographed. No further modifications were made to the chickens prior to the consumption portion of the study.

The chickens in the experiment ranged from 3.05 to 3.83 pounds, with paired sets in each experiment weighing approximately the same (Table 1). Odd numbered chickens were prepared whole and even numbered chickens were parted (Table 1). In Experiment 1, we boiled the chickens for one hour each, to food safe temperatures of at least 165^{o}F. We roasted the two birds in Experiment #2 at a starting temperature of 450^{o}F, immediately reduced to 350^{o}F for 20 minutes per pound, or roughly one to one and a half hours each, to food safe temperatures. The chickens of Experiment #3 were grilled, but unlike the previous experiments these chickens were cooked for different durations. The parted chicken cooked to food safe conditions in less than an hour but the whole chicken grilled for more than an hour.

Table 1: Project experiments and avifauna specimen data.

Experiment #	1		2		3	
Preparation	Boiled		Roasted		Grilled	
Chicken #	1	2	3	4	5	6
Condition	Whole	Parted	Whole	Parted	Whole	Parted
Weight	3.74 lbs	3.83 lbs	3.85 lbs	3.75 lbs	3.05 lbs	3.05 lbs
Cook Length	1.0 hr	1.0 hr	1.4 hrs	1.25 hrs	1.1. hrs	.6 hr

Five to six individual eaters (CF, EH, AT, JH, DP, and AB) selected portions of either the whole or parted chicken to eat according to personal preference. They cut or pulled each portion from the whole chicken or simply selected a pre-cut portion of the parted chicken. The remains of each portion were bagged separately for each eater. For example, in Experiment 1, CF created two sample bags of bones labelled

Chicken 1 and Chicken 2. Individual eaters recorded their consumption technique in narrative form after the consumption stage, describing their use of utensils, teeth, or hands. While difficult to assess and control for, each eater focused on following their typical consumption habits and refrained from eating to produce variable data. The reflexive act of debriefing afterward and describing eating habits was intended to maintain a strong focus on normalcy throughout the consumption stage of each experiment. Not all of the chicken portions were consumed during each experiment. Remaining portions were designated as "leftovers" and processed as packages from which portions were selected.

Back in the lab, we weighed and recorded the element packages produced by each eater during the consumption phase. A "package" included any still attached portions of bone or single, separated elements. For Experiment #1 we simply weighed each eater's bone bag as the package, but realized that we were missing critical aggregation/disaggregation data and modified our procedures to collect the more detailed bone package data for Experiments #2 and #3. The bone packages were placed into a dermestid colony for defleshing. The defleshed elements were washed in a fine mesh screen (1 mm) after removal from the colony and allowed to air dry prior to analysis. The elements then were subjected to a four-part analysis to identify elements and to record cut/chop marks, chewing marks, and burning. These analyses occurred under overhead fluorescent lights that were supplemented by focused ~60w equivalent bulbs and 3-5x magnification as necessary. Cut, chew and burning damage was identified with the naked eye and examined under the lighted 3-5x magnification lenses and, if necessary, a 10x LED lighted stereoscope. We identified the colors of burning using a Munsell color chart under fluorescent light following the methodology of McCutcheon (1992). We recorded data on standardized data sheets which included a sketch of an articulated bird skeleton for noting the location of bone modifications.

3.0 Results

3.1 Bone Modification

We recorded 67 cut, chop, and cleave marks (Table 2). As described above, cut marks were shallower and lighter and resulted from lower cutting force. Chop marks resulted from strong cutting force utilized during dismemberment and cleaves were successful forceful dismemberment chops resulting in sheared bone.

Cut marks were present on whole (n = 9) and parted (n = 13) chickens in similar amounts. They appeared mainly on the pectoral girdle, the pelvic girdle, and the ribs (Figure 1). The marks on the pelvic and pectoral girdles may have resulted from dismembering the chickens, caused by ineffectual cleave/chops. However, because cut marks appeared on whole and parted chickens, we must consider that they were caused by primary butchery and individual-secondary butchery. Only two wing elements showed cut marks, both eaten by CF from parted chickens in Experiment #1 (Chicken #2) and Experiment #3 (Chicken #6). Individual eaters varied in the number of cut marks they made. Only one eater (EH) made no cut marks. One eater (AT) made by far the most cut marks, with 8 out of the 22 identified. Cut marks on the leftover portion likely result from portion removal by the eaters.

Table 2: Damage to bone made by individual eaters.

Eater	Chew	Cut	Chop/Cleave
AB	2	1	14
AT	0	8	4
CF	0	4	5
DP	9	1	3
EH	5	0	10
JH	2	2	8
LEFTOVERS	0	6	1
Total	18	22	45

Cleave/Chop marks were distributed more evenly across skeletal elements, but they were limited to areas where the butcher had hewn the parted chickens (Figure 1). If the cleave/chop marks were the result of the dismemberment process, coracoids, humeri, sternums, synsacrums, and femurs should have the highest frequency of chops/cleaves. In fact, the parted chickens did have most of the cleave/chop marks with two exceptions: the sternum of the whole chicken (#5) from Experiment #3 had two cleave/chop marks, and the leftover chicken (#1) portion from Experiment #1 also had a cleave/chop mark on the furculum. The cleave/chop on the sternum from Experiment #3 was likely due to the spatchcock technique used to flatten the chicken for grilling. The cleaved furculum from Chicken #1 remains unexplained.

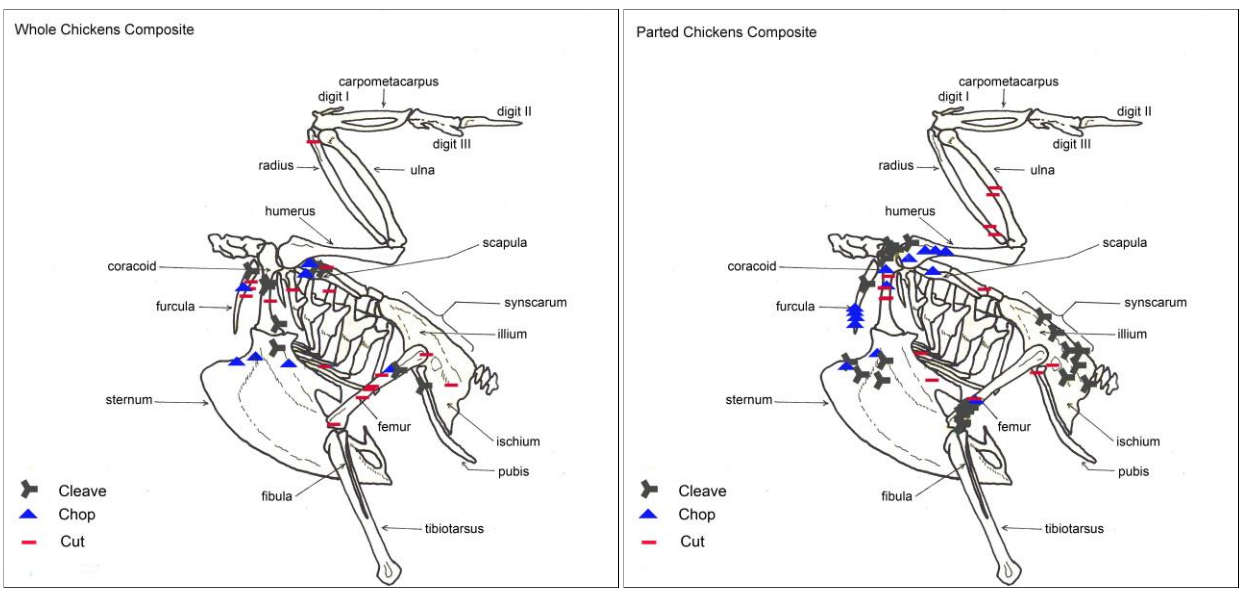

Figure 1: Position of cut, chop, and cleave marks (skeleton sketch derived from Cohen and Serjeantson 1996).

Eighteen skeletal elements had chew marks. The shaft of the humerus and the inside surfaces of the radius and ulna showed the most frequent damage from chewing (Figure 2). We found no difference in the number of elements with chew marks between whole and parted chickens. Three eaters in the study (EH, DP, and JH) were responsible for all of the chew marks (Table 2). The majority of chew marks were found on the boiled (n = 4, Chickens #1 and #2) and roasted specimens (n = 11, Chickens #3 and #4), while the grilled specimen showed almost no chew marks (n= 3, Chicken #5), despite the fact that eaters known to leave chew marks ate humeri and radii/ulnae from the grilled specimens (Figure 2). It is also worth noting that one eater (EH) consumed the digit III, phalanx II of digit II, part of phalanx I of digit II, and the unfused parts of the metacarpus while eating a wing of the whole grilled chicken (#5). These parts had become crunchy and easily crumbled during grilling and were consumed unknowingly while the eater enjoyed the crunchy skin.

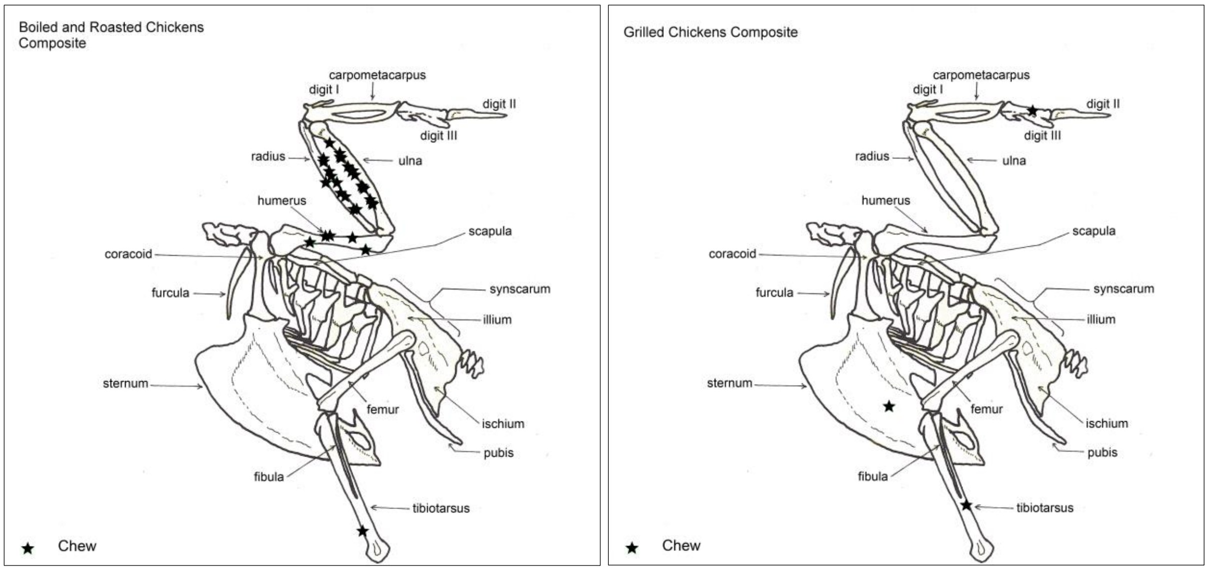

Figure 2: Position of chew marks (skeleton sketch derived from Cohen and Serjeantson 1996).

Burn marks were observed on skeletal elements from the roasted parted chicken (Experiment #2, Chicken #4), the grilled whole chicken (Experiment #3, Chicken #5), and the grilled parted chicken (Experiment #3, Chicken #6). On the roasted parted chicken, burn marks were recorded on the scapula, synsacrum, and vertebrae (Figure 3). On the grilled whole chicken, burn marks were recorded on the coracoid, sternum, vertebral ribs, and pelvis. On the grilled parted chicken, burn marks were recorded on the ribs, femur, and tibiotarsus. Burn marks ranged in color from Munsell 10YR 6/8 – 5YR 2.5/1, with some bones burned blacker than the Munsell range. These burn marks fall within the general range of colors that indicate burning without calcination (McCutcheon 1992; Shipman et al 1984). All of the burn marks were located where bones covered by very little flesh were directly exposed to heat. The boiled bones showed no burning damage, although they were occasionally deeply stained, presumably by boiled blood.

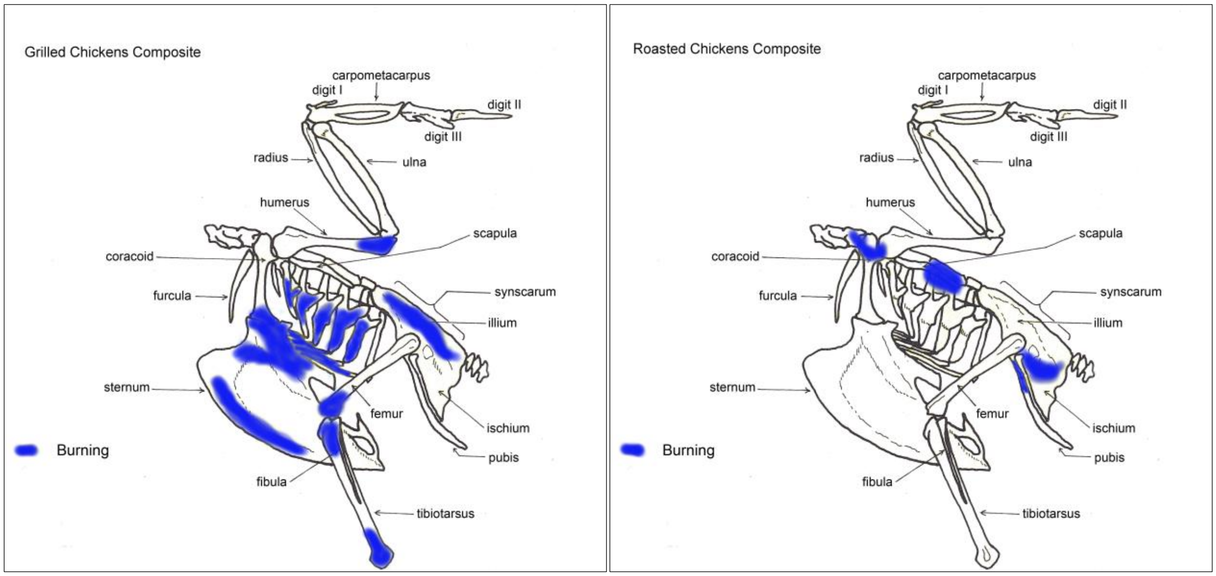

Figure 3: Burn damage location (skeleton sketch derived from Cohen and Serjeantson 1996).

3.2 Skeletal Part Disaggregation

A core assumption in our study was that discarded skeletal element packages, especially those with elements still connected via tissue, would remain contextually linked in the archaeological record. We thought that cultural preference would cause the formation of particular element packages during preparation and consumption. The packages in this study were formed by individuals from the northeastern United States: a fairly homogeneous group. Cultural preference presumably also would be active in discard practices, impacting the clustering or dispersal of individual and group meal discards, but this line of inquiry lies beyond the bounds of the current study.

3.2.1 Butchery Packages

We thought that the consumption of whole chickens would result in bone packages that are notably distinct from those produced by the consumption of parted chickens, because package selection opportunities obviously change when an individual is confronted by a whole chicken versus chicken parts. This was incorrect. There was no real difference and butchery did not impact the formation of packages.

Observed post-consumption package types include groupings of appendicular and axial portions (Table 3). The lower limbs are present in two package types, disarticulated: femur and tibiotarsus/fibula, and articulated: both elements. The wings are present in general packages as well, entire wings (humerus to phalanges), lower wings (ulna and radius to phalanges), and the humerus alone. As seen in the individual patterns below, the degree of disarticulation of the limbs during consumption varies. Axial skeletal portions were present in four types of packages: the upper breast area (scapula, coracoid, sternum portion, ribs), the lower breast area (ribs, synsacrum, pelvis), entire sides (ribs, sternum, pelvis, vertebrae), and spine (vertebrae, synsacrum gracile, pygostyle).

Table 3: Discard packages and cooking technique.

		Roasted		Grilled		Boiled*	
Portion/Package	Elements	Chicken 3 whole	Chicken 4 parted	Chicken 5 whole	Chicken 6 parted	Chicken 1 whole	Chicken 2 parted
Appendicular Portion							
leg	tibiotarsus	1			2	1	
leg and thigh disarticulated after eating	femur and tibiotarsus		1	2		1	2
leg and thigh articulated after eating	femur and tibiotarsus	1	1				
thigh	femur	1			1		1
lower wing more or less disarticulated after eating	radius, ulna, carpometacarpus, phalanges		1			2	1
lower wing more or less articulated after eating	radius, ulna, carpometacarpus, phalanges		1				
entire wing more or less disarticulated after eating	humerus, radius, ulna, carpometacarpus, phalanges	2		1	1		1
entire wing more or less articulated after eating	humerus, radius, ulna, carpometacarpus, phalanges			1	1		
humerus						2	
Axial portion							
upper breast area disarticulated after eating	sternum, keel, scapula, coracoid - variable combination		1	2	1		2
upper breast area articulated after eating	sternum, keel, scapula, coracoid - variable combination	1			1	LEFTOVER	
lower breast area disarticulated after eating						1	1
lower breast area articulated after eating	ribs, synsacrum, pelvis - variable combination	1				LEFTOVER	
spine distarticulated after eating							
sprine articulated after eating		1	1			LEFTOVER	
entire side portion disarticulated after eating	rib, sternum, pelvis, synsacrum - variable combination			2	1	1	1
						* limited package data	

3.2.2 Cooking Packages

Other authors suggested that boiling, roasting, and grilling cooking techniques would impact the disarticulation potential of birds (as in Roberts et al 2002; Serjeantson 2009), yet our study revealed limited differences in package creation among our three experiments (Table 3). We expected that boiling (Experiment #1, Chickens #1 and #2) in particular would result in a greater number of smaller (fewer bone elements present) packages. Indeed, lower wings easily disarticulated from distal humeri on the whole boiled chicken so that no one was able to select an entire wing. The humeri actually remained with the axial leftover carcass and were not selected for consumption. Other than this notable point of disarticulation and small package creation, however, the three cooking techniques produced similar packages.

3.2.3 Individual Consumption Packages

Individual consumption practices created distinct types of bone packages. As noted previously, the packages selected for consumption were unplanned and result from personal food selection preferences. We assumed at the start of the study that individuals would select packages according to personal preference in taste and ease of acquisition. Individual package data are available for Experiments #2 and #3 only (Table 4).

There was variability in the frequency of disarticulated and articulated packages for each individual eater in the study. Some individuals reduced meat packages to unconnected skeletal elements while others produced connected packages that arguably are more likely to remain in context during disposal and in the archaeological record. For example, Eater CF never produced disarticulated packages and discarded packages from her bird meals would tend to remain in associated context in the archaeological record. Other eaters variably produced articulated and disarticulated packages.

Table 4: Individual eater discard packages.

		Whole		Parted	
Package/Portion	Elements	Roasted	Grilled	Roasted	Grilled
Appendicular Portion					
leg	tibiotarsus	CF			DP
leg and thigh disarticulated after eating	femur and tibiotarsus		AT, JH	DP	
leg and thigh articulated after eating	femur and tibiotarsus	DP		AT	JH
thigh	femur	EH			
lower wing more or less disarticulated after eating	radius, ulna etc			EH	
lower wing more or less articulated after eating	radius, ulna etc			DP	
entire wing more or less disarticulated after eating	humerus, radius, ulna, etc	EH, AB	EH		DP
entire wing more or less articulated after eating	humerus, radius, ulna, etc		CF		CF
Axial portion					
upper breast area disarticulated after eating	sternum, keel, scapula, coracoid - variable combination		JH, EH	EH	EH
upper breast area articulated after eating	sternum, keel, scapula, coracoid - variable combination	AT			AT
lower breast area disarticulated after eating					
lower breast area articulated after eating	ribs, synsacrum, pelvis - variable combination	AB			
spine distarticulated after eating					
sprine articulated after eating		LEFTOVER		CF	
entire side portion disarticulated after eating	rib, sternum, pelvis, synsacrum - variable combination		JH, AB		AB

4.0 Interpretations

4.1 Bone Modification

4.1.1 Cleave, Chop, and Cut Marks

Chop and cleave marks matched avian processing patterns described in earlier studies across all three cooking techniques. While the presence of chop/cleave marks was generally consistent across birds regardless of cooking method or eater, the presence of cut marks was highly individualized. This suggests that, while primary butchery is culturally shared, secondary butchery reflects individual preferences. This observation may be useful when considering whether different types of butchery practices within a single site indicate different cultural groups (as in Stein 2012). Primary butchery may be the practice on which to focus, while secondary butchery may be less meaningful in terms of differentiating cultural groups.

4.1.2 Chew Marks

The presence of chew marks on bones was also highly individual. It was unrelated to whether the birds were whole or parted and it was only slightly related to cooking method. Most chew marks were found on the boiled and roasted chickens, fewer on the bones from grilled chickens. This suggests that the lack of chew marks on the skeletal elements of the grilled specimens may be due to different properties of the meat after grilling, causing it to pull away from the bone more easily and making it unnecessary to detach the meat with the teeth. Bones may also harden during grilling, making them less likely to be damaged by chewing. Like the presence of cut marks, the presence of chew marks may be less useful in differentiating cultural groups.

4.1.3 Burn Marks

All burning damage to bones occurred on the roasted and grilled chickens, but with lower frequency than might be expected. While many bones with little flesh on them that were directly exposed to heat developed burn marks, it is worth noting that not all bones with little flesh on them exhibit burn marks. This suggests that many cooking activities will not leave burn marks on avian bones and that the absence of burn marks does not demonstrate that the bones were not directly exposed to levels of heat sufficient for cooking. The absence of burn marks on avian bones should not be used as evidence that the bones are not anthropogenic in origin unless multiple other lines of evidence also indicate a non-anthropogenic origin.

4.2 Skeletal Part Disaggregation

4.2.1 Butchery Packages

Whole and parted chicken discard packages are not notably different from each other. The eaters in our experiments tended to self-select packages similar to those produced by the butchery process, resulting in similar packages from both whole and parted chickens. This may indicate that within any cultural region or time, butchery technique alone is not the significant aspect in the production of element packages. Instead, people use their culturally-specific portion selection protocol regardless of the presentation of the cooked bird. Butchery techniques likely derive from these existing preferences.

4.2.2 Cooking Packages

Our study did not show significant differences in cooking method impacts on the creation of discard packages. While the distal wings disarticulated easily from the boiled chickens, other bones did not disarticulate noticeably more easily. Perhaps if the birds had been boiled for a longer period of time, as in simmering for a stew rather than for consumption as whole carcasses, the disaggregative effect would have been stronger, a possibility worth investigating in a future study. As it is, when boiling the birds for consumption as whole carcasses, the effect on package formation was minimal and did not produce results dissimilar from the other cooking methods.

4.2.3 Individual Consumption Packages

Individual eaters in our study produced variably disarticulated packages. This degree of variation within our culturally uniform group suggests that such variation rests at the level of individual preference. Archaeologically, however, this variation may be difficult to parse out, given that waste disposal would tend to aggregate the consumption packages of many individuals. Given the high degree of individual variation indicated by our study, however, individual variation may be one confounding factor in finding clear patterns of disposal for avifaunal remains.

5.0 Concluding Remarks

5.1 Key Contributions on the Impacts of Cooking and Eating on Bone and the Development of Discard Packages

We can make a series of general statements that should be useful when interpreting archaeological avifauna assemblages. First, the cooking technique utilized influences the likelihood that human teeth marks will be visible on bone. We remain uncertain as to the underlying cause, but the grilled chicken bones in Experiment #3 did not have the chew marks expected given the patterns present in the boiling and roasting of Experiments #1 and #2. Second, burn marks were not ubiquitous on exposed bone in any of the three experiments. Boiling produced no burn marks and grilling and roasting did not always cause burns on exposed bone. The main implication of these observations is that burning cannot be employed as the primary line of evidence that humans created any given avifaunal assemblage. Nor can we look to burn marks as an indicator of cooking technique or even evidence for cooking at all. Finally, our cut and chop data conform to patterns already defined by previous works.

Our primary goal, describing the development of discrete discard packages, resulted in unexpected patterns. We observed that uniform packages resulted regardless of the cooking technique utilized. We also saw that eaters created similar elemental packages when forced to remove their own portions from an entire carcass and when offered pre-cut portions. We interpret these patterns as resulting from cultural preferences for types of packages that transcend the physical results of cooking or butchering. This means that unexpected, non-intuitive patterns in elements present in an archaeological assemblage may in fact be indicators of a local, temporally specific preference for eating birds in a particular way.

We thought we would observe that some packages tended to be created regardless of eater, but we found that individual eating styles resulting in a wide, unpatterned variability in the production of discrete, articulated packages and entirely disassembled bird portions. We believe this serves as a cautionary moment. Archaeological pattern seeking tends to average behavior. Analyses of bird bone packages in the archaeological record must be performed with the caveat that while cultural patterning may be visible, individual consumptive patterns likely were extremely variable within the larger context. If an archaeological assemblage for any given provenience seems to be an interesting mix of associated, articulated packages and disarticulated but related elements, it may be that the assemblage is the remains of a meal eaten by several variably finicky people.

5.2 Future Studies

Our study's focus did not allow for the exploration of related, potentially significant research. We see three clear avenues for research that will develop an understanding of patterns resulting from human consumption of avifauna in productive ways. First, exploring the impact of cooking technique on 1) the ease of removing cooked meat from bones and 2) the hardness of cortical bone and its subsequent resistance or susceptibility to human chewing forces would be useful. Second, understanding when bird bones will burn and the durability of burn marks after burial will help to define the broader usefulness of attempting to see patterns in burned bird bone. Finally, working with a larger group of eaters from a broader cultural spectrum, who are unaware of the purpose of the study would provide a mechanism for understanding the role of cultural preference on avifauna package development. It is our hope that others take on these challenges in future research.

Acknowledgements

This study was conceived, performed, and written in a collaborative effort by members of the University at Buffalo Zooarchaeology Group 2014-2015 (http://ubwp.buffalo.edu/ubzooarchaeology/). The University at Buffalo Department of Anthropology provided partial funding to support the research. The Primate Anatomy Lab in the University at Buffalo Department of Anthropology provides space for the dermestid colony. Bone analysis was performed in the Rat Islands Research Laboratory (NSF PLR-1303566) in the University at Buffalo Department of Anthropology. eHRAF research was performed using complimentary eHRAF access provided during the 2015 SAA Annual Meeting. Thank you to two anonymous reviewers, who helpfully improved the article with clear and useful comments.

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