



Understanding faunal contexts of a complex *Tell*: Tel Dor, Israel, as a case study

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ABSTRACT

The complex stratigraphy of the large Levantine tells and the complexity of human behavior that took place on them, poses a major challenge in understanding site formation processes and their reflection in the faunal remains. We studied the contextual deposition of faunal remains in Tel Dor, as a model for complex tell sites, and the possibility of using faunal remains as a tool to distinguish between context types. In addition, we asked how can we use this knowledge to elucidate site formation processes. Our results demonstrate that most loci defined in the field as primary refuse or purposive disposal are indeed different from the loci defined as secondary refuse. Different types of contexts can be differentiated, to a degree, from one another based upon multivariate analysis of faunal remains. Statistical as well as spatial analyses may help elucidate site formation processes and the use of space. Bones can, and in many cases do, reflect primary activities. Lumping zooarchaeological data into a single 'assemblage', as done in most zooarchaeological studies today causes major loss of information. Consideration of the specific location of faunal remains can be used as further indication for context identity and for understanding specific activities in a site, with care this can be done even in complex sites such as the 'urban mounds' of the Levant.

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1. Introduction

In recent years there is a growing realization that the analysis of ancient populations' economic and cultural activities, as reflected in animal bone remains, requires understanding of site formation processes (e.g. Lyman, 1994; O'Connor, 2000). Among these processes, the final deposition of artifacts, such as bones, may be influenced by both anthropogenic and natural factors. We studied potential differences between characteristics of faunal remains in different depositional units in a complex, stratified and continuously inhabited urban *tell*. Our main goal was to determine whether any of the faunal remains may be considered primary (reflecting the activities that took place where they were found), or whether they all reflect secondary disposal (material transferred after discard; see below). This distinction is especially crucial for assessing the potential contribution of animal bones to identifying activity areas and the functions of specific architectural units in *tell* sites.

The *tells* (mounds) of the Levant play a significant role in archaeological studies of the history and evolution of human

cultures and economies. The major *tells* are the town sites from the Bronze Age to the classical periods and as such provide us with unique insight into the workings of what are primarily urban societies. The constant use of a site creates over time a complex depositional history and stratigraphy, resulting from recurrent cycles of construction, use, re-use, destruction and occasionally abandonment processes over millennia. These involve the transfer of sediments (and artifacts within them) in order to be used in construction fills, foundation trenches, walls, etc. Hence, archaeological remains can be found at a certain location due to several factors: discard, abandonment, deliberate transfer, and to a lesser degree, natural agents.

Study of the major *tells* provide us with significant insight into past societies and their daily lives. An important aspect of the daily life is human diets and livestock management, which also reflect culture and identity. These issues have been studied extensively in the past 15 years in the southern Levant, focusing mainly on Bronze and Iron Age strata, and to a much lesser extent on later periods (e.g. Bar-Oz et al., 2007; Cope, 2006; Dayan, 1999; Hellwing and Feig, 1989; Hesse and Wapnish, 1998; Horwitz, 1996, 1998, 1999, 2000, 2003, 2006; Horwitz and Tchernov, 1989; Horwitz and Dahan, 1996; Horwitz et al., 1990, 2005; Lev-Tov, 2000, 2003; Maher, 2005; Marom et al., 2009; Raban-Gerstel et al., 2008;

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Redding, 1994; Sade, 1999, 2006). To date, however, and in spite of their historical significance and their prominence in the region's archaeological research, there has been no comprehensive study of the taphonomy of a *tell* site in the southern Levant from the zooarchaeological perspective. Most taphonomic research in this area focuses on prehistoric sites and on issues of bone preservation (e.g., Bar-Oz, 2004; Bar-Oz and Dayan, 2002, 2003; Bar-Oz et al., 1999, 2004, 2005; Bar-Oz and Munro, 2004; Munro and Bar-Oz, 2005; Speth and Tchernov, 2001; Stiner, 2002, 2005; Stiner et al., 2001; Weissbrod et al., 2005; Zohar and Belmaker, 2005); very few studies of later periods examined aspects of taphonomic history, and of those all focused on bone preservation of a single stratum or period (Raban-Gerstel et al., 2008; Sasson, 2008). Other zooarchaeological perspectives of site formation processes were largely neglected.

Schiffer's well-known and widely used depositional ontology (e.g., Schiffer, 1972, 1987) defines two main categories of *discarded refuse*: *primary refuse* (material discarded at its location of use) and *secondary refuse* (the location of the final discard is not the same as the location of use). We separate the latter into two categories, depending on the habitation stage (habitation or post habitation): *Purposive Disposal* – the material is deliberately discarded in a destined garbage pit, and *Secondary Disposal* – the material is transferred elsewhere as part of the sediment-moving processes. Another category defined by Schiffer is relevant to the abandonment phase, *de facto* refuse, but in the case of zooarchaeological finds, it is hard to distinguish *a-priori* from primary refuse, except for clear cases of abandonment.

At Tel Dor we use a slightly different terminology based on the archaeological context. We differentiate between various types of deposits mainly (though not exclusively) based upon the state of articulation of ceramic finds, which are ubiquitous in nearly every context: material discarded at the location of last use is called *in situ*. Pots discarded *in situ* usually retain approximate articulation. In certain *garbage pits*, which are regarded as 'purposive disposal', pottery is usually conjoinable. *Construction fills* and *robber trenches* are considered to be secondarily-deposited. Most of the volume of a typical Near Eastern *tell* consists of *secondary deposition*. Here we use the terminology formulated by Schiffer (1972), and adapt the terminology of Tel Dor to it.

In the past decade or so, most of the research conducted on refuse disposal as reflected in faunal remains focused on the Neolithic in Europe (e.g. Marciniak, 2005a, 2005b, 2006 and references therein), Iron Age Britain (e.g. O'Connor, 2003; Piper and O'Connor, 2001; Wilson, 1992) and the Balkans (e.g. Chapman, 2000). Earlier studies were carried on the Bronze Age in the Near East (Zeder, 1991), and on the Neolithic in Iran (Meadow, 1978). Although much data has accumulated from those studies, most studies concerned with the Levantine *tells* of the later periods to date lump together faunal remains from different types of loci, to represent the stratum/phase. So much information concerning site formation processes and spatial patterns of human behavior may be lost.

Understanding the depositional history of bones is also a prerequisite for assessing their value for analyzing spatial patterns in archaeological sites. We need to ask whether bones can represent activity that took place at the same place they were found, so that we can ask which activities they represent. In order to test this, it is important to ask whether the leftovers of food preparation or meals were discarded at their primary location of use, or whether floors were cleared daily by the site's inhabitants. So far there have been no attempts to evaluate these issues for historical periods in the Levant. The two extremes, of either analyzing all faunal remains together and viewing the site as spatially and behaviorally undifferentiated, or viewing the remains

as reflecting the activity that took place exactly where they were found, need to be reconsidered.

We studied the contextual deposition of faunal remains in a complex *tell* site, and the possibility of using faunal remains as a tool to distinguish between context types. We studied the faunal remains from the major city-port site of Tel Dor, asking whether there is a difference in the faunal characteristics of different depositional categories.

We asked whether in a large stratified urban site, where the presence of bones in the archaeological record is influenced by human activity, whether bones found in some contexts represent primary activities (systemic contexts), or are they all remains of secondary refuse? Is it possible to identify the depositional nature of contexts by using faunal characteristics? And finally, how can we use this knowledge to elucidate site formation processes?

These questions were addressed using three analytical approaches:

1. Study of differences in the faunal characteristics of loci assigned (on preliminary ceramic considerations) to one of three context categories: primary refuse, secondary disposal and purposive disposal.
2. Allowing for the fact that there might be some bias in the preliminary categorization of contexts, investigating if there is a difference in the faunal characteristics of different loci, *ignoring* their initial categorizations to contexts.
3. Focusing on a specific building and its environs, asking whether spatial analysis can contribute to distinguishing between context categories and reconstructing site formation processes.

We sought a better understanding of how site formation processes at Tel Dor, as a case study for Levantine *tells*, are reflected in the faunal remains of the site.

2. Methods

We studied *ca.* 10,000 bones, collected in the 2005–2009 excavation seasons at Tel Dor (Biblical Dor, Greek and Roman Dora), one of the main harbor sites on Israel's Carmel Coast. They originate in three adjacent detailed stratigraphic sequences in areas D2, D4 and D5 in the southwest part of the *tell*. These sequences represent six general periods: Iron Age I, transitional Iron I/II, Iron Age II, the Persian, Hellenistic and Roman periods (11th century BCE to the 3rd century CE) (preliminary reports: <http://dor.huji.ac.il>; recent overview: Gilboa and Sharon, (2008); full bibliography: <http://dor.huji.ac.il/bibliography.html>).

2.1. Laboratory analysis

Identified elements were coded according to their stratigraphic location and contextual deposition as defined by the excavators in the field. Assigning the remains to periods was based on pottery readings from the same locus and the stratigraphy. Loci with mixed-periods pottery were not analyzed. Skeletal elements (following Stiner, 2002, 2004) were identified to the closest possible taxonomic unit and recorded according to Dobney and Rielly's (1988) diagnostic zones. Percentages of the elements' diagnostic zones were used to calculate the minimum number of skeletal elements (MNE) and the minimum number of individuals (MNI), as outlined by Dobney and Rielly (1988) and following the guidelines of Klein and Cruz-Urbe (1984), Lyman (2008), and Grayson (1984).

Identified elements were examined for macroscopic surface modifications using a low-resolution magnifying lamp (2.5×). Modifications such as burning signs (evident as a visible change in

bone color), bone weathering (Behrensmeyer, 1978), butchery marks (Binford, 1981), and evidence of rodent gnawing, carnivore punctures and digestion, were recorded (Lyman, 1994). Fragmentation was calculated according to Morlan's (1994) percentage completeness (CN) using MNE values, a method suitable for quantifying element survivorship in an assemblage recorded by diagnostic zones (Morlan, 1994); skeletal element representation was correlated to density-mediated attrition (Lam et al., 1999; Symmons, 2005) and to the economic value of body parts (Metcalf and Jones, 1988).

The mineral content of the bones was examined using Fourier Transform Infra-Red (FTIR) analysis for a sample of 35 bones from area D5, representing all periods. Infra-Red Splitting Factor (IRSF) values (as determined by Weiner and Bar-Yosef, 1990: 190) were used to assess the state of diagenesis of the examined bones. The calculated IRSF is an arbitrary value, which resembles the "crystallinity index" of the bone powder.

The comparison between contexts of the three categories introduced above was carried out using three methods. Underlying them is the basic assumption that if most loci in the site do, in fact, represent some sort of secondary disposal, mainly due to substantial construction activities and other sediment moving operations, then their faunal characteristics should represent some 'average' and should not significantly differ between contexts. We carried out the following analyses:

1. We assigned loci to one of three categories (primary, secondary or purposive) and studied differences in sheep/goat skeletal frequency (NISP; divided into 7 body parts – cranial, trunk, upper forelimb, lower forelimb, upper hindlimb, lower hindlimb, feet) and in frequency of burning signs (NISP), using chi-square analysis. Those characteristics were chosen as they usually present a large enough database, for statistical analysis.
2. We sought patterns while ignoring previous categorization of the contexts, examining all loci (apart from "unique contexts" such as burials or cultic installations). We examined sheep/goat skeletal frequency (divided into 7 body parts), and species frequency (NISP; excluding rare species). The frequency of burning signs was not considered here, since it is too low to be analyzed at the locus level. We used Principal Component Analysis (PCA) as a visual approach for defining correlations. The generated plots portray which variables correlate with one another, and allow us to take an inductive approach.
3. We used spatial analysis to examine differences between contexts. Sometime in the Iron Age I (probably c. 1050 BCE), Tel Dor suffered a violent destruction. Thick burnt destruction-layers are evident in both area D2 and D5 (and other areas on the tell) furnishing us with the best examples of *in situ* ceramic assemblages. An Iron I house, which was destroyed in the fire, was exposed in area D5 (Phase D5/11) while the project reported here was carried out. The walls of the house were almost entirely robbed. The phase maps and data tables were uploaded to ESRI-ArcView GIS 9.3, and polygons were created for different floors and "robber trenches". The floors (with *in situ* assemblages on them) were *a-priori* regarded as primary refuse, and the "robber trenches" (back-fill of sediment after the walls were robbed) as secondary disposal (Fig. 5). We studied the density of bones per excavated volume (NISP/cubic meter). Excavated volume was calculated as the difference between the maximal and minimal elevations of each locus multiplied by locus area (as determined by GIS). We also examined frequency of burnt bones (identified and unidentified to element) and the density of microfaunal, bird, and fish bones per screened volume (1 mm mesh) of the different floors and "robber trenches".

3. Results

Of the 7500 mammal bones, Tel Dor fauna is dominated in all periods by domesticated livestock: Caprines (sheep/goat – *Ovis aries/Capra hircus*) and cattle (*Bos taurus*). In several periods pig (*Sus scrofa*) is also an important part of the economy. These are supplemented by various pack animals, wild animals, and birds. In addition, 2500 microfaunal bones and ca. 65,000 fish bones were recorded (Table S1 Appendix supplementary data for main animals). Since this paper focuses on methodology, we do not provide here the specific faunal data, nor discuss its economical and cultural implications (to be published elsewhere).

3.1. State of bone preservation

Studying the state of bone preservation helps us examine the presence of a possible bias in the collected assemblage. State of bone preservation in all the examined periods and areas at Dor is very good (Table 1): weathering stages (following Behrensmeyer, 1978) were low and very few gnaw marks or rodents marks were found, indicating that the bones were quickly covered after discard. A low frequency of burning signs was found in all periods except for the Iron Age I, when the burning signs may be attributed to a massive destruction at the site (see section 3.4). Fragmentation, expressed as the percentage completeness (Morlan, 1994) of sheep/goat bones is constant through the periods (Fig. 1). Significant relationships between bone structural density and sheep/goat or cattle bone survivorship (%MNE) (based on the DPD values of modern sheep for Caprines (Symmons, 2005), and on BMD₁₊₂ values of *Connachaetes taurinus* for cattle (Lam et al., 1999)) was found for Caprines in assemblages of the Iron I/II and Roman periods (Table 2), suggesting some level of influence of the bone density on the survivorship of bones. In addition, we found no meaningful relationship between sheep/goat or cattle bone survivorship (%MAU) and food utility index (FUI; calculated as the weight of usable tissue of *Rangifer tarandus*; Metcalf and Jones (1988)) (Table 3), suggesting there is no bias by preferring bones with higher nutritional value (for similar conclusions for the Iron Age Dor see Raban-Gerstel et al., (2008)). Possible changes to the mineral content of the bones are indicated by the IRSF values obtained by FTIR analysis (following Weiner and Bar-Yosef, 1990). The obtained values are in levels between 2.5 and 4, which represents a low level of diagenesis (Berna et al., 2004; Smith et al., 2007) (Table 4). This demonstrates that the mineral content of the bones was not highly altered after burial and did not affect bone preservation and fragmentation. Butchery marks, following Binford's (1981) typology were found on a few species (Table 5), most of them considered food.

3.2. Distinguishing between contexts based on categories defined in the field

A significant difference was found in sheep/goat body parts frequency between secondary disposal and purposive disposal

Table 1
State of bone preservation: Frequency of taphonomic agents in Tel Dor assemblages.

Period	Animal activity	Weathering > 3	Burning	Total NISP
Iron Age I	0.80% (7)	0.11% (1)	5.71% (50)	876
Iron Age I/II	1.63% (12)	0	1.09% (8)	734
Iron Age II	2.07% (18)	0.23% (2)	2.07% (11)	871
Persian	1.25% (19)	0.13% (2)	1.25% (13)	1523
Hellenistic	1.78% (49)	0.11% (3)	1.27% (35)	2752
Roman	3.52% (44)	1.52% (19)	0.88% (11)	1250

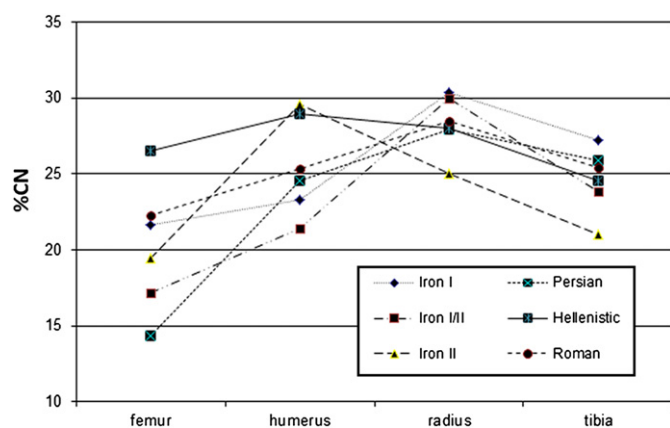


Fig. 1. Percentage completeness (CN; Morlan, 1994) of sheep/goat long bones throughout the periods in Tel Dor.

contexts for the data from the Iron Age II (NISP: secondary = 290, purposive = 52; $\chi^2 = 14.32$, $df = 4$, $p = 0.02$). The strength and direction of the residuals provided by the chi-square test reveal that the difference is evident for over-representation of trunk parts and upper hindlimbs (the meat-rich parts), and under-representation of lower forelimbs, lower hindlimbs, cranial and feet (the meat-poor parts) in the purposive disposal contexts, in comparison with secondary disposal (Fig. 2). This suggests the use of purposive disposal as garbage pits containing the leftovers of meals. For the Persian period, there is over-representation of trunk parts, upper forelimb and upper hindlimb, and under-representation of cranial parts, lower forelimbs, lower hindlimbs and feet in purposive disposal in comparison with secondary disposal (NISP: secondary = 274, purposive = 94; $\chi^2 = 24.83$, $p < 0.001$; Fig. 2), suggesting a similar use as in the Iron Age II purposive context. For other periods and other context groups, no significant difference was noted, when the assemblage was large enough to allow analysis (Table 6).

In contexts from the Hellenistic period (NSIP = 2604), a significant difference was found in the frequency of burning signs

Table 2
Correlation between bone survivorship (%MNE) and bone density values (following Lam et al., (1999) for cattle; Symmons (2005) for sheep/goat).

Period	Sheep/goat		Cattle	
	Spearman's <i>r</i>	<i>p</i>	Spearman's <i>r</i>	<i>p</i>
Iron Age I	0.44	0.08	0.03	0.86
Iron Age I/II	0.51	0.04	0.28	0.17
Iron Age II	0.45	0.08	0.03	0.85
Persian	0.48	0.06	0.09	0.65
Hellenistic	0.39	0.13	0.14	0.50
Roman	0.56	0.02	0.15	0.46

Bold values indicate significant correlations.

Table 3
Correlation between bone survivorship (%MAU) and Food Utility Index (following Metcalfe and Jones, 1988).

Period	Sheep/goat		Cattle	
	Spearman's <i>r</i>	<i>p</i>	Spearman's <i>r</i>	<i>p</i>
Iron Age I	0.01	0.95	0.07	0.72
Iron Age I/II	0.21	0.33	−0.09	0.69
Iron Age II	0.16	0.41	−0.10	0.63
Persian	−0.04	0.83	−0.06	0.77
Hellenistic	0.22	0.30	0.04	0.83
Roman	0.01	0.94	−0.12	0.53

between different categories of contexts ($\chi^2 = 14.66$, $p < 0.001$). Examining the strength and direction of the residuals provided by the chi-square test, reveals that a high frequency of burnt bones was found in purposive disposal as opposed to other contexts (Fig. 3). In other periods, frequency of burnt bones was too scarce to examine statistically.

3.3. Patterns in the data, ignoring their initial categorizations to contexts

Twelve PCA plots were produced, two for each examined period: one based upon sheep/goat body parts and one on species frequencies (NISP). The scree plot showing the relative explanatory value of the components suggests that in all cases the 1st and 2nd are responsible for most of the variance in the PCA plot, while none of the succeeding ones individually contribute much explanatory power (Fig. S1 Appendix supplementary data). Further analysis was therefore done only on the first two components. Examining the principal component loadings (Fig. S2 Appendix supplementary data) suggests that in all of the species analyses the most significant component differentiates between livestock animals and the rest of the species – with cattle, sheep/goat and – in the Hellenistic period – pigs getting high unidirectional loadings and all of the rest of the

Table 4
IRSF values calculated for samples of bones from Tel Dor.

Locus	Period	Context	SF
08D5-731	Persian	Bone installation	3.40
08D5-713	Persian	Sealed pit	3.03
08D5-736	Persian	Robber trench unsealed	2.89
08D5-753	Persian	Sealed fill	3.30
08D5-741	Persian	Unsealed fill	3.07
08D5-704	Hellenistic	Sealed pit	4.46
08D5-709	Hellenistic	Pit unsealed	3.30
08d5-776	Persian	Sealed floor makeup	3.18
08d5-749	Persian	Unsealed fill	3.07
08D5-708	Persian	Sealed fill below floor	2.94
08d5-766	Persian	Unsealed fill	2.93
08d5-767	Persian	Fill to floor, unsealed (primary)	3.23
08d5-714	Hellenistic	Unsealed pit	3.03
08d5-735	Persian	Fill to floor, unsealed (secondary)	3.03
08d5-766	Persian	Unsealed fill	3.34
08d5-710	Hellenistic	Unsealed pit	3.05
08d5-504	Hellenistic	Fill below floor, sealed	3.11
08d5-709	Persian	Pit	3.10
08d5-761	Hellenistic	Fill below floor, unsealed	3.01
08d5-750	Hellenistic	Sealed pit	3.07
08d5-633	Iron Age I	Unsealed fill	3.12
08d5-603	Iron Age I	Unsealed fill	3.22
08d5-600	Iron Age I	Unsealed fill	3.20
08d5-715	Hellenistic	Pit	3.14
08d5-632	Iron Age I	Unsealed fill	3.30
08d5-619	Iron Age I	Unsealed fill	3.29
08d5-623	Iron Age I	Unsealed fill	2.94
08d5-625	Iron Age I	Robber trench unsealed	3.25
08d5-607	Iron Age I	Robber trench unsealed	2.94
08d5-710	Hellenistic	Unsealed pit	3.40
08d5-714	Hellenistic	Unsealed pit	3.08
08d5-632	Iron Age I	Unsealed fill	3.09
05d2-027	Hellenistic	Sealed fill	3.20
06d5-235	Hellenistic	Floor makeup, sealed	4.11
08d4-307	Hellenistic	Sealed fill	3.24
08d4-329	Hellenistic	Unsealed fill	3.25
08d2-256	Iron Age I	Unsealed fill	2.91
08d2-237	Iron Age I	Accumulation of surfaces	2.92
08d2-231	Iron Age I/II	Sealed fill	2.92
05d2-021	Iron Age II	Sealed fill	3.02
07d2-046	Iron Age II	Ash-filled pit	3.11
08d2-260	Iron Age II	Unsealed fill	2.93
08d5-741	Persian	Unsealed fill	3.07
08d5-709	Persian	Pit	3.13

Table 5
Frequency of butchery marks at different periods at Tel Dor.

Period	Species/size class	N
Iron Age I	<i>Bos taurus</i>	9
	<i>Capra hircus</i>	6
	Large ungulate	2
	Ovis/Capra	9
	Ovis aries	8
Iron Age I/II	<i>Bos taurus</i>	10
	<i>Capra hircus</i>	3
	<i>Cervus elaphus</i>	1
	<i>Dama mesopotamica</i>	2
	Medium mammal	1
	Ovis/Capra	8
	Ovis aries	5
	Medium size bird	1
Iron Age II	<i>Bos taurus</i>	22
	<i>Capra hircus</i>	3
	<i>Cervus/Dama</i>	1
	<i>Dama mesopotamica</i>	1
	Large ungulate	1
	Ovis/Capra	12
	Ovis aries	2
	<i>Bos taurus</i>	8
	<i>Canis sp.</i>	1
	<i>Capra hircus</i>	1
Persian	Large ungulate	1
	Ovis/Capra	9
	Ovis aries	2
	<i>Bos taurus</i>	22
	<i>Capra hircus</i>	3
Hellenistic	<i>Equus sp.</i>	3
	Large ungulate	2
	Ovis/Capra	17
	Ovis aries	3
	<i>Sus scrofa</i>	3
	<i>Bos taurus</i>	9
	<i>Capra hircus</i>	1
	<i>Cervus/Dama</i>	1
Roman	<i>Cervus elaphus</i>	1
	<i>Equus sp.</i>	2
	Large ungulate	1
	Ovis/Capra	6
	Ovis aries	2
	<i>Sus scrofa</i>	1

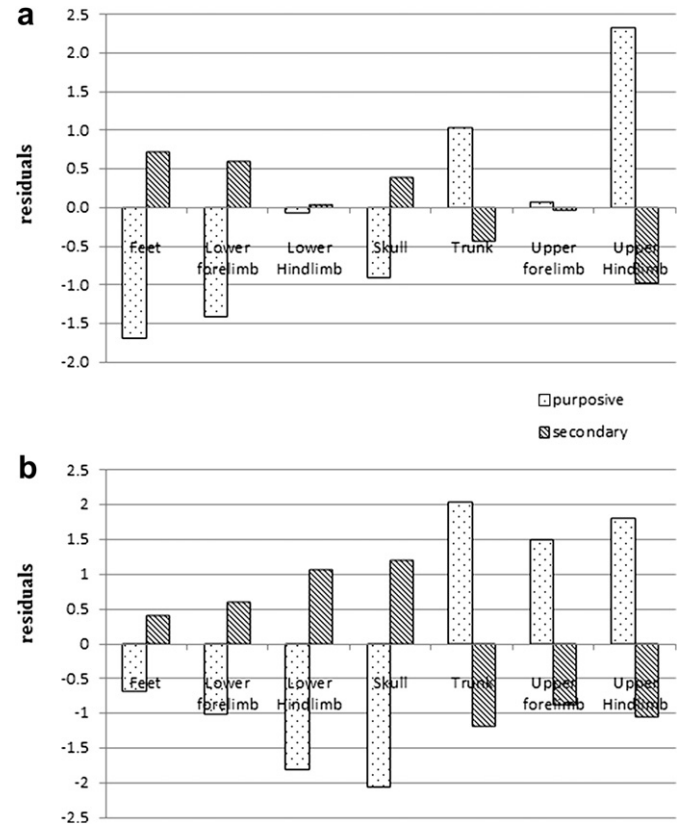


Fig. 2. Body part frequency of sheep/goat at different context types. Residuals of a chi-square analysis, showing the direction and strength. a. Iron Age II. b. Persian period.

in a random manner (as far as the bones are concerned), it acts as an “averaging” factor, rendering them similar to one another and differentiating them from the primary refuse and purposive disposal.

3.4. Spatial analysis as a tool to study differences between contexts: a case study – an Iron Age I burnt house

To examine whether bones in an *in situ* assemblage (as defined by the pottery) also represent a primary refuse (i.e. were present at the time of burning of the house) or secondary disposal (were brought in sometime after the destruction and before the context was sealed), we started by studying the frequency of burnt bones in different features (all fragments, hand-picked and wet sieved, whether identified to element or not, $N = 759$). The incidence of burnt bones in the burnt layer as a whole was indeed higher than the average for the site (Table 1). Moreover, Fig. 6 reveals that relative frequency of burnt bones on the floors is always higher than in the “robber trenches” between them, suggesting the bones were on the floor at the time of destruction. It also suggests that the back-fill of the “robber trenches” was mixed – some of it was the destruction-debris itself, but some originated elsewhere. Thus some of the bones in the secondary disposal are still in-context (temporally – if not spatially) but some are introduced from other contexts.

Next, we studied the density of bones per excavated volume (identified and unidentified to element, only hand-picked, $N = 203$). The purpose of this comparison was to examine if primary refuse contain bones at the same density as secondary disposal. Density of bones on floors (the primary refuse) is not lower than in “robber trenches” (the secondary disposal) (Fig. 7),

species contributing little to this component. The second component always differentiates *between* the main livestock animals – with cattle and sheep/goat getting the highest loadings again – but this time in the *opposite* direction (in the Hellenistic periods it contrasts cattle with sheep, goat and pig). No consistent pattern was found for the body parts analyses. Different parts are dominant in different periods.

In the next stage, scattergrams of the two principle components were plotted. Every point on the plane in the PCA plot represents a single locus with a known identity. In all cases, the PCA plot presents a central ‘cloud’ which contains loci similar to one another (Fig. 4 is an example for a plotted PCA; For all plots see Fig. S3 Appendix supplementary data). The “outliers” from the central cloud differ in some way from those in the central cloud. Examining the identity and preliminary classification to categories of the outliers reveals that in the Iron I, Iron I/II, Iron II and Persian periods, most outlying loci (two thirds) were those preliminarily classified as primary refuse or purposive disposal (Table 7). In the Hellenistic period, only one of the outliers was of purposive disposal. Very few contexts were defined as primary to begin with in the Roman period. It seems that in the earlier periods, the difference between the central cloud and the outliers reflects deposition. The similarity of the loci in the central cloud, suggests viewing them as secondary disposal contexts. As the secondary disposal is a result of moving the sediment from one area to another

Table 6

Comparing frequency of body parts between different deposition types. Result of chi-square analysis.

Comparing	Iron Age I	Iron Age I/II	Iron Age II	Persian	Hellenistic
Primary vs. Secondary	$\chi^2 = 5.74, p = 0.45$	$\chi^2 = 4.35, p = 0.62$	$\chi^2 = 2.51, p = 0.86$	$\chi^2 = 24.83, p < 0.001$	
Purposive vs. Secondary			$\chi^2 = 14.32, p = 0.02$		$\chi^2 = 9.71, p = 0.13$

Bold values indicate significant correlations.

implying that primary refuse does contain bones and that bones were not cleared daily. It is also evident from the figure that the density of bones in the north part of the house (floors #2, #3 and robber trench #1) is higher than in the south part. The lowest density of bones was found in robber trenches #3 and #5.

Studying densities of microfaunal, bird, and fish bones (NISP/sieved volume; total NISP = 3760) (Table 8) reveals no difference in their relative frequencies of rodents, amphibians, reptiles, and small birds between floors and “robber trenches”, but does show that the relative frequencies of fish remains are 3.5 times higher in the “robber trenches”, suggesting the fill was brought from another location at the site containing high frequency of fish bones.

4. Discussion

We asked whether faunal assemblages in complex *tells* typified by extensive sediment-moving operations, can be understood as representing systemic contexts, and how such assemblages might be identified.

When grouped by context definitions, different types of contexts can be differentiated, to a degree, from one another using faunal remains. In this particular study, skeletal frequency and burning signs on bones were the most useful proxies. This study also implies that not all bones from the site should be considered as part of the secondary disposal context. If that were the case we would expect all contexts to present some sort of “average”.

Ignoring the initial categorization to context by the archaeologists in the field, we also used a more inductive method, PCA analysis without pre-assigning loci to context type. Results imply that most loci defined in the field as primary or purposive are indeed different from the loci defined as secondary, by species frequency, sheep/goat body parts, or by both parameters. Most significant components contributing to the difference in species frequency are the relative frequency of livestock animals. As for the body parts, no consistent pattern was found. Different parts are dominant in different periods. However, in all periods some loci

defined as primary or purposive did not display characteristics different than the average. This can be due to several reasons: some primary deposition loci may not represent a distinct activity, or a variety of activities were carried in them and thus their faunal characteristics are similar to the average in that period. Based on the differences demonstrated here, studying the faunal characteristics of a specific context can help elucidate its depositional history, as was shown for the purposive disposal. We also see the significance of studying both primary and secondary deposits – as they may provide different pictures of the economy. For example, studying only primary and purposive contexts from the Iron II, we would assume that the site inhabitants only consumed the meat-rich parts, and would conclude that they were of high status, or that livestock was raised and butchered elsewhere. However, when examining the secondary disposal as well, we understand that meat-poor parts are present as well at the site, and that actually the consumed animals were most likely raised and slaughtered on site. Lumping the data together, although meaningful for studying the broad economy and environment of the site, obscures site-specific formation processes and prevents us from using this information to study spatial aspects of archaeological sites.

The spatial analysis of the Iron I house shed light on site formation processes and the different activities that took place in the house. Frequencies of burnt bones on the floors implied that at least some of the bones were there at the time of destruction and hence were part of the primary context. Following destruction, the walls of the house were robbed, and sediment was brought in to fill the trenches prior to new construction. Burning signs suggests that the fill for the “robber trenches” originated in the surrounding remaining floors of the house, as well as from someplace else on the

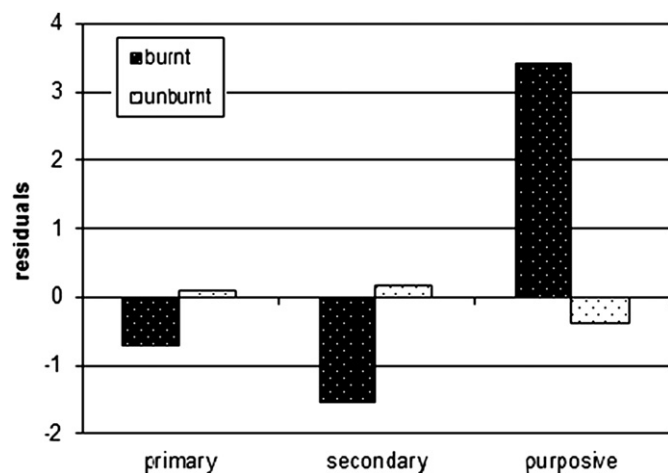


Fig. 3. Frequency of burned marks at different context types in the Hellenistic period. Residuals of a chi-square analysis, showing the direction and strength.

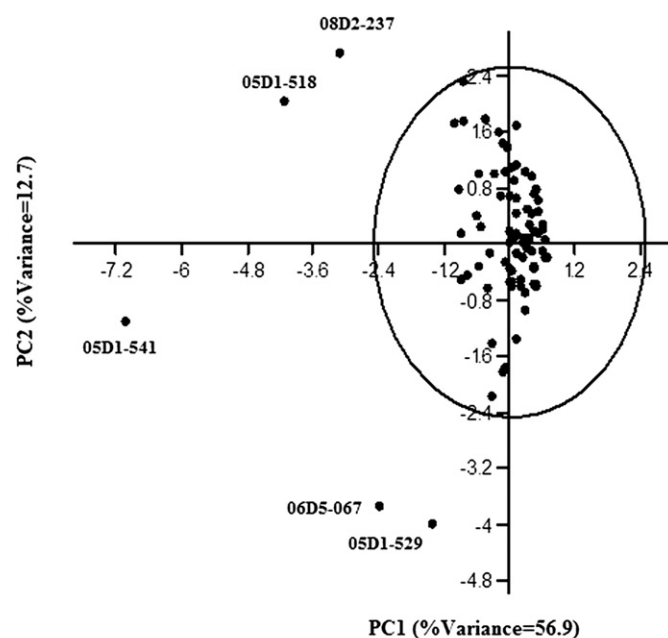


Fig. 4. PCA plot generated for the Iron Age I data, using body parts frequency.

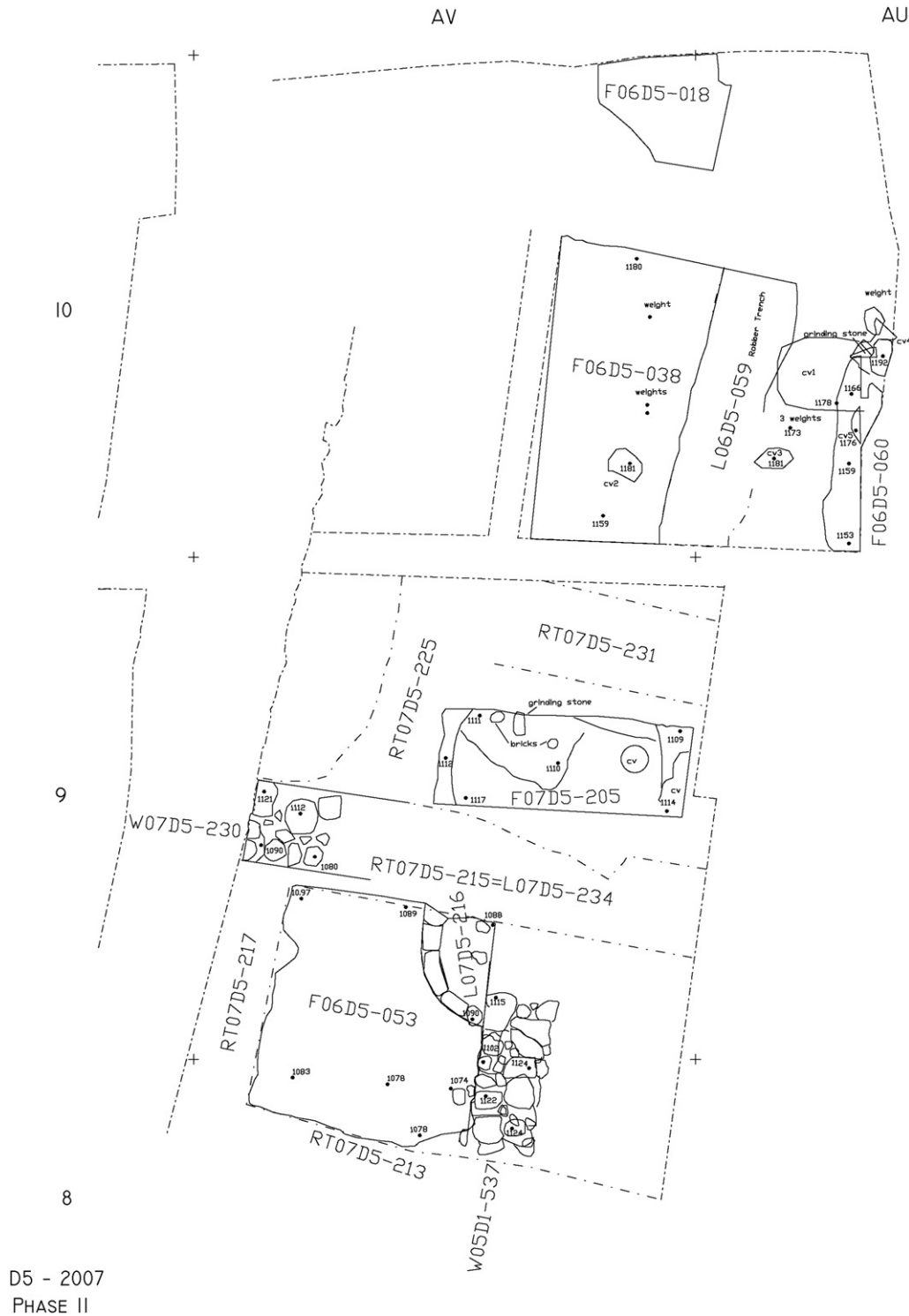


Fig. 5. D5 Phase II map.

tell. The faunal evidence here correlates with pottery evidence: some potsherds from the “robber trenches” mended with pots found in articulation on the floors. By-and-large, however, many pottery vessels on the floors mended into complete or nearly-complete pots while the pottery from the “robber trenches” did not. These results support the hypothesis that the fill was brought from the floor and from another area in the site as well.

In addition, we noticed that the density of bones in the northern part of the house is greater than the density in the southern part. In

the northern part of the house, various kinds of vessels were found (e.g. jars, krater, chalices, jugs, large monochrome flask, and bowls), indicating a variety of activities took place in this room. The pottery in the southern part indicates that this was the storage area: a “wavy band” pithos and two collared rim jars with handfuls of lentils in the bottom of one of them. A decorated hemispheric bowl and two grinding stones were also found on this floor. The large storage vessels, when complete, left almost no space in the southern rooms. It seems that the southern rooms were only used

Table 7

Identity of outliers' points produced by the PCA plot. PC1 and PC2 scores are appended only for the characteristics by which the locus differs from the 'average' loci.

Locus	Context	Discard	Species frequency		Body parts	
			PC1	PC2	PC1	PC2
a. Iron Age I						
09D2-343	Fill	Secondary	1.09	−2.88		
05D1-508	Pit	Purposive	0.08	−3.14		
07D5-221	Sealed fill	Secondary	1.70	2.60		
05D1-529	Olive pit floor	Primary			−1.39	−4.03
05D1-518	Fill to floor	Primary	4.40	−3.23	−4.10	2.00
05D1-541	Fill to floor	Primary	6.68	2.13	−7.04	−1.14
06D5-067	Fill down to floor	Primary	2.47	−3.04	−2.38	−3.79
08D2-237	Build-up of layers	Primary	3.65	−2.63	−3.10	2.69
b. Iron Age I/II						
06D5-036	Fill to floor	Primary	2.35	−1.38		
08D2-231	Sealed fill	Secondary	2.52	5.37		
07D2-021	Unsealed fill	Secondary	1.15	2.51		
07D2-004	Build-up of surfaces	Primary			1.97	2.20
07D2-068	Build-up of surfaces	Primary			0.26	−3.11
07D2-010	Fill	Secondary			1.40	−2.61
09D2-360	Phytolith makeup	Primary	3.71	0.45	3.09	−1.27
06D5-003	Floor makeup	Secondary	4.13	−4.02	4.81	1.25
c. Iron Age II						
09D2-323	Foundation trench	Secondary	1.97	6.30		
08D2-255	Fill to floor	Primary	2.57	−0.75		
05D2-013	Fill down to floor	Primary			2.66	0.86
06D2-056	Pit	Purposive			0.96	2.71
06D5-008	Floor surface of “olive pit” floor	Primary	1.94	−1.76	2.33	3.73
09D2-366	Floor makeup, sealed	Primary	2.53	−0.90	2.23	1.26
06D2-056	Pit	Purposive			0.96	2.71
05D2-015	Layer in basin	Primary	3.83	1.85	3.24	−0.55
09D2-397	Fill	Secondary	3.34	1.80	2.76	0.47
09D2-324	Robber trench	Secondary	6.10	−2.96	5.84	−4.78
d. Persian period						
06D5-400	Floor and floor makeup	Primary	1.47	4.68		
05D1-524	Pit	Purposive			0.97	2.80
08D5-509	Sealed fill	Secondary			1.04	−3.68
07D5-112	Fill & dog burials	Primary	3.98	0.52	3.57	−0.93
08D5-515	Fill below floor to floor	Primary	2.66	−2.25	2.21	−4.76
05D1-539	Pit	Purposive	4.80	2.01	4.50	2.74
05D2-044	Fill	Secondary	4.02	−3.31	3.76	1.57
07D5-125	Fill below floor	Secondary	2.90	2.28		
09D5-415	Fill	Secondary	0.90	−3.03		
e. Hellenistic period						
06D5-409	Pit	Purposive	−0.59	−3.57		
09D4-507	Fill	Secondary	−1.10	−3.87		
07D4-107	Floor makeup	Secondary			−1.38	−3.02
08D4-307	Sealed fill	Secondary	−0.82	2.57	−1.17	−2.70
08D4-305	Fill	Secondary	−3.07	−1.78	−2.87	−3.26
09D4-560	Fill	Secondary	−2.45	−1.08	−2.32	−1.49
08D4-335	Fill	Secondary			−1.89	1.78
08D4-308	Fill	Secondary	−4.54	6.19	−4.00	−2.86
09D4-506	Fill	Secondary	−2.47	3.15	−2.87	0.99
08D4-352	Fill/pottery dump	Secondary	−3.15	0.77	−2.75	−1.11
09D4-505	Fill	Secondary	−3.38	0.76	−3.42	2.13
08D4-361	Fill	Secondary	−5.66	0.03	−4.82	5.62
08D4-304	Fill	Secondary	−4.41	−2.18	−3.90	−1.67
08D4-354	Sealed fill	Secondary	−4.17	−2.65	−3.90	−0.43
08d4-335	Fill	Secondary	−2.05	−0.91		

for storage. The fact that the northern part of the house, where the domestic activities took place, contained a higher density of bones than the storage area suggests that bones were not cleared daily and that they were part of the "living phase". As all these activities were conducted indoors, the difference cannot be attributed to taphonomic agents such as ravaging dogs or weathering (as suggested by Meadow, 1978; Schiffer, 1983). Similar results were described by Sasson (2008), who studied the Iron Age of Tel Be'er Sheba. He mentions that 65% of the specimens were found indoors as opposed to open areas, and states that they were most probably part of the living phase (Sasson, 2008: 77). He also notes that the cellars house contained a low frequency of bones (Sasson, 2008: 79).

From a modern perspective, it is difficult to accept the hypothesis that people lived with the leftovers of meals. Murray's ethnographic research (Murray, 1984) showed that both sedentary and migratory populations discard materials outside their use location. He assumed that discarding them within primary habitation activity areas would create discomforts, safety or health hazards. Hayden and Cannon (1983) showed that in the villages of the Maya, there was little if any refuse which was left at the primary locations of use. Refuse was removed from living areas to secondary discard areas. However, Hayden and Cannon (1983) consider organic refuse, such as bones, to have little value or hindrance potential. They found that debris from food preparation and other activities such as woodworking was generally left where they had fallen on



Fig. 6. Frequency of burned bones in different features in the Iron Age I burnt house.

the floor, or dumped in nearby areas. Eventually, bones were generally removed from their initial place of discard by dogs. Bartosiewicz (2003) who studied the remains of a *murex* purple-dye workshop at Tel Dor, mentions that the procedure, producing repulsive smells, was executed within a residential district, upwind from the rest of the site, in the immediate proximity of high-status residences in the city. Studying several case studies, Bartosiewicz (2003) states that people can get accustomed to even a heavy stench in a relatively short time, and thus 'static' smells (as in the case of animal remains in or near the house) are often ignored. It seems that we cannot assume what is considered to be "acceptable" for people living 3000 years ago.

As for the analysis of past activities, it should be noted that if we would have "lumped" all floors of the burnt house together and then compared them to the "robber trenches" as a group, as was done in the first stage of the analysis of this research, no differences

would have been found, as the actual location of the floor/robber trench was also important in reconstructing the activity areas and the site formation processes.

Our results reveal different finds in different contexts. Thus, they suggest that although lumping zooarchaeological data into a single 'assemblage', as done in most zooarchaeological studies today, provides us with much information regarding the broader picture of what was eaten and the immediate environment of the site, it also causes major loss of information. Considering the specific origin of the bones can be used as another indication for context identity and understanding specific activities in a specific site. Even in complex sites such as the 'urban mounds' of the Levant, bones can, and in many cases do, reflect primary activities, and hence can and should be used in spatial analyses to reconstruct ancient life. To be meaningful, such analyses need to be done with careful consideration of the contextual integrity and identity of the



Fig. 7. Density of bones per excavated volume in different features in the Iron Age I burnt house.

assemblages, as well as of taphonomic factors. As demonstrated in the spatial analysis, site formation processes should be sought in the analysis of secondary refuse as well as the primary. The density of bones in a certain location can reflect past activities that took place where they were found, and not only various preservation factors. A much closer synergy in analysis between the

archaeologists in the field, and the scientists performing the artifactual and zooarchaeological analyses is required in order to bring together the various types of information: stratigraphy, architecture, contextual integrity, ceramic evidence, as well as the characteristics of the animal remains, in order to shed new light on past activities and on formation processes of complex sites. Adopting the method presented here as a working model can further our understanding of past societies.

Table 8

Relative frequency (NISP/sieved volume) of fish, bird, and microfauna in different context types in the burned house.

	Sieved volume (liter)	Fish	Rodent	Reptile	Bird
Primary	600	1.60	0.10	0.02	0.03
Secondary	528	5.42	0.12	0.02	0.03

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Appendix. Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.jas.2011.09.027.

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