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The excavation and analysis of porcupine dens and burrowing on ancient and recent faunal and human remains at Tel Zahara (Israel)

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Abstract: *The destruction to, and disturbance of, archaeological deposits by burrowing animals (bioturbation), and particularly by rodents (rodenturbation), is well-attested. The attraction of burrowing rodents to archaeological sites exists for the same reason that humans also desire to excavate them: the presence of architectural features, material culture, and other evidence of human activity left behind in the soil. For the human excavator, this presents opportunities to analyze the human past; for the burrowing rodent, the looser soil provides easier material through which to dig, as well as increased access to biological and other remains. In particular, cemeteries possess an additional attraction for these rodents, as the presence of human skeletal remains provide increased opportunities for bone-gnawing for the animal population. The recent investigation of modern Indian porcupine (*Hystrix indica*) activity in a pre-1948 Muslim cemetery and in other archaeological contexts at Tel Zahara, located in the Central Jordan Valley in Israel, has furnished further data regarding effects of burrowing activity and bone-gnawing on both faunal and human remains. These results have implications for future study of the role of rodents in the post-depositional modification of both cemetery and other stratified remains at archaeological sites in Israel and elsewhere.*

Key words: bioturbation; rodenturbation; Indian porcupine; Near East; Tel Zahara

Introduction

Archaeological reports often underestimate the role of burrowing animals in site formation processes of archaeological sites. It is necessary, however, to realize that through their activities, burrowing animals can potentially displace cultural material (thereby

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influencing chronological assessment based on stratigraphic relationships) and alter stratigraphy of archaeological deposits (resulting for example in the 'reversed stratigraphy' effect). In so doing, burrowing animals may have a very significant impact on the analysis and understanding of a site (e.g., Erlander 1984; McBrearty 1990; Leigh 1998; Rink et al. 2013). A Levantine example is the site of Tel Fendi in Jordan. At this mound, Blackham (2000) documented the impact of burrowing activities of the Palestine mole-rat (*Spalax ehrenbergi*) on the archaeological remains, and concluded that mole-rat activity may account for the high fragmentation and poor preservation of bone at this, as well as other, Levantine sites.

The attraction of rodents to archaeological sites most probably stems from the presence of comparatively looser archaeological sediments on the site that are less densely packed than those of the surrounding area which makes them eminently suitable for burrowing. In addition, the increased presence of food debris offers an easily obtained resource for rodent species that practice 'osteophagia' or bone gnawing. Indeed, the earliest example of mammalian tooth marks on bones of Late Cretaceous dinosaurs have been attributed to Cenozoic multituberculates or rodents (Longrich & Ryan 2010). It is thought that the practice of 'osteophagia' helps to meet the rodents' calcium, phosphorus and sodium demands (Brain 1980; Hansson 1980; Haglund et al. 1988; Rabinovich 1987; Thornton & Fee 2001), although experimental work by Hansson (1980) has shown that, at least for microtine rodents, phosphorus was unattractive while calcium and sodium attracted rodents only in high density populations. Another explanation offered for bone gnawing is that it serves to sharpen and trim the rodents' incisors which continue to grow throughout life. This claim seems more feasible given the presence of gnawed inorganic items (such as ceramics and plastic) in porcupine dens (Alexander 1956; Brain 1981; Duthie & Skinner 1986, Rabinovich & Horwitz 1994; Kibii 2007). Rodents preferentially select defatted, dry and weathered bones for gnawing—a phenomenon that Lyman (1994) explained as related to the greater ease with which they can gnaw weathered bones as opposed to fresh ones. Although some researchers have claimed that rodents ignore meat-covered bones (Alexander 1956; Brain 1981; Maguire 1976), there is extensive evidence, particularly from forensic studies, to indicate that in many cases they will freely gnaw fresh, greasy bones (Haglund 1992; Rabinovich & Horwitz 1994; Klippel & Synstelien 2007), although they may technically prefer defatted, dry ones.

In searching for the material to sharpen or wear down their ever-growing incisors, rodents may accumulate bones and other items in order to facilitate easy access to them. Porcupine osteophagia, for example, may result in the accretion of large piles of bones (and other objects) in their dens as documented by Brain (1980, 1981) and Maguire (1976) for the Cape porcupine (*Hystrix africaeaustralis*). Observation of the Cape porcupines' habits related to bone collection has led even to the statement describing the 'compulsive' character of that phenomenon. Alexander (1956) relates his observations of a captive porcupine (named Aristotle), which used to collect many bones and other hard objects, including artificial ones during its nocturnal wanderings. As for the Indian porcupine (*Hystrix indica*), known from the Near East, Mendelssohn and Yom-Tov (1999) have stated that this species brings no organic remains—lining or food—into its burrow, and may in fact not accumulate bones. Experiments carried out on captive animals in Israel by Rabinovich and Horwitz (1994), however, demonstrated that they readily gnawed bones and wood, often totally destroying the items. Thus, Indian porcupine gnawing may influence bone preservation in archaeological sites and porcupine gnawed bones are commonly found in prehistoric and archaeological sites in Israel, suggesting that this species should be considered as an important taphonomic agent in site development, regardless of whether or not this particular species collects bones in its burrow.

The current study describes bones collected from the entrance area of recent porcupine burrows together with material unearthed during a small excavation of two Indian porcupine burrow entrances and chambers, to examine the impact of porcupine activity on animal and human bones at the archaeological site of Tel Zahara. We addressed two questions: firstly, to determine whether or not the porcupines had collected bones in their burrows for gnawing and secondly, whether these remains derived from the archeological deposits on the mound or represented recent bones.

Material and methods

Numerous porcupine burrows dot the surface of the archaeological site of Tel Zahara, a small mound ca. 0.25ha in size, located approximately five km west of the modern town of Beth Shean, at the confluence of the Jezreel and Jordan Valleys on the south bank of Wadi Harod. On the surface of the tel is a pre-1948 Muslim cemetery which overlies a Roman farmhouse and associated structures (dating to the 1^{st}–3^{rd} centuries CE), which probably served as a satellite to the larger Roman city at Beth Shean (Scythopolis) during this era. The Roman material represents the bulk of the finds while beneath it are deposits dating to the Hellenistic, Middle Bronze Age II, and Early Bronze Age periods (Cohen forthcoming).

During excavations and surveys on the tel, the abundance of modern burrow entrances that dotted the surface was noted. The burrows were located primarily on the top and upper slopes of the mound, especially on the western side. Based on the size of the entrances, and the presence of porcupine quills, faeces and footprints at the entrance to some of the burrows, as well as reports of sightings of porcupine on or near the tel, the burrows were identified as belonging to the Indian porcupine (*Hystrix indica*). While the archaeological excavations were located in areas distant from the burrow entrances, encountering the results of porcupine activity at the site was unavoidable. The burrows often resulted in contaminated loci, and the tunneling sometimes caused later ceramic material to be found in earlier levels, or cut through archaeological features.

A total of 10 burrow entrances were located during a surface survey of Tel Zahara (**Figure 1**). Given the dense vegetation cover on the tel, however, it is likely that some burrow openings were overlooked. Some of the burrow entrances appeared to be disused. The number of porcupines inhabiting the tel is thus difficult to assess, especially since Indian porcupine dens usually have more than one entrance (Mendelssohn & Yom-Tov 1999). Indeed, excavation of an Indian porcupine burrow near Kibbutz Gesher, located in the Jordan Valley some 18km south of Tel Zahara, identified at least two entrances to the den some 8m apart (Rabinovich & Horwitz 1994).

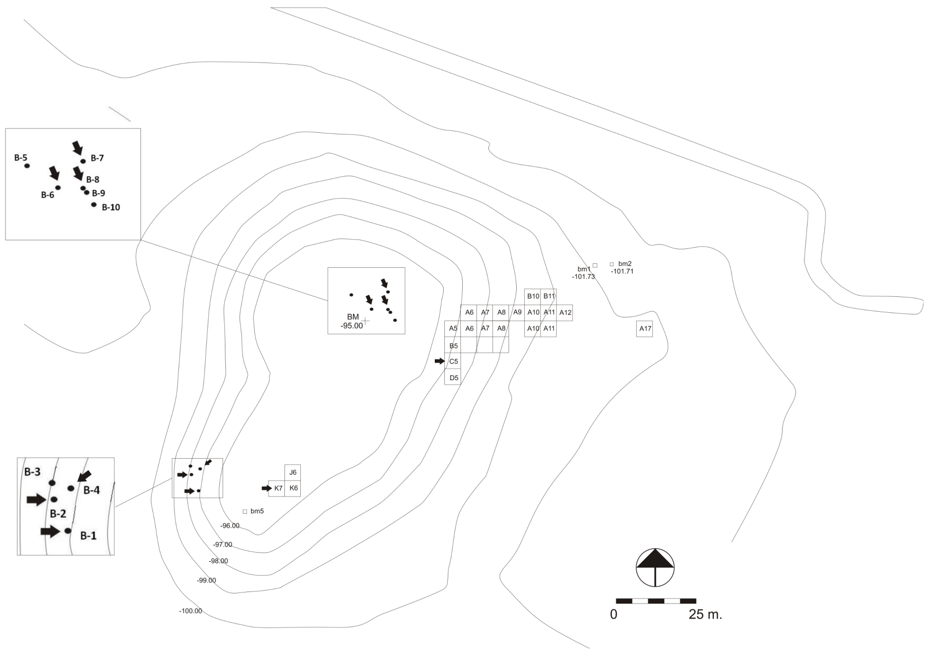

Figure 1. Map of Tel Zahara. Dots represent porcupine burrows, arrows show locales where human remains were present.

Each burrow entrance was assigned a unique number. The layer of the soil adjacent to the entrance, created when the burrow was dug and then occupied by the porcupine, was sifted (5mm mesh) and all the organic remains (plants, bones, quills and faeces), as well as items of material culture were collected for analysis. In the bone samples, both human and animal remains were identified. This material represents items collected/transported to the burrows by porcupines or other animals inhabiting them, or else derives from items encountered in the sediment while the porcupines were digging the burrows.

In addition to the surface collections, a small excavation was undertaken of two adjacent burrow entrances, B6 and B8, to map the extent and contour of this part of the burrow system and to investigate the burrow contents. A small trench (length = 6.50m, width = ca. 1.00m, maximum depth = ca. 1.30m), was excavated by hand in order to connect two den entrances, B6 and B8, and locate the burrow chamber (**Figure 2**). All the sediment from the excavation between B6 and B8 (see below), was screened using a 5mm mesh. Burrows B9 and B10 were left untouched, and are not included in the analysis below.

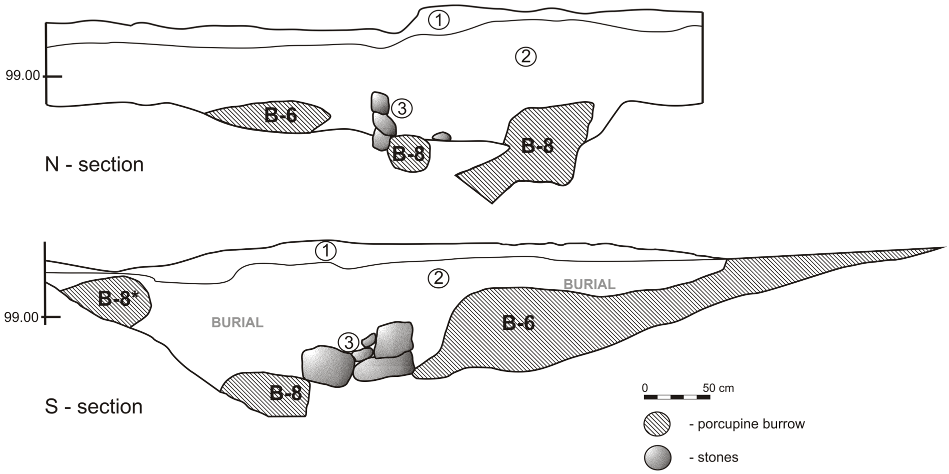

Figure 2. Sections of the trench dug between burrows B6 and B8 (1 – top soil; 2 – brown/grey soil; 3 – stone walls).

The bones collected from the entrance areas of six burrows, from inside B6, and from the excavated area between B6 and B8, were identified to species and skeletal element. Where it was not possible to identify the species, bones were placed in size classes: medium mammal=sheep/goat size, large mammal=cattle size. In addition, both identified bones and bone fragments were measured. The state of bone weathering was recorded using scores based on Behrensmeyer (1978). This was undertaken in order to ascertain whether the bones were recent or archaeological in origin. The surface of all animal and human bones recovered from the burrow entrances and inside the burrows were examined for evidence of damage, using a magnifying glass and microscope (10–30× magnification). The type and location of surface modifications were identified and recorded. These included cut marks, burning, rodent gnawing and carnivore damage (Brain 1981; Lyman 1994).

Rodent damage to bones (or other items) typically takes the form of quite broad but shallow, flat-bottomed grooves (Brain 1981; Haglund 1992; Rabinovich & Horwitz 1994; Klippel & Synstelien 2007). Usually rodent gnaw marks lie at a right angle to the long axis of the bone and form a series of parallel striae (**Figure 3**). Rodent damaged areas on bones are usually located where there is thick cortical bone, such as on the edges of bones or on jutting protuberances. These areas may also be chosen since they are more easily accessible to rodents which have a limited jaw gape. Researchers (Maguire 1976; Brain 1980; Haglund et al. 1988; Haglund 1992) have remarked that porcupines tend to ignore bones that are small or compact, while areas on a bone where the compact bone is thin, the typical rodent striae may be absent.

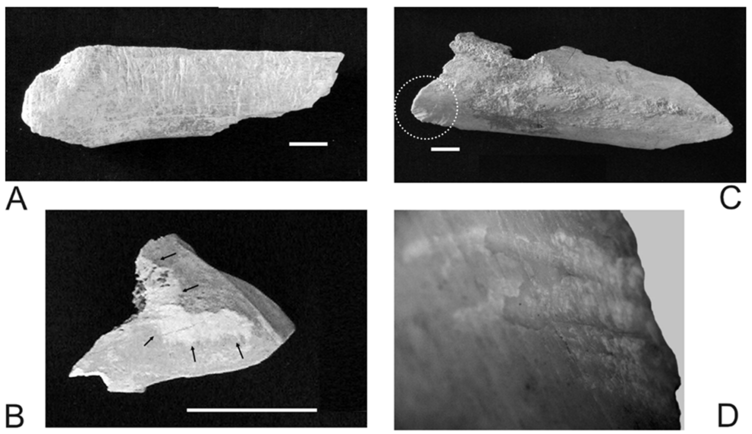

Figure 3. Examples of bones with porcupine gnaw marks: (a) Roman deposits on the tel—a gnawed medium-mammal shaft (L0003) (b) Roman deposits on the tel—a gnawed fragment of a calcaneum showing the exposed lighter coloured bone (due to gnawing), beneath the dark patina (L0024); (c) Porcupine den—NW B6, gnawed femur shaft, (d) close up of gnawing on lower left corner of femur shown in (c). Scale bar 1 cm.

Results of the analysis

Material culture associated with burrows

The survey and subsequent excavation of two of the porcupine burrows (B6 and B8) yielded a relatively small amount of material culture. A complete list is provided in **Table 1**. The vast majority of this material consisted of very small, plainware body sherds; in general, these sherds were either two small or too generic to be identifiable for either form or date. Other diagnostic sherds from the burrows ranged from the Early Bronze Age through the Islamic eras, which is consistent with what is known about the occupational history of Tel Zahara. This chronological range of material culture proves that porcupines are able to excavate into the mound quite deeply, disturbing some of the archaeological depositions and moving the material. In addition to the ceramic finds, the survey and excavations uncovered a small amount of flint, glass, and other small objects, including two beads; these last items might have been part of the grave goods associated with the disturbed human remains from the cemetery on top of the tel, although it is also possible that they were introduced into the area by the burrowing activity of the porcupines. This again indicates the mixing of material culture that occurs due to porcupine bioturbation. None of these cultural finds exhibited porcupine gnaw-damage, in contrast to reports of researchers examining den contents of African porcupine species (Maguire 1976; Brain 1980; Kibii 2009).

Table 1. Material culture associated with porcupine burrows.

Burrow	Material culture list
B1	2 pieces flint; 73 plainware body sherds, mixed periods; 1 bone bead (1×0.9 mm)
B2	1 stone weight(?), flat circular stone, pierced in center (3.9×0.7 cm); 1 stone bead, greenish (agate?), (0.8×0.4 cm); 3 pieces flint; 27 plainware sherds; 1 Early Bronze Age red slipped sherd; 1 red and black slipped sherd, possibly Early Bronze Age; 1 red slip sherd, interior and exterior, bowl, Bronze Age?; 1 red slipped body sherd; 1 large bowl rim, red slip interior and exterior, Early Bronze Age
B4	1 piece of flint; 1 sherd, open form, with vertical grooves on rim, date?; 45 plainware sherds, mixed periods
B5	2 pieces glass, modern; 1 stopper; 1 tessera; 86 plainware sherds, mixed
B6	1 piece flint; 1 jar rim, Roman; 1 rim and handle of jar; 24 plainware sherds
B7	1 piece flint; 1 waster, Islamic?; 1 bowl rim, Roman; 36 plainware sherds
B8	1 sherd Islamic glazed ware; 2 pieces flint; 1 red slipped bowl rim, Roman; 157 plainware sherds
trench between B6 & B8	1 piece Islamic glazed ware; 1 piece Roman glass; 2 tessera; 1 bowl rim, Roman 1 carinated bowl body fragment, Middle Bronze Age; 1 storage jar rim

Animal bones

Seven of the 10 located burrow entrances yielded animal bone remains. A total of 103 faunal items were recovered from the burrow entrances, and from inside burrow B6 as well as from the excavation between B6 and B8. The largest assemblage was from the entrance of B8 (36% of the sample) followed by B6 (19.7% of the sample). Only three bones were recovered inside the corridor associated with den B6 (at distances of

1.00m and 1.50m from the entrance), and a further seven bones were found during excavation between burrows B6 and B8, on the corridor floor (**Table 2**).

Table 2. Damage to bones from porcupine burrows and the Roman deposits at Tel Zahara, compared to Beriniki Cave (Rabinovich & Horwitz 1994) and Geula Cave (Monchot 2005).

Dens location	Rodent gnawed	Carnivore damaged	Burnt	Cut	Bleached	Worked (tools)
SW	2	1	-	1	4	-
NW	6	2	2	3	1	-
Inside B6	1	-	-	-	-	-
SE	4	7	4	-	1	2
trench	1	1	1	-	-	-
Total N	14	11	7	4	6	2
Total %	31.8%	24.9%	15.9%	9.0%	13.6%	4.5%
Zahara (Roman) N	22	-	9	17	-	6
Zahara (Roman) %	40.7%	-	16.6%	31.4%	-	11.1%
Beriniki Cave N	14	10	-	5	-	-
Beriniki Cave %	28.5%	20.4%	-	10.2%	-	-
Geula Cave N	145	65	-	-	-	-
Geula Cave %	13.8%	6.2%	-	-	-	-

In order to ascertain whether the bones recovered from the porcupine burrow system were recent or not, we compared several features of this sample with fauna recovered from Roman period deposits on the same mound (N=249). The first analysis focused on the species and size classes represented in both. As illustrated in **Figure 4**, although a similar range of domestic taxa was found on the tel and in the burrows (sheep, goat, cattle and pig), differences in the frequencies of wild versus domestic taxa were statistically significant, with higher frequencies of wild taxa in the den assemblage than on the tel (χ^2=65.473, df=9, p<0.0001). Many of these wild taxa represent natural mortalities of local taxa inhabiting the tel and its environs.

Analysis of bones from the porcupine burrows identified by body part classes cover the full range, with the majority representing trunk (32.6%) or cranial elements (24.4%). Foot bones are the least common. No statistically significant differences were found in this parameter between the porcupine den assemblage and that from the tel (Horwitz et al. forthcoming).

A total of 186 locally occurring aquatic molluscs (N=66; *Melanopsis buccinoidea*, *Melanopsis cerithiopsis*, *Unio terminalis terminalis*) and land snails (N=120; *Monacha obstructa*, *Xeropicta vestalis joppensis*, *Helix engaddensis engaddensis*) comprised a sizable component of the wild taxa recovered from the porcupine burrows (**Figure 5**). Six mollusc shells were found inside the excavated porcupine den (B6-B8) and probably represent natural inclusions in the soil matrix. This was the only locality to yield

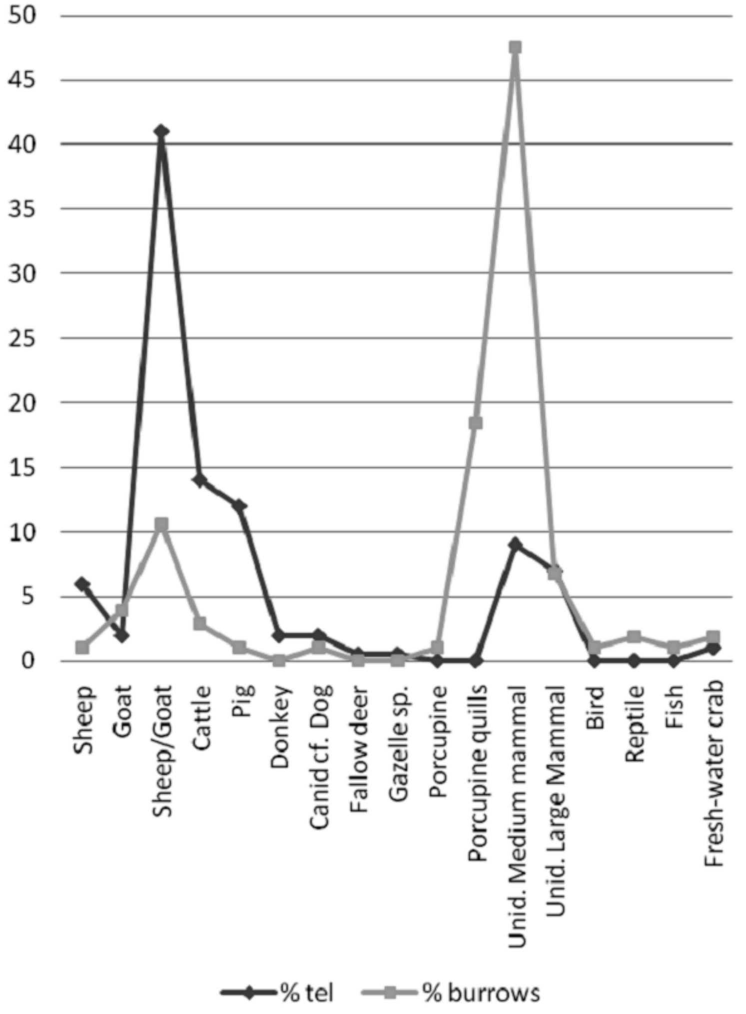

Figure 4. Animal species representation for the burrows and Roman deposits on the tel.

burnt shells, but they probably relate to bush fires on the mound. The different dens yielded similar ranges of molluscan taxa although there were slightly more specimens of *Monacha* and fewer *Helix* in the dens located to the SW than those in the NW (B1-B4). A large part of the *Melanopsis* shells (68.7%) showed damage to the aperture that was most probably caused by the freshwater crab *Potamon potamios*, which chips away the lip of the aperture with their pincers in order to feed on the snail's meat. Likewise eight shells out of a total of 72 belonging to *Monacha obstructa* and five shells out of 25 belonging to *Xeropicta vestalis joppensis* exhibited traces of predation by small mammals, which may be either shrews or rodents. These occur in both SW and NW assemblages. No evidence was found that the land snails and freshwater molluscs were exploited by humans or served as food for porcupines.

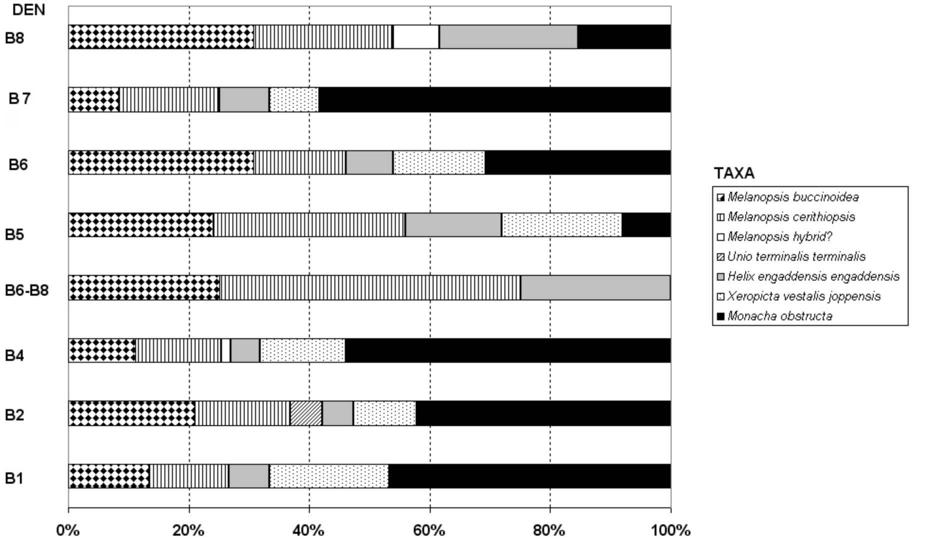

Figure 5. Mollusc species recovered from burrows.

Porcupine damage

Several analyses were performed to test the hypothesis that porcupines are interested in the older, dry bones coming from archaeological assemblages and are less interested in fresh ones. The first analysis focused on the observation of weathering of the bones associated with the burrows. This has shown that few bones were exposed on the mound's surface for a long time, with the majority either showing no weathering at all or only slight weathering indicative of rapid burial. Although the tel sample contains a handful of more severely weathered specimens, the majority either had no weathering or slight weathering. Overall, the extent of surface weathering observed on the fauna recovered from both samples is similar and no statistically significant differences were found between them, suggesting that the majority of bones in the burrow samples derive from the archaeological strata and not from recent (modern) carcasses (Horwitz et al. forthcoming). This is borne out by the dark patina present on all bones from the tel and those from the burrows, with the exception of reptile, rodent and bird remains recovered from the porcupine dens which appear to be recent in origin. On bones recovered from the tel and the burrows that had been gnawed by porcupines, the damaged area is lighter-colored and incised into the dark patina of the bones (**Figure 3**), indicating that the porcupine damage took place after the bones had been buried for some time. This reinforces the hypothesis that the majority of bones associated with the burrows represent ancient, dry specimens that originated from the archaeological deposits.

A breakdown of the frequencies of modified bones from burrows and the tel is not statistically significant (χ^2=3.46, df=3, p>0.05). The two assemblages yielded similar frequencies of burnt remains; 18.7% from the tel versus 16.2% from the burrows, however the tel assemblage had a far higher frequency of butchered (cut) bones than the burrow sample (35.4% on the tel compared to 9.3% for the burrows). A slightly lower frequency of bones with animal-derived damage are found on the tel (45.8%) compared to the burrows (58%) when bones with rodent and carnivore damage are pooled—the latter is represented by tooth puncture holes and v-shaped notches (**Table 2**). The tel assemblage had a surprisingly high frequency of rodent gnawed bones (40.7%) and no documented instances of carnivore damage, an indication of the extensive damage caused by porcupines to the archaeological deposits.

In the Zahara burrow bone sample, porcupine damage was significantly more common than carnivore damage (31.8% versus 11.3%). These proportions are similar to those reported for Beriniki Cave, a historical faunal assemblage identified as a mixed carnivore (cf. hyaena) and porcupine den—17.6% versus 10.5% (Rabinovich & Horwitz 1994). Beriniki Cave also lies in the Jordan Valley, some 40km north of Tel Zahara, on the mountain side above the southwestern bank of the Sea of Galilee. Likewise, the frequency of porcupine damage was much higher than carnivore damage in an assemblage from the Middle Paleolithic site of Geula Cave, located on Mount Carmel adjacent to the Meditterranean Sea coast. This site too has been identified as a mixed spotted hyaena and porcupine (*Hystrix refossa*) den (Monchot 2005). Porcupine damage at Geula Cave was noted on 13.8% of bones examined compared to only 6.2% carnivore damaged bones (**Table 2**). In both cave sites it was suggested that porcupines were not the primary collectors of the bones, but probably modified existing faunal assemblages introduced into the caves by carnivores and/or hominins. In the case of the Zahara porcupine burrows, the carnivore damage evident on the bones may derive from the use of the same burrow. Indeed, Mendelssohn and Yom-Tov (1999) have noted that carnivores are known to enter and use Indian porcupine burrows, although they enter via different tunnels. An alternative explanation for the carnivore damage at Zahara is that the porcupines had collected bones that had already been gnawed by another animal.

Porcupine burrowing and human burials

The excavation of the porcupine den between entrances B6 and B8 revealed that the burrow was quite complex (**Figure 6**). The western entrance (B6) led to the den chamber located ca. 1 meter from it to the south. Leading off was a system of several corridors, with one corridor leading southeast and sloping downwards. After ca. 1m the corridor started to climb up again and then connected with the sloping floor of the second corridor which led downwards and westwards from the eastern entrance (B8). This corridor eventually divided into two others. One of the new corridors led off to the southwest (apparently leading to the den chamber), and one corridor went north, most probably connecting with den entrance B7. A final corridor to the north led to a dead end. This one was most probably connected with the corridor between B7 and B8. There is a Roman or Byzantine wall in the middle of this system, which may explain why the corridor leading from B6 through the den to B8 had to dip down and then curved in order to connect with the corridor leading down from B8. It is not clear if the second entrance of B8 is part of this system or not. It can therefore be stated that most of the burrow entrances in this area, if not all, were part of one burrow system with a single central den chamber and several entrances/exits. To the east, ca. 1m from the eastern entrance of B6, a child's burial (Burial C) was found in the section, ca. 60cm below the top soil, right above the den (the head lay towards the west). The den was cut by the trench in the west, revealing the large inner chamber. In the roof of this chamber, two human leg bones (Burial D) were embedded, indicating that the den was excavated underneath and partially through a grave from the pre-1948 Muslim cemetery located on top of the tel (see **Figure 2**).

Given the close association between the porcupine burrows and human graves, it was not surprising then that during the survey of porcupine burrows on the tel, human remains were recovered on the surface adjacent to burrow entrances. These most probably derive from sub-recent graves lying close to the site surface (see **Figure 1**; Cohen & Więckowski 2007; Więckowski & Cohen forthcoming). Of the eight surveyed porcupine burrows, only two did not yield any human remains. One of these two were located in the south-western group on the eastern slope of the tel, away from the other burrows; the second was from the central group of burrows, but also some distance from those burrows that yielded human remains. The excavations in the trench between burrow openings B6 and B8 have shown that the burrows were located in close proximity to the human burials. There was one burial in the trench, right between the two burrow openings, and one possible *in situ* burial visible in the roof of the den chamber (**Figure 2**). While digging their dens, it is evident that the porcupines exploited the softer, less dense earth that had been previously disturbed by the human burials and so encountered and accidentally disturbed the graves.

Figure 6. Photographs of excavated burrows B6-B8: (a) the B6 burrow before excavation, (b) a close up of the burrow entrance, (c) the burrow system during excavation.

At least seven individuals are represented in the human remains found in the burrows. These remains derive from burrows in the south-western and central part of the tel and in most instances represented isolated bones. Only in one case were the human remains possibly in their anatomical position. These were the remains of a child from the entrance of burrow B8, discovered while excavating a trench to link the opening of burrow B8 and burrow B6. Limited horizontal exposure of this excavation made it difficult to establish the precise nature of this burial. Leg bones belonging to an adult individual found in the roof of den B6 were not analyzed in detail, since it was not possible to extricate them without destroying the den.

Some 90% of human bones examined had no weathering and only 10% fell in the slightly weathered category indicating that they were not exposed on the site surface (**Table 3**). Since the bones are all sub-recent in age, they lack the distinctive dark patina of the more ancient animal bones from the earlier archaeological deposits on the tel that have been buried for a much longer time. The majority of human long bones are missing their epiphyseal ends. In this regard, it is important to note that in at least one instance, burrow B6, the roof of the burrow contained human bones from an overlying grave, and that both tibiae were missing their epiphyses and the edges of the bone shafts were jagged. We were unable to prove whether porcupines or carnivores were the agents responsible for this damage, since these remains were not removed. No typical porcupine or rodent gnaw marks were observed on any of the human remains. However, it is possible that the thin cortical bone covering the epiphyses has impeded the preservation of typical porcupine gnaw marks (Haglund 1992; Haglund et al. 1988).

Table 3. Listing of modifications observed on human remains.

Burrow	Age	Skeletal element	Damage description
SW B1	adult	left and right humeri, radius, ulna, left and right femora, ribs, phalanges, pelvis	in all bones the edges are broken/gnawed; long bones are missing at least one epiphysis
SW B2	adolescent <18 y.o.	distal humerus	bleached on one aspect; two small pits on the distal shaft end
SW B4	child	rib	possible gnawed edges; puncture hole adjacent to one edge
inside B6	adult	radius	no epiphyseal ends; two small tooth pits adjacent to end of shaft (carnivore); adult calcaneum, half the bone is gone (broken/gnawed)
SE B7	adult	right tibia & fibula	distal shaft – uneven break; fibula is missing proximal end
SE B8	child 3-4 y.o.	left and right humeri, left and right radii, left and right ulnae, left and right femora, tibia	the long bones are missing; at least one epiphysis
trench	adult	metatarsal	bleached on one aspect indicating that it was exposed on the surface for some time; edges on both the distal and proximal ends are broken/gnawed

In at least two instances (B2 and entrance sample from B6), small tooth pits were observed adjacent to the broken/gnawed edges of the human bones, while typical carnivore puncture holes were found on the child rib in B4 and on an adult distal femur in B1. Thus, the most parsimonious explanation is that carnivores were responsible for most, if not all, of the observed damage to the human bones found on the mound surface. Given the small size of most of the pits, a small-sized carnivore such as a cat, fox or even a small dog, was probably the agent of modification. A larger sized set of puncture holes on a distal femur found outside burrow B1 suggests the activity of another larger carnivore such as a jackal or large dog. It is therefore possible that carnivores who used the porcupine burrows were responsible for bringing the human remains to the surface.

The cemetery on the tel

The information derived from both the survey and the porcupine burrow excavation enabled us to define the extent and chronology of the cemetery on top of Tel Zahara from which the human bones presented in this analysis most probably originated. Three of the porcupine burrows in the south-western part of the tel yielded human remains: B1, B2 and B4 (see **Figure 1**). The fourth burrow (B3) was situated slightly lower down on the slope and did not yield any human bones. From the group of burrows in the center part of the tel, human remains were found in the trench between burrow openings B6 and B8, as well as in the opening to burrow B7. Examination of the burrow chamber made visible by the excavations showed parts of a possibly in situ burial visible in the roof of the den chamber. Another burial came from the north section of the trench. This was a burial of a child, aged 3-4 years; no associated grave goods were discovered with this burial.

Regular archaeological excavations on the tel during the 2007 season uncovered and excavated two other burials, each containing a single individual. One of them was a primary burial located in the southwest corner of the tel in Square SW.K.7 (see **Figure 1**). The skeleton was in anatomical position and belonged to a five year old child buried with two bronze bracelets. The second was a disturbed burial of a four year old child recovered during excavations in Square SE.C.5 (see **Figure 1**) (Więckowski & Cohen forthcoming).

Taken together, these data clearly show that the cemetery was localized in the summit of the tel and probably also extended down the southwestern slope (Cohen & Więckowski 2007). The analysis of the bones suggest their recent origin as the weathering pattern and patina did not resemble that of the archaeological assemblages. Together with the orientation of the known and documented skeletons, it suggests that this was a Muslim cemetery used either by Bedouin tribes living in the Jezreel Valley or by one of the Palestinian populations resident in the area. Prior to 1948, the village of al-Sakhina was situated less than 500 meters from the site, on the north bank of Nahal Harod, and it is possible that the cemetery was associated with this village.

Conclusions

This study has demonstrated that the Indian porcupine is a major taphonomic agent in archaeological sites. Its burrowing and bone gnawing activities makes it responsible not only for bone modifications, but also for disturbances to archaeological sediments that may result in mixing and damage to archaeological material. It has also proved that, contrary to Mendelssohn and Yom-Tov (1999), this porcupine species appears to gnaw bones inside their dens. It is unclear, however, if the 'gnawing material' was intentionally introduced by the porcupines into their dens or was encountered accidentally while burrowing. Although no porcupine damage was found on the human remains, their role as taphonomic agent in this matter cannot be discounted entirely—it seems that graves with their unconsolidated earth specifically attracted porcupines as locales to dig their burrows and as a result led to the destruction and dispersion of the grave contents (see also Nawrocki 1995). From an archaeological point of view, porcupine burrowing activities may also unexpectedly produce positive results. The survey and presence of human remains in front of the porcupine burrows made it possible to establish the extent and possible chronology of the pre-1948 cemetery on top of the tel, adding to the overall knowledge of the history of human occupation at the site.

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