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Micromammal Taphonomy in the Site of Ohalo II (19 Ky., Jordan Valley)

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ABSTRACT: Micromammals are readily used to reconstruct the paleoenvironment of prehistoric and geological sites. Taphonomic analysis is crucial to remove biases due to differential deposition and accumulation processes. The submerged site of Ohalo II, Jordan Valley (radiometrically dated to 19400 BP) was chosen as a case study for micromammal taphonomy research in an open-air Early Epipaleolithic site. The excavated remains include brush huts, several hearths and a human burial. Preservation of *in-situ* organic remains is excellent. Remains of five micromammal species were found at the site: *Microtus guentheri* (social vole), *Meriones tristrami* (Tristram's jird), *Mus* cf. *macedonicus* (house mouse), *Rattus rattus* (black rat) and *Erinacaeus europaeus* (European hedgehog). The taphonomic study suggests that post-depositional process such as trampling altered the assemblage to such a degree that it prohibits the recognition of the origin of deposition.

KEY WORDS: EARLY EPIPALEOLITHIC, MICROMAMMALS, TAPHONOMY, OPEN-AIR SITES, OHALO II

RESUMEN: Los micromamíferos son frecuentemente utilizados para inferir el paleoambiente de yacimientos prehistóricos y geológicos. El análisis tafonómico resulta clave en la eliminación de sesgos debidos a procesos de deposición y acumulación diferenciales. El asentamiento subacuático de Ohalo II en el valle del Jordán (radiométricamente datado en el 19400 BP) fué seleccionado como un ejemplo donde llevar a cabo investigaciones sobre tafonomía de micromamíferos en un asentamiento del Epipaleolítico inicial al aire libre. Los restos excavados incluyen cabañas de matorral, una serie de hogares y un enterramiento humano. La conservación *in situ* de los restos orgánicos es excelente. Se recuperaron restos de cinco especies de micromamíferos en este asentamiento: *Microtus guentheri* (topillo social), *Meriones tristrami*, *Mus* cf. *macedonicus* (ratón casero), *Rattus rattus* (rata negra) y *Erinaceus europaeus* (erizo común). El análisis tafonómico sugiere que fenómenos post deposicionales, caso del pisoteado, alteraron la asociación hasta tal punto que resulta imposible reconocer el origen de los depósitos.

PALABRAS CLAVE: EPIPALEOLÍTICO TEMPRANO, MICROMAMÍFEROS, TAFONOMÍA, ASENTAMIENTOS AL AIRE LIBRE, OHALO II

INTRODUCTION

Micromammals (defined here as mammals with live weight of less than 3 kg) have been used extensively in paleoclimatic and paleoenvironmental reconstructions (Tchernov, 1968, 1975, 1986, 1988; Jaeger & Wesselman, 1976; Avery, 1977, 1990, 1992; Brain & Brain, 1977; Wesselman, 1982; Denys, 1985, 1986). Of the various taxa, rodents and other small mammals are perhaps one of the better groups to study in this aspect because they occupy distinct niches and environ-

ments. They are highly evolving taxa that adapt themselves readily to new environments and are quite abundant (Chaline, 1977).

When an archaeological assemblage is retrieved from a site, it represents a mere fragment of the original micromammal community that lived in the vicinity (Klein & Cruz-Uribe, 1984; Andrews, 1990). A paleoenvironment reconstruction is based on the relative frequency of species. Species that may have been present in the living community may be disproportionately represented in the assemblage or absent altogether thus analysis based on the death assemblage may be biased. Thus, a correct analysis depends on the identification of the living community rather than the death assemblage (Andrews, 1990).

Taphonomy is the study of the burial of bones and their transition from the biosphere into the lithosphere (Lyman, 1994). It includes the study of the processes of accumulation, dispersal, breakage and diagenesis of remains. The importance of determining the taphonomic history of an assemblage is crucial if we wish to use the assemblage in paleohabitat and/or paleoecological reconstructions. Some predators are species specific and therefore insert a bias in the death assemblage relative to the living community. Thus an archaeological assemblage that was deposited by predators may include or exclude common species and thereby bias the environmental reconstruction (Andrews, 1990). Assessing the agent of accumulation can remove such biases and aid in the interpretation of the data.

Two types of prehistoric sites in the Levant were commonly used for micromammal research. Excavations in Middle Paleolithic cave sites such as Tabun, Qafzeh, Hayonim and Kebara (Tchernov, 1986) usually revealed large quantities of micromammal remains, which were readily studied as paleoecological indicators. Other sites are usually very large open-air excavations such as Lower Paleolithic 'Ubeidiya (Tchernov, 1988) and African sites like Omo (Wesselman, 1982) or Laetoli (Denys, 1985, 1986), but the latter are usually geological formations, spanned over both space and time.

However, Levantine open-air Paleolithic sites with *in-situ* features are not very common. Many such sites have had their fauna published with little or no reference to micromammals e.g. Ein-Gev (Davis, 1974), Neve David (Bar-Oz, 1996, Bar-Oz *et al.*, 1999), Hayonim Terrace (Henry *et al.*, 1981) and Urkan -a-Rub IIa (Hovers *et al.*, 1988).

The major cause of death in micromammals is predation by both mammalian predators (carnivores) and avian ones (raptors) (Andrews, 1990), the predators deposit micromammal remains by means of coprolite and pellets respectively. Caves are most commonly used as places of perching and as lairs. Potential predators may return to the same location over and over again, thereby increasing the quantity of micromammal remains accumulated in the site to significant amounts. On the other hand, open-air sites do not commonly posses such an environment that will induce long term return to the same location. Open-air areas serving as latrines for carnivores or trees which serve as a perch for raptors usually allow only short-term accumulation of micromammal remains in comparison to caves in which the accumulation can span tens of thousands of years.

In cave sites, the abundance of microfauna is so great that even sorting from only a small portion of the excavated sediments reveals a large enough sample for a significant inference of the paleoecology. Such results from cave sites as Hayonim and Qafzeh indicate the presence of hundreds and at times over a thousand specimens (Tchernov, 1988). Once micromammal remains are deposited in a cave, the cave structure may protect the assemblage from further dispersal events. Since open-air sites provide no such protection, an assemblage may soon be dispersed due to taphonomic processes such as trampling and water weathering, rendering it unsuitable for archeofaunal research. In open-air sites, it seems that the small size of the sample and the bad preservation state of the assemblage would probably not be worth the effort of retrieving the micromammal from the matrix resulting in fewer studies and subsequently less publications on the topic.

The scope of this study is to evaluate the potential of open-air sites in micromammal research. The taphonomic history of the case study assemblage will be studied accordingly. The site of Ohalo II, Israel, was chosen as a case study for open-air sites due to the excellent state of preservation of small bones such as bird and fish as well as botanical remains. This study deals with results from the 1989-1991 seasons of excavation.

Ohalo II is an Early Epipaleolithic submerged open-air site located at the south western corner of Lake Kineret (the Sea of Galilee) at - 212.5 meters

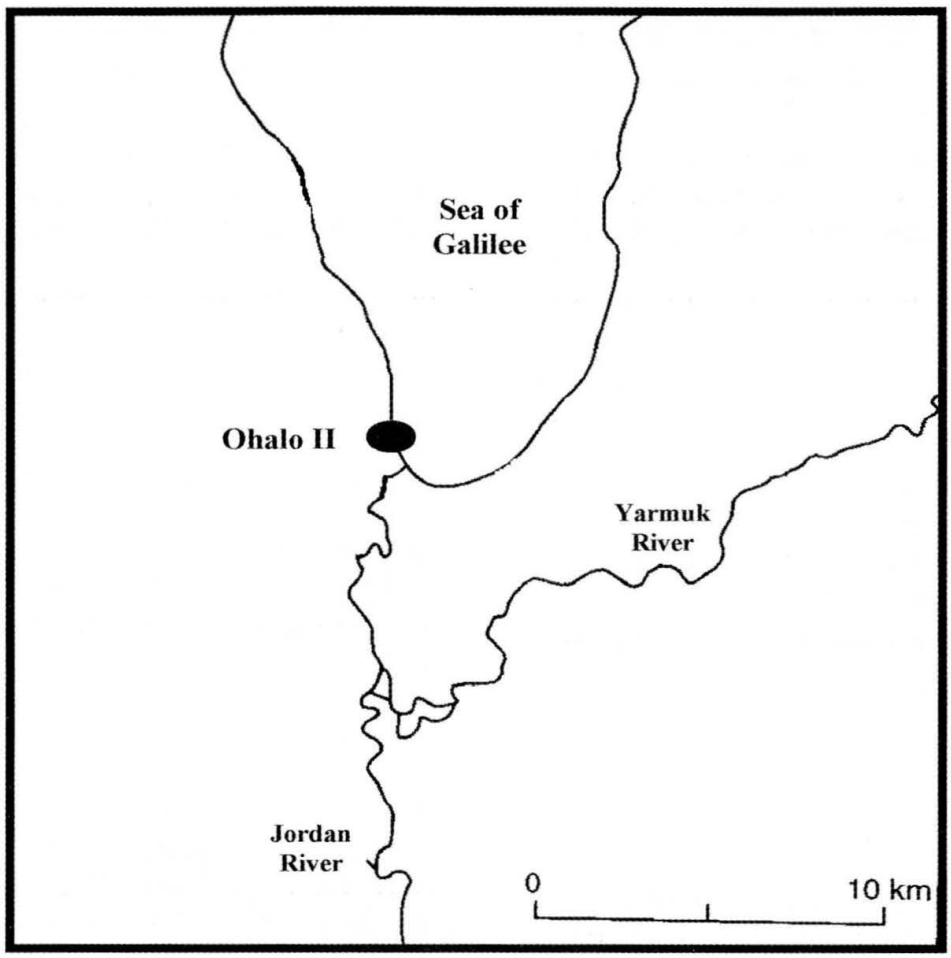

FIGURE 1
Location of Ohalo II.

below MSL (Figure 1). It was exposed as a result of the drop in water level in 1989 after several years of low precipitation.

The site size is estimated at over 2000 square meters of which ca. 400 were excavated to bedrock. The excavation was executed using a 1x1-meter grid subdivided into 4 sub-squares (Nadel, 1991, 1997). The site includes the remains of six brush huts with *in-situ* floors (Figure 2). Various hearths were found around the huts, as well as a dump area and a burial (Nadel, 1996, 1997, 2000; Nadel & Werker, 1999). There are 25 carbon 14 dates from eight loci averaging 19440 ± 770 B.P. (Nadel *et al.*, 1995). Large quantities of charred seeds, animal bones (Rabinovich, 1998a, 1998b) and flints were found on the floors and in the hearths. In several cases delicate fish bones were exposed in articulation. Concentration of bones and flint indicate the post-depositional movement of even the smallest remains was minimal (Nadel *et al.*, 1994; Nadel, 1997). The site surface includes thousands of remains of flints, animal bones, beads, seeds and which are an integral part of the site.

The reconstruction of the environment, based on botanical remains, indicates salt-water marshes at varying levels of salinity surrounded by a park-forest amidst open stands of wheat and barely (Kislev *et al.*, 1992).

MATERIALS AND METHODS

All excavated sediments were sieved through a 2 mm mesh during the first season and through a 1 mm mesh in all later seasons and was sorted specifically for micromammal remains by one of us (M. B). Specimens were observed under a stereomicroscope up to x 60 and identified to species and body part by comparison to the comparative collection of the Hebrew University of Jerusalem.

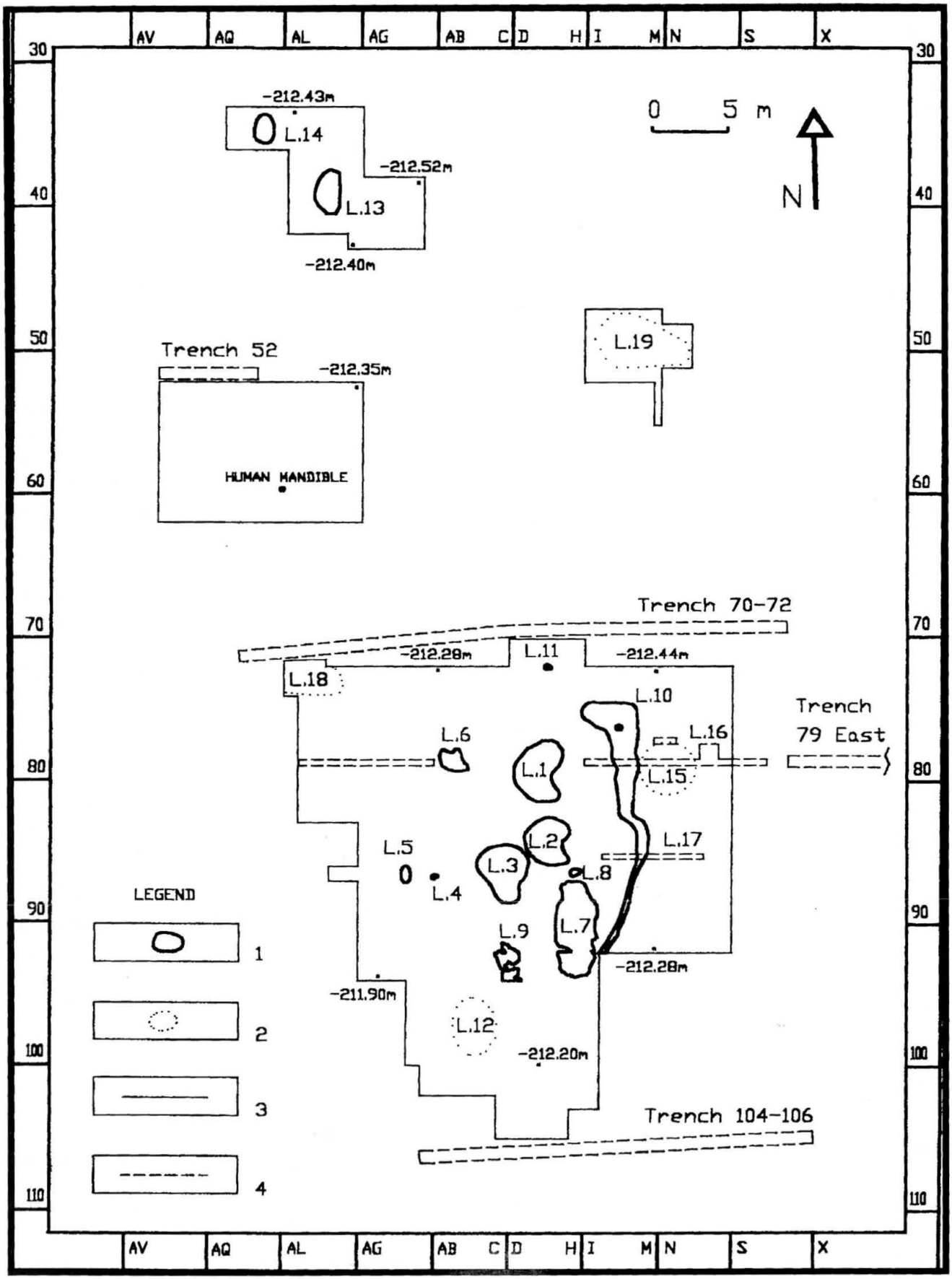

FIGURE 2
Ohalo II site plan 1989-1999.

Contrary to many microfaunal analyses, which use only cranial and dentition remains for species identification, we identified all retrieved elements found to the species level, including incisors and postcranial elements. This was found to be highly productive in increasing both Number of Identifiable Specimens (NISP) and Minimum Number of Individuals (MNI) counts.

RESULTS

Spatial distribution

Micromammals are not evenly distributed among the loci (Table 1). Ca. 20% are found in non-loci matrix in low concentration. Moreover, with the exclusion of locus 1, all other loci have similar low concentrations of micromammals. Locus 1 stands out with over 62% of the assemblage in a single brush hut. This raises the question whether the depositional agent of the micromammals in locus 1 is unique or a single agent of deposit is responsible for the entire assemblage. In this analysis we provide results for locus 1 and the entire assemblage.

Species distribution

A total of 261 micromammal remains were removed from a total of 4.2 cubic meter excavation volume for the total site and 0.82 cubic meters for locus 1. 83.9% (219 NISP) could be identified to species level. The remaining were too fragmented to enable systematic analysis but were included in the taphonomic analysis. These could be assigned to an MNI of 36. The Rodentia species were *Microtus guentheri* (social vole), *Meriones tristrami* (tristram's jird), *Mus* cf. *macedonicus* (house mouse), *Rattus rattus* (black rat) and *Erinacaeus europaeus* (European hedgehog) (Table 1).

For locus 1 (Table 1) species composition is confined to the most common three species; *Microtus guentheri*, *Meriones tristrami* and *Mus* cf. *macedonicus*, with similar NISP frequencies to those of the total assemblage.

The analysis included all Rodentia and included the 3 remains of the hedgehog.

Taphonomy

The majority of the remains are cranial remains; maxilla, mandibles, loose molars and incisors, which comprise ca. 80 % of the total assemblage. The key question here is whether predators deposited the micromammals in the site or were the micromammals part of the commensal fauna at the site. Each predator (mammalian or avian) can be diagnosed by the taphonomic indices of the assemblage it deposited. We followed the indices set forth by Andrews (Andrews, 1990) to identify the potential agent of accumulation.

A) Skeletal element proportion. The skeletal element proportions denotes the proportion of the body elements if all elements survived equally as indicated by the MNI. Thus, if the total MNI is 36 we expect to have 72 humeri (2x36) and 432 molars (12x36). Percentage is calculated per body part.

The Ohalo II micromammal assemblage is dominated by a very high proportion of cranial elements including mandible, maxilla, loose molars and incisors and a very low proportion of limb bones, with none of the smaller postcranial remains present in the assemblage (Table 2). The relative abundance in the locus 1 maintains a similar pattern. The assemblage of Ohalo II is reduced as opposed to both barn owl and fox assemblages. Different skeletal element are more similar to barn owl distributions (loose molars) whilst others are more reminiscent of the fox assemblages (loose incisors, mandibles). A majority of skeletal elements appear in frequencies much lower than those expected in predator assemblages and resemble neither.

B) Postcranial/cranial proportion. Different predators effect the preservation of proximal and distal elements differently. The determination of postcranial/cranial proportions is calculated by three indices. The first is the proportion of the proximal limbs, femur and humerus, to the cranial elements, mandible and maxilla. The second index is the proportion of distal limb elements, tibia and ulna to the proximal ones, femur and humerus. The third index is the proportion of the five limb bones representing the postcranial elements to the cranial elements including mandible, maxilla and the loose molars. This value is divided by 5/8 to correct for the different number of skeletal ele-

NISP	Total	1	2	3	7	10	11	12	13	Surface
Microtus gunetheri	155 (18)	109 (13)	2 (1)	6 (2)	2 (1)	7 (1)			4 (1)	25 (3)
Meriones tristrami	43 (8)	20 (6)	5 (3)	6 (2)		1 (1)				11 (3)
Mus cf. *macedonicus*	15 (4)	12 (3)		1 (1)	1 (1)					1 (1)
Rattus rattus	3 (1)	1 (1)						1 (1)		1 (1)
Erinacaeus europaeus	3 (2)				1 (1)					2 (1)
Rodentia gen. indet.	42 (3)	20 (2)	1 (1)	2 (1)		3 (1)		2 (1)	4 (1)	10 (1)
Total	261 (36)	162 (25)	8 (5)	15 (6)	4 (3)	11 (3)	0	3 (2)	8 (2)	50 (10)

TABLE 1

NISP (MNI) distribution for Ohalo II micromammal assemblage by species and loci.

ments in the body. All three indices are multiplied by 100 and given in percent (Andrews, 1990).

The values obtained for Ohalo II (Table 3) are similar for the entire assemblage and locus 1. Values for proportion of post crania to crania are much lower than the values given for carnivore or raptor assemblages (Andrews, 1990). Proportion of femur and humerus to mandible and maxilla are more similar to mammalian carnivore values than to those of birds of prey. The converse is true for the proportion of distal limb elements to proximal limb elements, which is similar to barn owl values.

C) Breakage of postcranial elements. Postcranial breakage patterns can be divided according to the part of the element preserved: complete, distal, proximal and shaft (Andrews, 1990). The index is calculated as the percent of each partial element from the total number of each limb bone. Results are similar for the complete assemblage and for locus 1. Complete limbs range up to 50%. Distal limb fragments range up to 84%. Proximal limb fragments range up to 50%. No shaft fragments were found (Table 4). None of the patterns could be associated with known predator assemblages.

An index of breakage was calculated in respect to portion of limb preserved without regard to part i.e. a complete limb was classified as 1, followed by 2 for half, 4 for a quarter and 8 for an eighth. Similar results (Table 5) were obtained for the entire assemblage and locus 1. The majority of limb bones were broken mid shaft, followed by fragment of eighth of a limb. Complete limbs are rare.

D) Skull and maxilla breakage. No skull remains were found in the Ohalo II assemblage.

Breakage of maxillae is scored with relation to isolated maxilla as opposed to those in skulls and the percentage of zygomatic bones present. All maxilla found in Ohalo II were isolated and without the zygomatic arches (Table 3).

Tooth loss is measured as percent of empty alveolar of the total expected. Maxillary molar loss for Ohalo II for the entire assemblage and locus 1 is ca. 15% and incisor loss is 0 (Table 3). Both values are much lower than both mammalian carnivores and birds of prey. Mandible molar loss is around 30% for both Ohalo II and locus 1 and is similar to barn owl assemblages (34%). Mandible incisor loss is ca. 40 % for Ohalo II and 70% for locus 1. This is similar to values given for red fox assemblages (75%).

The index as presented by Andrews (1990) ignores a situation, as presented at Ohalo II, of extreme breakage. In this case, many maxillae are too fragmented and thus no alveolars are present at all. This artificially decreases the number of empty alveolar, masking the results. To describe such breakage, an index of percent of alveolar present/alveolar expected is suggested. Values are similar for

	Ohalo II assemblage	Locus 1	Barn Owl Hula	Red Fox
Mandible	42.6	30.0	98.4	50
Maxilla	10.3	8.0	95	25
Incisor	63.2	55.0	24.2	68.8
Molar	22.1	20.0	15.8	31.3
Femur	29.4	24.0	68.3	100
Tibia	7.4	8.0	70	62.5
Pelvis	1.5	2.0	66.7	25
Calcaneum	0.0	0.0	15	25
Talus	0.0	0.0	13.3	12.5
Humerus	11.8	12.0	66.7	75
Radius	0.0	0.0	55	25
Ulna	4.4	6.0	63.4	37.5
Scapula	0.0	0.0	51.7	12.5
Ribs	0.0	0.0	23.6	8.3
Vertebra	1.3	0.4	44.2	23.4
Metapodial	0.0	0.0	21.8	28.9
Phalanges	0.0	0.0	10.2	20

TABLE 2

Relative abundance values for Ohalo II, locus 1 and selective modern assemblages. Modern assemblage data after Andrews (1990).

	Ohalo II assemblage	Locus 1	Barn Owl Hula	Red Fox
% postcrania/crania/(5/8)	45.71	50.63	251	183
% femur+humerus/mandible+maxilla	77.77	94.73	93	233
% tibia+ulna/femur+humerus	28.57	41.66	105	50
Skull breakage % complete	0	0	218	0
% maxilla with zygomatic	0	0	262	0
% maxilla molar loss	14.29	16.67	27	67
% maxilla incisor loss	0	0	26	100
Mandible breakage % complete	0	0	78	0
% inferior border broken	65.5	60	3	100
% mandible molar loss	23.0	33.3	34.00	58.00
% mandible incisor loss	41.4	70.6	3.00	75.00
% isolated molars	73.17	61.22	96	75
% isolated incisors	128	145	56	225
% molars broken *in situ*	36.36	48.77	0	0
% isolated molars broken	35.56	33.33	0	83.3
% incisors broken *in situ*	63.64	100	0	n.a
% isolated incisors broken	70.93	69.09	0	80
% molars digested *in situ*	6.061	5.88	1.1	54.5
% isolated molars digested	60.00	60.00	0.6	83.3
% incisors digested *in situ*	0	0	3.6	100
% isolated incisors digested	40.698	43.636	10.9	87.5
% total molars digested	45.528	48.052	1	70
% total incisors digested	36.082	40.678	5	90

TABLE 3

Taphonomy indices for Ohalo II, locus 1 and selective modern assemblages. Modern assemblages data after Andrews (1990).

locus 1 and the entire assemblage and average 50% for molar alveolar and 25% for incisor alveolar (Table 6).

E) Mandible breakage. No complete mandibles were found. Similar results were obtained for the entire assemblage and locus 1 (Table 3). Ca. 25% have the ascending ramus missing while ca. 60% have the inferior border broken. These values are higher than most birds of prey that range less than 15% and similar to mammalian carnivores which average over 75%.

Tooth loss calculated using only the percent of empty alveolars of those present. Mandible molar loss is similar for the entire assemblage and locus 1 and is ca. 30%. This resembles barn owl values (34%) for this index. Incisor loss is 40% for Ohalo II and 70% for locus 1. This is more similar to red fox assemblages (75%).

F) Tooth loss and breakage. Percent of isolated molars and incisors is calculated as percent of loose teeth of those of those expected (Andrews, 1990). Values for both molars and incisors are similar for Ohalo II and locus 1 (Table 3). Percent isolated molars for Ohalo II is ca. 70% and resembles the red fox assemblage (75%). Loose incisor values, average ca. 130% is an intermediate value between red fox (225%) and barn owl (56%).

Breakage of teeth is measured as the percent of broken to complete teeth. Breakage percentages for both *in situ* and isolated molars are in a similar range for the entire assemblage and locus 1 (Table 3). These values are higher in comparison to various modern raptors but lower than mammalian carnivores. Incisor breakage for both *in situ* and isolated incisors range between 70–100%. This is closer to the mammalian carnivores (80%) but much higher than birds of prey (0%).

Limb	Breakage	Ohalo II assemblage	Locus 1	Barn Owl Hula	Red Fox
Humerus	Complete	0.0	0.0	99	0
	Proximal	12.5	20.0	0	8
	Shaft	0.0	0.0	0	9
	Distal	87.5	80.0	1	83
Ulna	Complete	33.3	50.0	97	0
	Proximal	33.3	50.0	3	67
	Shaft	0.0	0.0	0	33
	Distal	33.3	0.0	0	0
Femur	Complete	5.6	0.0	97	0
	Proximal	88.9	90.9	1	53
	Shaft	0.0	0.0	2	21
	Distal	5.6	9.1	0	26
Tibia	Complete	33.3	0.0	98	0
	Proximal	33.3	50.0	1	67
	Shaft	0.0	0.0	1	33
	Distal	33.3	50.0	0	0

TABLE 4

Limb breakage for Ohalo II, locus 1 and selective modern assemblages. Modern assemblages data after Andrews (1990).

G) Digestion. Signs of digestion were observed on ca. 44% of the postcranial remains, 60% of isolated molars and 40% of the isolated incisors. Although very low values of digestion were found in *in situ* molars and incisors (5 and 0% respectively). Similar results were obtained for the complete assemblage and locus 1 (Table 3). Values for *in situ* digestions are more similar to barn owl assemblages while isolated teeth digestion values are inter mediate between mammalian carnivores (80-100%) and birds of prey (<5%).

When digestion categories are analyzed for loose molar digestion (Table 7), over 80% of the teeth are digested very slightly. This makes it difficult to conclude that the rounding of edges and destruction of dentine is digestion rather than mechanical damage and water weathering.

DISCUSSION

All species found at Ohalo II are Mediterranean species and correlate with the paleoenvironmental reconstruction suggested by the botanical remains (Kislev *et al.*, 1992).

	Category	Ohalo II	Locus 1
Humerus	1	0	0
	2	62.5	60
	4	12.5	0
	8	25	40
Ulna	1	33.33	0
	2	33.33	50
	4	0.00	0
	8	33.33	50
Femur	1	11.11	0.00
	2	55.56	63.64
	4	27.78	27.27
	8	5.56	9.09
Tibia	1	20.00	0.00
	2	40.00	50.00
	4	40.00	50
	8	0	0

TABLE 5

Postcranial breakage pattern for Ohalo II and locus 1

Quantitatively speaking, the NISP and subsequently MNI found at Ohalo II are larger (over 50%) than those found in other Epipaleolithic open-air sites. This is also true if one excludes the postcranial remains that were added to increase the NISP of the assemblage. Many publications concerning contemporaneous sites do not mention any micromammal remains. There are no published microfauna remains from the Kebaran site of Ein-Gev (Davis, 1974); the Geometric Kebaran site of

	Ohalo II	Locus 1
Molar alveolar present	52	29
Molar alveolar expected	114	57
% Molar alveolar present	45.61	50.88
Incisor alveolar present	19	10
Incisor alveolar expected	76	38
% Incisor alveolar present	25.00	26.32

TABLE 6
Mandible and maxilla breakage for Ohalo II and locus 1.

Digestion categories	Ohalo II	Locus 1	Ohalo II %	Locus 1 %
None	36	44	40.0	55
None to very slight	3	2	3.3	2.5
Very slight	9	8	10.0	10
Slight	27	16	30.0	20
Moderate	12	9	13.3	11.25
Heavy	3	1	3.3	1.25
Total	90	80	100.0	100

TABLE 7
Loose molar levels of digestion for Ohalo II and locus 1. Levels of digestion follow Andrews (1990).

Neve David has only few micromammal remains (Bar-Oz, 1996; Bar-Oz *et al.*, 1999). In Hayonim Terrace (Geometric Kebaran A, Natufian), only *Sciurus* and *Spalax* are mentioned although quantities are not given (Henry *et al.* 1981). Open-air sites from the Natufian site of Jebel Es- Saaide (Churcher, 1994) and Einan (Rabinovich, Personal communication), showed total NISP numbering few ten's compared to over one hundred of Ohalo II. Nevertheless, the quantity of micromammal remains at Ohalo II is small in comparison to the large quantities of Middle Paleolithic cave sites in the Southern Levant.

When the taphonomic data of Ohalo II is compared with the data obtained from modern pellet and scat assemblages, there is no specific predator species that the archaeological assemblage resembles with values commonly falling between the extreme values of the barn owl and red fox. The Ohalo II assemblage can be characterized in general as broken and fragmented, many elements are missing, and those present are broken. When observing the element proportion found at Ohalo II, the large percentage of loose teeth relative to other postcranial elements differs from modern comparative assemblages obtained from pellets and scats in which postcranial elements are usually over 50% compared to the 8% at Ohalo II. This could be the result of the unique accumulation, which was biased against limb bones. Such bias could be predator related or preservation bias, which may have eliminated limb bones and preserved the more endurable enamel coated dentition.

The results from the different taphonomic indices are conflicting. Some indices resemble barn owl assemblages while others are more similar to mammalian carnivores.

The increase destruction of proximal elements is more typical for mammalian carnivores than for avian ones (Andrews, 1990). Other indices that support mammalian predator for the assemblages are absence of cranial remains, a high proportion of broken limb bones, broken maxillae and mandibles and high isolated teeth broken. Indices that are more similar to the barn owl assemblages are the postcranial to cranial ratio, molar loss and *in situ* digestion levels.

Although many indices point to a carnivore origin for the assemblage, there are several other factors in which the Ohalo II assemblage differs from that of predators, both mammalian and avian, thus questioning a predatory origin all together. These include the extreme mandible and maxillae breakage beyond what is known for any predator and the absence of shaft fragments.

How can these seemingly contradictory results be explained? The assemblage could have been accumulated by causes other than predation (i.e. entrapment in pits or disease) or could have been accumulated by a predator not yet identified. The opposing model put forth is that post-depositional taphonomic processes may have altered the assemblage such as to render it unidentifiable by the given indices.

Such an activity may have been trampling. To mimic the effect of mechanical breakage and tram-

pling, modern barn owl pellets from the Hula valley were trampled for several minuets. All skull fragments were broken beyond recognition. Maxillas were all isolated from the skull and did not retain the zygomatic arch. Mandibles were less broken and could be categorized as levels B and C of Andrews (1990). Most maxilla and mandible fragments included 1-2 molar alveolars of the three expected. Postcranial elements were broken mid shaft. No shafts were present. The limb bones were most commonly broken in half or in eighth. Smaller postcranial elements processes. The origin of the assemblage cannot be discerned using modern controls. Moreover, the great similarity between the entire assemblage and locus 1 suggest that the two cannot be distinguish from a taphonomical point a view. Trampling would have produced similar assemblages from different depositional agents.

It is interesting to note those preliminary observations on the micromammal assemblages of two Paleolithic open-air such as 'Ubeidiya and Gesher B'not Ya'acov, were also dominated by teeth rather that postcranial elements. Albeit, that these sites are very different in nature from Ohalo II, this may suggests that trampling may be a phenomenon related to the attributes of an open-air site in comparison to cave site. Nevertheless, we would like to stress that although trampling processes maybe be present in other open-air sites, the origin of the Ohalo II assemblage might not be indicative of open-air sites as a rule, but rather a unique case of Ohalo II. Further taphonomic research in other sites will indicate if this is the case.

CONCLUSIONS

The open-air site of Ohalo II revealed significant amounts of micromammal remains. The agent of accumulation cannot be discerned due to post depositional processes that altered the assemblage. The taphonomic history of micromammal assemblages may differ in open-air sites as opposed to cave sites notably with an increase in trampling.

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