PALEOPATHOLOGY SURVEY OF ANCIENT MAMMAL BONES IN ISRAEL

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Abstract. In this paper, we present a survey of pathologies found on post-cranial and cranial bones of mammals from eight archaeological sites in Israel. The chronology of the sites spans from the Neolithic to Biblical, Middle Ages and Ottoman periods. This study is the first of its kind to be conducted on archaeological bone assemblages from the southern Levant. The majority of pathologies were observed on cattle, sheep and goat bones. Cattle bones manifested more pathologies than sheep and goat bones. The majority of pathologies among cattle appeared on the foot bones (predominantly the first phalanges). The range of pathologies found includes joint diseases, infections, trauma and dental diseases.

Key words: pathology; southern Levant; livestock management; draught.

ARCHEOLOGINIUOSE IZRAELIO PAMINKLUOSE RASTŲ ŽINDUOLIŲ KAULŲ PALEOPATOLOGIJOS APŽVALGA

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Santrauka. Straipsnyje pristatoma aštuoniuose archeologiniuose Izraelio paminkluose rastų skeleto kaulų ir kaukolių patologijų apžvalga. Paminklų chronologija apima neolitą biblijinį, viduramžių ir Otomanų imperijos laikotarpius. Šiame darbe pirmą kartą tirta pietinės Levanto dalies kaulinė medžiaga. Daugiausia patologijų nustatyta naminių gyvulių (galvijų, avių ir ožkų) griaučiuose. Didžiausia patologijų dalis rasta gyvulių pėdų ir plaštakų (daugiausia – pirmųjų pirštakaulių) kauluose. Nustatytos sąnarių ligos, infekcijos, traumos ir dantų ligos).

Raktažodžiai: patologija, pietinis Levantas, gyvulių priežiūra, darbiniai gyvuliai.

Introduction. The study of pathologies in animal skeletal remains retrieved from archaeological sites can provide insight as to how animals were raised, managed and exploited. Such data can serve as a powerful tool for assessing issues that are crucial for understanding herd management decisions and animal exploitation in past societies (O' Connor, 2000; Thomas and Mainland, 2005). Broad temporal surveys of types and frequencies of pathologies are particularly important in order to track changes in livestock management through time and space. To date, syntheses of pathological data on a regional and temporal basis are scarce in the archaeozoological literature (e.g. Murphy, 2005; Shaffer and Baker, 1997) and completely absent for the southern Levant. The dearth of published comparative data has restricted many analyses to little more then individual case studies (Thomas and Mainland, 2005). As noted by O' Connor (2003:195), with the disarticulated nature of the faunal remains, individual interpretation is hardly practicable. A diachronic analysis of the types and frequencies of pathologies, in addition to the common methods for studying animal management practices, such as skeletal element profiles (Munro and Bar-Oz, 2004), slaughtering patterns (Binford, 1981) and demographic profiles (Payne 1973; Silver 1969) can promote the understanding of changes in culling practices over time.

Here we report a survey of pathologies found in post-cranial and cranial bones of mammals from eight archaeological sites in Israel. The chronology of the sites spans from prehistoric to historic periods: from the Neolithic, Bronze and Iron Age, to the late Medieval and Ottoman Ages (Table 1). The objective of this paper is to present the different types of pathologies found on mammal bones from the different periods and to discuss their possible cultural and economical implications. This study is the first of its kind to be conducted on archaeological bone assemblages from the southern Levant.

Methods. The pathological specimens were noted while analyzing animal bones in the Laboratory of Archaeozoology, University of Haifa, and the Department of Zoology, Tel Aviv University. All bone remains were identified using comparative collections, measured when possible, and inspected for various macroscopic bone surface modifications. The relative abundances of the different taxa were quantified using the number of identified specimens (NISP). Age at death was determined using epiphyseal closure and tooth wear (Klein and Cruz-Uribe 1984). Each of the identified pathological specimens was separated from the original bone assemblages and was further processed by the first author. Further

processing included coding the bone to species and skeletal part and describing the pathological incident. Pathological specimens were identified and evaluated macroscopically, based on morphological changes and abnormality according to Jubb and Kennedy (1970) and Baker and Brothwell (1980).

Table 1. **Bone assemblages examined in the current survey**

Site	Period	Excavated by	Zooarch report
Motza	Early Pre Pottery Neolithic B (8,500-8,100 BCE).	H. Khalaily (Israel Antiquities Authority)	Sapir, 2005
Lod	Early Bronze (3,300-2,200 BCE)	D. Rosenberg, I. Paz and A. Nativ (Tel-Aviv University)	Bar-Oz and Raban-gerstel, nd
Tel Megadim	Early Bronze I (3,300-3,000 BCE) Early Bronze IV (2,200-2,000 BCE)	S. Wolf (Israel Antiquities Authority)	Sapir-Hen and Bar-Oz, nd
Kiryat Shmona South	Middle Bronze II (2,100-1,750 BCE)	A. Yasur-Landau and Y. Gadot (Tel-Aviv University)	Raban-Gerstel and Bar-Oz, nd a
Tel Dor	Iron I (1,200-1,000 BCE)	A. Gilboa and I. Sharon (Hebrew University and University of Haifa)	Raban-Gerstel et al., in press a.
Tel Rehov	Iron II (1,000-700 BCE)	A. Mazar (Hebrew University)	Marom and Raban-Gerstel, nd
Safed - El Wata	Mamluk (1,291-1,516 AD)	E. Amos (Israel Antiquities Authority)	Raban-Gerstel and Bar-Oz, nd b
Nazareth - Shihab a'Din	Crusader- Mamluk-Ottoman (1,017-1,917 AD)	Y. Tepper (Israel Antiquities Authority)	Raban-Gerstel et al., in press b.

Table 2. **Number of pathologies found per species in each of the studied sites** (NISP for each species are given in brackets)

Site	Period	Species	No. (sp. NISP)
Motza	Early Pre Pottery Neolithic B	*Sus scrofa (wild)*	8 (358)
		Gazella gazella	3 (2881)
Lod	Early Bronze	*Bos taurus*	1 (46)
Tel Megadim	Early Bronze I	*Bos taurus*	3 (247)
	Early Bronze IV	*Ovis/Capra*	1 (180)
Kiryat Shmona South	Middle Bronze II	*Bos taurus*	1 (47)
		Ovis/Capra	1 (57)
Tel Dor	Iron I	*Ovis/Capra*	2 (1359)
		Bos taurus	1 (435)
Tel Rehov	Iron II	*Bos taurus*	11 (1048)
		Ovis/Capra	19 (4348)
		Equus asinus	1 (138)
Safed - El Wata	Mamluk	*Ovis/Capra*	2 (390)
Nazareth - Shihab a'Din	Crusader-Mamluk	*Ovis/Capra*	1 (24)
		Ovis/Capra	1 (174)
	Ottoman	*Bos taurus*	2 (61)
Total pathologies			58

Results. Out of the 14,540 examined bone fragments from the eight sites studied, a total of 58 pathologies were identified (Appendix 1, Table 2). Only a few pathologies were found on wild animal remains: mountain gazelle (*Gazella gazella*, NISP=3) and wild boar *(Sus scrofa*, NISP=8), from the prehistoric site of Motza (Early Pre Pottery Neolithic B). Generally, pathologies are rare on wild animals in archaeozoological assemblages and were not observed on any of the studied assemblages from later periods. The frequency of pathologies found in Early Pre Pottery Neolithic B Motza (0.1% of the gazelle bones and 2.2% of the wild boar bones) is in accordance with what is expected in nature (2% for gazelles and 8% for wild boar; B. M. Rothschild, personal communication).

All pathologies in bones from the Early Bronze Age sites and onwards were observed on livestock mammals, which dominate the faunal remains in these periods: cattle (*Bos taurus*), sheep (*Ovis aries*) and goat (*Capra hircus*), with one case of pathology in a donkey (*Equus asinus*). Although most of the pathologies were found in sheep

and goat remains, overall the frequency of pathologies relative to specimens (%NISP) was twice higher for cattle compared to sheep and goat (χ^2 =9.53, P<0.005). Examination of pathological frequency for each species over time, reveals that prevalence did not exceed 5% in all studied periods (Figure 1, dates provided in Table 1). The highest frequency of pathologies (over 4%) was noted in the Crusader period; however, the sample size from this phase was very small. In some periods (Middle Bronze II, Iron I), the frequency of pathologies for cattle and sheep/goat is similar (MBII: χ^2=0.02, P=0.89; Iron I: χ^2=0.14, P=0.71). In the Ottoman period the frequency of pathologies for cattle is higher compared to sheep/goat, albeit the difference is not statistically significant (Ottoman: χ^2=2.05, P=0.1). In the Early Bronze the frequency of pathologies for cattle is high, without a single case of pathology in sheep/goat; conversely, in the Early Bronze IV, Crusader and Mamluk periods the opposite was observed, i.e., the frequency of pathologies for sheep/goat is high, without a single case of pathology in cattle. As there are no sources of data to compare the frequencies of pathologies found on livestock mammals, it is hard to determine whether the frequencies presented here are in anyway unusual.

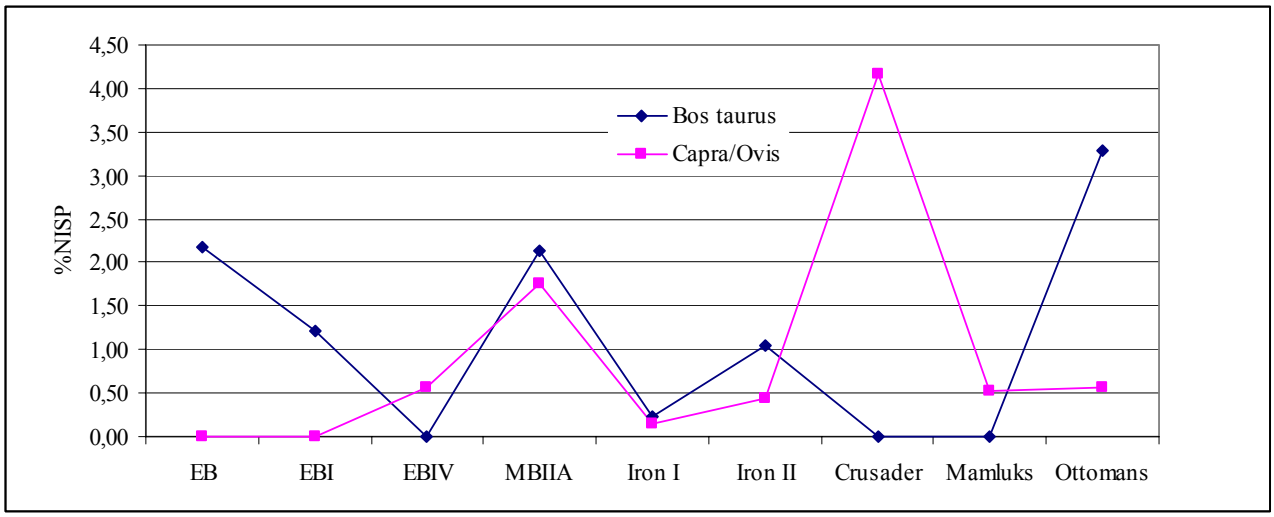

Figure 1. **Frequencies of pathological incidents found in the main studied periods.**

Table 3. **Diagnosis of identified pathologies divided by categories**

Pathology			Species	#no.
1. Induced			*Bos taurus*	13
2. Animal disease	A. Infectious		*Bos taurus*	1
			Ovis/Capra	1
			Sus scrofa	1
	B. Non-transmitted	degenerative	*Bos Taurus*	3
			Ovis/Capra	20
			Sus scrofa	6
			Gazella gazella	3
			Equus sp.	1
		trauma	*Ovis/Capra*	1
			Sus scrofa	1
		dental disease	*Ovis/Capra*	4
Un-specified pathology			*Bos taurus*	2
			Ovis/Capra	1
	Total			58

The diagnosis of the identified pathologies can be divided into two main categories (Table 3):

1) Pathologies induced by humans: This category includes pathologies that were caused by activities which are not considered natural for the animal, such as extensive physical activities, i.e., draught or plough traction, which can cause abnormal strain to the lower legs. These types of pathologies were found in the current survey solely on cattle remains from historic sites. Most cases were found on the 1st phalanges. One case of induced pathology was found on a cattle astragalus from EBI Tel Megadim, showing osteochondritis dissecans, resulting

most probably from the heavy weight carried by the animal. One case of periostitis was found on a cattle calcaneum from Early Bronze I Tel Megadim (Figure 2) probably due a local inflammatory process. This could have resulted from tying the animal from the lower part of the leg for a long time.

Figure 2. **Cattle calcaneum from Early Bronze I Tel Megadim. The specimen displays evidence for periostitis that could have resulted from tying the animal for a long time**

2) Animal disease: This category includes two types of diseases, infectious disease and non-transmitted disease. Evidence for infectious diseases was found in three specimens. Two cases of zoonotic disease (brucellosis or tuberculosis) were found on a sheep/goat pelvis from Iron II Tel Rehov, and in a wild boar metapodial from the Early Pre Pottery Neolithic B of Motza. The specimens were diagnosed based on studies of human paleopathology (Aufderheide and Rodriguez-Martin, 1998), as there is currently no source for comparing mammal remains. However, further analysis is needed to determine the source of infection. One case of arthritis was found in a cattle thoracic vertebra from Ottoman Nazareth (Figure 3). These cases of infectious disease could not be identified based on macroscopic inspection alone. A DNA analysis is required for proper diagnosis (Mays, 2005; Rothschild et al., 2001).

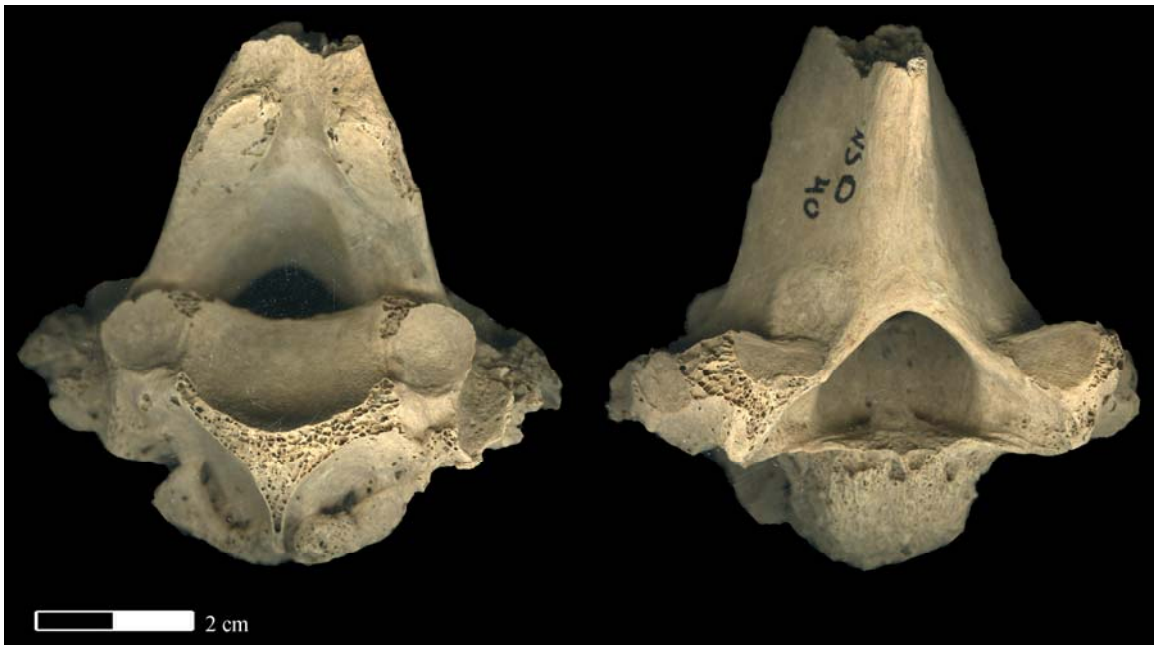

Figure 3. **Cattle thoracic vertebra from Ottoman Nazareth. The specimen displays evidence for infectious arthritis**

Figure 4. **Sheep/goat phalanges from Iron II Tel Rehov. The specimen displays evidence for degenerative diseases caused at older animals.**

Figure 5. **Sheep/goat radius from Iron II Tel Rehov. The specimen displays evidence of an healed oblique fracture.**

Figure 6. **View of the lingual aspect of sheep/goat mandible from Ottoman Nazareth. The specimen displays evidence for ante-mortem tooth loss.**

Non-transmitted diseases included degenerative joint disease (Figure 4), trauma (Figure 5) and dental disease (Figure 6). Most of the pathologies in the wild and domesticated animals are of the non-transmitted diseases category. Age-dependent diseases (osteoarthritis, spondyloarthropathy, Diffuse Idiopathic Skeletal Hyperostosis), were observed mainly in sheep and goat, on various body elements. The wild boar from the EPPNB Motza also manifested skeletal changes associated with spondyloarthropathy. Two cases of trauma (fracture) were found: one of wild boar metapodial from the prehistoric site of Motza, and one in a sheep/goat radius from the Iron II Tel Rehov. Both cases are of healed fractures. Following the fracture a displacement occurred resulting in shortening of the bone, and the fracture was associated with infection. However, it was most probably not active at the time of death. Also found were few mandibles of sheep/goat with evidence for oral disease; three mandibles showed ante-mortem tooth loss (two from Iron II Tel Rehov, one from Mamlukes Nazareth), and one mandible from Iron II Tel Rehov showed evidence of peri-apical abscess.

The breakdown distribution of pathologies to body parts for cattle and caprines (Figure 7) reveals that the majority of cattle pathologies appear on the foot bones (predominantly on first phalanges). These pathologies appear in all periods and sites where cattle pathologies were found (apart from Ottoman Nazareth). Sheep and goat pathologies appear on a wider range of skeletal parts and seem to be more related to senescence.

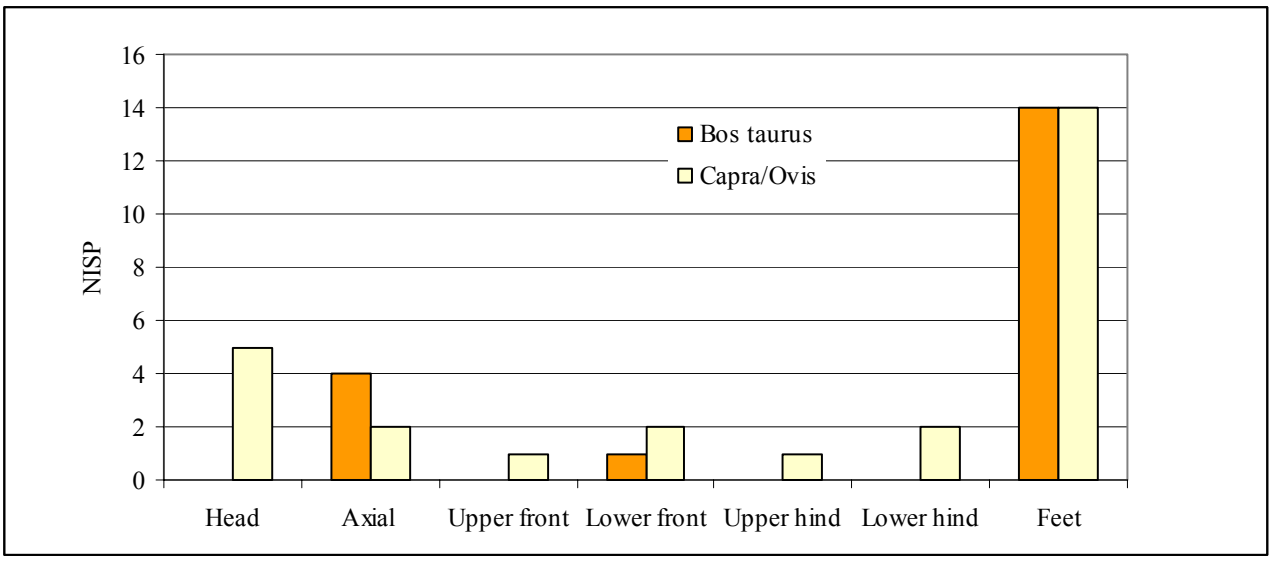

Figure 7. **Distribution (NISP) of pathologies by body parts for cattle and caprines in the total assemblage**

Discussion. In the present study, bone pathologies of mammals from various archaeological sites were reported. A few pathologies were found on wild animals in the prehistoric site of Motza. The majority of the pathologies, however, were found on livestock mammals in the historic sites. The relative frequency of pathologies

(%NISP) for each species is similar for the wild and the domesticated animals (Table 2). With the lack of a reliable data source regarding the frequencies of bone pathologies in livestock mammals, it is hard to determine the significance of our findings.

Appendix 1. **Pathological incidents recorded for the studied bone assemblages**

Site	Species	Element	Diagnosis
Motza	*Gazella gazella*	1st phalanx	ring bone
		thoracic vertebra	Diffuse Idiopathic Skeletal Hyperostosis
		lumbar vertebra	Diffuse Idiopathic Skeletal Hyperostosis
	Sus scrofa	2nd phalanx (6 specimens)	spondyloarthropathy
		metatarsal	infectious disease
		metacarpal	trauma
Lod	*Bos taurus*	2nd phalanx	unknown pathology
Tel Megadim		1st phalanx	enthosopathies
		calcaneus	periostitis
		astragalus	osteochondrosis
	Capra/Ovis	tibia	spondyloarthropathy
Kiryat Shmona South	*Bos taurus*	1st phalanx	enthosopathies
	Capra/Ovis	metacarpal	arthropathy
Tel Dor	*Bos taurus*	calcaneus	enthosopathies
	Capra/Ovis	calcaneus	arthropathy
		mandible	arthropathy
Tel Rehov	*Bos taurus*	1st phalanx	enthosopathies
			enthosopathies
		rib	arthropathy
		metacarpal	enthosopathies
		rib	unknown pathology
		1st phalanx	enthosopathies
			enthosopathies
			enthosopathies
			enthosopathies
			enthosopathies
			enthosopathies
	Capra hircus	2nd phalanx	spondyloarthropathy
		1st phalanx	spondyloarthropathy
		2nd phalanx	spondyloarthropathy
		1st phalanx	spondyloarthropathy
		3rd phalanx	arthropathy
		calcaneus	arthropathy
	Capra/Ovis	mandible	abscess
			abscess
		calcaneus	enthosopathies
		3rd phalanx	spondyloarthropathy
		femur	arthropathy
		humerus	spondyloarthropathy
		acetabulum	infectious disease
		mandible	abscess
		thoracic vertebra	arthropathy
		radius	trauma
		2nd phalanx	spondyloarthropathy
	Equus	mandible	spondyloarthropathy
	Ovis aries	1st phalanx	enthosopathies
			spondyloarthropathy
Safed - El Wata	*Capra/Ovis*	radius	unknown pathology
	Ovis aries	1st phalanx	arthropathy
Nazareth - Shihab a'Din	*Bos taurus*	thoracic vertebra	arthritis
		rib	arthropathy
	Capra/Ovis	1st phalanx	spondyloarthropathy
		mandible	abscess

Induced bone pathologies were found solely in cattle foot bones, most of them on the first phalanges. Pathologies in foot bones can probably be related to exploitation for draught or traction (Bartosiewicz et al. 1997), al-

though they also appear naturally on wild aurochs or on cattle (Johannsen, 2005). The presence of other pathologies, from the animal disease category, in butchered animals is probably a reflection of the culling practice to slaughter animals in the later stage of their working lives, after they were exploited for secondary products.

The case of a healed fracture in a wild boar leg could suggest that this animal was living in proximity to humans and may have been treated by them. However, one should keep in mind that a fracture in the mid-metapodial is not a critical injury, and an adult wild boar, even slightly handicapped, is not likely to be attacked by carnivores, and therefore could survive even without human interference.

All the historic sites examined here are dominated by domestic livestock. No apparent trend of change in pathology frequencies over time was observed. The difference in the frequency types of pathologies between the sites may be attributed to differences in livestock husbandry practices. Studying the pathologies with regard to herd demography for each site, as described in the faunal reports, can illuminate this aspect. A low percentage of young cattle, which suggests exploitation for milk or labor, was found in Early Bronze I Lod (Bar-Oz and Raban-Gerstel, nd), Early Bronze I Tel Megadim (Sapir-Hen and Bar-Oz, nd), and Middle Bronze II Kiryat Shmona South (Raban-Gerstel and Bar-Oz, nd a). This is in accordance with the pathological study which also suggests exploitation of livestock animals for draught. One case of degenerative joint disease (arthritis in a sheep/goat metatarsal) was found in the Middle Bronze II Kiryat Shmona South (Raban-Gerstel and Bar-Oz, nd a), where a high fraction of the animal assemblage consisted of old caprines. Noteworthy, however, is that in Early Bronze IV Tel Megadim (Sapir-Hen and Bar-Oz, nd) and Mamluk Safed (Raban-Gerstel and Bar-Oz, nd b) where juvenile caprines dominate the sample, age-dependent pathologies were also observed. These results may indicate that even when the economy is oriented toward juveniles, there are still older animals in the herd.

It is important to note that the sites included in this analysis were only those where pathologies were found. The low frequency of pathologies could be the result of a taphonomic bias, as bones with diseases can be more fragile. It could also stem from the difficulty to identify certain pathologies with naked eyes or from low awareness to the phenomenon. Unfortunately, Bartosiewicz et al. (1997:11) statement is still true: archaeozoologists usually lack a sound data-base for the description and identification of pathology.

Conclusions

The range of pathologies found in the current survey includes pathologies caused by different factors. The presence of induced pathology on cattle leg bones indicates the physical activities undertaken during their lives, which presumably include their exploitation as draught animals. The non-transmitted diseases described here are typical of old age, and considered together with age-at-death data, reveal a pattern of slaughtering older animals after exploiting them for other (secondary) purposes.

When trying to separate pathologies into two main categories (induced and animal disease), a difficulty to distinguish pathologies caused by natural causes (such as old age) from those induced by human interference based on macroscopic evaluation alone, emerge. This is mainly due to the fact that bones tend to react similarly to various pathogens or induced stresses. A further study of the changes occurring in the microstructure of the bone, using histological techniques, may assist us in the future to overcome this difficulty.

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