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RESEARCH ARTICLE

Wool sheep and purple snails—Long-term continuity of animal exploitation in ancient Meninx (Jerba/Tunisia)

Simon Trixl[1] | Sami Ben Tahar[2] | Stefan Ritter[3] | Joris Peters[1,4]

[1]Institute of Palaeoanatomy, Domestication Research and the History of Veterinary Medicine, Ludwig Maximilian University of Munich, Munich, Germany

[2]Institut National du Patrimoine, Borj Ghazi Mustapha, Houmt Souk, Tunisia

[3]Institute of Classical Archaeology, Ludwig Maximilian University of Munich, Munich, Germany

[4]SNSB, State Collection for Anthropology and Palaeoanatomy, Munich, Germany

Correspondence
Simon Trixl, Institute of Palaeoanatomy, Domestication Research and the History of Veterinary Medicine, Ludwig Maximilian University of Munich, 37 Kaulbachstr, Munich, 80539, Germany.
Email: simon.trixl@palaeo.vetmed.uni-muenchen.de

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Abstract

Archaeological research at the ancient city of Meninx in Jerba, Tunisia, carried out by the *Institut National du Patrimoine Tunisie* and Ludwig Maximilian University of Munich (LMU) produced more than 10,000 faunal specimens and shed light on subsistence activities spanning from the fourth century BCE until the seventh century CE. Despite its highly diverse fauna totalling at least 69 species of mammals, birds, reptiles, fish and molluscs, domestic livestock formed the mainstay of the economy at Meninx. Throughout site occupation and compared with contemporaneous sites in coastal Tunisia and Libya, sheep were of prime importance at Meninx. Diachronic demographic profiling illustrates an emphasis on the production of wool for making textiles. Together with the ubiquitous presence of crushed banded dye-murex (*Hexaplex trunculus*) shells implying exploitation of purple dyes, we assume that both activities were integrated into a single *chaîne opératoire* for making purple-dyed fabrics that were traded across the Mediterranean from Punic until Late Roman times. Zooarchaeological findings also suggest that during the Byzantine Period, this major economic activity came to a standstill, with people returning to more self-sufficient subsistence strategies. An intersite comparison furthermore revealed that high proportions of ovicaprines are a typical feature of Punic–Roman sites in Jerba. But even at the height of Roman power in the region, autochthonous husbandry traditions continued to exist on the island, as illustrated by the fauna from Henchir Bourgou.

KEYWORDS

Byzantine Period, marine snails, northern Africa, Punic Period, Roman Period, sheep, textile and purple dyes production, zooarchaeology

1 | INTRODUCTION

Except for Egypt, where since the 1960s faunal studies became an integrated part of archaeology, and the coastal Mediterranean strip, comparably few archaeofaunal analyses have been conducted in other parts of northern Africa. Insight into faunal developments in the latter region mainly comes from antique seaports, primarily Carthage (e.g., MacKinnon, 2010). In the last decade, however, particularly the eastern coast of southern Tunisia witnessed intense archaeological research, for example, at Ghizène (Ben Tahar, 2016/17), Zitha (Moses et al., 2019), Henchir Bourgou (Ben Tahar, 2018; Ben Tahar et al., 2020) and more recently, at Meninx, a major ancient harbour located on the island of Jerba (Ritter & Ben Tahar, 2020; Ritter, Ben Tahar, Fassbinder, & Lambers, 2018) (Figure 1). The site of Meninx has been the focus of investigation since 2015 and offers significant scientific potential due to the extensive excavations and field surveys

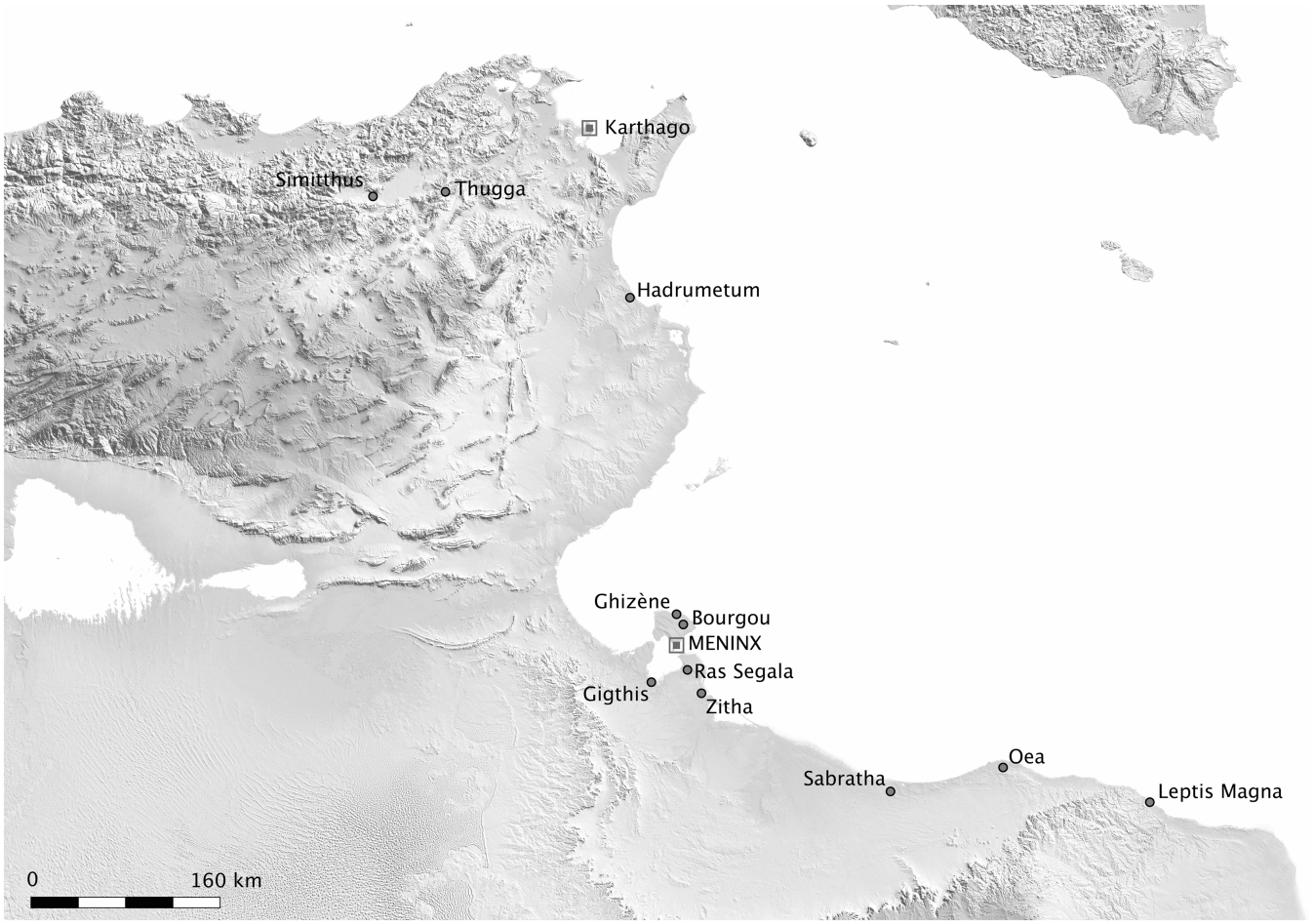


FIGURE 1 Location of Meninx in its contemporaneous North African context (Paul Scheding)

carried out by the joint efforts of the *Institut National du Patrimoine Tunisie* and Ludwig Maximilian University of Munich (LMU) (Ritter et al., 2018). Based on these as well as previous archaeological research carried out in the 1990s by the University of Pennsylvania (Fentress, 2018; Fentress, Drine, & Holod, 2009), it could be shown that Meninx was inhabited continuously from Punic until Byzantine times, that is, from the fourth century BCE to the seventh century CE.

In the course of more than a millennium of continuous site habitation at Meninx, exploitation patterns of local and nonlocal georesources and bioresources underwent modifications triggered by diverse economic, cultural and ecological factors. Particularly the lengthy conflicts between Rome and Punic northern Africa, terminating with the integration of the latter region into the *Imperium Romanum* (second/first century BCE), or the collapse of the Roman Empire succeeded by the Vandalic/Byzantine Period (fifth to seventh century CE), represented major political developments associated with significant sociocultural and economic consequences (e.g., Azaza & Colominas, 2019; MacKinnon, 2018; Moses et al., 2019). Arguably, processes of transformation were by no means of uniform intensity in Tunisia nor in the neighbouring regions. Rather, local patterns of economic continuity and discontinuity seem a much more likely model for such transitional periods (e.g., von Rummel, 2010). Evidence for settlement continuity at Meninx suggests that the inhabitants met the challenges of changing economic–political conditions, but to which extent the latter are reflected in the (bio-)archaeological record will be detailed below.

The production and supply of animal products identified in the archaeological record are excellent indicators for elucidating changes in the socio-economic fabric of ancient communities. One central pillar in the Meninx economy was the production of purple dye. As early as the first century CE, Pliny the Elder mentions the city as the source of the highest quality purple dyes in Africa (*Naturalis historia*, IX). This historical reference can be interpreted as a first indication of a well-organized *chaîne opératoire* for this valuable merchandise, from the acquisition of purple snails and their processing to the dyeing of fabrics and their secure transport to suitable markets. In light of the region's history, local animal subsistence practices and food economies likely changed with time at Meninx. In addition to other issues, this study will examine the faunal record with specific emphasis on changes brought about by the rise and fall of the Roman Empire and the extent to which Italian agricultural practices influenced local traditions of livestock husbandry. In order to address the wider perspective of the results obtained at Meninx, comparisons will be made with published archaeofaunas from Punic, Roman and Byzantine levels at

sites located in the Tunisian–Libyan coastal region, such as Benghazi (Barker, 1979a, 1979b), Bir Messaouda (Slopsma, van Wijngaarden-Bakker, & Maliepaard, 2009) and Carthage (e.g., MacKinnon, 2010) and Zitha (Moses et al., 2019). Archaeofaunal results from other Punic–Roman sites in Jerba, for example, Ghizène (Azaza & Colominas, 2019) and Henchir Bourgou (Ben Tahar et al., 2020), will be considered in order to provide details on insular developments. Furthermore, the study on faunal remains recovered during the excavations of the University of Pennsylvania in Meninx (Fabis, 2009) will be an important comparison for the results presented below.

2 | ARCHAEOLOGY OF MENINX

The animal remains examined in this study were excavated in 2017 and 2018 in the ancient seaport of Meninx, Jerba's largest antique city located in the southeast of the island on the Gulf of Bou Ghrara (Figure 1). Exploration of Meninx began early in the 19th century CE by Mohamed Abou Ras. However, systematic archaeological research only set in during the 1990s with a survey project directed by E. Fentress, A. Drine and R. Holod (Fentress et al., 2009). In 2015, a project codirected by S. Ben Tahar and S. Ritter was initiated to further detail the development of Jerba's most important antique city.

Located in a slightly hilly coastal terrain and currently sealed by sediments, research at Meninx started with geophysical prospections (Ritter et al., 2018) (Figure 2). Those investigations revealed the presence of at least three long main roads running roughly parallel to the coastline that were intersected by smaller streets. The resulting grid system created separate urban districts with distinct architectural features: the *forum* is located in the southwest with its public buildings. From the *horrea* and the *macellum* in the south up to the theatre in the north, a set of monumental building complexes with

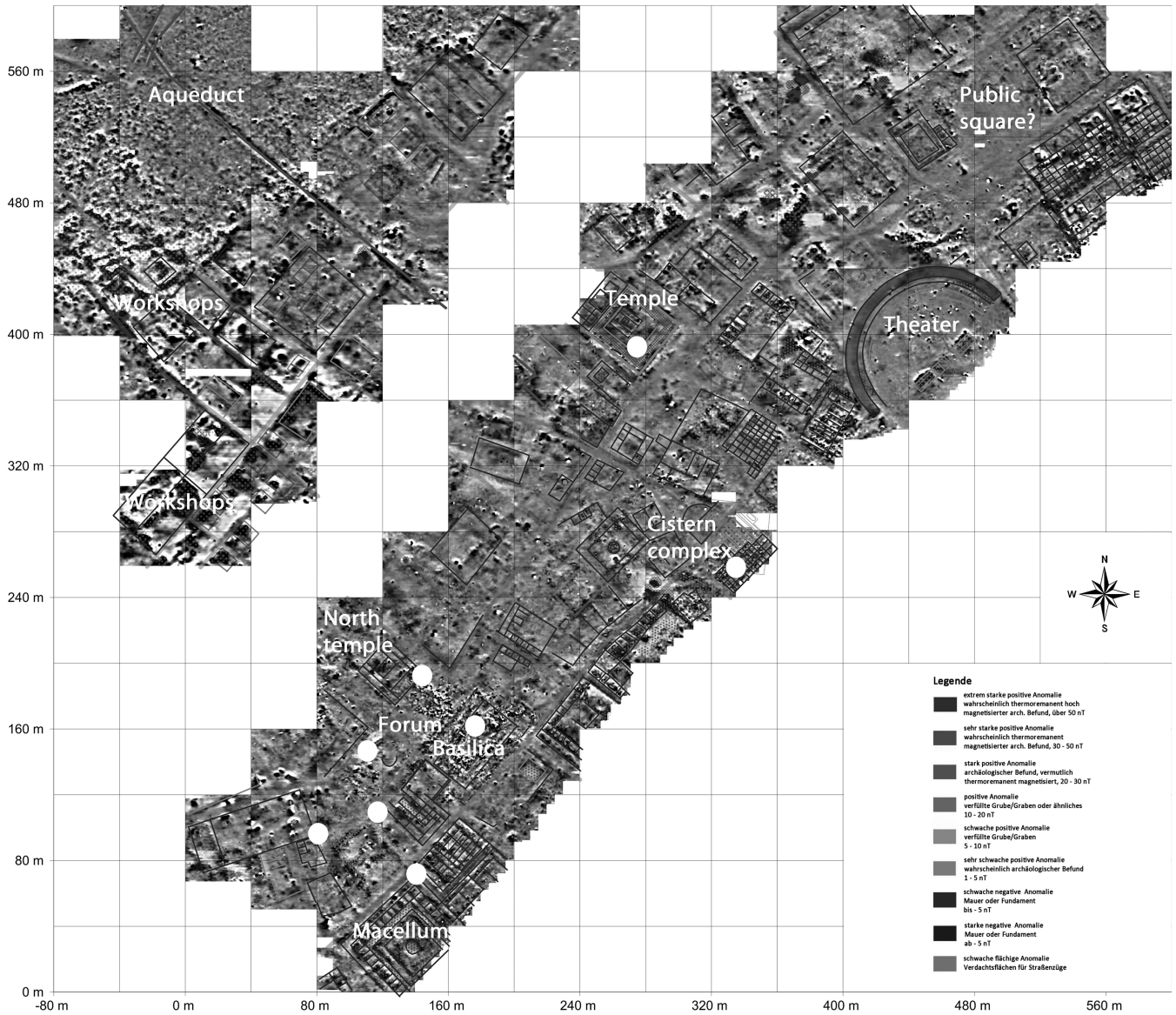


FIGURE 2 Meninx, magnetogram. Results of the prospections in 2015, 2017 and 2018, to which the preliminary results of the archaeological interpretation have been added (Jörg Fassbinder & Stefan Ritter). White spots: location of trenches excavated 2017/2018

predominantly economic function stretched along the ancient beach area. Inland, settlement structure becomes less regular, with predominantly residential architecture. Lastly, extensive workshop complexes were located in the flat area extending to the northwest of the present coastal road.

Excavations at Meninx were carried out in 2017 and 2018 (Ritter & Ben Tahar, 2020): in four trenches south and west of the *forum*, the *macellum* and its surroundings, two residential buildings and private *thermae* were recovered. Three trenches inside the *forum* were excavated to investigate the *basilica*, the sanctuary at the square's northern corner, adjacent residential buildings, streets, a temple as well as residential structures at its western corner. In addition, two trenches near the theatre revealed the presence of a sanctuary and an economic building on the coast.

Meninx witnessed intensive building activities since the middle of the fourth century BCE. The city participated in the Mediterranean economic network early in its history and continued to do so until the seventh century CE. In the earliest Punic contexts, ceramics consist of Western Greek amphorae together with attic and proto-Campanian black-glazed ware. Meninx's far-reaching connections across the Mediterranean are further illustrated by the adoption of vessel forms such as *lopades*. Although undoubtedly inspired by the Greek typological repertoire, their presence relates to Punic influence, as these forms are very common in Carthage (Bechtold, 2014).

The earliest evidence for monumental architecture in Meninx dates to the first century CE. In the late first and early second century CE, an extensive building boom occurred that, in particular, witnessed an expansion of the economic infrastructure of the coastal zone. In late antiquity around 400 CE, building activities ceased in parts of the settlement and processes of abandonment set in during subsequent decades. Nonetheless, occupation of the site lasted until the seventh century CE (Ritter & Ben Tahar, in preparation).

Jerba's history only recently came into the focus of research with evidence showing that the emergence of Meninx came in the aftermath of the Punic expansion during the fifth century BCE, a period during which most Tunisian coastal settlements such as Guellala (Ben Tahar, 2019) were founded. The only coastal settlement established prior to Meninx was Ghizène, a city involved in supraregional trade connections as early as the late sixth century BCE (Ben Tahar, 2016/2017). Ghizène's economic importance is linked to its role as a seaport for Henchir Bourgou, the oldest and most significant settlement on Jerba (Ben Tahar, 2018). Located in the hinterland, site habitation at Bourgou started early in the first millennium BCE and lasted until late antiquity, thereby losing its leading role to Meninx in the second century CE (Ben Tahar et al., 2020).

3 | MATERIALS AND METHODS

The archaeofauna presented here derives from the nine trenches excavated in 2017 and 2018 (see above) and comprises mainly domestic refuse, even if a small number of bones originate from sanctuaries. The last-mentioned fauna, however, does not differ from the findings recovered in residential contexts. The material consists mainly of hand-collected specimens, to which collections retrieved by wet-sieving have been added. The sample size studied totals 10,602 hand-collected specimens. Identification was carried out at the site and follows standard zooarchaeological identification and documentation procedures (e.g., Boessneck, Müller, & Teichert, 1964; von den Driesch, 1976). We used the database Ossobook® for data recording (Kaltenthaler et al., 2018) and the R software (R Core Team, 2017) with ggplot2 package for data analysis (Wickham, 2016). Caprine slaughter age determination is based on the work of Manhart (1998). Due to the small number of horn cores and pelvic bones, we approximated the ratio of ewes to rams/wethers applying the logarithmic size index method (e.g., Meadow, 1999) instead of morphological determination. To gain insight into the distribution of skeleton elements, we calculated the percentage deviation from weight standard values for the main body regions in sheep and goat. A modern horned male sheep housed in the State Collection for Anthropology and Palaeoanatomy, Munich, (inventory no. 8) served as standard individual.

Large quantities of tiny fish bones preserved in ceramic vessels and refuse pits representing the remnants of fish sauces and related products as well as significant concentrations of (crushed) mollusc shells found embedded in the sediments are not detailed further in this study. The first category of finds is currently analysed by W. Van Neer and W. Wouters (Royal Belgian Institute of Natural Sciences, Brussels), the second, by graduate students at LMU Munich.

A detailed periodization of the site has been compiled based on stratigraphic observations as well as the study of pottery and small finds (Ritter & Ben Tahar, in preparation). Our study does not follow this chronology in full detail, but subsumed the results into five main cultural periods to maintain statistically meaningful analytical units.

4 | RESULTS

4.1 | Taxonomic composition

Of the 10,602 specimens examined, 6,295 (59.4%) could be taxonomically classified (Tables 1 and 2). The spectrum is highly diverse and comprises at least 69 species of mammals, birds, reptiles, fishes and various classes of molluscs. Taxonomic composition and the significant contributions of molluscs and fishes clearly illustrate that the exploitation of marine resources played an important role in the food economy at Meninx. Amongst the marine gastropods, the banded dye-murex (*Hexaplex trunculus*) is the species most commonly observed. Far less frequent is the spiny dye-murex (*Bolinus brandaris*). Although both species were utilized as food, only *Hexaplex* played an apparent role in the production of purple dyes. This is evidenced by the low number of spiny dye-murex shells and their complete preservation: waste shells from purple dye extraction are usually highly fragmentary because removal of the colourful ink requires breaking the shells (Ruscillo, 2005).

Game species such as dorcas gazelle and hartebeest were on the menu as well, yet the dietary contribution of these and other

TABLE 1 Taxonomic classification of the archaeofauna from Meninx (fourth century BCE to seventh century CE): *Mammalia*, *Aves* and *Pisces*

***Mammalia* (domestic)**			***Mammalia* (wild)**		
Species	NISP (*n*)	%	Species	NISP (*n*)	%
Equus asinus, donkey	7 (5[a])	0.1	*Alcelaphus buselaphus*, hartebeest	2	<0.1
Equus caballus, horse	9	0.1	*Gazella dorcas*, dorcas gazelle	30	0.5
Equidae, equids	15	0.2	*Oryx dammah*, scimitar oryx	1	<0.1
Camelus dromedarius, dromedary	1	<0.1	*Ursus arctos*, brown bear	1 (2[a])	<0.1
Bos taurus, cattle	370 (17[a])	6.1	*Lepus capensis*, desert hare	6	0.1
Ovis aries, sheep	314	5.1	*Oryctolagus cuniculus*, European rabbit	3 (20[a])	<0.1
Capra hircus, goat	61 (4[a])	1.0	*Oryctolagus/Lepus*	2	<0.1
Ovis aries/Capra hircus	3,765	61.6	*Ictonyx libyca*, Saharan striped polecat	1	<0.1
Sus domesticus, pig	520 (7[a])	8.5	*Jaculus orientalis*, greater Egyptian jerboa	3	<0.1
Felis catus, cat	1	<0.1	*Jaculus* sp.	3	<0.1
Canis familiaris, dog	38 (69[a])	0.6	*Meriones libycus*, Libyan jird	13	0.2
			Rattus rattus, black rat	15	0.2

Aves			***Pisces* (*Osteichthyes* & *Chondrichthyes*)**		
Species	NISP (*n*)	%	Species	NISP (*n*)	%
Gallus gallus, dom. chicken	239	3.9	*Balistes carolinensis*, grey triggerfish	2	<0.1
Columba livia f. domestica, dom. pigeon	1	<0.1	*Balistidae*, triggerfishes	4	0.1
Alectoris barbara, barbary partridge	2	<0.1	*Carangidae*, jacks	3	<0.1
Columba livia, rock dove	2 (30[a])	<0.1	*Dentex dentex*, common dentex	1	<0.1
Columba palumbus, common wood pigeon	(5[a])	—	*Dentex* sp.	2	<0.1
Coturnix coturnix, common quail	1	<0.1	*Pagrus pagrus*, common seabream	1	<0.1
Lymnocryptes minimus, jacksnipe	1	<0.1	*Pagrus* sp.	2	<0.1
Numenius arquata, Eurasian curlew	1	<0.1	*Sparus aurata*, gilt-head seabream	9	0.1
Otis tarda/Ardeotis arabs, Arabian or great bustard	1	<0.1	*Sparidae*, seabreams	3	<0.1
Phalacrocorax carbo, great cormorant	1	<0.1	*Epinephelus aeneus*, white grouper	1	<0.1
Tyto alba, western barn owl	(18[a])	—	*Epinephelus* sp.	5	0.1
			Serranidae, combers	82	1.3
			Euthynnus alletteratus, little tunny	11	0.2
			Scombridae, mackerels, tunas and bonitos	3	<0.1
			Gobiidae, gobies	1	<0.1
			Carcharhinidae, requiem sharks	1	<0.1
			Triakidae, houndsharks	6	0.1
			Batoidea, rays	3	<0.1
			Myliobatidae, eagle rays	5	0.1

[a]Partial skeletons.

nondomestic mammals was insignificant. This also applies to the species of wild birds recorded at the site. Thus, despite the high diversity of wild taxa, domestic animals were the mainstay of meat procurement at Meninx. Their remains account for 87.4% of the identified specimens, whereby those of meat-producing cattle, sheep, goats and pigs constitute the bulk of the assemblage. Remains of animals not usually consumed as food including the donkey, horse and dog number few (Table 1). The domestic cat and the dromedary are even represented with only one specimen each. Dating to the late fourth/first half of the fifth century CE, the evidence for the dromedary is nevertheless noteworthy, as this species was successively introduced into Northern Africa only in Roman times (Peters, 1997). We also note that small domestic ruminants are the most commonly exploited animals (67.7%), with sheep outnumbering goats five to one. According to the comparatively high percentage of chicken remains (3.9%), poultry farming was economically rewarding as well.

From a diachronic perspective, taxonomic composition at Meninx proved to be surprisingly constant (Figure 3). Based on the relative frequencies of the main animal taxa, species composition did not vary significantly with time. Over the entire period of settlement, domestic ovicaprines contributed about or more than 60% to the faunal assemblages. Pigs and cattle were exploited in much lower numbers, with

TABLE 2 Taxonomic classification of the archaeofauna from Meninx (fourth century BCE to seventh century CE): *Bivalvia*, *Gastropoda* and additional taxa

Bivalvia			***Gastropoda* (marine and terrestrial)**		
Species	NISP	%	Species	NISP	%
Acanthocardia aculeata, spiny cockle	1	<0.1	*Bolinus brandaris*, purple dye murex	42	0.7
Acanthocardia tuberculata, rough cockle	3	<0.1	*Cerithium vulgatum*, common cerith	30	0.5
Acanthocardia sp.	1	<0.1	*Cerithium* sp.	12	0.2
Arca noae, Noah's Ark shell	2	<0.1	*Columbella rustica*, dove shell	1	<0.1
Atrina fragilis, fan mussel	6	0.1	*Conus mediterraneus*, Mediterranean cone	9	0.1
Cerastoderma edule, common cockle	1	<0.1	*Hexaplex trunculus*, banded dye murex	351	5.7
Chlamys varia, variegated scallop	2	<0.1	*Lunatia catena*, chained moon-shell	1	<0.1
Chlamys sp.	2	<0.1	*Naticarius stercusmuscarum*, fly-specked natica	3	<0.1
Mytilus edulis, blue mussel	1	<0.1	*Neverita josephina*, Josephine's moon snail	1	<0.1
Ostrea edulis, European flat oyster	2	<0.1	*Pisania striata*, striate pisania	1	<0.1
Pinna nobilis, noble pen shell	1	<0.1	*Turritella communis*, tower shell	1	<0.1
Spondylus gaederopus, European thorny oyster	36	0.6	*Zonaria pyrum*, pear cowry	1	<0.1
			Cernuella virgata, striped snail	1	<0.1
			Helix aspersa, brown garden snail	2	<0.1
			Helicidae, Roman snails	2	<0.1
			Otala sp.	1	<0.1

Note: Additional taxa (n = 26): *Brachyura*, crabs; *Canidae*, canids; *Caretta caretta*, loggerhead sea turtle; *C. caretta*/*Chelonia mydas*, loggerhead sea turtle/green turtle; *Homo sapiens*, human; *Sepia officinalis*, common cuttlefish.

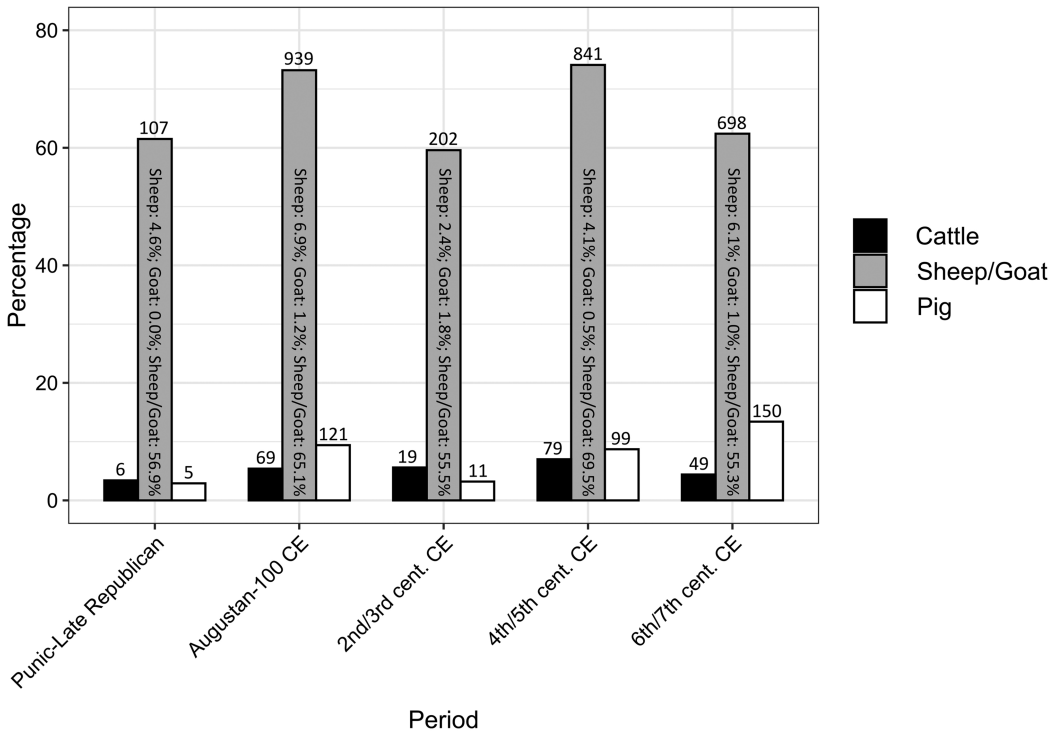


FIGURE 3 Livestock composition at Meninx. Diachronic development based on NISP counts

maximum contributions of 9.4% and 7.0%, respectively. Most notably, no significant changes in the economic importance of the individual species could be observed in any cultural epoch from Punic until Byzantine times, reinforcing the picture that during more than 1,000 years of livestock breeding in the site catchment of Meninx, sheep farming was the economic mainstay at all times.

Those patterns correspond well with the zooarchaeological results on smaller Imperial Period complexes from Meninx, which were

investigated during the excavations of the University of Pennsylvania (Fabis, 2009): here, too, small ruminants clearly prevail with about 72% according to number of identified specimens (NISP), while pig (about 12%) and cattle (about 2%) were economically far less important (calculated on the basis of data in Fabis, 2009).

4.2 | Caprine exploitation

The aforementioned does not necessarily imply, however, that the mode and hence goals of sheep exploitation remained constant throughout site occupation. To verify this, we analysed the sex and age profiles of sheep from the Augustan Period up to the fifth century CE versus the sixth–seventh centuries CE. As such, the logarithmic size index applied to osteometric data revealed marked size differences (Figure 4). Whereas measurements in the first population mainly cluster above or near the value of −0.11 and are therefore skewed to the right (Figure 4a), the material from the sixth–seventh centuries CE is skewed to the left, indicative of a shift towards smaller sized individuals (Figure 4b). With values below −0.11, the sheep of Byzantine Meninx likely had a lower body mass compared with their Roman counterparts. Application of the Wilcoxon rank sum test with alpha inflation according to Bonferroni to our data supports this observation because pairwise comparison of the data below and above −0.11 resulted in respective p values of 0.00005 and 0.00000047 for the sheep of the Roman and Byzantine occupation phases. In premodern animal husbandry systems, changes in size and/or stature of farm animals often result from crossbreeding with selected phenotypes deliberately introduced to produce some desired trait. Particularly in Roman provincial contexts, such new breeding goals are presumed to be the attempt to adapt indigenous husbandry practices to changing market demands in order to ensure the economic basis for local populations in the aftermath of the Roman occupation (e.g., Trixl, 2019). For Meninx, however, this scenario is not plausible, considering that prosperity was already on the decline during the Byzantine Period. Moreover, because size distribution in

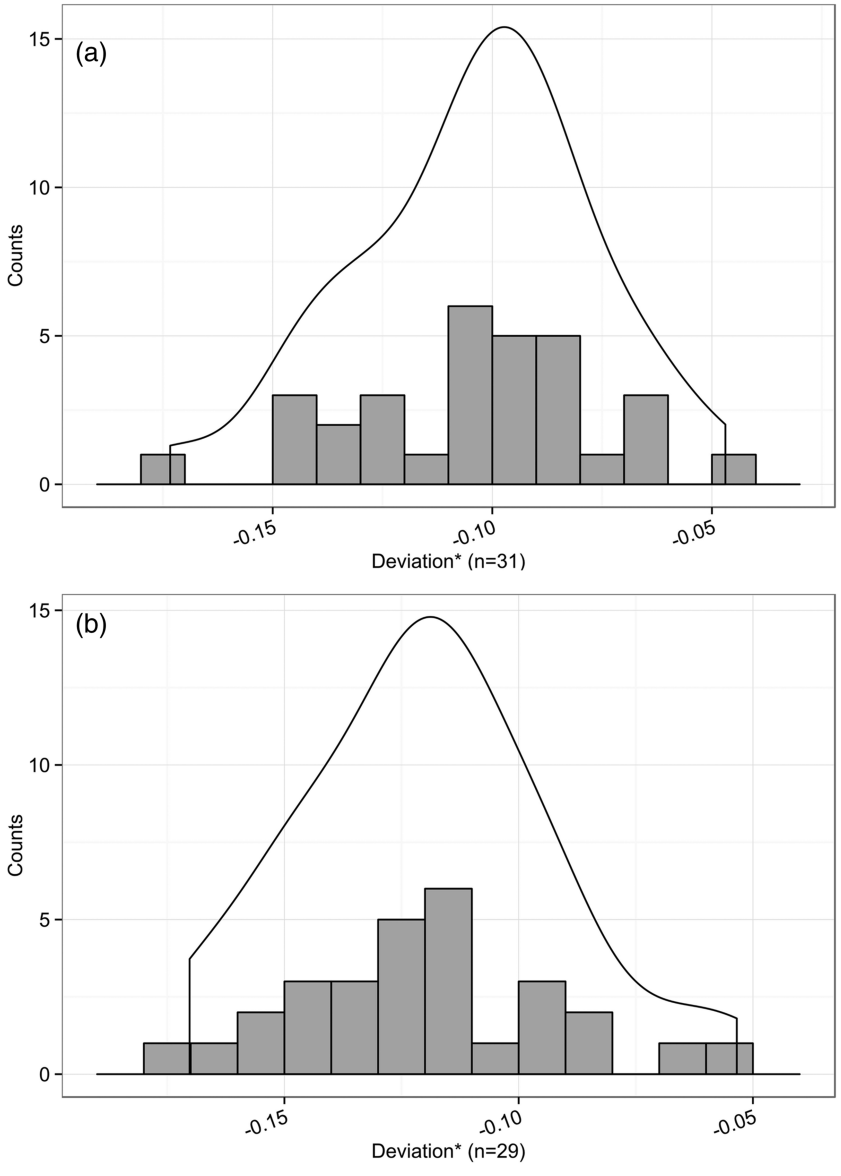


FIGURE 4 Sheep. Logarithmic size index. (a) Applied to bone measurements from the Augustan Period to the fifth century CE. (b) Applied to bone measurements from the sixth to seventh century CE *Standard individual: modern female sheep, Bavarian State Collection for Anthropology and Palaeoanatomy, Munich (individual no. 6)

Roman and Byzantine sheep overlaps (both at −0.18 and −0.05/−0.04) and because both populations separate around the same value at −0.11 (Figure 4), sexual dimorphism and more precisely the shift in the ratio of males to females seems a more likely explanation, with proportionately more male sheep being consumed in Roman Meninx versus a larger contribution of ewes to Byzantine meat provisioning.

Because goats occur in much smaller numbers in Meninx, no statistically reliable data regarding the size and sex distribution can be provided for this species.

Based on slaughter profiles (Figure 5), it becomes apparent that most age classes are represented, yet ovicaprines 2 years and older predominate. This implies that people exploited a significant part of the sheep population for their secondary (lifetime) products, such as milk, wool and dung. Conversely, a considerable proportion of animals had been eliminated from the flocks upon reaching their ideal slaughter weight at 1.5 to 2 years of age. This may reflect an additional focus on specialized meat production at Meninx in the first century CE. Secondary products nonetheless already played a role during Augustan times, as reflected by ovicaprines aged 2 years and older. In the course of site occupation, these age groups increased significantly. It seems plausible that also the economically far less important goat has been exploited for lifetime products, first and foremost milk, but this cannot be ascertained due to poor sample size (Figure 5). Another striking observation is the absence of bones of foetal and newborn ovicaprines, implying that sheep breeding and lambing took place *extra muros*. However, this does not apply to the pig because osseous remains of foetal/newborn piglets evidence reproduction and rearing in the settlement.

According to the distribution of skeletal elements, ovicaprines were driven to the settlement for slaughter: the ratio of meat-bearing body parts (consumption waste) and sections of low meat value (slaughter waste) is rather balanced across all periods. The values presented in Table 3 show an apparent underrepresentation of cranial elements, including horn cores, and elements of the trunk in particular. However, during skinning parts of the skull including the horns often remain in the skin to be processed elsewhere. During further processing for tanning, people likely removed the horn sheaths to make objects used in daily life (e.g., Peters, 1998). The low percentage of ribs and vertebrae in the Meninx assemblage can best be explained by their relative fragility compared with long bones, complicating identification of these elements, especially when heavily fragmented (e.g., Pucher, 2014). In addition, scavenging by dogs may have affected skeletal representation as well. The striking overrepresentation of the shin bone and forearm region (*Zeugopodium*) is explained by taphonomic bias as well: both the *tibia* and *radius* have a strong cortical bone structure favouring preservation. Moreover, these elements possess morphologically distinct characteristics that facilitate their identification, explaining why *Zeugopodia* are often 'overrepresented' in archaeofaunas (e.g., Trixl, 2019). Other meat-bearing body parts, such as the *Zonopodium*, show a normal and nearly equal distribution. This also applies to the *Autopodium*, which represents typical slaughter waste.

These distribution patterns deduced from the total ovicaprine assemblage are paralleled when considering just sheep (Table 3). The only striking difference is that trunk elements are even more underrepresented here. We explain this by the fact that specific

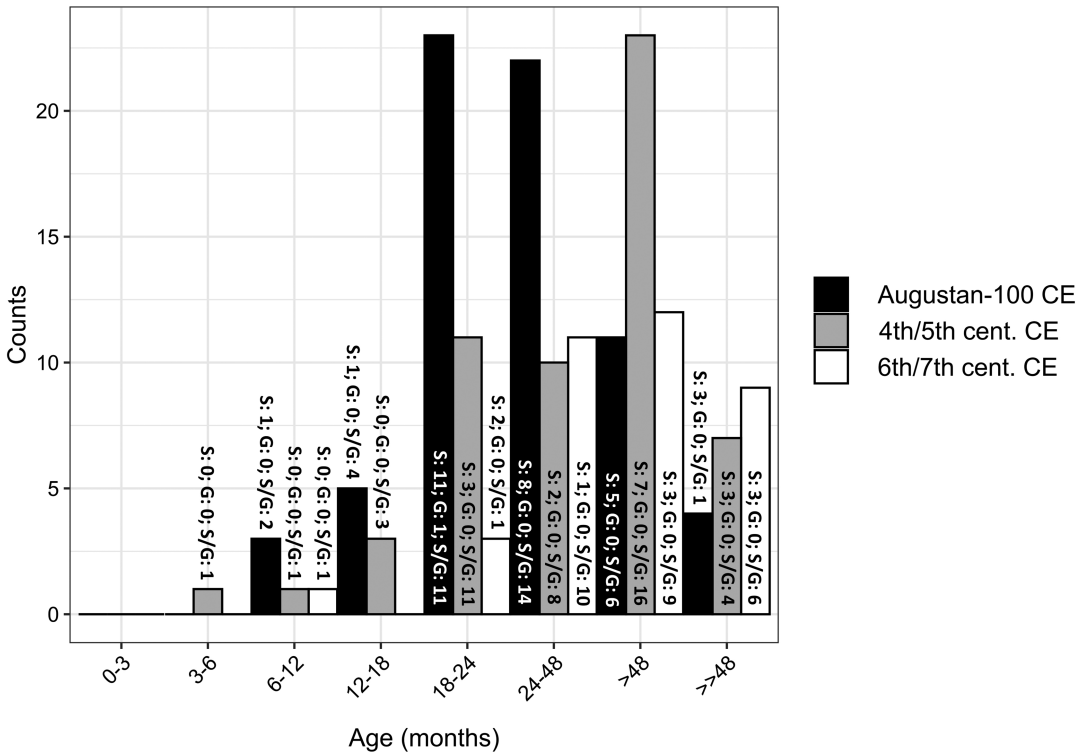
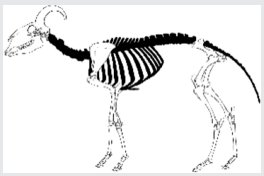
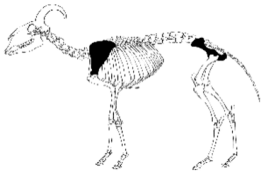
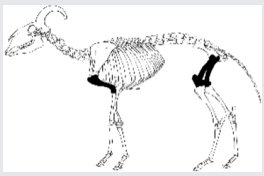
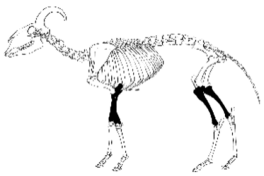
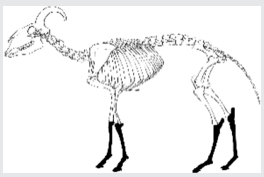


FIGURE 5 Sheep and goat. Age distribution based on mandibular and maxillary teeth. Abbreviations: S, sheep; G, goat; S/G, sheep/goat

TABLE 3 Skeletal element distribution in ovicaprines: deviation of percentage weight standard values

Body part		Period	Percentage deviation of standard weight values			
			Ovicaprines total	Sheep or goat	Sheep	goat
Head		Punic–Late Republican	−17.7	−18.8	−8.1[a]	no data
		Augustan–100 CE	−2.5	−15.9	37.9	14.3[a]
		2nd/3rd cent. CE	−2.4	−5.7	23.5[a]	−12.7[a]
		4th/5th cent. CE	3.6	−3.6	34.8[a]	53.4[a]
		6th/7th cent. CE	−7.4	−8.7	−1.6	−9.0[a]
Trunk		Punic–Late Republican	−24.8	−23.3	−33.6[a]	no data
		Augustan–100 CE	−21.4	−16.9	−33.6	−33.6[a]
		2nd/3rd cent. CE	−13.0	−8.4	−33.6[a]	−33.6[a]
		4th/5th cent. CE	−17.8	−15.0	−30.3+	−33.6[a]
		6th/7th cent. CE	−21.6	−18.5	−32.8	−33.6[a]
Zonopodium		Punic–Late Republican	5.3	7.4	−6.9[a]	no data
		Augustan–100 CE	3.4	4.6	0.1	−0.2[a]
		2nd/3rd cent. CE	−2.2	−1.2	−6.9[a]	−6.9[a]
		4th/5th cent. CE	−1.2	0.0	−6.9[a]	−6.9[a]
		6th/7th cent. CE	0.1	−0.2	2.1	−6.9+
Stylopodium		Punic–Late Republican	5.3	4.7	11.8[a]	no data
		Augustan–100 CE	5.1	8.9	−5.3	−3.6[a]
		2nd/3rd cent. CE	4.2	5.5	−8.1[a]	13.1[a]
		4th/5th cent. CE	1.4	3.2	−6.9[a]	−8.1[a]
		6th/7th cent. CE	6.2	9.5	−6.0	−8.1[a]
Zeugopodium		Punic–Late Republican	31.2	33.4	22.9[a]	no data
		Augustan–100 CE	16.8	23.1	−4.1	17.1[a]
		2nd/3rd cent. CE	12.5	13.0	4.4+	23.8[a]
		4th/5th cent. CE	16.5	20.9	−3.5[a]	−9.0[a]
		6th/7th cent. CE	20.5	21.6	16.5	17.6[a]
Autopodium		Punic–Late Republican	0.8	−3.5	31.2[a]	no data
		Augustan–100 CE	−1.5	−3.8	4.9	5.6[a]
		2nd/3rd cent. CE	0.9	−3.2	20.7	16.3[a]
		4th/5th cent. CE	−2.5	−5.5	12.8[a]	4.2[a]
		6th/7th cent. CE	2.1	−3.7	21.8	40.0[a]

[a]$n < 50$ (values not reliable).

identification of vertebrae and ribs is rarely possible. As outlined above, for reasons of small numbers, body part distributions of goats (Table 3) are not statistically reliable. Having said that, it can be postulated that goats, like sheep, were slaughtered on-site as well.

4.3 | Purple dye production

As mentioned earlier, antique Meninx was well known for producing high quality purple dyes. Marine gastropod composition at the site indicates that this activity depended exclusively on the exploitation of *H. trunculus*, a species used for this purpose since the Bronze Age (e.g., Marín-Aguilera, Iacono, & Gleba, 2018). Given the huge figures of snails required to produce an economically viable quantity of dye, the number of *H. trunculus* specimens observed in the hand-collected material from Meninx (Table 2) would hardly suffice to confirm Pliny the Elder's statement. Support comes, however, from several wet-sieved units containing large amounts of highly fragmented banded dye-murex specimens. For example, a soil sample of about 80 L originating from stratigraphic unit 4,028, a late antique context located in the *forum*, yielded 2,264 small fragments of *H. trunculus* representing at least 54 individuals. For understandable reasons, the bulk of the shell debris resulting from dye production was likely disposed of outside residential areas, as some very large heaps in the catchment area surrounding the Meninx site illustrate. Conceivably, broken shells stemming from the *Hexaplex* exploitation may only be found in accumulated deposits *intra muros* in specific situations, for instance, for drainage purposes. Although *Hexaplex* accumulations were not the

focus of recent excavations, other shell middens, some up to 5 m high, have been investigated during surveys conducted by the University of Pennsylvania (Fentress, 2018). Similar-sized gastropod shell deposits have been found in Guellala, approximately 8 km northwest of Meninx (Ben Tahar, 2019).

5 | DISCUSSION

The results presented here indicate that despite major political and cultural changes, livestock composition remained basically the same from the fourth century BCE until the seventh century CE at Meninx (Figure 3). Markers of Romanization including intensification of pig and poultry farming seem marginally visible in the faunal record. Conversely, the extraordinary importance of sheep as the mainstay of animal husbandry is to be emphasized. One explanation for this is offered by the eco-geographical conditions characterizing the southeastern Tunisian coastal region. Here, the conditions of the hot, arid steppe (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006) with vegetation adapted to frequent droughts offered suitable conditions for farming. Accordingly, ovicaprines are the predominant species in most Punic, Roman and Vandal/Byzantine archaeofaunas in arid Tunisia (Figure 6). Meninx, however, shows an exceptionally heavy reliance on sheep husbandry, even by northern African standards (see also King, 2001, with further references). This tradition was not interrupted by the economic transformations evoked by Roman occupation, as is illustrated by the results presented above as well as Fabis' study (2009). Therefore, in addition to suitable eco-geographic conditions, other factors must be considered

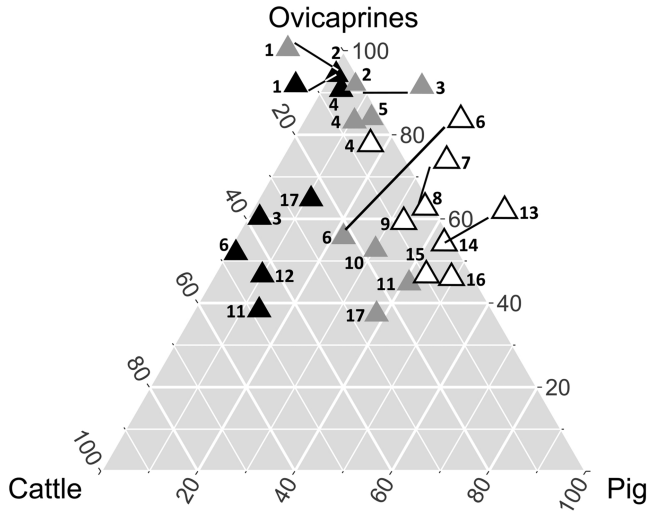


FIGURE 6 Composition of main livestock species at Meninx in relation to other Northern African sites based on NISP counts. Black = Punic; grey = Roman; white = Vandal/Byzantine. Sites: (1) Henchir Bourgou; (2) Zita; (3) Ghizène; (4) Meninx; (5) Meninx, Exc. Univ. Pennsylvania; (6) Benghazi; (7–16) (7) Carthage: Ecclesiastical Complex, (8) Avenue Habib Bourguiba, (9) Ile de l'Amirauté, (10) House of Greek Charioteers, (11) Quartier Magon, (12) Magon, (13) Cistern 1977.2, (14) Cistern 1977.1, (15) Yasmina, (16) Kobbat Bent el Rey; (17) Bir Messaouda

to explain the intensity of sheep breeding maintained throughout site occupation. For several reasons, economic specialization on wool production is probable. For example, age profiling of small ruminants illustrates an emphasis on the exploitation of secondary products. Also, judging from their contribution to meat provisioning at Meninx, male sheep were obviously kept in significant numbers until they reached adulthood. Because (castrated) male sheep are well suited for the production of large quantities of high-quality fleece (e.g., Khan et al., 2012, 13,764), herd management was adjusted to match these needs, a strategy recommended in antique writings on agriculture, for example, by Columella (*de re rustica* VII). As such, the production of wool combined with the compelling archaeological evidence for the exploitation of *Hexaplex* as well as written sources confirming the quality of purple dyes from Meninx support the postulation that manufacturing of coloured textiles contributed significantly to the city's economic prosperity (Figure 7). Analogous to other coastal sites in the Mediterranean world, an interdependent *chaîne opératoire* was established involving the breeding and selection of sheep, seasonal shearing of wool, washing and sorting the different qualities of fibre, gathering of snails and processing them for purple ink extraction, dyeing of wool and its spinning and finally weaving of the dyed fibres into varied kinds of textiles (Marín-Aguilera et al., 2018; Ruscillo, 2005). Selling these valuable goods was made possible through the opening of new markets following the integration of Meninx into the Mediterranean trade networks.

However, apart from the osteoarchaeological evidence, there are almost no other indicators for wool industry in Meninx. Because excavations focused on the urban core of the city, the absence of tools related to textile handicraft may be explained by hazard of discoveries. However, it seems even more plausible to assume that spinning and weaving took place in settlements elsewhere on Jerba and the African mainland. For instance, at Gigthis, a site situated only 30 km southwest of Meninx at the Gulf of Bou Ghrara, a Roman inscription was recovered mentioning *Memmius Messius Pacatus*, a city dignitary owning a local fullery (Constans, 1914). Because the dying industry itself was demonstrably located at Meninx, it can be argued that ready-woven but yet undyed textiles were provided by surrounding communities (Figure 7). Having said that, from experimental studies, we know that raw unwoven wool was by far the most suitable for dyeing (Marín-Aguilera et al., 2018; Ruscillo, 2005). In order to decide whether in Meninx this concept was abandoned in favour of others, today, unknown local constraints or whether the model proposed in Figure 7 will have to be modified, one has to await future excavations on Jerba, for example, at Henchir Bourgou (Ben Tahar et al., 2020), and the nearby mainland.

Equally difficult to answer for the moment is the issue whether at Meninx and its hinterland, the economic symbiosis of dying and weaving currently associated with the Imperial Period was rooted in Punic traditions. One major problem is that the age and sex distribution of pre-Roman sheep populations in Meninx cannot be detailed yet. Nonetheless, some observations suggest a Punic origin for this *chaîne opératoire*, more precisely the fact that (a) pre-Roman faunal samples already contained significant proportions of small ruminant remains (Figure 6) and (b) several fourth century BCE contexts yielded

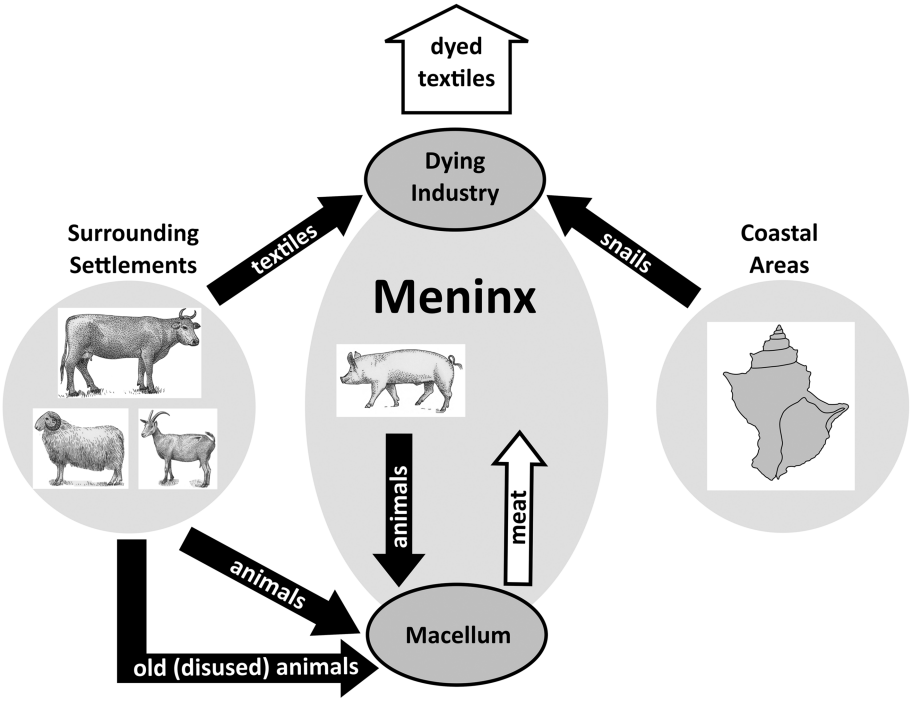


FIGURE 7 Exploitation model of animal resources at Meninx and its surroundings until the fourth/fifth century CE. Black arrows: resource provision; white arrows: product provision (drawings: Cornelie Wolff)

assemblages of highly fragmented *Hexaplex* shells (Ritter & Ben Tahar, 2020).

After the Imperial Period, this elaborate economic system was on the decline: although small ruminants remained prominent in the Byzantine diet (Figure 3), a shift in the sex ratio of adult sheep towards ewes suggests that in the sixth/seventh century CE, wool production had been cut back in favour of dairy farming. We also noted the lack of crushed purple snails in Byzantine strata, thus supporting the assumption that the manufacture of dyed textiles had by this time already been reduced or even ceased. Arguably, the transition from a specialized economic activity to a self-sufficient subsistence strategy likely relates to the upheavals associated with Rome's loss of power in the fifth century CE. The latter probably resulted in the disappearance of major markets formerly supplied with purple-dyed textiles and the emergence of novel strategies for making a living locally. Despite the loss of an important livelihood and a major source of wealth, Meninx apparently continued to participate in large-scale Mediterranean trade given the uninterrupted import of ceramic fine wares up to the seventh century CE.

In order to find out if the long-term continuity of economic structures like those seen in Meninx (Figure 7) was paralleled elsewhere in Punic–Roman settlements on the Tunisian and Libyan Mediterranean coasts, intersite comparisons were carried out (Figure 6). Like in Meninx, analysis of the archaeofauna from Libyan *Berenice* (Benghazi), for which Barker (1979b) also assumed production of purple dye, does not indicate a shift in relative frequency of domestic species from Punic to Roman times either, implying continuity. Conversely, at Carthage, pork became a much more important source of protein and fat during the Imperial Period in general. In other words, barnyard composition in the environs of Carthage was much more influenced by Roman–Italic husbandry practices (MacKinnon, 2018) than in Berenice or Meninx. Also, evidence for pig husbandry in Zitha implies new cultural influences in Roman times, even if in this case, the economic continuity into the Punic Period is much more stable (Moses et al., 2019). For some continuously inhabited sites like Bir Messaouda, decreasing proportions of cattle and an increase in ovicaprines could be observed, which may signify a higher demand for wool in Roman times (Azaza & Colominas, 2019).

Figure 6 illustrates that Jerbian animal economies stand out and are diachronically characterized by extraordinarily high proportions of sheep. Large parts of the island and perhaps the adjacent mainland probably focused on wool production, at least during the Imperial Period. However, even in Jerba, subsistence strategies varied locally. This is illustrated by the animal remains from Henchir Bourgou, where farming of pigs and poultry or the exploitation of *Hexaplex* were not practiced (Ben Tahar et al., 2020). This is also true for Henchir Bourgou's seaport, the site of Ghizène, where sheep and goat clearly prevail. Here, in the pre-Roman times, layer of remains of goats clearly outnumbered those of sheep, while the latter became more important during the Imperial Age (Azaza & Colominas, 2019). A similar development can be observed at Henchir Bourgou itself: breeding dairy goats was an important economic activity from the beginning of site occupation, which continued in Roman times when sheep farming was on the rise, albeit in a somewhat weakened form. We therefore hypothesize that the findings from Punic Henchir Bourgou may be reminiscent of subsistence practices rooted in pre-Punic cultures of southeastern Tunisia, but this needs to be verified with future archaeological work.

Finally, it could be expected that Bourgou's proximity to Meninx led to major adjustments to animal husbandry practices imposed by their powerful Roman neighbours, but this is obviously not the case. This poses the question whether its inhabitants consciously chose to reject Roman–Italic influences. While further investigations are

needed to clarify this, persistence of autochthonous cultural traditions has already been noticed elsewhere in the Roman provinces (e.g., Peters, 1998; Trixl, 2019).

6 | CONCLUDING REMARKS

Due to the large amount of material, its large biodiversity and the specific archaeological context, the archaeofauna from Meninx provides novel insights into the exploitation of bioresources by premodern societies in coastal northern Africa: for this Mediterranean island community, the economic symbiosis of purple dye and textile production was of crucial importance over a period of several hundred years. Thus, the city's prosperity was based above all on animals, especially sheep and (purple-)snails providing the raw materials for this much valued commodity. Furthermore, domestic animals and to some lesser extent a wide variety of game, birds and marine taxa ensured local supply with animal primary and secondary products (Figure 7).

Diachronic changes in exploitation patterns of these resources reflect sociocultural developments of supraregional significance. This is especially true for the decline of purple-dyed textile production in Meninx during the fifth/sixth century CE, for which the political upheavals of late antiquity with their far reaching economic consequences, first and foremost the collapse of former markets, may be responsible. Arguably, the abandonment of this highly specialized *chaîne opératoire* forced the local population to return to more self-sufficient subsistence strategies. According to archaeological findings, this socio-economic change went hand in hand with a phase of local disurbanization, at the end of which, in the seventh century CE, Meninx was finally abandoned.

In sum, zooarchaeological results from coastal Tunisia in general and from Jerba in particular show how diverse communities reacted and interacted in times of major cultural change.

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ORCID

Simon Trixl https://orcid.org/0000-0003-4303-3008
Joris Peters https://orcid.org/0000-0003-0894-2628

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