



Livestock Economy at Berenike, a Hellenistic City on the Red Sea (Egypt)

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Published online: 30 August 2019
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Abstract Berenike Trogodytika was one of the cities founded by Ptolemy II in the early third century BC as a trans-shipment point for importing East African elephants for the Hellenistic Egyptian army. Our archaeological research at the site has resulted in the analysis of 9498 animal remains and 8644 mollusc shells that revealed the environmental conditions of the Hellenistic port and fortress and some changes in the residents' food economy and diet. The diet of the Berenike garrison in the first period of operation (about the first half of the third century BC) was based on grains and marine fauna—fish and molluscs, with sheep and goats as supplementary sources of meat. In the “fort” area, remains of animals imported from the Nile Valley, namely cattle and pigs, appeared only sporadically. In the second half of the century, the importance of local products in the diet decreased. Instead, large cattle and very large and stout goats became the sources of the inhabitants' meat consumption. This shift demonstrates that Hellenistic Berenike was linked to well-organized food supply networks, especially with places that had a well-developed animal breeding economy. This article discusses the archaeological evidence of this shift in meat

consumption and the implications for livestock economy in Hellenistic Berenike.

Résumé Berenike Trogodytika était l'une des villes fondées par Ptolémée II au début du III^e siècle avant notre ère, principalement comme lieu de transbordement pour l'importation d'éléphants d'Afrique de l'Est pour l'armée égyptienne hellénistique. Les recherches archéologiques présentées ici ont analysé 9498 restes d'animaux et 8644 coquilles de mollusques révélant les conditions environnementales dans lesquelles le port et la forteresse hellénistiques avaient été construits. Le régime alimentaire de la garnison de Berenike au cours de la première période d'opération (environ la première moitié du III^e siècle av. J.-C.) était basé dans une large mesure sur les céréales et la faune marine - poissons et mollusques. La viande de mouton et de chèvre n'était qu'un supplément. Dans la zone dite «fort», des restes d'animaux importés de la vallée du Nil, notamment des bovins et des porcs, ne sont apparus que sporadiquement. Au fil du temps (seconde moitié du III^e siècle av. J.-C.), l'importance des produits locaux dans l'alimentation a diminué, ce qui est lié au fonctionnement de réseaux d'approvisionnement alimentaire bien organisés. Dans le Berenike hellénistique, il semble que les habitants utilisaient principalement des animaux provenant de zones d'élevage bien développées - gros bétail et chèvres très grosses et robustes.

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Keywords Archaeozoology · Livestock · Hellenistic Egypt · Ancient diet · Red Sea ports

Introduction

The Egyptian rulers' interest in the Red Sea dated, at least, as far back as the Middle Kingdom (Bard and Fattovich 2011). During the Ptolemaic period, this inhospitable area, with limited potable water or food supplies, was used as a base for mounting regular trading expeditions to what is now the Horn of Africa, Somalia, and Sudan. A vital element of this undertaking was the construction of a network of fortresses and ports, the most important of which was Berenike (Casson 1993, p. 257; Desanges 1978; Sidebotham 2011, p. 13; Wilcken et al. 1912, p. 452). The excavations at Berenike allow us to begin to understand how the Ptolemaic state provisioned this fort and port city. The viability of Berenike depended on state intervention in terms of ensuring that food supplies reached the military bases at the fort. Archaeological evidence shows an unprecedented scale of state investment in Berenike in terms of architecture and Hellenistic cultural influence. Not only is the pattern of meat consumption and the use of farm animals evident of Hellenistic influence but the logistics for provisioning the port

with drinking water and farm animal meat also show evidence of state intervention. All of these demonstrate that Berenike was a cornerstone of the Ptolemaic (and later, Roman) economic policy in transforming the Red Sea into a highway for supplying Egypt with products from the African hinterlands, India, and Arabia.

This study examines the fauna collected from the archaeological research in Ptolemaic Berenike during the 2010–2018 seasons under the direction of S. Sidebotham (University of Delaware) and I. Zych (PCMA UW) (Sidebotham and Zych 2011, 2017). The excavations that generated the data took place in the earliest Ptolemaic part of the fort and a few other areas of the port city. These were functionally diversified sites, and they dated from the third to the mid-second century BC.

Location

Our research encompassed the area west of the ruins of the Roman city (Fig. 1). The chronology of some Hellenistic structures was determined from coins and pottery. These finds indicate the second half of the third century BC as the

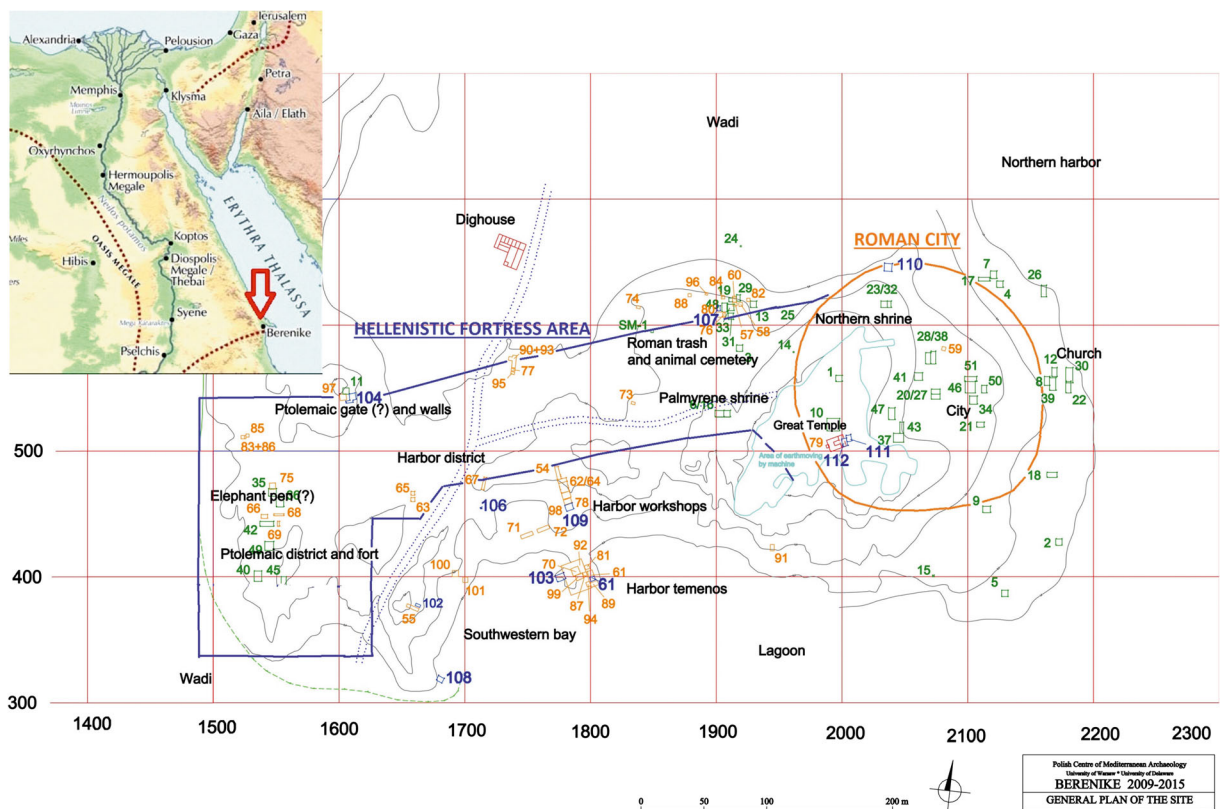


Fig. 1 Study Area: Hellenistic fortress and Roman city at Berenike (M. Woźniak)

peak of settlement activity. Excavations and magnetic surveys in 2010–2018 concentrated in four locations (Fig. 2). The first location is in the southwestern part of the site. A large fortified building (c. 150 m × 80 m) functioning as a warehouse/workshop—the so-called “fort”—was in this area during the early Hellenistic period (Woźniak and Rądkowska 2014, p. 511–513). Trenches located here (BE 10-66, BE 10-68, BE 10-69, and BE 11-75) exposed part of the western frontage of rooms adjacent to a vast yard, some storage features, and portions of the so-called “V-shape ditch” (Sidebotham and Wendrich 2002, p. 26–27; Sidebotham et al. 2008, p. 162–164). This dry ditch, according to one hypothesis, surrounded an enclosure for elephants transported through Berenike in the Ptolemaic period (Sidebotham et al. 2008, p. 162–164; Woźniak and Rądkowska 2014, p. 511).

The second research area comprised of three trenches (BE 12-83, BE 12-85, and BE 12-86) and included the remains of a corner tower in the northern courtyard of the “fort” (Woźniak and Rądkowska 2014, p. 516). The stratigraphy of these trenches indicates that this area was the oldest part of the structure, and was connected with the V-shaped ditch, which was developed several times into a large “fort” in mid-third century BC. Four trenches (BE

11-77, BE 13-90, BE 13-93, and BE 14-95) were sited in the third location, near the northern defensive wall of the city and at the trash dump locales to the south (Woźniak 2018, p. 45–46). These dump sites were associated with the residential quarter of Berenike in the second half of the third century BC. The fourth group of trenches consisted of BE14-97 and BE15/18-104, located north of the “fort.” They exposed the well-preserved remains of a stone gate dated to the early Hellenistic period (first half of the third century BC) and rebuilt, in the second half of the century, into a large building with an internal well and a sophisticated water distribution system (Woźniak 2018, p. 50–57).

Material and Methods

During the seven seasons (2010–2018) of excavations, we collected a total of 9498 remains of vertebrate animals and 8644 fragments of shells of molluscs from the four excavated areas of Ptolemaic Berenike (Table 1). Due to the specificity and richness of data and our expertise, the present paper focuses mainly on the analysis of mammalian and bird remains. Belgian scientists exploring the site in the late twentieth century also

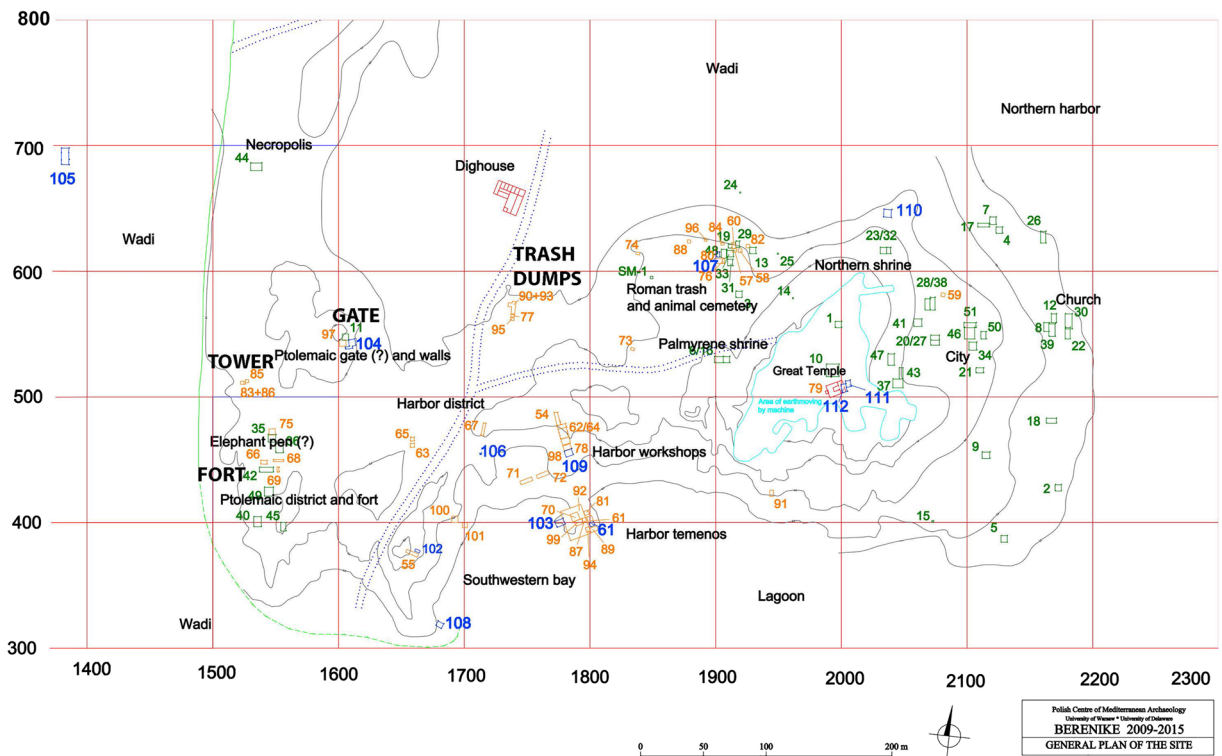


Fig. 2 Localization of four groups of trenches excavated during the 2010–2018 seasons (Woźniak)

Table 1 Frequency and percentages of remains representing animal taxa, Hellenistic Berenike

Taxa	N	%
Invertebrates (<i>Brachyura</i> , Gastropoda, Bivalvia, Cephalopoda)	8644	65.5%
Fish (Serranidae, Lethrinidae, Scaridae, Lutjanidae, Acunthuridae, Platacidae, Pomacanthidae, Siganidae, Ostraciidae, Tetraodontidae, Diodontidae, Sparidae, Dasyatidae, Mugilidae, Carcharinidae, Carangidae, Scombridae)	2982	22.6%
Reptiles (Cheloniodea)	15	0.1%
Birds (<i>Coturnix</i> , <i>Gallus</i>)	160	1.2%
Mammals (Rodentia, Canidae, Felis, Elephantidae, Camelus, Equidae, Sus, Bovidae)	1404	10.6%
Total	13,205	100

reported Ptolemaic archaeozoological materials from Berenike (Van Neer and Ervynck 1998, 1999; Van Neer and Lentacker 1996). Their collections came from different locations and cannot be reconciled with any specific spatial contexts. Thus, we decided not to include it in the present study.

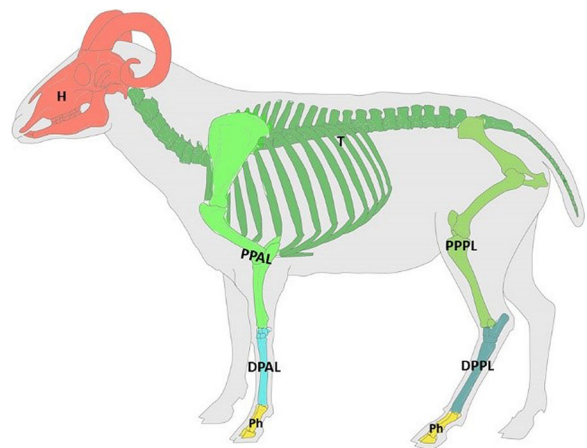
The vertebrate remains were recovered in poor preservation conditions (Fig. 3). Many taphonomic factors, appearing both at the biostratinomic and diagenetic stages, caused this poor preservation (Marom 2016). Our quantification method used numbers of identified specimen (NISP) to report the remains of the vertebrates. The analysis used the standard zoological nomenclature for domesticated and wild animals

**Fig. 3** State of preservation of animal remains from Ptolemaic archaeological contexts in Berenike (M. Osypińska)

(Cichocki et al. 2015; Gentry et al. 2004; Mammals of Africa 2013; Stuart and Stuart 2006; Walker 1985). We aimed for precise identification of species in the mammalian assemblage (Grigson 1978). But this was often difficult, and impossible in many instances, for the remains of domesticated small ruminants, especially due to the high morphological similarity of sheep and goat skeletons (Halstead et al. 2002; Schramm 1967; Zader and Lapham 2010; Zader and Pilaar 2010). The remains of rodents and gazelles were identified using the comparative collections from Berenike and what is available in the literature (Peters 1986).

Anatomical identification consisted of the determination of individual skeletal elements from which the particular bone elements derived. On this basis, anatomical distributions were analyzed for the remains of species whose assemblages were statistically significant. The remains of the primary species (for human consumption) were divided into seven groups: head, torso, proximal part of anterior limb, distal part of anterior limb, proximal part of posterior limb, distal part of posterior limb, and phalanx. The main criterion for this division was the location of the bone in the skeleton (Fig. 4). On this basis, the percentage of remains from individual parts of the carcass was calculated with reference to the number of bones in the reference skeletons (Lasota-Moskalewska 2008). Studies of anatomical distributions of remains were also carried out, taking into account the chronological and functional diversity of particular contexts from which the remains had come.

Observations were made regarding the age of animals at the time of death based on the stage of ontogenetic development of teeth and bones. These considered the

**Fig. 4** Schematic anatomical divisions of a mammalian carcass

extent of epiphyseal fusion with the diaphysis (Lasota-Moskalewska 2008; Reitz and Wing 2008; Schmid 1972). We also determined the age of animals by recording the tooth wear in livestock following established protocols (for sheep and goat: Greenfield and Arnold 2008; Payne 1973; Vigne and Helmer 2007; cattle: Grant 1982; pig: Desbiez and Keuroghlian 2009; Grant 1982). One element of archaeozoological analysis that has provided the most scientifically valuable data is the study of the morphology of breeding species using the standardized osteometric protocols (von den Driesch 1976). Based on the bones' metrics, the height at the withers was calculated using recommended coefficients for cattle (Fock 1966; Matolcsi 1970; von den Driesch and Boessneck 1984), sheep (von den Driesch and Boessneck 1984), goats (Schramm 1967), and pigs (von den Driesch and Boessneck 1984).

Results of Faunal Analysis

Birds

The remains of birds were few, and these came mostly from the domesticated chicken (*Gallus gallus* f. *domestica*). One quail bone (femur) was also identified (*Coturnix coturnix*; Table 2). All the domesticated chicken bones were well preserved. One of the remains came from a cock indicated by the presence of a spur. The faunal record shows that poultry served as a supplement to the diet of the garrison of Hellenistic Berenike. A chicken could be easily transported by sea and, subsequently, kept for a long time and fed with grain, which constituted some of the supplies sent to the fortress (Casson 1993, p. 257–258).

Mammals

In terms of frequency, the remains of mammals constituted the second largest group of vertebrata remains, after fish, comprising of 1404 fragments of wild and domesticated mammalian bones, 29.0% of NISP. The remains of 11 mammalian taxa were identified (Table 2). At least four different categories of bones can be distinguished in the group of mammalian remains from the Hellenistic layers at Berenike (after Gautier 1987). The first of these consists of the remains of wild animals (“intrusives”), not directly related to the economic and consumption activities. These are primarily rodents, and there is no way to

assess the period when these small wild mammalian remains appeared in the archaeological deposits. The second group of remains belongs to animals raised and used by the community in the Hellenistic period, but most likely not consumed. Their remains appeared secondarily in the examined layers, in the second phase of the biostratigraphic stage. This category of animals includes the remains of cats, dogs, elephants, and probably some camels and donkeys. The carcasses of these animals seem to have been abandoned away from the main roads and residential contexts (dumpsites?). The third category of remains consists of craft debris (“artisanal refuse”) of which turtle bones are predominant. The fourth and most numerous category is consumption refuse. In addition to the characteristic anatomical distributions of the assemblages in this fourth category, their features include traces of chopping and filleting as well as damage caused during meat processing at high temperatures. These faunal remains were mainly of sheep, goats, pigs, and cattle, and a few bones of donkeys.

Wild Mammals

The remains of wild animals constituted a small part of the materials. These were rodents whose presence was not directly related to human consumption. Of these, two species were identified: Egyptian spiny mouse (*Acomys cahirinus*) and an animal from the gerbil (*Gerbillinae*) subfamily; the other remains were assigned to the “small rodents” group. Most of the remains of wild animals belong to dorcas gazelle (*Gazella dorcas*), a species classified as “small bovids” and the only species whose presence can be associated with hunting activities. Remains of gazelles were discovered in only two trenches, in the trash dumps: BE 13-90/10 and BE 13-93/004. These comprised of the phalanxes (I, II, and III) and a metatarsal in BE 13-90/10 and fragments of the horncore base, skull, and vertebrae in BE 13-93/004. All gazelle remains came from mature specimens. Dorcas gazelle is a species currently found along the coast and in the Red Sea Hills. In the mountains, dorcas live mainly in ravines (Arabic: *wadi*). Osteometric data, though few, indicate that the Berenike specimens are slightly larger than those found in the Western Desert (Linseele and Pöllath 2015). It seems the dorcas bones discovered in Berenike came mainly from males (or animals better fed on the rich mountain pastures). The location of Berenike excludes the possibility of the occurrence of another, morphologically very

Table 2 List of identified mammalian species and the proportions of animal remains, Hellenistic Berenike

Taxa	Group I (fort)	Group II (tower)	Group III (dump)	Group IV (gate)	Total	
	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>	<i>N</i>	%
Chicken (<i>Gallus gallus f. domestica</i>)	129	0	17	13	159	3.3
Quail (<i>Coturnix coturnix</i>)	0	0	1	0	1	0.04
Birds (<i>Aves</i>)	129	0	18	13	160	3.3
Gerbils (<i>Gerbillinae</i>)	2	0	0	1	3	0.06
Spiny mouse (<i>Acomys cahirinus</i>)	6	3	26	3	38	0.8
Dorcas gazelle (<i>Gazella dorcas</i>)	0	0	46	0	46	0.9
Dog (<i>Canis lupus f. familiaris</i>)	5	0	69	0	74	1.5
Cat (<i>Felis catus</i>)	7	0	14	0	21	0.4
Elephant (<i>Elephantidae</i>)	24	0	3	0	27	0.5
Dromedary (<i>Camelus dromedarius</i>)	8	0	0	18	26	0.5
Donkey (<i>Equus asinus</i>)	40	0	149	2	191	3.9
Pig (<i>Sus scrofa f. domestica</i>)	6	0	56	25	87	1.8
Cattle (<i>Bos primigenius f. domestica</i>)	1	0	62	49	112	2.3
Sheep/goat	277	22	264	216	779	16.2
Sheep (<i>Ovis aries</i>)	35	8	51	4	(98)	
Goat (<i>Capra hircus</i>)	121	5	154	41	(321)	
Mammals (<i>Mammalia</i>)	376	25	689	314	1404	29.2
NIP	1516	1522	1156	613	4807	50.6
Unidentified remains (mammals)					4 691	49.4
Total					9498	100

similar, small and slender-horned gazelle (*Gazella leptoceros*) which lives in the Sahara west of the Nile Valley (Berke 2001; Linseele and Van Neer 2010; Pöllath 2010; Van Neer and Uerpman 1989).

The last group of wild animals recorded in Ptolemaic Berenike came from the genus *Loxodonta* (Table 2). Its remains have no connection with local hunting. Brief surface excavations in trench BE11-75 (the fort area) recorded the highly eroded cheek tooth of an elephant, and in trench BE 13-93 (trash dumps), there were fragments of the frontal bone of this animal. Morphological features of molars indicate that it did not come from an Indian elephant (*Elephas maximus*). The large degree of erosion and fragmentation, however, prevented precise identification of which of the two species of the genus *Loxodonta* we are dealing with: African savanna elephant (*Loxodonta africana*) or African forest elephant (*Loxodonta cyclotis*).

Domesticated Mammals

Bones of domesticated species dominated the mammalian remains: mainly sheep, goats, donkeys, and cattle

(Tables 2 and 3). Most numerous were fragments of sheep and goat skeletons ($n=779$). These data are analogous to those recorded in earlier studies (Van Neer and Ervynck 1998, 1999). Among the identified remains, bones of goat (*Capra hircus*) were slightly more frequent than sheep (*Ovis aries*). In all the excavated areas of Ptolemaic Berenike, the dominance of sheep and goat remains is very clear (Table 3), accounting for 61.4% of all the domesticated species used for human consumption. In excavated units located in the area of the so-called “fort” and “northern corner-tower,” only ovicaprid bones were found. They were also the main component of the faunal remains in the “gate” zone. A much lower number and percentage of sheep and goat bones appeared in the Hellenistic trash dumps (Table 3).

An analysis of the anatomical distribution of the sheep and goat remains indicated that *torso* elements dominated (vertebrae and ribs), constituting 52.7% of the bones of these animals. There are also high percentages of the remains from the proximal part of posterior limb (pppl), head, and proximal part of anterior limb (ppal). Comparative analysis with the reference data of ruminants shows that the hind leg bones are in surplus,

Table 3 Proportions and spatial distribution of the economically most important mammalian species, Hellenistic Berenike

Taxa	Group I (fort)	Group II (tower)	Group III (trash dumps)	Group IV (gate)	Total in ptolemaic Berenike
Sheep-goat	85.5%	100%	49.8%	74.0%	61.4%
Cattle	0.4%	–	11.7%	16.8%	8.8%
Donky	12.3%	–	28.0%	0.7%	15.0%
Pig	1.8%	–	10.5%	8.5%	6.8%
	NISP = 324	NISP = 122	NISP = 531	NISP = 292	NISP = 1269

as are the remains of the torso (t) and ppal or shoulder. Remains from the other parts of the carcass are scarce (Fig. 5). This body of data indicates a consumption character; there is evidence of a meticulous disarticulation of the most desired parts of the sheep and goat carcasses—hind legs and shoulders.

The proportions of the anatomical distribution of the carcasses of small ruminants were similar in three of the four locations: within the “fort,” “northern corner-tower,” and “trash dumps.” However, in the vicinity of the “gate,” which also functioned as a *hydreuma* (watering station), the proportions of the remains of small ruminants were slightly different (Fig. 5). Here, there are larger percentages of carcass elements with low consumption qualities. The percentage of head and phalanx remains was much higher than in other locations while the proportion of the meatiest carcass elements (e.g., the limbs) was relatively lower. It is possible that there was a slaughterhouse somewhere near the “gate” with water installations. During the initial division of the carcass, such waste of undesirable parts would have been abandoned here and slightly spread around later.

In the group of sheep and goat remains, we found a high percentage of bones from young specimens. The remains of animals killed at a sub-adult age, between 12

and 48 months, dominated (12.2%). In contrast, there is a small percentage of juvenile specimens, 6–12 months (1.5%) (Table 4). Remains of immature specimens were recorded in trenches at two locations: in the fort and the trash dumps. The sheep and goats in Hellenistic Berenike belonged to the horned varieties. Comparative analysis of morphological features and the applied point-based method for comparing the osteometric features of animals from the area of NE Africa showed that goats from Berenike were of large breeds (about 70–80 cm tall) (Table 5). Unfortunately, their height was calculated based on the *tali* (talus bones) only, which are not the best indicator of size. However, very high values have also been obtained from ancient populations from the Nile Valley. Goats of similar height (65–72 cm females and 70–80 cm males) are known, for example, from houses on Elephantine Island (Boessneck and Von den Driesch 1993), albeit from a much earlier period, eighth through sixth century BC. The comparison of osteometric data (phalanxes) also indicated that the goats in Hellenistic Berenike had a very massive body structure (Table 5; Fig. 6). In the case of sheep, the height at the withers was also calculated based on the length of the *tali*. They ranged from 64 to 68 cm (Table 5). These values corresponded well with the

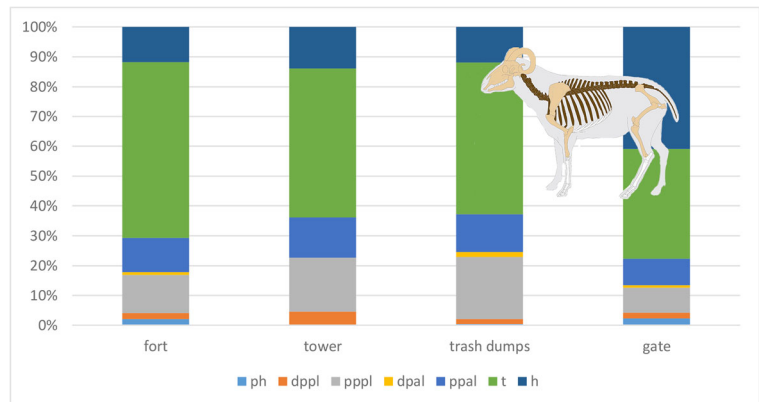
Fig. 5 Anatomical distribution of ovicaprids remains in various Hellenistic zones in Berenike (NISP=779)

Table 4 Shares of the young animal remains from Hellenistic contexts in Berenike

	Juvenis	Sub-adult	Percentage of young animals in taxonomic group
Sheep/goat	1.5%	12.2%	13.7%
Cattle	–	–	–
Pig	26.4%	39.1%	39.3%
Donkey	0.5%	–	0.5%

contemporaneous sheep in the Nile Valley. The sheep in Ptolemaic Berenike, compared to other populations from northeast Africa, can be described as medium-tall, of quite a slim body, analogous to those that have been found since antiquity until modern times in the Nile Valley, as well as in the Eastern Desert.

The remains of the donkey are the second in frequency, accounting for 3.9% of the faunal materials from Ptolemaic Berenike (Table 2). An unusually large assemblage of donkey bones was found in trash dumps (BE13-90 and BE13-93), where they constituted 28.0% of the total domesticated species (Table 3). In comparison with the reference data (proportions of the equine skeleton), there was a high number of donkeys' skull remains in the fauna assemblage and a low number of the trunk elements (Fig. 7). These discrepancies may have resulted from preservation issues. For example, teeth are easy to identify, even in materials with a high degree of fragmentation. The elements of the donkey limb skeleton were similar in proportions to the reference ones, which indicates that they were not subject to intense modification in the process of carcass preparation (Fig. 7). Most donkey remains came from adult specimens (Table 4). There was only one foal bone less than one year old. Donkeys played a significant economic role in Berenike, and there was the need to maintain a large population of them. Donkeys served as the primary means of transportation. They were used for hauling building materials from quarries located in the Ras Banas peninsula, as well as transport of fuel and food from to the Nile Valley, and potable water from nearby sources in Wadi Kalalat and Sikeit.

The third species of mammals in terms of frequency of remains was cattle. As in the case of donkey bones, cattle remains were also found mainly in trash dumps (BE11-77, BE13-90, and BE 13-93) where their percentage was 8.8% (Table 3). They were found in small

quantities near the “gate” (BE 14-95): 3.9%. The remains of the cattle in Hellenistic trenches did not represent all the elements of the skeleton (Fig. 8). There were no fragments of the mandible, elbow, wrist bones, tarsal bones, or second phalanxes. In general terms, the skull elements dominate the cattle remains (31.6%), followed by the pppl (26.2%), torso (18.0%), and ppal (15.5%) elements. Comparative analysis, with reference data of the cattle skeleton, reveals high proportions of head, ppal, and pppl remains. There was a dearth of bones from the other parts of the cattle remains. Such an anatomical distribution indicates a post-consumption character. During analysis, no cattle bone was found from young animals. Only one cattle bone maintained metric traits, and this is a fragment of the first phalanx (Table 4). The measurement value was high. Similar bones of such a large width of the proximal epiphysis were noted, for example, in materials from much earlier Kerma (Chaix 2013). Populations of cattle from the Nile Valley, neighboring deserts, and even Berenike in the later Roman period, had lower values of the width of the proximal epiphysis of the first phalanx (Table 5). The cattle in Berenike were horned.

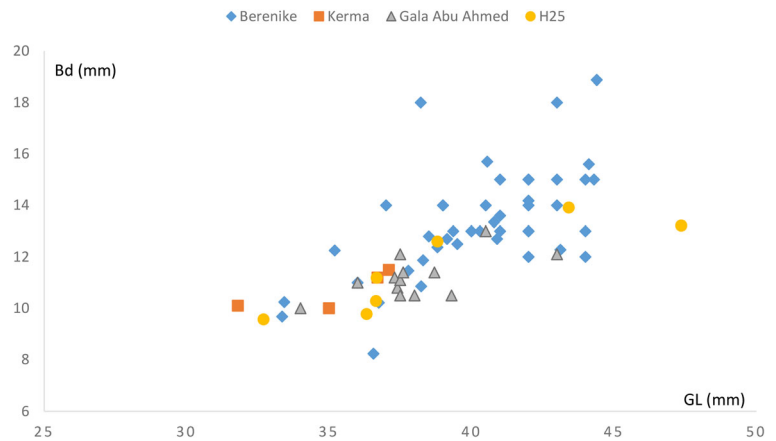
The fourth species in the mammal's group was the pig (*Sus scrofa f. domestica*). Eighty-seven fragments of its skeleton and teeth were identified. The main assemblage came from the “trash dumps” (BE 11-77, BE 13-90, and BE13-93); and a small assemblage was found at the “gate” (BE 14-97 and BE 15-104). Pig bones accounted for 6.8% of the domesticated food species (Table 3). Anatomically, the remains of the torso (55.7%) and head (20.2%) were dominant. Significant percentages were obtained from bones coming from proximal limbs, while distal parts and phalanxes were represented by small numbers of remains (Fig. 9). Comparative analysis with data from the reference of pig skeleton indicated a large representation of torso bones and minimal presence of bone originating from proximal limbs (ppal and pppl). The elements of the distal parts and phalanxes are rare. The presence of bones representing all the elements of the skeleton and teeth and, above all, phalanxes, indicates that the pigs were killed in the central or eastern part of the site (near the civilian residential quarter) and their carcasses were divided there.

The other species of domesticated animals recorded in Hellenistic Berenike were few in frequency and unevenly distributed. There was a large part of a dog skeleton found in the “trash dumps” (BE 13-93). However, there is no certainty as to the dating of this deposit.

Table 5 Osteometrical data from Hellenistic contexts in Berenike

Taxa	Bone	Osteometry (mm)	WH	
Sheep	Humerus	Bd-32.3		
	O. metacarpi	Bp-25.8		
	Tibia	Bd-30.4		
	O. metatarsi	Bd-25.95		
	Talus	GLI-30.1 GLm-17.3	68.0 64.4	
		GLI-28.3 GLm-25.6 Bd-17.5	69.1	
		GLI-30.5 GLm-30.5 Bd-18.5	67.2	
		GLI-29.6 GLm-30.4 Bd-18.9	66.6	
		GLI-29.4 GLm-28.1 Bd-18.2		
	Ph. proximalis	GL-44.1 Bp-14.6 SD-12.05 Bd-14.5; Bp-15.3		
Ph. medialis	Bp-14.3 SD-10.7 Bd-11.2 Glpe-41.7			
Goat	Scapula	GLP-35.8 SLC-19.5		
		GLP-35.3 SLC-19.2		
		GLP-32.6 SLC-17.3		
		GLP-29.6 SLC-15.2		
	Humerus	GLP-35.2		
		Bd-34.6, 33.6, 32.1, 32.8, 30.7, 30.6		
	Tibia	Bd-27.8		
	Talus	GLI-35.7 GLm-35.3 Bd-23.3	81,	
		GLI-33.1 GLm-31.8 Bd-21.4	75, 73.2, 71.2, 70.7,	
		GLI-32.3 GLm-30.1 Bd-21.2	69,	
		GLI-31.4 GLm-29.6 Bd-21.0	66,	
		GLI-31.2 GLm-30.1 Bd-19.7	65,	
		GLI-30.4 GLm-28.5 Bd-19.3	61.4,	
		GLI-29.1 GLm-27.3 Bd-17.3	65.3	
		GLI-28.8 GLm-24.2 Bd-18.7		
		GLI-27.1 GLm-24.9 Bd-17.8		
		GLI-28.8; GLI-30.9		
		O. metacarpi	Bp-23.2	
		O. metatarsi	Bd-26.3; 23.6	
		Ph. proximalis	Bp-13.3 SD-9.9 Bd-11.7 GL-40.8	
Ph proximalis		GL-44.3 Bp-15.4 Bd-13.3		
	GL-44.1 Bp-15.2 Bd-15.3 SD-12.1			
	GL-43.5 Bp-15.2 SD-13.0 Bd-14.2			
	GL-43.1 Bp-14.2 SD-12.0 Bd-14.1			
	GL-43.0 Bp-14.1 Bd-14.0			
	GL-42.8 SD-12.9 Bd-14.0			
	GL-42.4 Bp-15.5 SD-12.5 Bd-14.2			
	GL-42.1 Bp-14.7 Bd-12.4			
	GL-42.0 Bp-15.1 Bd-12.4			
	GL-41.7 Bp-15.2 SD-13.0 Bd-13.1			
	GL-39.2 Bp-14.8 Bd-11.4			
	GL-38.7 Bp-14.8 Bd-12.5			
	GL-38.4 Bd-12.7 Bd-12.1			
	GL-37.8 Bp-14.1 Bd-12.3			
	Bd-15.3			
Cattle	Ph. proximalis	Bp-38.2		
Pig	Tibia	Bd-27.2		
	Scapula	GLP-30.3 SLC-24.3		
Dromedary	Radius	Bp-100.51		
Donkey	O. metacarpi	Bd-39.6 SD-27.9		
	Tibia	Bd-61.9		
	Ph proximalis	GL-82.4 Bp-43.4 SD-26.8 Bd-37.3		
	Ph. media	GL-34.8 Bp-34.8 SD-28.0 Bd-30.4		
		GL-37.5 Bp-36.8 SD-31.5 Bd-31.6		
	Ph distalis	DLS-35,84		

Fig. 6 Osteometric data of goats' proximal phalanx from Berenike, Kerma, Gala Abu Ahmed, and H25



A few dog and cat bones were also recorded in trenches BE 10-66 (“fort”), BE 13-90, BE 11-77, and BE 14-95 (“trash dumps”), and BE 15-104/21 (“gate”). None of these, apart from trench BE 15-104/21 (“gate”), presented anatomically consistent assemblages. The least frequently recorded domestic species was dromedary (camel). Excavations recorded only 26 bones of this animal, mainly in trenches BE 11-77 and BE 14-95 (“trash dumps”). These were ppal and torso (ribs, vertebrae, and scapula), ppp1 (pelvis and femur), and dpal (fragments of metacarpus) elements.

The distribution patterns of domesticated food animal species in Hellenistic Berenike and other sites in the Western Desert (Table 6) show significant differences that are indicative of site functions and chronology. For example, Berenike and Bir Samut (mine facilities and way-station), contemporaneous but functionally different (Leguilloux 2018), significantly diverge in the proportions of their domesticated food animal species. There was a higher significance of ruminants (ovicaprids and cattle) in Berenike’s economy and consumption than in

Bir Samut. And, pork was much less important in Berenike than in the small Hellenistic sites located in the Red Sea Mountain region (Leguilloux 1997). The importance of sheep, goats, and cattle is also noticeable in the following periods: Early Roman and Late Roman in the large ports by the Red Sea—Quseir/Myos Hormos and Berenike (Hamilton-Dyer 2011; Van Neer 1997; Wattenmaker 1979, 1982). Smaller way stations (“*praesidia*”) lying on the road between the Nile Valley and the Red Sea, excavated by *Mission archéologique française du désert Oriental*, had a distinctly different consumption model in which pork was dominant while the beef was almost absent (Leguilloux 2018).

Discussion: Environment and Meat Consumption Patterns

The environment in which the Ptolemaic fort at Berenike was founded and functioned had limited resources. Today, the narrow strip of the coast between the

Fig. 7 Anatomical distribution of donkey remains from Berenike compared to the model values of an equine skeleton

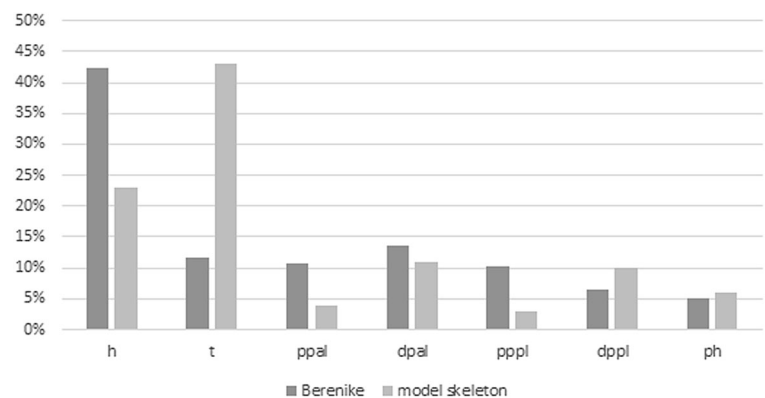
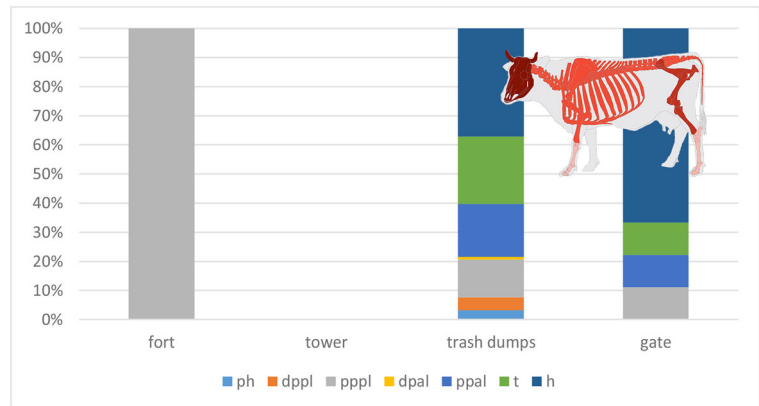


Fig. 8 Anatomical distribution of cattle remains from Hellenistic Berenike



sea and the escarpment/mountains is a semi-desert and desert area with very modest vegetation, mainly consisting of halophytes and few acacias. However, geoarchaeological work has provided evidence for the presence of more precipitation in the early Hellenistic period than today (Kotarba-Morley 2017). Berenike functioned as a way-station for the transportation of food supplies, and for supporting the caravans that transported elephants and other merchandise from the Red Sea to the Nile Valley.

The insignificant number of game species documented from Berenike, limited in the Ptolemaic period to dorcas gazelles, seems to confirm the low possibility and interest in hunting in the semi-desert environment. On the other hand, the Berenike community benefited from the wealth of marine fauna: fish and molluscs. In the harsh environmental conditions of the port, the only domestic food animals that can be sustainably raised are sheep and goats because these can easily endure high temperatures, and tolerate limited access to water and poor quality of food. This explains the dominance of

sheep and goats in the diet of Berenike. This environmental condition also explains the lower occurrence of animals with higher maintenance requirements—cattle and pigs—in the faunal record. Both depend on constant access to drinking water, and cattle need much better quality food than ovicaprids. Moreover, pigs are somehow *competitive* with humans in terms of diet, a factor that has been used to explain the limitation of pig breeding in sub-Saharan Africa (Blench 2000). However, in a state-controlled settlement as Berenike, it was possible to maintain cattle and pigs in this fragile ecology because of the regular supplies of food from the central government. Berenike was regularly supplied with a large amount of grain, intended not only for feeding people but also animals. A large amount of dry animal feed was probably delivered to the fortress. The elephants, transported via Berenike, as well as cattle and donkeys, consumed a vast amount of this feed. Pigs were maintained not only because they could live on human-like food but could also subsist on the sea-borne food commonly used in Berenike, especially the highly

Fig. 9 Anatomical distribution of pig remains from Hellenistic Berenike

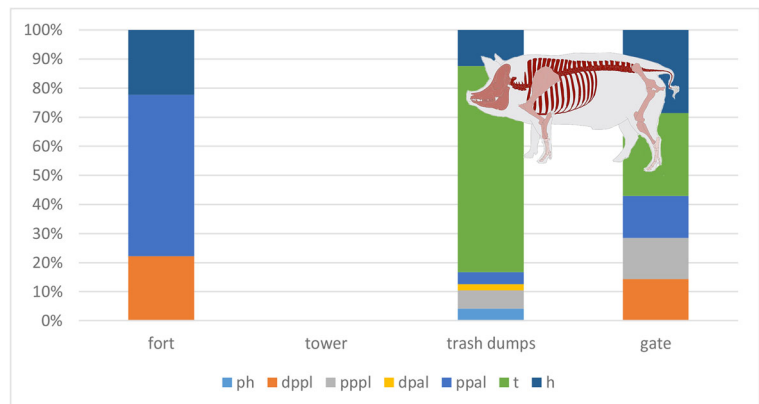


Table 6 Faunal remains from the Hellenistic and Roman sites on the Red Sea coast and in the Western Desert

	Hellenistic Berenike (3rd c BD)	Bir Samut2 (3rd c BD)	Bir Samut (3rd c. BD)	Early Roman Berenike (1st–2nd AD)	Krokodilo (2nd AD)	Quseir/Myos Hormos (2nd–3rd AD)	Late Roman Berenike (3rd–4th AD)	Maxi- mianon (3rd AD)
Sheep/goat	65.7%	11.8%	7.7%	48.0%	5.0%	80%	96.5%	10.5%
Cattle	8.6%	–	–	10.6%	0.6%	5%	2.2%	0.04%
Pig	7.3%	17.2%	13.8%	11.4%	50.4%	12%	0.2%	60.6%
Donkey	16.1%	39.0%	28.0%	2.8%	16.9%	–	0.03%	8.1%
Dromedary	2.2%	32.0%	50.0%	27.1%	27.2%	3%	1.0%	20.6%

nutritious sea snails. Undoubtedly, maintaining pork and beef in the Berenike residents' diet required considerable logistical effort for both the transportation of food reserves (feeds and animals) from the mainland and the breeding of these food animals on site.

In the early phase of Ptolemaic Berenike, fish played a significant role in the diet of the port city. Fish were caught both near coral reefs and in deeper waters. They were a primary dietary component for the inhabitants of the fortress/port. Another element of the diet was the meat of domesticated animals, mainly of mammals, but also of birds. Goat meat and mutton dominated. The remains of domesticated animals significantly increased in the faunal assemblage during the second half of the third century BC. Irrespective of the period, animal carcasses were used very carefully, as is evident in the meticulous butchering process. The butchering method indicates that small portions of meat with the bone dominated. Mostly matured cattle were also sent to slaughter houses. The division of cattle carcasses was very meticulous, although carried out slightly differently than in the case of ovicaprids. Meat with bones from the meatiest parts of the carcass—shoulders and limbs—was finely divided, while sirloins and loins were filleted from the vertebrae. The people of Berenike preferred to stew the beef rather than roast it over an open fire.

Most commonly slaughtered pigs were male, young, and sub-adult, but much younger pigs were sometimes killed by the end of the first year. Meat adhering to the ribs was usually divided with the bone, with fragments measuring up to 10 cm long. As in the case of ruminants, the limbs and shoulder meat were generally cut with the bone. There was no trace of the burnt mark on the epiphysis of the pig remains. Such marks would have indicated roasting over the fire. The very fine bone fragmentation suggests the preference for cooking meat

with bone. Occasionally, poultry, mainly chicken, supplemented the diet of Berenike's inhabitants in the Ptolemaic period. There was also occasional consumption of wild game—dorcass gazelle and, most likely, sea turtles. Archaeological data indicate, however, that hunting did not play a significant role in the diet. There are indications that donkey meat might also have played a role in Ptolemaic Berenike's diet. These are very few traces of cuts on the bones which would have resulted from butchering. There are other lines of evidence suggestive that donkey meat might have been consumed if only episodically. There was a shortage of trunk elements and proximal parts of the donkey limbs in the archaeological assemblage. These are parts of the carcass that would have been attractive for consumption. And, donkey remains were in the same locations where domesticated animal food remains were found.

Local or Imported—Animals in Ptolemaic Berenike

Considering the settlement history and demographic situation on the Red Sea coast in antiquity, it is likely that most livestock was imported into the Hellenistic port, especially in the initial phase of its operation (first half of the third century BC). However, the pioneering garrison, and later the "civilian" inhabitants possibly acquired a certain number of animals from the local population, the nearby nomads. These would include goats, and perhaps sheep and camels. Cattle, pigs, and donkeys, as well as poultry, were certainly imported to Berenike, likely from the Nile valley, slaughtered quickly, or held for a short period in the settlement. Considering the osteometric data of ruminants, their large size, the lack of phenotypic gauntness or nutritional deficiencies, one should assume that they originated from areas providing access to good quality pastures. As will be

discussed below, it is unlikely that the fields or pastures in the vicinity of Berenike could sustain such healthy and large heads of cattle, goats, and sheep during the third century BC.

The faunal assemblages at Berenike seem to reflect both Hellenistic culinary practices and adjustment to necessity in a frontier environment. Beef and pork may be considered as an element of Hellenistic diet, but it is difficult to assess whether the donkey and horse meat consumption resulted from culinary habits of the Hellenic world or response to overcoming the scarcity of meat among the residents of Berenike. The large-scale construction projects in the frontier town (e.g., the building of the “fort” and a line of defensive walls) required the use of stone blocks, a large pool of labor, and many traction and pack force animals such as donkeys and camels. As a result, those traction/pack animals unfit for work could have been used for meat. It is therefore not surprising that the donkeys whose remains were found in the archaeology deposits were almost exclusively adults.

There were two options to ensure an adequate number of donkeys, as well as cattle and pigs in Berenike during the Hellenistic period. One of them was keeping livestock in the mountains (valleys), where more abundant vegetation and the presence of wells created the possibility of grazing. This is, however, less likely in light of how this Hellenistic fort was built. Surrounded by strong fortifications, and having its own water intake supplied by the sea, the Hellenistic stronghold in Berenike seems to have a much more “closed” character than the later Roman Berenike which lacked fortifications and more easily interacted with the surrounding local population and landscape. The more likely alternative was that Hellenistic Berenike depended on the supply of livestock, mainly pigs, cattle, donkey, and horses from the Nile Valley, supplemented with limited local breeding. In this scenario, the cattle and pigs especially would have been there only for a short time before slaughter. The age of the slaughtered animals indeed suggests a less developed local animal husbandry, given that there are almost no young or very young cattle in the assemblage that would have indicated local breeding.

On the other hand, the slaughtered pigs almost exclusively represent young animals and are quite homogeneous in the age range. These indicate that the pigs were slaughtered shortly after arriving at the port. Young pigs may have been preferred for transportation because they were easy to carry in cages. They also need less

food than an adult. The archaeozoological studies carried out thus far in Berenike do not indicate the import of pork as processed meat (e.g., salted), as suggested for the *praesidia* along the road linking the Nile Valley and the Red Sea coast (Leguilloux 2018). The complete list of pigs' skeletal elements in the Berenike fauna assemblage indicates local slaughtering and consumption of fresh pork. The comparatively low numbers of cattle and pig remains in post-consumptional waste shows that obtaining beef and pork was difficult and were rarely eaten. Considering that the central government financed the founding and initial operation of a distant settlement like Berenike, it follows that the maintenance of the garrison, including a significant amount of food supply, was also centrally organized to some extent.

The presence of elephant remains (aside from the ivory), in Berenike's archaeological contexts supports the thesis that in the Ptolemaic period, at least episodically, elephants stayed in the fortress. The archaeological evidence is not clear about the scale of import of these animals. Written sources indicate that elephants were imported from the coastal parts of eastern Africa, in today's Sudan, Eritrea, and Somalia (Burstein 1996, p. 800; Casson 1993, p. 248-249). And, one hypothesis suggests that Ptolemaic Egypt imported elephants from the Kingdom of Meroë (Shinnie 1986).

Soldiers and Civilians: Chronological and Sociotopographic Diversity of the Diet in Berenike

Despite the limitations in context dating, the osteological materials showed a process of gradual changes in the meat consumption patterns in Berenike during the Hellenistic period. It seems that the initial garrison, when the fortress was under construction, lived under logistically difficult conditions, especially in terms of the availability of meat. However, access to meat significantly improved in the later phase of the Hellenistic occupation. The different parts of the port city also had unequal access to meat. In the earlier and western part of the site, where the typical military and state architectural features—fort, gate, and tower—are located, fish remains constituted 80–90% of the faunal material. The small quantity of domestic animal food remains in this area was almost exclusively of goats and sheep.

The remains from the central and eastern (later) parts of Hellenistic Berenike appear to be different. In the “trash dumps,” a later deposit identified with the living quarters of a socioeconomically diverse segment of the

population, the percentage of fish remains was very low, only 8%, whereas the bones of mammals, both domesticated and wild, were dominant in the dumpsite. It was the only place where remains of game animals—gazelles—were found. Almost half of the bones of domesticated animals came from ovicaprids, which is the lowest percentage in the other locations. Noteworthy is the relatively high proportion of donkey remains. The third species present in these assemblages was cattle. A lot of pig remains were also found in the trash dumps. The data suggest various types of meat in the diet of perhaps a more stable and socioeconomically diverse community, including a large percentage of the “civilian” population, in the eastern part of the city.

This spatial and temporal diversification of animal food consumption indicates that in the early stages of the Hellenistic settlement, Berenike was probably inhabited mostly by soldiers who were also involved in the construction of the fort and other installations, such as a well and fresh water tanks. Their diet was based on fish, molluscs, and, to a limited extent, meat from small ruminants, which easily tolerate poor quality of food and limited access to drinking water. Once the military base was firmly established, civilians—artisans and merchants, among others—settled in the area of the fortress, helping to catalyze its growth and diversify its economic activities. The diet of the civilian population differed from the military one. It was more varied, based less on fish and molluscs, and more on the meat of ruminants and perhaps donkeys. Also, pork played a much larger role in the community’s diet at the end of the third century BC than before.

Conclusion

Archaeological research in and adjacent to the Ptolemaic fort at Berenike has provided a large assemblage of faunal materials though most of them were poorly preserved. These remains provide us with insights on how to imagine how newly established frontier military towns functioned during the Ptolemaic period and the strategies of adaptation in those areas. This study has implications for understanding the model of livestock economy and animal use both in the Ptolemaic period and in the succeeding Roman frontier towns in northeast Africa, most of which were located in the areas of the earlier Ptolemaic facilities.

The results of zooarchaeological analyses in Ptolemaic Berenike shed some light on the prevailing

environment in which the fort and the port city thrived. They provide information on the adaptive skills of people who lived in an area deficient in drinking water and food resources. Presumably, at an early stage of the construction and operation of Berenike, locally available sources of meat were used—fish and molluscs, and a limited amount of sheep and goats. Over time, importation of livestock from the Nile Valley developed, which corresponded to consumer preferences of the Hellenized population and the elite—officers and a growing number of artisans, government officials, and merchants. Interestingly, the percentage of food products that were easier to obtain locally—fish, molluscs, and ovicaprids—decreased in the diet of the latter Hellenistic Berenike. Imported animals, comprising mainly of cattle, goats, and pigs and, to a less extent, donkeys and camels, increased in the food consumption of the port city in the second half of the third century BC.

Acknowledgments Both authors wish to thank Steven S. Sidebotham for his inspiring comments and editorial assistance. We also appreciate the comments and suggestions of the three anonymous reviewers.

Funding Information M. Woźniak’s research in Hellenistic Berenike was financed by the National Science Centre (grant UMO-2015/17/N/HS3/00163). Archaeozoological research in Berenike was conducted with funding from the National Science Centre (grant UMO-2016/23/B/HS3/03576).

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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