Close companions: Early evidence for dogs in northeast Jordan and the potential impact of new hunting methods

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Abstract

Current evidence suggests domestications of the dog were incipient developments in many areas of the world. In southwest Asia this process took place in the Late Epipalaeolithic Natufian (~14,500 – 11,600 cal BP) with the earliest evidence originating from the Mediterranean zone of the southern Levant. This paper presents new data for the importance of early domestic dogs to human groups in the region beyond this 'core' area where the Late Pleistocene and Early Holocene environment is usually thought of as less favourable for human occupation. By the Pre-Pottery Neolithic A it is demonstrated that dogs were living alongside humans in significant numbers. Most discussions of early domestic dogs assume that these animals would have facilitated the hunting of larger prey following the innate behavioural traits of their wolf ancestors. This paper suggests that the benefits of hunting with dogs could also extend to the capture of smaller prey. An increase in the hunting of such animals, as part of the broad-spectrum revolution, was not necessarily a response limited to resource reduction in the Late Pleistocene and factors such as new hunting methods need consideration.

Keywords: Natufian; Pre-Pottery Neolithic; Dog; Hunting; Broad-Spectrum Revolution; Faunal.

Introduction

The evolving relationship between humans and dogs has attracted significant research interest. This is partially because dogs were the earliest domesticated animal, but many people today have a close connection to this species fuelling interest into the origin of our familiar companion. The bond between humans and dogs developed to the extent that both species benefited in some manner and, for many millennia, dogs have been important in the lives of humans. The extent to which people found dogs a source of protection and comfort, as well as hunting tools are important questions as to how the early alliance flourished (Perri 2016; Lupo 2017; Guagnina et al. 2018).

In this paper, we present evidence from the Pre-Pottery Neolithic A (PPNA) settlement of Shubayqa 6 in northeast Jordan where the close relationship between humans and dogs is evident. This reciprocal tie involved dogs extensively scavenging through waste discarded at the settlement and, in return, they may have provided humans with the means to hunt more effectively, as well as offering security and early warning of danger. Based on the longer-term patterns of faunal exploitation in the region, the cooperation between humans and dogs may have started earlier in the final stages of the Natufian at a time when widening of the resource base has been repeatedly linked to climate change and population expansion depleting environmental reserves (Bar-Yosef and Belfer-Cohen 2002; Stutz et al. 2009). The importance of the Younger Dryas (~12,900 – 11,600 cal BP) as an influence on subsistence strategies has been questioned in recent years (Maher et al 2011a; Caracuta et al 2016) and the use of new hunting techniques offers a different factor that should be considered in the interpretation of these developments. It is impossible to assess the level of companionship dogs afforded people from the archaeological record, but this should also be born in mind (Manwell and Baker 1984). Although cultural attitudes to dogs vary significantly, dogs may well have been more than just hunting tools. However, a main reason for humans to tolerate dogs living amongst them in large numbers would probably have been to utilise their hunting abilities. The question, therefore, is how did the use of dogs influence hunting and the prey targeted as people learnt to hunt more effectively with their new companions?

Background

Identification of early domestic dogs on morphological aspects of their skeletons is problematic. The earliest dogs in the Levant would have been of a similar size to smaller races of wolf such as those in southwest Asia. Additionally, the presence of jackals, which are within a broadly corresponding size range, introduces a further species to which fragmented faunal remains of canids may belong (Clutton-Brock 1961; Dayan 1994). There is the potential for geometric morphometric analysis of faunal remains to aid identification of early dogs (Evin et al 2016) but, again, high fragmentation of faunal material limits the prospects of such analyses. Tooth crowding as a result of foreshortening of the snout was among the criteria previously used (Tchernov and Valla 1997) although recent work has challenged the reliability of such

benchmarks (Ameen et al 2017). Associations between humans and canids are alternative criteria to indicate the presence of domestic dogs. Humans caring for sick animals that would have died in the wild is one line of evidence (Janssens et al 2018). Potentially the analysis of the isotopic signatures of large carnivores (Bocherens 2015) might indicate if dogs had access to different meat than their wolf ancestors (Ewersen et al 2018). Another line of evidence is the burial of humans together with their companion dogs. Early evidence of this nature, showing dogs interred alongside humans during the Natufian occurs at sites in the Mediterranean zone of the southern Levant at Hayonim and Ain Mallaha (Davis and Valla 1978; Tchernov and Valla 1997). It should be mentioned that the interment of wild animals alongside humans is also known with the Middle Epipalaeolithic site of 'Uyun al-Hammam demonstrating this with a fox skull found below the ribs of a human (Maher et al 2011b). However, Tchernov and Valla (1997: 93) argued the level of diminution of carnassials from Natufian canids was sufficient to "indicate that all the recorded Natufian dogs are different even from the recent small-sized Levantine wolves". This indicates that early dogs, either intentionally or accidentally, underwent some form of size selection but large metrical data from the southern Levantine region are lacking for the initial period of dog domestication. Further evidence for the close association between humans and canids in the Late Natufian comes from Hilazon Tachit where a lower carnassial tooth of a canid was recovered. This had been drilled through in two places on the roots, probably allowing the tooth to be worn as a pendant (Grosman 2003).

Since the Natufian period then, dogs and humans had begun living side-by-side although it remains uncertain if later dogs are descendants of these Natufian dog populations. Mitochondrial DNA evidence suggests that grey wolves from the Middle East were a critical source of the genetic component of modern dogs (vonHoldt et al 2010). A recent publication has suggested that farmers brought dogs from Southwest Asia during the expansion of the farming way of life into Europe (Ollivier et al 2018). Other genetic evidence has been interpreted to indicate a European origin of present day domestic dogs (Thalmann et al 2013) and further studies still highlight the importance of southern East Asia as the area from which many modern-day domestic dogs descended (Ding et al 2012). Whilst the question of the genetic lineage of modern dogs is an ongoing discussion, it does not detract from the fact that multiple lines of evidence suggest that dogs were present in the lives of the Natufian populations in the Mediterranean zone of the southern Levant from around 14,500 cal BP onwards.

There is evidence of trade and translation of cultural traditions between Natufian groups in the 'core' western, Mediterranean portion of the southern Levant and contemporary groups in the eastern steppe region, or Badia, of northeast Jordan (Richter et al 2011). There has been no conclusive evidence, until now, that dogs were also present in this eastern zone at a similar date. This is partially a resultant effect of the extent of fieldwork with comparatively few Natufian or PPNA sites excavated in this region (Martin et al 2016). Recent work at Shubayqa (Richter et al 2012, 2014, 2016a, 2016b, 2017) is beginning to fill this gap by providing substantial faunal

assemblages from the Late Epipalaeolithic through to the Early Neolithic (Yeomans et al 2017a, 2017b, Yeomans and Richter 2018, Yeomans 2018), and from which there is mounting evidence for domestic dogs towards the end of this sequence. This paper first presents conclusive evidence that domestic dogs were present in the Badia region by at least the early PPNA and perhaps earlier in the final centuries of the Natufian period. Secondly, we consider some theoretical implications of dogs as hunting companions on subsistence strategies. Shifts in the prey composition of faunal assemblages can be caused by numerous factors such as seasonal timing of occupation (Davis 1983), climate change and population pressure (Munro 2004) or hunting methods (Campana and Crabtree 1990). The development of communal hunting and structures such as kites have been considered important and several authors have speculated about the impact that these would have had on prey (Henry 1975; Campana and Crabtree 1990). Similar discussions on the influence of hunting dogs are lacking.

Shubayqa 6

Several sites spanning the Late Epipalaeolithic and PPNA have been located around the Qa' Shubayqa in the Harrat al-Sham (Black Desert) of northeast Jordan (Figure 1). On the northern edge of the Qa', approximately 900m from the Natufian site of Shubayqa 1, is the site of Shubayqa 6. Initial results suggest that, at the time when the site was occupied, the Qa' would have flooded to form a seasonal, if not year-round, water source. Radiocarbon dates and preliminary analysis of the lithic assemblage from Shubayqa 6 indicate occupation extending, perhaps not continuously through the PPNA. The site was intensively occupied; faunal evidence indicates that humans were present throughout the year and probably for many consecutive years.

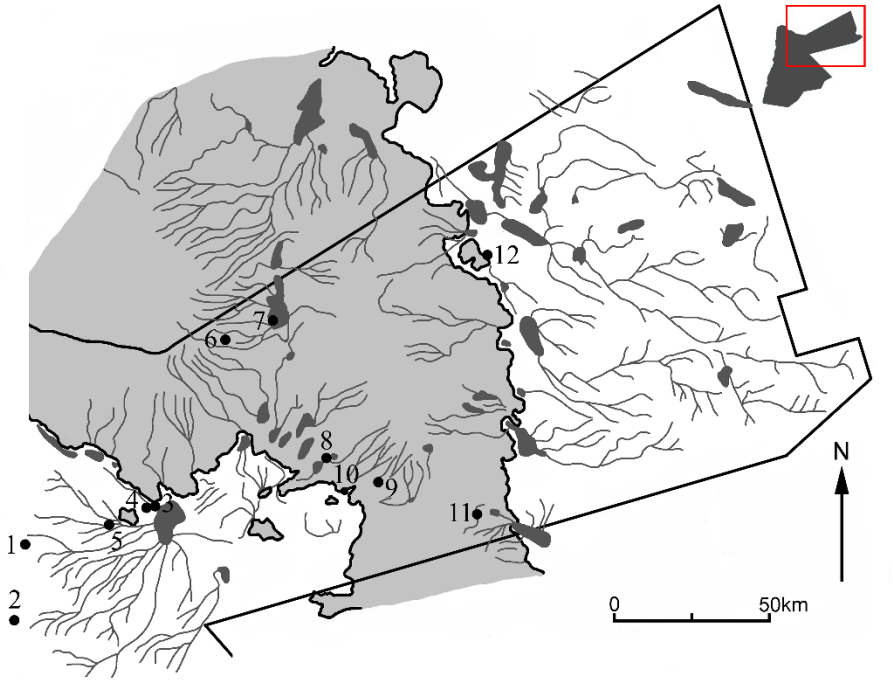

Figure 1: Map showing location of Shubayqa and other sites in the Eastern Badia region of Jordan mentioned in the text (also indicated is the extent of the basalt forming the Harrat al-Sham, wadis and the seasonally flooded Qa' areas). 1 Kharaneh IV, 2 Wadi Jilat, 3 'Ayn Qasiyya, 4 Azraq 18, 5 Uwaynid 18, 6 Khallat Anaza, 7 Shubayqa, 8 Dhuweila, 9 Ibn el-Ghazzi, 10 Gebel Naja, 11 Wisad Pools, 12 Burqu'.

Excavations at Shubayqa 6 are continuing but have already yielded an exceptionally large faunal assemblage that is currently being analysed. At this stage in post-excavation work, a sample of identified faunal remains can chart the changing frequencies of prey animals from the Early Natufian, by comparison to the fully analysed sequence of Shubayqa 1 (Yeomans et al 2017b), to the Late PPNA. This data provides the backdrop of animal exploitation against which the introduction of domestic dogs can be set. At Shubayqa 6, two phases of occupation dated to the Early PPNA and Late PPNA (Figure 2) have been defined. The evidence derives from three areas of the site forming a substantial dataset that will be added to once remaining samples have been processed and exported for identification.

Two adjacent spaces in use in the Early PPNA are discussed here. Space 4 is a well-preserved basalt structure with paved floor slabs and tiers of benches build into the walling (see Figure 2a). Once the initial use of the structure had ceased, the enclosed space functioned as a food processing area. The midden-like fill contained within the structure was rich in animal bone as well as burnt basalt rocks, chipped stone, ground stone and charred plant remains. Occupation, either directly within the space or in surrounding buildings, led to the accumulation of a huge quantity of waste in Space 4. Radiocarbon dates (Table 1) place the activities that led to the infill of the structure in the Late Natufian/Early PPNA and the chipped stone assemblage is characteristic of an Early PPNA date. The hearth from the use of the Space 4 and lowest infilling deposits and have not yet been dated, so the structure itself may predate the infilling deposit.

Lab No.	Context	Space	Context Description	Material	Radiocarbon Age	Standard Deviation	Years cal BP at 68.2% confidence	Years cal BP at 95.4% confidence
RTD-9338	76	3	Hearth fill	*Vitex* sp.	9922	42	11386-11249	11600-11231
Poz-76085	69	3	Possible surface	*Fraxinus* sp.	9440	50	10729-10588	11063-10521
RTD-9341	250	4	Hearth fill	Salicaceae	10035	43	11691-11400	11755-11330
RTD-9342	256	4	Midden	*Hordeum spontaneum*	9962	42	11595-11267	11610-11250
RTD-9343	264	4	Possible surface	*Vitex* sp.	10072	43	11758-11410	11933-11357

Table 1: Radiocarbon dates.

Outside and northwest of Space 4, another midden layer (context 220) spread over a large area. The animal bone from this midden differed slightly, with much larger bone fragments not intensively processed and smashed for marrow and grease extraction. There are some minor differences between the two areas, but this seems related to the use of the external area for initial

butchery. Samples for radiocarbon dating have been submitted for analysis, but dates are not yet available. Stratigraphically this midden, below Space 3, is probably of a Late Natufian or Early PPNA date with the chipped stone assemblage characteristic of the latter.

In the Late PPNA a new structure was constructed. This structure, Space 3, stratigraphically overlays the earlier deposits described above. Compared to Space 4, Space 3 was smaller, without benches and constructed in a different manner (Figure 2b). Larger basalt boulders were set upright and formed the structures walls. This tradition differed to the earlier construction methods of Space 4, which comprised of roughly horizontal coursing of flattish basalt slabs. Space 3 is dated to the Late PPNA on the basis of radiocarbon dates (Table 1) and stratigraphy.

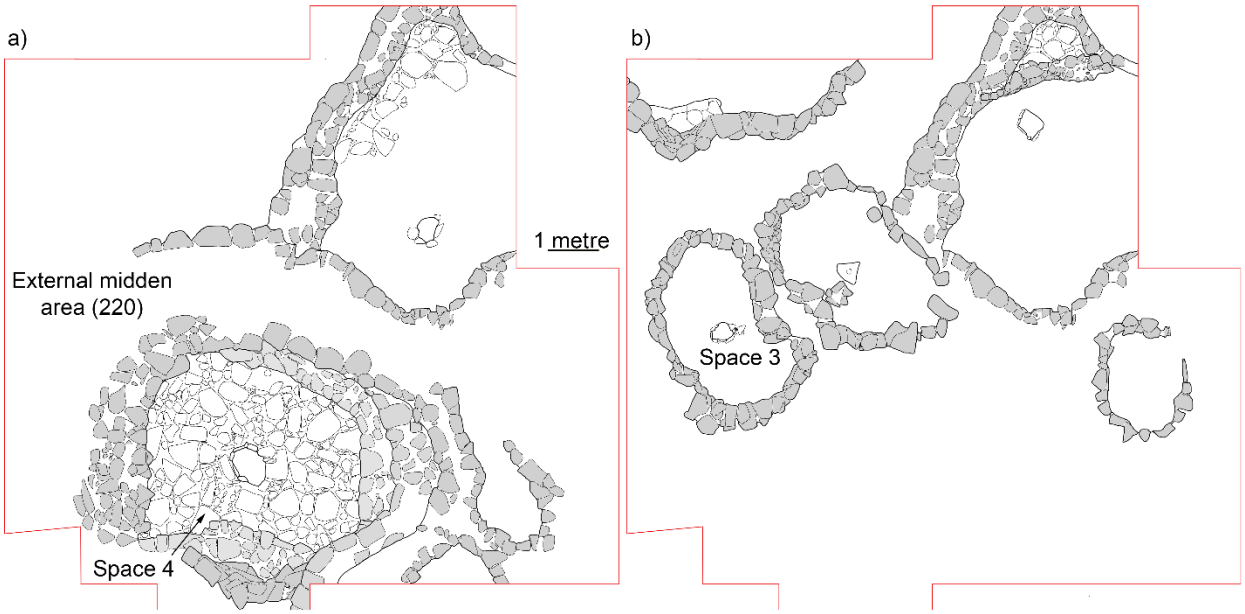

Figure 2: Two phases of occupation at Shubayqa 6 with the locations of the studied groups of faunal remains indicate. a) Early PPNA phase and b) Late PPNA phase.

Osteological evidence for dogs at Shubayqa 6

From the three different groups of contexts at Shubayqa 6 which form the preliminary analysis of the faunal remains, 55 bones were identified as large canid in an assemblage of 3819 mammal bones excluding microfauna. The majority of the canid remains are fragmentary and dispersed amongst the general waste from the site with no evidence of cut-marks or burning. There is no evidence to suggest the canids were buried carefully, consumed or treated in any unique way.

The canid bones are larger than those of jackal and probably of a similar size to wolves that would be expected in the region. Figure 3 shows a canid astragalus and radial carpal from Shubayqa 6 compared to the same bones of an Afghan hound and greyhound (*Canis familiaris*), grey wolf (*Canis lupus*) and two examples of golden jackal (*Canis aureus*). These are examples from the Zoological Museum in Copenhagen, with the wolf deriving from the Finnish population

and therefore larger than the size of wolves in southwest Asia. However, from the similarity of the bones shown in Figure 3, it is clear than identification to canid species is not possible although jackal can be discounted on the basis of size. Further examples of canid bones from Shubayqa 6 are shown in Figure 4 and measurements obtained from the canid remains are presented in Table 2 allowing future comparisons. However, at this stage, the fragmentary nature of the canid bones from Shubayqa 6, which lack the good preservation offered by interments of complete animals, makes osteometric and morphological methods for identifying the remains to a specific species of canid unreliable. Other lines of evidence are necessary to clarify whether dogs were therefore present. Collagen preservation at Shubayqa is very poor and aDNA has not been successfully extracted from any bone material. Fortunately, there is very clear evidence from the taphonomic study of the faunal remains.

Element	Measurement		
Axis	LCDe 48.8mm		
Scapula	GLP 30.1mm	LG 26.2mm	BG 19.2mm
Radius	Bp 16.5mm	articulated	
Metacarpal V	GL 58.8mm		
Metacarpal IV	GL 69.3mm		
Metacarpal III	GL 69.7mm		
Metacarpal II	GL 61.6mm		
Metacarpal I	GL 21.7mm		
Metacarpal IV	GL 85.5mm		
Astragalus	GL 24.7mm		

Table 2: Measurements of canid bones following von den Driesch (1976); each row represents a single bone specimen.

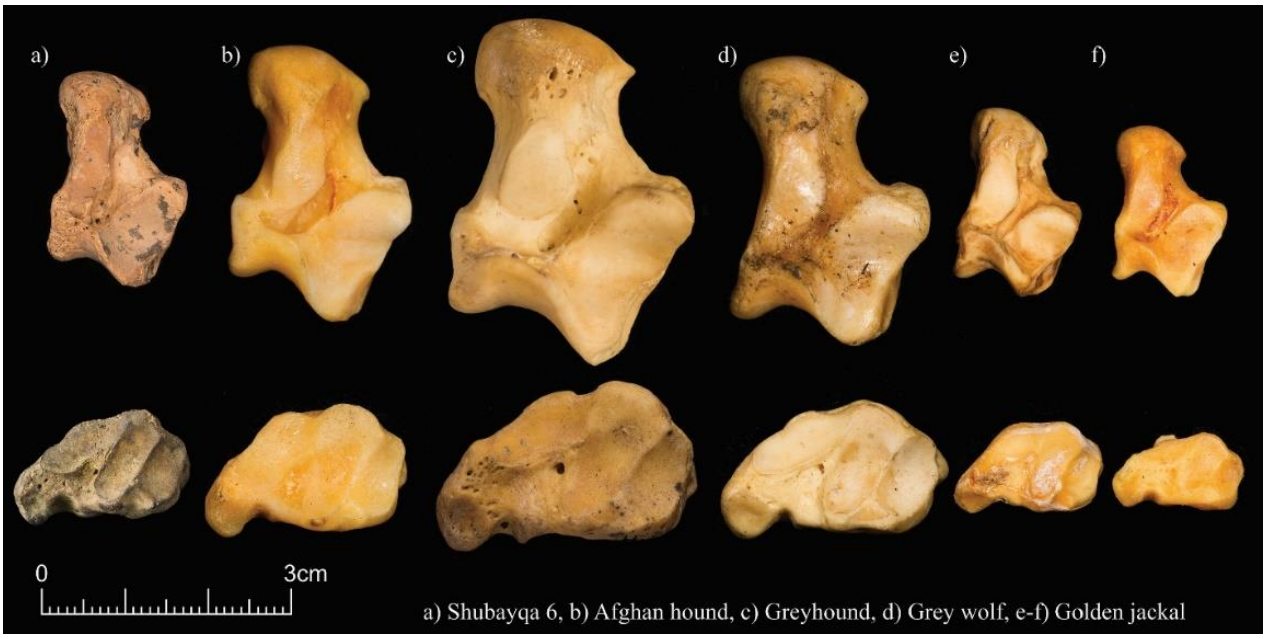

Figure 3: Large canid bones from Shubayqa 6 compared to modern dogs of known breeds, wolf and jackal. Top row - astragalus; bottom row - radial carpal.

Figure 4: Further examples of the canid bones recovered from Shubayqa 6. Top row – scapula, radial carpal, axis, radius; bottom row – humerus, maxilla, astragalus from young dog.

Taphonomic evidence for dogs

Bone that has passed through the digestive tract or been regurgitated from the stomach of a carnivore displays characteristics caused by the hydrochloric stomach acid. This includes the visible widening of the Volkmann's or perforating canals - the pores through which blood vessels from the periosteum feed into bone. The edges of these canals are often widened. Areas of the compact bone may be removed exposing the underlying trabecular bone. The surface of a

digested bone can display a scalloped appearance and original bone surfaces that have been attacked from various sides result in areas of sharpened bone. Digested bone can also appear slightly polished and based on these criteria it is often possible to identify bone that has been digested (Payne and Munson 1985). Figure 5 shows a number of bone examples from Shubayqa 6 that have been digested. Whilst digested bone is frequent, bones that have been gnawed by carnivores are not common. This suggests that the dogs were either intensively feeding on discarded bones, chewing them into pieces small enough for swallowing thus removing traces of gnawing, or were swallowing bones already intensively processed by humans and heavily fragmented. Dogs were clearly responsible for most of the bone that has been digested based on the size of the digested bones. Figure 6 shows a comparison of the sizes of bones from the three groups which are digested and undigested. Most bones in the digested group are 1 or 2cm, but some were larger. Russell and Twiss (2017) note that humans can swallow bone but probably not pieces more than 1cm in size whereas dogs can swallow bones 3-4cm in size and occasionally 5cm in size. Wolves may consume pieces up to 8cm in size. The size distribution of the digested bone from Shubayqa 6 is what would be expected for dogs.

Figure 5: Selection of gazelle bones from Space 3 at Shubayqa 6 displaying evidence for having been in the digestive tract of a carnivore. Top row - medial and lateral a view of 3rd phalanx, medial and lateral view of 2nd phalanx, dorsal and lateral view of 2nd phalanx, lateral and ventral view of metapodial. Middle row – lateral and medial view of 2nd phalanx, lateral and medial view of 2nd phalanx, ventral view of tibia. Bottom row – dorsal and ventral view of 1st phalanx, lateral and posterior view of metapodial, dorsal view of 4th carpal.

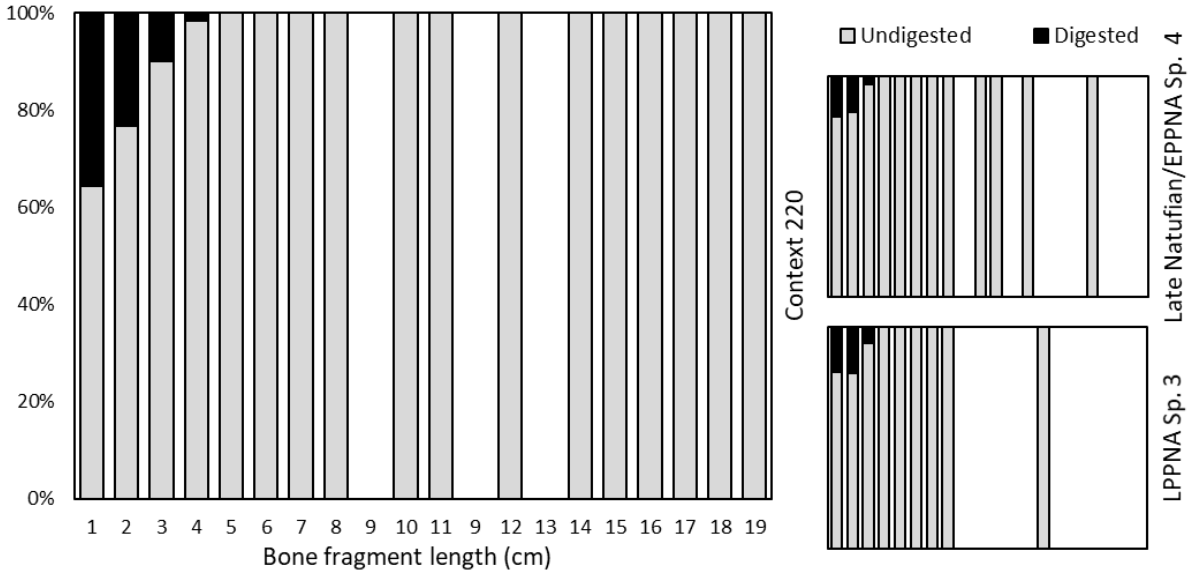

Figure 6: Proportion of bones of different sizes affected by digestion from the three groups of contexts. Context (220) contained more of the larger bones, whereas Space 4 and especially Space 3 produced few bones larger than 8cm in size.

Bones digested by carnivores are common archaeologically but the interpretation of their presence has been debated. Davis (1985) found that 78.8% and 47.8% of gazelle bones from Hatoula, in the Natufian and PPNA phases of the site respectively, displayed traces of digestion and identified domesticated dogs as the culprits. Horwitz (1990) suggested using the occurrence of digested bones cautiously when claiming evidence for dog domestication. She argued that wild carnivores would be attracted to feed on waste from human settlements and then defecating and regurgitating bones at the feeding site. However, unlike cave and temporally occupied sites, a substantial settlement occupied for long periods would not offer a suitable den for carnivores and any wild carnivores scavenging on waste are more likely to drag away refuse to consume undisturbed by humans. A high percentage of bone that has been digested, as at Hatoula, would seem to be obviously attributable to the presence of domestic dogs and as Davis (1985) states, this evidence is corroborated by the presence of dog skeletons buried with humans in the Natufian period. All the evidence (seasonal birds, extent of architecture, accumulation of deposits and lack of contexts associated with periods of abandonment) suggests that Shubayqa 6 was occupied throughout the year. The occurrence of digested bone in all contexts types indicates that the carnivores responsible for the digested bone were living with the humans rather than visiting the site if there were any periods of abandonment.

At Shubayqa 1 only 0.8%, 0.5% and 7.5% of the small ungulate bone are digested in the Early Natufian, Late Natufian and Final Natufian respectively. By the time that Shubayqa 6 is occupied the frequency of digested ungulate bone has risen to 22.3% and 22.8% in the Early PPNA and Late PPNA respectively (Figure 7). Although canid bones are only found in the faunal

assemblages from Shubayqa 6 in any significant number, the gradual increase in the proportion of bone that has been digested from the end of the Natufian occupation at Shubayqa 1 is evident. This suggests that dogs were possibly present in the period of occupation corresponding to the Younger Dryas at Shubayqa 1 and, in the succeeding periods of occupation, this increased. The frequency of digested bone can be used as a proxy for the arrival (or even incipient domestication) of dogs in the final stages of the Natufian, and then their increasing importance in the Early Neolithic.

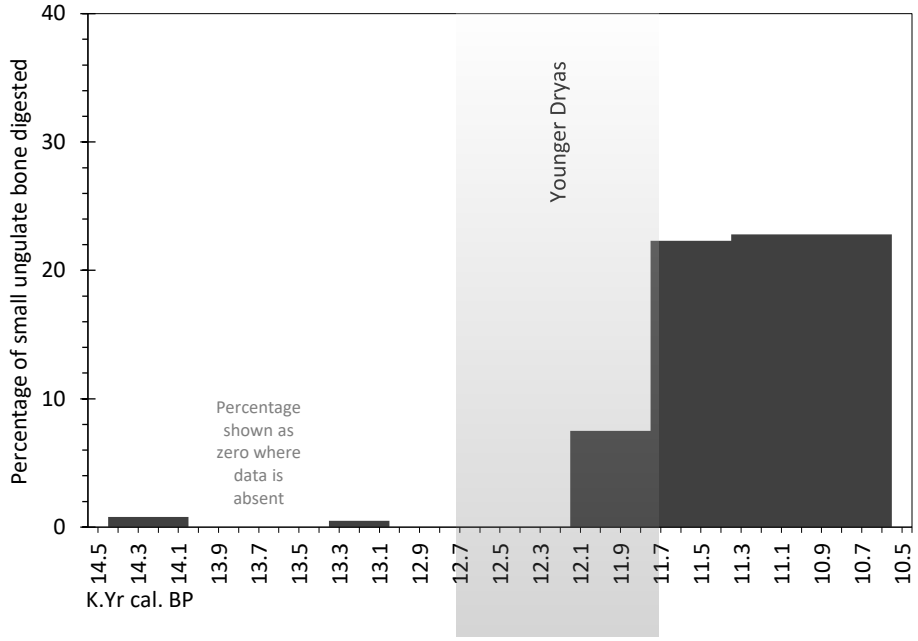

Figure 7: Frequency of small ungulate bone that had been affected by digestion at various sites and phases of occupation around the Qa' Shubayqa showing approximate date range of assemblages as well as the date range of the Younger Dryas climatic event.

Of the bone from Space 3 at Shubayqa 6, 22.8% of small ungulate bones shows traces of digestion. In the midden infill of Space 4 19.3% of the equivalent bones are digested and in the midden outside Space 4 the frequency is 26.4%. Whilst not as high as the frequency of digested bone at Hatoula, it is nevertheless a significant proportion of the assemblage. The difference between the areas at Shubayqa 6 may reveal something about the presence of dogs around the settlement. The highest frequency of digested bone was in the external midden area possibly where the earliest stages of butchery were taking place and where large bones, not intensively processed, were recovered. No doubt dogs were attracted to this waste and would have spent more time in this area, perhaps resulting in the presence of more dog bones (49 of the 52 from the Early PPNA phase), including portions of articulated limbs (Figure 8) in this area. Remains of digested bones were common inside structures in the floor layers. The floor layers probably included material than had been brought into the structures to prepare a new surface and does not necessarily suggest that dogs were defecating inside the structure. However, the canids were kept at the fringes of the settlement but were closely integrated into all aspects of day-to-day life and

allowed to feed on scraps. There is the question of why humans allowed the waste from their day-to-day life accumulate around the settlement where dogs could scavenge and defecate without attempts to reduce this waste. Our own notions of cleanliness makes it hard to imagine that humans would tolerate such a situation but as Hardy-Smith and Edwards (2004) argue, minimal effort was invested in removing waste in the PPNA but perhaps by the PPNB the recycling and removal of waste material became more common practice.

Figure 8: Articulated dog bones (left radius, ulna, carpals, metacarpals and phalanges) found close to a wall in the external midden area in the Early PPNA phase.

Self-domestication?

A number of researchers have proposed that humans did not actively domesticate the dog and domestication occurred as wolves began to hang around human settlements, attracted to the possibility of scavenging waste from human occupation (Montagu 1942; Rindos 1984; Budiansky 1992; Coppinger and Coppinger 2001). Overtime people found that these animals were not a hindrance, but scavenging had the effect of cleaning away detritus. In the initial stages of the domestication process, if this were how it happened, wolves would presumably drag scraps of waste away from the settlements to feed undisturbed. The alternative of humans finding wolf puppies and rearing these animals is also possible, and perhaps the actual process was a combination of the two. By the stage that dogs are fully domestic, and living in and around human settlements, it seems probable that they were used as hunting aids. Defining where, on a scale of humans and dogs becoming reliant upon one another, the two species had reached at Shubayqa 6 is questionable. However, it does not seem that we are studying the earliest stages of the domestication process; dogs had been associated with human groups for some time, leaving people with time to learn how to hunt with these companions. The investment people seem to

have made in bringing up, keeping and training dogs would probably have made them quite valuable and this could explain why they were living in such close proximity to humans and fed and/or were allowed to pick-over refuse in the settlement.

Dogs as early hunting aids

Having demonstrated the presence and increasing importance of dogs at the Shubayqa sites, we can question if the use of dogs influenced hunting practices. The assumption has often been made that when dogs were initially domesticated they were used to hunt larger prey since wolves hunt in packs to take down animals of a large size (Clutton-Brock 1980). However, wolves can and do hunt solitarily for small prey (Lupo 2011). There are numerous ethnographic and iconographic examples of humans using dogs to hunt smaller animals especially those that evade capture by flight (Kent 1993; Lupo 2011; Guagnin et al. 2018). In Nicaragua, the use of dogs to hunt small mammals increases the efficiency of hunting small mammals (Koster 2008). The idea that early domestic dogs were only used to hunt larger animals clearly overlooks an important possibility.

In southwest Asia the traditional dogs are salukis and, whilst genetic evidence is contradictory about the history of the breed, this type of dog may have been one of the earliest to develop (Parker et al 2004; Freedman et al 2014 but see Larson et al 2012). These dogs are long-legged sight-hounds typically used to hunt small fast prey and, even today, hare coursing is common with similar breeds (greyhounds and lurchers). In dogs, the amylase gene (AMY2B) allows the digestion of starch and therefore represents the ability for dogs to feed on non-meat foods. The copy number of this gene was high in salukis suggesting that this breed of dog was an early development having adapted to human type, starch-rich diets (Freedman et al. 2014). Some of the oldest depictions of dogs date from the 8th Millennium BC, where saluki or Persian gazelle hound type dogs were shown on pottery from Tepe Sabz and Chogha Mish in Iran (Hole and Wyllie 2007). Fired clay figurines of canids are known from older sites such as Jarmo in Iraq and Sarab in Iran (Hole and Wyllie 2007). Further illustrations of dogs from the Susa period in the 4th Millennium BC again show Saluki and Afghan hound types of dogs and a skull, identified as a saluki, was recovered from Tepe Gawra (Hole and Wyllie 2007). In analysis of the genetic sequence of purebred dogs, Parker et al. (2004) found that several breeds, including the saluki and Afghan hound, had ancient origins whereas most breeds were recent developments. However, work by Larson et al. (2012) has suggested that this was a reflection of modern isolation of these breeds rather than reflecting their ancient ancestry. The genetic evidence is providing conflicting results, but iconographic evidence suggests that hunting of gazelle and hare using dogs of a sight-hound type has a long history in southwest Asia (Guagnin et al. 2018).

Other iconographic and ethnographic evidence exists for the steppic region in the vicinity of Shubayqa including rock art of the cairn of Hani (Harding 1954: 358, fig 3) which arguably shows gazelle driven into a desert kite with dogs. Until recently, desert kites were still used; in

1909 Musil (1928) notes how once in the traps the narrow opening would be blocked with stones as soon as the gazelle were inside and greyhounds or salukis attack the prey.

We cannot the assume that dogs were used to only hunt large prey in the initial period after domestication and the possibility that they were also used to hunt small, fast prey needs more discussion. Gazelles are by far the most common mammal hunted at Shubayqa and even this animal is smaller than the larger ungulate prey that are tackled by packs of wolves. Red deer weight somewhere in the region of 200kg, fallow deer around 57kg and the gazelle species hunted around Shubayqa is more likely to have weighed 24kg. In the Mediterranean zone of the southern Levant humans may have enlisted the help of dogs to tackle larger species, larger mammals were very infrequently hunted in the Badia region and dogs would probably have been trained to hunt gazelle, or drive them into communal hunting structures or netting. Given the ethnographic evidence above, there is also the possibility that they also hunted hares and foxes, considered in the following section as small prey as they weigh less than 15kg.

Canids and small prey in the archaeological assemblages

Table 3 is a standardisation of the current data on the presence of canid bones at sites in the Badia region from the Epipalaeolithic to Neolithic. It also contains the frequency that small, fast prey such as hare and fox have been identified at these sites and evidence for gnawed and digested bone. It should be remembered that a canid bone may represent the presence of wolf or jackal in the assemblage. The frequency of canid bones is low throughout the sequence of published data, even when it is known that domestic dogs are present. This is not surprising, since the bones of these human companions are less likely to be found at habitation sites mixed in with the waste of food preparation activities. In many instances dogs probably died on hunting trips and it is unlikely that their remains would be brought back to the settlement.

The data in Table 3 shows an increase in the proportion of hare identified during the Late Epipalaeolithic. It is not until the PPNA, however, that there is clear evidence for dogs in substantial numbers at Shubayqa 6. Hare are also common at the PPNB sites of Wadi Jilat 7, Wadi Jilat 32 and Azraq 31 but there is no clear evidence for the presence of dog at these sites. A low number of hare bones were identified at Dhuweila in both the PPNB and Late Neolithic phases, but as Martin (1998: 170) points out, the assemblage produced “very little evidence of carnivore activity” with only 0.1% apparently gnawed and none of the bone showed signs of digestion. Dhuweila was interpreted as a specialised hunting camp focusing on gazelle. In the Wadi Jilat area and in Azraq, the pattern of hare bones being well represented continues from the PPNB into the Late Neolithic. Several fairly small assemblages were studied from Late Neolithic sites around Burqu’ with hare well represented at all of these sites. At Burqu’ 27000 there was evidence for carnivore activity with 12 bones displaying pitting probably from carnivore gnawing and four bones displayed the taphonomic signatures of digestion (Betts et al 2012). The faunal remains from Wisad Pools, also of Late Neolithic date, are not fully published, but a

footnote in a general paper on the archaeological remains by Rollefson et al (2014) mentions the presence of domestic dog, and hare bones are estimated to form about 25% of the assemblage.

Site	Phase/Space	Date	NISP	% canid	% digested	% gnawed	% hare	% fox	Reference
Wadi Jilat 9	-	Late Upper Epipal	15	-	0.0	0.0	6.7	-	Martin 1994
Kharaneh IV	KHIV D	Geometric Kebaran	7274	0.1	0.0	0.0	3.0	2.0	Martin *et al* 2010
Kharaneh IV	KHIV C	Late Kebaran?	293	-	0.0	0.0	5.1	2.4	Martin *et al* 2010
Kharaneh IV	KHIV B	Kebaran	1568	0.1	0.0	0.0	1.5	5.4	Martin *et al* 2010
Kharaneh IV	KHIV A	Early Kebaran	1761	0.3	0.0	0.0	2.2	1.2	Martin *et al* 2010
Wadi Jilat 6	Upper	Late Kebaran?	2249	0.3	0.0	0.0	2.5	0.8	Martin *et al* 2010
Uwaynid 18	-	Early Epipal	461	<0.1	0.0	0.0	1.5	-	Martin 1994
Ayn Qasiyya	A	Early Epipal	1047	1.5	0.0	0.0	6.8	2.5	Martin *et al* 2016
Ayn Qasiyya	B	Early Epipal	3341	0.6	0.0	0.0	2.5	0.7	Martin *et al* 2016
Wadi Jilat 8	-	Middle Epipal	77	-	0.0	0.0	1.3	-	Martin 1994
Wadi Jilat 10	-	Middle Epipal	41	2.4	0.0	0.0	-	-	Martin 1994
Wadi Jilat 22	-	Mid to Late Epipal	1065	3.7	0.2	0.0	4.3	1.7	Martin *et al* 2013
Azraq 18	-	Late Epipal	291	0.3	0.0	0.0	0.3	0.3	Martin 1994
Khallat Anaza	-	Late Epipal	34	2.9	0.0	0.0	8.8	-	Garrard 1985
Shubayqa 1	Phases 7-4	Early Natufian	4434	<0.1	<0.1	0.1	17.4	1.7	Yeomans et al 2017b
Shubayqa 1	Phases 3-2	Late Natufian	6104	-	0.5	0.1	4.1	3.1	Yeomans et al 2017b
Shubayqa 1	Phase 1	Late Natufian	1035	-	6.6	0.1	1.4	0.9	Not yet published
Shubayqa 6	Space 4	EPPNA	684	0.4	20.6	0.1	12.1	8.0	Not yet published
Shubayqa 6	Midden (220)	EPPNA	1956	2.5	23.7	0.3	3.4	4.0	Not yet published
Shubayqa 6	Space 3	LPPNA	1179	0.3	19.8	0.7	10.1	5.1	Not yet published
Wadi Jilat 7	Phase 1	Early PPNB	324	-	1.6	0.0	48.8	4.8	Martin 1994
Wadi Jilat 7	Phase 2	Middle PPNB	537	0.2	0.0	0.0	19.0	4.1	Martin 1994
Wadi Jilat 7	Phase 3	Middle PPNB	257	-	1.1	1.0	35.8	9.3	Martin 1994
Wadi Jilat 7	Phase 4	Middle PPNB	314	0.3	0.0	0.0	53.5	14.3	Martin 1994
Wadi Jilat 26	-	Mid PPNB	12	-	0.0	0.0	58.3	8.3	Martin 1994
Wadi Jilat 7	Phase 5	Mid-late PPNB	91	2.2	0.0	0.0	44.0	6.6	Martin 1994
Wadi Jilat 32	-	Mid-late PPNB	156	-	0.0	0.6	89.1	7.1	Martin 1994
Azraq 31	-	PPNB	56				10.7	0.0	Martin 1999
Dhuweila	Stage 1	PPNB	2778	0.1	0.1	0.4	1.3	0.5	Martin 1998
Ibn el-Ghazzi	-	Late PPNB	20	-	0.0	0.0	10.0	-	Martin 1994
Burqu' 35000	Combined	LPPNB/ELN	56	-	0.0*	0.0*	8.9	-	Betts *et al* 2012b
Wadi Jilat 25	Early	PPNC/ELN	154	-	0.0	0.0	17.5	1.3	Martin 1994
Wadi Jilat 25	Late	PPNC/ELN	19	-	0.0	0.0	42.1	5.3	Martin 1994
Wadi Jilat 13	Phase 1	PPNC/ELN	2640	0.6	0.1	2.3	22.2	7.2	Martin 1994, Yeomans 1998
Wadi Jilat 13	Phase 2	PPNC/ELN	907	0.4	0.4	2.8	25.0	5.6	Martin 1994, Yeomans 1998
Wadi Jilat 13	Phase 3	PPNC/ELN	1089	0.6	0.5	1.5	30.6	6.3	Martin 1994, Yeomans 1998
Azraq 31	-	Late Neolithic	1217	1.8			29.3	4.2	Martin 1999
Dhuweila	Stage 2	Late Neolithic	8382	0.2	0.1	0.2	1.6	<0.1	Martin 1998
Burqu' 27000	Combined	Late Neolithic	257	2.3	1.7	7.2	16.3	0.4	Betts *et al* 2012b
Burqu' 03000	Combined	Late Neolithic	220	3.6	N/A	N/A	15.0	-	Betts *et al* 2012b
Burqu' 11000	Combined	Late Neolithic	25	-	N/A	N/A	48.0	-	Betts *et al* 2012b
Burqu' 20000	Combined	Late Neolithic	12	-	0.0	8.3	8.3	-	Betts *et al* 2012b
Jebel Nadja	-	Late Neolithic	9	-	N/A	N/A	22.2	-	Betts et al 2012a
Wisad Pools	-	Late Neolithic	280	Present	N/A	N/A	c.25%	No data	Rollefson *et al* 2014

*Table 3: Frequency of canid bones at sites in the Badia region from the Epipaleolithic to Late Neolithic based on published NISP counts. Excludes avifauna, tortoise and micro-faunal remains to standardise the data between sites. *surface condition limited ability to see gnawing/digestion.*

Overall, in the Late Epipalaeolithic there is notable increase in small prey species (mainly hare but also fox to a certain extent) and this continues through until the PPNB, when domesticated sheep and goats change the economy of human settlements. Even when domesticated livestock

first arrive, hares and foxes are still commonly hunted and it is only in the Late Neolithic that these resources gradually reduce in importance. There are a few outliers, such as Azraq 18 where wild cattle formed an unusually high proportion of the animals hunted and at Dhuweila which has been interpreted as a specialised gazelle hunting camp (Martin 1998). Based on the taphonomic evidence there is a decrease in the dogs in the PPNB whilst hares and remain frequent. Perhaps this is related to changing refuse disposal, hunting practices or even that dogs were kept more marginal from settlements as valuable livestock were close to settlements.

Age profile of hunted hares

Examining the possible methods by which hares could have been taken in more detail with some discussion of the time costs and resulting mortality profile of the hares is useful. Speck and Schaffer (1950) describe rabbit hunting in America where rabbits were driven using nothing more than clubs or sticks with a return of 45-60 animals during a three-hour hunt. In their review of the ethnographic literature, Lupo and Schmitt (2005) present evidence that in northwest America large numbers of rabbits could be taken by communal net drive. Such nets took a long time to make and needed significant maintenance as well as the considerable effort used in the actual hunting process. Snares, on the other hand were much quicker to make and once set, only needed checking every few days thereby requiring less effort. Of relevance for trying to interpret the archaeological methods of hunting Lupo and Schmitt (2005) found a difference between the mortality profile created by hunting duiker with nets and snares. When hunting with nets, the frequency of animals of different ages obtained corresponded to the number of animals found in a living population but juveniles were less common when trapping with snares. This related to two factors; young animals were less likely to follow an adult into a snare and their body weight could be too low to trigger a snare.

Examination of the mortality profile of the hare remains from Shubayqa (Figure 9) indicates that although hares were common during the phases of occupation before domestic dogs were present, the mortality profile of the hares hunted changes significantly after the introduction of domestic dogs. Does this represent a shift in the hunting strategies? In the earlier phases of the Natufian the mortality profile is similar to what might be expected when nets were used to trap hares with a high proportion of young animals. The hares consumed at Shubayqa 6 differ in terms of their age profile with more of a focus on adult animals. As argued by Dean and Beaver (2017), season of hunting and population pressure are unlikely to have created a shift in the mortality profile. Firstly, hares breed throughout the year and secondly, if the hare population was over-harvested then the opposite shift in mortality profiles would be expected. The shift is more likely associated with a change in hunting technique from a method, such as netting, that saw an unselective portion of the hare population captured, to a selective method of hunting in which individual animals were targeted. This could have been achieved by snares, clubs, projectiles or dogs. This might also reflect a change from communal hunting practices with a net

to hunting individually, perhaps mirroring other changes in human groups at this time with cooking becoming internalised within domestic spaces (Wright 2000).

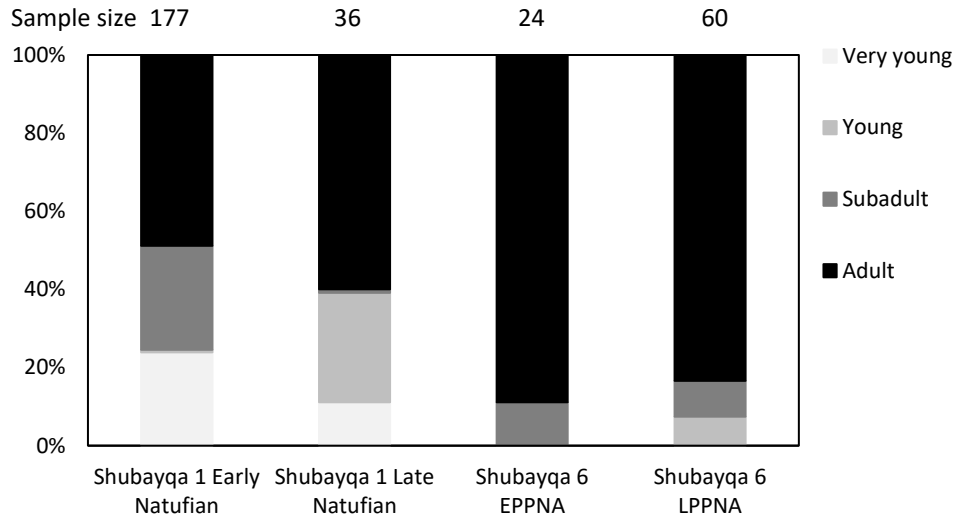

Figure 9: Mortality profile of the hares at Shubayqa based on the fusion of three groups of elements defined by Dean and Beaver (2017) with different fusion times (insufficient data from Final Natufian phase of Shubayqa 1 to be included).

Hares and foxes hunted for their furs?

Hares and foxes may have been hunted for furs rather than meat and adult animals would provide better materials. The skeletal element representation of these animals does not alter through the sequence and includes all elements (Figures 10 and 11), so there is no evidence that the furs were the primary resource exploited from the carcasses as hunting of these animals intensified. This does not mean that the furs were not an important material, but it does indicate that the whole carcasses were brought to the settlement.

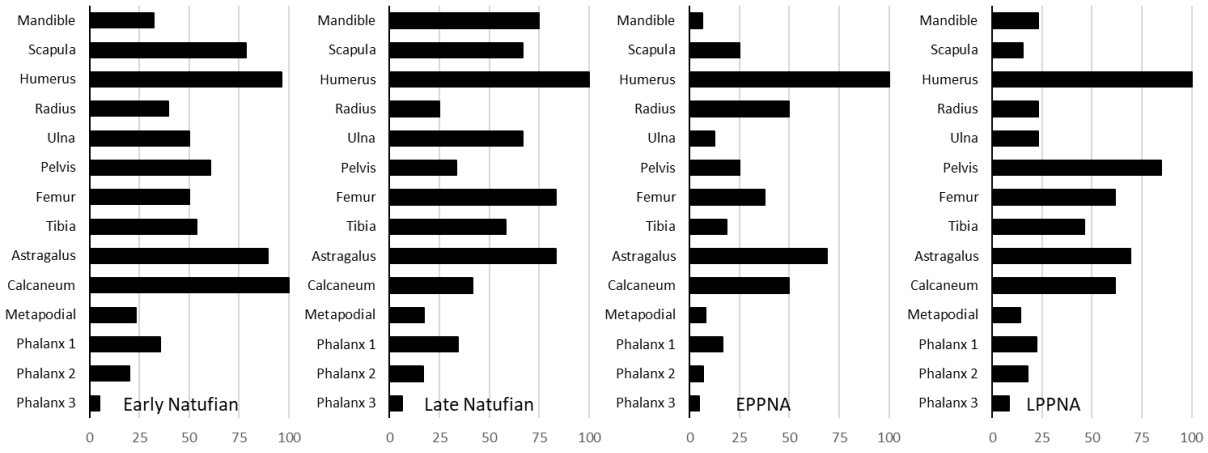

Figure 10: Skeletal element representation of hares through the Early Natufian to Late PPNA sequence at Shubayqa. Calculated from the minimum number of elements as a proportion of their expected representation based on the minimum number of individuals.

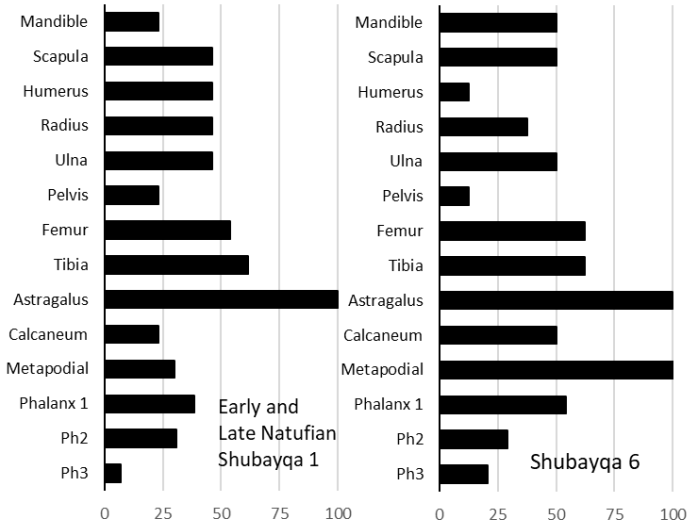

Figure 11: Skeletal element representation of foxes prior to dogs being present at Shubayqa 1 and after dogs are known to be common at Shubayqa 6 in the PPNA. Calculated from the minimum number of elements as a proportion of their expected representation based on the minimum number of individuals.

The carcasses of hares and foxes could have provided meat and there is evidence for the bones of these animals being used extensively for the manufacture of beads. In the Natufian, the bones of birds, especially the tibiotarsus bones, were selectively transported to the settlement and deep transverse cuts indicate that they were probably cut into segments to be worked into beads (Yeomans and Richter 2018). At Shubayqa 6, different bones start to be used as the raw material for beads and the bones of smaller mammals (probably hares and foxes) were commonly utilised (Figure 12). Off-cuts from the process of bead manufacture indicate that hares often provided the raw materials for working into beads (Figure 13). At Shubayqa 6 there is evidence for the manufacture of various greenstones and ostrich eggshell into beads on a massive, almost industrial, scale. These are presumed to be for export given their sheer number and therefore it is possible that bone beads and furs were part of materials traded alongside these other goods. Hunting of hares and foxes may have therefore become more common to supply furs, but other materials from the carcasses were also used. Some groups of articulating bones from the forelimb of hares and foxes are present in the assemblage and these were probably cut from the carcass and left attached to the furs.

Figure 12: Beads from Space 3 made from the bones of small animals, most are mammal bones where identifiable.

Figure 13: Off-cuts of hare bones as a by-product of bone bead manufacture. Left to right – distal metapodial of a hare with cuts encircling the shaft, hare humerus and radius with traces of polishing with cutmarks and a burnt hare humerus with deep transverse cuts.

Ethnographic evidence of hunting smaller mammals with dogs

Lupo (2011) discusses groups of foragers in the Central African rainforest where dogs are very useful in capturing giant pouched rats. Kent (1993) also found that Kalahari Bushmen used dogs to hunt hares, ground squirrels, mongoose, wild cats, jackal and fox. Admittedly, the case studies above are far removed from the earliest domestic dogs in the southern Levant, but they serve as a reminder that dogs can be used to hunt smaller animals. Hare coursing still offers amusement to some nowadays and this practice has been pursued for centuries (Attfield 1991). Dogs that hunt by sight are well-suited to the open, dry environments and could easily spot hares resting in the midday sun in shallow depressions amongst the scrub. Based on the possible long lineage of sight-hounds in the region of the southern Levant and the use of dogs of this type, an argument can be made for questioning whether dogs were used in the hunting of hare in addition to their use in hunting gazelles. There is a general increase in the proportion of hare bones recovered from sites at the time when we know that dogs were domesticated. The higher representation of hares compared to tortoises suggested by some (Stiner et al. 2000) as evidence for increasing sedentism is, as is the use of dogs in hunting hares, a theoretical possibility for the changing representation of different species. It is not the point to argue here that the use of dogs is the

definite cause of a change in the prey composition, but it is suggested that it is a factor that could be related and researchers should keep this in mind when discussing faunal assemblages from the Natufian and later periods. In southern Africa domestic dogs only started to be common in hunter-gathers groups about 2000 years ago. Yet in a review of the evidence, Mitchell (2008) suggests that one of the main benefits for keeping dogs was their use to hunt hare and other small fur-bearing carnivores. The benefits and use of dogs to hunt smaller mammals seem to be inadvertently overlooked as a possibility for earlier periods when dogs were first domesticated, on the basis of arguments that dogs are likely to have followed the behaviour and hunting techniques used by their ancestors.

Game birds

The use of dogs to hunt small mammalian prey is well documented ethnographically and the majority of zooarchaeological reports present the frequency of these animals. Data for birds are not consistently reported so it is not possible to generate a similar table as Table 3 displaying the relative frequency of bird species. In an examination of the relative frequency of birds with different environmental preferences from Shubayqa (Yeomans 2018), there was evidence for an increase in ground dwelling species such as quail (*Coturnix coturnix*) and corncrake (*Crex crex*). This work demonstrated that the environmental conditions were changing through the sequence at Shubayqa with water resources diminishing. This could well have influenced the prey perused by humans. It is probable that the ground dwelling birds were present throughout the sequence, but people started exploiting them more frequently as other resources, such as the waterfowl, were gradually changing. The corncrake is a bird that runs, rather than flying from danger, and will hide in scrub rather than flee (Ashoori and Zolfirejad 2008). In a conservation study of corncrake, Ashoori and Zolfirejad (2008) note that the birds used to be hunted for meat in the Caspian lowlands, but the practice is now illegal. However, for conservation reasons local people were employed to catch birds with their dogs searching for this species, as well as other birds such as quail, by smell. "Corncrakes rarely fly … when humans are present, so it is necessary for the hunters to use hunting dogs. As soon as a quarry is located, the dog wags its tail and watches the quarry keenly from a distance of 0.5–1.0 m. This alerts the hunter who approaches the dog and gets ready with his net. A well-trained hunting dog does not let the bird escape but makes the bird fly on a signal from the hunter. Then the hunter has to capture the bird by skilfully throwing his net." (Ashoori and Zolfirejad 2008: 93). In the central and southern wetlands of Anatolia, the Turkish Tazi is a classic sighthound-greyhound and popular for its superior skills to hunt quail, partridge, rabbits and foxes (Yilmaz and Ertugrul 2011). Given descriptions such as these, it also seems likely that dogs could have been used from an early date to target game birds, flushing them out of scrub, helping humans locate birds and running down their quarry.

Canids and kites

There is a whole other avenue to pursue when research into the dating of desert kites is more conclusive. Campana and Crabtree (1990) and others (Henry 1975) have suggested that communal hunting may have developed in the Natufian. Desert kites are a common feature of the

landscape of eastern Jordan and, whilst interpretations vary, they are often considered as communal hunting structures and have been discussed extensively in the literature (Picalouse et al 2004, Bar-Oz et al 2011, Zeder et al 2013, Barge et al 2016). Depictions of dogs on rock art in north-western Saudi Arabia dated to the 7th or perhaps 8th Millennium BC appear to show dogs as hunting companions (Guagnin et al 2018) and other depictions are known that show dogs associated with desert kites (Picalause et al 2004). If communal hunting occurred by the Natufian, and domestic dogs were present by this date, then there is the possibility that dogs helped drive herds of animals into desert kites. Dating of the desert kites is notoriously tricky. Bar-Yosef (2001) has suggested that features became important in the PPNB providing hunters with surplus meat and hides to trade with herders. There are now suggestions that some of the structures may predate the Late Neolithic (Betts and Burke 2015) making the possibility that these were used, perhaps with the aid of dogs, at an early date an option. In the limestone steppe some kites have been dated to the PPNB with a clear function as hunting structures for the *en masse* procurement of gazelle (Abu-Azizeh and Tarawneh 2015). Without diverging into this line of research extensively, it is worth noting a few temporal characteristics of the faunal sequence from Shubayqa that should be born in mind. Firstly, there is no major change in the mortality profile of gazelle except adults become marginally more frequent (Yeomans et al 2017b). This suggests that there is no obvious change in the hunting strategy. There is an increase in the frequency of wild sheep from the Late Natufian onwards (Yeomans et al 2017b). Whilst it is not known if sheep were the target prey of desert kites in Jordan, it is worth mentioning that Betts and Yagodin (2000) note that in Uzbekistan wild sheep (*Ovis ammon arcal*) were targeted by similar structures, since sheep are creatures of habit and use regular paths. At Shubayqa, other explanations for the increase in sheep are not readily obvious, but the evidence is far too circumstantial at this stage to postulate a correlation. Nevertheless, desert kites, nets and even stepper sections of the Wadi Rajil could have made suitable locations for dogs to drive prey animals. Similar hunting approaches are documented in ethnographic literature (Musil 1928) and Frison et al (1986) note the use of nets to hunt both rabbits and larger animals indicating that even if well-suited terrain is not obvious such hunting is still possible.

Discussion

In their review of the relative proportion of hare in prehistoric assemblages from Israel and the southern Sinai, Bar-El and Tchernov (2000) note a dramatic increase in the proportion of hare bones from the Natufian. In this region domestic dogs are present from the Natufian period. Bar-El and Tchernov (2000) discuss how the hare is a highly agile animal and suggest that trapping or netting techniques may have been in use from the Natufian period onwards to capture such animals. The use of dogs is an alternative means that this evasive prey could have been caught. The implications for the use of dogs as a means to hunt different prey are important. In 1969 Flannery suggested the idea of a broad-spectrum revolution whereby human communities, beginning in the Epipalaeolithic, started exploiting a wider range of resources (Flannery 1969). Since then some scholars identified this change as a response to resource pressure created by

population growth and increased sedentism further influenced by climatic fluctuations (Stiner et al 2000; Munro 2004). The strain placed on the availability of food has been argued to be one of the key reasons why agriculture developed. Grounded in optimal foraging theory, the work of Stiner and Munro suggested that hunting fast prey, such as hare, would only be resorted to when other prey were a diminished resource, as the effort expended on catching these agile animals yielded minimal return given the relatively small amount of meat a hare carcass provides. This avenue of investigation has been used to suggest that during the period preceding the shift to agriculture, people resorted to hunting hares as they had been forced to deal with a limited supply of alternative resources. However, if new hunting tools, for example dogs, are introduced into the equation, then it becomes more efficient to hunt small fast prey.

Ethnographic evidence shows how dogs are used by recent and contemporary hunter-gatherers in tracking and killing small prey, as well as digging them out of their burrows (Mitchell 2008). As the long history of dog use, to hunt both small as well as larger prey, is well known in the region, to not consider the potential for early domestic dogs to be used for such activities is overlooking a potential cause for changes to the subsistence base. Although, as Lupo (2017) points out, identification of the impact that dogs had when they arrived and were used as hunting companions is a challenging question, it is not one that should be overlooked. The potential of novel hunting approaches as an influence on the changing representation of small prey in faunal assemblages of Early Holocene date has been raised before. In 2002 Keith Dobney published an intriguing paper on the origins of falconry and questioned whether "the prey remains identified … represent evidence for an additional hunting strategy employed to catch smaller, prey species?" (Dobney 2002: 76). Dobney (2002) concluded that there was insufficient evidence to categorically demonstrate that falconry did take place in pre-agricultural communities but notes how the potential for new hunting strategies in this pivotal period, for reasons of both climatic change and shifting economic strategies, warrants further evaluation. It is hoped that this paper emulates some of the critical consideration Dobney requested.

Conclusions

Unlike in the Mediterranean zone of the southern Levant, at Shubayqa 6 there is no cultural evidence for the burial of dogs alongside humans to indicate the presence of domestic animals. However, no burials have been found at Shubayqa 6 except from later reuse of the settlement after the PPNA. There are a significant number of large canid bones and, more importantly, a substantial proportion of the faunal remains display the clear taphonomic signatures of having passed though the digestive tract of another animal. This suggests that dogs were allowed to freely roam around the site picking over the discarded waste, but also defecating in the vicinity of where humans were inhabiting. Dogs were present in the Badia region of northeast Jordan by the PPNA and possibly earlier in the final Natufian. Their use as hunting aids at Shubayqa 6, as well as at other sites, could provide an alternative explanation for increase in hare and other small, fast prey. Furthermore, whilst we are still bringing all the various lines of evidence

together, our work from Shubayqa has shown no evidence of a population struggling to cope with diminished resources. There was plentiful supply of waterfowl during the cooler months. The frequency of juvenile gazelle in the assemblage suggests extensive exploitation of this animal but this does not seem to have had long-term impact on the species. Continuing work at Natufian and PPNA sites around the Qa' Shubayqa is beginning to illustrate that people in these settlements in a so-called 'marginal zone' were not living at the edge of sustainability during the Late Pleistocene. There was an abundance of resources, such as birds whose carcasses were expediently processed (Yeomans and Richter 2018). Prey such as hares may not just have been resorted to because of a reduction in foods that could be obtained easier. New hunting techniques had a role to play in the shifting use of resources and hunting with dogs was undoubtedly an important development.

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