On the Stone Age archaeobotany of the Zagros Mountains

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Jonathan Baines
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Dekan:	Prof. Dr. Wolfgang Rosenstiel
1. Berichterstatter:	Prof. Dr. Nicholas Conard
2. Berichterstatter:	PD Dr. Simone Riehl

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Abbreviations

m.a.s.l.	metres above sea level
BP	before present (before 1950)
TISARP	Tübingen Iranian Stone Age Research Project
MIS	marine isotope stage
IWGP	international work group for palaeoethnobotany
mm	millimetres
cf.	refer to
sp.	species

Summary

This dissertation examined the archaeobotanic assemblages from two Stone Age sites in the Zagros Mountains of Iran. It describes what part of the vegetation was like in their vicinity. Environmental conditions signalled by the recovered taxa are investigated and their impact on the way people occupied the sites. Because both sites are situated in a harsh, yet diverse landscape with various regionalised ecotones nearby, subsistence was seasonal and relied on great mobility. Regarded in a broad perspective, the vegetation composition identified in both assemblages record a similar local flora.

The Upper Palaeolithic cave Ghar-e Boof, was in a favourable setting in the landscape for camping and revealed evidence for the consumption of vetch pulses. The tell Chogha Golan formed out of consecutive visits of Pre-Pottery Neolithic date that suggest its setting also enabled good access to resources and nourishment in the surrounding area. Due to the incompleteness of its excavation, various interpretations of the mode of residence and subsistence strategies during the midden occupation are compatible with its particular plant record. The assemblage does not let one distinguish between possible site use, habitation patterns and subsistence activities as either sedentary/agricultural or nomadic/hunter-gatherer.

Because of the close resemblance in vegetation composition with the cave and comparable contemporary sites further West in the Levant, the validity of a weed community in the midden horizons is debated. Although inter-band relationships became more complex during the midden's development, I hypothesise the visitors/occupants continued the hunting and gathering strategies and mobile traditions of the Upper Palaeolithic. The same breadth in grasses, herbs and pulses, that share the same habitat with the wild progenitors identified at both sites, indicate wild foraging rather than cultivation. The discrepant spectrum of high value plant foods between the midden and the cave assemblages: like *Lens*, *Pisum, Triticum* and *Pistacia,* is due to changed availability, and ecological conditions, rather than harvest choice. Whilst climatic amelioration was causal in the recovery and availability of specific taxa, its influence in the development of a permanent residence, and more sedentary food acquisition, is not certain in the midden's or other contemporary archaeobotanic records of Southwestern Asia. To conclude, the botanic record at both sites reflects their local surrounding vegetation and the results of hunter-gatherer subsistence activities without that this agency seriously impacted the deposition of the wild flora from the encountered habitats.

Zusammenfassung

Diese Dissertation erforscht die archäobotanische Sammlung zweier steinzeitlicher Fundstellen des Zagros Gebirges im Iran. Hierbei wird beschrieben, was für eine Vegetation in der unmittelbaren Umgebung der Fundstellen vorherrschte. Untersucht werden die Umweltbedingungen, die durch die entdeckten Taxa angezeigt werden sowie deren Auswirkungen auf die dort damals ansässigen Menschen. Da geographisch beide Fundstellen in unwirtlichen Gegenden liegen, sich jedoch in unmittelbarer Nähe zu diversen Landschaften mit unterschiedlichen regionalen Ecotonen befinden, war die Lebensweise der Menschen durch eine große saisonale Mobilität geprägt. Von einer breiteren Perspektive aus betrachtet, weist die Vegetationszusammensetzung, wie sie in beiden Assemblagen identifiziert wurde, eine ähnliche lokale Flora auf.

Die Früh-Paläolitische Höhle Ghar-e Boof, befindet sich in einer günstigen geographischen Lage und zeigt Beweise für den Konsum von Wicken, Hülsenfrüchten und einer möglichen Nutzung von Seggen als Bodenbelag. Die Tell Chogha Golan, gebildet aus aufeinander folgenden Besuchen in der Neolithischen Vorkultur, ermöglicht auch durch ihre Lage einen guten Zugang zu Ressourcen und Nahrung in der Umgebung. Aufgrund der Unvollständigkeit der Ausgrabung sind verschiedene Interpretationen von der Art und Weise der Aufenthalts- und Subsistenzstrategien während der Midden Besetzung kompatibel mit der ihr eigenen Pflanzenaufzeichnungen. Die Assemblage lässt nicht unterscheiden zwischen möglicher Lagernutzung, Bewohnungsmustern und Lebensunterhaltsaktivitäten, die eindeutig sesshaft oder landwirtschaftlich sind.

Wegen der engen Ähnlichkeit in der Vegetationszusammensetzung der Höhle und einer vergleichbar zeitnahen Fundstelle weiter westlich gelegen, in der Levante, wird die Gültigkeit einer Unkrautgemeinschaft in dem Midden Horizont diskutiert. Obwohl während der Midden Entwicklung inter-band Beziehungen komplexer wurden, glaube ich, dass die Besucher/Bewohner die Jagd- und Sammelstrategien sowie die mobilen Traditionen des Früh-Paläolithikums fortsetzten. Der ahnliche diversitat in Gräsern, Kräutern und Hülsenfrüchten, die den gleichen Lebensraum teilen mit den wilden Vorläufern von gegessen pflanzen identifiziert auf beiden Fundstellen,zeigt wild Futter sammeln anstatt von Kultivierung. Das diskrepante Spektrum von hochwertigen Pflanzen zwischen den Midden und der Höhlen Assemblage: wie *Lens, Pisum, Triticum* und *Pistacia ist* auf veränderte Verfügbarkeit und ökologische Bedingungen zurückzuführen anstatt auf die Erntewahl. Während eine Verbesserung des Klimas mit der Erholung und Verfügbarkeit

spezifischer Taxa kausal verbunden ist, kann nicht mit Sicherheit gesagt werden, dass die Klimaverbesserung einen Einfluss auf die Entstehung eines permanenten Wohnsitzes und einem eher sesshaften Lebensmittelerwerb hatte. Dies geht nicht aus der Midden oder anderen zeitnahen archäobotanischen Aufzeichnungen aus Südwestasien hervor. Zusammenfassend ist festzuhalten, dass die botanische Aufnahme beider Fundstellen ihre lokale pflanzliche Umgebung widerspiegelt. Außerdem zeugen die Ergebnisse von Jäger-Sammler Subsistenz Aktivitäten, welche keine Beeinträchtigung für die wilde Flora darstellen.

List of publications in the thesis

First article :

Jonathan Baines, Simone Riehl, Nicholas Conard & Mohsen Zeidi-Kulehparcheh
Upper Palaeolithic archaeobotany of Ghar-e Boof cave, Iran: a case study in site disturbance and methodology.
Archaeological Anthropological Science 7/2 p.245-256
DOI 10.1007/s12520-014-0191-6

Second article :

Jonathan Baines
From forager to cultivator: a case study in the Zagros Mountains of Iran.
International Journal of Social Science Studies 3/6 p.231-249
DOI 10.11114/ijsss.v3i6.1183

Personal contribution

I analysed the samples from Ghar-e Boof (excavation prior to 2015) and Chogha Golan (Horizon XII and XI) reported on in both articles and this thesis with the supervision of Simone Riehl at the Institute for Natural Scientific Archaeology, Tübingen University.
This doctoral thesis is not part of particular university project, but the fruit of my own curiosity and work following acceptance of my candidacy (matriculation number 3574915) in January 2011 by my supervisors Simone Riehl and Nicholas Conard at the Institute for Natural Scientific Archaeology, Tübingen University.
I contributed 100 percent to the writing of both articles and this doctoral thesis.

1. Introduction

In this manuscript the partial archaeobotanic record of two Stone Age sites are presented in two articles and discussed in the accompanying dissertation. I write “partial” because further excavation was carried out by Tübingen University at Ghar-e Boof after publication of the two articles and the analyses of Chogha Golan' assemblages are still ongoing.

The first article details the plant remains, analysed by the author, recovered from Ghar-e Boof; an Upper Palaeolithic cave in Southwestern Iran. The second article discusses the plant remains from the midden occupation of Chogha Golan; a pre-pottery Neolithic tell in Southwestern Iran. To relay the meaning of the two articles for the field of scholarly archaeology, some further analyses and interpretations are given with thoughts on the modes of residence and mobility at both sites. The charred seed and fruit remains were examined for signs of the past vegetation and subsistence. Tables presenting the author's identifications (colleagues also studied the younger site (D. Karakaya, A. Weide, K. Deckers S. Riehl and others at Tübingen University) are discussed in the articles. The data was compared with the plant remain records from other sites in the wider area. After appreciating their location in the physical and vegetative landscape, more effort was given to describing the access to comestible plants. In the earlier period food was a substance that followed the seasons in an environment interpretable today through comparison with other archaeological and anthropological records. However, the same cereals and pulses eaten then, were cultivated in the later period. Gardening increased the volume harvested, but did not unhinge the dependence on the seasonal cycle. Innovative storage and food preparation techniques without ceramics could have bridged the leaner months, but these perished tracelessly like the inhabitants.

At first the background of the sites and the way of life of their inhabitants is sketched. Multiple forms of occupancy and food acquisition strategies are explored theoretically. Because farming and the adoption of sedentism are such long-lasting topics in Humanities, the principal scenario of a homestead that cultivates and hunts its food to last the year, is presented. However, the midden's archaeological record need not be interpreted in that way. Because there are few clear signs of storage or sedentism *per se* at the midden and little change in the lithic and bone assemblage compared to the later tell horizons, I finally turn to examine just the botanic record.

1.1 The setting

1.1.1 Ghar-e Boof

The Zagros Mountains straddle the modern border of Iran and Iraq. They rise as hills gradually; from the Turan plateau to the East and the Mesopotamian plain to the West, and attain peaks around 4 000 m.a.s.l. Whilst the uplands are characteristically of gentler gradient and rocky, the highlands are jagged and inhospitable. The research concentrates on the Upper Palaeolithic site of Ghar-e Boof, in the Dasht-e Rostam. This is a u-shaped valley that cuts through the uplands of the central part of the mountain range. The limestone cave faces at 650 m.a.s.l north-northeast across the valley floor 100 metres below. Despite the small swathes of marsh and springs found throughout the valley, the surroundings are dry with scarps and much rockfall littering the slopes. Lithic surface finds picked up around the nearby springs are similar in technology to the artefacts in the cave (Heydari-Guran pers. comment). These stone artefacts were part of a microlithic industry that contrasts with the other knapping traditions in the region. Named after the valley, the distinguishing characteristic of the Rostamian is the production of bladelets (Conard and Ghasidian 2011). Radiocarbon dates of grass and pea seeds from the cave place this technology between 37 000 and 31 000 calibrated years BP.

Following van Zeist's vegetation zones of the Zagros, the cave is set at the junction of ecologies in a diverse landscape that contain a number of the wild food sources investigated here (van Zeist 2008). According to his research the cave lies at the transition between the "lowland and foothill" zone and the "mountain" zone. The occupants had complete access to water, to animals that passed through the corridor on their way to another valley and raw materials for fires and crafting tools. The shape of the cave's entrance in the rock wall reduced the deposition of blown material from further out on the slopes. Its protection against the rougher elements meant the cave was an ideal site for setting up a brief camp overlooking the valley floor.

Without domesticated herds, according to ethnographic accounts, survival in the intermountain valleys of the Zagros, relies on the prolonged abandonment of a hunting and foraging domain, so the targeted food sources can regrow (Hole 1977). Year after year longer-term occupation of the cave was therefore unlikely, though possible if interspersed over multiple years. Briefer visits, with sparser consumption, like a need to seek shelter, or short stays whilst acquiring new cores and repairing the stone toolkit, left a gentler footprint on the Dasht-e Rostam's environment. Such occupation could then occur more repeatedly or in consecutive years.

The setting is more complicated though. I suppose the consistent plant record, at least in the horizons I studied, the surface lithic finds and the zoological remains indicate a stable occupation in the area without clear shifts in subsistence or residence. Perhaps because food and resources were stashed, which changed the cave into a more reasonable energy and time efficient transitory camp, few traces of extraordinary living were left. As will be discussed later on, storage increases the capacity for surplus beyond the returns of a successful hunt or bountiful forage. The additional surplus created through storage, when the season of their acquisition has passed, allowed sharing of that momentary affluence with needy people. Although indeed interpreted as a nomadic community, the people living at Ghar-e Boof could therefore deal in favours and debts, like at the later tells of the pre-pottery Neolithic. Because contact with other bands was likely infrequent, the behaviour patterns of communal meeting and sharing were still in their infancy.

Suffice to write that conditions at Ghar-e Boof were favourable for a regularly migrant lifestyle, yet harsh or unendurable if less mobile. It is very hard to look at the demographic setting of the Palaeolithic in the Zagros Mountains without the data to project the population number in the region (cfr. Bocquet-Appel & Demars 2000, for contemporary Western Europe). Rather than differences in landscape or ecological setting, Ghar-e Boof and Chogha Golan contrast more in how people could relate with each other, due to their individual developments in residence, resource acquisition, storage and mobility. These developments improved people's subsistence efficiency, for example in their time management and better energy cost-return ratios. Still, environment and climate are determinant in the food security of humans, regardless of their efforts to subjugate nature.

To appreciate the differences in setting of both sites, we can take a closer look at their environment. Under the term environment, characteristics like mean temperatures, precipitation, ecology and proximity to the Persian Gulf are explored. These were determinant to the kind of vegetation that grew around Ghar-e Boof and Chogha Golan. Plants were an underlying factor in nomadic food security. Their use dictated what residence and mobility strategy visitors followed. Try cooking porridge in a leather sack with heated rocks. Then walk and collect enough new seed to repeat the night's meal. Soon, wherever one went, the grain had already ripened and but a bird's scraps were left. Eventually roaming the higher elevations for late-comers becomes insufficient as well. Shelter was sought in the landscape's larder: a cave central in the Dasht-e Rostam. But what plants were eaten there, when everywhere else they had long given away their bounty? Question not what impact the vegetation had on humans, rather what people did with plants to overcome their seasonal dormancy. Did people store surplus from their extended harvest in caves sitedalong good winter hunting? I presume so, though no signs for such behaviour are identifiable in Ghar-e Boof's archaeology. Apart for the charred seeds I examined and discuss here, no other organic material preserved. The faunal deposits are equally inconclusive and were laid down in unchanged assemblages throughout the cave's occupation horizons. They imply a traditional survival in a stabile environment.

A little prior to when the cave's record began, the climate of Southwestern Asia followed that of continental Europe in a warmer and moister interstadial. In the preceding and subsequent Eras, the climate was colder and ice sheets had trapped enough water to reduce sea levels so that the Persian Gulf was a swampy plain and estuary to the Tigris and Euphrates. It was a vast wetland with a thriving ecology on the Southern shore of the continent 80 kilometres away from Ghar-e Boof. The last records of the Gulf as a giant brackish bog were about 15 000 BP; time enough for both fauna and flora to adapt and stabilise to the change before the onset of the Neolithic. Yet perhaps it featured in the migration pattern of those who passed by the cave. To those aceramic people, the reeds and sedges growing along banks in the floodplain were a fantastic resource for making weaved receptacles, or a fowl hunting hide. Without the tempering effect of the sea, not the shores, but the uplands like the Dasht-e Rostam, would feel the weather more severely. Small though the Gulf is, this fluctuating state of sea or basin, affected the temperature and precipitation further inland. The label used in my first article: “The onset of glacial interstadial 8 in MIS 3: milder and moister phase in an Ice Age,” is therefore liable to localised changeability (Wasylikowa 2005). The cave site's environmental setting, and that of Chogha Golan, is further elaborated on in chapter 1.2.

1.1.2 Chogha Golan

Chogha Golan lies about 600 kilometres Northwest from Ghar-e Boof on a plateau in the Ilam province. The Konjan Cham river flows about 200 metres away from the tell and provides a perennial source of fresh water to the otherwise semi-arid upland environment. This condition can be deduced by looking at the past tree cover, for example through the analysis of charcoal. The identification of *Hippophaë* charcoal (Buckthorn) from the tell suggests a moderate drought stress (Riehl et al 2015 p. 16). Herbs also inform us; the presence of *Chenopodium* and *Artemisia* seed on site*,* indicate warm and dry summers, but not all year round low precipitation. However, pollen analysed from contemporary lake sediments from Urmia and Zeribar further North suggest that the valley ecologies are rather distinct in the Zagros Mountains. What is true at a lake 450 kilometres away is not a necessarily accurate reflection of the situation at Chogha Golan. Much attention is given to these proxies, but should rather be taken with a pinch of salt. They propose that the treeline in the highlands declined and boreal vegetation spread along the valley slopes (Moslimany 1986). But the longer-term scale of the available pollen sequences miss the delicacies of the strong seasonal nature of the climate in the Zagros Mountains. They draw a picture of the vegetation accumulated over years rather than particular phases of the annual cycle. Indeed this is really needed in order to further unravel the issue of subsistence and residence during the midden occupation of Chogha Golan.

The higher elevations themselves, which rise up, near the Konjan Cham river to over 2000 m.a.s.l. further diversified the plant and animal spectrum available to the Neolithic occupants, but are fairly uniform across the range's length. The archaeobotanic literature for the region speaks of Pistachio and Oak woodlands, riparian vegetation and extensive stands of grasses that included *Hordeum* (barley), *Aegilops* (goatgrass): a forebear of free threshing wheat, and *Triticum* (wheat). They often locate Chogha Golan, and other such sites in Southwestern Asia, at the junction of multiple ecotones, meaning that the occupants could forage, hunt and acquire resources from a small, yet concentrated area during their passage in a wider seasonal or annual migration. Though indeed easily eaten and nutritious whilst on the move, these gathered foodstuffs are bulky and not readily preserved without processing and storage efforts. Nomadism was therefore the traditional system of living in the Central Zagros till later in Prehistory. Bridging leaner months and handling months of surplus relied on conventions central to that way of life: like sharing and cooperation.

Yet during the eleventh millennium BP people chose to live permanently in the same spot. The tell formed over generations of occupancy. To query *how* brings the botanic evidence from Chogha Golan together with its archaeology. But no description of a site is complete without mention of its physical surroundings. These, as much as climate and soil conditions, affect an area's vegetation.

The river meanders North-East to South-West over a bedrock that slants by enough degrees to allow long, but short, scarps to form. These are carved perpendicular to the general East-West gradient of the landscape and provide shade and shelter form high winds. The scarps are occasionally more pronounced and form higher ridges that separate the drier v-shaped tributaries. The soil is eroded by rainfall and cropping ungulates. The ravines bloom during rain showers. Then, predominantly the hardier herbs of the Chenopodiaceae family for example, or spread-out dwarfed evergreen trees such as Pistachio, Buckthorn and Juniper would dominate the land. The orientation of these side valleys reduces the amount of sun exposure and creates rockier habitats compared to along the main river bed, where a more riparian flora flourishes. Steep uplands must be crossed to the East to reach a parallel valley. To the West the land levels gradually into the Mehran plain. That people frequented this wider region, and also earlier during the Palaeolithic, as an easier location for traversing the many intermountain valleys of the Central Zagros, is hinted at by the many scattered lithic surface finds (Darabi & Fazeli 2009). Perhaps because of this connectivity to other valleys, one could afford a stationary residence that relied on reciprocation for hospitality in food. Craftwork and rendering services alleviated the debt, but would there be enough visitors to survive? There is little archaeological proof that concludes people resided all year round during the midden's development, rather than made repeated short term visits. Indeed contrasting the material record of all the site's horizons very broadly reveals no significant changes in lithic technology or faunal remains. No architecture or dry storage developed (like pottery, clay-lined bins or walls). With these lines of evidence hinting mainly at a continuation of the earlier subsistence strategies, must the linear interpretation of the midden as a sedentary and agricultural precursor to village life, be followed? Assuredly, there are signs later on of cultivation and domesticated crops at Chogha Golan, but this does not mean the whole occupation sequence was a development to that end. Looking at the faunal, botanic and material archaeology in the same light as other authors, some alternatives are possible.

1.1.3 Other sites in the wider region

The Zagros Mountains are long longitudinally and narrow latitudinally. To cross the range nearby either studied site means transversing multiple watersheds that form a rippled relief of uplands. I hesitate therefore to write about direct contact with other sites in the region. However, knowing what was buried there, allows conjectures, not only of what was available, as the ecological setting in the mountain range differs little from the Levant in the West, but also on how the remains were deposited. Alas few sites on the Turan Plateau to the East have published archaeobotanic records to compare with. Even though contact was unlikely, associations between the sites exist in the form of enacted shared human behaviour. But these traces are accompanied by a myriad of floor sweepings, accidents and natural propagation from the local vegetation that were left to char. Hence appreciating each site's setting, and environmental conditions, is necessary to distinguish between patterns inherent to human actions or the landscape's past flora. Table 1 in the second article presents a presence or absence tally of plants consumed at 20 sites contemporary with Chogha Golan, alongside three particular plants (*Aegilops*, triticoid-types and *Taeniatherum)* further discussed in the articles and the case studies below. Whilst four of the sites are in the Zagros Mountains, the others are in Palestine and along the Tigris and Euphrates rivers. The assemblages, and occasionally chosen plants therein, of various arrangements of these 20 sites are examined in the second article to contrast or compare with the midden's record. The sites straddle the familiar crescent of uplands surrounded topographically by a high plateau to the East and a wide basin to the West. Likewise their ecology is related in seasonality, vegetation composition and recuperation from the effects of the Pleistocene. The absence of *Amygdalus* at Chogha Golan for example, is more likely due to unavailability, than disinterest, as it was found nearby at Ganj Dere Tepe and most contemporaneous sites in the list to the West. Notable exception to this notion of shared human and botanic background are the remains of *Cicer*, found just at Kebara in the Palaeolithic and Dja 'de, a relatively short aceramic Neolithic occupation.

The significance of a relative age amongst the younger sites, lies I believe equally in its proximity to the climatic changes of the Era, as to the Neolithisation process occurring then. The consumption of *Cicer* at Kebara cave more than 48 000 BP means its presence in Dja 'de's record is not because of the Neolithisation underway in Southwestern Asia. Rather, it was deposited there because of the plant's significance as food, in the same regard as vetches were consumed at Ghar-e Boof, or *Pisum* at the midden, or *Lens* during the Epi-Palaeolithic at Ohallo II. Whether the vetches, *Lens* and *Cicer* were foraged, or cultivated, at Dja 'de changes the debate from direct contact with plants, to exploitation *en mass,* or manipulation, of particular taxa. I believe these activities represent a part of the Neolithisation process interpreted, and beginning right then in those millennia, in the region. Why *Lens* and *Cicer*, or *Pisum* at other sites, may have been cultivated, yet vetches (*Lathyrus*/*Vicia*) not, illustrates a human mechanism in that process; dedicating some time to richer returns, over just foraging wild taxa. However, as both Ghar-e Boof and the midden represent consecutive occupation horizons over hundreds of years during which similar pulses were consumed, this mechanism does not necessarily imply a break from nomadism and the adoption of sedentism. Rather it means a need to intensify returns on expended energy acquiring food.

As pulses were central in my evaluation of comestible plants at Ghar-e Boof, and often feature in the discussions on consumed and domesticated plants in the Stone Age in Southwestern Asia, their relevance in the archaeobotany of the wider region and this dissertation needs some elaboration (Weiss 2004). The theoretical background for their domestication can be summed up as a search for a reliable, local, nutritious source of food. Kaufman saw a contrast between residential and logistical mobility, whereby the former sees consumers moving to their exploited resources and the latter sees the resources brought to the consumers (Kaufman 1992). By reducing the distance across which people and their food must move, the second strategy offers the better energy returns. Hence early on in the endeavour to intensify food acquisition the focus lay in harvesting rich plants near to one's camp. Practically, this meant impacting the natural selection of pulses' descendants through three conscious activities. One, acting on factors external to the plant: like management of soil, moisture and light conditions or controlling competitors. Two, targeting the plants directly: like imposing new germination or growth regimes and seed scarification (Abbo et al. 2013). Three, maintaining the plants' new situation. When people selected seeds for the next year's sowing from mature plants grown under these modified conditions, and exhibiting characteristics preferential to greater yield, it led over prolonged time to morphological and or ecological distinctions compared to the plants' wild ancestors. In some cases it even led to speciation (Fuller et al. 2012a). Though most of the above is widely accepted as probable, it is the timescale involved in this process that is much debated (for example Abbo 2013, Albert 2000, Barlow 2002 or Fuller et al. 2012b). In sum, the scholarly clash revolves around a protracted development of pre-domestication cultivation practices by mobile and early sedentary hunter-gatherers on the one hand, and a quickly developed innovation that was widely passed amongst sedentary communities on the other hand. However, neither side refutes that these efforts were exclusive to a core area or always successful. Some trials were abandoned for instance, like the attempts with *Vicia peregeina,* possibly cultivated between 11 300 - 10 900 years ago at Netiv Hagdud in Southern Jordan (Melamed 2008). Or the successful domestication of *Cicer arietinum* at Tell el-Kerkh in Northwestern Syria 10 000 year ago and still eaten today (Tanno & Willcox 2006).

After further reading I could question whether the technological record (lithics, fibres, or other wooden and bone implements) from these and other sites in the region also indicate intensified use, or increased complexity to capitalize on the seasonal bounty. The development of tells, or the need to stay put year-round, may be connected to other mechanisms in the Neolithization process. Such as for instance to changes in inter-band relationships, for example due to improved food acquisition strategies or the strains of living in one place. These made matters of for example ownership or sharing more complicated. However, a particular issue in placing Chogha Golan's assemblages in a region wide archaeological record that permits examining the Neolithization process underway there, is that the site was not excavated enough in a way that allows me to interpret the possible changes in habitation and human relationship in that Era. Both the environmental and material remains recovered give a basis for comparison with the other sites, but lack archaeological detail that allow for closer cross-examination. Examples of this are the many surface find concentrations, contemporary with Ghar-e Boof and Chogha Golan, identified in Saman Heydari's extensive research in the Central Zagros Mountains (Heydari 2014). However, much can be said on people's subsistence and residence at these small sites individually, but less on how these camps related to the wider area and the developments underway there (Zeidi and Riehl personal comments). Therefore this dissertation leans on the archaeobotanic assemblages, and the landscape and environmental setting, of both sites, with an eye cast on the records of other comparable sites in Southwestern Asia, to suggest what plant diet and vegetation were possible.

1.2 Climatic background

The physical surroundings of Ghar-e Boof and Chogha Golan were discussed separately in their respective setting chapters 1.1.1 and 1.1.2, but their climatic conditions feature here together, because they are better described through direct comparison. Whist both fall for instance in the Pleistocene, the older site was occupied at the beginning of a warming phase, and the younger site at the end of a colder phase. Thus in colloquial terms they may be labelled as Ice Age archaeology, yet to be more precise the former was visited during an interstadial and the latter during a stadial. In other terms, people frequented the cave during the phase of climatic recovery, or improvement, from the severe glacial conditions millennia earlier, called Heinrich Event 4 (Otte *et al.* 2011). The midden arose either during the waning of the Younger Dryas, which was also a period of climatic degradation, or soon after it had ended. Whether terminal of the one phase or initial of another, weather conditions early 12th millennium BP were no longer hard glacial (Bottema 1995). However, the large proportion of *Hippophae* charcoal identified in the midden, compared to in the later horizons, evince a change from drier to more damp conditions in the site's history (Riehl *et al.* 2015 p.14).

Research into the impact of the stadial climate on the precipitation, particularly the South-West monsoon, of Southern Iran suggests spells of prolonged aridity and reduced aquifer recovery in the midden establishment period (Kober *et al.* 2013). Drier conditions then are corroborated by the analysis of stable carbon isotopes in wild barley grains from horizon XI which indicate that these plants underwent a moderate drought stress (Riehl *et al.* 2015 p.15). The monsoon shift meant that the Makran highlands, and the neighbouring Zagros to the North-Westwards, suffered greater erosion and drier weather than in the ensuing Holocene. Moreover, the analyses of sediment formations and composition indicate that both sites were occupied in periods that followed soon after phases of enhanced monsoons and more stable precipitation (see figure A). On the one hand this could suggest that the biological environment went into decline from a state of abundance and diversification, but examination of regional lakeshore pollen cores rather indicate that the vegetation composition remained stable (Kehl 2009). So on the other hand, it might rather imply that the Southern Zagros underwent less direct impact from the glacial situation which was felt further Northwards in Eurasia. Rather, the mountain range could have acted as a buffer against ecological loss, and despite the increased salinity and aridity noticed in the regional palynology, the native Pleistocene vegetation at both sites were unlikely to have been impoverished (abridged references for lake Urmia (Djamali *et al.* 2008), lake Mirabad (van Zeist 1968), lake Zeribar (Moslimany 1987) and lake Maharlou (Djamali *et al.* 2009).

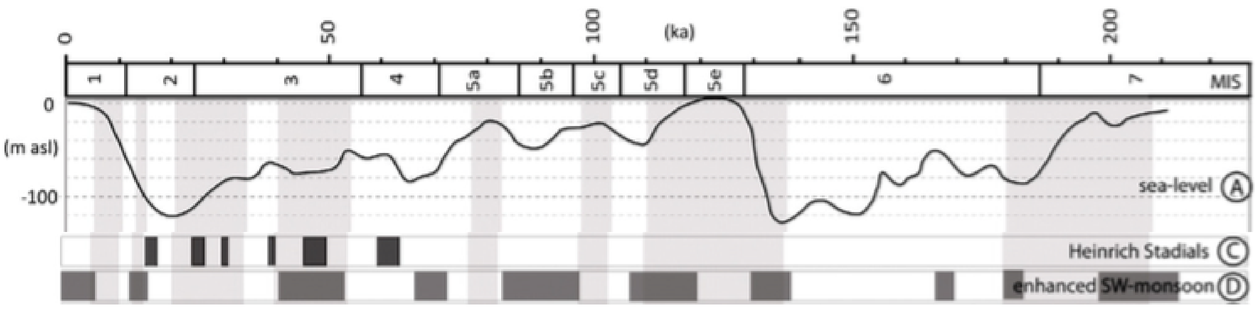
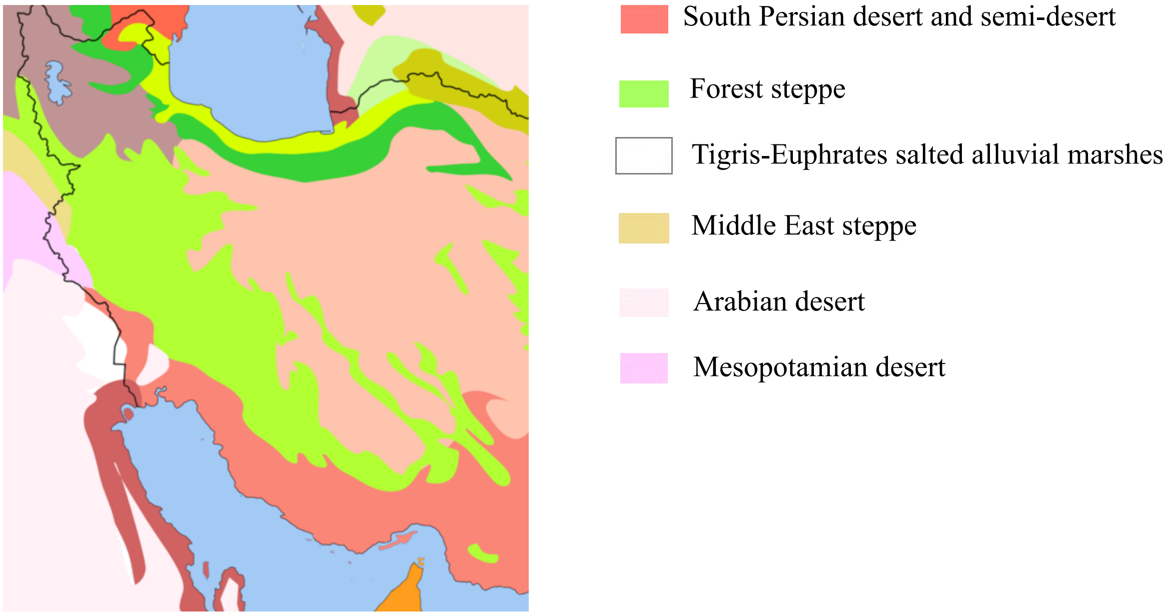


Figure A: Illustration of the hypothetical sea level of the Persian Gulf, the relative timing of Heinrich Events and the proposed occurrence of enhanced South-West monsoons in Southern Iran. MIS chronology and age BP are shown.
Adapted from Kober *et al.* 2013, fig. 8 p.143

A page of confusing terminology based on geological eras and environmental studies, describing the climate at both sites as not yet stable, due to relative proximity to global phase shifts, still has to answer how it affected living conditions on the ground. Map 2 illustrates the varied tapestry of biotopes during the Holocene and reveals their setting near the junction of multiple plant ecologies. The governing 'glacial' climate will have impacted each zone individually, but did not restrict the availability in plant food and resources, as a diversity could still be encountered during seasonal migration. Even the predominantly drier and flatter environment to the West offered sustenance and materials during its moments of abundance. Whilst the “highly dissected limestones of the Zagros” provided shelter for game and people alike in harsher months and lush vegetation at other times, its topography accentuated the climatic conditions affecting the seasonal bounty and logistics.
The change in vegetation from the Rostamian cave occupation, to the midden development along the Holocene boundary, depicted by map 2, is characterised according to the four lake pollen cores of Western Iran, by a shift from an upland steppe vegetation to a river valley one (Stevens 2001, Wasylikowa 2005, Djamali 2008). If any climatic determinism did play a role in the transition from an Upper Palaeolithic lifestyle to an aceramic Neolithic existence, it may well have been this ecological shift. People gradually responded by adapting their migration patterns from roaming across the mountain range and its surrounding plateau and riparian lowlands, as dictated by the seasons, to a dependence on the river valleys.



Map 2: Modern biotopes of Iran, adapted from Fabien Khan 2006.

However, Stone Age sites were plentiful across most of the Zagros' relief; spreading from 500 to about 2 500 m.a.s.l., which indicates that people remained highly mobile in the region in order to meet the pendulum between: drier and cooler, and slightly damper and warmer conditions, then extant in both climatically shifting eras (Zeidi 2009, Heydari 2014).

1.3. Alternative interpretations to non-sedentary midden development

As the faunal and lithic remains stay broadly similar throughout Chogha Golan's earlier occupation, I put forward the premise that they indicate little change in the occupant's means and ways of subsistence. Based on this, it is possible there were different lifestyles at the midden and the tell's last horizons. First let me pick apart the vocabulary used in this chapter. These interpretations are not new or of my own devising. My work rather is their presentation as alternatives to the view of the midden as a sedentary camp. In this dissertation, the words tell or midden refer to the site, or its setting, not the inhabitants, which are referred to by that noun. Whether the midden was visited, or lived on permanently, it had an occasional archaeologically tangible characteristic: the location became tied into the roaming humans' landscape, because visiting the site had an extra worth.

Since a single mound of superimposed camps, rather than multiple nearby short-lived encampments, developed at Chogha Golan, I suggest this extra worth was for example in the preparations available, or materials on hand, for visitors to spend a night. A tradition would emerge of maintaining the one spot before leaving it in readiness for the next visitors. As the location became a greater focus in the region's nomadism, the midden would grow. Indeed a tell is a vaster midden of gradually accumulated domestic refuse. I see this tradition as an expected and relied upon behaviour by its partners. Once tied-in, obligations and credit usually kept you in. As the customs and relationships at the midden became more developed, so did the added value of visiting rise. Over time additional complexities stemming from social and economic relationships between human groups made this tradition more intricate, be they between units as small as extended families or between larger congregates. For example, prearranged meetings at the midden to share larger bounties maintained the feeling of being a unit. The values of reciprocity and hospitality that developed at the midden would trigger innovations specific for life at a particular location, rather than targeted at only the innovator's moving world. Moreover, not just her or his immediate family benefitted from the novelties, but also the other people visiting the midden. Indeed the more the midden became tied into the wandering human's landscape, the more it began to connect these visitors to each other and to that particular spot. This characteristic, over time, became as it were omnipotent because the people became too caught up in a valuable social and economic system (an unusual one to them, because it occurred at a specific location, whilst they still maintained a nomadic lifestyle) and so could not abandon it easily. In such a scenario dominated by novelties for the humans of the Early aceramic Neolithic, it is possible to imagine that huge changes came about, without each person being wholly in control, or cognisant, of the developments individually, but rather that they happened to the inhabitants as in a cooperative. Read *cooperative*, because these people had to actively keep the midden ready as a valuable base for themselves and each other. It was a job to do if one wished to appreciate the added worth of visiting the midden and not camp at another random spot along the way. Without this effort the midden had no extra value and so the characteristic would fall apart. However, storage disturbs the described collective. Hypothetically though, as no remains of storage devices were found in the midden, or at Ghar-e Boof for that matter. If keeping surplus safe for months for later consumption was possible, then the greater weight, or bulk, in valuable material each individual human could possess, would have affected the rules on ownership. Instead of having to carry one's possessions, they could be kept or buried at a friendly spot. Keeping a particular location operative to service other people was likely a novelty. However, committing the effort to keep a stock of fuel, prepared cores and shelter at the midden is different to storing food in common. There is a difference between tasks that can be done year-round and tasks that are seasonal or even fleeting. So the products of the latter tasks became material of higher value than those of the former tasks and so were more prone to arguments when left in common. It is at this point that both the inhabitants and their archaeology are confronted by divergent choices. How to share the midden and all that is stored there? Whilst this questions the relationship between people and their material possessions, the issue of landownership of the midden is a less solid discussion. This topic however leads to intangible thoughts on claiming and identifying with an area, which lie beyond my reading.

First two nomadic alternatives are presented and then they are compared to sedentism at the midden itself. One alternative is for a unit of people to visit the midden during their passage through the region (see figure 2). Whether they return or not is unsure. The prominence of the area led other units, or the same unit, to camp there and so over generations a midden arose. A stable, functional and local zoological, botanical and lithic archaeological record is gradually buried.

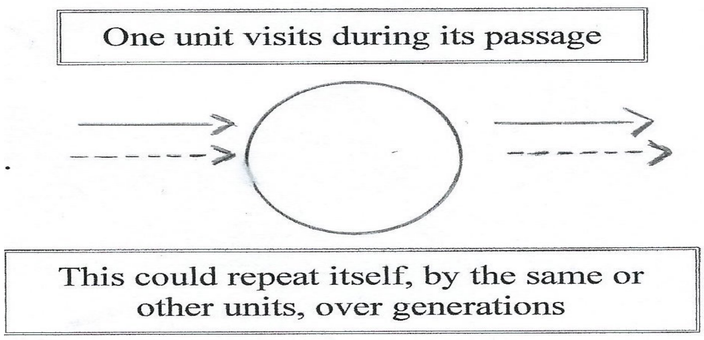


Figure 2: illustrates the consecutive build-up of the midden by multiple visiting units

The other alternative is for a band of multiple units to camp individually, or together, at one location (see figure 3). Over time, persistent meetings gave rise to a midden. In such a scenario a relationship between the bands developed and the people held the site in common. Whilst services, or preparations at the midden, without actual contact with the patron were described earlier, now the benefit of the meetings possible in this second alternative are explored. It could have meant as much as having a fireplace, fuel and bedding already set for an arriving band, or a camp already set up after a long hike in cold weather. The visitors returned this favour in the best way they could, or later. Such meetings could facilitate leaving messages, or goods, in safekeeping for another band passing by on a different route. In both alternatives storage and a sheltered place to stay were possible. This reduced the food stresses on the visitors. It also meant they had more time for craftwork, rest or leisure, but this is also the case if the midden were lived at permanently by one band. Archaeologically the two scenarios would not leave a very different record compared to a sedentary midden occupation. Hence the magnitude in research and debate on the topic of sedentism and its relationship with the development of agriculture.

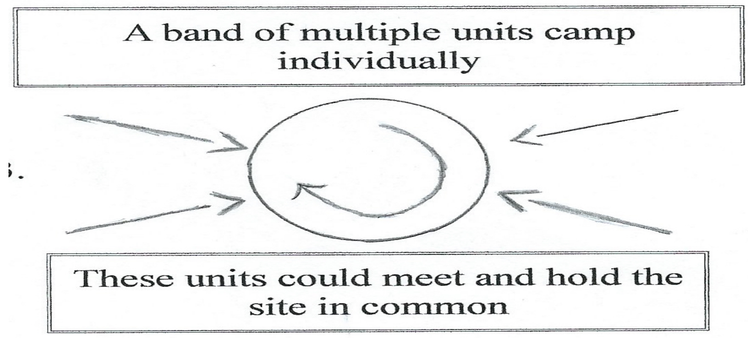


Figure 3: illustrates the consecutive build-up of the midden by recurring visits.

The population size visiting or occupying Chogha Golan is also hard to decipher from the site's archaeological record. It could range from one extended family living on site, to numerous related families orbiting the site, or a family passing by. In the first option, the inhabitants relied more on contact with the nomads, rather than vice versa, for out of season foods. This helped the residents overcome the intermittent phases of food scarcity. However, as not a great many people passed the Konjan Cham, the band living in the midden horizon faced food scarcity more pronouncedly than did their nomadic counterparts. To set up of a permanent camp at Chogha Golan, long distance hunting and gathering excursions, like those practiced in the Upper Palaeolithic at Ghar-e Boof, were likely maintained. As new storage techniques developed to keep the surplus from moments of seasonal abundance for the leaner months, the food situation improved till it equated that of the nomads. The archaeological deposits brought in from these excursions are so similar, whether the midden was a settlement or a camp, that either occupation was possible. In both cases acquiring provisions from further afield was necessary at some time in the yearly passage through the landscape or to survive seasonal shortages whilst residing in one spot. For this reason it is assumed that the seasonally nomadic herdsman living in the Zagros Mountains today, like the hunter-gatherers of the past, subsisted for about 60% on a broad spectrum of vegetative foods (Gilbert 1975 & Stauffer 1965) and such diet is maintained through year-round roaming of the diverse environments that comprise the wider region.

Turning now to permanent residency at Chogha Golan and the development of a tell (see figure 4). One major difference stands out in comparison to the two previous alternatives, and that is a feature absent in the archaeological record: storage. Most of the theoretical background given earlier goes as well for life at a homestead, as for visitors or a place held in common by multiple families. Just the issue of being able to keep surplus for the winter, or share it, changes the whole relationship between people and nature and between themselves. Without traces of storage in the midden horizon this avenue of discussion is cut off. So the botanic record stands alone to inform what contact people had with plants, by the presence of particular specimens in the form of charred plant remains.

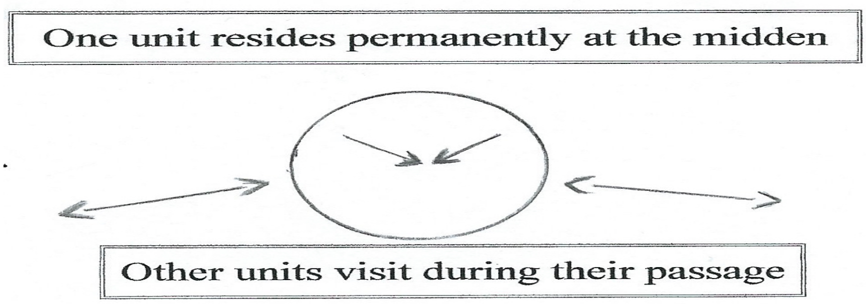


Figure 4: illustrates how the midden formed out of the sedentary occupation of a single unit

2. Doctoral research objectives and output

In June 2011 I drew a diagram (see appendix) of the position of my dissertation at its beginning. I had two data sets of charred plant macro-fossils upon which played two restrictions. First, that they were made up of many individual specimens each bound to a particular moment and manner of deposition that may or may not be congruous in age with each other. My first article investigated signs of disturbance and anachronistic objects to better understand this issue at Ghar-e Boof. The second restriction is that these specimens belonged to an *implied* archaeological horizon, which connects it to other artefacts in its assemblage that bear witness to the event of their deposition. Archaeobotany principally investigates how plant remains were fossilised and that process tells us of the past vegetation. Further interpretation of human use, or consumption, of the parent plants comes from the archaeological chair, rather than the results of digging and laboratory study. Thus two narratives conflate in my dissertation. The first that examined the plant remains and tells the physical and botanic side of their deposition. The second reflected on the role of humans, or if they had no such role, in the deposition of the studied objects. What vegetation do the remains represent? The verifiable answer is the taxa tally in the appendix. Perhaps also an estimate of its carrying capacity of edible food, or reconstruction of the site's plant ecology. Reading on the subject formed theories, that utilise the data sets to express hypotheses, founded on scholarly research, of life in the Stone Age. For example, if the right time for humans to harvest plants effectively is seasonal, then nomads are drawn in specific months to particularly rewarding localities. Over time, this repetition leaves consecutive occupation remains in propitious camp sites like a cave or those overlooking a stream. The material record at Chogha Golan reflects the same stable exploitation of the Zagros Mountains as during the Rostamian: no change in lithic technology, no dry storage vessels, no distinct change in animal remains and no clearly identifiable signal for cultivation of the charred seeds. How does the midden's plant record fit in the Neolithization process that unfolds in the younger tell horizons? I see a continuation of the mostly lower-ranked taxa found in the cave, together with some richer relatives of the edible grasses and pulses in the Upper Palaeolithic. Explaining the availability of these new, arguably anthropogenic, taxa raises questions on the occupants' mode of residence and mobility, a debate which is central in the Neolithization process, yet unclear in the midden's archaeology. In sum, the human community changed in Chogha Golan's Age, and so the archaeobotanic record of that encampment differs from the natural plant community of the locality.

3. Results and Discussion

3.1 Studied assemblages

Ghar-e Boof, also known as Boof cave, at the time of writing the first article, implied an Upper Palaeolithic site formed through 5 distinct occupation horizons (see figure X). The cave surface and modern deposited sediments are Horizon I. Horizon II was subdivided into three distinct archaeological layers (II, IIa and IIb). Horizon III was also subdivided into three distinct archaeological layers (III, IIIa and IIIb). However, these subdivisions were not recognised throughout the entire excavation trench. Hence the necessity to describe and discuss the site's formation process and post-depositional disturbances in the first article. Horizon IIIa for instance was not identified towards the cave rear (western end of the trench), but was clear in the middle and towards the cave entrance. Note the slanting stratigraphy towards the East and the large roof collapse and ensuing rubble deposition in the trench middle. The lowest level, Horizon IV, was also subdivided into three distinct archaeological layers (IV, IVa and IVb) and were discernible throughout the entire 2007 excavation trench.

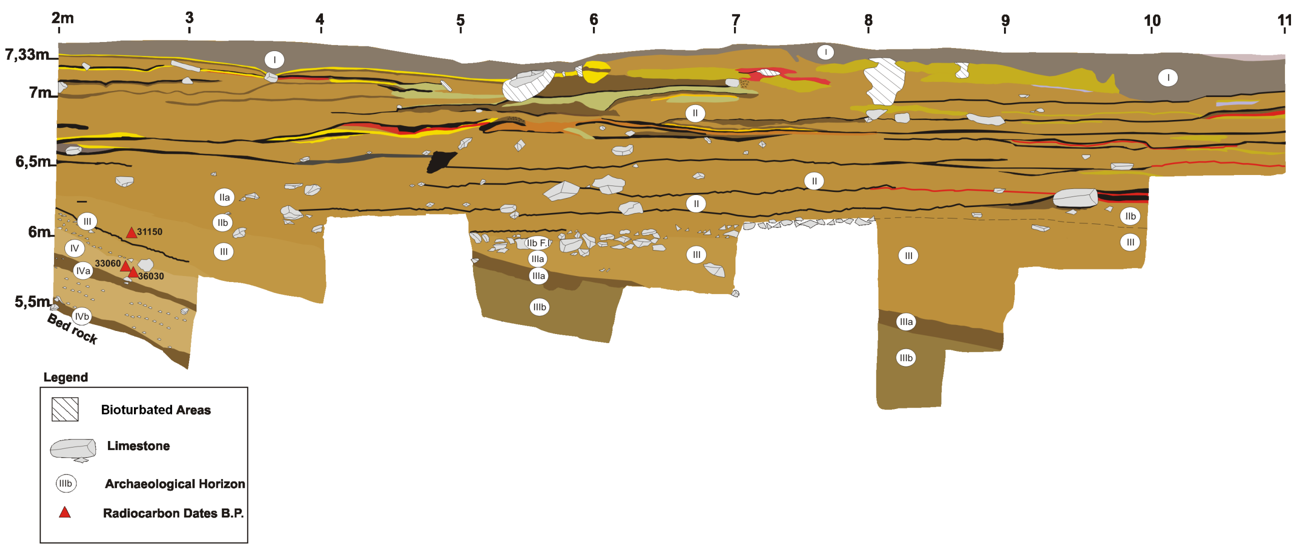


Figure X: Ghar-e Boof 2007 excavation North-South profile

(Drawing made by TISARP: M. Zeidi & N. Conard)

All 352 samples from the 2007 excavation were made available by TISARP for analysis by the author for this dissertation. No material from the more recent 2015 excavation was examined. However, as the bedrock was reached at the bottom of Horizon IV, it is reasonable to assume no deeper Horizons existed at the time of writing, although of course further subdivision or correction of the stratigraphy is possible. Any discrepancies with regards the current understanding of the site formation and horizons are therefore due the time-lag between the author's examination of the samples and their publication and the prospective dissertation's defence.

The tell's 25 midden samples examined by the author represent Chogha Golan's earliest occupations: horizon XI and the surface horizon XII. They were retrieved from floatation of the excavated sediments of a deep, but small, sondage between 2009 and 2011. Although the younger horizons of this Pre-Pottery Neolithic tell contained clay figurines, the midden horizons were devoid, as far as I am aware, of any ceramics. Like Ghar-e Boof, Chogha Golan was excavated using a grid system typical to Tübingen University methodology, whereby the sample names correspond to the coordinates in the trench.

3.1.1 Data collection and presentation

Ordinarily one divides carpology into seed and fruit, but the nature of preservation and deposition contexts of a cave or midden leave little fruit recovered for analysis. All the sorted material is charred and a conscious skepticism of contemporaneity occurs whenever uncarbonised seeds are encountered. The examined samples were secured by floatation of sediment recovered from the excavated squares and therefore include a number of *modern* seeds (some of which have revealed a fresh endosperm upon dissection) originating in the water source. These are tallied in a separate data set, as they represent the background flora of the investigated sites today, but are treated as intrusive objects and as such are excluded from the statistics and interpretation.
How then did I differentiate between included and rejected uncarbonised specimens? Whilst the bountiful *Reseda luteola* seed for instance, often have fruit husks still attached and appear too immaculate to be Pleistocene relics, discrimination against the few *Urtica urens* and *Ranunculus* sp. is not so easy. Deciding therefore against all uncarbonised material invokes the misconception that all charred objects belong to the Upper Palaeolithic. A number of free threshing *Triticum* sp., *Oryza* sp. and cultivated *Hordeum* sp. were identified in otherwise to be considered safe locations. The latter may however, represent a wild type native to region. I chose therefore to discount those subsquares (individual samples), wherein any doubtful material were found, from the statistical

examinations. The recovered specimens however, are tabulated to maintain a depth of the overall potential plant community at the sites.

All identifications were made following the nomenclature advised by the Integrated Taxanomic Information System in the *Catalogue of life 26 July 2011* found at (www.catalogueoflife.org).

Specimens are entered binominally in the data set by family. This means that if a particular object has ambiguity between one or more possible genera or species, for example *Lathyrus/Vicia* sp., there is no preferred choice, the alphabet is merely followed to allocate a position. However, since not all objects could be identified at the same level, a complication arises in entering some remains into the data set for statistical analysis and interpretation. Chenopodiaceae, *Chenopodium* sp. and *Chenopodium murale* for example, occur in the same sample and, whilst associated with somewhat similar habitats, they are not to be counted together as one "analytical unit" or considered indicative of similar environmental conditions (Popper 1988 p.61). I have chosen therefore for maintaining as much of the detail from identification as possible and recording specimens from each taxonomic step individually in the data set. In some cases in the statistical analysis, dependent on the questions posed, they may however be grouped together.

The provenance of each identified specimen is recorded in excavated spits of 10 litre buckets. This spatial and relative temporal distribution of the plant remains allows on-site comparisons and investigation into changes in the assemblage's composition. The analytical units contrasted or discussed are therefore the ¼ m^2 and 3 centimetres deep spit with their "collections of entities of different types": the individual specimens (Baxter 1994 p.20). My analytical units can therefore be handled in two ways. First, for a quantitative count of the recovered specimens and tallied identifications. Second as a list of the ubiquity of identifications (at the species, genus or family level) in a given set of samples. The first has its uses in direct comparisons, although archaeologists deal just with what is left to them, not the entire plant spectrum in contact with at the time. The scale of economic or agricultural activity for instance may be interpreted through quantitative analysis of an assemblage or particular plants therein. Riehl and colleagues for example contrast the proportions of Goatgrass and wild Barley in the whole stratigraphic sequence of the Tell to detect trends in weed and crop presence in each horizon (Riehl *e al.* 2015). This quantitative count enables numerical discrimination: a threshold number of specimens must be reached to enter the type in statistical calculations or interpretation (Popper 1988). Such a method can filter out, or accentuate, particular plants, but also specific deposition or preservation routes. Vast amounts of Pistacio shell fragments were recovered for example, but to how many complete shells do they add up? Figs produce very many seeds that preserve well and so would quickly skew numerical analyses. Ubiquity, which disregards how many specimens were found, but tallies presences only in a sample, is in some cases therefore a more appropriate method of recording and analysis. A taxon frequency table can be drawn up for each taxa recorded, whereby the number of analytical units "in which a taxon is present is expressed as a percentage of the total number of [analytical units] in a chosen group". Significantly this approach can help designate own groups for examination according to interest. A presence vs. absence table of taxa in chosen groups for instance, can be insightful in understanding the plant assemblages and composing other groups for further analyses. Moreover, Popper writes that "scores of different taxa can be evaluated independently", but without comparing and attributing significance between different taxa directly (Popper 1988 p. 61).

Both methods were used in the first article to investigate the recovered plant spectrum in predefined groups: particular chosen samples, squares, arbitrary depth units or horizons for instance. Analyses that compared Chogha Golan's record with records from other sites in the broader region, in the second article, also looked at ubiquitous specimen counts, because sample volumes or the analytical units there were not always the same. This method tries to equate the data set for fairer analyses, despite differences in identification, recording or even recovery technique in the field at other sites.

3.1.2 Specimen case studies

3.1.2.1 triticoid types

First I must acknowledge Simone Riehl's help in appreciating the diversity of triticoid type grains. van Zeist's drawings and description made it possible for me to write on a seed that has no clear definition or ecological provenance, but is known among archaeobotanists that study the Neolithic. Specimens shown at the microscope meeting of the 2013 IWGP in Thessaloniki were acknowledged as matching van Zeist's triticoid types. The scholars agreed that they are most likely members of the Triticeae tribe, because of occasional resemblances to genera in that tribe (*Aegilops*, *Hordeum*, *Secale* and *Triticum*). The first of the four genera listed is thought to be paternal of a genome in bread wheat: *Triticum aestivum* and conspicuously present in all Chogha Golan's horizons. More is said of

Aegilops in the second article. Though some triticoid types resembled *Secale,* no clear Secale grains were found in the midden assemblage. Unlike *Hordeum* and *Triticum,* two cereals believed to have been cultivated during the tell occupation or harvested in the neighbourhood, with which some triticoid types also shared affinities.

Numerically they scored 15th out of the 96 identifications, with 378 tallied specimens overall. Though they occurred in 16 of the 17 samples of horizon eleven, they occurred only once in the 7 samples of horizon twelve. Note each sample came from about 10 litres of sediment. Perhaps this indicates a stronger relationship with the midden *per se,*and the plant contact then active, rather than with the midden's surface, that is completely at the start of its development. They range in size lengthwise (measured from nadir to apex) between 2.5 and 1.8 millimetres and in breadth (measured across the ventral side) between 1 and 0.5 millimetres. Their widely different appearance and shape was likely affected by carbonisation. Triticoid types were plants of the past; either the product of human influence, or a species that went extinct in the Early Holocene. Future research looking for modern comparatives, or archaeobotanic recovery, may shed light on their place in prehistory as a failed domestication experiment or as a replaced progenitor to other Triticeae.

3.1.2.2 *Pistacia*

Eight whole *Pistacia* and incalculable shell fragments were found in the midden. The tree cover around Chogha Golan is often described as semi-arid *Pistacia* and deciduous *Quercus*, but no *Quercus* was found (Asouti & Kabukcu 2014). It is unlikely that preservation conditions were less favourable to acorns than pistachios. Both tree populations are thought to have diminished in the Zagros Mountains during the final cold phase of the Pleistocene. *Pistacia* trees prefer the greater aridity and cooler climate likely extant in the 12th millennium BP, compared to the settled milder conditions a few millennia later, when *Quercus* became more widespread. So probably an overall lower moisture level around Chogha Golan was the determining factor for the absence of *Quercus.* Given the many ravines in the rough landscape and under such climatic conditions, *Pistacia* recolonised and represents a significant fraction of the larger macro-fossils analysed in the midden assemblage. Despite the impressive fragmentation of *Pistacia* shell in the samples, they do add up and present a viable case for reliability in the landscape which was happily exploited by people.

3.1.2.3 Small shrubs of the Legume family

This chapter explains the decision to combine flowering plants in the Fabaceae family of morphologically similar seed appearance into one identification. Rather than record thousands of specimens as undetermined, due to indecision between *Astragalus / Trigonella* or *Medicago / Trifolium*, they were collated by size in groups of closest morphological seed resemblance.

Horizon XI					
	< 1 mm	482		< 1 mm	407
Astragalus / Trigonella	1 - 1.5 mm	931	*Medicago / Trifolium*	1 - 1.5 mm	366
	> 1.5 mm	4781		> 1.5 mm	2234
Horizon XII					
	< 1 mm	1		< 1 mm	3
Astragalus / Trigonella	1 - 1.5 mm	13	*Medicago / Trifolium*	1 - 1.5 mm	3
	> 1.5 mm	4		> 1.5 mm	3

Besides debris of cereal processing like rachis remains, pistachio shells and other grass seeds, the record is poorer in horizon XII. Presenting the data of the midden horizon and its surface separately reveals these legumes were significant from the very beginning, either as a conspicuous part of the natural seed deposition of the immediate vicinity or from human contact.

Note that in both plant tallies of this dissertation some specimens were identifiable to *Medicago radiata,* a more singular species, others to a type of *Trigonella astroites* and some were certainly in the clover genus (*Trifolium*). It is not an unusual method of preserving some detail in the list of identified specimens, without giving in to bolder unsure classifications. I also combined *Cerastium*, *Gypsophila* and *Setaria* in the Caryophyllaceae, although there again some objects belonged to just one genus: *Gypsophila*, for sure. Other articles write that these small shrubs of the legume family are useful as kindling, which might explain the numerous presence of their charred seeds in both assemblages as well as in the midden's later horizons (van Zeist & Bakker-Heeres p.234 1984). However, at Ghar-e Boof the much poorer number and distribution of these four legumes indicates that their seeds were either not so readily deposited from natural stands or accidentally charred. As other similar legumes were extant, like the edible *Scorpiurus* or the useful broom (*Genista*), the contrastingly greater presence of comestible vetch seed (*Lathyrus* and *Vicia*) accentuates their significance in the cave assemblage as discussed in the first article. Note that Scholars interpret the *Onobrychis* remains at Netiv Hagdud; a legume not unlike vetch and also found at Ghar-e Boof, was likewise consumed in the Epi-Palaeolithic (Bar-Yosef *et al.* 1991). In sum, the availability of these four legumes in the immediate landscape was more determinant to the amount of seeds charred, than the volume recovered is an indication of their use as kindling.

3.3 Discussion

The first article examines what macro fossils were recovered from the cave floor sediments. Identification enabled description of the past vegetation. Spatial analyses revealed disturbances and contamination, but also deposition patterns suggestive of contact with people (cf. vetches). A sketch was drawn of the access visitors had to comestible and useful plants when camping at Ghar-e Boof. It relayed signals of environmental conditions found in the assemblage. Yet how does the cave's overall archaeobotanic record fit, relate or compare, with Chogha Golan's midden assemblages? They fit together by sharing a similar setting in the landscape, whose plant species dominate by their ubiquity the assemblages, yet retain a detectable base of annual grains and pulses. The near absence of aquatic plants, should not make us believe the sites were far from flowing water. It merely indicates the strength proximity played in the inadvertent deposition and combustion of remains from the local vegetation. There are parallels to be compared at both sites, despite their obviously different Era. The dominant edible pulses recovered at the cave are *Lathyrus* and *Vicia.* They are similar in size, preferred ecology, effort to harvest and reward as *Pisum* and *Lens,* their counterpart in the midden assemblages. The discrepant appearance of these pairs of pulses in the records reflects the hypothetical economy of each site. Ghar-e Boof reflects the nomadic system of exploiting that which is readily available, and had lentils and peas been widespread in the Rostamian, we may have recovered more of them. Chogha Golan's midden operated the same system, but because of its greater potential for storing surplus, efforts were made to obtain larger yields. Hence all four pulses were exploited and those that permitted the best storage and largest quantity would be preferred. The same applies to the harvested grains at both sites, only here the scales of comparison are different. The candidates from the cave assemblages are smaller, often considered weeds at later agricultural sites, but share the same characteristics of effort, reward and ecology. Often it would not have been people's worth to collect these seeds, but denser stands of these mixed grasses growing along gullies provided enough to leave an archaeological trace. A few such events occurring scattered across the cave's horizons would deposit the assemblage presented today and each of these harvests relates with the various cereal gatherings recorded in the midden horizons. Again the contrast between both sites lies in the discrepant species recovered: *Alopecurus* (± 2 by 3 mm), *Panicum* (± 2.5 by 4 mm), *Lolium* (± 2.5 by 5 mm) and *Bromus* (± 2 by 5 mm), versus *Hordeum* (± 2.5 by 6 mm) and *Triticum* (2.5 by 6 mm), not in the candidacy of edible grasses. The different scale in number of specimens is due to taphonomy, or occupation intensity, as the same breadth in diversity is evidenced, rather than harvesting efficiency.

There is such a thing as tradition in excavation, from buying a stepladder that looks the part, to profile drawing with colourful pins, or working pictures rather than a view of the excavators' bums. It goes much further and affects how the archaeology is recorded. The same crew dug both sites, so the data was measured in such a way that lends itself well to comparison between assemblages and to appreciate what they mean to the archaeoboany of the wider region.

Prior to food security from stable cultivation results, (an unlikely situation in the midden horizons) the length or type of occupation depended on the landscape people travelled through. Nourishment and material resources came from accessible caches around each encampment in their yearly passage. Richer environments meant more intense occupation or acquisition were possible. Hence reflections vary in scale; from scattered surface finds, to complex camps or middens, and in the nutritional value of foraged foods. The roughly contemporaneous Abu Hureyra 1 occupation near the Euphrates river reveals various high quality cereals (oat and barley) and pulses (chickpea, lentil and pea), whilst Hallan Cemi in the uplands above a Tigris subsidiary evinces vetches, lentils and less familiar large seeded grasses. Over time desirable plants spread across the wider region and dominate the assemblages. The record of fruits, nuts and seeds typical to a lakeside base-camp overlooking the Jordan valley in the Late Natufian, Wadi Hammeh 27 for example, gives way to more determined contact with richer cereals and pulses in the aceramic Neolithic across the valley at Netiv Hagdud (Edwards 2013). One and half millennia separate latter counterparts, and though the wild fruit and grain record remains present, the availability of greater nutritious plant food swings the assemblage towards their descendants at the younger site. In all the diversity of sites in the region roughly contemporaneous to the midden, a discussion ensues on the interpretation of plants as *weeds* in that particular assemblage. Do they follow the cultivars, or are they part of the foraged background vegetation? In referring to the debate on a broad spectrum diet of nomads in the Stone Age, a variety of plants did not loose their value amidst the rising harvest of crops and therefore persist at younger Neolithic sites in the region (see table 1, article 2). Research at Abu Hureyra 1 underlines the value of the *other,* lower value, comestible plants recognised as staples to hunter-gatherers in the native ecology of rye and other cereals (Hilman *et. al* 2001). When the availability of higher-ranked species declined, subsistence relied on the depth of diet maintained during the palaeolithic to overcome famine (Colledge and Conelly 2010). As conditions improved, there as at other sites, people again turned to these plumper plants and learnt to care for them by sowing and removing competitors (weeds ?), so as to raise their harvest at the cost of time spent foraging the *other* edible seed and fruit. Which plants could be exploited from landscape travelled through was therefore ultimately depended on the governing environment, rather than on the capability to improve harvest returns.

When comparing sites in the region with the nearest overlap in age with the midden {Hayonim cave, Hallan Cemi and Wadi Hammeh 27}, it may seem like the riparian state of a site positively influences the availability of quality plant food. In those particular plants, the assemblage at Chogha Golan is more diverse than the other sites. When comparing the midden with younger sites in the region, the riparian state of for example Abu Hureyra and Dja 'de, further upstream on the Euphrates, enabled collection of a greater diversity in nutritious seed and fruit. The resemblance of a weed ecology in the midden's assemblages, interpreted as indicative of cultivation in younger horizons at other sites in the region, I believe supports the view that these plants shared the habitat of later crops and charred alongside them. Some corroboration for this opinion may be seen in the development of taxa group proportions at Chogha Golan (fig. 5 & 6 Riehl *et al.* 2015 p.13). They reveal a drop in arable weeds and small seeded Fabaceae between the midden's rise and the tell's early horizons - which was possibly the time of strongest change *vis à vis* the adoption of sedentism and new subsistence strategies. The latter is reflected in the increased proportion of wild progenitors, and Aegilops and small-seeded grasses that were inadvertently harvested with the crops.

In the archaeobotany of all time periods there is a difference between the recorded taxa recovered from the samples - read the archaeological plant community, because their deposition is associated with the human occupation - and the natural plant community - the natural seed bank of the vegetation that grows just beyond the excavated site (Cappers & Neef 2012). The margin of difference between both communities is dependent on the human activities on and off-site in the near vicinity. Thus in the Palaeolithic this margin relates to hunting and gathering local wild taxa, with a degree of selection or preference. In the Epi-Palaeolithic to aceramic Neolithic transition, human contact with plants altered and so the difference between the two plant communities changed. At Ghar-e Boof for example, no *Aegilops* or Triticoid-type seeds were recovered. No rachides - the stems or stalks that bear the flower, and later the seed - were recovered that are otherwise indicative of threshing the harvested wild grasses in preparation of consumption (Madella *et al.* 2002). Beside the few *Hordeum* and *Triticum* specimens, interpreted in the first article as anachronistic products of localised taphonomic disturbances, scarce wild progenitors of cereals or pulses were found. However, the cave's record of plant remains of Upper Palaeolithic date is not the product of propagation of plants growing in the neighbourhood alone. Notable exceptions are the few wild millet (*Panicum*) and linseed (*Linum*) grains and the vetches discussed earlier.

The number and distribution of sedges in Ghar-e Boof are another illustration of human agency in the deposition of its plant assemblage. A flooring of sedges was plausibly laid down in the cave. Through occasional burning, in preparation of a new layer, a disproportionate number of for example *Scirpus* seed fossilized throughout archaeological horizon III. They are an archaeobotanic record of the conscious activities of floor establishment and subsequent incineration. Fire was an expedient method of cleansing the living space, or for clearing rubbish, and whilst this act was deliberate, numerous naturally dispersed propagules, and ones inadvertently brought inside the cave by animal and human movement, were accidentally burnt. Though their deposition *per se* was not the result of a conscious human activity, their combustion associates them with the human occupation. These remains are therefore an archaeobotanic record of activities in the cave, rather than a record of natural dispersal (See Bottema 1984 and Van der Veen 2007 for descriptions of the charring processes of plant remains resulting from prehistoric human activities). In this regard, only occupation hiatuses, or sterile layers, in a site document the natural dispersal of seed and fruit. Whilst such strata are not unusual in caves; people may have visited other favourable localities in the region during which time sedimentation continued undisturbed in such an enclosed space, the exposed setting of a midden, and its formation through the consecutive accumulation of encampment refuse, reduces the preservation of a naturally deposited seed and fruit assemblage.

Whilst natural seed dispersal and human agency on and off-site determined what taxa could be deposited, only the on-site human activities, and the site's exposure, confines and setting, dictated the plant remains' preservation. Hence analyses of spatial and temporal distribution and proportion of recovered taxa can provide an insight into the zones and nature of human activities, as well as the site's formation, taphonomy and post-depositional disturbances. These issues were approached methodologically for Ghar-e Boof, and the findings were discussed, in the first article. Because Chogha Golan's excavation was preliminary at the time of writing, its contextual situation is still unclear (S. Riehl personal comments). This means its record does not allow us to make conclusions on habitation patterns or zones of activity. However, unlike the cave whose occupation was restricted in area to within its enclosed space, Chogha Golan's space was unrestricted by its setting. Instead, because tells form through the gradual accumulation of refuse from repeated visits to the same spot, its site formation and taphonomy was almost not influenced or impacted by complex natural factors, but rather by human factors alone.

My final point to raise with regards the triangular association between dispersal, collection and deposition is that all are connected through incineration and preservation to the natural setting and the events that took place there. Because human behaviour was causal to the conservation of the botanic assemblages - inadvertently or through domestic activities, both are the results of activities central in their existence: keeping warm and eating - the archaeology of temporary encampments at the other end of the Zagros Mountains can be compared with. The Azokh caves, Hovk or Aghitu-3 in the South-eastern Lesser Caucasus evince the existence of a Stone Age highland corridor that stretches far South (Fernandez-Jalvo 2014). The terrain and the human behaviour leave a similar vegetation composition behind in the Upper Palaeolithic there, as they did along the Euphrates and Tigris rivers during the Early Neolithic. People supported themselves best in familiar manners with their surroundings. Change, when it comes about, draws all to the trend, for few choose to fall behind and see their traditions become an inferior lifestyle.

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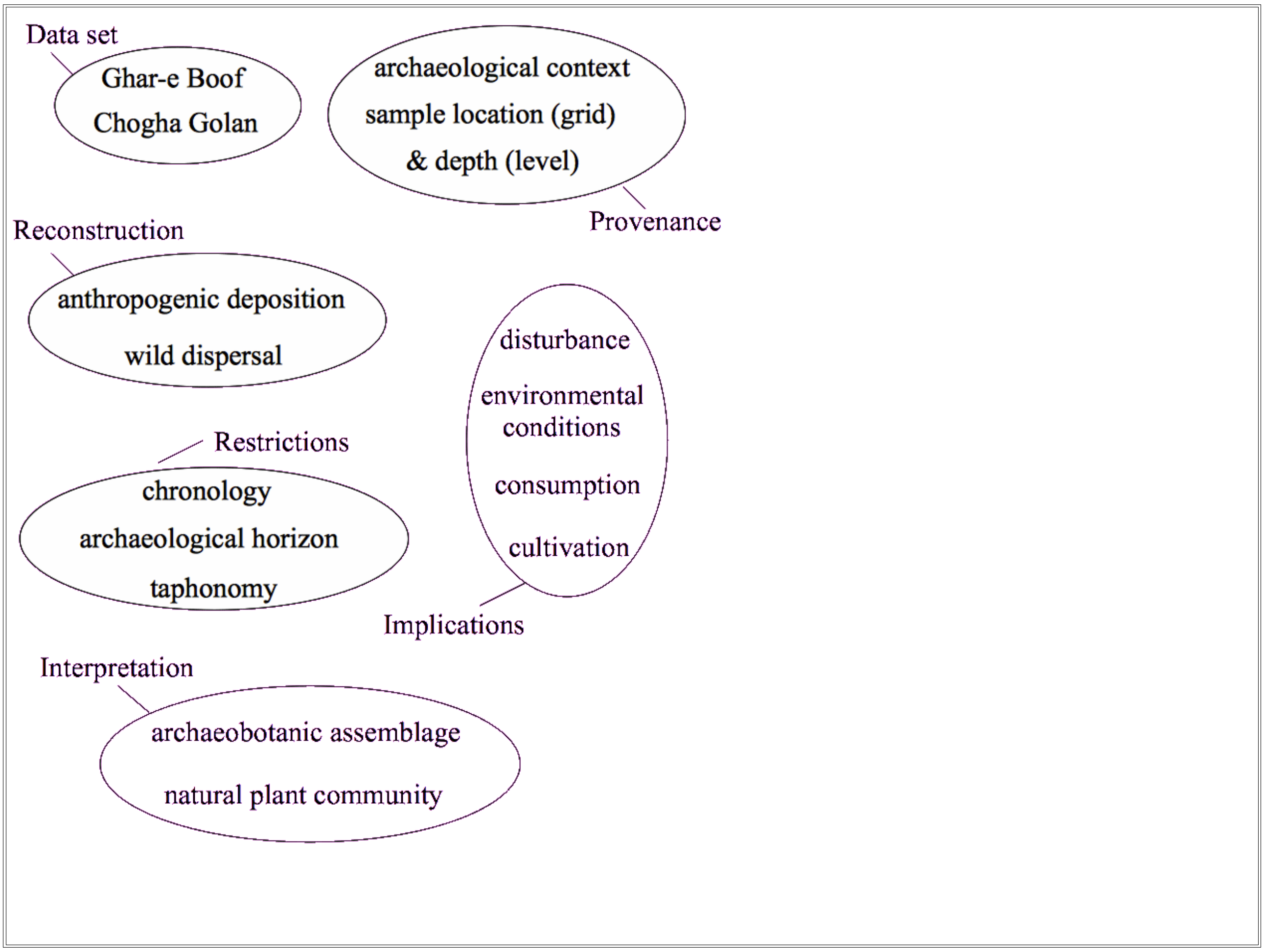
5. Appendices

5.1 Diagram dissertation outline June 2011



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ORIGINAL PAPER

Upper Palaeolithic archaeobotany of Ghar-e Boof cave, Iran: a case study in site disturbance and methodology

Jonathan A. Baines · Simone Riehl · Nicholas Conard · Mohsen Zeidi-Kulehparcheh

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Abstract The excavation of Ghar-e Boof, a cave in the Zagros Mountains, places the site not only at the center of discussion on the transition to and development of its regional lithic tradition: the Rostamian (37,000–31,000 BP), but also in differentiating between plants used by humans or mere traces of the surrounding vegetation. The large pulses of *Lathyrus* or *Vicia* sp. recovered from this shallow cave in the southwest of Iran may, for instance, represent food collected from wild stands already in the early Upper Palaeolithic. The seeds of barley (*Hordeum* sp.), although not all clearly domesticated, are without doubt signs of disturbance or bioturbation since the historic era. Analysis of cave deposits over 30,000 years old raise a number of methodological and interpretive challenges. Human, taphonomic, or biomechanical disturbances impact the deposition of plant remains, as well as affect the composition of the assemblages, undermining spatial and ecological examination of the data set. Comprehension of provenance of the samples, site genesis, and matrix development, through detailed micromorphological and stratigraphical studies, is thus suggested in conjunction with the archaeobotanical analyses, to identify disturbances, define their cause, and treat them appropriately. Numerical studies and ecological interpretations of climate, vegetation composition, or indications of human activity therefore follow specific criteria discussed here. Despite signs of disturbance in the plant assemblages, archaeobotanic research can lead to recognition of environmental conditions, plausible human subsistence, site use and seasonality, and sound vegetation description.

Keywords Archaeobotany · Upper Palaeolithic · Cave · Disturbance · Methodology

J. A. Baines (✉)
Institut für Naturwissenschaftliche Archäologie, University of Tübingen, Rümelinstrasse 23, 72070 Tübingen, Germany
e-mail: jojobaines@gmail.com

S. Riehl
Institut für Naturwissenschaftliche Archäologie and Senckenberg Center of Human Evolution and Palaeoecology, University of Tübingen, Rümelinstrasse 23, 72070 Tübingen, Germany

N. Conard · M. Zeidi-Kulehparcheh
Institut für ältere Urgeschichte and Senckenberg Center of Human Evolution and Palaeoecology, University of Tübingen, Burgsteige 11, 72070 Tübingen, Germany

Introduction

A methodology for archaeobotanical analysis of Upper Palaeolithic cave sediments is discussed through a case study of material from Ghar-e Boof in the Iranian Zagros Mountains. From this cave site, carbonized seed and fruit remains from seven horizons dating to the Rostamian (from 36,000 to 31,000 uncalibrated years BP) were examined. This methodology integrates approaches from various fields in archaeological sciences: botanic (Bouby and Marnival 2004; Borojevic 2011; van der Veen 2007), taphonomic (Johnson 2002), archaeological (Lange 1990) and statistical (Hubbard and Clapham 1992; Jones 1992; Mitka and Wasylikowa 1995; Popper 1988). It first tackles the issues of site taphonomy and formation, alongside intrusions in the plant assemblage of Ghar-e Boof. A secondary focus lies in the description of the extant vegetation and the identification of possible past vegetative food (like the collection of pulses of the *Lathyrus* and *Vicia* genera). Understanding the deposition history, chronological patterns and formation of a site, as mentioned in earlier papers (e.g., Allison and Briggs 1991; Behrensmeyer et al. 2000; Miksicek 1987; Schiffer 1983; Spicer 1980, 1991) is essential in reconstructing past diets and plant environment and to separate dubious from reliable evidence. In following these previous researches, which highlighted the issues of

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disturbance and site taphonomy in interpreting archaeobotanic assemblages from all types of sites and eras, four steps are put forward to address these challenges.

First, identified plant remains must be cataloged for ecological and archaeological temporal and spatial analysis. The second and third steps in the research are micromorphological and topographical analyses. They contribute to detecting and interpreting sedimentation processes and disturbances. The fourth step is in three parts: first, to integrate local animal and human sustenance, then to differentiate between intrusive or anachronistic plants, and finally, to describe the biotic environment. This facilitates recognizing animal and human agency in the deposition of plant remains, on one hand, and characterizing their usage and occupation of the site on the other.

Background

Study area

Ghar-e Boof cave was excavated in 2007 as part of Tübingen University's TISAR Project. It lies in the Dasht-e Rostam valley in the southern Zagros Mountains of Iran, see Fig. 1 (Conard et al. 2006). During the Upper Palaeolithic this range of mountains formed a natural obstacle between the Levant and South West Asia. Dictated by an irregular, obstructive, and varied topography, today's vegetation in the region is made up of diverse small patches. It is a mosaic of landscape structures and climatic conditions where much biological interchange occurs between the different ecotones. Due to the orientation of the intermountain valleys and their interconnections, the common direction of travel is to follow the range rather than to traverse it (Heydari-Guran 2007; Weeks 2006). Because people had to avoid depleting the wealth of their environment in search of nutrition, traveling across the entire breadth and height of the mountains was the best way of safeguarding prey and edible plants. Sites, though predominantly found nearer the valley floor, have therefore been identified in most parts of the Zagros relief, spreading from 700 to about 2,500 m.a.s.l. (Zeidi et al. 2009). The change in vegetation from the Pleistocene to the Holocene; as identified from lake pollen cores retrieved in the central Zagros Mountains, is characterized by a shift from an upland steppe vegetation to a river valley one (Bottema 1993; Fazeli 2008). Climate changed overall from drier and cooler to slightly damper and warmer conditions (Djamali et al. 2008; Stevens et al. 2001; Wasylikowa 2005).

The sediment was deposited during two broad time periods (see Fig. 2). First, overlying the limestone bedrock, an Upper Palaeolithic layer ~ 1-m-thick dates from around 36 to 31 kyears BP {horizons IV, IVa, IVb, III, IIIa, IIIb, and IIb.1}; see Table 1 for radiocarbon dates. Micromorphological analysis suggests that this layer was little altered or impacted over the following 25,000 years (Schilt 2011). Some remains from the Upper Palaeolithic occupations were also found in horizon IIb, but their deposition is likely the result of human and biotaphonomic disturbances such as worm activity and root canals. This horizon, together with the surface horizon I and the intermediate layers II and IIa, form the second period of Ghar-e Boof. These horizons consist of modern rubbish, organic debris, some post-Islamic pottery and vast amounts of dung and ash from recent animal penning activities. The matrix itself was mostly comprised of this material as well as a little aeolian sand, mixed in with rockfall from the shelter's wall and roof.

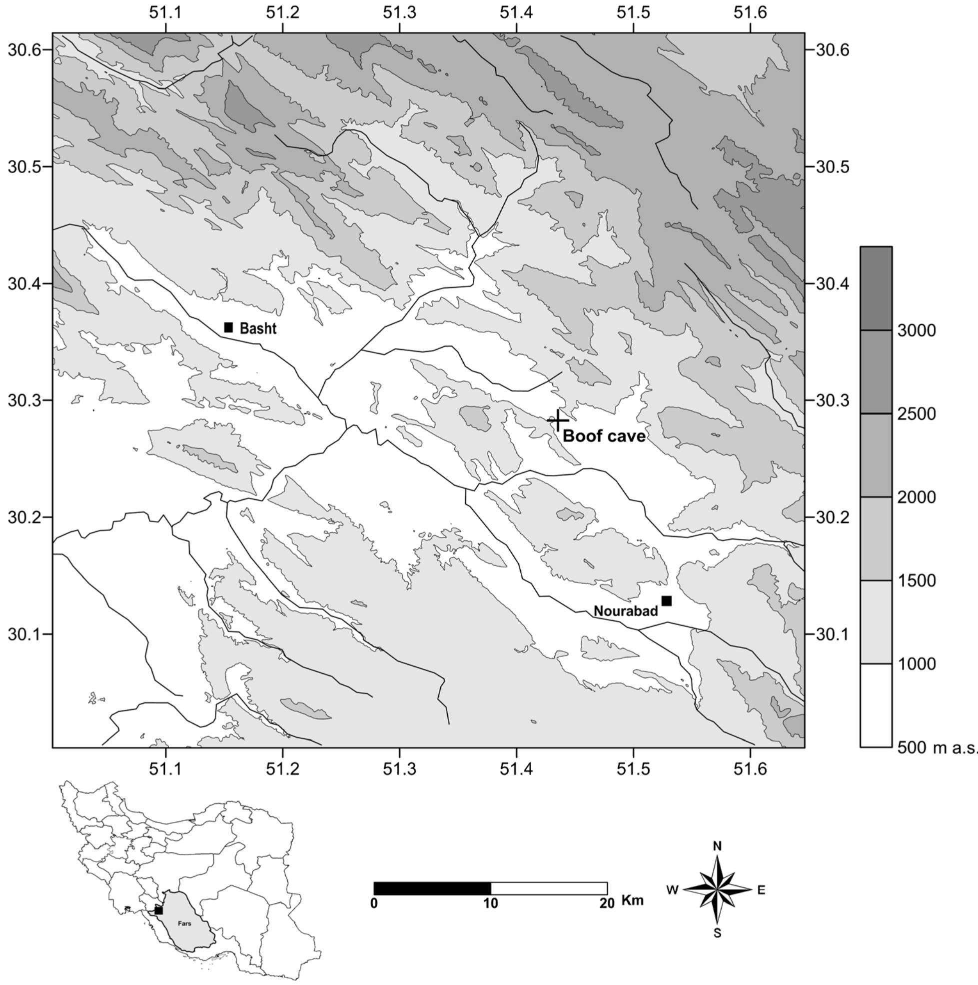
The Upper Palaeolithic

A review of the archaeology of the Zagros Mountains as presented by Hole and Woosley (1978), Conard and Ghasidian (2011), and Heydari-Guran (2014) reveals that hunter gatherers who frequented these highlands left a rather homogenous material record. Culturally, however, Ghar-e Boof is significant as the type site for the Rostamian lithic tradition. This early Upper Palaeolithic phase, comparable in radiocarbon dates with the Aurignacian in Europe, stands out from the Zagros' other sites typified as the Baradostian (Ghasidian 2010). The main difference lies in the reduced size, fineness and lamellar appearance of the stone tools more reflective of an epi-Palaeolithic assemblage. Ethnographic accounts of hunter-gatherers provide no viable parallel for Palaeolithic transience and subsistence strategies in the West-Asian highlands. A tenuous assumption, however, that people then subsisted for about 60 % on vegetative foods may seem plausible in view of the diet maintained by the seasonally nomadic herdsman living there today (Gilbert 1983; Stauffer 1965). Landscape structure and seasonality, for example, in recognizing the maturity of edible/useful plants or the prime hunting time were therefore central in archaic migration and temporary residence cycles. Preference for camping or occupying caves in locations that optimized access to resources in relation to traveling time and energy/nutritional return finds support furthermore in Heydari-Guran's surveys of Palaeolithic occupations in the Southern Zagros mountains (PhD in press).

Materials and methods

All the samples were obtained from a single 2×9 m trench. In this article, each square meter is referred to by two digits. The first digit is its Easting (row 6 or 7) and the second its Northing (running from squares 2 to 10). No samples are available from squares 4, 7, and 10. Each sample is the flotation residue of a 20 l bucket of excavated sediment. The samples were then dry-sieved through three mesh sizes: 1, 0.63, and 0.18 mm. These sizes were chosen to ease the sorting process. The finest

Fig. 1 Ghar-e Boof location in the Dasht e Rostam valley, southwestern Iran



sieve was chosen to optimize the chances of catching the very smallest seeds. Tübingen University's comparative collection and reference books were consulted for verifying the identifications with a binocular microscope (Berggren 1981; van Zeist and Bakker-Heeres 1984; Nesbitt 2006; Bojňanský and Fargaŝová 2007). All available materials from horizons IV, IVa, IVb, III, IIIa, IIIb, IIb, and IIb.1 were examined and are presented in Appendix.

Plant remains do not fall into orderly or roughly regular numbers of specimens per square meter of a site. The distribution of seed and fruit may be influenced by human or animal movements, by postdepositional modification or even inadvertent introduction of specimens from the surrounding environment. For these reasons, it was considered appropriate to establish one parameter that is valid for all recovered specimens, and thus we decided to take only an equal volume of sample material. This would allow the analysis of distributions or other spatial factors to be made under standard conditions. About 10 % of the samples came from buckets with a different volume and so were excluded from analysis. A few samples from horizons I, II, and IIa were studied, but were likewise excluded as they were not strictly Upper Palaeolithic. Only carbonized specimens were studied and included in the analyses for this article, because desiccated material was often of a dubious age.

Birks, Cappers, and others have explained that several levels of detail are required in archaeobotanical research (Birks and Birks 2006; Cappers and Neef 2012). We suggest six levels for this site. The left side of the diagram (see Fig. 3) lists them spatially according to the area, location, and amount of material discovered. This from the largest parameter (a regional climate) to the smallest (an identified specimen). The left arrow indicates the decreasing amount of elapsed time covered, or needed for the formation of the material. Hence, we suggest to proceed from the geological timescale of the eons involved in the genesis of landscapes and their climate, to the passing of years for the formation of a site or a number of events for archaeological horizons and assemblages, and finally to a single event for the deposition of an identified specimen. The right-hand side of the diagram lists them qualitatively. The arrow there indicates decreasing complexity, amount of details involved and interpretability of evidence. For this site, the principal reason for the reduced interpretability of the evidence for the three lower levels of the

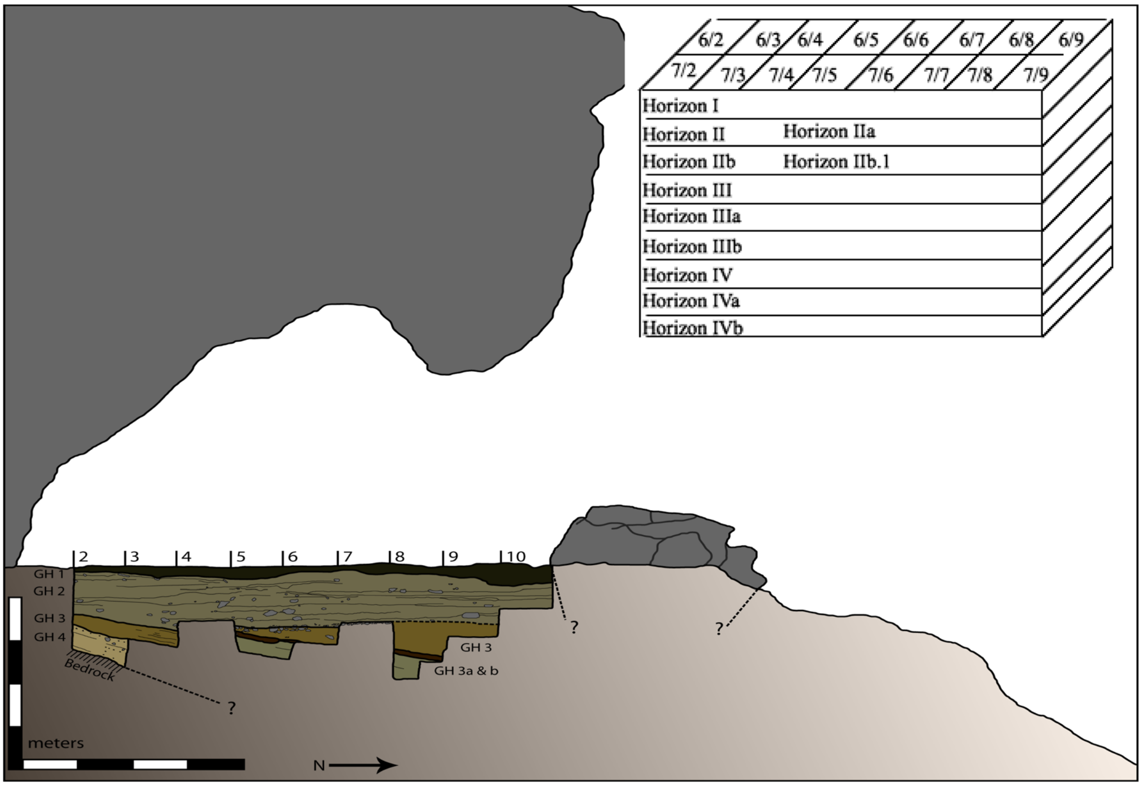


Fig. 2 Ghar-e Boof profile, adapted after Flora Schilt's MA thesis "Micromorphology of Upper Palaeolithic and historic sediments from Boof Cave, Iran." Tübingen University, 2011, Fig. 1.8, page 14

diagram is postdepositional movement. Other causes affecting them, as well as the higher three levels on a longer timescale, are human activities and environmental change.

Following the above perspective, we decided the data set must be treated according to two separate methodologies; one for each aim of this paper (Mitka and Wasylikowa 1995). The first aim is to distinguish between cases of disturbance associated with formation and taphonomic processes, on the one hand, and human activities (past or recent) on the other. This first methodological approach involves analysis of details from the last four levels, to secure a comparative picture. The second aim is to describe the extant vegetation at the site. To achieve this, a list is compiled of the taxa identified from the last level of detail alone. For the first methodology, let us presume that strictly site taphonomic processes affect taxa equally, whereas human activities affect particular taxa. Thus the number of specimens per taxon is significant to distinguish between both cases, because human activities lead to concentrations or anomalies in the plant assemblage, while other disturbances alter the assemblage more homogeneously (Cappers and Neef 2012). For example, the burning of dung raises the volume of small Fabaceae; the laying down of bedding leads to higher Cyperaceae counts (van Zeist and Bakker-Heeres 1984). Similarly, the remains of human subsistence may be recognized in a dominance of edible seed and fruit. For the second aim, however, each identified taxon (either to a family, genus, or species) is counted, regardless of how many specimens were found, because it represents a trace of the surrounding vegetation.

Table 1 Uncalibrated radiocarbon dates BP of Ghar-e Boof in stratigraphical order

	Square and horizon	Plant type	Age BP	±Error
KIA-32762	6/9 II	Poaceae	790	20
KIA-32761	6/2 III	Poaceae	31,150	25
KIA-32764	6/9 III	Poaceae	845	25
OxA-25784	7/5 IIIa	*Medicago*	1,047	26
OxA-25726	6/5 IIIa	*Scirpus*	903	24
OxA-25783	6/8 IIIb	*Lathyrus*/*Vicia*	33,850	650
OxA-25785	6/8 IIIb	*Lathyrus*/*Vicia*	34,900	600
KIA-32763	6/2 IV	Poaceae	33,060	270
KIA-32765	6/2 IV	Poaceae	36,030	390

Results

In order to compare the data set spatially and temporally, it was ordered by excavation square and horizon. Due to the volume of material studied (see Table 2); a brief overview of

Fig. 3 Six levels of detail in the archaeobotany of Ghar-e Boof

* regional climate
* surrounding topography
* site
* archaeological horizon
* plant assemblage in one sample
* identified specimen

decreasing time covered ↓

decreasing ↓
* complexity
* amount of details
* interpretability (due to an increasing potential for disturbance)

Ghar-e Boof's plant remains is presented here, with reference to the whole data set in the Appendix. This assemblage of 352 samples, of which 118 had no finds, had 2,876 specimens identified to a plant family.

The plants found may be divided into three groups: those collected as food, those collected for a particular use, and those with no obvious relation to the human occupants of the cave. The first are, for example; small Poaceae seeds and *Lathyrus* and *Vicia* pulses (Lev et al. 2005). Gathering of sedges for bedding could be an example from the second group (Sievers and Muasya 2011). The third group are those plants unaffected by the cave occupants and are here referred to as the vegetation background. Because the taxa from the third group usually have a small specimen count, and an unclear status with regard to human activities, they are often discarded from numerical analyses as noise (Jones 1992). As an illustration of how much material remains if taxa are discounted as noise, because they do not reach a certain specimen count, Table 3 illustrates numerically what was found per square only in horizon III. A minimum of seven specimens was chosen as a threshold to separate this noise from the usable data. The count of seven was chosen as it represents the rough average of what is suggested by a few authors, namely, Jones (1992), Lange (1990), Mitka and Wasylikowa (1995), Baxter (1994), Hubbard and Clapham (1992), and Popper (1988).

We decided not to apply criteria for discounting noise because otherwise most of the plant diversity would be discarded in this paper. As may be seen from Appendix, the other horizons scored even poorer than horizon III. Contrasting the botanic data with the number of lithic artefacts found in horizon III puts the paucity in perspective with the level of intensity in occupation of the cave. Totalling 406 cores, 51 complete blades, 286 retouched bladelets, 82 end scrapers, and 92 retouched flakes, these stone artefacts establish Ghar-e Boof as an intensely used "base camp that could have simultaneously served as a workshop" (Ghasidian 2010, p. 161). Even without disregarding noise in the plant assemblage, the overall record remains low in specimens and identified taxa. Nonetheless, three broad interpretations could be made from the results and are presented here with their evidence in separate sections.

Disturbance or human activity

Sieving every bucket of excavated sediment means that localized analyses are possible as shown in Table 4. In some cases, a peculiar variety, quantity of specimens, or specific plants may indicate the results of geogenic or anthropogenic disturbance. In Table 4, the plant assemblages from the four quarters of a square, all recovered from the same level in horizon III, are compared. Identification of *Oryza* sp. (rice), *Triticum* sp. (wheat), and *Hordeum* sp. (barley) in only one quarter, but not the other three subsquares, indicates an anomaly. Moreover, rice and wheat were not found in any of the neighboring squares. The identification of rice, normally not encountered in the region before the Parthian Age, and the barley and wheat with distinctively domesticated morphologies, suggest bioturbation, rather than human activity transported material downwards from the higher levels (Miller 1981).

As mentioned in Fig. 3, identification of crop plants in any one sample does not mean the other specimens in the same sample are also intrusive. While the intrusive specimens reflect deposition with manipulation at a later moment, the other plant remains in the sample can reflect an unaffected in situ deposition, or a series of depositional events. Two observations may be drawn from these results. First, comparisons within or between plant assemblages may, in those cases where movement by disturbances are possible, be invalidated due to the uncertainty of the original deposition of specimens. Second, if discrepancies occur as illustrated in Table 4, they could be examined further to distinguish between anthropogenic or natural disturbances. Following Johnson's (2002) natural disturbances in a studied

Table 2 The number of samples, specimens, taxa, and samples without finds analyzed from the studied horizons at Ghar-e Boof

	IIb	IIb.1	III	IIIa	IIIb	IV	IVa	IVb	Totals
Samples	17	12	205	35	33	24	16	10	352
Specimens	437	307	1,687	231	204	4	0	6	2,876
Taxa	27	30	69	32	25	3	0	2	84
Samples without finds	3	2	53	5	8	22	16	9	118

Table 3 Identified specimens from horizon III, Ghar-e Boof

Square number	6/2	6/3	6/5	6/6	6/8	6/9	7/2	7/3	7/5	7/6	7/8	7/9
Samples per square	16	20	8	16	38	25	6	18	8	8	23	19
Samples without finds	5	7	1	4	12	5	2	4	0	0	8	5
Specimens per square	129	152	51	90	96	452	118	98	46	110	216	137
Taxa entered	19	18	18	24	24	34	19	20	16	19	22	24
Taxa with ≥seven specimens	4	3	1	0	5	13	5	3	1	3	7	5

matrix may be biomechanical, (e.g., through burrowing animals, worms, or plant roots), or geological like erosion, the movement of water, or temperature changes. The anthropogenic disturbances include pastoral and agrarian activities and the digging of pits and hearths. These actions lead to a recognizable dominance of particular taxa in a plant assemblage, like an increase in legume remains (see Fig. 4) resulting from dung burning (van Zeist and Bakker-Heeres 1984), weed and crop remains from winnowing and threshing (Cappers and Neef 2012), or the downward movement of intrusive material originating in those activities.

Locating intrusive material in the matrix can highlight those areas of a site that were disturbed. For this purpose, Table 5 records where the anachronistic barley grains were found at Ghar-e Boof. Besides their conspicuous seed morphology and rachides, one grain was radiocarbon dated to about 845 BP±25. Were it not for these indicators to the contrary, identification of barley grains in a Rostamian context could have furthered debate on inclusion of this cereal in the Upper Palaeolithic diet as grain collected from wild stands (Hillman et al. 1997; Piperno et al. 2004). Some of the small Poaceae seeds, on the other hand, like those of the *Panicum*, *Setaria*, or *Tetrapogon* genera (see Fig. 5), may have been eaten (Weiss et al. 2004). Although only 80 % of the samples with barley grains had intrusive chaff, the other grains are unlikely to be Palaeolithic in date. Before the results of Table 5 are interpreted, further information on site genesis and development must be given. A patch of larger ceiling collapse in the middle of the excavation trench, for instance, protected an underlying Palaeolithic horizon designated IIb.1. Later, this area around the boulders became a focus of dung sweeping and burning. Pits were dug disturbing the matrix up to horizon IIIa. The two modern radiocarbon dates (see Table 1) obtained above and below horizon IIb.1 further highlight the effects of this event. Many samples taken in the vicinity from horizon II, IIa, IIb, and III, but not from the relatively protected IIb.1 area, were disturbed with uncarbonized seed and fruit from the dung and anachronistic *Triticum*, *Hordeum* (see Fig. 6) and *Oryza* which had moved down from the ash lenses. It is noteworthy that samples taken nearer the edge of the excavation reflected more uncarbonized seed and fruit as well as proportionately more intrusive taxa. The likelihood of encountering disturbance could thus be said to increase toward the trench edges compared with the trench middle.

Table 5 shows that barley was recovered down to and within horizon III, an otherwise securely-dated Rostamian horizon, but not in horizon IIb.1. These results confirm Johnson's opinion that contamination reaches far below the original deposition; in this case, 1.7 m lower down (Johnson 2002). The absence of barley in horizon IIIb, IV, Iva, and IVb

Table 4 Seed and fruit remains from four samples of square 7/2, Ghar-e Boof horizon III

	Subsquare Sample depth	*a* 596	*B* 595	*c* 600	*D* 598
Boraginaceae	*Lithospermae*	–	1	–	–
Chenopodiaceae	*Chenopodium* sp.	–	7	–	–
Cyperaceae	*Scirpus* sp.	2	27	5	–
	undetermined	–	1	–	–
Fabaceae	*Hippocrepis* sp.	–	5	–	–
	Lathyrus/*Vicia* sp.	–	1	–	–
	Medicago sp.	–	25	1	–
	Trifolium sp.	–	2	–	–
	Undetermined	–	16	–	–
Malvaceae	*Althaea officinalis*	–	1	–	–
	Malva sp.	–	1	–	–
Poaceae	*Alopecurus* sp.	–	1	–	–
	Hordeum sp.	–	1	–	–
	Lolium sp.	–	2	–	–
	Oryza sp.	–	1	–	–
	Stipa sp.	–	1	–	–
	Triticum sp.	–	1	–	–
	undetermined	3	9	–	–
Portulacaceae	*Portulaca oleracea*	–	1	–	–

Fig. 4 Carbonized Fabaceae pod and seeds from Ghar-e Boof, Horizon III

Table 5 The number of *Hordeum* sp. grains in Upper Palaeolithic horizons of Ghar-e Boof

		II	IIb	IIb.1	III	IIIa	IIIb	IV	IVa	IVb
Number of liters studied		100	280	200	2,960	600	500	440	–	20
Number of specimens		26	45	–	18	1	–	–	–	–
	6/2	6/3	6/5	6/6	6/8	6/9	7/2	7/3	7/5	7/9
Number of liters studied	260	280	360	260	620	440	240	220	240	320
Horizon II	–	15	–	–	–	11	–	–	–	–
Horizon IIb	11	–	2	–	–	–	31	–	–	1
Horizon III	4	1	–	1	1	7	1	1	2	–
Horizon IIIa	–	–	1	–	–	–	–	–	–	–

is either because a depth limit was reached or because the biomechanical or taphonomic influences affecting the matrix had waned. Indeed micromorphological investigations identified extensive evidence for bioturbation, such as root canals and worm tunnels, in horizon III and the higher horizons, but less in the lower horizons (Schilt 2011). Comparing the occurrence of barley across the excavation, the middle of the cave appears no more affected than the entrance and rear. One could conclude therefore that the dung burning and animal penning activity that was focused in the cave middle was itself less a cause of contamination than the bioturbation and taphonomic disturbances which moved seed and fruit remains downwards.

An indication of how human activity alone affected, but did not disturb, the plant assemblage are the *Lathyrus*/*Vicia* remains found at Ghar-e Boof (see Fig. 7). These pulses were found in 21 samples across horizons III, IIIa, and IIIb, but could never be identified more precisely than to this cumulative type. The concentration of *Lathyrus* (vetchling) or *Vicia* (vetch) in square 6/3 of horizon III, in particular, point to these legumes being collected as food. The two dates obtained from the *Lathyrus*/*Vicia* remains recovered from horizon IIIb: 33,850 BP±650 and 34,900 BP±600, firmly secure these pulses as Upper Palaeolithic, rather than as modern intrusions. Though van Zeist and Bakker-Heeres (1984) suggests legumes of these genera were used as kindling in the Levantine Neolithic, such an interpretation makes little sense for Ghar-e Boof, where over 75 % of the 352 samples studied revealed wood charcoal. We prefer to interpret the pulses as food, rather than fuel remains (Kislev et al. 1992; Miller 1996; Hillman et al. 1997; Lev et al. 2005).

Distribution of plant remains and site genesis

One way of examining distribution or other spatial analysis under equal conditions is to study the number of specimens per sample volume (Jones 1992). Seed and fruit do not order into a roughly regular number of specimens recovered per square meter excavated (Schiffer 1983). This is because their location may be influenced by human or animal movements, postdepositional disturbance or inadvertent introduction of specimens from the surrounding environment. In sum, plant remains are not deposited evenly about the surface of an archaeological site. Thus, it is not surprising that the number of specimens and taxa recovered at Ghar-e Boof varies horizontally, i.e., among subsquares, and vertically, i.e., between horizons, or even between arbitrarily chosen depths. A first

Fig. 5 Carbonized seeds from Horizon III, showing the diversity in small Poaceae from Ghar-e Boof. Included are species of the *Setaria*, *Panicum*, and *Tetrapogon* genera

Fig. 6 A domesticated carbonized *Hordeum* sp. seed from Ghar-e Boof, Horizon III

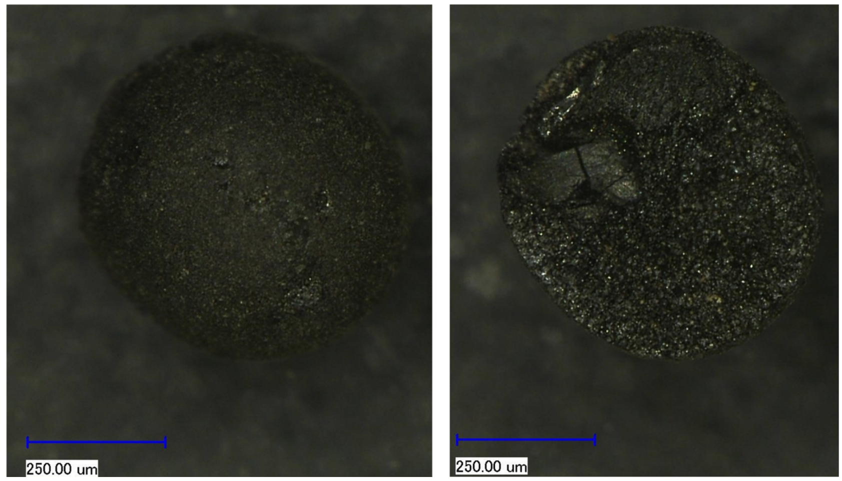


Fig. 7 Carbonized *Lathyrus*/*Vicia* sp. seeds from Ghar-e Boof, Horizon IIIa

observation made from the complete data set (see Appendix) is that the cave rear and entrance did not preserve different plant assemblages. One might presume that the cave rear would preserve a more homogenous assemblage, compared with the other areas, because of its more enclosed nature, and the cave entrance a more varied assemblage because of its greater exposure to the outside, but this was not the case. The site middle preserved a different overall plant record, however. It is likely that the burning of dung and animal penning activities, which was focused there, increased the number of identified herbaceous plants. In particular. the *Chenopodium*, *Echium*, *Medicago*, and *Scirpus* genera, which are commonly grazed by ungulates in the Southern Zagros Mountains, were more widespread (Rechinger 1968). Perhaps the wealth in Caryophyllaceae (carnations) and Poaceae (grasses), compared to the overall paucity and variation in taxa in horizons II, IIb, and III, is a further sign that some mixing occurred.

To verify whether postdepositional impacts affect the matrix stratigraphically, arbitrary depths were compared in Table 6. A sample for the cave rear, middle, and entrance were examined at three different levels in horizon III. Because of the significant intrusion of recent material above and into horizon III, making vegetation reconstruction and both horizontal and vertical assemblage comparisons problematic, a depth near the horizon's base was chosen for this table. The measured depths differ a little between squares due to the gradient, or slope of the cave sediments, but fit as a former level or surface of the cave. Note that repositioning of macro fossils may be affected and increase along a sites' gradient (Spicer 1991).

The contrasts observable in Table 6 could be due to the dynamism of bioturbation, the effects of gravity or other taphonomic processes (Behrensmeyer et al. 2000). This is not only recognizable at Palaeolithic sites, for example, at Kebara cave, Israel (Bar-Yosef et al. 1992), but also at prehistoric and historic sites, where macrofossils moved downwards through the matrix from their initial position (Johnson 2002; Borojevic 2011). The prevalence of Boraginaceae specimens in the *Lappula* and *Echium* genera in both figures is a result of their preponderance in the vegetation and their better preservation potential due their hard calcitic coat (Rechinger 1968; Pustovoytov et al. 2004). Like the smaller Chenopodiaceae, these plants most likely grew along the cave edge in the Upper Palaeolithic, but were of no direct significance to the human occupiers.

Using the same divisions of cave rear, middle, and entrance at arbitrary depths, the occurrences of indicator taxa for damp—*Portulaca oleraceae* (common purslane) and *Helianthemum salicifolium* (willowleaf frostweed)—and dry conditions—*Salsola laricina*—were compared to investigate which plant ecology in the Dasht-e Rostam was predominantly favorable (Rechinger 1968). *S. laricina*, though absent in the cave rear, was found, associated with perennial plants that tolerate diverse circumstances, in the entrance and middle zone. It is unlikely therefore that its identification means overall drier, more saline conditions. Retrieval from all the excavated squares and horizons of the damp indicator taxa and *Malva*, *Alopecurus*, and *Plantago*, which also prefer moist ground, rather suggest an environment with a tendency toward wetter conditions.

Palaeovegetation description

For future work, we suggest that a description of the palaeovegetation would benefit from sampling together with charcoal and pollen analysis, which should transect the landscape. By including all of the area's topographic features; valley floors, slopes, ridges, and gullies, and more botanic proxies, coverage of both the variety in elevation and available ecotopes in the area would be enlarged for analyses and discussion. Still, the record from Ghar-e Boof alone already informs what plants grew in its vicinity between 31,000 and

Table 6 Tally of dominant plants in the cave rear (square 6/3), middle (square 6/6) and entrance (square 6/9) at three corresponding levels in horizon III

Level	Cave rear			Cave middle			Cave entrance		
	a	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
Alopecurus sp.	–	–	–	–	–	–	1	3	1
Atriplex sp.	–	2	–	–	–	–	3	–	–
Cerastium sp.	–	–	–	–	1	–	–	–	–
Chenopodiaceae indeterminable	2	40	4	–	1	11	14	9	12
Chenopodium sp.	1	26	–	1	1	2	–	2	1
Echium cf. *vulgare*	5	1	–	4	3	3	7	8	3
Fabaceae indeterminable	–	3	–	4	1	3	2	–	1
Lappula sp.	5	–	1	–	–	–	5	2	4
Lathyrus/*Vicia* sp.	–	37	1	–	–	–	1	–	–
Medicago sp.	1	2	2	1	3	3	–	2	6
Onosma cf. *tauricum*	–	2	–	–	5	–	–	–	–
Plantago sp.	–	–	–	–	1	1	1	–	–
Poaceae indeterminable	2	–	1	3	3	5	4	–	–
Polygonum sp.	–	2	–	–	–	–	1	–	1
Scirpus sp.	–	2	2	–	7	–	7	7	12
Trifolium sp.	–	–	–	–	4	1	–	–	–
Other taxa	2	4	2	–	5	8	3	3	2

The depths are measured from the excavation 0 elevation mark (level *a*: 550–558 cm, level *b*: 562–577 cm, and level *c*: 580–593 cm)

36,000 BP. All the identified taxa were categorized into six groups dependent on their life cycle or physiognomy—wild legumes: Fabaceae, grasses: Poaceae, shrubs and perennial herbs: Cistaceae and Boraginaceae, rushes and sedges: Cyperaceae, and mixed lifecycle herbaceous: Malvaceae, Scrophulariaceae, and Brassicaceae (Bakels 1999). This paper discourages associating plants for ecological interpretations in this way in the distant past, because such associations are prone to oversimplify, to making unsound clusters, and to ignoring possible changes in the plants' or community's life (Ellenberg 1979). We made these categorizations, however, to observe the composition of the vegetation in each horizon and to see if any changes occurred during the few thousand years of deposition at Ghar-e Boof. Though it is not debated here that the *Hordeum*, *Triticum*, *Linum* (Flax), and *Papaver* (poppy) found are not native to the Zagros Mountains, it would be erroneous to include anachronistic plants in these groupings. Thus the *Hordeum*, *Oryza*, and *Triticum* specimens were excluded from this examination. From Table 7, it is clear that the numerical discrepancy between the horizons is due to the different amount of samples studied in each horizon. Note that this table presents how often the taxa were found (the amount of records) in each horizon, not how many specimens in each taxa, following the methodology outlined in Section 3.

While depth affects the amount of contamination numerically; that is, the lower down a sample lies from the

Table 7 The left number gives the amount of records per horizon for each vegetation type. The right number gives the amount of records per litre sediment sampled. Horizon VIa is omitted due to the absence of any finds

	IIb.1		IIb		III		IIIa		IIIb		IV		IVb	
Legumes	22	0.09	23	0.07	161	0.04	18	0.03	11	0.02	2	0	–	–
Grasses	5	0.02	22	0.06	70	0.02	13	0.02	11	0.02	–	–	–	–
Herbaceous	20	0.08	10	0.03	190	0.05	29	0.04	19	0.03	–	–	1	0
Shrubs and perennial herbs	12	0.05	2	0.01	125	0.03	30	0.04	13	0.02	–	–	1	0
Rushes and sedges	8	0.03	10	0.03	72	0.02	7	0.01	7	0.01	1	0	–	–
Mixed lifecycle herbaceous	2	0.01	3	0.01	32	0.01	2	0	2	0	–	–	–	–
Total litres and mean find density	240	0.05	340	0.04	3985	0.03	700	0.02	660	0.01	480	0	200	0

disturbance, the less greatly it is affected (see Table 5 on the barley contamination), Table 7 suggests it does not influence the vegetation composition. No specific indications of season of occupation were found because plant maturity, seed dispersal of the vegetation types identified, and the natural preservation thereof extended over too much time. The sole exception to this: *S. laricina*, a fragile seed indicative of the middle summer (Novikova et al. 2011) does not change this scenario. In sum, Dasht-e Rostam's palaeovegetation was rich in legumes, particularly those no larger than 2 mm, and had a balance of rocky, wet, and steppe plants.

Conclusions

This paper explored the use of contextual information like site genesis and taphonomy, bioturbation, human activity, and nativity/coevality for evaluating the fidelity of plant assemblages. Leaning on theoretical frameworks and observations made by other authors, a dual methodology is described to tackle the paper's two aims. Through division of the data set in stratigraphic and spatial analytical units, cases of disturbance and irregularities in an assemblage were interpreted as either due to an agency external to the site (biological, human, or climatic) or due to its formation. These can alter the composition of an assemblage, introduce anachronistic or alien taxa, or displace plant remains from their original deposition. Thus archaeobotanical research should incorporate methods for identifying and treating disturbed samples since the source of the intrusion or disturbance may highlight human activities of archaeological interest, reflect diet or changes in the local vegetation. A broad description of the palaeovegetation, including a variety of small pulses, grasses, and perennials that charred accidentally during the cave occupation, was feasible. Identification of *Lathyrus*/*Vicia*-type pulses across Ghar-e Boof's Upper Palaeolithic horizons was interpreted as a sign that the Rostamian occupants of the area collected the legumes as food. Summing up, it was found that disturbed samples, either through natural or anthropogenic agency in an area of the site, render a different plant record compared to unmodified samples. Examined and contrasted together, they can still provide valid windows to describe the past vegetation, environmental conditions, the route taken by plant remains up to deposition and possible human activities.

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Appendix

	Number of specimens						Number of records					
	IIb	IIb.1	III	IIIa	IIIb	IV	IIb	IIb.1	III	IIIa	IIIb	IV
Alopecurus sp.	16	–	8	1	1	–	1	–	7	1	1	–
Althaea officinalis	–	–	1	–	–	–	–	–	1	–	–	–
Asteraceae indet.	–	–	2	–	–	–	–	–	2	–	–	–
Astragalus sp.	–	1	1	–	–	–	–	1	1	–	–	–
Atriplex sp.	–	2	13	1	–	–	–	1	8	1	–	–
Brassicaceae indet.	–	–	2	–	–	–	–	–	2	–	–	–
Bromium sp.	1	–	–	–	–	–	1	–	–	–	–	–
Camelina sp.	–	–	1	–	–	–	–	–	1	–	–	–
Carex sp.	–	1	6	–	1	–	–	1	3	–	1	–
Centaurea sp.	–	1	–	–	–	–	–	1	–	–	–	–
Cerastium sp.	–	–	7	–	–	–	–	–	4	–	–	–
Chenopodiaceae indet.	100	44	221	25	18	4	4	8	61	13	9	1
Chenopodium foliosum	–	–	2	–	–	–	–	–	2	–	–	–
Chenopodium murale	14	28	22	1	–	–	3	5	8	1	–	–
Chenopodium sp.	21	9	139	14	12	–	2	2	48	5	4	–
Chenopodium urbicum	–	–	1	–	–	–	–	–	1	–	–	–
Cyperaceae indet.	–	2	5	–	–	–	–	2	5	–	–	–
Echium cf. *vulgare*	1	–	157	20	3	–	1	–	58	15	3	–
Eleusine sp.	–	–	–	–	1	–	–	–	–	–	1	–
Epilobium cf. *palustre*	–	–	–	2	–	–	–	–	–	2	–	–
Fabaceae indet.	17	4	74	9	1	1	2	3	33	5	1	1
Ficus sp.	–	1	1	–	–	–	–	1	1	–	–	–
Galium sp.	–	–	6	–	3	–	–	–	6	2	–	–
Genista sp.	–	–	1	–	1	–	–	–	1	–	1	–
Geranium sp.	–	–	–	–	1	–	–	–	–	–	1	–
Glaucium sp.	–	–	2	–	–	–	–	–	2	–	–	–
Helianthemum salicifolium	–	3	3	–	–	–	–	3	3	–	–	–
Helianthemum sp.	–	1	8	1	–	–	–	1	4	1	–	–
Heliotropium europeum	–	1	4	–	–	2	–	1	3	–	–	1
Hippocrepis sp.	2	3	16	2	–	–	1	3	12	1	–	–
Hordeum sp.	45	–	18	1	–	–	11	–	13	1	–	–
Hypericum sp.	1	–	–	–	–	–	1	–	–	–	–	–
Lallemantia cf. *peltata*	–	–	–	1	–	–	–	–	–	1	–	–
Lapulla sp.	–	2	52	36	94	–	–	1	28	9	8	–
Lathyrus/*Vicia* sp.	16	2	80	2	14	2	3	1	21	1	3	1
Lepidium sp.	–	–	2	–	1	–	–	–	2	–	1	–
Linum sp.	1	–	–	–	–	–	1	–	–	–	–	–
Lithospermae	10	15	34	1	–	–	1	5	19	1	–	–
Lolium perenne	1	–	–	–	–	–	1	–	–	–	–	–
Lolium sp.	3	1	12	1	–	–	2	1	4	1	–	–
Lotus/*Melilotus* sp.	–	–	2	–	–	–	–	–	2	–	–	–

	Number of specimens						Number of records					
Malva sp.	3	–	24	2	–	–	3	–	21	1	–	–
Medicago sp.	91	80	251	23	6	–	11	9	66	10	6	–
Melica sp.	–	–	1	–	–	–	–	–	1	–	–	–
Minuartia sp.	–	–	4	2	–	–	–	–	1	2	–	–
Onobrychis sp.	1	–	–	–	–	–	1	–	–	–	–	–
Onosma cf. *tauricum*	–	–	16	5	1	–	–	–	9	4	1	–
Oryza sp.	–	–	2	–	–	–	–	–	2	–	–	–
Panicum sp.	–	–	–	1	1	–	–	–	–	1	1	–
Panicum/ *Setaria*– *Tetrapogon*	–	2	9	4	2	–	–	2	7	4	2	–
Papaver sp.	–	–	1	–	–	–	–	–	1	–	–	–
Persicaria hydropiper	–	–	3	–	1	–	–	–	1	–	–	–
Phalaris sp.	1	–	4	–	–	–	1	–	4	–	–	–
Plantago cf. *lagopus*	–	2	3	–	–	–	–	1	3	–	–	–
Plantago sp.	–	1	11	1	3	–	–	1	11	1	3	–
Poaceae indet.	6	2	58	6	8	–	2	2	29	5	6	–
Polygonaceae indet.	–	–	2	–	–	–	–	–	3	–	1	–
Polygonum aviculare	–	–	2	–	–	–	–	–	1	–	–	–
Polygonum sp.	–	–	1	–	–	–	–	–	1	–	–	–
Portulaca oleracea	–	–	1	–	–	–	–	–	8	1	1	–
Portulacaceae indet.	–	–	11	1	5	–	–	1	2	–	–	–
Prunus sp.	–	–	6	2	–	–	–	–	–	–	–	–
Ranunculus sp.	–	4	2	–	–	–	–	–	2	–	–	–
Reseda cf. *lutea*	–	–	2	–	–	–	–	–	15	–	3	–
Reseda sp.	–	–	23	–	3	–	–	–	6	–	1	–
Rumex sp.	–	–	4	–	–	–	–	–	4	–	–	–
Salsola cf. *laricina*	–	–	2	–	2	–	–	–	2	–	1	–
Scirpus sp.	68	75	282	61	20	1	10	5	64	7	6	1
Scorpiurus sp.	2	1	6	–	–	–	2	1	5	–	–	–
Scrophularia sp.	–	1	2	1	–	–	–	1	–	–	–	–
Silene cf. *otitis*	1	–	3	–	–	–	1	–	3	–	–	–
Silene colorata	–	–	1	–	–	–	–	–	1	–	–	–
Silene linicola	–	–	1	–	–	–	–	–	1	–	–	–
Sisymbrium sp.	–	–	2	–	1	–	–	–	2	–	1	–
Solanum sp.	–	–	1	–	–	–	–	1	–	–	–	–
Stellaria sp.	–	–	3	1	–	–	–	–	3	1	–	–
Stipa sp.	–	–	3	–	–	–	–	–	3	–	–	–
Trifolium sp.	2	16	31	1	–	–	2	4	18	1	–	–
Trigonella sp.	1	–	3	–	–	–	1	–	2	–	–	–
Triticum sp.	11	–	2	–	–	–	3	–	2	–	–	–
Urtica urens	–	1	–	–	–	–	–	–	1	–	–	–
Valerianella cf. *dentata*	1	–	3	2	–	–	1	–	3	1	–	–
Verbascum sp.	–	1	–	–	–	–	–	–	1	–	–	–
Veronica sp.	–	–	–	–	–	–	–	1	2	1	–	–
Number of samples	17	12	205	35	33	50						
Number of specimens	437	307	1,687	231	204	10						

The amount of records means how often the taxa were found in each horizon

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From Forager to Cultivator: A Case Study in the Zagros Mountains of Iran

Jonathan Adam Baines[1]

[1]Tübingen University, Institut für Naturwissenschaftliche Archäologie, 23 Rümelinstrasse, 72070 Tübingen, Germany.

Correspondence: Jonathan Adam Baines, Tübingen University, Institut für Naturwissenschaftliche Archäologie, 23 Rümelinstrasse, 72070 Tübingen, Germany.

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Abstract

This paper examines the early aceramic Neolithic botanic assemblage from Chogha Golan, Iran, for signs of cultivation. Based on the presumption that people's engagement with the local vegetation altered due to a changing mode of residence and mobility during that period, its record of edible and useful plants ought to look different compared to that of the site's later assemblages that include domesticated emmer. The study involved data from coeval sites in the region and three Palaeolithic outliers, including Ghar-e Boof, a Rostamian cave occupation in the Zagros Mountains. Though the information does not refute efforts at cultivation at the site during the midden's initial occupation, the analyses rather suggest that a realignment of hunter-gatherer traditions took place, with local plant exploitation targeting a wider breadth in the landscape. Inherited subsistence strategies were adapted to the new human and natural setting inhabited, in which high yield legumes and grasses dominated procurement and became the focus of the incipient agricultural transformations underway.

Keywords: Archaeobotany; Zagros Mountains; aceramic Neolithic

1. Introduction

The Tübingen Iranian Stone Age Research Project (TISARP) was founded to address gaps in the Iranian Palaeolithic record. These blanks include the regional development of lithic technology, dispersion of population and Palaeolithic occupation (Conard 2011; Ghasidian 2014; Heydari-Guran 2014). Though the region is often mentioned in archaeobotany alongside the Levant as a locus for wild exploitation and pre-domestication cultivation, few sites are actually recorded (Colledge 2004; Martinoli 2004; for a comparable research see Fuller 2012a and Willcox 2013). Therefore to complement TISARP's efforts, the archaeobotanical analysis was undertaken on two sites excavated between 2006 and 2011 in the Zagros Mountains. Ghar-e Boof is a Rostamian, or Upper early, cave site with occupation horizons dating between to 36 000 and 31 000 BP. Chogha Golan is an aceramic tell site whose hunter-gatherer sequence begins at the end of the Younger Dryas (about 10 650 BP) and ends about 9 000 BP. Both sites have been partially published, their archaeobotanic examination is still ongoing (Riehl *et al*. 2011 and 2013, Baines 2014). This article addresses the question: did hunter-gatherer behaviour turn from “passive recipients of the environment” (Rowley-Conwy 2011 p.851) to “ecosystem engineers” near the end of the Palaeolithic (Jones *et al*. 1994)? The archaeobotanic assemblages of Ghar e Boof, Chogha Golan and a few selected Epi-Palaeolithic and pre-pottery Neolithic A (PPNA) sites in Southwestern Asia (see figure 1), are examined for signs of cultivation and alterations in the plant communities. Factors complicating this question are the people's mode of residence and mobility, their community dynamics and the palaeo-environmental setting inhabited with its own climate conditions.

2. Site Descriptions

The Zagros Mountains stretch from Armenia Southwards along the Western border of Iran to the Gulf coast and covers a wide variety of landscapes and ecological zones. Its higher elevations reach beyond the tree line up to 4 000 m a.s.l. and are surrounded by widely spreading foothills and intermountain valleys. Both sites are situated near year-round flowing water and close to marshy areas, with a surrounding rocky and rough terrain, offering plentiful stone, plant and animal sources.

Ghar-e Boof is situated in one of these intermountain valleys: the Dasht-e-Rostam, in the Fars Province. The area receives most of its rainfall during winter (annually about 450 mm.) with almost no precipitation the rest of the year

(Heydari-Guran 2007). The valley forms a transition between the *lowland and foothill* (between 200 and 800 m a.s.l.) and the *mountain* zones (800 to over 2 000 m.a.s.l.) according to van Zeist's (2008) vegetation zones of the Zagros. The limestone cave lies at 650 m a.s.l and faces north-northeast across the valley floor 100 metres below. The recovered stone tools and debitage are best described as Rostamian, a lithic typology that stands apart from the region's otherwise common Baradostian assemblages (Ghasidian 2014). The cave's occupation was temporary, intensive and without domestic features like hearths or permanent structures. The location of the site, at the intersection of several varied ecological zones, provides diverse and seasonally abundant resources. A suite of palynological studies from lake cores suggests the existence of this wide botanic diversity in the region during the late Pleistocene (see Hole 1978 and Bottema 1993 for lake Zeribar; see Moslimany 1987 and Wasylikowa 2005 for lakes Maharlou and Urmia; and see Djamali 2008 and van Zeist 1967 for lake Mirabad).

Chogha Golan is situated 600 km northwest of Ghar-e Boof in the Ilam province in the Zagros foothills. It lies in the Kanjan Cham valley overlooking the Mehran plain and is at 485 m a.s.l. Only samples from the sites' first occupation were examined. Excavation at this site has focussed on the later phases of occupation, limiting interpretation of this midden. Its later horizons feature in the comparative part of this study together with the other selected Southwestern Asian sites. Though use was made of the same datasets, as will be seen below, my conclusions on this horizon differ from earlier interpretations of the site and its place within the development of agricultural systems in this region (Riehl *et al*. 2013).

Figure 1. Locations of the sites mentioned in the text

(1) Ghogha Golan
(2) Ghar e Boof
(3) Ganj Dareh Tepe
(4) M'lefaat
(5) Qermez Dere
(6)Hallan Cemi
(7) Mureybet
(8) Abu Hureyra
(9) Djade
(10) Demirköy
(11) Jerf el Ahmar
(12) Qaramel
(13) Gilgal
(14) Dhra
(15) Wadil Jilat
(16) Wadi Feiran
(17) Boker Tachtit
(18) Dja 'de
(19) Tell Abr
(20) Hayonim cave
(21) Kebara
(22) Ohalo II
(23) Wadi al Hammeh
(24) Wezmeh cave
(25) Öküzini
(26) Netiv Hagdud
(27) Tell el Kerkh
(28) Shanidar III
(29) Iraq ed Dubb
(30) Tepe Abdul Hosein
(31) Ali Kosh
(32) Cayonu
(33) Tell Aswad
(34) Sheikh-e Abad

Table 1. Presence or absence of selected taxa common at aceramic Neolithic sites in Southwestern Asia

		Aegilops sp.	*Amygdalus* sp.	*Avena* sp.	*Capparis* sp.	*Carthamus* sp.	*Cicer* sp.	*Hordeum* sp.	*Juniperus* sp.	*Lathyrus/Vicia*	*Lens* sp.	*Pisum* sp.	*Pistacia* sp.	*Taeniatherum* sp.	*triticoid-type* sp.
Abu Hureyra 1	11 150 - 10 450			x	x		x	x		x	x		x		
Ali Kosh	8 528 - 7 220	x		x	x			x		x			x		
Cayonu	9 442 - 7 000		x					x		x	x		x		
Chogha Golan	12 000 - 9 800	x			x	x		x	x	x	x	x	x	x	x
Dhra'2	9 600 - 8 300			x		x		x		x	x	x	x		
Dja 'de	11 000 - 10 300	x	x		x		x	x		x	x	x	x		
Ganj Dere Tepe	9 848 - 8 110		x					x		x	x		x		x
Ghar-e Boof	36 030 - 31 000									x					
Hallan Cemi	12 000 - 10 900		x							x	x		x		
Hayonim cave	12 047 - 12 010		x					x				x			
Iraq ed Dubb	9 700 - 8 800	x	x					x		x	x		x		
Jerf al Ahmar	9 800 - 9 740		x		x			x		x			x		
Kebara	60 000 - 48 000	x		x		x	x	x		x	x	x	x		
M'lefaat	9 500 - 8 800	x						x		x	x		x	x	x
Murreybet 2	9 700 - 8 500				x			x		x	x	x	x		x
Netiv Hagdud	11 300 - 10 900	x	x	x				x		x	x		x		
Ohalo II	19 000	x	x	x				x			x		x		
Qermez dere	9 287 - 9 700	x						x		x	x		x		
Sheikh-e Abad	10 100 - 9 140	x	x					x		x	x	x	x	x	
Tell 'Abr	9 500 - 9 200							x		x	x	x			
Tepe Abdul Hosein	8 450 - 8 655		x	x				x			x		x		
Telll Aswad	9 574 - 8 540		x		x			x		x	x	x	x		
Wadi Hammeh 27	12 200 - 11 920	x						x			x		x		
Wadi Jilat (6 & 7)	± 11 000			x	x	x		x		x	x		x		
Wezmeh cave	19 000 & 12 000								x						

Selected sites mentioned in the text with their radiocarbon dates in calibrated years BP. Kebara is included as a Middle, Ghar-e Boof as an Upper and Ohalo II as an Epi- Palaeolithic outlier. Wezmeh cave is a non-anthropogenic late glacial vegetation background of the Central Zagros Mountains.

3. Methods

This paper reports only on the charred remains as the desiccated ones may be of a dubious age. The ordination and cluster analyses were made using the statistical programme 'Past' (Hammer *et al* 2001) and involved the following 12 sites: Abu Hureyra, Cayonu, Ganj dere Tepe, Hallam Çemi, Iraq ed Dubb, Jerf al Ahamr, M'lefaat, Murreybet, Netiv Hagudud, Wadi Hammeh, Wadi Jilat and Chogha Golan horizon XI. The samples from Chogha Golan were floatation and sieving residues from 33 spits from the tell's midden horizon. 23 of these samples were examined by the author; the results are published in the supplementary data for this article, the other eight are published in Riehl *et al*. 2013.

The ADEMNES database and archaeobotanic reference collection of Tübingen University were used for compiling the analysed datasets. The volumes of sediment and the number of specimens and samples in the studied assemblages were discrepant. For this reason, as the plant diversity broadens in line with the amount of sediment analysed, ubiquity, rather than NISP, was chosen for the analyses (cf. Colledge & Conelly 2010). Following Colledge's suggestion (2002 p.142) to "look for patterns and trends in data that reflect developmental changes associated with the control and use of plant resources throughout time," correspondence analyses were chosen to "investigate the taxonomic composition" of the assemblages. Using this method the composition of the wild edible taxa and the flora traditionally labeled as weeds from the selected sites were compared. The theoretical background outlined in chapter four discusses the significance of the mode of mobility and residence and the environmental setting inhabited by both plants and humans in examining the assemblage data for signs of cultivation.

4. Theoretical background

Literature on the development of agriculture in Southwestern Asia usually states that this process did not occur on its own, but in tandem with a reduction in mobility, more permanent occupation of the landscape and a climatic deterioration connected with the Younger Dryas (Byrd 2005). Whilst the climatic upheaval is evidenced empirically at the regional level in the Levant from speleothems in Soreq cave (Bar-Matthews *et al*. 1998), and globally in the Greenland ice cores (Severinghaus *et al* 1998), the two other factors are debated more theoretically.

The task of foraging is disrupted by many factors out of the control of human: For example the cyclical nature of plant life, seasonality, climatic shifts and natural disasters. Thus the plant environment is perpetually in motion; their occupancy in the landscape fluctuates and their composition changes. To overcome the shifting habitat conditions, people must be adaptive. Plants, animals and humans have instinctive, but also develop, strategies to deal with such threats and with varying levels of inter and intra species "competition and population pressure" (Hardesty 1975 p. 73). Humans respond either passively to these changes and pressures (i.e. not affecting other species or its own directly), or actively by modifying their situation, or that of other organisms. An example of 'active' behaviour is the selection of seeds for next year's sowing (Odling-Smee *et al*. 2003, Laland and O'Brien 2010). As Fuller *et al*. (2012b p. 625) write: "early foragers focused on increasing the populations of food plants [indirectly] and reducing competition, while yield factors like larger grain, apical dominance, and non-shattering are better understood as unintended consequences selected slowly by some early cultivation practices."

F palaeolithicher examples of active ways to overcome changes in both the human and natural environment are technological innovation, changed subsistence and realigned mobility and residence strategies. Riel-Salvatore (2010 p. 328), for instance discerns alternations between "residential and logistical land-use strategies in response to [the] fluctuating [habitat] conditions." This may equally be called adaptation. Here "residential mobility implies the frequent relocation of base camps in response to depletion of immediately available resources" (*ibid*.). In this system a pay-off may have existed between the longevity of gathered food sources in an area and their proximity to the residence. "In contrast, logistical mobility implies the more long-term occupation of a base camp provisioned with needed resources through forays at distant points on the landscape targeted at specific resources (*ibid*.)." In broad terms, the difference between residential and logistical mobility is whether consumers travel to exploit resources (the former), or whether base camps were located in proximity to these resources (the latter). Ghar-e Boof's occupation fits the first pattern: its inhabitants, as traditionally postulated for the Upper Palaeolithic, maintained a broad diet foraged from a range of ecological zones. Chogha Golan's midden occupation can instead be interpreted as transitory, or logistically mobile. Hence the mode of foraging, i.e. subsistence targets and strategies, varied between those sites. Due to the different logistic costs for example, there was a discrepant energy return per foray. Also the abundance and diversity of accessible plants met with whilst roaming would differ.

The ability to store resources is balanced against the satisfaction of the "immediate relative short term needs" of foragers practicing residential mobility with those maintaining logistical mobility (Kaufman 1992 p.172). Sedentism furthers this contrast through the ability to store temporary overproduction of plants and supplement seasonal foraging shortages due to the reduced mobility. Following Hayden (1990), I hypothesise that the greater ability to store endurable food in a system of logistical mobility in the Neolithic, compared with the fleeting food supplies of the Palaeolithic, gave rise to a network of hospitality and reciprocity between tell communities. Moreover, changes in systems of residence and mobility fluctuated (cf. Munro 2013) during the Upper and Epi-Palaeolithic and was driven by the era's technological innovations and pressures on the abundance (or not) of food sources. The initial midden occupations of tell sites were at a pivotal point between transitory exploitation with migration between areas, and settling down to a localised subsistence strategy. These frequented loci gradually became focal points in the landscape for camping and social meetings (cf. Hayden 1990). Through these recurring social engagements, the hypothetical system of hospitality and reciprocation could emerge alongside the notion of territoriality. It can be argued that a steadier means of obtaining high value food, than could previously be foraged for, was sought for to maintain the new social interactions, which led to cultivation and gradually to a permanent occupation of the landscape. The tell at Chogha Golan may therefore have developed as succeeding generations of intra-community relationships focussed on the same favourable spot in tandem with more prolonged localised labour efforts to keep up with the needs of cultivation.

In theory, cultivation relies on a minimum of two stimuli that alter the growth of a targeted plant. These in turn also affect the other taxa (plant, animal, insect, fungi, bacteria, etc.) cohabiting its ecology. A key action is *modification*; either of a particular plant, its community, or its habitat conditions. The activities for example are: pulling out competitors, cutting back old growths to encourage fresh growth, irrigation, shade or light management and turning earth. Once modified, the new environment requires a second stimulus: *control*, so the modifications do not revert (Jones *et al*. 1994). If however the process did not begin with an aim in view, or as a mindful experiment, but rather by fluke, then it would be hard to suppose inadvertent maintenance of the plants' new situation. In that case the effort of encouraging or discouraging plant growth for improved yield would have fallen through.

I suggest cultivation is a threefold interdependent engagement. One part acts on factors external to the plant; like management of soil, moisture and light conditions or controlling competitors. A second targets the plants directly, like imposing new germination or growth regimes (Abbo *et al*. 2013). The third act is to maintain the plants' new situation. When people selected seeds for next year's sowing from mature plants grown under these modified conditions, and exhibiting characteristics preferential to greater yield, it led over prolonged time to morphological and or ecological distinctions compared to the plants' wild ancestors. In some cases it even led to speciation (Fuller *et al*. 2012a). The amount of time people allocated to modification of the local vegetation and planting depended, according to Barlow (2002), less on yield return from these activities, than on the harvest of higher-return wild resources. If the efficiency of wild plant foraging dropped, due to changing climatic and vegetation conditions then people would have turned to other food sources, or acquired better strategies for obtaining them.

If, however the modifications, brought about by this broadening failed, due to extrinsic factors such as pests or disease, then the energy expended on these efforts was lost without the buffer of wild foraging. Hence it is likely that the earliest stages of this behaviour, expressed for instance by the hunter-forager-cultivators initially frequenting Chogha Golan's midden site, occurred when people were still relatively mobile and able to supplement cultivation with wide foraging forays. Kingwell-Banham and Fuller (2012 p.89) for instance, question whether successful planting certain species “required agricultural intensification and fixed field systems?” Note that most of the species targeted in early cultivation in the archaeobotanic record are plants which provide easily storable food (Zohary 1973) and that the impact of some modifications took longer than one season or one year to appreciate. These then represent, such as in the consumption of fruit and nuts from tended trees, a delayed long-term return on expended effort (Rosenberg *et al*. 1998, Martinoli 2004, Willcox *et al*. 2008). This would imply chance to start with.

In sum, no single factor dominates a theoretical background to the development of pre-domestication cultivation, but rather a number of factors are interrelated. A current consensus suggests the change emerged gradually, dependent on regional environmental conditions and local food sources and originating in multiple places (Willcox 2013). Yet underlying the process, in Southwestern Asia, is a concentration of people in the landscape and in their foraging efforts. Arising at the end of the Younger Dryas, but not necessarily directly connected to this climatic fluctuation, a closer look at the environmental conditions in the Zagros Mountains is useful to interpret the developments at Chogha Golan.

5. Environmental conditions in the Southern and Central Zagros Mountains

Environmental conditions postulated for intermountain valleys in the Northern and Western Zagros (like Yafteh or Shanidar Cave, cf. Henry 2011) during the Palaeolithic were likely different to those extant in the Dasht-e Rostam or Konjan Cham, because the mountain ranges acted as barriers, which affected the weather and created micro-environments. The complex topography thus limits the use of data from pollen diagrams obtained from lakes further North like Zeribar, Mirabad or Urmia, in interpreting environmental conditions in a more central river valley like the Konjan Cham. Still, as meta-data to the botanic record examined from Ghar-e Boof and Chogha Golan, some wider comparison and use of environmental indicators can be pertinent. From the speleothem research in Soreq cave for example we learn that the timing and length of the Younger Dryas can shift dependent on the landscape setting. According to this site 50 km. from the Mediterranean, the Younger Dryas is considered 400 years shorter (from about 13 200 to 11 400 cal. BP) than suggested by the Greenland ice core (Bar-Matthews *et al*. 1998 and Severinghaus *et al* 1998). As such palaeo-climatic data is lacking from the Ilam province, it is possible that the YD occurred there later than further West in the Fertile Crescent. Alternatively, this late-glacial stage did not affect the early occupation of Chogha Golan as much as suggested at other sites like for example Abu Hureyra (Hillman *et al*. 2001). Indeed the significance of the YD in the emergence of pre-domestication cultivation, and its role in the vegetation changes - like the decline of the steppe species (e.g. Chenopodiaceae and Artemisia) and the gradual establishment of open woodland plant communities - is debated. Colledge and Conelly (2010) for example, criticise Hillman's *et al*. 2001 interpretation of the environmental conditions along the Euphrates and the influence this had on the development of cultivation. According to them, the “changes in the proportions of plant taxa between the earlier and later phases at Abu Hureyra” are neither due to an altering climate, or agricultural practices (Colledge 2010 p. 125). For a comparable zooarchaeological conclusion that doubts the “causal role of the YD in the adoption of agricultural economies,” see Munro 2003. In her analysis of small game hunting in the Southern Levant, she does not see the YD as causing food stress, or that this led to a change in subsistence strategies.

In brief, Ghar-e Boof was occupied during the onset of the glacial interstadial 8 in MIS 3. According to oxygen isotopes, and the lower cores from lake Zeribar, the climate was likely to have been mild and moist, or a less colder stage during the glacial period (Wasylikowa 2005). At the beginning of Chogha Golan, aridity was high, yet decreasing and the mean temperature was climbing. This means the habitats of wild grasses, pulses and fruit plants foraged for were spreading. With the reestablishment of tree cover and diverse, yet lower-yield, plants, it is unfounded to speak of a contraction of exploitable plant and animal food sources in the landscape around the tell. For the Central Zagros (cf. lake Hula for the Western Levant; Stevens *et al*. 2001), environmental and climatic conditions were unlikely therefore to cause a large drive to cultivation of high-yield plants as a supplement to poor foraging returns (Bottema 2002 p. 37). The social conditions developing around widening networks of production at favourable and frequented loci in the landscape, like tells, perhaps ask for renewed interest (Hole 1978).

6. Results

6.1 Legume foraging tradition

Recovery of *Cicer* sp., *Lathyrus* sp., *Pisum* sp. and *Vicia* sp. at Ohalo II and Kebara cave suggests pulses were collected in the Epi- and Middle Palaeolithic respectively (Albert 2000, Weiss 2004). People continued foraging for them throughout the succeeding millennia, though “in the absence of substantial storage” ability and yield enhancement, they would have provided less “post-encounter nutritional returns than big game” (Stutz *et al*. 2009 p. 9). The tradition persisted throughout the Upper Palaeolithic at sites like for instance Ghar e Boof or Hayonim Cave (Hopf 1987).

Natufian stone tool use-wear analysis by Dubreuil (2004) also indicates an increased use of flat grinding stones or querns for breaking legume and cereal seeds into meal in the Western Levant. By the Neolithic, practices were developing, perhaps leaning in part on a long legume foraging heritage, to obtain higher yields and a storable seasonal surplus. For legumes, as with cereals, temporary residence opened the way to increased exploitation and storage capacity, when compared to the small caches of nomads. According to Abbo *et al*. (2008) sedentarism also played a role in making possible the discovery and application of seed manipulations like scarification and new germination regimes, that led over time to domestication of some selected species. Contrary to a protracted development of pre-domestication cultivation suggested by Fuller and other scholars, Abbo and Albert disagree on the time-span involved between the first planting attempts and domestication (Abbo 2013, Albert 2000 and Fuller *et al*. 2012b). They believe this development occurred quickly and in sedentary communities, rather than during a long process of practice and innovation passed down through millennia by mobile hunter-gatherers. However, Abbo does not refute the significance of a longstanding custom of legume foraging in the process of developing their cultivation and later domestication (Abbo 2013). Nor that these efforts were always successful or exclusive to a core area. Some trials were abandoned for instance, like the attempts with *Vicia peregeina,* cultivated between 11 300 - 10 900 years ago alongside *Hordeum* sp., at Netiv Hagdud in Southern Jordan (Melamed 2008). Many were successful and still common today, like the domestication of *Cicer arietinum* at Tell el-Kerkh during the late 10th Millennium BP in Northwestern Syria were (Tanno & Willcox 2006). Note that though chickpeas were also found in the Middle Palaeolithic horizons of Kebara cave, they do not occur at the other PPNA sites examined in this paper (see table 1 and figure 2).

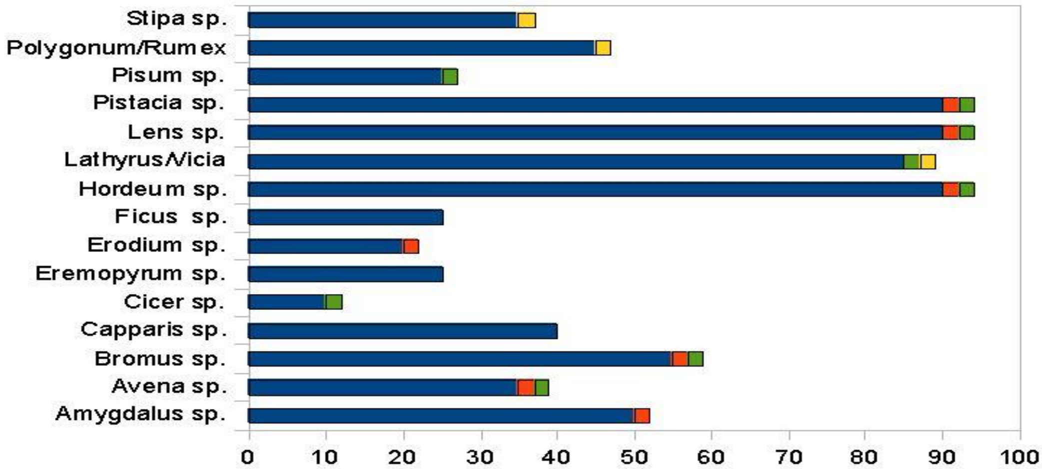


Figure 2. The ubiquity of selected edible taxa by percentage of presence at the aceramic Neolithic sites of table 1 in blue with the three outliers: Ohalo II in orange, Ghar-e Boof in yellow and Kebara in green

Proponents of early pulse cultivation question however the efficiency of wild collection at a time when residential mobility was declining (cf. the Kebaran-Natufian transition in Jordan Diaz *et al*. 2012). The sparse coverage of legumes in the landscape meant sowing them nearby the settlement, and/or tending wild patches in its wider vicinity, would reduce the otherwise high logistic cost and small energy return of just foraging for them nomadically. Balancing or improving the cost-benefit ratios of foraging were therefore central concerns in the development of legume cultivation. The Fabaceae recovered from sites in our study area are therefore divided into two categories depending on the energy expenditure and return from collecting them (Zohary 2012 and Edwards *ed al*. 2004). Those plants returning a low amount of energy or a small volume per unit of time were likely avoided, but may have entered the analysed assemblages inadvertently when targeted plants were collected. The presence of some of these smaller seeds and fruit is conditionally indicative of cultivation as weed flora; mainly of Poaceae but also Fabaceae (Garrard *et al*. 1988, Savard *et al*. 2003). Our modernity clouds this categorisation however. Known useful small seeded plants like Brome grass (*Bromus* sp.) Lupine (*Lupinus* sp.) and mustard (*Brassica* sp.) are recognised as foraged at Ohalo II (Diaz *et al*. 2012). Yet other small seed and fruit, the possible consumption or uses of which are nowadays unknown, are not considered as exploited. The vast array of *Astragalus, Medicago, Melilotus, Scorpiurus, Trifolium, Trigonella,* among other Fabaceae, are thus not considered targets of cultivation (Abbo *et al*. 2008). Other uses are for example the laying down of Fabaceae, and Cyperaceae, as bedding material as is evident at Ohalo II and Abu Hureyra (Hillman *et al*. 2001, Nadel *et al*. 2004). Foraging Fabaceae was a seasonal supplement in a broad diet package, rather than a staple resource, because of the high travelling and preparation cost expended (Abbo *et al*. 2008, Ladizinsky 1987, Weiss *et al*. 2004). But later, when people began cultivating pulses, these expenditures dropped below the gains and they became more attractive food sources. Note that not all the legumes discussed are climbing plants needing care in order to obtain serious yields: the carob seed (*Ceratonia siliqua*) found in the Sinai at Wadi Feiran and Boker Tachtit drop plentifully from a sturdy bush (Phillips 1988).

6.2 Fruits and nut trees

Identification of juniper (*Juniperus* sp.) and (*Morus nigra*) pips at Chogha Golan is neither exceptional - they are evident at Öküzini, Gilgal 1 and other Levantine Epi-Palaeolithic and PPN sites (see figure 2) - nor straightforward evidence of manipulation of their parent trees (Bar-Yosef *et al*. 1977, Kislev *et al*. 2006 and Noy 1989). That junipers grew in the Zagros Mountains during the late glacial era finds support in pollen remains from hyena coprolites from Wezmeh cave dating to 19 000 and 12 000 cal. BP (Djamali 2011). Juniper however was not identified at the other sites in table 1. Note other usages of arboreal fruit were possible as must be the case for the conspicuous identification of poisonous *Rhamnus palaestinus* seed at numerous sites in the region like Wadi al Hammeh 26, Kebara cave and Abu hureyra (Bar-Yosef *et al*. 1977). Nevertheless, even the numerous pistachios (*Pistacia* sp.) and almonds (*Amygdalus* sp.) recovered are not proof that people planted, pruned or gave particular care to fruit and nut bearing trees in order to obtain larger yields (Willcox *et al*. 2009). Remark how almond joins on the edge of the cluster plot in figure 3 with weeds typical of early cereal cultivation, yet it is distant from the wild grasses common to cereals' habitat. If cultivation was practised, then almonds lie contrastingly with those plants understood as discarded. Supposing it was only in its infancy alongside a hunting and gathering subsistence, then these weeds came with the foraged seeds, fruits and nuts that grow near each other.

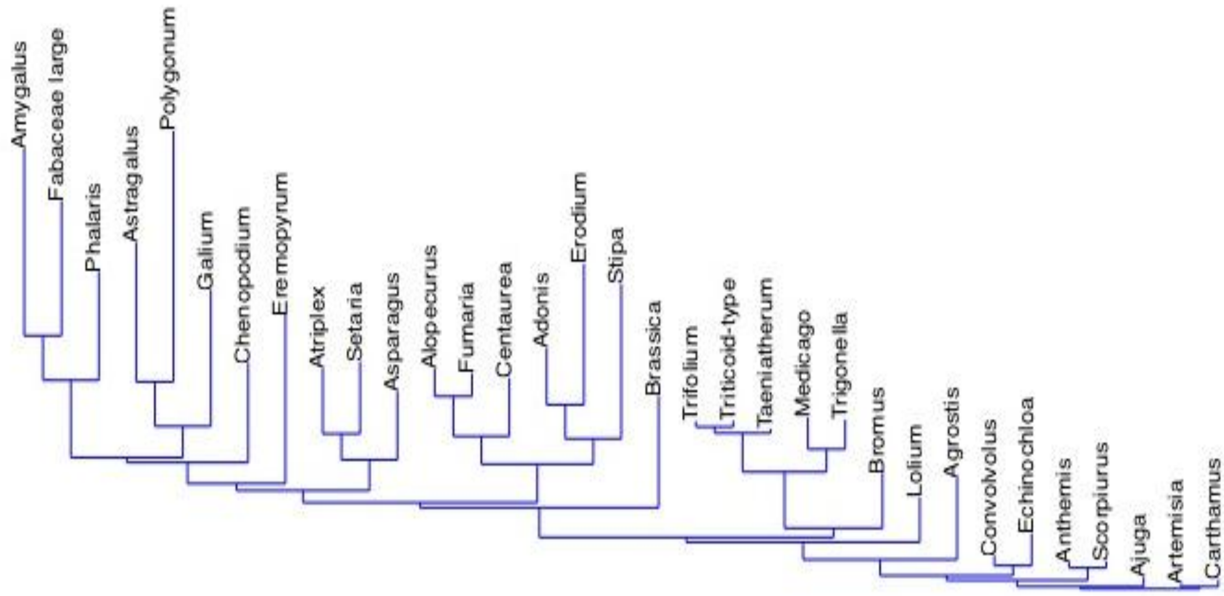


Figure 3. Cluster plot of the ubiquity of weeds and medium seeded grasses in the assemblages of the 12 chosen sites with almond as an outlier.

6.3 Tending and planting cereals

A central way discussed in the literature to distinguish between seeds that were the produce of cultivation, and those of foraging wild stands, is to analyse the presence of weeds (Colledge 2004). Weeds may in this case be considered as niche companions of cultivated plants. They could benefit from modifications aimed at improving the yield of the tended plants. They may even have been removed from cultivation plots as unwanted, but in the absence of firm evidence this is speculation. Though many taxa share, for example barley's (*Hordeum* sp.) habitat, a few particular genera of weeds stand out proportionally and are ubiquitous compared to the other plants in the analysed assemblages (Savard *et al*. 2006). Even under stress of changing climate, cereals and weeds conspicuously persevere. Fuller suggests that they "persisted in a new habitat (Fuller 2007 p.907)." Thus a side-effect of cereal cultivation was that *weeds* also benefited from an increased resilience to adverse conditions in the environment that was constructed to further the target plants. Table 2 and figures 4 and 5 suggests horizon XI of Chogha Golan had a particular weed component (cf. Colledge *et al*. 2004, Willcox 2009). This could signal that barley was cultivated near the tell, and that some of its wild habitat companions (i.e. *weeds*) grew and were harvested along with the cereal.

Table 2. The presence or absence of arable weed taxa

	Abu Hureyra	Chogha Golan	Dja de	Ganj Dere Tepe	Ghar e Boof	Iraq ed Dubb	Jerf al Ahmar	Kebara	M' lefaat	Murreybet	Netiv Hagdud	Ohalo II	Wadi Hammeh	Wadi Jilat
Adonis sp.		x	x				x		x	x	x			x
Arnebia sp.	x		x		x					x	x			x
Astragalus sp.		x		x	x			x	x	x	x			
Bellevalia sp.	x	x						x	x	x	x			
Bromus sp.	x	x	x	x		x	x	x		x		x	x	x
Centaurea sp.		x	x		x		x		x	x	x			x
Chenopodium sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fumaria sp.		x	x	x						x	x			x
Galium sp.		x	x	x	x	x	x	x		x		x		
Glaucium sp.	x	x	x	x	x	x	x					x		
Heliotropium sp.	x	x	x	x	x				x	x	x			x
Lepidium sp.	x	x			x									
Lolium sp.	x	x			x		x						x	x
Papaver sp.	x	x	x		x									x
Polygonum sp.	x	x	x		x		x		x	x				
Setaria sp.	x				x		x			x		x		
Silene sp.		x	x	x	x		x			x	x			
Spergula sp.	x	x												

The sites in table 2 are broadly contemporary to Chogha. Ohalo II, Ghar e Boof and Kebara are included as Epi-, Upper and Middle Palaeolithic outliers.

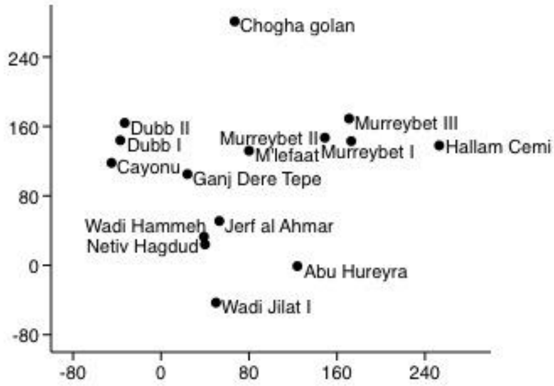


Figure 4. Ordination plot of the ubiquity of the weed taxa in the assemblages of sites contemporary to Chogha Golan and other aceramic Neolithic sites in Southwestern Asia.

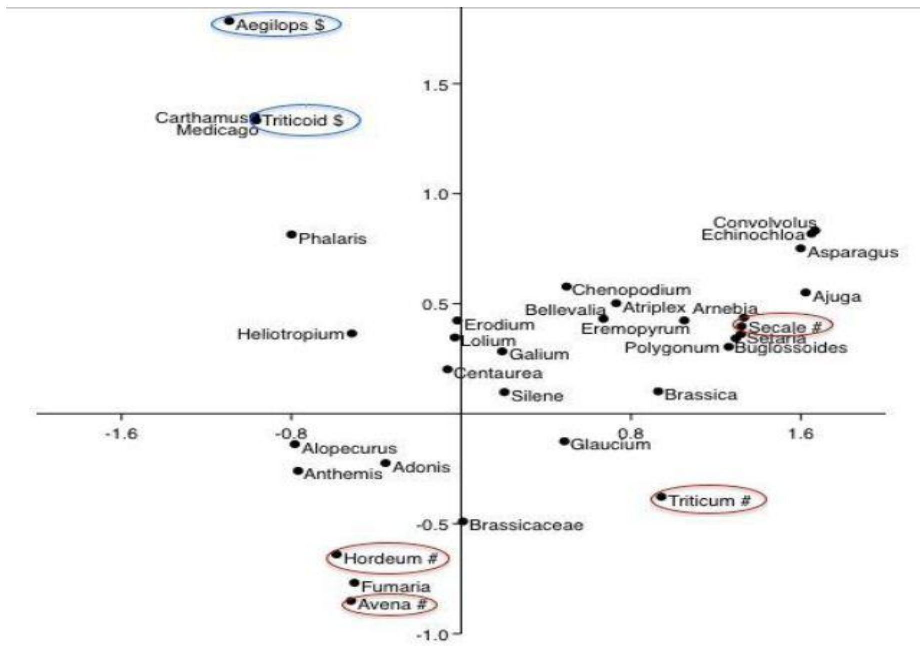


Figure 5. Correspondence analysis of the ubiquity of recorded weeds and cereals in the assemblages from the 12 chosen sites. # sign marks traditional cereals and $ marks those grasses that were possibly eaten.

In a reassessment of Abu Hureyra's assemblage, Colledge and Conolly (2010) suggest a widening of foraging activities to include “lower-ranked” foods, rather than cultivation as was suggested by Hillman (2001). Indeed identifying a weed component in a horizon need not be interpreted as modification of a plant's wild growing conditions to the extent of cultivation, as these plants share the same ecology with cultivated species in the wild. In figure 6, which plots all the edible, useful and weed taxa found in Chogha Golan's lowest horizon, the larger edible grasses, legumes and nuts cluster on the lower right quarter of the graph, yet in proximity to a few companions of their wild habitat. However, some of the other edible seeds and fruits, but also weeds, scatter arbitrarily across the rest of the plot. This corresponds to gathering of the wider spectrum of edible regional vegetation; including a number of cohabiting non-useful plants, inadvertently harvested with the targeted species. Because such foraging did not affect the plants directly in the sense of changed seed morphology or plant physiology, no distinguishing characteristics between targeted and randomly gathered seed and fruit were found. Therefore I suggest that shifts in subsistence procurement took place, rather than cultivation per se, following hunter-gatherer responses and actions inherited from when people came under stress due to their demography or behaviour or changes in their environment (cf. resilience theory followed by Rosen 2012).

Signs for associations between taxa that are edible and share the same ecology, such as *Taeniatherum* sp. and *Eremopyrum* sp., (cf. Fairbairn *et al*. 2007) and the typical crop or functional plants, were looked into as well. Though some edible species cluster near one another, as do some cultivated plants, they are rather scattered and associate rather more closely to those taxa that share their preferred environmental conditions. I hypothesise this indicates targeting plants of specific worth, over less energetically economic or useful ones. Exceptions in the plots are noticeable however, as is the case with *Capparis* sp. (cf. Garrard 1988 and Willcox 1996) and *Amygdalus* sp. which might indicate that these plants are site-context specific (see figure 2 and 6). The analyses nonetheless suggest more close correspondence ecologically between plants than any groupings derived from removing targeted plants from their wild companions in the local environment. This would agree with predictions from behavioural ecological models that hunter-gathers primarily foraged for high yield food, over less rich plants (Broughton *et al*. 2010, Colledge 2010). Yet as plants with preferential traits to the occupants of tell sites, they do not stand out from the other plants that share their ecology in the wild. Thus the analyses sway me more towards broad foraging in the landscape, rather than adjusting plants to people's new needs or situation through cultivation.

Eating wild cereals in the Middle Palaeolithic finds support in the identification of ripe grass panicles at Amud Cave, intentionally brought on site by its Neanderthal inhabitants (Madella 2002 p.714). *Hordeum* sp. starch moreover, trapped in the dental calculus of a Neanderthal, was found at Shanidar III in Iraq (Henry 2011). Note that starch grains of dates (*Phoenix* sp.), water lilies (*Nymphaeae* sp. and *Nuphar* sp.), legumes and a relative of sorghum were also identified in the same study from Spy cave in Belgium (*ibid*.). Wild cereal seeds retrieved from samples dating to 19 000 BP from Ohalo were similarly interpreted as foraged, in the absence of a distinct weed complex (Kislev 1992).

The assemblages were also analysed for indicators (such as *Ajuga* sp. and *Galium* sp.) that cereals were cut low by the base, or uprooted (Kislev *et al*. 2004). This could in part have explained the weed component's strength, but the datasets lacked clear signs. Identifications to the species level within the same genus in the dataset were also investigated for clustering or correspondences (see figure 7). Whilst plots of the number of specimens revealed nothing conclusive, plots of species ubiquity shows how the edible *Vicia* / *Lathyrus* cluster with *Vicia ervilia,* but are only distantly joined to *Vicia faba* and the undefined *Vicia* sp. As no other associations are obvious, we conclude that the loss of detail by working with datasets of identification only down to the genus level remains acceptable.

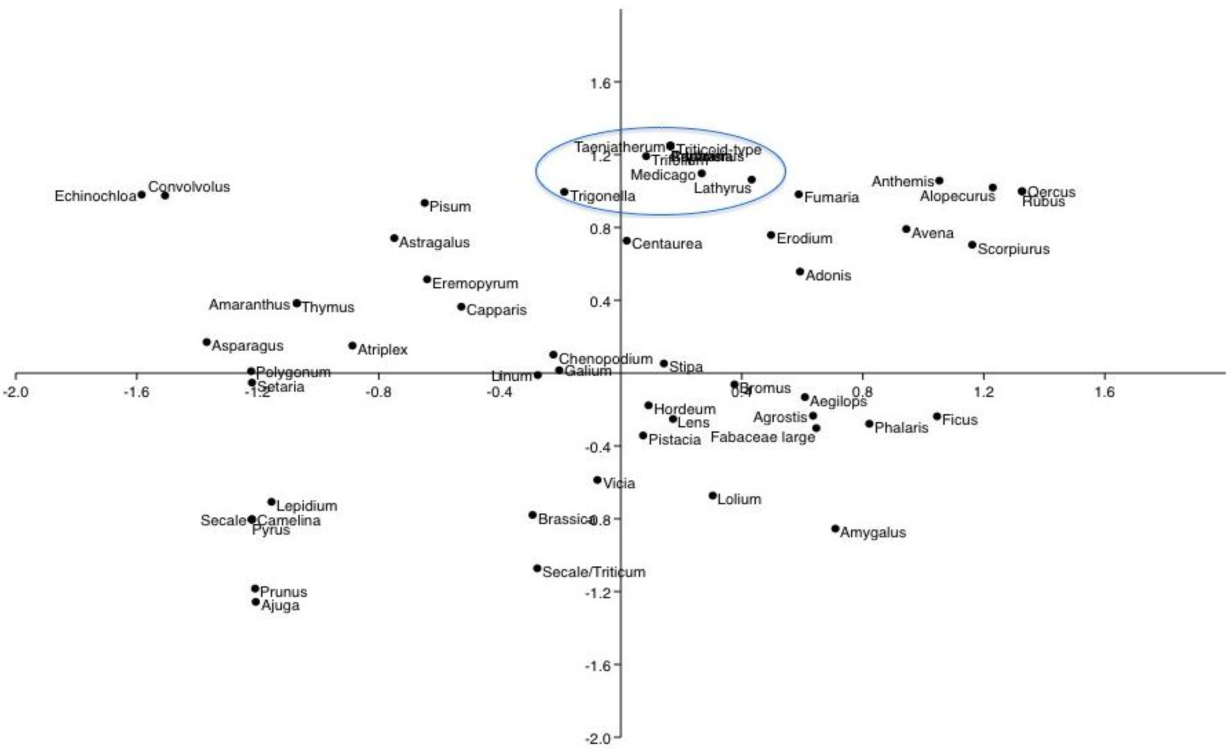


Figure 6. Correspondence analysis of the ubiquity of recorded edible, useful and weed taxa from horizon XI at Chogha Golan's. Note moreover that the triticoid-types lie in a recurring constellation of taxa (Taeniatherum, Trifolium and Carthamus) as in figures 3 and 5.

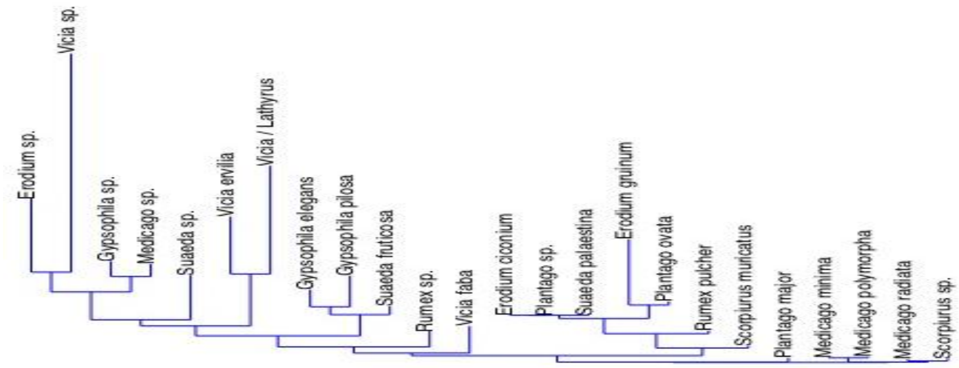


Figure 7. Cluster plot of the ubiquity of selected grasses, herbs and legumes from Chogha Golan's first horizon to examine how closely statistically associated are related plants that were identified to the genus and species level.

Over prolonged association in the arable field and due to the effects of cultivation, hybridization can occur between weeds and cultivated plants. A typical example can be shown with the appearance of free threshing wheat (*Triticum aestivum*) and will be briefly discussed before turning to other steppe and meadow plants. Although goatgrasses (*Aegilops* sp.) were abundant at Chogha Golan, the agent behind the emergence of free threshing wheat: emmer (*Triticum dicoccum*), which was later found, *Triticum aestivum* has not been found. Nor were any *Aegilops tauschii* specimens, the source goatgrass of the hybridization, identified. As both parent plants were native to the region, we presume that free threshing wheat's full hybridization occurred after the site's use ended. Moreover, as goatgrasses were equally comestible as wild emmer, it is unlikely that their high specimen count in the earliest tell horizon was due to purposeful burning as rubbish. Rather, it makes sense to conclude that the foraging efforts during this horizon did not exclude goatgrasses. Whilst *Triticum boeoticum*/*dicoccoides* became more numerous in later horizons, the proportion of *Aegilops* dropped. I see this, with slim corroboration from other sites (see table 3 charting *Aegilops* sp. and selected small-seeded grasses and legumes and figure 5 (cf. Hillman 2001; Savard *et al*. 2006 and Willcox *et al*. 2009), as an indication that people, upon adoption of cultivation practices, began better sorting through their seed stock for sowing and removing of weeds to keep them out of cultivated plots.

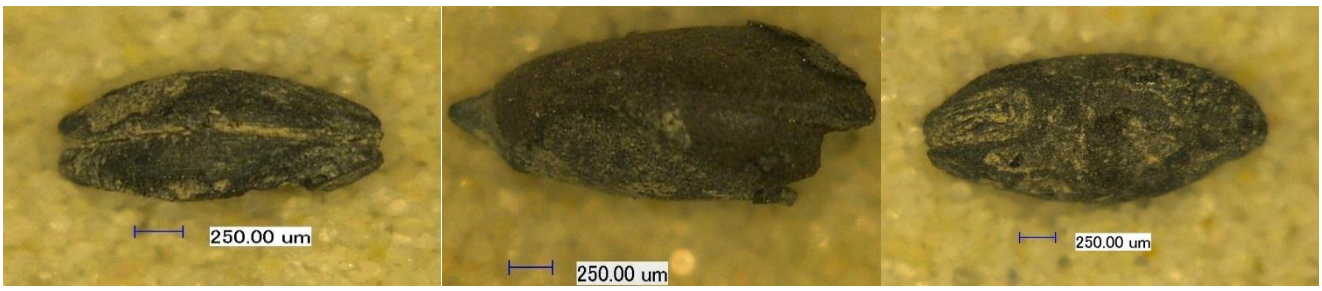
Table 3. Presence of small-seeded grasses, legumes and herbs

	phase 1	phase 2	horizon XI	horizon VIII	horizon V	earlier phase	later phase	late Natufian	Khiamian	PPNA
	Abu Hureyra		Chogha Golan			Iraq ed Dubb		Murreybet I		
	13 250 - 12 750 BP	10 000 - 9 300 BP	11 500 BP	10 700 BP	10 000 BP	11 175 - 10 000 BP	10 000 - 9 300 BP	12 500 - 12 000 BP	12 000 - 11 500 BP	11 500 - 11 200 BP
Aegilops sp.	0	0	x	-	-	x	-	0	0	0
Astragalus sp. *Trigonella* sp.	x	+	x	-	-	0	0	x	-	-
Chenopodium sp.	x	+	x	-	-	x	-	x	-	-
Eremopyrum sp.	x	+	0	0	0	0	0	x	-	-
Medicago sp. *Trifolium* sp.	x	+	x	-	+	?	?	x	-	-
Phalaris sp.	0	0	x	-	+	x	-	0	0	0
Polygonum sp.	x	-	x	?	?	x	?	0	x	+
Scirpus sp.	x	+	x	-	-	0	0	x	+	x
Setaria sp.	x	-	0	0	0	?	?	x	-	-
Stipa sp.	x	+	x	?	+	0	0	0	0	0

Table 3 compares the record of some small seeded grasses, legumes and herbs between Chogha Golan, divided into an early, middle and late occupation phase, and the main occupation phases of three other roughly contemporaneous sites in Southwestern Asia. x means a presence, 0 means an absence, ? means data unknown, - represents a proportional decrease and + represents a proportional increase compared to the previous period.

It would be wrong to impress on the reader a view that cultivated food species never disappeared, and that only those plants known today as crops were cultivated in the past. Archaeobotanical evidence for instance “indicates a number of lost crops, which were cultivated and even morphologically domesticated, but are no longer extant” (Fuller *et al*. 2012b p. 629). We examined whether the triticoid-types from Chogha Golan also fit this scenario. When plotted amongst weeds and cereals, they lie away from the latter, but correspond closely to some weeds (see figures 5). Plotted amongst edible and useful plants and weeds, they again ordinate near weeds (see figure 6). Plotted by number of specimens, rather than by ubiquity as in the previous two analyses, again triticoid-type does not ordinate with true crop plants. Note however, that they were found in low amounts at just three other sites: Ganj Dere Tepe, Murreybet and M'Lefaat (Savard *et al*. 2003). They are specimens that have no known modern comparative in the Zagros Mountains, but occur at various prehistoric sites in the region like Ganj Dareh Tepe and the Northeastern Syrian Khabur (see photograph 1). Their typology follows van Zeist's (1984 & 2001) descriptions and lean towards *Hordeum* sp., *Secale* sp. or *Triticum* sp., but do not fit either of these genera conclusively, so the label triticoid-type is most correct. Either they are grains from plants not yet found in the wild, or that have gone extinct. Or more plausibly, like the two grained form of einkorn (*T. Urartu*), they are traces of an abandoned early cultivated lineage of a grass in the triticae tribe (Fuller *et al*. 2012b p. 620).

Photograph 1. three triticoid-type grains from Chogha Golan horizon XI, Iran



6. 4 Wild plants from the arable field

Another group of plants grew among the wild cereals and in cultivation plots that are not considered weeds. Like *Aegilops* sp., they either entered the site assemblage inadvertently during collection of targeted species, or on purpose as food. In the Middle Palaeolithic levels of Kebara Cave for example, bromegrass (*Bromus* sp.) and safflower (*Carthamus* sp.) were found (Lev 2005). In the archaeobotanical record of sites dating to the following tens of millennia, the list of small seeded grasses and legumes and genera in the dock (Polygonaceae), sedge (Cyperaceae) and beech (Fagaceae) families, found in contexts with the aforementioned food plants, increase and diversify (Hopf 1987; Kislev 1988; Savard 2006 and Willcox *et al*.2008). That they remained an integral part of the wild plant use of early farmers is attested to by Fairbairn *et al*.'s (2007) research of assemblages dating between 6200 and 6600 cal. BC from Çatal Höyük and Savard *et al*.'s (2003) studies at M'lefaat from around 9900 uncal. BC. By the PPN, the range of wild plants identified as possible seed, leaf and nutlet additions to the diet of hunter-gatherers clouds a strict definition of which plants were chosen in early cultivation attempts. Because cereals or pulses do not occur alone in wild stands, but together with these other plants, when people modified their wild ecology, it affected their habitat companions as well.

I hypothesise that as people began cultivation proper, that is in a way noticeable in the archaeobotanic record, which is suspected at Chogha Golan in the horizons succeeding its initial one, then the volume of specifically targeted species should increase, whilst the number of smaller edible taxa, but not weeds, would decrease. The analyses by Weiss *et al*. at other sites suggest such a trend, and they describe it as a shift in the hunter-gatherer broad spectrum diet. They saw for instance in the assemblages from Ohalo II, and 19 other selected sites in the Levant, a gradual decline in the small seeded grasses between the Epipalaeolithic and the PPNB (Weiss *et al*. 2004 and a similar study cf. Colledge *et al*. 2004). However, a hypothesised trend for a region is not a given for each site. Environmental conditions, residence context and the availability and diversity of food sources dictated the opportunistic hunting-gathering-cultivating strategies at each locality. Hence exceptions like: M'lefaat, Qermez Dere, Abu Hureyra, Çatal Höyük, Zharat adh-Dhra' 2 and Iarq ed-Dubb, where subsistence was diverse and not based primarily on large seeded grasses, are reported (cf. Savard *et al*. 2006 and Edwards *et al*. 2004). The number and diversity in these smaller edible legumes and grasses remains similar, or even increases, during Chogha Golan's occupation (see table 3 and Riehl *et al*. 2013 supplement). I surmise that the people, who initially visited the site and raised the midden, foraged wild plant food mainly, yet also experimented with cultivation.

7. Conclusions

One can speak of the development of agriculture at the end of the Palaeolithic as a realignment of hunter-gatherer traditions to a transforming human and natural setting. Increased foraging efficiency and stability were sought, as were the adoption of new residence and mobility strategies, in order to overcome the pressures of fluctuating demographies in both the human and edible plant populations. This study presumes these behavioural adaptations relied on a suite of actions and responses to ecological conditions, passed down the generations since the emergence of targeted plant foods procurement. The main targets, recognisable in the archaeological record, were to reduce the logistical costs, improve the ability for longer-term storage and increase yields per hour of invested labour. I hypothesise that modification of plant habitats was part of this development through activities such as: weeding, selective sowing and altering germination, moisture, soil fertility and light regimes. The carbonised plant assemblage of Chogha Golan and coeval sites in Southwestern Asia, with Ohalo II, Ghar-e Boof and Kebara as Palaeolithic outliers, were examined for signs of these activities. From ordination and cluster plots made, together with comparative analyses of the identified plant taxa, those assemblages near to 11 000 years old resembled the earlier Palaeolithic sites in their diversity of edible plants. Before cultivation and gathering storable and seasonal high yielding taxa developed, wild exploitation focussed on breadth in foraging as a guard against the risk of unstable returns. During the adoption of longer residence in the landscape, the ensuing economisation on logistic costs affected the selection of gathered species, yet wild legumes and grasses did not diminish in ubiquity in the studied samples. I suggest the later cultivation of a domesticated emmer was dependent on the local plant ecology, the inhabitants' altered migration patterns, mode of residence and hunting-gathering strategies. In sum, this study suggests that the people occupying Chogha Golan experimented with cultivation, as indicated for example by the triticoid-types found, but subsisted as the Rostamians did 25 000 years earlier from local foraging with a greater focus on high yield plants.

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Appendix.

A list of the plant remains identified by the author from Chogha Golan horizon XI. Central Zagros Mountains, Iran.

The taxa are ordered alphabetically by family. Each sample had the same 20 liter volume. They are further subdivided by excavation square (1 meter squares). The plant remains were analyzed and are stored at Tübingen University, Germany.

square number	1#9	1#10	0#0	0#99	0#1	1#1
amount of samples	2	3	6	8	3	3
Pistacio whole nut	4	0	3	0	1	0
Asteraceae / Cyperaceae	0	5	0	0	2	2
Anthemis / Aster	1	0	0	0	0	0
Artemisia	0	0	0	0	3	0
Carthamus	2	0	1	0	0	0
Centaurea	4	9	4	0	0	3
Asteraceae indeterminable	7	1	9	4	8	3
Heliotropium europeum	12	30	21	2	21	16
Echium Vulgare	0	1	2	0	1	0
Lepidium	0	0	0	0	0	1
Brassicaceae indeterminable	3	4	1	1	5	2
Capparis	4	2	2	1	2	1
Caryophyllaceae / Malvaceae	1	0	0	0	0	0
Caryophyllaceae / Chenopodiaceae	1	1	0	0	3	0
Cerastium/Gypsophila/Stellaria	54	91	26	4	62	39
Gypsophila	88	181	51	11	114	36
Caryophyllaceae indeterminable	10	17	5	0	30	4
Lychnis / Silene	1	0	0	0	0	0
Sagina	0	0	1	0	0	0
Silene	7	7	3	1	16	5
Spergula	0	4	1	0	0	0
Spergularia	0	0	2	0	0	0
Atriplex	1	1	4	0	3	0
Atriplex / Chenopodium	7	30	16	2	12	4
Chenopodium	10	21	6	4	27	8
Halimione	0	0	1	0	0	0
Chenopodiaceae indeterminable	10	12	13	0	42	12
Salsola	5	10	8	2	5	4
Salsola laricina	3	0	1	2	0	2
Salsola -type	2	4	8	0	1	0
Suaeda	2	16	2	2	4	3
Juniperus	3	0	0	0	0	0
Scirpus	39	71	90	21	40	41
Cypereaceae indet.	2	0	0	0	0	1
Astragalus/Trigonella < 1 mm	83	107	34	27	195	37
Astragalus/Trigonella > 1.5 mm	253	132	263	78	145	73
Astragalus/Trigonella 1 - 1.5 mm	609	1039	927	172	1353	685
cf. Pisum	26	11	39	4	7	0
Fabaceae indeterminable	83	94	92	29	53	82
Lathyrus / Vicia	34	49	42	18	69	22
Lens	14	17	24	11	43	23
Medigaco/Trifolium < 1 mm	63	107	57	21	125	37
Medicago/Trifolium > 1.5 mm	96	80	53	24	90	26
Medicago/Trifolium 1 - 1.5 mm	345	451	407	84	751	199
Medicago radiata	26	20	16	6	20	9
Melilotus	0	0	0	4	0	1
Pisum	4	12	12	2	23	1
Trifolium	1	0	0	0	0	0
Trigonella astroites -type	50	59	34	32	156	64
Fumaria densiflora	1	0	0	0	1	1
Gentianella	0	2	0	0	1	0
Erodium	6	7	17	6	9	8
Capparis / Salsola	0	1	1	1	0	0
Lamiaceae indeterminable	0	1	1	0	2	0
Lamium	2	0	0	0	0	1
Bellevalia	1	0	2	3	4	1
Liliaceae indeterminable	4	2	3	2	8	6
Ornithogalum	3	2	1	0	0	0
Malva	20	24	48	8	51	13
Ficus	0	0	0	0	1	0
Glaucium	0	1	0	0	0	0
Papaveraceae indeterminable	0	2	1	0	0	0
Plantaginaceae indeterminable	0	0	0	0	2	0

Poaceae < 1 mm.	5	34	64	15	80	64
Poaceae > 3 mm.	122	236	492	61	362	266
Poaceae 1.5 - 2.5 mm.	145	481	703	175	593	956
Aegilops	37	29	80	44	62	19
Aeluropus	0	0	0	0	1	0
Agropyron	0	0	1	1	2	0
Alopecurus	0	0	0	1	1	0
Alopecurus / Phalaris	6	4	11	0	6	1
Arrhenatherum	0	4	0	0	0	0
Bromus	0	12	3	3	0	10
cf. Hordeum	54	115	236	7	88	35
Eragrostis / Phleum	1	0	0	0	4	0
Chrysopogon / Helictotrichon	0	1	0	0	0	0
Hordeum	126	186	271	105	304	160
Hordeum / Triticum	10	3	5	2	5	1
Lolium temulentum	0	0	0	0	0	1
Lolium	0	0	0	3	3	1
Phalaris	33	56	17	6	54	21
Phleum	0	0	0	0	8	0
Stipa	0	0	0	1	0	0
Taeniatherum	27	29	19	24	33	33
triticoid -type	68	64	79	38	96	33
Rumex	0	0	0	0	1	0
Persicaria	0	0	0	0	1	0
Polygonaceae indet.	1	0	0	0	0	0
Adonis	0	0	3	0	2	1
Ranunculaceae indet.	0	0	1	0	0	0
Ranunculus	0	0	1	0	0	0
Ranunculaceae / Solanaceae	0	0	1	0	0	1
Reseda luteola	2	2	10	0	5	0
Rubiaceae indeterminable	1	0	1	0	0	0
Galium	9	32	19	3	24	9
Asperula / Galium	0	0	1	0	0	0
Scrophulariaceae	1	0	0	0	0	2
Solanum	1	0	1	0	0	0