A Comparative Study of Archaeobotanical remains from Neolithic and Chalcolithic sites in Northern Fars, Iran

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Abstract

Fars is an area characterised by a great diversity not only in natural resources, but also in cultural and economic aspects. Reconstructing subsistence strategies of prehistoric settlements has always been one of the main objectives of the archaeological research undertaken in this region. In particular, discussions have been centred on whether the emphasis was on agricultural or pastoral activities. However, these arguments were mainly based on archaeological finds and settlement distributions rather than primary bioarchaeological evidence. The recent zooarchaeological studies in the region provided important insights into the prehistoric subsistence strategies practiced by the prehistoric inhabitants of Fars. However, the current archaeobotanical record of Fars is rather limited. Therefore, to shed more light, new macrobotanical remains (seeds and charcoal) were collected from three recently excavated sites in Fars namely Rahmatabad, Nurabad, and Mehrali. The analysed plant assemblages from these sites cover a long sequence of occupation from the late 8th to the Late 4th millennium B.C. The results of this study significantly expanded the archaeobotanical dataset of the region and added new important insights into the plant subsistence practices, woodland exploitation and fuel collection of these prehistoric communities. They indicated the likely importation of cereal crops (rather than a local domestication event), the significant role and exploitation practices of specific wild plant resources for food and fuel, and an overall regional variety and flexibility in subsistence practices. Ultimately, the comparison of these new data with other archaeobotanical evidence in Fars and the wider area significantly enhanced our understanding of prehistoric human-vegetation interactions.

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Chapter 1

Introduction

This chapter provides an overview of the limitations of archaeobotanical studies in Iran and discusses their potential and the significance of the area under study. It also presents the aims and objectives of the thesis followed by an introduction to the research questions. In the last section, the chapters of the thesis are summarised.

1.1 Archaeobotanical studies in Iran: an overview

Iran has a long history of archaeological investigations and has been one of the major centres for archaeological research in the Near East over the past 150 years. These investigations, however, have undergone many changes over the past decades (Alizadeh 2004; Azarnush and Helwing, 2005). The particular emphasis of the initial archaeological explorations in Iran was based on recording monuments as well as large-scale excavations aiming to find art objects. After the 1979 Revolution, almost all archaeological activities ceased for a decade. Nevertheless, since the 1990s, the number of field expeditions in Iran has increased considerably with more focus on a range of different periods, including prehistoric, historical and Islamic (Alizadeh 2004; Azarnush and Helwing, 2005). Collaborative archaeological projects between Iranian and international teams became active again, some of which, however, were stopped or restricted. Overall, these disruptions delayed the progress of archaeological investigations at different stages (*ibid*). It is important to mention that archaeobotanical sampling was not conducted in many of these archaeological projects partly due to the lack of awareness of the potential of these type of studies. Although in the last decade there has been an increasing tendency to collect archaeobotanical material from prehistoric sites, some of these assemblages have never been analysed and are often destroyed due to poor storing conditions. Other issues, such as field logistics and the lack of experts in the country, have created additional restrictions for archaeobotanical studies.

Overall, the available archaeobotanical evidence of Iran largely comes from old excavations or from recent investigations with focus on certain areas. Therefore, considering the large size of the country, our knowledge of the prehistoric land use patterns, plant subsistence practices and food production based on primary plant evidence is limited in many regions. These limitations and the need for more archaeobotanical studies in Iran prompted the author to start building a comprehensive archaeobotanical dataset. To achieve this goal several archaeobotanical samples from prehistoric sites were collected. The main aim of this project was to raise the awareness of the important role of these analyses in archaeological investigations. Analysing the collected samples could also significantly advance our understanding of key aspects of human-plant relationships from the areas that are archaeobotanically under-represented or never been investigated before. During this field sampling, some modern botanical specimens were also gathered to create a local reference collection. As part of this ongoing project archaeobotanical material (seed and charcoal) for the current study were collected from three recently excavated sites in Fars, southwest of Iran. These plant assemblages contain material recovered from the sites of Rahmatabad, Nurabad and Mehrali, covering a long sequence of occupation from the late 8th to the Late 4th millennium B.C.

1.2 The significance of Fars and choice of the studied material

The south-west of Iran that includes the Fars province has always been a key area in the long history of archaeological investigations. Fars has been the main route between the lowland and highland areas of Zagros Mountains throughout prehistory (e.g. Mashkour, 2009; Mashkour *et al*., 2006; Alizadeh, 2006; Weeks *et al.*,2006). In addition to the strategic location of Fars, the suitable environment of this region (e.g. fertile plains, sufficient annual rainfall and access to various natural resources) attracted human groups over a long period of time (Roustaei *et al*., 2009; Sardari, 2013; Bernbeck *et al*., 2005; Azizi *et al*., 2014). Overall, the following factors led to the choice of material from this region for the current study:

1.2.1 Recent archaeological discoveries: Until recently, the transition from the Epi-Palaeolithic to the Ceramic Neolithic period of Fars was unknown. The new discovery of the Early Holocene sites in the Tang-e Bolaghi (Tsuneki *et al*. 2007; Tsuneki and Zeidi 2008) as well as the Aceramic deposits of Rahmatabad dated to the Late 8th millennium B.C. (Bernbeck *et al*, 2005; Azizi *et al*., 2014) started filling up the gap of the chronological sequence of the region (Weeks, 2013). The new archaeological evidence provided a unique opportunity to examine the subsistence economy of this period. In addition, excavations at prehistoric sites, such as Bashi (Pollock *et al*, 2010), Rahmatabad (Bernbeck *et al*, 2005; Azizi *et al*., 2014) and Nurabad (Weeks *et al*., 2006,2009; Potts *et al.*, 2009), significantly improved our understanding of the Neolithic communities of Fars. The new archaeological excavations at the multi-period mounded sites in Northern Fars as well as systematic surveys in the region also shed more light into the Chalcolithic occupation of the region (e.g. Weeks *et al.* 2006, 2009; Petrie *et al.* 2009, Zeidi *et al.* 2009; Sardari and Rezaei, 2007; Hewing *et al*., 2010; Sardari, 2011, 2013). Most notably, new excavations at prehistoric sites, such as Rahmatabad, Nurabad and Mehrali, indicated continuous human occupation over a long period of time. Therefore, studying the plant assemblages of these sites provided an opportunity to reconstruct the main characteristics of the plant economy and the environment of prehistoric Fars from the Early Neolithic to the end of the Chalcolithic period.

1.2.2 New zooarchaeological evidence: Analysis of the faunal remains from the abovementioned sites also provided further insights into the subsistence strategies practiced by the prehistoric inhabitants of Fars from the Epi-Palaeolithic to the Late Chalcolithic period (e.g. Hongo and Mashkour, 2008; Payen, 1999; Mashkour *et al*., 2006; Mashkour, 2009; Mashkour and Bailon 2010; Sheikhi, 2008). The overall results of these analyses appear to represent a strong material index of the process of Neolithisation in Fars (Mashkour, 2009; Weeks, 2013) to which the plant data could provide an excellent complement.

1.2.3 Paucity of archaeobotanical studies: Despite the relatively large-scale archaeological investigations in Fars, the current archaeobotanical evidence is rather limited. The previous archaeobotanical analysis undertaken at few prehistoric sites in the region included Tal-e Malyan (Miller, 1982, 2011,2013) , Cave TB75 (Tanno, 2008), Tal-e Mushki, Tal-e Jari (A , B) and Tal-e Bakun A and B (Miller and Kimiaie, 2006) Tol-e Bashi (Kimiaie, 2010) and second season of Rahmatabad (Tengberg and Azizi, 2016). It is important to note that some of these studies were limited to analysing few flotation samples and (except Tal-e Malyan) wood charcoal remains recovered from these sites have not been analysed. Therefore, the results of the current study could vastly expand the current archaeobotanical dataset of Fars. Furthermore, since the collected assemblages for this study represent multi-occupation settlements, it would allow us to observe any continuity or changes (similarities/differences) in the plant management strategies throughout time.

It must be noted that although the potential of the chosen material is great there are some limitations that need to be considered. The archaeological investigations at Nurabad and Rahmatabad were intended to be long-term projects, however, excavations at both sites remained incomplete. Consequently, the archaeological information used for this study is rather restricted and any further sampling from these sites was not possible. Nevertheless, this at the same time renders the completion of the study of this material timely and imperative.

1.3 Research aims and objectives

The primary aim of this study is to shed more light on key aspects of human-plant relationships (particularly food production and fuel use) in prehistoric Fars. In order to achieve a comprehensive understanding of the subject and develop reasonable arguments, the research includes archaeobotanical material (seed and charcoal) from three different prehistoric sites.

Burning of animal dung as fuel was reported as the main source of some carbonised seed assemblages previously analysed in Fars (Miller, 1982; 1984, 2013; Miller and Kimia, 2006). Therefore, one of the principle objectives of this study was to identify the source of recovered charred plant materials from the sites under study. After assessing the effect of taphonomic factors, the following questions are addressed:

1.3.1 Site-specific questions:

Which plant species/crops are present?

Are there any differences between the samples and context types? Could plant remains from each site shed light on the use of space?

What other types of plant resources were gathered? Were there any wild plants resources included as part of the plant economy?

What was the (primary) source of fuel? What other sources were used if any?

Was there a significant difference in the range of crops and wood taxa exploited throughout the sequence?

1.3.2 Regional questions:

The following questions are addressed using the results of this study and other available archaeobotanical evidence in Fars:

Which wild plants and cultivated crops were exploited during the Aceramic period? Were the crops locally domesticated?

Which crops were part of the main agricultural production in the Neolithic and Chalcolithic period in the area?

Are there any similarities/differences in plant subsistence strategies practised by the Neolithic and Chalcolithic inhabitants of Fars?

1.4 Outline of the thesis

The thesis is structured as follows:

Chapter 2: outlines the geographical location, climatic characteristics and modern vegetation of the Fars province. It also reviews the history of archaeological investigations in Fars from the Aceramic to the end of Chalcolithic period and introduces the three sites under study.

Chapter 3: lays out the recovery and laboratory methods used for the selection, assessment and identification of macrobotanical remains (seed and charcoal).

Chapter 4: provides the taphonomy assessment, which details any biases introduced by the field methods including sampling strategies and discusses the formation processes that shaped the archaeobotanical assemblages under study.

Chapter 5: contains morphological descriptions and ecological information of the wild and woody taxa identified in the three-archaeobotanical assemblages.

Chapters 6-8: present the results of the analysis of the macrobotanical remains (seed and wood charcoal) recovered from Rahmatabad, Nurabad and Mehrali.

Chapter 9: compares the results of the current study with the relevant bioarchaeological, ethnographic, ecological and archaeological evidence at regional level and in a wider context and discusses the main characteristics of the subsistence economy and the environment (woodland vegetation and fuel exploitation) of the prehistoric settlements of Fars through time.

Chapter 10: presents the overall conclusions and suggestions for future research.

Chapter 2

Study area background

This chapter reviews the environmental and archaeological background of the area under study. The first section of the chapter includes a short discussion of the geographical location, climatic characteristics and modern vegetation of the region. Moreover, due to the geographical location of Northern Fars (situated in the southern part of the Zagros Mountains), a brief history of the vegetation and palaeoenvironmental records of the Zagros region is also provided. The second part of the chapter presents an overview of the archaeological investigations conducted in Fars from the Aceramic to the Late Chalcolithic period as well as introduces the sites under study.

2.1 Environmental setting

2.1.1 Geographical location, physical features and boundaries

The study area falls into the southern part of the Zagros Mountains range. The Zagros Mountains range dominates the entire wester portion of Iran comprising some of the most imposing fold structure and clusters of high peaks in Iran and within the whole of the Middle East (Fisher, 1968, p 7). The Zagros range is formed of several tectonic zones and the Fars province stretches across both the Zagros Crush Zone and the Zagros Folded Belt (Roustaei *et al*, 2009, p 17). The Zagros mountain range (with northwest to the southeast direction) extends towards the central parts of the Fars province. Elevations in the northern parts is reported reaching higher than 3900 above sea level while the southern parts are mostly less than 500 m a.s.l. (Sadeghi *et al*, 2002, p 334). Shiraz is the largest town of this southern region of the Zagros system that lies among the major Zagros chains (Fisher,1968, p 22) (Fig 2.1). The Fars province lies between the Persian Gulf in the south and the Esfahan province in the north. It borders the Kerman and Yazd provinces on the east and northeast and the Boyer Ahmadi-Kohkiluye on the west. (Fig 2.2). As shown in Figs.2.3 and 2.4 the sites under study are located in the northern part of the Fars in Mamasani district (Nurabad), Eqlid district (Mehrali) and Marvdasht district (Rahmatabad). Mamasani district is the western-most region of the Fars province. Mamasani is tectonically active and located close to the Kazerun-Qatar fault, which continues to produce earthquakes and fractures (Roustaei *et al*, 2009, p 17). The northern end eastern parts of the district include Javid and Doshman Ziari mountains regions. The central intermontane plains of Mamasani include Dasht-e Nurabad, Dasht-e Javid, Dasht-e Rostam-e Yek and Dasht-e Rostam-e Do. The western and southern parts include Mahour-e Milati and Mahour-e Zirband (Roustaei *et al*, 2009, p17). The central plains of Mamasani are situated 120 km to the west-northwest of Shiraz, the capital of Fars province (*ibid*).

The Eqlid district is located 200km northwest of Shiraz, which is one of the uppermost regions of the Fars province. This district is one of the most significant parts of Northern Fars consisting of the following plains: Ujan, Khosrow Shirin, Khonjasht, Sedeh and Koshk-e Zard (Sardari *et al*., 2011, p 242). Rahmatabad is located in the Kamin Plain at the southerly end of the Bolaghi valley that is one of the small basins formed by the Zagros suture (Azizi *et al*, 2014, p 1; Bernbeck *et al*, 2005). The Kamin Plain is situated 118 km northeast of Shiraz

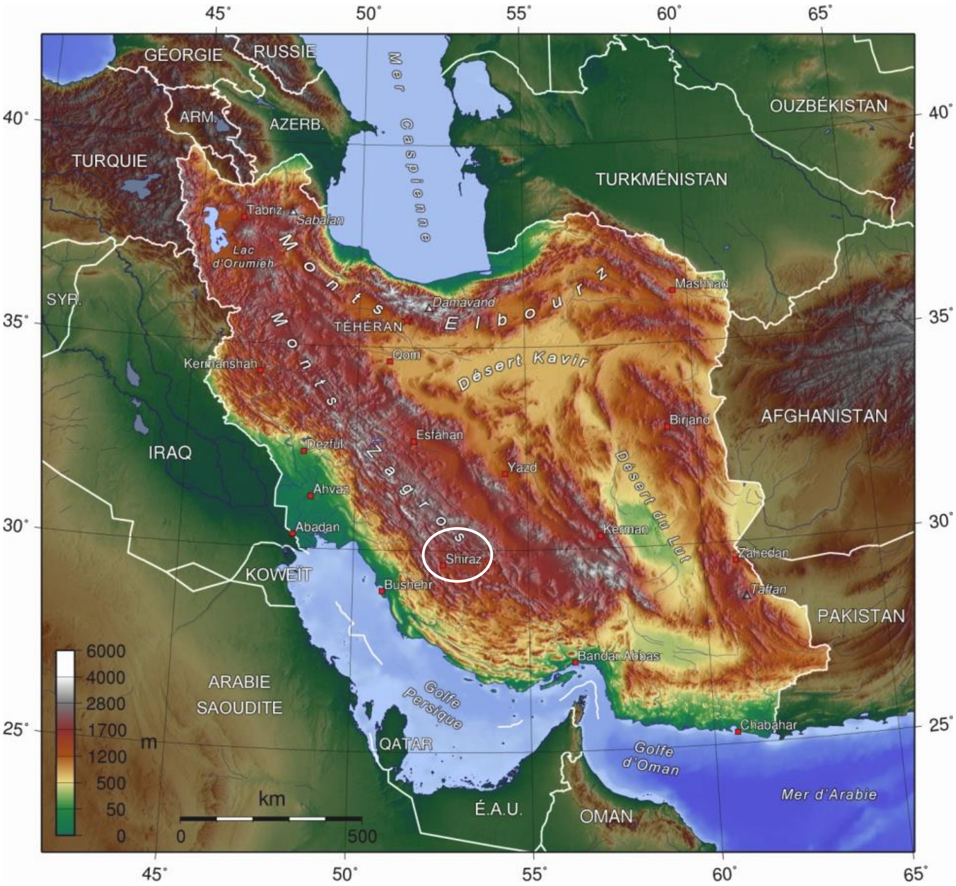


Fig 2.1. Topographic map of Iran showing the capital of Fars province, Shiraz (photo from www.worldofmaps.net) https://www.worldofmaps.net/en/middle-east/maps-of-iran/map-of-iran-topographic-map.htm

Fig 2.2. Map of Iran showing the location of Fars province (photo from www.worldofmaps.net)

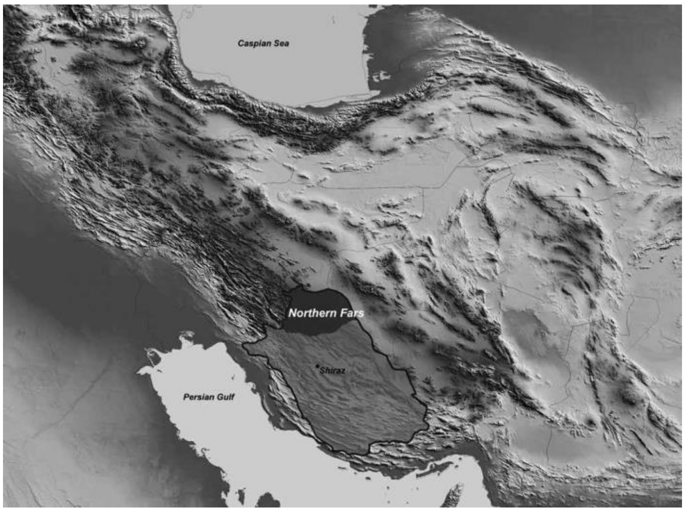


Fig. 2.3. Fars province, the area under study is marked as Northern Fars. (photo from Sardari, 2013, p 191)

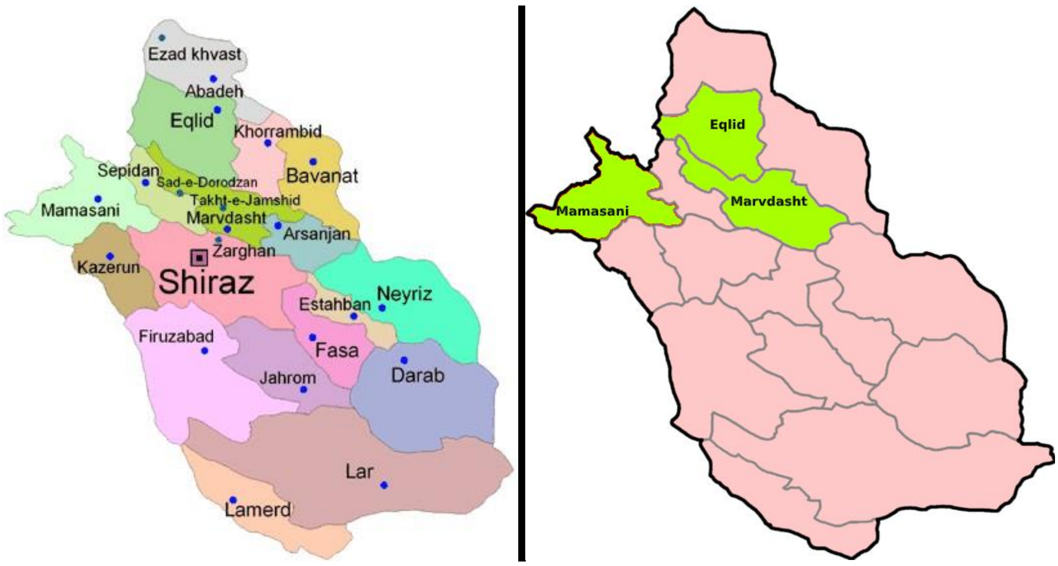


Fig 2.4. Left: Map of Fars province, Right: location of the Mamasani district (Nurabad), the Eqlid district (Mehrali) and the Marvdasht district (Rahmatabad)

(Source: Fars province organization of Industry, mine & Trade) https://en.mimt.gov.ir/general_content/404723-Fars.html?t=General-content

2.1.2 Climate (temperature, precipitation and land use)

Generally, temperature decreases over Iran from the south-east to the north-west. However, due to the spatial deposition of the mountain ranges in Iran the influence of the sea tends to be limited to their immediate neighbourhood, which is important in controlling the temperature of the area. In general, January is recorded as the coldest month of the year in Iran (Ganji, 1968, p 220-230). In Iran different environmental and climatic zones are traditionally classified as ''*garmsir*'' (warm land) for the southern, semi-tropical foothills and lowlands, *'' sardsir''* (cold land) for cool upland valleys and plateaus (Bobek, 1968, p 284) and ''*motadel* '' which is the temperate zone that lies in between and all three zones are reported from the Fars province (Alizadeh, 2006; 30-31). The central plains of Mamasani, including Nurabad lie in the ''*motadel* '' zone (Roustaei *et al*, 2009, p 18) and Mehrali falls within the '' sardsir'' zone (Sardari, 2013, p 191). In Fars province, January is recorded as the coldest month and July as the warmest month of the year. Generally, in Iran precipitation decreases from North to South and from West to East. (Ganji, 1968, p 234). Across the country the total frequencies of the precipitation also decrease from north to south (Alijani and Harman, 1985, p 411). Precipitation is an important factor in agricultural water management especially in dry land farming of Iran (Sadeghi *et al*, 2002). In general, the concentration of rainfall is in the winter months while there is little or no rainfall in the summer (Ganji, 1968; Sadeghi *et al*, 2002; Alijani and Harman, 1985). According to a study on Iran's precipitation climate, the Fars province falls within the normal annual precipitation series (Dinpashoh *et al*., 2004). Due to the geographic location of the Zagros mountain range, a major part of the rain producing air masses enter the region from the west and the north-west, with relatively high precipitation amounts for those areas. The amount of rainfall is reduced towards the south and southeast of the province (Sadeghi *et al*, 2002). The winter precipitation in the north-west area is in the form of snowfall and for other areas, it is mostly in the form of rainfall (Sadeghi *et al*, 2002, p 334). Rain events of the north and the north-west areas are characterised by long durations and low intensities. The mean annual precipitation for the province ranges between 50 and 1000 mm (*ibid*). In the area under study, Nurabad has the highest average annual rainfall, 570-600 mm (Roustaei *et al*, 2009, p 18). Mamasani is also reported as a well-watered area with a high-water table at most times of the year (Roustaei *et al*, 2009, p 21). The water table around the site of Nurabad is reported high which is generally 1-3 meters below the modern ground surface. The Fahlian River is the main river of Mamasani that is up to 1km wide (*ibid*). The Pulvar River in Kamin plain is the closest water source to Rahmatabad and the Balengan River in Sedeh plain to Mehrali (Azizi *et al*, 2014; p,1 Sardari,2013, p198). In addition, there are numerous ephemeral watercourses and natural springs in each plain that are produced by the high annual rainfall. It has been reported that the modern inhabitants of the Mamasani mainly use ephemeral streams that flow from the mountains to irrigate the lower fields (Roustaei *et al*, 2009, p 21).

Overall, the sites are located in fertile plains with sufficient water resources and today, most of their surrounding areas is under cultivation. The area under study is considered as one of the most fertile and strategic regions in the southwestern Zagros (Roustaei *et al*., 2009; Potts *et al*., 2009; Sardari, 2011, 2013; Petrie, 2011). Northern Fars is also reported as a suitable summer pasture for mobile pastoralist groups (Alizadeh, 2006, p 31). In addition, this region provides an essential link to Kur River Basin in the south, central Zagros in the North and lowland of Khuzestan in the west (Sardari, 2011, 2013).

2.1.3 Modern vegetation of Fars

The Zagros forests are semi humid expanding from the north west of Iran to the Fars province. In general, the modern vegetation of Zagros is comprised of *Quercus- Pistacia - Amygdalus* steppe forest or zones and the distribution of these forest types changes based on elevation (Zohary,1973; Bobek, 1968). The most characteristic of these forests are reported as *Quercus brantii, Q. libanii, Q. boissieri* accompanied by elm, maple, celtis, walnut, Syrian pear, pistachio (*P. khinjuk*, *P*. *atlantica*) and several almond trees (Bobek, 1968, p 286). Special moisture-loving associations of poplar, willow, alder, elm are also recorded in the ravines (*ibid*). In Fars, *Quercus brantii* is reported from higher elevations and *Pistacia - Amygdalus* steppe forest from the lower altitude (Zohary,1983, p 582-583). *Pistacia – Amygdalus* scrub is better adapted to drier habitats and can withstand the long summer drought, but oak woodland requires shorter dry period during the summer and more rain in the spring (El- Moslimany, 1986). Examination of the undisturbed part of this oak woodland showed a three-crown cover of *Quercus-Pistacia-Acer* (Van Zeist, 2008). *Quercus brantii* has been reported as the dominant tree of the Zagros oak-woodland, which is well adapted to the summer dryness (*ibid*). The moisture requirements of *Q. boissieri* is higher than *Q. brantii* (Zohary, 1973). In the north-western part of Fars open oak forest occur, however, *Juniperus* and *Acer* also grow in the mountains and hills of this area. In the southern and eastern parts, the *Pistacia–Amygdalus* scrub replaces the oak woodland in many places (Bobek, 1968; Zohary 1973; Djamali *et al*., 2009; Miller, 1982). It has been noted that due to drier and hotter climate conditions and lower spring rainfall, the *Pistacia-Amygdalus* communities in the southern parts of the province are less rich in woody species compared to their counterparts in the north-western and central Zagros (Djamali *et al*., 2009, 125). Fars is reported as the main habitat for *Pistacia atlantica* spreading out in two thirds of the central and northern parts of the province (Nejabat *et al*., 2017). *Salix, Populus, Fraxinus*, *Acer and Celtis* are also reported present at the forested area of the region in higher elevations (Sabeti, 1966; Miller, 1982; Negahdarsaber *et al*., 2017). The lower elevations of the Fars province, around Lake Mahalou is reported covered by ''xeromorphic dwarf-shrub lands'' containing shrubs such as *Cerasus microcarpa, Ficus carica, Rhamnus persica* and dwarf-shrubs such as *Artemisia* spp., *Astragalus fasciculifolius, A. susianus, A. campylanthus, Cousinia* spp., *Capparis spinosa, Convolvulus acanthoclados, C. dorycnium, Ephedra ciliata, Dendrostellera lessertii , Helianthemum lipii,* as well as other herbaceous species (Djamali *et al*., 2009, p 125). Moreover, in the cold and temperate zones ''*sardsir* and *motadel''*, cultivated fruit trees (apple, pomegranate, pear, grapes, fig and olive) and timber trees (willow, poplar and ash) also form part of the landscape. The crops growing in the region include wheat, barley, alfalfa, rice, sugar beet and cotton (Alizadeh, 2006 p,31: Miller, 1982, p 64).

2.1.4 The vegetation history of the Zagros

Palaeoenvironmental studies reconstructing the vegetation and climatic history of this region are based on palynological investigations from the Lakes Zeribar (central Zagros), Mirabad (north western Zagros) and Maharlou (south - eastern Zagros). The location of these lakes is marked in Figs 2.5 and 2.6. The pollen assemblage of Zeribar showed that during the late glacial period the region was cold and dry with semi-desert vegetation of *Artemisia* and shrubs (Van Zeist and Bottema, 1977). However, later in Early Holocene (12000 B.P) the *Pistacia – Quercus* forest steppe gradually expanded and was replaced by

Zagros oak woodland at the end of the Holocene 6200 B.P. (*ibid*). Based on the re-analysis of these pollen diagrams it is suggested that the Zagros climate was very arid between 8000-5800 B.C. during the Holocene, followed by wetter conditions between 4900-3800 B.C. (El-Moslimany, 1987). In general, the Southwest Asia is characterised by a rapid rise in temperature in the Early Holocene. The pollen evidence from the Zagros-Taurus region shows that grasses replaced *Artemisia* and Chenopodiaceae with low percentage of *Quercus* and *Pistacia* (Stevens *et al*., 2001). Overall, it is argued that the Zagros region was drier than other regions of the Near East during this period (*ibid*). However, analysis of plant macrofossil and diatom data from Lake Zeribar indicated higher water table and marshlands in the region during the Early Holocene (Wasylikowa *et al*. 2008). New archaeobotanical evidence from the Early Neolithic sites (11000 -9000 B.P) in the Zagros region also indicated a rich range of ecological zones near these settlements (Rahiel *et al*., 2012; Matthews *et al*., 2013). Moreover, the more recent pollen data from Lake Maharlou in the Fars province provided some new evidence for the vegetation of the south-eastern part of the Zagros during the Late Holocene (Djamali *et al*., 2009). Lake Maharlou is located in a region where the climate is strongly influenced by the aridity of central and southern Iran. The pollen record from this Lake showed that *Quercus brantii* woodland and *Pistacia–Amygdalus* scrub dominated the area during the late Holocene (Djamali *et al*., 2009, p 123). The maximum expansion of the *Quercus brantii* woodland occurred about 2100 B.P. and remained relatively stable until the end of the pollen diagram at 400 B.P. (*ibid*). The results of this study also showed the appearance of several cultivated tree species such as *Juglans, Olea, Vitis* and *Platanus* in Fars at 4300 B.P. It is also suggested that the destruction of the extensive *Pistacia–Amygdalus* scrub of the area around 2700 B.P. could have been due to over-exploitation (*ibid*).

Fig 2.5. Shaded relief map of SW Asia with locations of the Lake Van (1), Lake Urmia (2), Lake Zeribar (3) and Lake Mirabad (4) (photo from Djamali *et al*., 2010, p.814).

Fig 2.6. **A**: Location of Lake Maharlou in Fars Province (photo from Djamali *et al*., 2009, p. 124)

2.2 Archaeological background

Fars has a long history of archaeological research including surveys, excavations, and test pits. The following section provides a brief review of the archaeological investigations undertaken in the region covering the Aceramic, Ceramic Neolithic and Chalcolithic periods.

2.2.1 Fars in the Aceramic Period

Archaeological investigations in Fars indicated the presence of some Palaeolithic and Epi-Palaeolithic occupations. However, the evidence of occupations from the end of the Epi-Palaeolithic period to the appearance of Ceramic Neolithic communities of the region was not clear (e.g. Weeks *et al*. 2006; Weeks, 2013). The recent archaeological investigations in the Marvdasht Plain, however, provided important evidence on this transitional era. The new archaeological excavations at two Caves (TB75 and TB130) in Tang-e Bolaghi shed some light on the cultural sequence of the region from the Epi-Palaeolithic to the Proto-Neolithic period (Tsuneki *et al.*, 2007). Based on the archaeological findings of these caves it has been suggested that they were probably used temporarily by hunter-gather communities for cooking, butchering animals and lithic production (Tsuneki and Zeidi, 2008). The Proto-Neolithic phase of these Caves dating to 10th to 8th millennium B.C. is regarded as a significant period in understanding the Neolithisation of the region (Weeks, 2013). Unlike central Zagros and Khuzestan where several Aceramic Neolithic sites were discovered, this period in Fars is relatively unknown. It is noted that although a few Aceramic sites were reported from the archaeological surveys of the Kur River Basin during 1950s, their existence was never confirmed by later extensive surveys (Sumner, 1977; Weeks *et al*. 2006; Weeks, 2013b). In addition, none of the excavated Ceramic Neolithic sites in the region (investigated during 1950s-1970s) contained Aceramic deposits (Weeks, 2013b). However, the recent excavations at Rahmatabad in the Kamin plain yielded the first evidence for this period providing new insights into the spread of the Neolithic ways of life across the southern Zagros (Bernbeck *at al*., 2005; Azizi *et al*., 2014; Weeks, 2013b). Two seasons of excavations at this site revealed a long cultural sequence containing Aceramic, Ceramic Neolithic, and Chalcolithic phases. The Aceramic deposits at this site were stratified below the Pottery Neolithic levels dated to the Late 8th millennium B.C. (Bernbeck *at al*., 2005; Azizi *et al*., 2014).

2.2.2 Fars in the Ceramic Neolithic Period

Archaeological investigations on the Neolithic period of Fars are divided into two stages: Early and recent fieldwork (e.g. Weeks *et al*., 2006 and references therein). The evidence for Neolithic settlements in Fars was first recorded during the early archaeological projects undertaken in the 1920s. However, the systematic investigations of Neolithic sites in the region started in the early 1950s. In the large-scale regional surveys undertaken in different regions of the Fars province during the 1960s and 1970s, several Neolithic sites were found (Weeks *et al*., 2006, p 3). The first substantial excavations at two key Neolithic sites of the region (Mushki and Jari) provided important material for the relative chronology of Fars (Fukai *et al.*, 1973; Egami, 1967; Egami *et al.,* 1977). Based on stratified ceramic types of these excavations the ceramic Neolithic period of Fars was classified into three chronological phases: Mushki, Jari and Shamsabad, from the earliest to the latest (Weeks *et al*., 2006 ,p 4). According to archaeological surveys in the Kur River Basin (Sumner, 1994) an increase in the number of sites from the earliest to the latest Neolithic phases was recorded. It has been noted that although the results of these early archaeological investigations generated a basic ceramic chronology and provided some information on the developments of local Neolithic settlements, they were characterised by a culture-historical approach (Weeks *et al*., 2006, p 4). Therefore, hypothesis on the subsistence practices was mainly based on site location and archaeological surveys (*ibid*). However, over the last twenty years a series of new archaeological investigations conducted in the region, which significantly contributed to understanding the Neolithic period of Fars. Applying new archaeological techniques, theories and approaches in most of these research projects provided important insights into the cultural developments and subsistence strategies of this period (Weeks *et al*., 2006, p3-4). These projects include regional surveys and re-excavations at two key Neolithic sites of Fars (Mushki and Jari), new excavations at Tol-e Bashi in Ramjerd plain, at Nurabad in the Mamasani Plain and at Rahmatabad in the Kamin Plain (Abdi *et al*., 2003; Alizadeh *et al*., 2004; Alizadeh, 2006; Pollock *et al.*, 2010; Potts *et al.*, 2009; Bernbeck *et al.,* 2003, 2005; Weeks *et al*., 2006, 2009; Azizi *et al*., 2014). In addition, some archaeological material recovered from the old excavations at Mushki and Jari was re-examined (Nishiaki, 2010a; Nishiaki, 2010b; Nishiaki and Mashkour, 2006). Furthermore, the discovery of new Pottery Neolithic sites in regional surveys of the Kur River Basin (Kushk-e Hezar) and the Qara Aghaj valley (Kavar and Hokvan) provided important insights into several technological and social aspects of this period (Alden *et al*., 2004; Bernbeck *et al*., 2006).

The results of these new investigations also provided detailed information on the chronological order of the Mushki, Jari and Shamsabad occupation phases. Overall, based on the new evidence the Mushki phase dated to 6300 B.C. which was followed by the Jari phase dated to 6000 B.C. and the Shamsabad phase dated to 5500 B.C. The end of the Neolithic in Fars is known by the appearance of a distinctive black on buff ceramic called Bakun ware, which is characteristic of the Chalcolithic period of Fars (Weeks *et al*., 2006; Weeks, 2013). It is reported that in contrast to the Kur River Basin where sites usually showed limited phases of occupation, the results of archaeological excavations and surveys in the Mamasani Plain indicated the presence of multi-period mounded sites such as Tol-e Nurabad and Tol-e Spid, attesting occupation over many millennia from the Neolithic period onwards (Weeks *et al.* 2009; Zeidi *et al.* 2009; Weeks, 2013).

The Mushki architectural remains have been described as individual structures made of mudbrick or *chineh* (packed mud). The later ceramic Neolithic sites of Fars appeared to have been permanent or semi-permanent villages with rectilinear multi-roomed houses (Fukai *et al*. 1973; Egami *et al*. 1977; Nishiaki, 2010b; Weeks *et al*. 2006; Pollock *et al*., 2010; Weeks, 2013).

Different scholars have discussed the cultural development and complexity of the Neolithic communities of Fars (Sumner, 1977, 1994; Alizadeh, 2006; Weeks *et al.*, 2006; Pollock *et al.*, 2010; Nishiaki, 2010; Weeks, 2013). Some have suggested a degree of cultural isolation for the Neolithic societies based on the existence of local styles of pottery as well as other archaeological finds (Sumner, 1977; Pollock and Bernbeck 2010). For instance, it has been argued that the Neolithic inhabitants of Bashi had no attachments to their objects as most of the items found at this site were similar and used for sharing within the settlement but not for exchange with other communities (Pollock and Bernbeck 2010). At this site, factors, such as the lack of elaborately painted ceramics and exotic imported objects as well as conducting the village activities in a public area were considered as evidence indicating a society that systematically minimized the importance of material objects (*ibid*). However, it has been suggested that unlike the material remains from Bashi, a diverse range of elaborately decorated ceramics were reported from other Neolithic sites in Fars, particularly in Mamasani district (Weeks, 2013).

In addition, the findings of artefacts, such as obsidian, marine shell, bitumen and copper from sites across the region provided evidence for exchange relations between the Neolithic communities of Fars and other neighbouring regions (Weeks, 2013; Azizi *et al*., 2014). Overall, it has been argued that factors, such as continuous increase in the number of Neolithic settlements, seasonal mobility, herding and hunter/foraging practices, would have increased the possibilities for contact and interactions between communities across the region (Detailed discussion, Weeks *et al*., 2006; Weeks, 2013).

2.2.3 Fars in the Chalcolithic Period

The Early Chalcolithic period of Fars (5th millennium B.C.) is referred to as the Bakun period. Archaeologically this phase is defined by the appearance of a distinctive type of black on buff ceramic. The archaeological evidence for this period comes from several regional surveys and excavations, most notably at Deh Asiab and Do Tulan (Stein, 1936), Tal-e Khar and Tal-e Nokhodi (Goff, 1963, 1964), Tal-e Bakun (Langsdorff and McCown, 1942; Egami and Masuda, 1962; Alizadeh, 2006) and TB19, TB91 (Helwing and Seyedin, 2010). In addition, Bakun occupation levels were also reported from excavations at Nurabad, Rahmatabad, Mehrali and Tol-e Spid (Petrie *et al.*, 2007,2009; Sardari, 2011; Potts *et al.*, 2009; Bernbeck *et al*., 2005). Many Bakun sites were also recorded at archaeological surveys all across Fars (Zeidi *et al.*, 2009; Alizadeh, 2003, 2006: Sumner, 1994; Helwing *et al*., 2010; Sardari, 2011). This phase was followed by the Lapui phase (4th millennium B.C.) defined by the appearance of a specific red ware known as Lapui ware (Sumner, 1990). Our knowledge of the Lapui period comes from a limited number of excavations including Tal-e Kureh (Alden, 2003), Nurabad (Weeks *et al.*, 2009), Tol-e Spid (Petrie *et al.*, 2009) and Mehrali (Sardari, 2011, 2013).

In general, it is argued that Fars witnessed a number of social, economic and technological changes throughout the 5th and 4th millennium B.C. Several aspects of the Bakun period such as chronology, settlement patterns, cultural development and technological changes have been discussed by different scholars of this region (e.g Alizadeh, 2006; Petrie, 2011, 2013; Helwing *et al*., 2010; Weeks *et al*., 2010).

It is important to note that there are different opinions between scholars of this period over a number of issues, such as stratigraphic phases, settlement developments and cultural material. Some researchers put emphasis on local cultural continuity, arguing that this significant transformation in settlement development, craft activities, administrative practices, sealing technology and so on was the result of two millennia of progressive experiences of village based Neolithic societies (Sumner, 1977, 1990; Petrie, 2011, 2013; Weeks *et al.*, 2006, 2010). However, another suggested hypothesis is that nomadic pastoralist groups influenced the cultural complexity and technological transformations of this period (Alizadeh, 2003, 2006).

The mobile pastoralism hypothesis was suggested based on a re-evaluation of the Tal-e Bakun material, archaeological surveys in the Marvdasht Plain as well as ethnographic data from modern Iranian pastoralist groups in the Fars region. Alizadeh (2006, p 91-99) argued that this phase was a period of increasing interregional contact between lowland Susiana and highland Fars as indicated by the similarities in ceramic shapes, painted motifs and compositions, and the appearance of copper and turquoise. Based on the archaeological findings of Tal-e Bakun (e.g. the presence of a number of pottery kilns and a large open area filled in with thick layers of ash and other industrial by-products) this site was reported as a regional manufacture and distribution centre (*ibid*). The site has been also reported as a good example of socioeconomic complexity in Fars during the Bakun phase with most of the characteristics of a prehistoric large urban centre (e.g. administrative technology, craft specialisation, segregated residential and industrial quarters) (Alizadeh, 2006), but in a small site of village size. Several aspects of this model have been debated/criticised, in particular, the form of pastoralism proposed for the Chalcolithic communities (fully-fledged nomadic pastoralists). The ethnographic aspect of this model (similarities with the modern Bakhtiyari and Qashqai tribes) has been also debated (Potts, 2008,2014; Weeks, 2010; Petrie, 2013).

Similar to the Bakun period, there are also different interpretations regarding the settlement trajectories and socio-economic developments of the Lapui period. The regional surveys in the Kur River Basin indicated a progressive decline in the number of Lapui settlements (Sumner, 1988). Based on this pattern (reduction in sedentary population) a shift from agricultural based village life to a more mobile pastoralist way of life was suggested (Sumner, 1986,1988). Alizadeh however, recorded a gradual increase in the number of settlements during this period (Alizadeh, 2003, 2006). In general, it has also been proposed that while Kur River Basin witnessed a significant transformation and reduction in the settlement size and number during the 4th millennium B.C., Northern Fars had a high degree of continuity in settlement population and size (Petrie, 2013; Sardari, 2011, 2013).

The architectural remains dated to the Bakun phase of these sites were reported as multi-roomed, rectilinear structures made of mudbrick or *chineh* with little unequivocal evidence for significant distinction in building size or architectural elaboration (Weeks *et al.*, 2010; Petrie, 2013). The Lapui period architecture is characterised by a mixture of river stone and mudbrick structures with rounded stones used as foundations (Petrie *et al*, 2009; Sardari, 2011,2013). Furthermore, the evidence of interaction with other areas, such as the Kur River Basin, central Plateau and lowland Susiana as well as other longer distances has been reported during the Chalcolithic period (Weeks *et al.*, 2010; Petrie, 2013).

Overall, unlike the Neolithic of this region, the Chalcolithic period of Fars has received less attention. As a result, there are still many unanswered questions regarding cultural developments, subsistence practices, human behaviour and life ways in general (Weeks *et al.*, 2010; Petrie, 2013).

2.3 The sites under study

Archaeobotanical material for the current study were collected from three multi-period sites located in Northern Fars, namely Rahmatabad, Nurabad and Mehrali. The following section introduces the sites under study and presents the available information of the excavated trenches and other archaeological finds.

2.3.1 Rahmatabad excavations

Rahmatabad is located in the Kamin plain at 40 km northeast of Persepolis. The site covers an area of 0.5 ha and rises 5 m above the surrounding plain (Azizi *et al*., 2014, p 1, Figs. 2.7 and 2.8). In 2005, a rescue excavation was conducted at the site as the southern and western parts of the mound was expected to be destroyed by the enlargement of the Esfahan-Shiraz highway (Bernbeck *et al*., 2005, p 95). A joint team from University of Tehran, and University of Binghamton, carried out the first season of excavation. The second season of excavation at the site was carried out in 2009 with the main objective of refining the absolute and relative chronological sequence of the Neolithic and Chalcolithic occupations (Azizi *et al*., 2014, p 1). The archaeobotanical data included in this study were recovered from the first season of excavation. The uppermost part of the mound consisted of substantial layers of reddish eroded mudbrick and a massive wall relatively dated to the Parthian or Sasanian historical periods (Bernbeck, et al., 2005, p 97). The excavation strategy included exploring the southern part of the mound, close to the Esfahan-Shiraz highway, therefore, three 10 × 10 m trenches (A, B and C) were opened (Fig 2.9). In addition, to clarify the stratigraphy of the site, three smaller 2 × 2 m trenches were also opened in the south (D), west (E) and north (F) of the mound (Fig. 2.10). However, later it was decided to excavate another 2 x 2 m test pit in the northern corner of Trench A to explore the depth of Early Neolithic deposits. Trench A contained deep cultural deposits and excavation at this stratigraphy trench revealed some evidence of Ceramic Neolithic and Aceramic occupation. The Aceramic layer of the site containing more than 2.5 m of deposits dated to the Late 8^{th} millennium B.C. (Bernbeck *et al*., 2008) and provided the first evidence of Aceramic occupation in the region (Fig. 2.11,2.12). The other excavated trenches contained rich cultural layers dating to the Chalcolithic period (Bakun phase). It is important to note that the relative chronology of this period was based on initial observation of the Bakun ceramic remains (Fig.2.13). The Chalcolithic occupation of Rahmatabad was divided into two residential and industrial phases. The oldest phase was reported as a densely settled village with multi-roomed houses, courtyard and alleys and the second phase was reported as a pottery production workshop, containing complex ceramic kilns, slags, and huge amounts of pottery remains (Bernbeck *et al*., 2005, p 97).It has been suggested that during the second phase the area might have not been used for residential purposes (*ibid*). The fire installation found in the industrial area was reported with different shape and structure to those identified in the domestic area. Large amounts of ashy deposits indicating fires of very high temperature as well as a large number of well-preserved pottery vessels were found in this area (Figs 2.14-2.15). The residential phase of this site has been described as a densely built up village consisted of large sized buildings and some of the discovered rooms contained complex ovens (Fig.2.16). The buildings were frequently modified and the use of internal space and access patterns changed over time. Different materials, such as mudbrick, mud plasters and wood, were used in building constructions of this phase. For example, it has been reported that houses in the Rahmatabad village might have had flat roofs made of stem and twigs covered with a thick layer of mud indicated by the evidence of broken T-shape clay pieces that were originally the top layer of roof (Fig. 2.17) (Bernbeck *et al*, 2005b). A distinct use of space for different purposes was observed in the residential phase of Rahmatabad. For instance, the courtyards of the domestic area contained substantial amount of debris, such as tokens, lithic, tools and ceramic remains, indicating the use of these spaces for rubbish disposal. It has been also suggested that the alleys were used as workspaces for processing of materials as indicated by the remains of stone features used as working platforms. The remains of a human burial was also found in this phase, however, the preservation of the skeleton was very poor (Bernbeck *et al*,. 2005a and 2005b).

Fig 2.7. Location of Rahmatabad in the Kamin Plain (Photo from Azizi *et al*., 2014, p.2)

Fig 2.8. Aerial photo of Rahmatabad (photo from Bernbeck *et al*., 2005a, p.94)

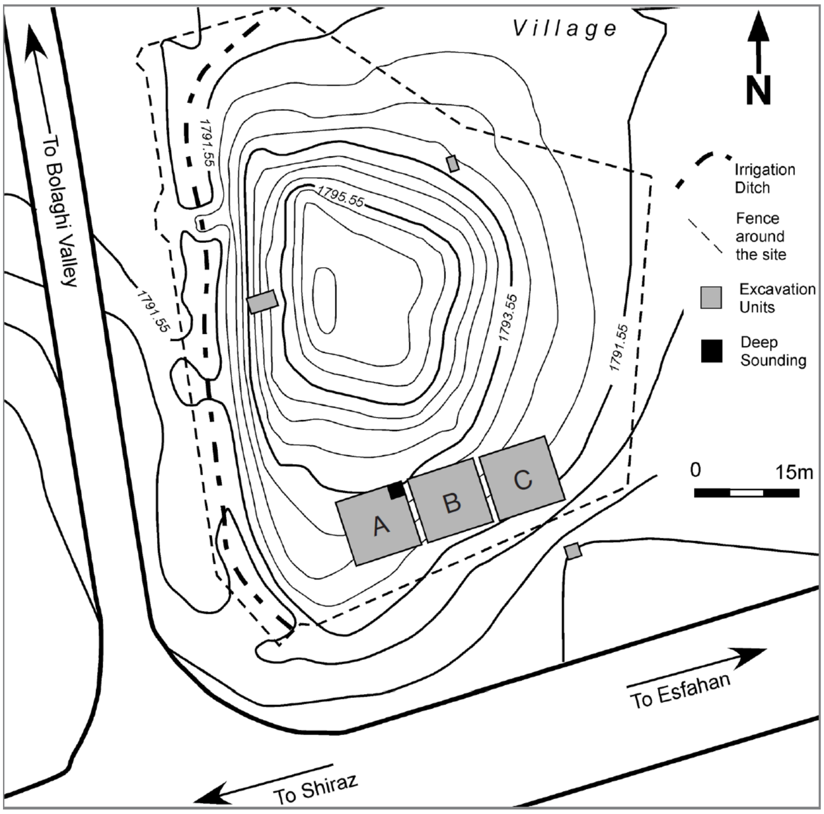


Fig 2.9. Topographic plan of Rahmatabad showing the location of trenches (photo from Bernbeck, *et al.*, 2008, p.38)

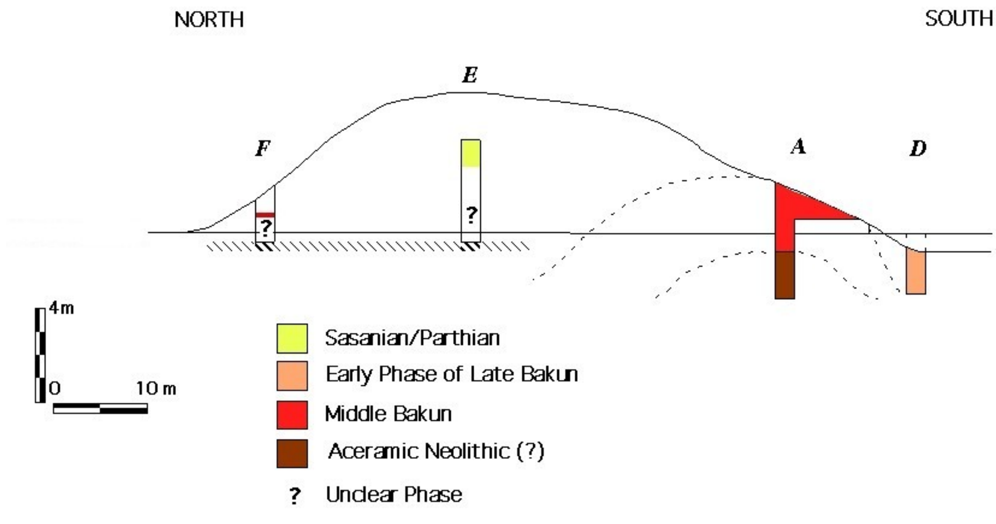


Fig 2.10. Schematic Section through Rahmatabad with Trenches (photo from Bernbeck, *et al.*, 2005b, p.28)

Lab number	Provenience	Material	Lab date bp	Calibrated date BC (2 sigma range)[1]
KIA33174	Unit A Loc 53, Level A IV	charcoal	7945 +/-	7040-6690
KIA33173	Unit A Loc 61, Level A VI	charcoal	8023 +/- 45	7080-6770
UZ 5331/ETH 31882[2]	Unit A Loc 62, Level A VII	charcoal	7925 +/- 75	7050-6640

Fig 2.11. Radiocarbon dates from the deep sounding in Trench A, Rahmatabad (photo from Bernbeck, *et al*., 2008, p.38) * Locus A53: The context from which this sample came dates archaeologically to the Chalcolithic period.

Fig 2.12. Stratigraphic trench A at Rahmatabad (photo from Bernbeck, *et al*., 2005b, p. 3)

Fig 2.13. Bakun Pottery samples from Rahmatabad (photo from Bernbeck, *et al*., 2005a, p 101)

Fig 2.14. A pottery kiln in the industrial phase of Rahmatabad (photo from Bernbeck, *et al*., 2005a, p.98)

Fig 2.15. Ceramic remains in the industrial phase of Rahmatabad (photo from Bernbeck, *et al*., 2005b, p.3)

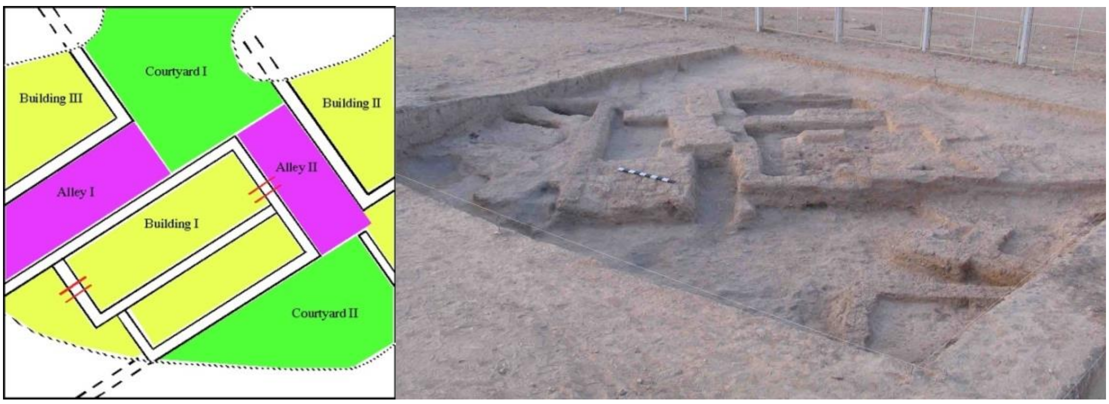


Fig 2.16. Overview of Architecture in the residential phase of Rahmatabad and the schematic plan of buildings (photo from Bernbeck, *et al*., 2005b, p.17)

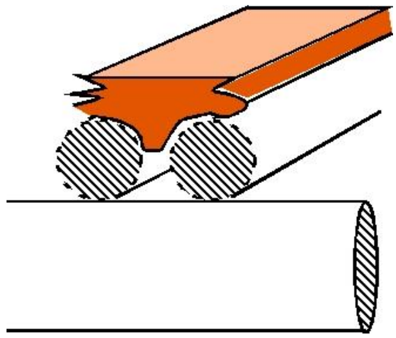


Fig 2.17. Drawing of the T-Shaped Pieces of roof construction (photo from Bernbeck, *et al*., 2005b, p. 22)

2.3.2 Nurabad Excavations

Nurabad mound has a height of 23 m and is located in the Mamasani Plain covering an area of 9 ha (Weeks *et al.* 2006, p 6, Figs 2.18 and 2.19). The site was first excavated in 2003 (trenches A and B) and 2008 - 2009 (Trenches C and D) as part of the Mamasani archaeological project by the Iranian Centre for Archaeological Research (ICAR) and the University of Sydney (Weeks *et al.* 2006, 2009; Potts *et al*., 2009). A smaller mound is located a few hundred metres to the north-west of the main mound separated from it by a small permanent stream. The main mound has been substantially disturbed by earth-moving activities (Weeks *et al*., 2006, p 6). In order to achieve a deep stratigraphic section showing a long sequence of occupation, two trenches A and B were opened in a stepwise fashion. The total depth of trench A was approximately 15 m. During 2008 and 2009 two 5x5m trenches, trench D containing mainly Neolithic and trench C containing Chalcolithic deposits were also excavated (Figs. 2.20 and 2.21). Archaeobotanical material included in this study were collected from these two trenches. The occupation phases were defined according to the evidence of stratigraphy and examination of changes in material culture, such as ceramics. Overall, the excavation revealed a long sequence of occupation from ceramic Neolithic, followed by Chalcolithic material from the Bakun period (5th millennium) and later cultural phases (Fig. 2.22). Radiocarbon dates from the Neolithic deposits indicated that these Neolithic phases were deposited over the course of some generations in the first half of the 6th millennium B.C. (Fig. 2.23). The Neolithic occupation showed a protracted sequence with Neolithic deposits containing 10 distinct phases. The lowest 5 m of the Neolithic deposits provided evidence of the initial occupation at Nurabad attested during the Mushki period, characterised by an ashy fireplace and its overlying fill. In contrast to the earliest occupation phase, the majority of Neolithic occupation consisted of substantial amounts of mudbrick and *chineh* rectilinear buildings with plaster coating that were preserved up to one meter in some instances (Weeks *et al.*, 2006, 2009). Various archaeological material including ceramics, animal bones, charred botanical remains, chipped stone, beads and labrets were recovered from the Neolithic phase of this site. The Chalcolithic phase of Nurabad falls into the second quarter of the 5th millennium B.C. In general, architectural remains of the Chalcolithic phase of the site demonstrated broad similarities with the Neolithic period. Overall, excavations at Nurabad contributed significantly to understanding of the timing and nature of the living space, continuity in occupation and social developments of the region during the Neolithic and Chalcolithic periods (Weeks *et al.*, 2006, 2009).

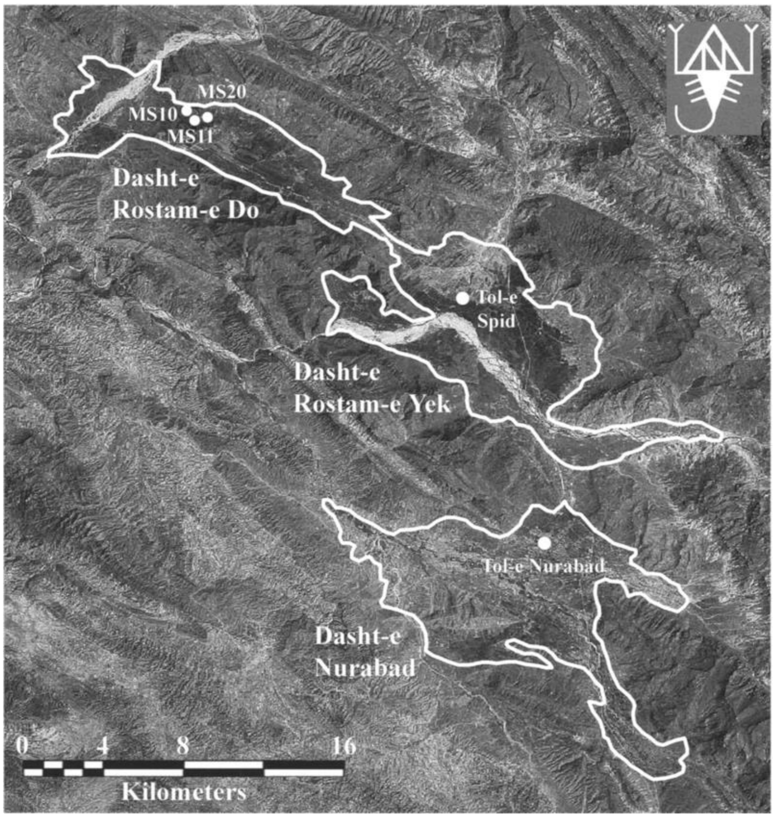


Fig 2.18. Satellite image of the Mamasani Archaeological location of the excavated sites and Nurabad (photo from Weeks *et al*., 2006, p. 5)

Fig. 2.19. View of Nurabad Mound (photo from Mamasani Archaeological Project website)

https://www.arch.cam.ac.uk/research/projects/archived-projects/mamasani-archaeological-project

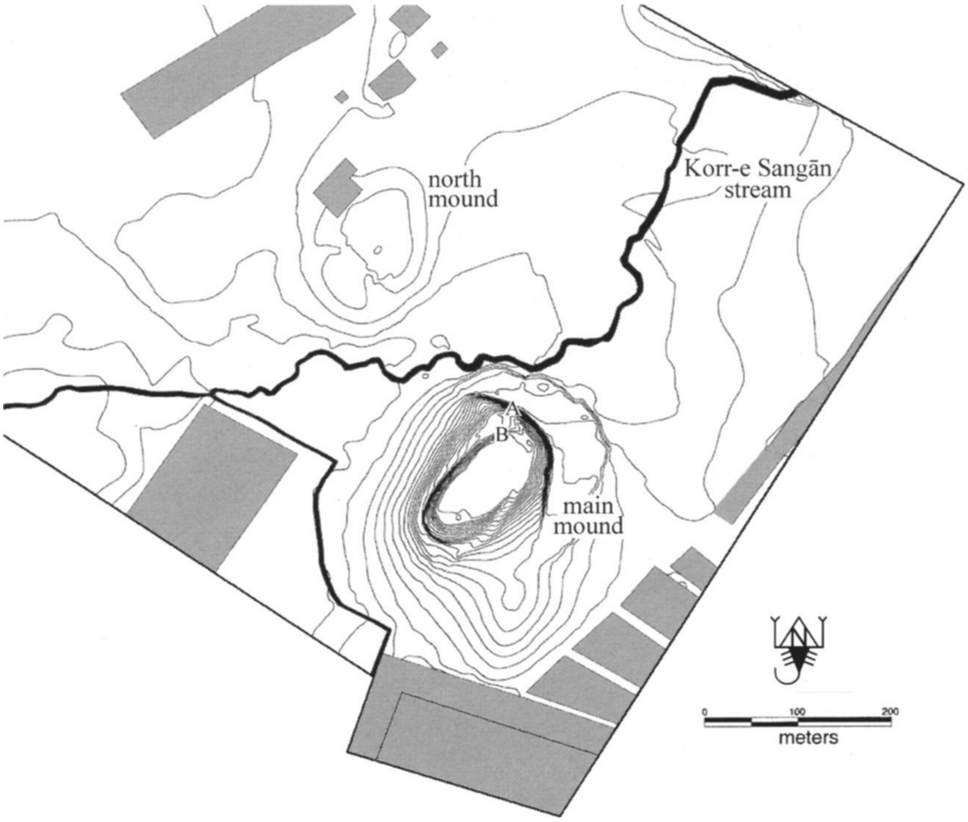


Fig. 2.20. Topographic plan of Nurabad showing the location of trenches A and B (photo from Weeks *et al*., 2006, p. 6)

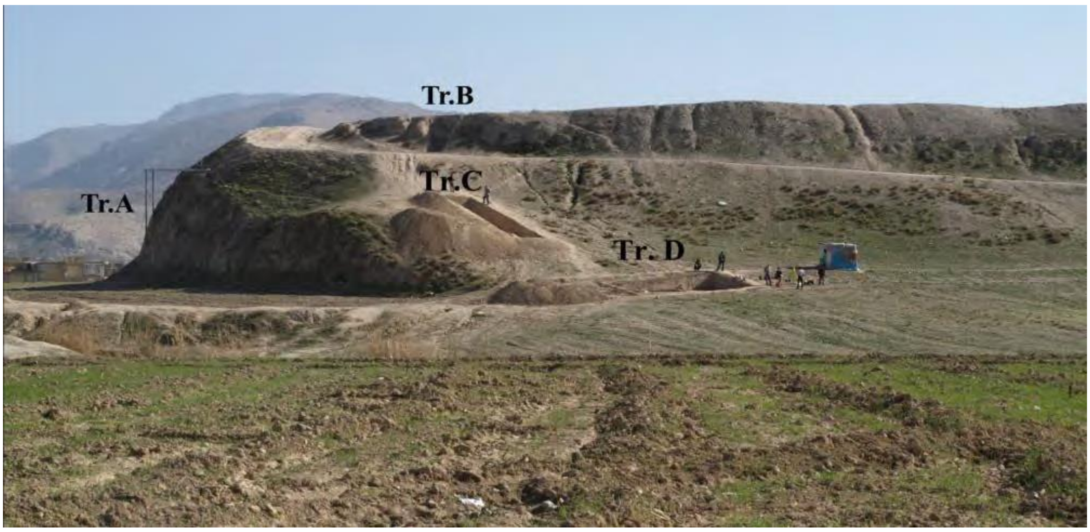


Fig. 2.21. Location of the excavated Trenches (A, B, C and D) at Nurabad (photo from Sardari, 2011, PhD dissertation, p.128)

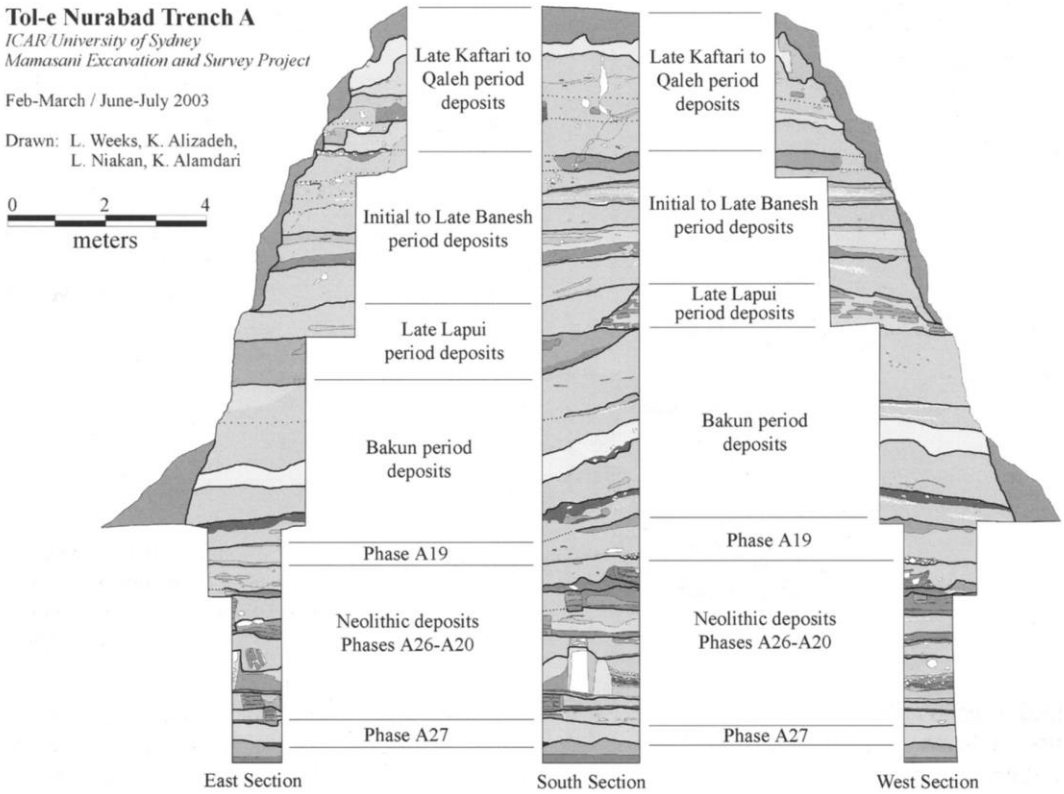


Fig. 2.22. Occupational phases of trench A, Nurabad (photo from Weeks *et al*., 2006, p. 7)

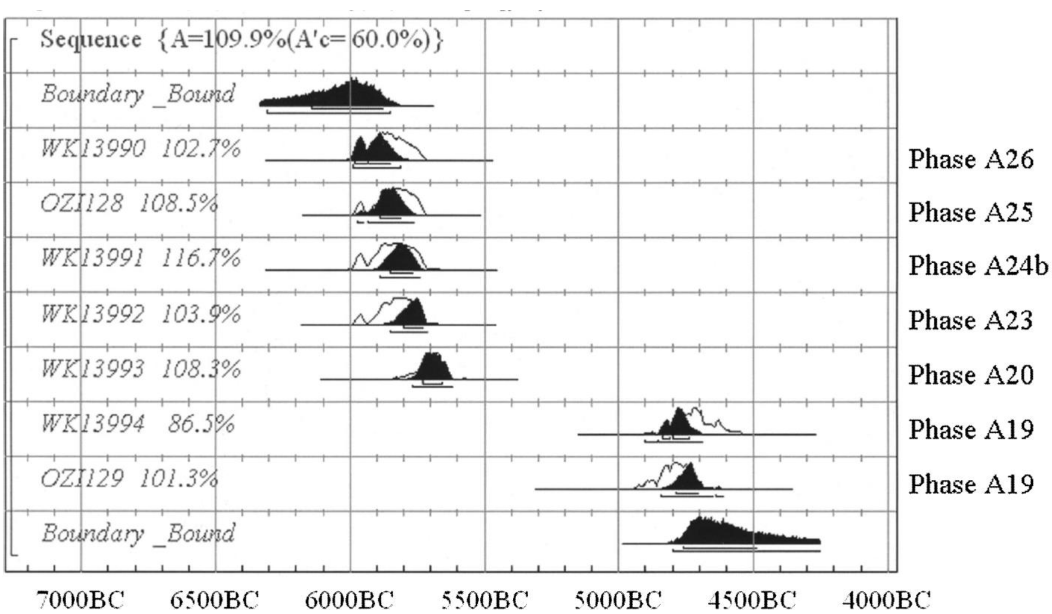


Fig. 2.23. Radiocarbon dates from Neolithic phases at Nurabad (photo from Weeks *et al*, 2006, p.17)

2.3.3 Mehrali Excavations

The Mehrali mound has a height of 12 m and is located in the Sedeh Plain covering an area of 1.2 ha (Sardari, 2013, p 192) (Fig. 2.24). The site was discovered during the preliminary survey of the Eqlid plain in 2005 (Sardari and Rezaei, 2007). Two seasons of rescue excavations were carried out at Mehrali during 2006 and 2008/2009, as the site was to be submerged by the Molla Sadra Dam reservoir (Sardari, 2011, 2013). Archaeobotanical data included in this study were collected from both seasons of excavations. In order to record the stratigraphic sequence of the site two stratigraphic trenches were opened on the highest level and another step trench with six steps on the eastern side of the mound (Fig. 2.25). In addition, six (5 x 5 m) trenches were opened in the central, eastern and western parts of the mound to explore the architectural remains of Bakun and Lapui phases. Excavation at the stratigraphic trenches revealed that the site was occupied during the Bakun period (5th millennium B.C.) and continued to be occupied until the end of the Lapui period (Late 4th millennium B.C.) (Sardari, 2013, p 192, Figs. 2.26-2.28). Excavation at Mehrali provided important insights into the Lapui occupation of Fars that was previously unknown. The architectural remains of the Bakun and Lapui phases showed some similarities in orientation and structure (Sardari, 2013, p 195). In the central part of the mound a ''complex structure' 'was found comprising of several units in different size. The buildings were made of rectangular rooms and some buildings with mud-brick walls were found decorated with brown and green colours. The architectural remains dated to the Lapui phase were built on river stone foundations and it was observed that the floors had been reconstructed several times (Figs. 2.29 and 2.31). The presence of fire installation in the buildings was observed and a big storage jar was also found inside the rooms (Fig 2.32). Two large fire installations found were described as '' complex ovens''. It is noted that these two-storey ovens had a firing chamber that separated the fuel from the material to be heated. It has been suggested that these ovens might have been used for cooking and crop processing (Fig. 2.33). Due to the presence of animal bone remains near these features, it is suggested that they could have been also used for smoking/preparing meat (Sardari, 2013, p 195). Other archaeological material found at Mehrali excavations included chipped stones, pottery slag, spindle whorls and grinding stones. One of the significant findings of the Lapui phase was stamp seals and sealings decorated with geometric designs (Fig. 2.34). The sealings were typical of portable containers or jars that were presumably meant to safeguard content of containers (Sardari, 2013, p 198-199). The evidence for administrative technology at Mehrali indicated local exchange and regional trade between communities in the region. Overall, the archaeological investigations at this site showed several similarities throughout its sequence in terms of cultural material, management mechanisms, and construction techniques, indicating a degree of continuity in the socioeconomic system from the earlier to the later Chalcolithic period (Sardari, 2011, 2013; Sardari *et al*., 2011).

Fig. 2.24. Mound Mehrali, north view (photo from Sardari, 2013, p.194)

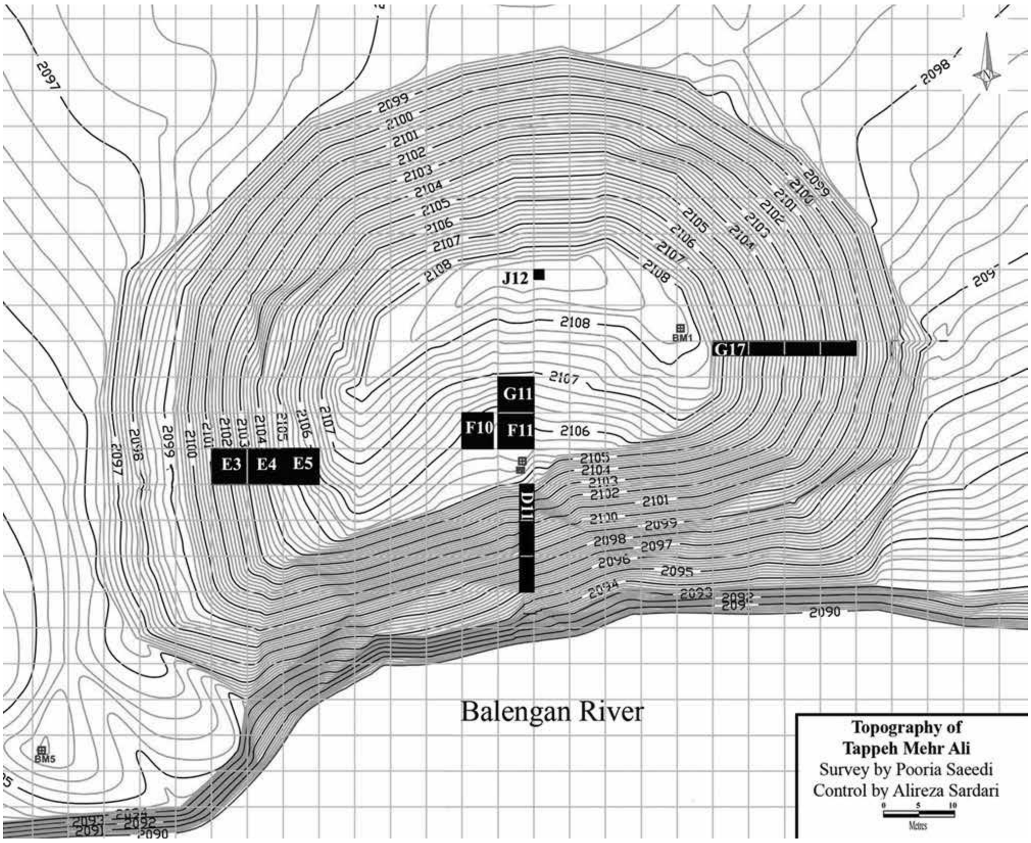
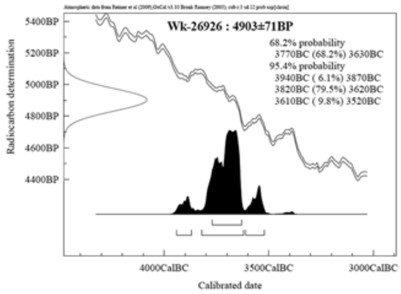
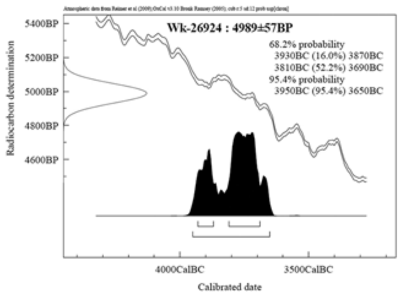


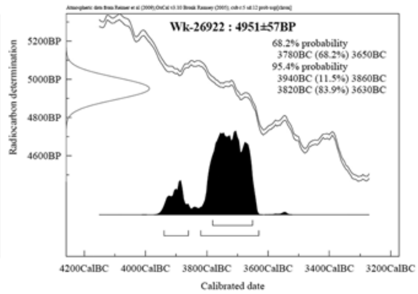
Fig. 2.25. Topographic plan of Mehrali showing location of the trenches (photo from Sardari, 2013, p. 193)



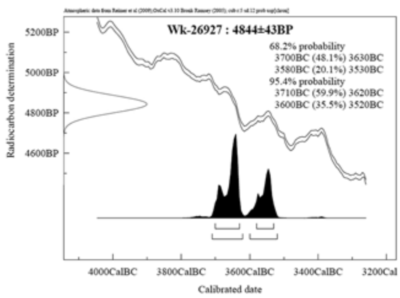
Tr. J12 / Phase 8 / Loc. 42



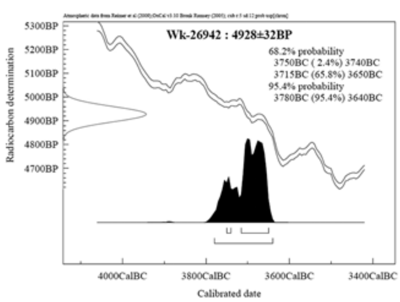
Tr. J12 / Phase 7 / Loc. 34



Tr. J12 / Phase 5 / Loc. 25



Tr. F11 / Phase 2 / Loc. 32



Tr. D11 / Phase 3 / Loc. 14

Fig. 2.26. Radiocarbon dates from Mehrali (photo from Sardari, 2013, p. 197)

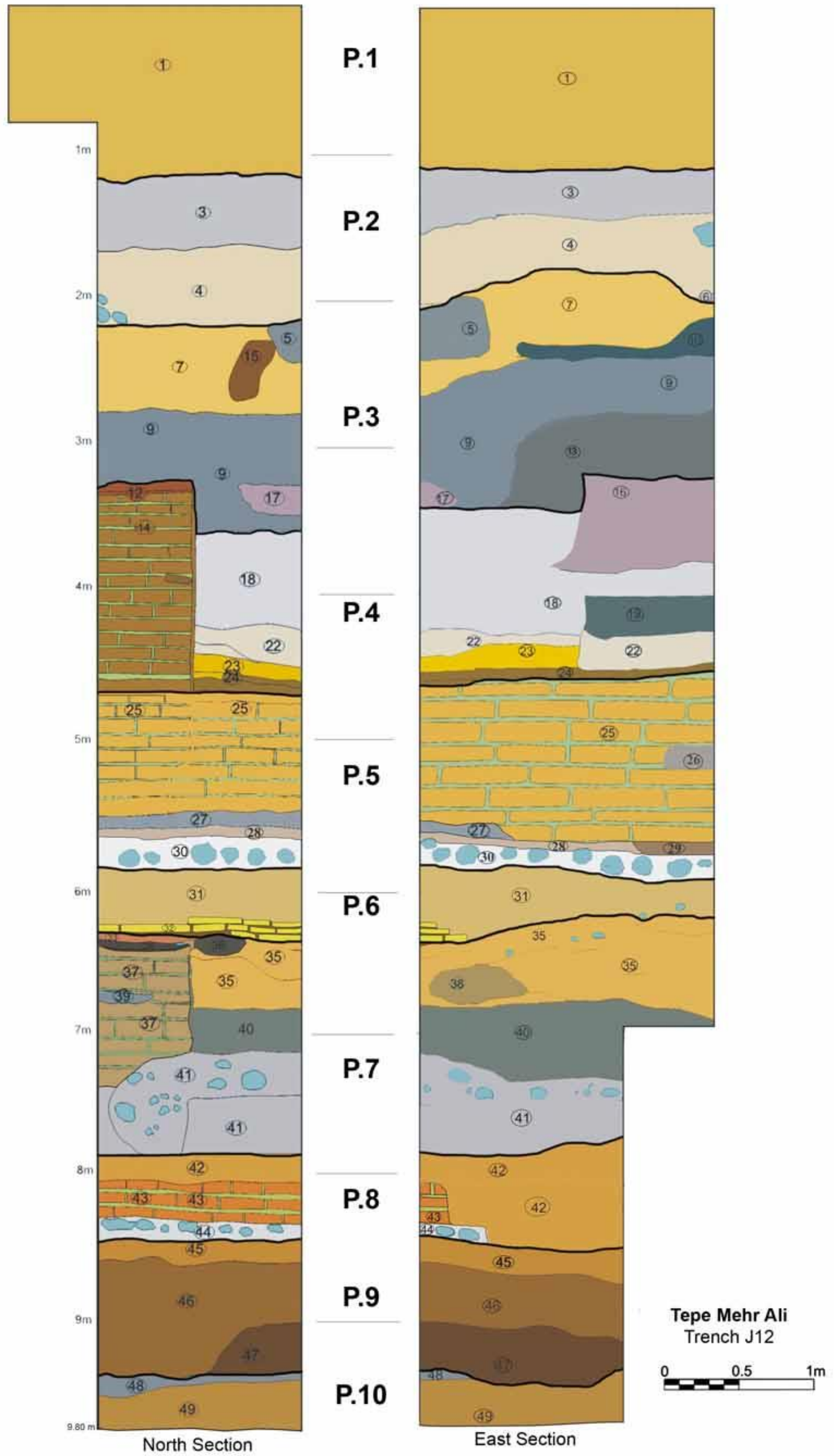


Fig. 2.27. Stratigraphic Trench J12 at Mehrali, P: phase (photo from Sardari *et al*., 2011, p.246)

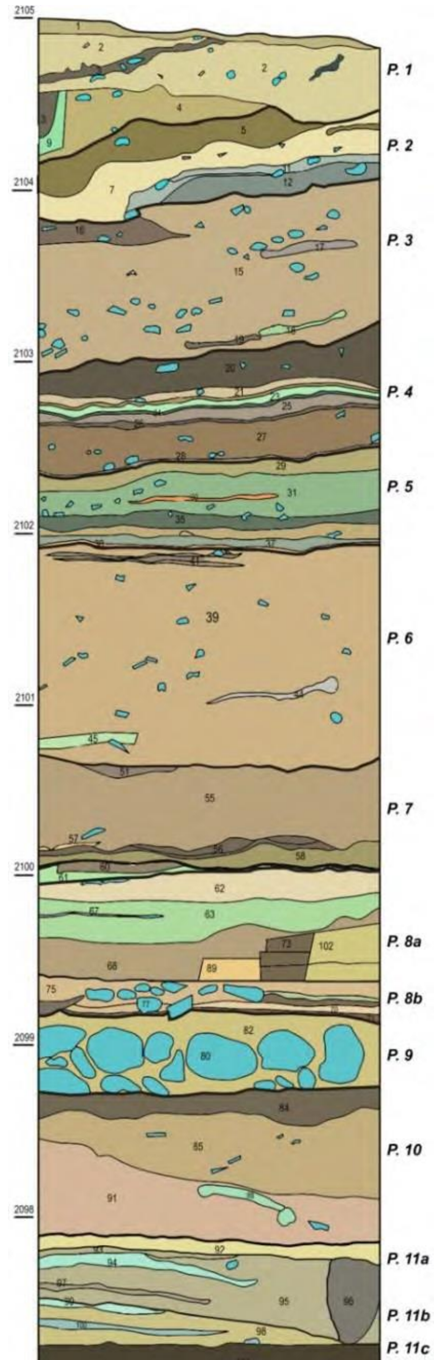


Fig 2.28. Stratigraphic trench D11 at Mehrali (photo from Sardari, 2011 *et al*., p.248)

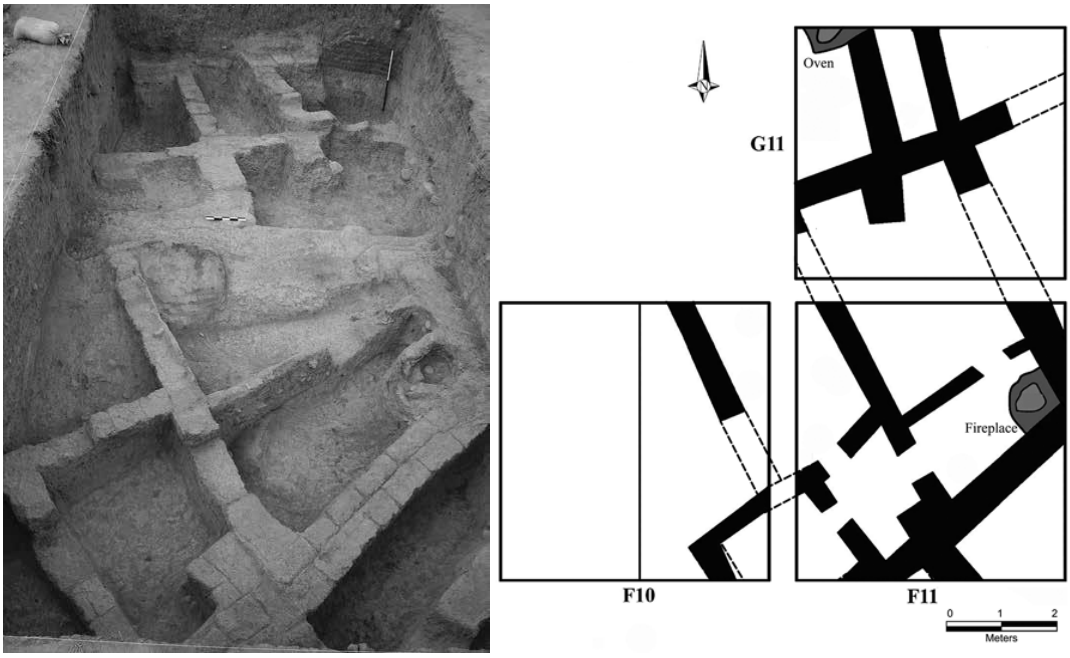


Fig 2.29. left: Central trenches of Mehrali, right: plans of architectural remains of the Lapui occupational phase (photo from Sardari, 2013, p.197)

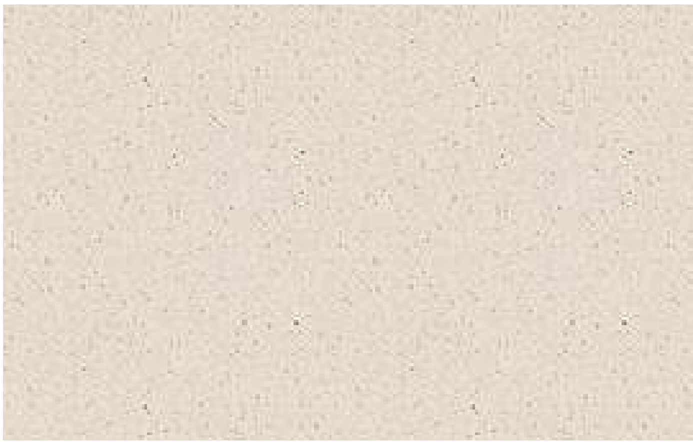


Fig 2.30. Isometric plan of the Lapui architecture at Mehrali (photo from Sardari, 2011, p.286)

Fig 2.31. River stone foundation of the Lapui phase at Mehrali (photo from Sardari, 2011, p.221)

Fig 2.32. A storage ceramic jar in the Lapui buildings of Mehrali (photo from Sardari, 2011, p.221)

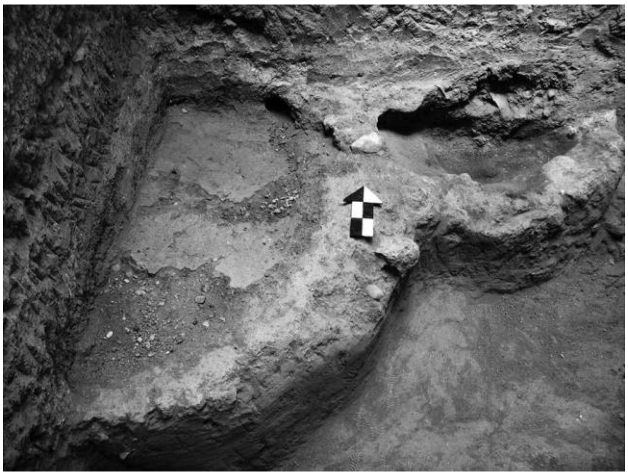


Fig 2.33. Two- storey oven in the trench J12 of Mehrali (photo: Sardari, 2013, p. 198)

Fig 2.34. Sealings from Mehrali (photo: Sardari, 2013, p. 199)

Chapter 3

Methodology

This chapter lays out the recovery and laboratory methods used in the study of archaeobotanical material from the sites under study. The field methods including sampling strategies, the quantity, preservation and overall quality of each assemblage is further discussed in Chapter 4 as part of the taphonomy assessment. Detailed descriptions of sampled contexts/features at each site are available in Chapters 6, 7 and 8. The first part of this chapter presents the recovery methods employed to extract macrobotanical remains at the sites under study. The second section reviews the laboratory methods for selection, assessment and identification of macrobotanical remains (seed and charcoal).

3.1 Recovery of plant material

The sampling strategy was based on the judgement of the excavators, who collected samples from a variety of features and stratigraphic levels that had good potential for the recovery of organic material. Processing of the samples from all three sites was carried out in the field by water flotation tank. In Rahmatabad and Mehrali excavations, the recovery of the samples was done by project staff and in Nurabad by the author. Two screens were used: a 1mm interior mesh to collect heavy residues and a minimum mesh size (250µ) to capture the light floatable fraction. Both heavy residues and light fraction were air-dried under shade. The volume of each deposits was recorded on site in order to calculate the density of plant remains. The heavy residues from all sites were sieved into 4mm, 2mm and 1 mm fractions and labelled accordingly. Except for Nurabad, the heavy residues were fully sorted for the recovery of artefacts, animal bones and charred plant materials.

3.2 Laboratory processing (seeds)

3.2.1 Assessment and sorting

All flots (light fractions) collected from each site were dry-sieved in Endecott brass sieves into fractions of 1mm and 0.25mm and assessed in the lab in order to determine their richness by observing the content of each sample. The flots were sorted under a stereoscopic microscope with magnifications ranging from x7 to x45 for plant macrofossils. The fractions were also measured by weight (g) and volume (ml). Due to the small amount of plant material recovered from all three sites, coarse flots, fine flots and heavy residues (when available) for each sample were fully sorted to obtain the maximum information. Identifiable plant remains, both whole and fragmented were extracted from the coarse and fine flots, including seeds, grain cereal chaff, fruits and nutshells. The specimens were transferred into labelled tubes in context order.

3.2.2 Identification and Quantification: Crops, weeds and wild plants

The processing of the charred specimens (excluding wood) took place at the Archaeobotany Laboratory of the University of Nottingham. Botanical identification of the material to family, genus or species level was carried out with the help of comparisons with modern reference collections (University of Nottingham, UK and University of Tehran, Iran). Photographs, drawings and descriptions of plant taxa from various manuals and publications (e.g. Jacomet, 2006; Nesbitt, 2006; van Zeist *et al*., 1984; van Zeist and Bakker-Heeres, 1982-1984-1985; Zohary and Hopf, 2000) were also used to aid identification. The full list of references and photos of charred specimens are provided in Chapter 5, where the identification criteria for wild and woody taxa, ethnobotanical and ecological information are presented. To explore the potential routes of entry in the assemblages of the identified wild plant taxa, these were also classified according to flowering/fruiting period in relation to regional harvest time. The palatability of identified wild plants and their likelihood of surviving in animal digestion based on size, hardiness and overall state of preservation were also considered. In addition, due to the exceptional preservation of some nutshell remains (*Amygdalus* and *Pistacia*) found in Mehrali, an attempt was made to identify them further through morphological comparisons with species growing in the region. Chapter 8 provides detailed information on the identification of nuts along with measurements and photos of the specimens. Moreover, a general morphological description of the identified crop remains (cereals and pulses) from each site is available in the results chapters (Chapters 6, 7 and 8). In regards to quantification, as counting all grains and chaff fragments could be misleading in quantifying data, it has been suggested that the characteristic part of the seeds for each species should be selected as the quantifiable item (Jones, 1991; Van der Veen, 1992). Therefore, the 'minimum number of individuals' (MNI) principle was used for the quantification of identifiable charred plant remains here: embryo ends of cereal grains, glume bases of glume wheats, and the upper part of rachis were counted. For the final count of glume bases, two glume bases were considered as one spikelet fork. Wild taxa and pulses were quantified based on the embryo ends or assigned diagnostic part of seeds. The analysed samples from each site were tabulated in Excel. The density of charred plant remains (excluding wood), expressed as numbers of items per litre of floated sediment, was calculated and the comparison of density of plant remains by period for each site was presented in separate tables (see Chapters 4-8). In addition to absolute counts, percentage presence or ubiquity for each taxon (the number of samples in which a taxon occurs) was also calculated.

3.3 Laboratory processing (charcoal)

3.3.1 Recovery and Assessment

All analysed charcoal fragments come from flotation samples as hand-picked fragments from all three sites were collected only for radiocarbon dating. Although most of the flotation samples contained wood charcoal fragments in variable quantities, it was not possible to examine the entire charcoal assemblage due to time constraints. Therefore, the identification of wood charcoal remains was based on a limited number of samples from each site. In total, eight flotation samples from Rahmatabad, seven samples from Mehrali and eleven samples from Nurabad were targeted for analysis. The selection of samples for this study was based on consideration of their archaeological contexts. The examined charcoal samples cover the Aceramic, Neolithic and Chalcolithic deposits of the sites under study. In order to make charcoal analysis possible a suitable subsampling strategy was applied. Subsampling involved making a decision on the number and size range of fragments to be examined to obtain a representative picture of sample composition. Using the saturation curve is a common method to determine at which point the optimal representation of the taxa is obtained. Based on this method, the number of identified taxa raises sharply after the examination of the first few charcoal specimens, however after identification of more fragments it gradually settles down. The suggested minimum number of fragments per level is between 100 to 250 fragments and could extend up to 500 fragments depending on the diversity observed within the charcoal assemblage (Smart and Hoffman, 1988; Chabal *et al*., 1999; Keepax, 1988; Asouti and Austin, 2005). For the current study, given the low taxonomic diversity observed, a subsample of 50 fragments (4mm and 2 mm fractions) of the dry-sieved flots was examined. It has been noted that there is a marked reduction in positive type identification with the reduction in size of charcoal fragments (Keepax 1988). For this study, the decision to include 2mm fractions was due to the lack of enough 4mm fractions in some examined samples. It is important to note that samples containing less than 50 fragments were examined in their entirety. In order to observe any correlation between analysis by fragment count and weight all examined >4mm and >2mm charcoal fragments were also weighed. The same principle applied to all charcoal samples from all the three sites under study.

3.3.2 Identification and quantification: Wood charcoal

The identification took place at the Archaeobotany Laboratory of the department of Archaeology Classics and Egyptology, University of Liverpool, under the supervision of Dr E. Asouti. Anatomical identification of charcoal was carried out with a reflected light microscope equipped with bright field and dark field settings at magnifications of x50, x100, x200 and x500. Samples were pressure-fractured by hand or with a backed carbon-steel razor blade depending on the size of each fragment. This was done in order to get a fresh surface of all three anatomical planes (transverse, radial longitudinal and tangential). Identifications were made by comparison to wood anatomical descriptions and microphotographs available in wood anatomy atlases of European and Eastern Mediterranean arboreal floras (Fahn *et al*., 1986; Schweingruber, 1978, 1990; Hather, 2000; Akkemik and Yaman, 2012). Unidentified fragments were recorded as ‘indeterminate’ as their botanical identification was not possible due to their small size and/or the presence of mineral precipitates. Indeterminate fragments were excluded from the sums of each sample in order to give a clear picture of the fluctuation in the abundance of individual taxa and to allow drawing comparisons between different settlement phases. Percentage fragment counts were calculated based on the number of identified specimens for each sample. The abundance of individual taxa within each sample and their presence across the assemblage was also measured. To investigate the taphonomic characteristics of the assemblages (following Asouti, 2003), the fragmentation/preservation index (ratio of unidentified to identified fragments) and charcoal density (the total weight of charcoal material per litre of floated sediment) were also calculated for each sample.

Chapter 4

Taphonomy assessment

The aim of this chapter is to discuss the formation processes that shaped the archaeobotanical assemblages under study. In general, the sequence of these processes includes a series of cultural, natural and methodological factors affecting the composition and preservation of archaeobotanical material. As a result, a detailed understanding of the nature of these processes acting as filters on different stages (pre-depositional, depositional and post-depositional) is crucial for the accurate interpretation of data (see e.g. Clarke, 1973; Dennell, 1976; Schiffer, 1987; Willerding, 1991; Jacomet and Kreuz, 1999; Van der Veen, 2007; Livarda 2019). The cultural factors affecting the assemblages under study are discussed in chapters 6, 7 and 8, according to the results they generated. The focus of this chapter is to assess the impact of charring, methodological and post-depositional processes on the quantity, preservation and overall quality of each assemblage and consequently discuss possible explanations of potential differences.

4.1 Sampling and recovery of data

As the sites under study are multi-period mound sites (tell sites), their sampling strategy aimed to create a large dataset covering a wide variety of deposits from different occupation levels in each site. However, the size of archaeobotanical assemblage recovered from each occupation phase was different. This was partly due to the larger scale of excavations in the Chalcolithic layers of Rahmatabad and Mehrali providing more samples from this phase. Excavation of early phases, like Aceramic and Neolithic (particularly in Rahmatabad), was limited to a small stratigraphic trench. There were also some variations in the quantity (volume) and the number of collected soil samples from each site, conditioned by decisions taken by the respective excavators and directors. For example, at Nurabad and Mehrali the targeted volume of samples for flotation was at least 30 litres from each excavated unit, whereas In Rahmatabad smaller amounts of soil were collected for processing due to time and logistical constrains. Table 4.1 lists the total number of flotation samples, total volume of processed soil, total volume of samples containing archaeobotanical material and the number of excavation seasons at each site. As indicated in Table 4.1, archaeobotanical material for this study were collected from two seasons of excavations at Nurabad and Mehrali, covering a wider variety of excavated units as well as a larger quantity of processed sediment. In contrast, the Rahmatabad material comes from only the first season of excavation.

	Rahmatabad	**Nurabad**	**Mehrali**
Total volume of processed soil	850	2291	2145
Total volume of soil containing charred plant remains	148	1771	1557
Number of excavation seasons	1	2	2
Total number of collected samples	98	63	66

Table 4.1. The list of flotation samples collected from all three sites

In terms of recovery, however, the same method (flotation) was employed in all three sites and a mesh size of 0.25mm was used to capture the light floatable fraction. This ensured that even small sized archaeobotanical remains were recovered. It must be mentioned that there were variations in the composition and texture of sediments taken from different archaeological contexts. The soil samples taken from disposal pits and fire installations was loose/ashy and easily floated. In contrast, some of the room fill deposits took longer processing time due to relatively compact texture of the soil. According to experimental data, longer processing time could increase the fragmentation, damage or loss of material, especially in the case of more fragile plant taxa (Wright, 2005). Thus, the particular characteristics of sediments could have also partly influenced the rate of recovery. Nevertheless, every effort was made to ensure the recovery of the maximum potential of archaeobotanical material available at least during the processing stage of the samples available. The sorting, identification and quantification methods were also similar for all three assemblages (see details in chapter 3). Although most of the flotation samples contained wood charcoal fragments in variable quantities, it was not possible to examine the entire charcoal assemblage due to time constraints. Therefore, the identification of wood charcoal remains was based on a limited number of samples from each site (Table 4.2). The selection of charcoal samples for this study was based on consideration of their archaeological contexts. Charcoal fragments originating from *in situ* domestic fire installations were collected to identify the types of wood used as fuel at each site. In addition, contexts such as room fills and disposal pits containing long-term accumulation of fuel waste were also included, in order to understand the general pattern of wood use over long periods. All analysed charcoal fragments come from flotation samples as hand-picked fragments from all three sites were registered only for radiocarbon dating. Moreover, wood fragments smaller than 2 mm were excluded from identification due to insufficient diagnostic anatomy. As a result, some woody taxa with higher tendency of fragmentation into pieces <2 mm, including small shrubs and twigs, may be underrepresented. Overall, the analysed charcoal assemblage for this study may be thus not fully representative of the full range of wood taxa used as fuel in the prehistoric past.

Period	**Aceramic**		**Neolithic**		**Early Chalcolithic**				**Late Chalcolithic**	
Site	**Rahmatabad**		**Nurabad**		**Rahmatabad**		**Nurabad**		**Mehrali**	
Number of flotation samples	5		33		8		11		37	
Number of analysed samples	2	40%	6	18%	6	75%	5	45%	7	18%
Number of identified charcoal taxa	5		5		5		6		5	

Table 4.2. List of total number of charcoal samples recovered from each occupation phase and the number of analysed samples for this study

4.2 Overall preservation

Assessment of the archaeobotanical material recovered from the sites under study highlighted two important issues: 1- the absence of charred plant material in some of the flotation samples; 2- the higher level of fragmentation in the wood charcoal assemblages retrieved from the early phases. During five seasons of excavations at the three sites under study in total 227 soil samples (5286 litres of soil) were collected from various contexts, of which 100 flotation samples contained archaeobotanical data. In the Rahmatabad excavation a total of 98 samples (approximately 850 litres of sediment) were floated, of which only 13 samples (144 litres) included charred plant remains. In Nurabad and Mehrali, however, the majority of the flotation samples contained macrobotanical remains in variable amounts (Table 4.3). One explanation for the large number of flotation samples with no archaeobotanical material at Rahmatabad could be the location of the sampled contexts. Most of these samples were collected from deposits very close to the surface of the mound.

In general, archaeobotanical samples retrieved from lower levels of stratigraphy and horizontal trenches of all three sites had better state of preservation. Therefore, the paucity or poor preservation of material recovered from upper layers or open areas might be due to longer exposure to post-depositional processes, such as mechanical soil disturbance, erosion and higher rate of mixing with other material. The second issue relates to the extreme fragmentation of charcoal remains recovered from the Aceramic and Neolithic phases, limiting the number of suitable samples for charcoal analysis. In both phases <1 mm fragments made up the majority of the wood charcoal assemblages. In general, fragmentation can occur during combustion (depending on temperature, moisture content, size and the form of wood used), deposition (discarding practices) and post-depositional processes (trampling, soil moisture, surface exposure, mechanical pressure, freeze-thaw cycles, roots and microorganisms) (e.g. Asouti and Austin, 2005; Thery-Parisot *et al*., 2010a; Thery-Parisot *et al*., 2010b; Chrzazvez *et al*., 2011; Chrzazvez *et al*., 2014; Lancelotti *et al*., 2010; Allue *et al*., 2009). It has also been reported that charcoal originating from the combustion of decayed wood fragments results in smaller sized particle (Thery-Parisot *et al*., 2010b). Among post-depositional processes, trampling and sediment pressure, are regarded as important factors causing fragmentation of charcoal derived from fuel waste. The preservation of archaeobotanical material can also be influenced by soil pH and the permeability of the soil (Braadbaart *et al*., 2009). Currently, however, no information is available regarding the soil pH values of the sites under study. Charred plant remains consist of benzenoids, components that are unstable in basic or alkaline conditions; therefore, alkalinity of the soil could increase the rate of fragmentation and further loss of plant material in archaeological deposits. It is also reported that due to alkalinity of ash, charred plant debris may have been disintegrated and lost if buried together with ash from fireplaces (Braadbaart and Poole, 2008; Braadbaart *et al*., 2009; Huisman *et al*., 2012). At this time, it is not possible to verify the degree of damage caused by high or low alkalinity of the soil on the preservation of charred plant remains recovered from these sites. Measurement of soil pH from different deposits in the future would allow us to have better understanding of the sites' formation processes.

4.3 The nature of the sites and contexts

An overall assessment of the three archaeobotanical assemblages showed that they have rather low seed densities (Table 4.3). The average density of seeds and chaff remains was one item/litre across the samples and throughout the chronological sequence. Comparison of the number of samples and the number of identified taxa from each occupation phase showed a more or less positive correlation (Fig 4.1). For example, lower number of taxa were identified from the smaller assemblages like the Rahmatabad Aceramic phase, indicating the effect of assemblage size on the number of recovered taxa. All sites under study were settlement sites with substantial architectural remains used for residential purposes. The only exception was the industrial area of Rahmatabad in the Chalcolithic phase used for pottery production. The low seed density in this area could be related to its specific function, as no context or feature directly related to food preparation was found. In contrast, larger proportions of wood charcoal remains were recovered from this industrial area. The low density of charred plant remains (particularly seed and chaff) in the residential areas might be partly due to the type of sampled contexts. As outlined in Table 4.4, more than half of the analysed samples for this study were taken from general room fill deposits (55 samples). In general, these types of contexts are less likely to have large amounts of charred plant remains due to constant cleaning of the common habitation areas. In addition, continued trampling in these areas causing fragmentation could affect the preservation of charred plant remains. The number of samples taken from the content of fire installations used for domestic proposes was also low (11 samples in total, of which 8 samples come from the Late Chalcolithic layers of Mehrali). Although hearths/ovens are regarded as more promising contexts in terms of recovery of material, the density of recovered plant remains of these features was not significantly different from the room fill deposits. Regular cleaning of these features can be suggested as one possible explanation for the low density of recovered material. However, it is important to note that samples classified as ash deposits represent material recovered from piles of ash deposited near the fire installations on occupation floors (frequently found inside the buildings in the Mehrali excavation), however in Nurabad excavation these type of deposits represent the content of disposal pits scattered in the residential area. Samples from this group of contexts contained a somewhat higher number of charred plant remains. In total eight samples were collected from the *in situ* content of features/contexts defined as disposal pits in the Chalcolithic layers of these sites. Excavations at all three sites was mainly focused on revealing the building structures in trenches with relatively limited size, therefore, external locations or open spaces (where disposal pits are usually located) were not fully excavated. Overall, variation in excavation strategies, sampling methods (both numbers and volume of soil samples), location/depth of deposits and the type of sampled contexts could have partly contributed to differences in the presence and quantity of charred remains recovered from the sites under study.

Period	**Aceramic**	**Neolithic**		**Chalcolithic**			
Date	**Late 8^{th} B.C.**	**7^{th}- 6^{th} B.C.**		**5^{th} B.C**			**4^{th} B.C**
Site	**RA**	**RA**	**NA**	**RA**	**NA**	**MA**	**MA**
Number of samples taken	22	15	41	61	22	24	42
Number of samples with archaeobotanical remains	4	1	33	8	11	6	37
Total items (seeds and plant parts)	146	14	628	129	124	151	1264
Total soil volume	44	9	1224	95	547	153	1404
Average number of items/Litres	3.3	1.5	0.5	1.3	0.2	0.9	0.9
<50 items	2	1	31	8	11	4	28
50-100 items	2	0	1	0	0	1	5
>100 items	0	0	1	0	0	0	4
Number of identified taxa	19	10	26	23	22	8	24

Table 4.3. Summary of the number of charred plant remains recovered from the sites under study, ordered by period (RA= Rahmatabad, NA= Nurabad, MA= Mehrali)

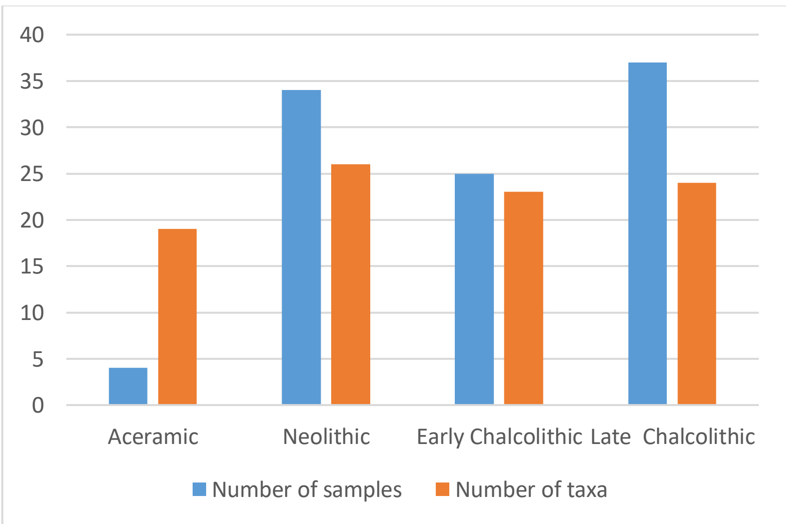


Fig 4.1. Bar chart showing the relationship between the number of analysed samples and the number of identified taxa

Site	Rahmatabad			Nurabad		Mehrali		
Phase	AC	NE	ECH	NE	ECH	ECH	LCH	
Room fill	3	1	6	19	8	3	15	**55**
Pit	-	-	1	-	2	3	2	**8**
Fire installation	1	-	1	1	-	-	8	**11**
Floor	-	-	-	-	-	-	1	**1**
Ash	-	-	-	10	1	-	11	**22**
Human burial	-	-	-	3	-	-	-	**3**

Table 4.4. Context type of the recovered plant remains from all three sites (AC: Aceramic, NE: Ceramic Neolithic, ECH: Early Chalcolithic, LCH: Late Chalcolithic)

4.4 The impact of charring

Given that all three archaeobotanical assemblages were preserved by charring, the biases imposed by this mechanism also needs to be considered. Although charring is important in preserving plant remains, there is only narrow window of temperatures and related conditions that allow plant remains to persist in an identifiable state (Wright, 2003). The results of experimental studies have demonstrated that a variety of factors including, thermal intensity, duration of exposure to heat, the presence of oxygen, size, shape, structure, chemical and moisture content of species could influence the carbonisation process, and the survival rate of various plant. Therefore, the composition of carbonised plant assemblages is also biased by this mechanism (Wilson, 1984; Wright, 2003, 2008; Boardman and Jones, 1990: Smith and Jones 1990; Braadbaart *et al*., 2007; Braadbaart and van Bergen, 2005; Markel and Rosch, 2008). For example, according to the results of charring experiments on different cereal plant components, straw and free-threshing cereal rachis survive less well than glume bases of glume wheats, while grains exhibited the widest range of survival conditions (Boardman and Jones, 1990). As a result, the chaff of free-threshing cereals will tend to be under-represented compared to glume wheat chaff (*ibid*.). Oily seeds are also reported to have less chance of survival in comparison to starchy seeds (Wright, 2003, 2008; Markel and Rosch, 2008; Lopez-Doriga, 2015). It is also noted that the size of drier seeds changes less than seeds with high moisture content (Wilson, 1984; Wright, 2003). Regarding wood, this mechanism (combustion) is also regarded as a second taphonomic filter producing important modifications. The changes that occur during wood combustion depend on variables related to wood properties (taxon, size, thermal conductivity and porosity) as well as temperature, heating rate, duration of exposure and the structure of hearths. The combustion process produces mass reduction, fragmentation and anatomical distortion (Thery-Parisot *et al*., 2010; Chabal *et al*., 1999, Allue *et al*., 2009; Braadbaart and Poole, 2008). Therefore, in evaluating the representatives of the archaeobotanical assemblages under study the possible impact of these factors needs to be considered.

Chapter 5

Wild and Woody taxa: Seed and Charcoal Identification and Ecological Information

The morphological descriptions and ecological information of the wild and woody taxa identified in the three-archaeobotanical assemblages are provided in this section. The wild taxa were grouped based on the family taxonomic level and are presented in alphabetical order. The identifications are based on illustrations in seed atlases, identification manuals and archaeobotanical reports (Cappers *et al*., 2006; Cappers *et al*., 2009; Jacomet, 2006; Willcox, 2002; Nesbitt, 2006; van Zeist *et al*., 1984; van Zeist and Bakker- Heeres ,1982-1984-1985; Miller, 1982; Miller and Kimiaie, 2006; Miller, 2010) as well as on comparison with the modern seed reference collection at the Archaeobotanical lab of the University of Nottingham, UK, and University of Tehran, Iran. The list of identified specimens was checked with the *Flora of Iran*, *A Dictionary of Iranian Plant Names* and *Weeds of Iran* (Ghahreman, 1975-2007, Mozaffarian, 2006, Karimi, 1995) to extract the list of geographically relevant taxa and their ecological information. In most cases, identification was only possible to the genus level, and since different species of a genus could have very different ecological requirements, the information presented here is often general. The minimum and maximum measurements of each taxon were recorded, as well as the total number of specimens assigned to each taxon. Ethnobotanical information about the culinary, medicinal, fodder and fuel uses of the wild taxa was gathered from different publications (Hooper and Field, 1937; Miller, 1982; Amin, 2005; Karimi, 1995; Moghadasi, 1995; Ajaib *et al*., 2010; Zohary and Hopf, 2000; Shafaghat *et al*., 2010; Wollstonecroft *et al*., 2011; Mosaddegh *et al*., 2012; Zandi *et al*., 2017; Asadi *et al*., 2014). In addition, the morphological descriptions of the wood taxa identified in the current assemblages are provided in the last part of the chapter. Anatomical descriptions of the wood taxa are based on laboratory observations and comparison with wood anatomy atlases and anthracological reports (e.g. Fahn *et al*., 1986; Schweingruber, 1978, 1990; Hather, 2000; Akkemik and Yaman, 2012; Willcox, 1990; van Zeist *et al*., 1984; Miller, 1982).

Abbreviations: RA: Rahmatabad, NA: Nurabad, MA: Mehrali, AC: Aceramic, NE: Ceramic Neolithic, CH: Chalcolithic

5.1 Wild taxa catalogue

5.1.1 Taxon: *Centaurea* sp.

Family: Asteraceae (daisy family) تیره مینا

Common name /Local name: Knapweeds، گل گندم

Measurements: 1.7 mm x 0.9 mm- 2.1 mm x 0.9 mm

n= NA: 4

Description: cylindrical shape, rounded at the apex and tapered at the base, large indentation base. The outer fruit wall was damaged due to carbonisation.

Regional/Temporally Similar Archaeological Occurrences: The presence of *Centaure*a sp. has been attested at archaeological sites in Iran, such as Malyan (3rd millennium B.C.) and Chogha Golan (Early Neolithic) (Miller, 1982; Weide *et al*., 2017).

Geographical Distribution: Iran, Afghanistan, Pakistan, Turkey, Iraq, Syria, Central Asia, North Africa, Europe.

Habitat: 74 annual/perennial species of *Centaure*a are reported from Iran (Mozaffarian, 2006). The genus commonly grows on open ground and ripens in the late summer of fall (Ghahreman, 1975-2007). In a vegetation survey of Fars, the following four species were observed *C. calcitrapa*, *C. depressa*, C. *phyllocephala* and *C. solstitialis* (Miller, 1982, p 169).

Uses/Ethnographical examples: Many species of *Centaurea* have spiny leaves and are not suitable for fodder (Karimi, 1995). Local people in Iran use flower buds, leaves and seeds of *Centaurea cyanus* as herbal medicine (Amin, 2005). Seeds of *Centaure*a in archaeological sites are more likely to represent accidental inclusion by wind in fodder or food grain (Miller, 1982, p 169).

Photo: not available

5.1.2 Taxon: *Lithospermum* cf. *tenuiflorum*

Family: Boraginaceae (borage family) تیره گاوزبانیان

Common name /Local name: Gromwell, Stoneseeds ، سنگدانه

Measurements: 2.1 mm x 1.8 mm – 2.5 mm x 1.9 mm

n = RA: 4

Description: All four seeds were mineralised, pyriform, elongated pointed apex, small rounded base, the surface is covered with tubercle like pattern. These four seeds were morphologically similar to those described by van Zeist and Bakker-Heeres identified as *Lithospermum tenuiflorum* (van Zeist and Bakker- Heeres, 1982).

Regional/Temporally Similar Archaeological Occurrences: The occurrence of uncarbonised fruits of Boraginaceae have been reported from prehistoric sites of the Central Plateau, Fars and southwest of Iran (Fazeli *et al*., 2009; Miller, 1982; Miller and Kimiaie, 2006; Whitlam *et al*., 2013). Determining the origin of these mineralised seeds (ancient or modern intrusion) in archaeological sites could be problematic. However, different methods (FT-IR, SEM-EDX, and radiocarbon dating) have been carried out to identify the origin of these uncharred seeds found in large numbers at archaeological deposits (Pustovoytov *et al*., 2004; Messager *et al*., 2010; Shillito and Almond, 2010).

Geographical Distribution: Iran, Afghanistan, Pakistan, Turkey, Iraq, Syria, North Africa, Europe.

Habitat: *Lithospermum* consists of six annual species usually growing in crop fields and waste ground (Ghahreman, 1975-2007; Mozaffarian, 2006). It is reported that *Lithospermum tenuiflorum* occurs in fields and steppe vegetation (van Zeist and Bakker- Heeres, 1982).

Fig 5.1 *Lithospermum* cf. *tenuiflorum*

5.1.3 Taxon: *Capparis* sp.

Family: Capparidaceae (capper family) تیره کبریان

Common name /Local name: caper کبر ، کلیر

Measurements: 2.2mm x 1.9 mm – 2.4 x 2 mm

n= RA: 34, MA= 4

Description: Obovate shape, tapering from the top to base in the side view, predominant curved radicle, in most cases, the outer seed wall was damaged.

Regional/Temporally Similar Archaeological Occurrences: The occurrence of *Capparis* has been reported from the Near Eastern archaeological sites (van Zeist and Bakker- Heeres, 1982, 1984). The remains of *Capparis* seeds are reported from Early Neolithic and Bronze Age sites in Iran, such as Ali Kosh, Tape Sabz and Shahre Sukhte (Helbaek, 1969; Woosley, 1996; Constantini, 1977).

Geographical Distribution: South of Iran, India, Egypt, Iraq, Saudi Arabia.

Habitat: *Capparis* has five perennial species (shrubs and weeds) growing in arid or semiarid areas in south of Iran (Mozaffarian, 2006).

Uses/Ethnographical examples: the fruits of *Capparis spinosa* are used as vegetable condiments consumed either raw or pickled. The seeds and roots of this plant have medicinal use (Hooper and Field, 1937; Karimi, 1995). *C. decidua* is used in traditional medicine for digestion issues (Amin, 2005; Mosaddegh *et al*., 2012).

Photo: not available

5.1.4 Taxon: *Silene* sp.

Family: Caryophyllaceae (pink family) تیره میخک

Common name /Local name: Catchfly،سیلن ، مگس گیر

Measurements: 0.9 mm x 0.8 mm- 1.1 mm x 1 mm

n= NA: 2, MA: 3

Description: Reniform with concentric rows of elongated verrucae on the side faces and the dorsal surface.

Regional/Temporally Similar Archaeological Occurrences: Small numbers of *Silene* seeds are reported from Neolithic and Chalcolithic sites of Fars (Miller, 1982, Miller and Kimiaie, 2006). The presence of *Silene* type seeds are also reported from Early Neolithic archaeobotanical samples in south west of Iran (Van Zeist *et al*., 1984, Whitlam *et al*., 2013, 2018; Riehl *et al*. 2012; Weide *et al*., 2017)

Geographical Distribution: Iran, Turkey, Iraq, Europe, Syria, Central Asia.

Habitat: *Silene* includes almost 100 annual/perennial species growing in Iran (Mozaffarian, 2006). In the regional survey undertaken by Miller (1982, p 166) the following species were observed; *S. conoidea* (growing in irrigated and non-irrigated fields) and *S. spergulifolia* (common in unirrigated fields).

Uses/Ethnographical examples: Suitable for fodder (Mozaffarian, 2006). In Iran, local people collect young shoots of *S. conoidea* in spring to add to stews and yogurt drinks (Miller, 1982, p 166; Mosaddegh *et al*., 2012).

Fig 5.2 *Silene* sp.

5.1.5 Taxon: *Vaccaria* cf. *pyramidata*

Family: Caryophyllaceae (pink family) تیره میخک

Common name /Local name: cowherb صابونک، جغجغک

Measurements: 1.4mm x 1mm- 1.6 mm x 1mm

n= RA: 4

Description: spherical shaped, the surface is densely covered with tiny papillae, the seeds were puffed and deformed due to carbonisation.

Regional/Temporally Similar Archaeological Occurrences: The presence of *Vaccaria pyramidata* is reported from archaeobotanical samples of the region (Miller, 1982; Miller and Kimiaie, 2006; Tengberg and Azizi, 2016) and also from the Early Neolithic sites of Sheykhi Abad and Chogha Golan (Whitlam *et al*. 2013, 2018 ; Weide *et al*., 2017)

Geographical Distribution: Turkey, Syria, Iran, Afghanistan, Turkmenistan (Ghahreman, 1975-2007; Mozaffarian, 2006).

Habitat: Annual weed common in irrigated and unirrigated fields (Miller, 1982, p 166; Mozaffarian, 2006). *Vaccaria pyramidata* is cultivated for fodder in spring and autumn crop fields. Other Vaccaria species are also reported as weeds of fields and roadsides (Karimi, 1995).

Uses/Ethnographical examples: Collected as fodder (Miller, 1982, p 166). Local people in Iran use the seeds and roots of this species in herbal medicine (Karimi, 1995).

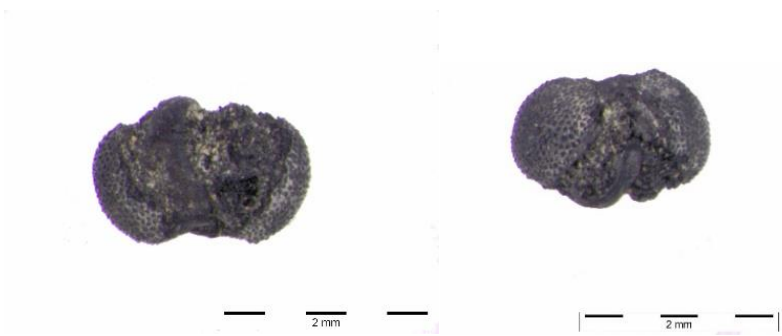


Fig 5.3 *Vaccaria* cf. *pyramidata*

5.1.6 Taxon: *Salsola* sp.

Family: Chenopodiaceae (goosefoot family) غازیا, تیره اسفناج

Common name /Local name: saltwort, علف شور

Measurements: 1mm x 1mm

n= RA: 1

Description: One seed was tentatively identified as *Salsola* sp. The seed was relatively flat with a visible curled embryo.

Regional/Temporally Similar Archaeological Occurrences: Charred remains of *Salsola* sp. are reported from Chia Sabz an Early Neolithic site in the Central Zagros (Riehl *et al*. 2012).

Geographical Distribution: Iran, Syria, Africa, South East Asia, North America, Australia.

Habitat: *Salsola* consists of 40 annual/perennial species and most of them are salt-tolerant plants growing in arid /sandy fields (Mozaffarian, 2006; Ghahreman, 1975-2007).

Uses/Ethnographical examples: *Salsola* is a favourite animal plant that hardly reaches flowering time due to over grazing. The fruits ripen in the late summer (Moghadasi, 1995).

Fig 5.4 *Salsola* sp.

5.1.7 Taxon: *Convolvulus* sp.

Family: Convolvulaceae (morning glory family) تیره پیچک،

Common name /Local name: bindweed, پیچک

Measurements: 2.6 mm x 2.2 mm

n= RA: 2

Description: the seeds were obovate in outline, three sided (two flat sides and one distinctly domed), rounded triangular hilum at the basal end, the surface was smooth and damaged in some parts.

Regional/Temporally Similar Archaeological Occurrences: a few charred seeds of *Convolvulus* are reported from Sheikh-e Abad (Whitlam *et al*., 2013, 2018).

Geographical Distribution: Iran, Afghanistan, Pakistan, Iraq, Central Asia, Europe.

Habitat: *Convolvulus* has 45 annual/perennial herbaceous and woody shrubs species mostly growing in temperate regions of south of Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). Growing along roadsides, disturbed fields and crop fields (Karimi, 1995).

Uses/Ethnographical examples: *Convolvulus arvensis* has long roots and it is a suitable plant for stabilising sand dunes (Karimi, 1995).

Fig 5.5 *Convolvulus* sp.

5.1.8 Taxon: *Brassica/Sinapis* type

Family: Cruciferae (mustard family) تیره شب بو ،

Common name /Local name: Mustard, کلم

Measurements: 1.2 mm x 1mm – 1.4 mm x 1.1 mm

n= NU: 4

Description: Spherical shape, the seeds' wall was broken and damaged, distinct reticulate surface, circular hilum scar. *Sinapis* seeds have fainter reticulum than seeds of *Brassica* (van Zeist *et al*., 1984) but this distinction was not possible to make here due to poor preservation.

Regional/Temporally Similar Archaeological Occurrences: The presence of *Brassica/Sinapis* type seeds is also attested in archaeobotanical samples of Early Neolithic sites in south western Iran (Van Zeist *et al*., 1984, Whitlam *et al*., 2013, 2018). From the mustard family small numbers of *Alyssum* seeds and siliques of *Euclidium* have been reported from prehistoric sites of Fars (Miller and Kimiaie, 2006).

Geographical Distribution: Iran, Syria, Turkey, Iraq, North Africa, Europe.

Habitat: *Brassica* has 17 species while *Sinapis* consists of the following three species; *S. alba*, *S. arvensis* and *S.aucher* in Iran (Mozaffarian, 2006). Generally, members of this large family are plants of open ground (Miller and Kimiaie, 2006).

Uses/Ethnographical examples: Cruciferous taxa (*Brassica* and *Sinapis*) are noted as common archaeological finds, providing oil and flavourings for millennia (Zohary and Hopf, 2000). The oil extracted from seeds of *Brassica nigra*, *Brassica rapa* and *Sinapis alba* have culinary and medicinal uses (Hooper and Field, 1937; Amin, 2005). *Sinapis arvensis* seeds are used for flavouring food (Karimi, 1995).

Photo: not available

5.1.9 Taxon: *Carex* cf. *divisa*

Family: Cyperaceae (sedge family) تیره جگن،

Common name /Local name: sedge, جگن

Measurements: 2.4 mm x 1.9mm – 1.7mm x 1.6 mm

n= RA: 1, MA: 138

Description: The morphological description of *Carex* seeds was similar to *Carex* cf. *divisa* described by van Zeist and Bakker-Heeres (van Zeist and Bakker- Heeres, 1982). Relatively flat seeds with distinct epidermis cells, oval to circular in outline, the ventral side is flat, the dorsal side is concaved (roof-shaped), and the surface is granular. The same species was observed by Miller (1982, p 155) growing along the irrigation diches and in the poorly drained pasture near Malyan.

Regional/Temporally Similar Archaeological Occurrences: *Carex* seeds were frequently present in the archaeobotanical assemblages of Fars from the Neolithic period to the Bronze Age period (Miller, 1982; Miller and Kimiaie, 2006) and also at the Early Neolithic site of Sheykhi Abad in the Zagros region (Whitlam *et al*. 2013, 2018).

Geographical Distribution: Iran, Syria, Turkey, Central Asia, Europe.

Habitat: This genus has forty-five perennial species in Iran that commonly grow in moist ground (Mozaffarian, 2006).

Uses/Ethnographical examples: *Carex* plants can be used to prevent soil erosion (Karimi, 1995). The *Carex* seeds found in the archaeobotanical assemblage of Malyan are reported as driving of dung used as fuel (Miller, 1982, p 155).

Fig 5.6 *Carex* cf. *divisa*

5.1.10 Taxon: *Scirpus* sp. or *Bolboschoenus glaucus*

Family: Cyperaceae (sedge family) تیره جگن،

Common name /Local name: club rush, تزک

Measurements: 2.5 mm x 1.8 mm - 1.8 mm x 1.4 mm

n= RA: 63, NU: 4

Description: seeds that were classified as *Scirpus* or *Bolboschoenus glaucus* were obovate in outline, relatively flat in ventral side, roof shaped in the dorsal side, with shiny outer layer and prominent shoulders. In terms of size, the seeds were similar to *B. glaucus*.

Regional/Temporally Similar Archaeological Occurrences: the seeds of *Scirpus* have been identified in Early Neolithic sites of the Zagros region (Riehl *et al*. 2012; Whitlam *et al*. 2013, 2018; Weide *et al*., 2017). The frequent occurrence of *Scirpus maritimus* has also been reported from Ganj Dareh (van Zeist *et al*., 1984). However, in a relatively recent study of this plant, most of the archaeological specimens previously identified as *Sirpus maritimus* were re-classified as *B*. *glaucus* (Wollstonecroft *et al*., 2011).

Geographical Distribution: Iran, Turkey, Syria, Europe, North America.

Habitat: The most common species of *Scirpus* in Iran are S. *maritimus*, S. *mucronatus* and S. *lacustris* (Mozaffarian, 2006; Ghahreman *et al*., 1975-2007). European *Bolboschoenus* has five species; *B. maritimus*, *B. laticarpus, B. yagara, B. planiculmis* and *B. glaucus* (Wollstonecroft *et al*., 2011). *B. glaucus* is reported as the most frequent species in Iran (Amini Rad *et al*., 2010) occurring along rivers, rice fields and in secondary habitats near villages.

Uses/Ethnographical examples: *Bolboschoenus* nuts and tubers are rich in energy and contain high amounts of carbohydrates (Wollstonecroft *et al*., 2011).

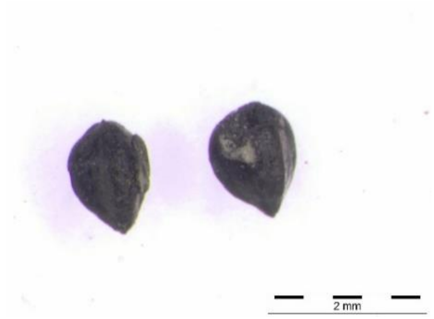


Fig 5.7 *Scirpus* sp. or *Bolboschoenus glaucus*

5.1.11 Taxon: *Astragalus* sp.

Family: Fabaceae (pea, clover family), تیره باقلاییان

Common name /Local name: milk-vetch, گون

Measurements: 2.6 mm x 2.3mm- 1.9mm x 1.4 mm

n= RA: 7, NU: 130, MA: 13

Description: seeds of *Astragalus* sp. occurred in different sizes and morphologically were similar to those identified in Ganj Dareh (van Zeist *et al*., 1984), laterally compressed seeds, obliquely quadrangular to almost triangular in outline, hilar notch.

Regional/Temporally Similar Archaeological Occurrences: relatively large number of *Astragalus* seeds have been reported from other prehistoric archaeobotanical assemblages of Fars (Miller, 1982; Miller and Kimiaie, 2006; Kimiaie, 2010; Tengberg and Azizi, 2016). Several indeterminate species of *Astragalus* have been reported from irrigated and unirrigated fields and on waste areas of the region. A. hamosus is reported as a good forage species. The archaeological samples with such seeds have been recorded as probably representing animal fodder (Miller, 1982, p 172). *Astragalus* seeds were also attested frequently from various Early Neolithic sites of the Zagros region (van Zeist *et al*., 1984; Riehl *et al*. 2012; Whitlam *et al*. 2013, 2018; Weide *et al*., 2017).

Geographical Distribution: Iran, Turkey, Syria, Afghanistan, Pakistan, Iraq, Central Asia.

Habitat: *Astragalus* has around 800 species in Iran categorised into eight subgenera and eighty-five sections. In the Zagros region alone, over hundred species of *Astragalus* are reported occurring in a wide verity of habitats from steppe to cultivated fields (Mozaffarian, 2006; Ghahreman, 1975-2007).

Uses/Ethnographical examples: none-spiny species of *Astragalus* are used as fodder (Hosseini, 2011; Karimi, 1995). The leaves, stem and roots of Astragalus are also used in traditional medicine (Hooper and Field, 1937; Ajaib *et al*., 2010; Ertug, 2000; Mosaddegh *et al*, 2012; Amin, 2005). In Iran, Tragacantha is one of the most important subgenus of *Astragalus* with eight species producing tragacanth gum with many medicinal, food and industrial uses. The woody shrubs of *Astragalus* are commonly used as fuel (Karimi, 1995).

Fig 5.8 *Astragalus* sp.

5.1.12 Taxon: *Trigonella* cf. *astroites*

Family: Fabaceae (pea, clover family), تیره باقلاییان

Common name /Local name: شنبلیله

Measurements: 1.9mm x 1mm – 1.4mm x 0.7 mm

n= RA: 3, NU: 1, MA: 15

Description: Latterly compressed seeds and elliptic in outline, rounded upper end, transversally wrinkled surface. The morphological description was similar to *Trigonella astroites* seeds identified in Ganj Dareh (van Zeist *et al*., 1984).

Regional/Temporally Similar Archaeological Occurrences: Charred seeds of *Trigonella* were reported from Neolithic and Chalcolithic sites of Fars (Miller and Kimiaie, 2006). They have also been attested at Early Neolithic sites of the Zagros region (van Zeist *et al*., 1984; Riehl *et al*. 2012; Weide *et al*., 2017).

Geographical Distribution: Iran, Turkey, Syria, Afghanistan, Pakistan, Iraq, Central Asia, India, Saudi Arabia, North Africa.

Habitat: Thirty-two species of *Trigonella* have been reported from Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). They occur in steppe vegetation and cultivated land (Miller and Kimiaie, 2006).

Uses/Ethnographical examples: Useful forage legume for livestock fodder and a natural nitrogen fixer of soil. The seeds and leaves of *T. foenum-graecum* are used in traditional herbal medicine to reduce blood glucose and the cholesterol levels (Amin, 2005; Mosaddegh *et al*, 2012; Zandi *et al*., 2017).

Fig 5.9 *Trigonella* cf. *astroites*

5.1.13 Taxon: cf. *Ornithogalum*

Family: Liliaceae (lily family), تیره سوسن

Common name /Local name: star of –Bethlehem, شیر مرغ

Measurements: 1.6 mm x 1.4 mm - 1.1 mm x 1 mm

n= NU: 4

Description: Irregularly shaped, elliptic to ovate to semi – circular in outline, reticulate surface pattern, hole at apex, hilar scar at base.

Regional/Temporally Similar Archaeological Occurrences: From the lily family *Bellevalia* and *Polygonatum* seeds were tentatively identified at Tall-e Bakun in Fars (Miller and Kimiaie, 2006). A few seeds were identified as *Ornithogalum* from the early Neolithic sites of Chogha Bonut and Chogha Golan (Miller, 2003; Weide *et al*., 2017).

Geographical Distribution: Iran, Turkey, Syria, Afghanistan, Iraq, South West Asia, Europe.

Habitat: *Ornithogalum* is a spring flowering plant and thirteen different species of this genus have been reported from Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). They usually occur in grasslands, gardens, and damp waste areas as weed (Karimi, 1995).

Uses/Ethnographical examples: Species of *Ornithogalum* are used in Iranian traditional medicine to treat inflammatory and respiratory diseases (Mosaddegh *et al*, 2012; Asadi *et al*., 2014).

Photo: not available

5.1.14 Taxon: *Malva* sp.

Family: Malvaceae (mallow family), تیره ختمی

Common name /Local name: hock herb, mauls, پنیرک

Measurements: 1.1mm x 1 mm – 1.3 x 1 mm

n= NU: 2

Description: Reniform seed, deep hilar notch, slightly concave surface, smooth seed wall, thinner at the inner ventral side.

Regional/Temporally Similar Archaeological Occurrences: The seeds of *Malva* are reported from archaeobotanical assemblages of the region (Miller, 1982; Tengberg and Azizi ,2016). *Malva* was also attested at the prehistoric site of Farukhabad in Deh Luran Plain (Miller, 1981) and at the Early Neolithic site of Chogha Golan (Weide *et al*., 2017).

Geographical Distribution: Iran, Turkey, Afghanistan, Iraq, Central Asia, Europe.

Habitat: *Malva* has 10 annual/perennial species flowering from spring to autumn (Mozaffarian, 2006; Ghahreman, 1975-2007). It occurs in fields, along paths, and in waste areas (Miller, 1982, p 174; Karimi, 1995).

Uses/Ethnographical examples: The flowers and roots of *Malva sylvestris* and *Malva neglecta* are widely used in Iranian traditional medicine (Hooper and Field, 1937; Amin, 2005; Mosaddegh *et al*, 2012).

Fig 5.10 *Malva* sp.

5.1.15 Taxon: *Fumaria* sp.

Family: Malvaceae (mallow family), تیره ختمی

Common name /Local name: hock herb, mauls, پنیرک

Measurements: 1.4mm x 1.1 mm

n= NU: 2

Description: Circular in outline, rough surface and two rounded holes at the base of the fruit that is a characteristic feature (van Zeist and Bakker- Heeres, 1982).

Regional/Temporally Similar Archaeological Occurrences: *Fumaria* seeds are reported from Tall-e Malyan in Fars and Sheikh-e Abad in the Zagros region (Miller, 1982; Whitlam *et al*. 2013, 2018).

Geographical Distribution: Iran, Syria, North Africa, Turkey, Afghanistan, Iraq, Pakistan, Turkmenistan, Central Asia, Europe.

Habitat: Seven annual weed species of *Fumaria* have been reported from Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). The seeds are dispersed in the summer and it has been mentioned as a possible weed of cultivation (Willcox, 2002).

Uses/Ethnographical examples: *Fumaria vaillantii* is recorded growing in the irrigated fields of the region; used for medicinal purposes and as fodder or graze (Miller, 1982, p 160). The aerial part of *Fumaria parviflora* has medicinal properties and the herb is prepared like tea to tread back pain (Hooper and Field, 1937; Amin, 2005; Mosaddegh *et al*, 2012).

Photo: not available

5.1.16 Taxon: *Aegilops* spikelet type

Family: Poaceae (grass family), تیره گندمیان

Common name /Local name: goat face grass, چمن بز

Measurements: 2.1 mm x 1.7 mm - 1.8mm x 1.5mm

n= NU: 3

Description: The *Aegilops* spikelet disarticulates in three ways, often surviving charring (Nesbitt, 2002). Spikelet bases were wide and robust, flat at the base. Lines on the outside, the inside of spikelet had concave form.

Regional/Temporally Similar Archaeological Occurrences: *Aegilops* grains and spikelet bases have been reported from Neolithic and Chalcolithic sites of this region (Miller and Kimiaie, 2006, Kimiaie, 2010; Tengberg and Azizi,2016) as well as Early Neolithic sites of the Zagros region (Riehl *et al*. 2012; Whitlam *et al*. 2013, 2018; Weide *et al*., 2017).

Geographical Distribution: Iran, Syria, North Africa, Turkey, Afghanistan, Iraq, Pakistan, Turkmenistan, Central Asia, Europe.

Habitat: Twelve annual weedy species of *Aegilops* have been reported from Iran usually growing in arable lands and waste areas (Karimi, 1995; Mozaffarian, 2006). They also grow annually in dry grasslands and weedy places (Nesbitt, 2002). Some *Aegilops* plants were observed by Miller (1982, p 164) in unirrigated wheat and barley fields of the region. They ripen in early spring and are mentioned as good plants for grazing by goats (Karimi, 1995; Miller, 1982).

Uses/Ethnographical examples: Useful fodder plants (Moghadasi, 1995). *Aegilops* found at the archaeological site of Malyan were assumed to be a constituent of dung used as fuel (Miller, 1982, p 164).

Fig 5.11 *Aegilops* spikelet type

5.1.17 Taxon: *Avena* sp.

Family: Poaceae (grass family), تیره گندمیان

Common name /Local name: oat, یولاف، جو دو سر

Measurements: 4.2mm x 1.5 mm – 3.8 mm X 1.3 mm

n= NU: 2

Description: ovular in cross section, the widest point is in the middle of the grain, slight depression above the embryo, rounded apex, shallow ventral groove.

Regional/Temporally Similar Archaeological Occurrences: The presence of *Avena* is attested in the archaeobotanical assemblage of Tall-e Malyan (Miller, 1982). Miller (1982, p 159) reported that wild oats rarely occur in the fields of the region and one example growing as weed was tentatively identified as the cultivated species *A. byzantine.* It is also reported from the Early Neolithic assemblage of Chogha Golan (Riehl *et al*., 2015; Weide *et al*., 2017).

Geographical Distribution: Iran, Syria, Egypt, Turkey, Afghanistan, Iraq, Pakistan, Central Asia, India, Europe.

Habitat: Ten different species of *Avena* are reported as weeds in arable land as well as cultivated crops in Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). Wild oat occurs in arable land and waste areas and the plant is tolerant to both alkaline and acidic soils (Karimi, 1995)

Uses/Ethnographical examples: used as food or fodder; *Avena sativa* is mentioned as an important plant in Iranian traditional medicine (Molazadeh and Kadvari, 2014).

Photo: not available

5.1.18 Taxon: *Eremopyrum* sp.

Family: Poaceae (grass family), تیره گندمیان

Common name /Local name: false wheatgrass بیابان گندمی

Measurements: 2.8 mm x 1.1 mm – 2.2mm x 0.9 mm

n= RA: 4, NU: 8

Description: the grains were similar in morphology to those described as *Eremopyrum* by van Zeist and Bakker- Heeres (1982); grains were grooved with a narrow dorsal view, short embryo, long linear hilum and sharply keeled in dorsal side, the greatest width in the lower half of the grain.

Regional/Temporally Similar Archaeological Occurrences: *Eremopyrum* grains were also present in the archaeobotanical samples of other prehistoric sites of Fars (Miller, 1982; Miller and Kimiaie, 2006; Kimiaie, 2010) and Early Neolithic sites of the Zagros region (Weide *et al*., 2017; Whitlam *et al*. 2013, 2018).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, Turkmenistan, Europe.

Habitat: *Eremopyrum* often grows in dry plains or deserts in Iran and the reported species include: *E. distans*, *E*. *triticeum*, *E*. *bonaepartis*, *E*. *confusum* and *E*. *orientale* (Mozaffarian, 2006). E. *bonaepartis* was occasionally observed by Miller, (Miller, 1982, p 165) growing in waste areas near the archaeological site of Malyan.

Uses/Ethnographical examples: Useful fodder plants.

Photo: not available

5.1.19 Taxon: *Lolium* sp.

Family: Poaceae (grass family), تیره گندمیان

Common name /Local name: rye grass, چچم

Measurements: 2.8 mm x 1.2 mm

n= RA: 1

Description: the *Lolium* grain had a flat ventral surface, compressed dorsally and ventrally, the greatest width was in the middle of the grain, the apical end was rounded.

Regional/Temporally Similar Archaeological Occurrences: small numbers of *Lolium* grains were found in the archaeobotanical samples of Fars (Miller and Kimiaie, 2006; Tengberg and Azizi, 2016). *Lolium* was frequently present among the archaeobotanical samples of Sheikh-e Abad in the Central Zagros (Whitlam *et al*., 2013).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, Turkmenistan, India, Europe.

Habitat: the following six species are reported from Iran which are often seen growing as weeds in arable lands; *L. loliaceum*, *L. multiflorum*, *L. perenne*, *L. persicum*, *L. rigidum*, *L. temulentum* (Mozaffarian, 2006). *L. perenne* commonly grows along ditches and alfalfa fields (Karimi, 1995) which was also observed growing in the region (Miller, 1982, p 160).

Uses/Ethnographical examples: *Lolium* is considered a good forage grass (except *L. temulentum*) (Hooper and Field, 1937; Miller, 1982, p 160).

Fig 5.12 *Lolium* sp.

5.1.20 Taxon: *Rumex* sp.

Family: Polygonaceae (knotweed family), تیره هفت بند

Common name /Local name: dock, sorrel, ترشک

Measurements: 1mm x 0.8 mm

n= NU: 1, MA: 2

Description Triangular shape with squared ridges, sharp at the apex and wider in the base, smooth seed wall.

Regional/Temporally Similar Archaeological Occurrences: a few *Rumex* seeds were identified from archaeological sites of the region, such as at Malyan and Tall-e Bakun (Miller, 1982; Miller and Kimiaie, 2006). Seeds of *Rumex* were also present in the archaeobotanical assemblages of Early Neolithic sites of the Zagros region (Whitlam *et al*. 2013, 2018; Riehl *et al*., 2015; Weide *et al*., 2017).

Geographical Distribution: Iran, Turkey, Iraq, Central Asia, Armenia.

Habitat: twenty- three annual/perennial species of *Rumex* are reported from Iran often growing in cool and moist areas (Mozaffarian, 2006; Ghahreman, 1975-2007). Three species of *Rumex* (*R. crispus, R. dentatus* and *R. conglomeratus*) were found in the region growing in the well-irrigated alfalfa fields, near diches and in a cool moist poplar groove (Miller, 1982, p 158).

Uses/Ethnographical examples: leaves and seeds of *R. acetosa* are commonly used in traditional medicine and also serve as food (salad, stew). Some species of *Rumex* are collected as fodder (Karimi, 1995). The seeds of *R*. *conglomeratus* are used in traditional herbal medicine (Hooper and Field, 1937; Amin, 2005).

Fig 5.13 *Rumex* sp.

5.1.21 Taxon: *Polygonum* sp.

Family: Polygonaceae (knotweed family),تیره هفت بند

Common name /Local name: knotweed, persicaria, هفت بند، بندواش

Measurements: 1.6mm x 1mm- 1.4 x 1mm

n= RA: 5

Description: Ovate in outline, pointed at the apex, embryo on the angle, wider toward the base, smooth surface.

Regional/Temporally Similar Archaeological Occurrences: The presence of *Polygonum* seeds was also attested in Chalcolithic samples of the region (Miller, 1982; Miller and Kimiaie, 2006) as well as Early Neolithic samples of the Zagros region (Weide *et al*., 2017; Whitlam *et al*. 2013, 2018).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, Afghanistan, Pakistan, Africa, Europe.

Habitat: *Polygonum* consists of 35 annual/perennial herbaceous and woody shrub species in Iran (Mozaffarian, 2006; Ghahreman, 1975-2007). The following species were observed in the region growing in irrigated gardens, along the ditches and in cool moist poplar groves: *P*. *aviculare*, *P*. *eguisetiforme* and *P*. *lapathifolium* (Miller, 1982, p 157).

Uses/Ethnographical examples: some species are collected for fodder (Miller, 1982). *P. aviculare* and *P. bistorta* are used in traditional medicine (Hooper and Field, 1937; Karimi, 1995).

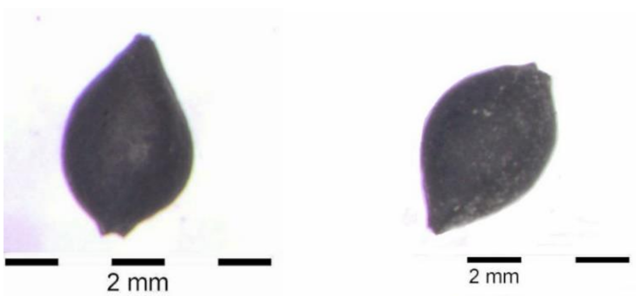


Fig 5.14 *Polygonum* sp.

5.1.22 Taxon: *Adonis* sp.

Family: Ranunculaceae (buttercup family), تیره آلاله

Common name /Local name: pheasant's eye, چشم خروس

Measurements: 2.1mm x 1.8 mm

n= RA: 2

Description: the two seeds identified as *Adonis* were similar to those described by van Zeist and Bakker- Heeres (1982) as "Bio-convex fruit, margin with a keel, ovate to almost circular in outline, rugose reticulate surface pattern, prominent ribs'' .

Regional/Temporally Similar Archaeological Occurrences: A few *Adonis* seeds were identified in archaeobotanical samples of Malyan (Miller, 1982). In addition, from the Ranunculaceae family two seeds of *Ceratocephalus* were found in the samples of Tall-e Bakun (Miller and Kimiaie, 2006). The presence of *Adonis* seeds has been also reported from Sheikh-e Abad in the Zagros region (Whitlam *et al*., 2013, 2018). One seed was tentatively identified as *Adonis* from Farukhabad, probably representing a field weed (Miller, 1981).

Geographical Distribution: Iran, Turkey, Iraq, Afghanistan, Pakistan, Europe.

Habitat: *Adonis* incudes seven annual/perennial flowering species in Iran usually growing in arable lands, waste areas, irrigated gardens and along ditches (Mozaffarian, 2006; Karimi, 1995). Some Adonis species are mentioned as common weeds in fields (van Zeist and Bakker-Heeres, 1982; Willcox, 2002).

Uses/Ethnographical examples: Due to the toxic content of some *Adonis* species it is not suitable animal fodder (Karimi, 1995).

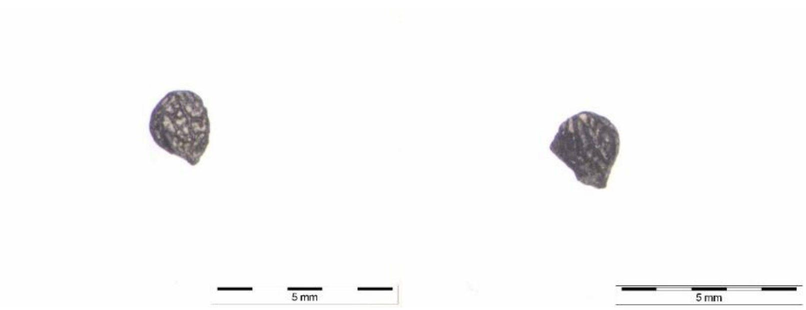


Fig 5.15 *Adonis* sp.

5.1.23 Taxon: *Galium* sp.

Family: Rubiaceae (bedstraw family), تیره روناس

Common name /Local name: bedstraw, شیر پنیر

Measurements: 2.1mm x 1.8 mm- 1.7 mm x 1.5 mm

n= RA: 1, NU: 9, MA: 2

Description: spherical seeds with a slightly depressed hole on the ventral side (indicating the position of the hilum), no surface pattern.

Regional/Temporally Similar Archaeological Occurrences: seeds of *Galium* have been found in samples from most of the prehistoric sites of Fars (Miller, 1982, Miller and Kimiaie, 2006; Kimiaie, 2010; Tengberg and Azizi,2016). The presence of *Galium* is also reported from archaeological sites in other regions, such as the Central Plateau and the Zagros region (Miller, 1981; Fazeli *et al*., 2009; Riehl *et al*. 2012; Whitlam *et al*. 2013, 2018; Weide *et al*., 2017).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, North Africa, Europe.

Habitat: *Galium* is one of the biggest genera of the Rubiaceae family in Iran and more than fifty species are reported from Iran. *Galium* is a varied genus that includes annuals and perennials; the annual species of *Galium* are weeds of fields and cultivated grounds whereas the perennials often grow in mountainous areas (Mozaffarian, 2006; Ghahreman, 1975-2007).

Uses/Ethnographical examples: in Iran some *Galium* species are traditionally used to coagulate milk and for this reason this plant is called ''yogurt herb'' in Farsi. The following species are also used in herbal medicine: *G*. *aparine, G. cruciata* and *G. vernum* (Shafaghat *et al*., 2010). Some *Galium* species reported eaten by animals (Miller, 1982, p 175).

Fig 5.16 *Galium* sp.

5.1.24 Taxon: *Hyoscyamus* sp.

Family: Solanaceae (nightshade family), تیره سیب زمینی

Common name /Local name: hog bean, henbane, بنگ دانه

Measurements: 2 mm x 1.4 mm

n= MA: 1

Description: Reniform in outline, reticulate surface relief.

Regional/Temporally Similar Archaeological Occurrences: A few seeds of *Hyoscyamus* were found in archaeological samples of Fars, such as at Tall-e Bakun and Malyan (Miller, 1982; Miller and Kimiaie, 2006) and at Sheikh-e Abad in the Zagros region (Whitlam *et al*., 2018).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, Afghanistan, Pakistan, Saudi Arabia.

Habitat: Eighteen different perennial species of *Hyoscyamus* have been reported from Iran (Mozaffarian, 2006; Ghahreman, 1975-2007) and some of these species were observed growing in Fars in Irrigated fields and along the ditches (Miller, 1982, p 161). Some species are toxic.

Uses/Ethnographical examples: Dry leaves of *H. niger* are used in traditional herbal medicine. Sometimes the seeds of this plant are baked in bread and consumed as psychoactive drug (Karimi, 1995). The species *H. officinalis* and *H. reticulatus* are also used in traditional medicine (Hooper and Field, 1937; Amin, 2005; Mosaddegh *et al*, 2012).

Fig 5.17 *Hyoscyamus* sp.

5.1.25 Taxon: *Thymelaea* cf. *passerine*

Family: Thymelaeaceae (Daphne family), تیره دافنه

Common name /Local name: sparrow wort, دانه پرستو

Measurements: 1.8 mm x 1. 2 mm

n= RA: 1

Description: small seed with elongated apex, rounded at the base, shiny surface.

Regional/Temporally Similar Archaeological Occurrences: the presence of *Thymelaea* sp. is attested at Sheikh-e Abad in the Zagros region (Whitlam *et al*., 2018).

Geographical Distribution: Iran, Syria, Turkey, Iraq, Central Asia, Afghanistan, Pakistan, Africa, Turkmenistan, Europe.

Habitat: *Thymelaea* has two annual weed species *T. mesopotamica* and *T. passerine* in Iran. They grow aggressively in dry pastures and disturbed grounds and are unpalatable to livestock (Mozaffarian, 2006; Ghahreman, 1975-2007).

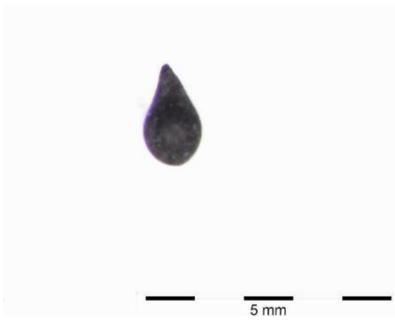


Fig 5.18 *Thymelaea* cf. *passerine*

5.2 The sources of wild taxa

In order to distinguish the sources of wild taxa, their ecological characteristics relating to preferred habitat types, life history (annual, perennials) and seasonality were investigated (e.g. Charles,1998; Charles and Bogaard ,2010). In addition, other factors, such as the economic value of some wild plants for human consumption, palatability to livestock and fuel value were also assessed for each assamblage (details are provided in chapters 6, 7 and 8). Information on the habitat preferences and life history of the wild taxa identified to genus and species level is presented in table 5.1. The classification of wild/weedy taxa based on their flowering time in relation to the cereal harvest time is available in table 5.2. In addition, the archaeobotanical contents of each sample and contextual information were carefully observed to provide more information on the possible origin of the wild taxa (see Chapters 6, 7 and 8).

The majority of the wild taxa recovered from the sites under study have the potential to grow in cultivated fields or disturbed grounds. As many of the wild species have arable fields/disturbed grounds as one of their principle habitats, they were classified as arable/ruderal taxa. Some wild taxa, such as *Carex, Rumex*, *Polygonum* and *Bolboschoenus,* have been described as plants of damp grounds usually growing along diches and riverbanks, classified as wet-environment habitats. Wild taxa in this group could also be associated with crop fields.

Another group of taxa that were commonly found (e.g. *Astragalus* sp.) have broad ecological tolerances growing in variety of habitats including waste grounds, steppes and grasslands. Another example is *Galium*; the annual species of the *Galium* genus are weeds of fields and cultivated grounds while the perennials often grow in mountainous areas. Therefore, some of the large taxonomic groups could not be assigned to one specific habitat type.

Furthermore, in order to determine whether wild taxa have arrived on site as harvested along with crop weeds, they were classified to early, intermediate and late taxa according to their flowering time in relation to the approximate harvest time. It must be noted that the flowering time grouping is general as most of the wild taxa are identified to genus level. In the Fars province, harvesting wheat usually starts in June and continues throughout July, sometimes until August. Harvesting barley begins slightly before wheat in the region. Based on regional ethnobotanical observations, Miller (1982, pp 78-80) notes that winter wheat is planted in September and irrigated first after two weeks and again in spring and harvested in mid-June. Barley is sown in October, irrigated right away and again in May, then harvested a few weeks before wheat. Overall, June-July was assumed as the potential harvest time for prehistoric winter cereal crops. Wild species that flower before and during the harvest time are classified as early taxa. Most of these taxa are observed as occurring in cultivated fields and, therefore, it is possible that their seeds arrived on site with harvested cereal crops (an observation that is discussed alongside sample composition in Chapters 6, 7 and 8). The flowering time of the intermediate group begins before the cereal harvest time and extends beyond it, indicating that they could have been harvested with cereals; however, other routes must be also considered. The majority of the identified wild taxa fall into this group. Most of the intermediate taxa also have diverse ecological preferences (cultivated fields, grasslands, wet places, dry/sandy areas, steppe, and hillsides), which is further evidence to their multiple routes of entry. In the late taxa group, flowering time happens during and after the indicated crop harvest time. Although arriving with harvested crop is a possibility, it is more likely that they have arrived at the site through different routes.

In terms of palatability to livestock, most of the identified wild taxa are suitable for animal grazing/fodder. The few exceptions are the toxic species of *Adonis*, *Galium, Hyoscyamus* and the spiny species of *Astragalus* and *Centaurea.* The overall ubiquity of wild/weedy taxa from the three studied sites was calculated to distinguish between the frequent and rare species (Table 5.3). In total 100 samples were analysed and taxa that were present in fewer than five samples (less than 5%) were considered as rare. The most common wild type in the samples were small seeded wild legumes occurring in 41 out of 100 samples (41%), followed by medium sized grasses (24%) and sedges (15%). Other wild plants, such as bedstraw (*Galium* sp.) and knotweed (*Polygnum* sp.), were also reasonably common, present in 8% and 5% of the samples, respectively.

Taxon	Site	Period	Lifecycle	Habitat preferences
Centaurea sp.	NA	NE	Annual/perennial	Cultivated fields, waste areas, hillsides, grasslands
Lithospermum cf. *tenuiflorum*	RA	AC/CH	Annual herbaceous plant	Crop fields, waste grounds, roadsides
Capparis sp.	RA, MA	AC/NE/CH	Perennial shrubs, small trees, edible fruits	Rocky hillsides, roadsides, waste grounds
Silene sp.	NA, MA	CH	Annual/perennial	Cultivated fields, waste grounds, rocky slops
Vaccaria cf. *pyramidata*	RA	CH	Annual herbs	Cultivated fields, waste grounds
Salsola sp.	RA	AC	Annual/perennial herbs and shrubs	Salt-tolerant plants, Sandy fields, waste grounds
Convolvulus sp.	RA	AC	Annual/perennial herbaceous and woody shrubs	Roadsides, disturbed fields, crop fields, sandy fields
Brassica/Sinapis type	NA	CH	Annual herbaceous plant	Crop fields, Waste grounds, grasslands
Carex cf. *divisa*	RA, MA	CH	Perennial herbaceous plant	Poorly drained pasture, ditches, damp grasslands
Bolboschoenus cf. *glaucus*	RA, NA	AC/NE	Perennial herbs, edible nuts	Marshy hay fields, shores of rivers or lakes, meadows, pastures
Astragalus sp.	RA,NA,MA	AC/NE/CH	Annual/perennial herbs and shrubs	Various including fields, open ground, waste ground, grassland
Trigonella cf. *astroites*	RA,NA,MA	AC/NE/CH	Annual/perennial herbs	Steppe, cultivated fields
Ornithogalum sp.	NA	NE, CH	Perennial herbaceous plant	Arable fields, grasslands
Malva sp.	NA	CH	Annual/perennial	Cultivated fields, waste grounds, steppe
Fumaria sp.	NA	CH	Annual herbaceous plant	Cultivated fields, waste grounds
Aegilops	NA	NE	Annual grasses	Cultivated fields, waste areas, grasslands,
Avena sp.	NA	NE	Annual grasses	Cultivated fields, waste areas

Table 5.1: Habitat preferences of wild taxa (identified at least to Genus level), AC= Aceramic, NE= Ceramic Neolithic, CH= Chalcolithic, RA= Rahmatabad, NA= Nurabad, MA= Mehrali

Taxon	Site	Period	Lifecycle	Habitat preferences
Eremopyrum sp.	RA, NA	AC/NE/CH	Annual grasses	Waste grounds, hillsides, dry steppes, disturbed grounds, over grazed pastures,
Lolium sp.	RA	CH	Annual/perennial grasses	Cultivated fields, along ditches, disturbed grounds
Rumex sp.	NA, MA	CH	Annual/perennial	Cultivated fields, along ditches, riverbanks, marshes
Polygonum sp.	RA	AC/NE/CH	Annual/perennial herbaceous and woody shrubs	Cultivated fields, ditches, mostly moist to wet areas
Adonis sp.	RA	AC	Annual/perennial herbaceous plant	Cultivated fields, waste areas, hillsides
Galium sp.	RA,NA,MA	NE/CH	Annual/perennial herbaceous plant	Annual species of *Galium* are weeds of fields and cultivated grounds , the perennials often grow in mountainous areas
Hyoscyamus sp.	MA	CH	Perennial herbaceous plant	Dry lands, Irrigated fields, waste grounds
Thymelaea cf. *passerine*	RA	CH	Annual herbaceous plant	Cultivated fields, dry/sandy places

Table 5.1: continue

Taxa												**Classification group**
	Mar	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	
Centaurea sp.		×	×	×	×	×	×	×				Intermediate
Lithospermum cf. *tenuiflorum*	×	×	×									Early
Capparis sp.				×	×	×	×	×				Late
Silene sp.		×	×	×	×	×	×					Intermediate
Vaccaria cf. *pyramidata*	×	×	×	×	×							Early
Salsola sp.			×	×	×	×	×	×				Intermediate
Convolvulus sp.		×	×	×	×	×						Intermediate
Brassica /Sinapis type		×	×	×	×	×						Intermediate
Carex cf. *divisa*	×	×	×									Early
Bolboschoenus cf. *glaucus*	×	×	×	×	×	×						Intermediate
Astragalus sp.	×	×	×	×	×	×	×					Intermediate
Trigonella cf. *astroites*	×	×	×	×								Early
cf. *Ornithogalum*	×	×	×	×								Early
Malva sp.		×	×	×	×	×	×					Intermediate
Fumaria sp.		×	×	×	×	×						Intermediate
Aegilops	×	×	×	×								Early
Avena sp.		×	×	×	×							Intermediate
Eremopyrum sp.		×	×	×	×	×						Intermediate
Lolium sp.		×	×	×	×	×						Intermediate
Rumex sp.		×	×	×	×	×	×					Intermediate
Polygonum sp.		×	×	×	×	×	×	×				Intermediate
Adonis sp.	×	×	×	×								Early
Galium sp.		×	×	×	×	×	×					Intermediate
Hyoscyamus sp.			×	×	×	×	×					Intermediate
Thymelaea cf. *passerine*	×	×	×	×	×	×	×					Intermediate

Table 5.2: classification of wild/weedy taxa based on their flowering time in relation to the cereal harvest time

Wild/wed taxa	**Total number of items**	**Ubiquity**	
		n =100	
		u	**%**
Centaurea sp.	4	1	1%
Lithospermum cf. *tenuiflorum*	4	3	3%
Capparis sp.	38	3	3%
Silene sp.	5	4	4%
Vaccaria cf. *pyramidata*	4	2	2%
Salsola sp.	1	1	1%
Convolvulus sp.	2	1	1%
Brassica/Sinapis type	4	2	2%
Carex cf. *divisa*	139	5	5%
Bolboschoenus cf. *glaucus*	67	5	5%
Cyperaceae	99	15	15%
Astragalus sp.	150	41	41%
Trigonella cf. *astroites*	19	7	7%
Small-seeded legumes	40	14	14%
Ornithogalum sp.	4	3	3%
Malva sp.	2	1	1%
Fumaria sp.	2	2	2%
Aegilops spikelet	3	2	2%
Avena sp.	2	2	2%
Eremopyrum sp.	12	8	8%
Lolium sp.	1	1	1%
Gramineae (medium size grass seeds)	55	24	24%
Rumex sp.	3	2	2%
Polygonum sp.	5	5	5%
Adonis sp.	2	1	1%
Galium sp.	12	8	8%
Hyoscyamus sp.	1	1	1%
Thymelaea cf. *passerine*	1	1	1%

Table 5.3 frequency of wild/weedy taxa, n= total number of samples from the three studied sites, ubiquity count = the number of samples in which the species is found, % = the number of occurrences of a species in samples compared to the total number of analysed samples.

5.3 Wood taxa

5.3.1 Taxon: *Amygdalus* sp.

Family: Rosaceae

Description: Distinct growth boundaries. Ring porous. Large vessels in earlywood solitary or in short radial groups. In latewood vessels are small and mostly solitary. Rays mostly multiseriate, uniseriate rays present as well (4-8 cells wide). Simple perforation plates. Spiral thickenings in vessels.

5.3.2 Taxon: *Pistacia* sp.

Family: Anacardiaceae

Description: Ring porous. Large solitary pores in the earlywood, pores are small and arranged in radial bands or clusters in the latewood. Sometimes tyloses present in earlywood vessels. Simple perforation plates. Rays bi- to 3-5seriate, heterogeneous. Resin canals present. Spiral thickenings in vessels.

Habitats: In general, *Pistacia*– *Amygdalus* steppe-forest forms a vegetation belt around the Zagros oak woodland (Zohary, 1973). *Pistacia* is reported as the dominant taxon of the steppe forest association commonly found with *Amygdalus* spp. or (*Prunus amygdalus*). This association is widespread on the lower slopes of the Zagros (*ibid*). The area under study lies across the heart of the southwestern Zagros where different species of *Amygdalus* (*A. reticulata, A. elaeagnifolia*, *A. hussknechtii*, *A. glauca, A. scoparia* and *A. eburnea*) and *Pistacia* (*P. atlantica* and *P. khinjuk*) grow as trees and shrubs (Mozaffarian, 2009; Negahdarsaber *et al*., 2003; Nejabat *et al*., 2017; Vafadar, *et al*., 2010; Khalily, 2008; Pazuki *et al*., 2010; Khatamsaz, 1992; Owji and Hamzehpour, 2012).

5.3.3 Taxon: *Quercus* sp.

Family: Fagaceae

Description: Ring porous. Distinct growth rings. Solitary large pores at earlywood, small pores at latewood in radial to dendritic arrangement. Simple perforation plates. Homogenous rays, of two types: uniseriate and multiseriate (>10 cells wide). Large vessel-ray pits.

Habitats: *Quercus brantii* (Persian oak) is one of the most important woody species of the Zagros forests; it usually appears in pure stands and has an altitudinal distribution of 800 to 2400 m a.s.l, indicating its ecological flexibility (Zohary, 1973; Hosseini *et al*., 2008; Pourhashemi *et al*., 2013; Hassanzadh Navroodi *et al*., 2015).

5.3.4 Taxon: *Juniperus* sp.

Family: Cupressaceae

Description: Distinct growth rings. Gradual transition from earlywood to latewood. No resin canals. Axial parenchyma cells. Tangential walls of ray cells are thin with nodules. Pits cupressoid/taxodioid generally in earlywood. Ray height mostly 2-5.

Habitats: In general, juniper can survive under harsh climatic conditions and occurs in the mountain chains and higher elevations in Iran as trees growing up to 25 m and occasionally as shrubs. The Zagros mountain chain in the west and southwest of Iran has been reported as one of its natural habitats. This genus is represented in Iran by five species, with *Juniperus excelsa* as the most common, which also forms open forests growing mixed with *Acer monspessulanum* and *Amygdalus scoparia* in the mountainous areas of the Fars province (Mozaffarian, 2009; Khalily, 2008; Assadi, 1998; Baravardi *et al*., 2014). It also comprises parts of oak-scrub communities with *Pistacia khinjuk* and *Pistacia atlantica* in the Junipereto-Pistacietea steppe forests of Iran (Zohary, 1973).

5.3.5 Taxon: *Tamarix* sp.

Family: Tamaricaceae

Description: Ring to semi-ring porous. Pores are large in earlywood and small in latewood, solitary or in small groups. Heterogeneous multiseriate rays (6- to 20 seriate). Vessels storied together with parenchyma cells. Simple perforation plates. Small and numerous ray-vessel pits.

Habitats *Tamarix* spp. are adaptable halophytic and xerophytic plants that appear as shrubs, semi-shrubs and trees that can grow up to 18 m in height and regenerate quickly from cutting. They are generally more drought-tolerant and numerous species are adapted to moist and often saline soils in arid and semi-arid climates. Around twenty-five species of *Tamarix* are reported from Iran and two species (*T. mascatensis* and *T. kotschyi*) from the Fars province (Khalily, 2008; Arianmanesh *et al*., 2015; Akhani *et al*., 2019).

5.3.6 Taxon: *Salix*/*Populus* sp.

Family: Salicaceae

Description: Diffuse to semi-ring porous. Pores mostly in short radial multiples, rarely solitary in earlywood. Uniseriate rays, generally homogenous. Simple perforation plates. Large and simple ray-vessel pits.

Habitats: In the areas with semi-arid climate, willow and poplar can survive in locations where there are permanent water sources, like near streams or springs (Willcox, 1990). In the Fars province, two species of *Populus* (*P. alba* and *P. nigra*) and one species of *Salix* (*S. excelsa*) have been reported, generally occurring along the rivers and streams (Sabeti, 1966; Miller, 1982, p. 187).

5.3.7 Taxon: *Fraxinus* sp.

Family: Oleaceae

Description: Ring-porous. Large pores in earlywood, solitary or in short radial multiples of 2-3. Latewood pores are small with similar arrangement and distinctly paratracheal parenchyma. Simple perforation plates. Rays bi- to 3-4seriate generally homogenous. Vessel-ray pits small and numerous. Libriform fibres present.

Habitats: Two species of *Fraxinus* (*F*. *excelsior* and *F*. *angustifolia*) are widely distributed in Iran, the former is best known for producing timber (Kaveh *et al*., 2014). Both species of *Fraxinus* are observed in Fars (Khalily, 2008).

5.3.8 Taxon: *Ulmus* sp.

Family: Ulmaceae

Description: Ring-porous. Large pores in earlywood, latewood pores grouped in oblique to tangential bi-to 4 seriate bands. Simple perforation plates. Rays 4- to 5-seriate, mostly homogenous. Spiral thickenings present in small vessels.

Habitats: In general, four *Ulmus* species grow in Iran as trees. *U. boissieri* is reported as an endemic species also growing in the Zagros forest (Mozaffarian, 2009).

5.3.9 Taxon: *Rhamnus* sp.

Family: Rhamnaceae

Description: Distinct growth boundaries. Diffuse- to semi-ring-porous. Pores solitary or in small cluster forming dendritic flame-like bands. Simple perforation plates. Biseriate rays, heterogenous. Distinct spiral thickenings.

Habitats: In general, eight species of *Rhamnus* grow in Iran usually as small trees and shrubs and two species (*R. persica* and *R. cornifolia*) are reported from Fars (Sabeti, 1966; Mozaffarian, 2009; Azadbakht *et al*., 2015).

5.3.10 Taxon: *Acer* sp.

Family: Aceraceae

Description: Diffuse porous, pores widely spaced solitary and in short radial of two or more. Simple perforation plates, distinct spiral thickenings, homogenous rays, 2 to 4 seriate.

Habitats: The Zagros Mountains have been reported as one of the main distribution centres of *Acer* (maple) in Iran. Among eight different *Acer* species that grow in Iran, *Acer monspessulanum* has the greatest range of distribution and diversity occurring as small trees and sometimes shrubs in some harsh conditions (Mozaffarian, 2009; Amini *et al*., 2016; Nikzat Siahkolaee *et al*, 2017). In the Fars province, *A. monspessulanum* is reported (Miller, 1982; Khalily, 2008).

Chapter 6

Rahmatabad: Archaeobotanical analysis

This chapter presents the results of the analysis of the macrobotanical remains (seed and wood charcoal) recovered from Rahmatabad to offer insights into general sample composition, frequency and abundancy of the taxa, as well as the use of space. The archaeobotanical results are presented based on chronological order.

6.1 The samples and context types

A total of 98 samples were processed from the first season of excavation at Rahmatabad from a variety of contexts, including room fill deposits, pits, domestic hearths, and pottery kilns, in horizontal and stratigraphic trenches. Of these only thirteen samples (<15%) contained seed/fruits and chaff remains in variable amounts (Table 6.1). Four of these samples recovered from the Aceramic Neolithic deposits of a deep sounding in trench A, one sample from the Pottery Neolithic deposits of Trench A and eight samples from the Chalcolithic deposits of horizontal excavations in Trenches A, B, C and D. Overall, the archaeobotanical assemblage had a low density of archaeobotanical material (seeds and other plant parts) ranging between 0.2 and 6.8 items per Litre of processed soil. Most of the samples contained less than 20 plant remains and only two samples from the Aceramic deposits (A49, A66) included more than 50 items. The overall archaeobotanical assemblage amounts to a total of 289 items. Almost all plant remains were preserved by charring with the exception of few mineralised seeds of *Lithospermum* cf. *tenuiflorum* (gromwell). Although the quantity of the material was low, the preservation of the charred specimens was relatively good, and it was possible to identify most of the specimens to family, genus or species level. The contextual and chronological information of each sample, the volume of processed sediments, the density and the list of identified taxa is presented in Table 6.2. In addition, the ubiquity and abundance of each plant taxon and type for all chronological phases are available in table 6.3. The archaeological information of this site was gathered from the following publications and excavation reports: Bernbeck *et al*., 2005a; Bernbeck *et al*., 2005b).

Trench	Period	Total number of processed samples	Number of samples with archaeobotanical material
A	Aceramic	22	4
A	Neolithic	15	1
A	Chalcolithic	12	3
B	Chalcolithic	25	2
C	Chalcolithic	14	3
D	Chalcolithic	10	1

Table 6.1. Summary of flotation samples collected from Rahmatabad's excavation units

6.2 Plant remains from the Aceramic and Neolithic deposits

In summary, a total of 146 items of plant remains and 19 taxa were identified in the Aceramic samples. These included cereal grains, pulses and mostly wild taxa (Table 6.2). Cereals were only present in the form of grains and no cereal chaff (rachis segments, glume bases and culm nodes) was found in these four samples. The absence of cereal chaff among the samples could be the result of taphonomic factors. For example, charring experiments have indicated that cereal chaff has less chance of being preserved than cereal grains (Boardman and Jones 1990). The small size of the assemblage could also have contributed to the observed pattern. The identified cereals consisted of emmer wheat grains (*Triticum dicoccum*), indeterminate wheat grains (*Triticum* sp.) and indeterminate cereal grains. In terms of cultivated pulses, only two large indeterminate legumes were found in sample A66, (Yellowish, sandy fill) and due to their poor preservation, it was not possible to assign them to genus or species level. It is important to note that although wild pistachio (*Pistacia*) and almond (*Amygdalus)* nuts/shells were absent in the Aceramic seed assemblage, wood charcoal remains of both these taxa were identified in the wood assemblage of this phase (Table 6.4). A wider variety of wild taxa was present in the Aceramic assemblage although they occurred in small numbers. In total, 15 wild herbaceous taxa were identified and, in most cases, the identification was restricted to family or genus level due to relatively poor preservation and the low numbers of seeds (Table 6.2). The Aceramic samples were relatively similar in terms of archaeobotanical contents. In order to distinguish the sources of recovered plant remains, contextual information, sample composition, the ecology of wild taxa and other available archaeological finds were investigated. Three samples from this cultural phase derived from contexts classified as fill deposits (A 49, A51, and A66). Two of these contexts (A 49 and A66) produced the richest archaeobotanical samples of the whole assemblage with 6.8 and 4.3 items per liter of sediment. Due to the small size of excavated area in the sounding trench there is limited information available about the exact function of these Aceramic contexts. These samples contained a mixture of few cereal grains, pulses and a mixture of wild species from a variety of habitats, including wet environments (*Bolboschoenus* cf*. glaucus,* Cyperaceae), cultivated fields or disturbed grounds (*Eremopyrum* sp.), as well as various other pasture and ruderal weed species (*Astragalus, Trigonella*). Charcoal fragments recovered from fill deposits were identified as pistachio (*Pistacia* sp.), almond (*Amygdalus* sp.), willow/poplar (Salicaceae) and ash (*Fraxinus* sp.) (predominantly *Pistacia*). In addition to the plant materials substantial amount of animal bone remains, lithic and clay objects were recovered from these deposits, suggesting their secondary deposition from a variety of sources and activities in the habitation area. The fourth sample (A69) was recovered from an ashy deposit (associated with a fireplace).This sample had the lowest density of plant material and contained only a few seeds of wild taxa that were a mixture of possible arable or ruderal weeds and wet-loving species, some of which may have been burnt accidentally or as part of fuel. One of the Rahmatabad archaeobotanical samples (A 44, Buff, compact wall with surface) derived from the pottery Neolithic deposits of phase V in Trench A. The archaeobotanical data from this sample were recovered from sediments that represented collapsed building material containing the remains of Mushki style sherds, which are characteristic of the Fars pottery Neolithic period. The sample had a low density (1.55 items / L) of archaeobotanical material containing 14 plant items in total. The cereal assemblage included emmer, indeterminate wheat grains and six-raw barley (*Hordeum vulgare*) in both forms of grains and chaff. The few identified wild species were a mixture of possible steppe/grassland, wet-loving species and arable/ruderal habitats (Tables 6.2). Similar to the Aceramic samples, this sample was also relatively rich in wood charcoal remains and the remains of cereal grains and chaff as well as seeds of wild taxa was a small component of the flotation sample. The identified wild plants could have entered the site through different routes, including discarding weeds of crops, kindling, through animals (dung used as fuel) or collected from the surrounding environment for different purposes. Ecological information relating to the preferred habitats, flowering/fruiting time of the identified wild taxa were considered to investigate the possible routes of entry (details available in chapter 5). In addition, the available ethnobotanical research was also used to assess the potential uses of wild plant taxa. According to the modern ecology information, most of the identified wild taxa from the Aceramic and Neolithic phases could be either from arable or ruderal habitats. Small seeded legumes depending on species could also grow in steppes and grasslands. Classification of the identified wild/weed taxa based on their flowering/fruiting time in relation to the cereal harvest time showed that most of the taxa are in the intermediate group (coincide with harvest time and continues beyond it). This indicates that some of them might have been harvested with cereal crops, however other routes should be also considered. For example, considering the ecological information it is more likely that some wild taxa, such as *Adonis* sp., *Lithospermum* and *Eremopyrum,* have been brought into the site with the harvested crops and discarded in the domestic fire. It is worth noting that *Adonis* plants have toxic content that could cause animal poisoning (Karimi, 1995). In the Aceramic wild plant assemblage, the seeds of *Capparis* sp. and *Bolboschoenus* cf. *glaucus* occurred in higher quantity in comparison to the other wild taxa. Perennial shrubs of (*Capparis spinosa*) commonly grow in the region and has great economic value (medicinal and culinary uses). The capper plants are highly drought tolerant plants growing in arid and semi-arid climate zones in Iran (Mozaffarian, 2006; Mosaddegh *et al*., 2012). The presence of capper seeds has also been reported from the Neolithic archaeobotanical assemblage of Ali kosh in southwest of Iran (Helbaek, 1969). Helbaek (1969, p 399) notes '' Heard men and other passers-by eat the fruits in the autumn when they are mature''. The fruiting time of *Capparis* (late taxa) indicates that it is unlikely to have been harvested with crops. The presence of capper seeds in two samples (A49, A51) of the Aceramic assemblage might represent the use of this edible wild plant for human consumption or medicinal purposes. Charred seeds of *Bolboschoenus* cf. *glaucus* were also recovered from two samples (A 66 and A69) in relatively large numbers (62 items in total, 57 occurred in a single sample). See-club rush has been frequently found in archaeological sites of Southwest Asia and Iran (Savard *et al*., 2006; Helbaek, 1969; van Zeist *et al*., 1894; Whitlam *et al*.,2013; Rahiel *et al*.,2012, 2015; Weide *et al*.,2017; Wollstonecroft *et al.,* 2011). This plant could have arrived on archaeological sites through different routes. The seeds/tubers of see-club rush could have been used as food for humans or grazed by animal and enter the site through animal dung burnt as fuel. Stalks of this plant can be used as craft/building material (Wollstonecroft *et al.,* 2011). They also could have entered into the sites as weeds harvested with crops. No tubers of *B. glaucus* was found in the samples and only the charred nutlets were present in the samples of this phase. However, based on the available data, the deliberate gathering of this plant for consumption cannot be suggested with certainty. Other common wild taxa occurring in all samples were small seeded legumes (mainly represented by *Astragalus* sp. and *Trigonella*), present in small numbers. High proportion of small seeded legumes has been attested at several prehistoric sites elsewhere in Iran too and various purposes have been suggested for their use, such as human consumption, animals grazed/fodder, fuel (including animal dung), and cultivation with crops as natural field fertilizer (Helbaek, 1969; van Zeist *et al*., 1984; Whitlam *et al*., 2013; Rahiel *et al*., 2012, 2015; Weide *et al*., 2017; Fazeli *et al*., 2009; Tengberg, 2003, 2004; Roustaei *et al*,2015). *Astragalus* is one of the most characteristic features of vegetation of this region and local people regularly collect woody shrubs of this plant for fuel (Maassoumi, 1990, 1993, 2003). Animals also commonly eat non-spiny species of *Astragalus*. In addition to their uses as fuel and grazing/fodder, some *Astragalus* species also have medicinal properties (Mosaddegh *et al*., 2012; Karimi, 1995; Mozaffarian, 2009). In arid and semi-arid regions where archaeobotanical assemblages are mostly preserved by charring, the burning of animal dung as fuel is regarded as one of the main sources of plant remains (Miller 1984, 1996; Miller and Smart 1984; Anderson and Ertug- Yaras, 1998; Charles, 1998; Valamoti and Charles 2005). The composition of dung –derived plat materials is the result of a long and complex series of processes including plant selection, animal digestion, preparation of fuel and incorporation into the archaeological record (Charles, 1998; Wallace and Charles, 2013). Charring and animal digestion are considered as two destructive processes typically resulting in over-representation of resilient plant parts (Valamoti and Charles 2005; Wallace and Charles, 2013). The experimental studies on the effect of animal digestive processes (sheep and goat) on plant composition have demonstrated that crop material rarely survive digestion. In contrast, small sized wild seeds (less than 2 mm) or hard- coated ones have high survival rate in the animal digestive system (Valamoti and Charles 2005; Wallace and Charles, 2013). In one experimental work, the glume wheats chaff recovered from the goat pellets that survived digestion appeared to be damaged demonstrating ‘’rugged ‘’ surface on their internal surface (Valamoti, 2013). The ethnographical and experimental works have showed that the plant content of animal dung could survive charring, however the temperature and the duration of fire could significantly affect their survival (Bottema, 1984; Miller, 1984; Charles, 1988; Valamoti and Charles 2005). It is important to note that in the Aceramic and Neolithic samples of Rahmatabad no animal dung pellets (whole), dung amorphous lumps or grain/seeds with adhering dung material was observed. The emmer chaff (spikelet forks and glume bases) found in the Neolithic sample (A44) had smooth surface and were well preserved bearing no indications that they were the remains of digested material from animal dung. As a result, it is unlikely that the analysed material in this phase have dung origin. The recovered cereal grains (glume wheat grains, barley) and pulses could have been the remains of food preparation/consumption episodes, accidentally burnt in the fire. Generally, seeds preserve better under charring compared to chaff (Boardman and Jones 1990) therefore the presence of emmer chaff in the deposits of a room fill (A44) points to the possibility that some crop processing activities were taking place in this space. Glume wheats are usually stored in their spikelets and require rigorous de-husking, which would normally take place piecemeal based on the individual needs (Jones *et al*., 1986). Based on the consistent presence of wood charcoal remains in the analysed samples it can be suggested that wood might have been the primary source of fuel used in these contexts. The overall picture of the analysed samples from this phase showed a mixture of crop remains, wild taxa and wood charcoal fragments indicating secondary accumulation of food preparation and consumption episodes mixed with fuel scattered across the excavated area.

6.3 Plant remains from the Chalcolithic deposits

The analysed samples of this phase derived from trench A (contexts 28 and 30), trench B (contexts 51 and 92), trench C (contexts 20, 59, 102) and trench D (context 35). Among the Chalcolithic samples Trench C produced the highest density of material with 2.05 items/L (context C 20) while the lowest density of material was found in the sample from Trench D with 0.2 items/L (context 35). Overall, the Chalcolithic plant assemblage came from two main levels, one containing purely industrial installations, another one with substantial domestic architecture (Bernbeck *et al*., 2005). In summary, a total of 129 specimens and 23 taxa were identified in the Chalcolithic assemblage that comprised cereals, pulses, nutshell fragments and wild taxa. In comparison to the Aceramic assemblage, the wild taxa were less frequent and mostly occurred sporadically. The cereal grains and chaff (glume wheat predominantly) were the main component of these samples. The overall ubiquity and abundance of each plant taxon and type is available in table 6.3. The cereal component of these samples was a mixture of glume wheat and 6-row barley both in the form of grain and chaff. In addition, a few indeterminate glume wheat grains and unidentifiable cereal grains were present. In the pulses group there were four specimens identified as *Vicia/Lathyrus* sp. (vetch/grass pea). A few nutshell fragments of almond and pistachio were also present among the samples. In addition, there were a total of 30 items from 14 wild/weedy taxa, including weeds of cultivation, ruderal, steppe/grassland and species typical of wet environments. Two of these samples (A28, A30) derived from deposits of an area reported as the pottery production phase of Rahmatabad. In this phase, a fire installation (pottery kiln) was found in the northwest of the trench A. Finds from this installation included pottery vessels, building material from the kiln, such as bricks, stones and burnt clay, as well as large amount of slag (Bernbeck *et al*., 2005). Both samples were collected from the secondary deposits of this area containing a mixture of ash and compact clay pieces from the structural remains. Archaeobotanical samples from this area included a few cereal grains and chaff (emmer and barley), nutshell fragments of almond and a low number of wild taxa from a variety of habitats (arable/ruderal, grassland). Both samples also contained wood charcoal remains of almond, pistachio, ash and to lesser extend willow/poplar (Table 6.4). The mixture of crop items, wild seeds and wood charcoal in these sample point to the variety of sources/activities. The nutshell fragments of almond could represent food residue, burnt as part of fuel after consumption, it is also possible that some of the nuts have entered through branches/twigs used directly as fuel. The rest of the Chalcolithic samples were retrieved from the area reported as a residential phase of Rahmatabad. According to the Rahmatabad excavation report (Bernbeck *et al*., 2005b), this area has been used for various activities involving fire, as indicated by a large fire installation, burnt lenses, and complex ash-filled pits. Sample (B51) recovered from gray ash deposits of a large fire installation that consisted of three distinct chambers in trench B. It is suggested that this fire installation was used for domestic purposes (cooking/heating). The archaeobotanical content of the *in situ* domestic hearth included a single emmer grain and one unidentified cereal grain, two wild grasses (one identified as *Eremopyrum* sp.) and one seed of *Vaccaria* cf. *pyramidata*. In addition, relatively high quantity of wood charcoal fragments was also present in the same sample that have not been analysed yet. The identified wild taxa were from arable/ruderal habitats. It can be suggested that some food related activities involving fire were taken place in this domestic hearth and the remains of cereal grains could have been burned either accidentally during cooking or could be the result of burning crop-processing debris in the fire. Equally weedy taxa may indicate that some crop processing, such as removal of the larger weeds prior to preparation of the crop for food consumption, was taking place near there. Another sample from this area (B92) derived from deposits of an external area associated to a room in level III of trench B. The ash deposits of this pit also contained bone remains, charcoal fragments, pottery remains and stone artifacts, indicating some intentional deposition of materials (Bernbeck *et al*., 2005b). Plant remains recovered from this area contained a mixture of few cereal grains, one fragment of pistachio nutshell, as well as low numbers of wild taxa from variety of habitats. Although charcoal fragments of *Pistacia* (predominant wood taxa), *Amygdalus* and *Tamarix* were present, only one fragment of pistachio nutshell was found in this sample that could have been attached to a branch burnt as fuel. Considering the context of this sample, it represents food and fuel debris possibly generated in the residential building nearby. The last three samples were taken from contexts (C20, C59, and C102) in trench C that yielded a relatively higher quantity of material. Context C20 was collected from the ashy deposit of a small pit found in an area where several other pits with relatively standard size (20 to 30 cm diameter) were found. An accumulation of stones and shreds were also recovered from this space. In some of these pits, sherds were used to stabilise the conical sides of these pits, and pebbles to cover the bottom, and it is suggested that these pits might have been used for heating (Bernbeck *et al*., 2005b). The other two samples (C59, C102) were recovered from room fill deposits of buildings in level III of trench C containing complex features, such as ovens inside the rooms and working platforms in open spaces. A wide variety of objects were also found in the buildings, including ceramic pestles, tokens, few figurines, spindle whorls and high quantity of pottery remains. All these three samples were quite similar in terms of their archaeobotanical components, containing a mixture of predominantly cereal grains and chaff (emmer, barley, indeterminate wheat grains), and smaller number of pulses, nuts, and wild species from arable/ruderal and grassland habitats. Sample C102 from this area also contained charred wood remains of almond, pistachio, tamarisk and willow. In addition to the plant remains derived from inside the rooms (C59, C102) and a pit (C20) located in the external area of the same building, charred dung pellets (whole and fragmented) were also present. Based on the size, shape (the pointed end of the pellets) and their surface texture, the pellets were identified as deriving from sheep/goat. The charring experiments on sheep dung have shown the fire reduces the weight of pellets (up to 50%) while the effect on the size is less significant (Linseele *et al*., 2013). Dung pellets usually catch fire quickly and turn into ashes (depending on the types of fire); therefore, the charred pellets found in archaeological deposits must have been shortly exposed to fire (Charles, 1998; Linseele *et al*., 2013). At present, there is no information available regarding the animal species or the composition of Rahmatabad bone assemblage, however the frequent presence of domesticated sheep, goat and cattle has been attested from other Neolithic and Chalcolithic sites of the region (Mashkour *et al.*, 2006; Mashkour, 2009; Mashkour and Bailon 2010). The presence of charred livestock pellets indicates the burning of dung as a possible source of fuel in the Chalcolithic phase of Rahmatabad. In the Fars region the use of animal dung (unprocessed or in the form of dung cake) is one of the traditional fuel sources commonly used for cooking and heating purposes. The preparation of dung usually carried out during spring and summer by women and the mixture of compacted dung, straw and water, is rolled into balls and then flattened to be sun dried (Miller, 1982, p 91). Wood has been reported as the preferred choice of fuel for domestic purposes in the region, however, it cannot be used frequently due to limited available sources and as a result, most fires are dung cake fueled or fueled with a mixture of wood and dung (*ibid*). Other dried plants (sesame) and straw are also used nowadays as part of fuel particularly for bread baking fires ''tanur'' (Miller, 1982, p 91).

The intact plant content of the preserved dung pellets could provide important information on the livestock feeding regime (Miller and Smart 1984; Anderson and Ertug- Yaras, 1998; Charles, 1998). In total four whole and six fragmented pellets were found in these three samples. The complete pellets were dissected to observe their content. In all completed pellets, a compact mass of plant parts (cereal chaff/grass stem) and other unidentifiable material was observed. No visible seed or grain was found embedded within the recovered dung pellets. Based on the plant content of these pellets it can be suggested that cereal chaff (at least partly) has been used as fodder. The plant material embedded in the dung pellets were very fragmented and badly damaged whereas the overall state of other plant remains found in physical association to dung pellets was good and no dung material adhering to them was observed. Moreover, no evidence of digestion, such as any rugged surface, was seen on the glume whet chaff remains found mixed with the dung material in these three samples. At present, only cereal chaff was observed in dung pellets, therefore co-occurrence of dung remains and cereal grains and chaff in the samples could been the result of mixing either deliberately (in dung cake preparation) prior to deposition or by post-depositional processes. In Rahmatabad samples, this pattern is more likely to be the result of post depositional mixing as most materials are recovered from secondary deposits. Emmer spikelet forks and glume bases were found mixed with glume wheat grains in most of the samples (higher concentration in residential buildings) indicating de-husking practices taking place in this domestic area. Crop processing residues could have been discarded into fires, some of which were fueled at least partly by dung. The wild taxa observed in connection with dung samples included very few seeds mostly from arable/ruderal habitats. As wood charcoal remains (mostly *Pistacia* and *Amygdalus*) were recovered from most of the Chalcolithic samples, it appeared that dung (dung cake) has been used as (complementary) fuel or in conjunction with wood in the analysed samples. Due to the presence of dung pellets in the samples it is possible that some material might have entered through this route, however it is not an unambiguous indicator that all recovered plant remains have dung origin. For example, considering the high survival rate of some small sized or hard- coated wild seeds (e.g. small seeded legume, *Polygnum* sp.) these taxa have the potential to be dung derive. However, based on the available evidence this cannot be fully established or completely rolled out. In the wild assemblage, species growing in arable/ruderal habitats were well represented and in terms of seasonality, the flowering/fruiting time of most wild taxa coincide with the crop harvesting time and continues beyond it (details in Chapter 5). Therefore, they may or may not have arrived into the site as potential crop weeds.

6.4 The wood charcoal remains

Eight charcoal samples amounting to 238 wood charcoal fragments were analysed from two occupation phases of Rahmatabad. The charcoal assemblage included two Aceramic samples from Trench A (contexts 59 and 49) and six Chalcolithic samples from Trench A (contexts 28, 30), Trench B (context 92), Trench C (context 102) and Trench D (contexts 25, 30). The results (including the list of identified taxa, absolute fragment counts, charcoal weight, volume of floated sediment and context information) are presented in Table 6.4. The raw/percentage fragment counts and ubiquity (sample presence) from each phase are available in Table 6.5. A total of 66 charcoal fragments (1.124 g) were analysed from a fill sample (A49,) and an ash deposit (A59) of the Aceramic phase and total of 182 fragments (23.9 g) from 4 room fill samples (A28, A30, C102, D35) and 2 disposal pits (B 92, D25) of the Chalcolithic phase. The Rahmatabad charcoal assemblage comprised five charcoal taxa, including almond (*Amygdalus*), pistachio (*Pistacia*), ash (*Fraxinus*), tamarisk (*Tamarix*) and willow/poplar (Salicaceae). *Amygdalus* was present in all eight samples (100% presence) being the most common taxon, followed by *Pistacia*. Other taxa such as *Tamarix*, Salicaceae and *Fraxinus* also occurred throughout the sequence and display similar presence scores values (50 %) in both periods (Table 6.5). According to the percentage fragment counts, *Pistacia* and *Amygdalus* together accounted for over 70 % of the sample composition within each assemblage (Table 6.5 and Fig 6.1). The Aceramic assemblage had low charcoal density and no fragments >2 mm were present however; the number of unidentifiable fragments was low. The Chalcolithic charcoal assemblage had higher densities of charcoal remains and most samples contained 4mm charcoal fragments. The number of unidentifiable fragments was also lower than the Aceramic phase indicating the overall good state of preservation (Table 6.4). Despite the fact that more samples were analysed from the Chalcolithic deposits the same range of wood taxa present in approximately similar proportions to the Aceramic phase were observed. Overall, based on the similarities observed in the taxonomic composition and relative proportions of individual wood taxa it appears that the same wood taxa were exploited throughout the occupation sequence at Rahmatabad. Fuel wood was probably gathered from the same vegetation catchments (*Pistacia-Amygdalus* steppe forests and riparian woodlands) that were available in the surroundings of the site (see also discussion in Chapter 9).

Rahmatabad	Trench	A	A	A	A	A	A	A	B	B	C	C	C	D
	Locus	**51**	**66**	**49**	**69**	**44**	**28**	**30**	**51**	**92**	**20**	**59**	**102**	**35**
	Phase	**AC**	**AC**	**AC**	**AC**	**NE**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**
	Context	**Fill**	**Fill**	**Fill**	**Fl**	**Fill**	**Fill**	**Fill**	**Fl**	**Ash**	**Pit**	**Fill**	**Fill**	**Fill**
	Volume (L)	**7**	**18**	**8**	**11**	**9**	**8**	**10**	**10**	**14**	**15**	**9**	**19**	**10**
	Items per/L	**1.7**	**4.3**	**6.8**	**0.8**	**1.6**	**0.5**	**1.1**	**0.5**	**0.9**	**2.6**	**1.6**	**2.1**	**0.2**
Cereals														
Triticum dicoccum grain		1	1	1		1	1		1		2	1	1	1
Triticum dicoccum spikelet fork						1		1			12	7	1	
Triticum dicoccum glume bases						2		1			9	1	8	
Triticum sp. grain		2		2		3	1	1			2	3	9	
Hordeum vulgare grain						1		1		2	1			1
Hordeum vulgare rachis													2	
Cerealia			2						1	3	7	2	8	
Pulses														
Fabaceae			2											
Vicia/ Lathyrus											1	1	2	
Fruit/Nuts (nutshell fragments)														
Pistacia sp.										1				
Amygdalus sp.							1	2					1	
Wild taxa														
Adonis					2									
Capparis sp.		4		30										
Lithospermum cf. *tenuiflorum*					1							1	2	
Bolboschoenus cf. *glaucus*			57		5	1								
Cyperaceae			8		2									
Labiatae			1	1										
Carex cf. *divisa*							1							
Chenopodiaceae				2	1									
Compositae										1				
Brassicaceae		1				1		1						
Polygonum sp.					1	1		1		1			1	
Salsola sp.			1											
Leguminosae Small		2	1	18	1			1		1	1			
Trigonella cf. *astroites*			2							1				
Astragalus sp.		1	3			2				1				
Galium sp.											1			
Gramineae						1		1	1	2	2			
Eremopyrum sp.		1							1			1	1	
Vaccaria cf. *pyramidata*									1				3	
Convolvulus sp.			2											
Thymelaea cf. *passerine*														1
Lolium sp.											1			
Wild Indet.		1						3	1		1	2		1
Animal dung remains											**+**	**+**	**+**	
Total		13	80	54	13	14	4	13	6	13	40	19	39	3

Table 6.2. List of identified taxa, densities of plant remains and contextual information from Rahmatabad assemblage. **AC**= Aceramic, **NE**= Pottery Neolithic, **CH**= Chalcolithic, Bakun phase

Phase	Aceramic			Neolithic	Chalcolithic		
Number of samples		**4**		**1**	**8**		
Number of taxa		**19**		**10**	**23**		
	Ubiquity %	**Total sum**	**Max per/S**	**Total sum**	**Ubiquity %**	**Total sum**	**Max per/S**
Cereals							
Triticum dicoccum grain	75	3	1	1	62	6	2
Triticum dicoccum spikelet fork	-	-	-	2	50	21	12
Triticum dicoccum glume bases	-	-	-	2	50	19	9
Triticum sp. grain	50	4	2	3	62	16	9
Hordeum vulgare grain	-	-	-	1	50	5	2
Hordeum vulgare rachis	-	-	-	-	12	2	2
Cerealia	25	2	2	-	62	21	8
Pulses							
Fabaceae	25	2	2	-	-	-	
Vicia lathyrus	-	-	-	-	37	4	2
Fruit/Nuts							
Pistacia sp.	-	-	-	-	12	1	1
Amygdalus sp.	-	-	-	-	37	4	2
Wild taxa							
Adonis	25	2	2	-	-	-	-
Capparis	50	34	30	-	-		
Lithospermum cf. *tenuiflorum*	25	1	1	-	25	3	2
Bolboschoenus cf. *glaucus*	50	62	57	1	-	-	-
Cyperaceae	50	10	8		-	-	-
Labiatae	50	2	1	-	-	-	-
Carex sp.	-	-	-	-	12	1	1
Chenopodiaceae	50	3	2	-	-		
Compositae	-	-	-	-	12	1	1
Brassicaceae	25	1	1	1	12	1	1
Polygonum sp.	25	1	1	1	37	3	1
Salsola sp.	25	1	1	-	-	-	-
Leguminosae Small	75	21	18	-	37	3	1
Trigonella cf. *astroites*	25	2	2	-	12	1	1
Astragalus sp.	50	4	3	2	12	1	1
Galium sp.	-	-	-	-	12	1	1
Gramineae	-	-	-	-	50	6	2
Eremopyrum sp.	25	1	1	1	37	3	1
Vaccaria cf. *pyramidata*	-	-	-	-	25	4	3
Convolvulus sp.	25	2	2	-	-	-	-
Lolium sp.	-	-	-	-	12	1	1
Thymelaea cf. passerine	-	-	-	-	12	1	1
Total:		**146**		**15**		**129**	

Table 6.3. Ubiquity and abundance for each plant taxon and type in Rahmatabad plant assemblage

Trench	A	A	Total	A	A	B	C	D	D	Total	
Context	**59**	**49**	**AC**	**30**	**28**	**92**	**102**	**25**	**35**	**CH**	
volume	**18**	**8**		**10**	**8**	**14**	**19**	**12**	**10**		
Description	**Ash**	**Fill**		**Fill**	**Fill**	**Pit**	**Fill**	**Pit**	**Fill**		
Time period	**AC**	**AC**		**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	
Total charcoal weight:	0.671	0.453	1.124	1.058	1.579	0.885	6.597	8.442	5.299	**23.9**	
4, mm weight:	-	-	-	-	1.203	-	2.343	3.186	3.472		
2,mm weight:	0.671	0.453	1.124	1.058	0.376	0.885	4.236	5.256	1.827		
Charcoal density	0.037	0.056	0.043	0.10	0.19	0.06	0.34	0.70	0.52	0.32	
Fr/Pr Index	0.14	0.19	0.13	0.2	0.13	0.02	0	0	0.04	0.06	
Amygdalus	11	2	13	12	1	7	10	8	39	70	83
Pistacia	28	8	36		10	23	10		4	47	83
Salicaceae		5	5		2		2			4	9
Fraxinus		2	2	12				4	2	18	20
Tamarix	1		1			4	2	19		25	26
Indet.	5	4	9	6	2	1	0	0	2	11	20
Total	35	21	66	30	15	35	24	31	47	182	238
Total (- Indet.)	30	17	57	24	13	34	24	31	45	171	

Table 6.4. List of wood taxa identified in the Rahmatabad charcoal assemblage, **AC**= Aceramic, **CH**= Chalcolithic, **Fr/Pr**= Fragmentation/Preservation index (In Asouti's assemblages, an index of <0.5 was used to indicate overall good preservation, 0.6-0.9 moderate to high proportions of indeterminate fragments and 1-5 very high proportions of indeterminate fragments showing poorly preserved fragments (Asouti, 2003: p. 1193).

Phase	**Aceramic**			**Chalcolithic**		
Taxa	**C**	**%**	**U**	**C**	**%**	**U**
Amygdalus (almond)	13	22.80	2	70	40.93	6
Pistacia (pistachio)	36	63.15	2	47	27.48	4
Salicaceae(willow/poplar)	5	8.77	1	4	2.33	2
Fraxinus (ash)	2	3.50	1	18	10.52	3
Tamarix (tamarisk)	1	1.75	1	25	14.61	3
Total	57	100	(n=2)	171	100	(n=6)

Table 6.5. Quantified anthracological data from Rahmatabad **C**= Absolute fragment count, **%** = Percentage fragment count, **U**= Ubiquity

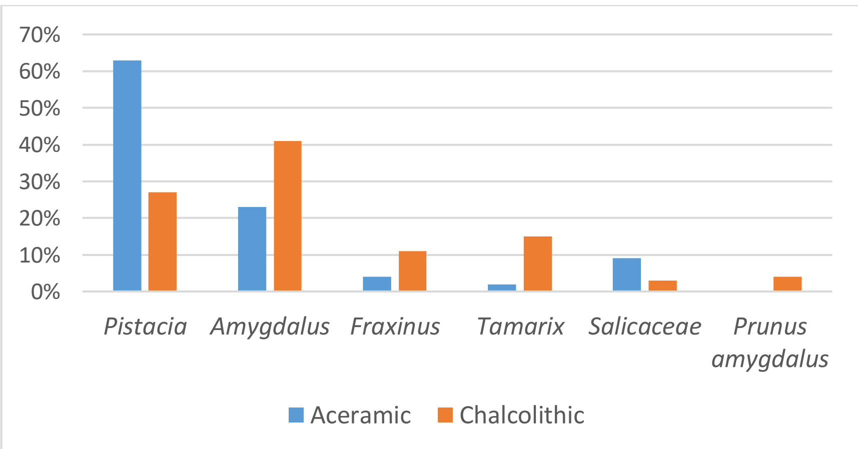


Fig 6.1. Bar chart showing percentage fragment counts of the main taxa represented in the Aceramic and Chalcolithic phases (n=8)

Chapter 7

Nurabad: Archaeobotanical analysis

This chapter presents the results of the analysis of the macrobotanical remains (seed and wood charcoal) recovered from Nurabad to offer insights into general sample composition, frequency and abundancy of the taxa, as well as the use of space. The archaeobotanical results are presented based on chronological order.

7.1 The samples and context types

A total of 63 samples were processed from two seasons of excavations at Nurabad during 2008 and 2009. Of these, forty- four samples (70% of the processed samples) contained archaeobotanical remains (Table 7.1 Fig 7.1). Thirty-three flotation samples were recovered from the Ceramic Neolithic deposits of Trench D and eleven samples from the Chalcolithic/Bronze Age deposits of Trenches D and C. The volume of processed sediments was relatively large, however depending on the size of excavated unit the volume of individual samples varied from 4 to 140 litres. The flotation samples contained archaeobotanical remains in variable amounts however, the vast majority of samples contained less than 20 plant items (excluding wood charcoal) and only two Neolithic samples (1046, 1088) had more than 50 items in total. Accordingly, most samples had low density of plant remains ranging between 0.02 to 4.47 items per litre of processed sediment (Table 7.2). The overall archaeobotanical assemblage amounts to a total of 752 items recovered from 1771 liters of processed sediments. All samples were preserved by charring and the overall state of preservation was relatively good allowing the identification of the specimens to family, genus or species level. The contextual and chronological information of each sample, the volume of processed sediment, the density and the list of identified taxa are presented in Tables 7. 2 and 7.3. The ubiquity and abundance of each plant taxon and type for both chronological phases are available in table 7.4. The archaeological information of this site was gathered from the following publications and excavation reports: Potts *et al*. 2009; Weeks *et al*. 2006, 2009.

Trench	Period	Total number of processed samples	Number of samples with archaeobotanical material
D	Neolithic	41	33
D	Chalcolithic	7	3
C	Chalcolithic	15	8

Table 7.1. Summary of flotation samples collected from Nurabad's excavation units

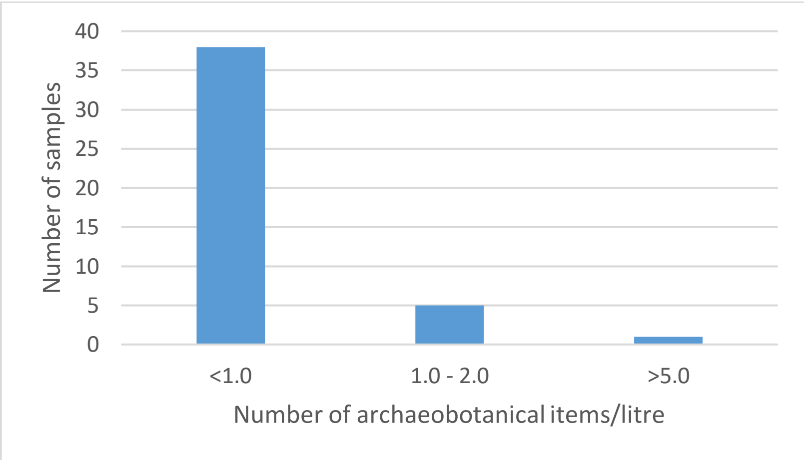


Figure 7.1. Density of plant remains across Nurabad samples

7.2 Plant remains from the Neolithic deposits

The Ceramic Neolithic deposits of Nurabad were characterised by Mushki pottery and various architectural phases with a relatively short duration. Overall, continuity in building structure, ceramic types and evidence from radiocarbon dating indicated that these Neolithic phases were deposited over the course of some generations in the first half of the 6th millennium B.C. The majority of Neolithic occupation consisted of substantial amounts of mudbrick and *chineh* rectilinear buildings with plaster coating, fire installations and other archaeological material, such as ceramics, chipped stones, animal bones and charred botanical remains (Weeks *et al.*, 2006, 2009). The end of this phase was dated to 4700 B.C. (Weeks *et al.* 2009). Most of the Neolithic archaeobotanical samples retrieved from secondary deposits of the habitation areas, including 19 samples deriving from room fill deposits, 10 samples from ash deposits (scattered layers of ash and burnt sediments) and 3 samples from mixed deposits near human burials. One sample was also collected from the ash content of a fire pit (D 1023). No evidence of storage contexts was observed in the excavated area. In trench D a total of 628 items of plant remains, corresponding to 26 plant taxa and types were recovered from 33 Neolithic samples (Table 7.3). The Neolithic plant assemblage consisted of charred grains and seeds, chaff as well as nutshell fragments. Cereals were the most abundant taxa in the assemblage, consisted of emmer wheat grains and chaff (*Triticum dicoccum*), einkorn wheat grains (*Triticum monococcum*), indeterminate wheat grains (*Triticum* sp.) and hulled barley (*Hordeum vulgare*) in both forms of grain and chaff (Table 7.2). Based on the morphology of the recovered barley rachis six-row barley was positively identified in the assemblage. In terms of grains, both straight and twisted ones were present; the latter present in smaller numbers but also verifying the presence of six-row barley. Einkorn wheat grains were identified as one-grained einkorn (laterally compressed, convex and pointed grains) and only two einkorn spikelet forks were tentatively identified as such. A few cereal grains that were unidentifiable to genus or species level were also present among the samples and were classified as Cerealia. The main cereal crops present in the Neolithic assemblage were barley grains in 18 samples (54%) followed by wheat grains present in 16 samples (48%). Among the cereal chaff, emmer spikelet forks were the most ubiquitous items occurring in 26 samples (78%), followed by emmer glume bases present in 14 samples (42%). In contrast, barley rachis only occurred in two samples (6%). This pattern could be the result of different crop processing requirements for glume wheat grains and barley. In order to release glume wheat grains an extra processing (de-husking) is required that would normally take place piecemeal (Jones *et al*., 1986). As a result of this practice on a daily basis more glume wheat chaff could have been generated and by discarding them into domestic fires, they would have had a higher chance of becoming charred and preserved. In addition, charring experiments have demonstrated that glume bases preserve better than light chaff and rachis fragments (Boardman and Jones, 1990). Therefore, considering the higher survival rate of glume wheat chaff in fire than barley rachis, they have better chances to become charred and preserved. In the pulses category, lentil (*Lens* sp.), vetch/grass pea (*Vicia/Lathyrus* sp.) and vetch/pea (*Pisum/Vicia*) were present. Apart from lentil, it was not possible to identify the rest of the pulses to genus or species level due to their poor preservation (e.g. lack of testa and hilum). Among legumes, lentil was the most frequent taxon, present in 13 samples (39%). Nutshell fragments of wild almond (*Amygdalus* sp.) and wild pistachio (*Pistacia* sp.) were also found in the Neolithic assemblage.

In addition to the nutshell fragments of pistachio, five complete pistachio nuts were also present in contexts 1046, 1065 and 1088.

The wild plant assemblage of this phase included 13 taxa, mostly occurring in low numbers. Small seeds of wild pulses (Leguminosae), and medium sized grasses (Gramineae) were the most frequent wild taxa, present in 19 samples (57%) and 11 samples (33%) respectively. The rest of the wild taxa, such as *Galium* sp., *Centaurea* sp., *Bolboschoenus* cf. *glaucus*, *Ornithogalum* sp., Chenopodiaceae and Cyperaceae, occurred in one or limited number of samples (Table 7.4). To shed more light on the possible sources of the recovered plant material, different lines of evidence were assessed, including composition of samples, contextual information, archaeological and bioarchaeological findings as well as the ecology of wild taxa. Room fill deposits constituted the main group of samples retrieved from the Neolithic phase. Out of 19 samples in this group, only one sample (1046) produced rather high density of material (2.1 items/L). Samples in this group were relatively similar in terms of their archaeobotanical components, containing a mixture of cereal grains, chaff, pulses, nuts and wild taxa. The second group of samples was recovered from the habitation area classified as ash deposits, representing a mixture of ash layers and burnt sediments. Among the samples recovered from ash deposits, one sample (1072) had the highest density of material within the entire Nurabad assamblage (4.74 items/L). These samples also presented the same picture of a mixture of cereal grains and chaff, pulses, followed by nutshell fragments and low numbers of wild taxa. The remains of animal bones, pottery fragments and wood charcoal were recovered from these deposits suggest their secondary deposition from a variety of sources and activities. It is important to note that even samples collected from deposits with human burials (1068, 1080, and 1089) also showed the same taxa composition that could be the result of mixing burial deposits with sediments from the domestic area.

The ash content of the fire installation had very low density of material (0.16 items/L) containing only a few fragments of pistachio nutshells that might have been burned as fuel either intentionally (discarded in the fire after consumption) or accidentally (attached to pistachio branch used as fuel). The purpose of this fire installation (food preparation/cooking, heating, etc.) is not clear; however, analysing the charcoal remains of this context would shed more light of the type of wood used as fuel and thus provide some more insights in its use.

Most of the samples collected from the Neolithic deposits of trench D contained wood charcoal fragments in various proportions. The results of the analysis of the charcoal fragments recovered from room fills (1037, 1037, 1052, 11074), ash deposit (1088) and human burial (1068) indicated the presence of oak (*Quercus*), pistachio (*Pistacia*), almond (*Amygdalus*), maple (*Acer*) and elm (*Ulmus*). However, in most samples, *Amygdalus* was the predominant wood taxon (Table 7.5). One important aspect of the Nurabad Neolithic assemblage was the frequent presence of glume wheat chaff remains throughout the samples in relatively high proportions. The overall state of preservation of these materials was good with no evidence of passing through the animal digestive system, and possibly representing the remains of crop processing activities that were exposed to fire directly. The recovered cereal grains (glume wheat grains, barley) and pulses could have been the remains of food preparation/consumption episodes, accidentally burnt in the domestic fire. Overall, wild taxa occurred in very low numbers and due to the very mixed nature of the samples, it is difficult to determine their sources with certainty. However, some more insights can be gained by looking at ecological information. Most of the identified wild taxa from the Neolithic phases could be from arable or ruderal habitats and their flowering time, when possible to infer, overlaps with the assumed harvest time and extends beyond it (intermediate taxa). As a result, it is plausible that many of them could have arrived on the site with harvested crops, such as *Eremopyrum, Aegilops*, *Avena* and *Galiu*m. On the other hand, other taxa could have derived through different means. As mentioned above carbonised seeds of *Astragalus* sp. commonly occurred in the Neolithic samples although in small numbers. They could have been originated from a number of sources however the most probable explanation is fuel. The woody species of this plant might have been used directly as fuel or to assist fire. The carbonised seeds of *Astragalus* could also represent plants grazed by livestock incorporated in the assemblage through animal dung used as fuel. It should be stressed, however, no evidence of animal dung pellets, or plant remains with adhering dung material was observed in the analysed samples. Overall animal dung burned as fuel is unlikely to be the origin of Nurabad archaeobotanical material. The results of the Nurabad faunal analyses indicated the exploitation of domesticated animals, such as sheep and goat (predominant), as well as cattle during the Neolithic period (Mashkour, 2009) therefore, livestock dung would have been available to be used as a source of fuel. However, due to the frequent presence of wood charcoal remains in the analysed samples, wood might have been the primary source of fuel used in these contexts. The overall picture of the archaeobotanical material recovered from the Neolithic phase of trench D seemed to suggest domestic preparation/cooking and consumption debris mixed with fuel scattered across the excavated area. It was not possible to make any suggestion regarding the specific use of space for food processing and cooking activities due to limited contextual information and secondary deposition of the samples. However, the overall picture indicates that some cereal processing activities were taking place within the buildings.

7.3 Plant remains from the Chalcolithic deposits

Archaeobotanical samples of this phase were retrieved from a domestic area containing the remains of mudbrick buildings, compact floors and fire installations dated to the 5th millennium B.C. The Chalcolithic assemblage of Nurabad included three samples from trench D and eight samples from trench C. With the exception of one samples (C 511), the rest of the Chalcolithic samples had very low density of material ranging between 0.5 to 0.06 items/L. In summary, a total of 124 specimens and 22 taxa were identified in the assemblage including cereals, pulses, nutshell fragments and wild taxa. The overall ubiquity and abundance of each plant taxon and type is available in table 7.4. The cereal component of the Chalcolithic samples was a mixture of glume wheats and barley both in the form of grain and chaff. It must be mentioned that cereal grains and chaff were less frequent among the Chalcolithic assemblage. In terms of pulses, the same species that identified in the previous phase were also present in the Chalcolithic assemblage (Table7.3). Pistachio and almond nutshell were only present fragmented. The wild plant assemblage contained a total of 74 items that belong to ten wild/weedy taxa, dominated by Leguminosae (81%) and Gramineae (45%). In addition, very low numbers of other wild taxa, such as *Malva* sp., *Fumaria* sp., *Galium* sp., *Silene* sp., *Rumex* sp., *Ornithogalum* sp. and *Brassica/Sinapis* type were also present. The wild species were a mixture of arable and ruderal weeds, grassland and steppe vegetation with different ecological qualities. The identified wild taxa could have been derived from a variety of sources, including possibly crop processing or from the surrounding natural environment. Wood charcoal remains of this phase were identified as *Amygdalus*, *Pistacia*, *Quercus*, *Tamarix*, Salicaceae and *Juniperus* (Table 7.5). Classifying the Chalcolithic samples based on their context type (general room fills and ash deposits) did not show a clear pattern. The archaeobotanical content of both groups of samples was similar, containing a mixture of crop items, wild seeds and wood charcoal fragments pointing to the secondary accumulation of remains of food preparation and consumption episodes mixed with fuel scattered across the excavated area. Similar to the previous phase no animal dung material was found in the analyzed samples from this phase. The overall state of preservation was also similar to the samples from the earlier phase, indicating similar charring conditions and taphonomic processes and pointing to some continuity in at least part of the agricultural activities.

7.4 The wood charcoal remains

In total, 11 charcoal flotation samples amounting to 216 wood charcoal fragments were analysed from two occupation phases of Nurabad. Although more samples were examined from the charcoal assemblage of Nurabad the overall charcoal density was low. As presented in Table 7.5, most of the examined samples contained less than 50 charcoal fragments. The low charcoal densities of these samples could be the result of preservation issues affected by several taphonomic factors (e.g. burning conditions, wood properties, discarding practises, depositional and post-depositional processes).

The Neolithic charcoal assemblage included 6 samples and the Chalcolithic 5 samples. The list of identified charcoal taxa, absolute fragment counts, charcoal weights, volume of floated sediment and context information are presented in Table 7.5. The raw/percentage fragment counts and ubiquity (sample presence) from each phase are available in Table 7.6 and Fig 7.2. A total of 80 charcoal fragments (5.62 g) were analysed from Neolithic room fill deposits (1033, 1037, 1047 and 1053), an ash deposit (1088) and a burial fill (1068). A total of 136 charcoal fragments (5.94 g) were analysed from Chalcolithic room fill deposits (509, 527) and pits (508, 511, and 1009).

The Nurabad charcoal assemblage comprises 8 different taxa, including almond (*Amygdalus*), pistachio (*Pistacia*), ash (*Fraxinus*), willow/poplar (Salicaceae), oak (*Quercus*), juniper (*Juniperus*), maple (*Acer*) and elm (*Ulmus*). *Amygdalus* and *Quercus* were the most abundant taxa (80%) being present in 9 out of 11 sampled contexts (Table7.6). *Pistacia* charcoal was present in 3 out of 11 samples (27%). It is important to note that the some identified taxa such as *Ulmus* and *Acer* appeared only sporadically in the Neolithic assemblage. Other identified taxa including *Juniperus, Fraxinus* and Salicaceae were present only in the

Chalcolithic assemblage with lower frequencies (Table 7.6). The percentage fragment counts indicate that the dominant taxa *Amygdalus* and *Quercus* together accounted for >90 % of the Neolithic charcoal sample composition (Table 7.6). In the Chalcolithic phase however, *Fraxinus* and *Quercus* had the highest relative proportions, making up approximately 90% of the assemblage. It must be noted, however, that this pattern is strongly conditioned by the high abundance of *Fraxinus* in just two Chalcolithic samples, making up 60% of the fragments. One of these samples is an ash deposit (C511) and another from a generalised fill deposit (C509). Both contexts were located in close proximity and it is possible that their deposits were mixed, as their archaeobotanical content was almost identical (Table7.3). The charcoal assemblage of Nurabad was very fragmented in general. No fragments >2 mm were present in the analysed samples of both phases; nevertheless, the number of indeterminate fragments was low, particularly in the Chalcolithic assemblage (Fr/Pr index, Table 7.5). It is important to note that some taxa (e.g. oak, ash) are easy to identify even with small fragments. Regarding the indeterminate fragments, botanical identification was not possible due to the presence of thick layers of salt/mineral precipitates covering the wood anatomical features. These layers possibly were formed in archaeological sediment as part of natural post-depositional processes. Some radial cracks were also observed in some of the identified fragments recovered from both occupation phases. The occurrence of radial cracking on archaeological charcoal is associated to factors like the initial moisture content of wood, temperature, time of exposure, the size of rays and the nature of fibres (Prior and Alvin, 1983, 1986; Thery-Parisot and Henry, 2012; Braadbaart and Poole, 2008). The results of an experimental study demonstrated that radial cracks can appear on both green and dry/seasoned wood, however the radial cracks were more numerus and less developed on green wood whereas the seasoned wood had fewer and more developed radial cracks (Thery-Parisot and Henry, 2012). Moreover, the presence of fungal hyphae was observed within the vessel walls of a few *Quercus* fragments retrieved from disposal pits (possibly indicating the burning of deadwood and/or defunct timber). The results of experimental studies demonstrated that fungal hyphae can be preserved within the wood charcoal after burning (Moskal-del Hoyo *et al*., 2010; Henry and Thery-Parisot, 2014). Based on the results of analysed data it appears that different local vegetation communities including oak forest (*Quercus, Juniperus, Acer*), steppe forest (*Amygdalus, Pistacia*) and riparian forests (*Fraxinus,* *Ulmus* and Salicaceae) were exploited by the inhabitants of the site for fuel and possibly timber too (see also discussion in Chapter 9).

Nurabad	**Trench**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**
	Locus	**1015**	**1023**	**1028**	**1036**	**1037**	**1046**	**1051**	**1052**	**1057**
	Phase	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
	Context	**Fill**	**FI**	**Fill**	**Fill**	**Fill**	**Fill**	**Fill**	**Fill**	**Fill**
	Volume (L)	**80**	**30**	**140**	**35**	**45**	**60**	**30**	**45**	**30**
	Items per/L	**0.26**	**0.16**	**0.07**	**0.17**	**0.2**	**2.1**	**0.2**	**0.5**	**0.36**
Cereals										
Triticum monococcum grain							1			
Triticum monococcum/ dicoccum spikelet fork							2			
Triticum dicoccum grain							1			
Triticum dicoccum spikelet fork		7			2		25	2		2
Triticum dicoccum glume bases										2
Triticum sp. grain				1			6	2		
Hordeum vulgare grain		1		1		2	9	3	2	
Hordeum vulgare rachis							12			
Cerealia							1			
Pulses										
Vicia/ Lathyrus				2		2	12			
Pisum/Vicia						2	3			
Lens		2				3	9		3	2
Fruit/Nuts										
Pistacia (complete nut)							2			
Pistacia sp. fragments			5				5			
Amygdalus sp. fragments						2	2			2
Wild taxa										
Centaurea sp.							4			
Chenopodiaceae		1								
Cyperaceae				3	2					
Bolboschoenus cf. *glaucus*				1						
Leguminosae Small		1								
Trigonella cf. *astroites*										
Astragalus sp.		4		1	2		16			
Ornithogalum sp.										
Gramineae		4		2			8			
Aegilops spikelet							2			
Avena		1								
Eremopyrum sp.										2
Galium sp.							1			1
Wild Indet.		1					3			
Total		**22**	**5**	**11**	**6**	**11**	**123**	**7**	**5**	**11**

Table 7.2. List of identified taxa, densities of plant remains and contextual information from the Neolithic phase of Nurabad assemblage. **HB**= Human burial, **FI** = Fire installation, **NE**= Ceramic Neolithic

Nurabad	**Trench**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**	**D**
	Locus	**1059**	**1061**	**1063**	**1065**	**1066**	**1067**	**1068**	**1070**	**1071**
	Phase	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
	Context	**Fill**	**Fill**	**Fill**	**Fill**	**Fill**	**Fill**	**HB**	**Fill**	**Fill**
	Volume (L)	**25**	**72**	**14**	**20**	**30**	**40**	**34**	**20**	**30**
	Items per/L	**0.08**	**0.02**	**0.3**	**0.5**	**0.13**	**0.52**	**0.4**	**0.5**	**0.36**
Cereals										
Triticum monococcum grain							1			
Triticum monococcum/ dicoccum spikelet fork										
Triticum dicoccum grain						2	1			
Triticum dicoccum spikelet fork			2	2	2		5	2	5	4
Triticum dicoccum glume bases					3			1	3	2
Triticum sp. grain						2	1			1
Hordeum vulgare grain					1		1			2
Hordeum vulgare rachis										
Cerealia										
Pulses										
Vicia/ Lathyrus									2	1
Pisum/Vicia								2		
Lens							2			
Fruit/Nuts										
Pistacia sp. (complete nut)					1					
Pistacia sp. fragments					2		2	2		
Amygdalus sp. fragments		2			2			3		
Wild taxa										
Centaurea sp.										
Chenopodiaceae										
Cyperaceae							2			
Bolboschoenus cf. *glaucus*										
Leguminosae Small							1			
Trigonella cf. *astroites*										
Astragalus sp.							3			1
Ornithogalum sp.								2		
Gramineae				2						
Aegilops spikelet										
Avena										
Eremopyrum sp.										
Galium sp.							2	2		
Wild Indet.							2			
Total		**2**	**2**	**4**	**11**	**4**	**23**	**14**	**10**	**11**

Table 7.2. (Continue)

Nurabad	Trench	D	D	D	D	D	D	D	D	D
	Locus	**1072**	**1073**	**1074**	**1075**	**1076**	**1079**	**1080**	**1082**	**1084**
	Phase	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
	Context	**Ash**	**Fill**	**Fill**	**Fill**	**Ash**	**Ash**	**HB**	**Ash**	**Ash**
	Volume (L)	**4**	**24**	**28**	**36**	**24**	**52**	**8**	**30**	**28**
	Items per/L	**4.74**	**1.7**	**0.7**	**1**	**0.75**	**0.36**	**0.25**	**0.4**	**0.8**
Cereals										
Triticum monococcum grain		1								1
Triticum monococcum/ dicoccum spikelet fork										
Triticum dicoccum grain					5					
Triticum dicoccum spikelet fork		2	5	3	3	2	5		8	2
Triticum dicoccum glume bases		3	4			10	1			5
Triticum sp. grain		2	3	1		1	1		3	1
Hordeum vulgare grain			3	8	10		2			2
Hordeum vulgare rachis										
Cerealia					2					
Pulses										
Vicia/ Lathyrus							2			2
Pisum/Vicia							2			
Lens				2	1		4			4
Fruit/Nuts										
Pistacia sp. (complete nut)										
Pistacia sp. fragments				2						
Amygdalus sp. fragments		2	5		4	3				
Wild taxa										
Centaurea sp.										
Chenopodiaceae		3								
Cyperaceae		2								
Bolboschoenus cf. *glaucus*										
Leguminosae Small					1					
Trigonella cf. *astroites*			1							
Astragalus sp.		3	14	3	3	2	2	2		2
Ornithogalum sp.					1					
Gramineae		1	3		2				1	2
Aegilops spikelet				1						
Avena										
Eremopyrum sp.			2		3					
Galium sp.										
Wild Indet.										
Total		**19**	**40**	**20**	**35**	**18**	**19**	**2**	**12**	**21**

Table 7.2. (Continue)

Nurabad	**Trench**	**D**	**D**	**D**	**D**	**D**	**D**
	Locus	**1086**	**1088**	**1089**	**1093**	**1098**	**1099**
	Phase	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
	Context	**Ash**	**Ash**	**HB**	**Ash**	**Ash**	**Ash**
	Volume (L)	**24**	**76**	**12**	**32**	**32**	**34**
	Items per/L	**1.66**	**0.96**	**0.5**	**0.4**	**0.25**	**0.73**
Cereals							
Triticum monococcum grain			2				2
Triticum monococcum/ dicoccum spikelet fork							
Triticum dicoccum grain			1				3
Triticum dicoccum spikelet fork		7	20	2	2	1	13
Triticum dicoccum glume bases		13	2				
Triticum sp. grain		4	12		1		
Hordeum vulgare grain			4		1	1	2
Hordeum vulgare rachis			2				
Cerealia		1					
Pulses							
Vicia/ Lathyrus		1					
Pisum/Vicia		1	4				
Lens		6	5				2
Fruit/Nuts							
Pistacia sp. (complete nut)			2				
Pistacia sp. fragments			2		2	1	2
Amygdalus sp. fragments						2	
Wild taxa							
Centaurea sp.							
Chenopodiaceae							
Cyperaceae							
Bolboschoenus cf. *glaucus*			3				
Leguminosae Small				3			
Trigonella cf. *astroites*							
Astragalus sp.		5	7	1	7	2	
Ornithogalum sp.							
Gramineae		2	4				
Aegilops spikelet							
Avena							1
Eremopyrum sp.						1	
Galium sp.							
Wild Indet.			3				
Total		40	73	6	13	8	25

Table 7.2. (Continue)

Nurabad	**Trench**	**D**	**D**	**D**	**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**
	Locus	**1003**	**1004**	**1009**	**502**	**505**	**509**	**511**	**516**	**527**	**528**	**532**
	Phase	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**	**CH**
	Context	**Fill**	**Pit**	**Pit**	**Fill**	**Fill**	**Fill**	**Ash**	**Fill**	**Fill**	**Fill**	**Fill**
	Volume (L)	**30**	**45**	**80**	**45**	**45**	**75**	**45**	**32**	**55**	**65**	**30**
	Items per/L	**0.13**	**0.5**	**0.05**	**0.28**	**0.15**	**0.11**	**1.04**	**0.06**	**0.12**	**0.13**	**0.06**
Cereals												
Triticum monococcum grain				1				1				
Triticum dicoccum grain				2								
Triticum dicoccum spikelet fork										2	2	
Triticum dicoccum glume bases								2				1
Triticum sp. grain				1								
Hordeum vulgare grain			2					2				
Hordeum vulgare rachis											1	
Pulses												
Vicia/Lathyrus							4	12				
Pisum/Vicia			1			2						
Lens			3									
Fruit/Nuts												
Pistacia sp. (complete nut)								1		1		
Pistacia sp. fragments					2			2			1	
Amygdalus sp. fragments					2						1	1
Wild taxa												
Brassica/Sinapis type					2			2				
Silene sp.			1				1					
Leguminosae Small		1	4					4				
Astragalus sp.		2	9		7	5	1	6	2	3	2	
Ornithogalum sp.								1				
Malva sp.								2				
Fumaria sp.			1				1					
Gramineae		1					1	8		2	1	
Rumex sp.			1									
Galium sp.			1					2				
Wild Indet.								3				
Total		4	23	4	13	7	8	48	2	8	8	2

Table 7.3. List of identified taxa, densities of plant remains and contextual information from the Chalcolithic phase of Nurabad assemblage. **CH**= Chalcolithic

Phase	Neolithic			Chalcolithic		
Number of samples		**33**			**11**	
Soil volume (L)		**1224**			**547**	
Number of identified taxa		**26**			**22**	
	Ubiquity %	**Total sum**	**Max per sample**	**Ubiquity %**	**Total sum**	**Max per sample**
Cereals						
Triticum monococcum grain	18%	9	2	18%	2	1
Triticum monococcum/ dicoccum spikelet fork	3%	2	2	-	-	-
Triticum dicoccum grain	18%	13	5	9%	2	2
Triticum dicoccum spikelet fork	78%	143	27	18%	4	2
Triticum dicoccum glume bases	42%	49	13	18%	3	2
Triticum sp. grain	48%	42	12	9%	1	1
Hordeum vulgare grain (Hulled)	54%	55	10	18%	4	2
Hordeum vulgare rachis	6%	14	12	9%	1	1
Cerealia	9%	4	2	-	-	-
Pulses						
Vicia/ Lathyrus	24%	24	12	18%	16	12
Pisum/Vicia	18%	14	4	18%	3	2
Lens	39%	45	9	9%	3	3
Fruit/Nuts (nutshell fragments*)*						
Pistacia sp.	30%	30	5	27%	7	3
Amygdalus sp.	33%	29	5	36%	4	2
Wild taxa						
Centaurea sp.	3%	4	4	-	-	-
Brassica/Sinapis type	-	-	-	18%	4	2
Chenopodiaceae	6%	4	3	-	-	-
Cyperaceae	12%	9	3	-	-	-
Bolboschoenus cf. *glaucus*	6%	4	3	-	-	-
Silene sp.	-	-	-	18%	2	1
Leguminosae Small	12%	6	3	27%	9	4
Trigonella cf. *astroites*	3%	1	1	-	-	-
Astragalus sp.	57%	80	16	81%	37	9
Ornithogalum sp.	6%	3	2	9%	1	1
Gramineae (medium- sized grasses)	33%	31	8	45%	13	8
Aegilops spikelet	6%	3	2	-	-	-
Avena	6%	2	1	-	-	-
Eremopyrum sp.	12%	8	3	-	-	-
Malva sp.	-	-	-	9%	2	2
Fumaria sp.	-	-	-	18%	2	1
Rumex sp.	-	-	-	9%	1	1
Galium sp.	12%	6	2	18%	3	2
Total:		**634**			**124**	

Table 7.4. Ubiquity and abundance for each plant taxon and type in Nurabad plant assemblage

Trench	**D**	**D**	**D**	**D**	**D**	**D**		**D**	**C**	**C**	**C**	**C**		
Context	**1033**	**1037**	**1047**	**1053**	**1068**	**1088**	**Total**	**1009**	**508**	**509**	**511**	**527**	**Total**	
volume	**18**	**45**	**30**	**45**	**34**	**76**	**NE**	**80**	**30**	**75**	**45**	**55**	**CH**	
Description	**Fill**	**Fill**	**Fill**	**Fill**	**HB**	**Ash**		**Pit**	**Pit**	**Fill**	**Ash**	**Fill**		
Time period	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**		**CH**	**CH**	**CH**	**CH**	**CH**		
Total charcoal weight:	0.04	0.239	1.595	1.971	0.332	1.443	**5.62**	0.092	0.397	2.458	2.883	0.114	**5.94**	
2 mm weight:	0.04	0.239	1.595	1.971	0.332	1.443		0.092	0.397	2.458	2.883	0.114		
Charcoal density	0.002	0.005	0.05	0.04	0.009	0.01	**0.02**	0.001	0.01	0.03	0.06	0.002	**0.02**	
Fr/Pr Index	0.25	0.2	0.13	0.3	0.4	0.09	**0.17**	0.5	0	0	0.02	0.3	**0.02**	
Amygdalus	1	7	22	6		13	**49**	1	8	4		2	**15**	64
Pistacia			1			2	**3**				1		**1**	4
Quercus	2	1	2		3	4	**12**		13	2	5	3	**23**	35
Juniperus							**0**		5	3			**8**	8
Acer				1			**1**						**0**	1
Salicaceae							**0**		1	6			**7**	7
Fraxinus							**0**			35	43		**78**	78
Ulmus			1				**1**						**0**	1
Indet.	1	2	4	3	2	2	**14**	1	0	0	1	2	**4**	18
Total	4	10	30	10	5	21	**80**	2	27	50	50	7	**136**	216
Total (- Indet.)	3	8	26	7	3	19	**66**	1	27	50	49	5	**132**	198

Table 7.5. List of wood taxa identified in the Nurabad charcoal assemblage, **NE**= Neolithic, **CH** = Chalcolithic, **Fr/Pr**= Fragmentation/Preservation index (In Asouti's assemblages, an index of <0.5 was used to indicate overall good preservation, 0.6-0.9 moderate to high proportions of indeterminate fragments and 1-5 very high proportions of indeterminate fragments showing poorly preserved fragments (Asouti, 2003: p. 1193).

Phase	Neolithic			Chalcolithic		
Taxa	**C**	**%**	**U**	**C**	**%**	**U**
Amygdalus (almond)	49	74.24	5	15	11.36	4
Pistacia (pistachio)	3	4.54	2	1	0.75	1
Quercus (oak)	12	18.18	5	23	17.42	4
Juniperus (Juniper)		-		8	6.06	2
Salicaceae(willow/poplar)		-		7	5.30	2
Fraxinus (ash)		-		78	59.09	2
Acer (maple)	1	1.51	1		-	
Ulmus (elm)	1	1.51	1		-	
Total	66	100	(n=6)	132	100	(n=5)

Table 7.6. Quantified anthracological data from Nurabad grouped by phase. **C**= Absolute fragment count, **%** = Percentage fragment count, **U**= Ubiquity.

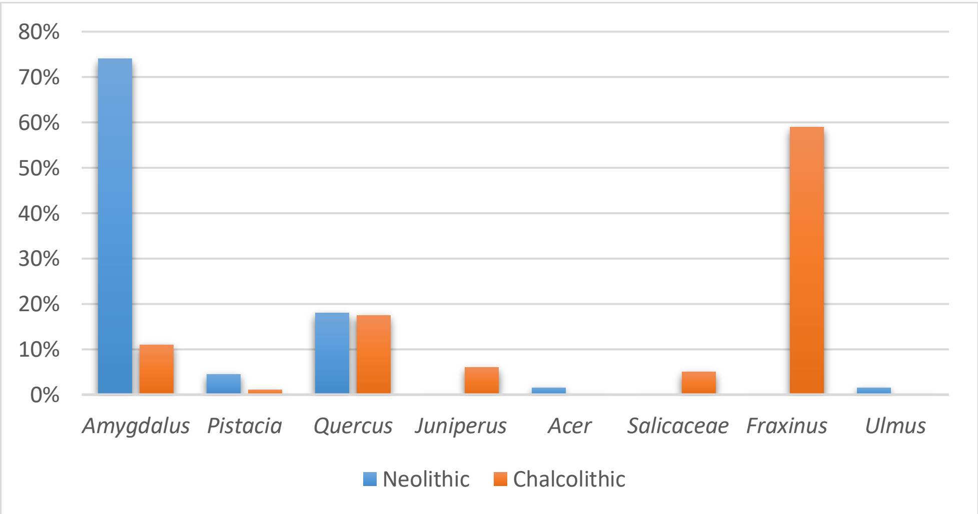


Fig 7.2. Bar chart showing percentage fragment counts of the main taxa represented in the Neolithic and Chalcolithic phases (n=11)

Chapter 8

Mehrali: Archaeobotanical analysis

This chapter presents the results of the analysis of the macrobotanical remains (seed and wood charcoal) recovered from Mehrali to offer insights into general sample composition, frequency and abundancy of the taxa, as well as the use of space. The archaeobotanical results are presented based on chronological order.

8.1 The samples and context types

During two seasons of excavations in 2006 and 2008 at Mehrali, 2145 liters of sediment were processed from 66 contexts, including room fills, pits, ash layers, floors and fire installations in horizontal and stratigraphic trenches (Table 8.1). In total, forty- three samples (65% of the processed samples), contained archaeobotanical remains, including six samples from the Early Chalcolithic deposits (Bakun period, 5^{th} millennium B.C) and thirty-seven samples from the Late Chalcolithic deposits (Lapui period, 4^{th} millennium B.C). The flotation samples contained archaeobotanical remains (seeds and other plant parts) in variable amounts however, most samples (30) had low density of plant remains (> 1.0 items/L). The rest of the samples exhibited relatively higher density with 1-2 items/L in seven cases and >6.5 items/L in another six (Fig 8.1). The overall archaeobotanical assemblage amounts to a total of 1415 items recovered from 1557 liters of processed sediments. All items were preserved by charring and due to their relatively good state of preservation, it was possible to identify most of them to family, genus or species lever. In some cases, the state of preservation was exceptional as some complete pistachio and almond nuts were recovered. The contextual and chronological information of each sample, the volume of processed sediments, the density and the list of identified taxa is presented in Table 8.2. The ubiquity and abundance of each plant taxon and type for both chronological phase are available in Table 8.3. The archaeological information of this site was gathered from the following publications and excavation reports: Sardari, 2011, 2013; Sardari *et al*., 2011.

Trench	Period	Total number of processed samples	Number of samples with archaeobotanical material
J12	Chalcolithic	11	7
D11	Chalcolithic	10	4
F10	Chalcolithic	10	8
F11	Chalcolithic	8	3
E5	Chalcolithic	20	18
G11	Chalcolithic	3	1
G20	Chalcolithic	2	1
G22	Chalcolithic	2	1

Table 8.1. Summary of flotation samples collected from Mehrali excavation units

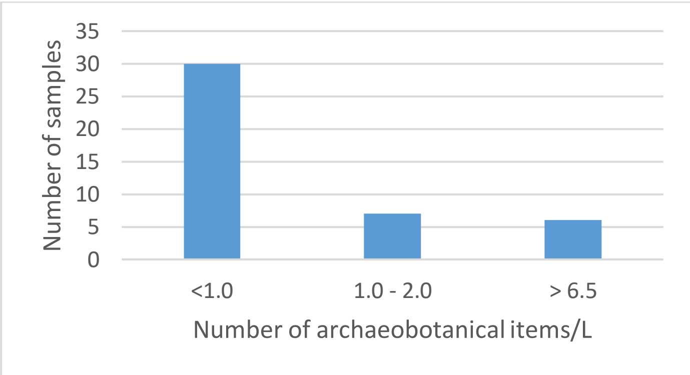


Figure 8.1. Density of plant remains across the Mehrali samples

8.2 Plant remains from the Early Chalcolithic period

The Bakun archaeobotanical assemblage was much smaller than the Lapui one containing only six samples that were recovered from three stratigraphic trenches (J12, F10 and D11). Charred plant remains from this phase were recovered from a domestic area containing mudbrick buildings with several rooms and various fire installations (Sardari, 2011). The overall density of the assemblage was low and the richest samples (D11 45, D11 47) had 3.8 and 1.29 items per liter of sediment, respectively. In summary, a total of 151 items of plant remains and 8 taxa were identified in the Bakun samples. These included cereal grains, nutshell fragments and wild taxa (Table 8.2). In the cereal category, only a few grains of barley (*Hordeum vulgare*) were present. Low quantities of almond (*Amygdalus* sp.) and pistachio (*Pistacia* sp.) nutshell fragments were present in most of the samples. The wild plant assemblage of this phase contained five taxa, including *Carex* cf. *divisa* and other indeterminate Cyperaceae, *Silene* sp., Brassicaceae and Chenopodiaceae, mostly occurring in low numbers. Three samples (D11 45, D11 47, and F10 90) derived from room fill deposits of a mudbrick building with a compact floor contained a mixture of a few barley grains, nutshell fragments of pistachio and almond as well as low numbers of wild species from arable/ruderal habitats. The other three samples from this phase were retrieved from ashy content of small pits. These pits were found in an open area along with several other similar pits connected to a mudbrick building through a canal. The pits and canal were filled with green ashy deposits with very fine texture. It was assumed that this structure was a rubbish disposal system to transfer the domestic refuse to an open area located farther away from the residential buildings (Sardari, 2011). The archaeobotanical content of these samples was a mixture of predominantly wild species (sedges), nutshell fragments of pistachio and two barley grains (Table 8.2). From this pits large quantity of other archaeological material (small pottery fragments, clay objects, lithic) and bioarchaeological material (burnt animal bones, wood charcoal) was also recovered, which indicated secondary deposition of debris generated in the habitation area (Sardari, 2011). The presence of same range and type of species in the domestic contexts and in these pits may support the idea that refuse from the house was deposited in these pits. The few identified wild species in this phase were a mixture of possible arable/ruderal and wet-loving species. Only the seeds of two wild taxa (*Silene* sp. and *Carex* cf. *divisa*) were identified to genus and tentatively spices level, identification of other few wild taxa was restricted to family level. Charred seeds of Cyperaceae were the main component of the wild assemblage, present in four samples in relatively large numbers (85 items in total, 61 occurred in a single sample). The identified wild plants could have entered the site through different routes, such as weeds harvested with crops or from the surrounding environment discarded into the domestic fire as part of fuel. No evidence of animal dung pellets or plant remains with adhering dung material was observed in the analysed Bakun samples. The recovered barley grains could have been the remains of food preparation/consumption episodes, accidentally burnt in the fire. Other food plants included some pistachio and almond shell fragments occurring in most of the samples. The nutshells of both plants might have been used as supplemental fuel after consumption of the edible nuts. It is important to note that in both groups of samples (room fills and pits) wood charcoal fragments were present (higher concentration in pits) which was a further evidence to mixed nature of the samples originating from different sources including food preparation/consumption and fuel. The identification of charcoal fragments from these contexts (not analysed yet) would shed more light of the type of wood used as fuel.

8.3 Plant remains from the late Chalcolithic period

During the two seasons of excavations at Mehrali the remains of several Lapui architectural phases were discovered indicating that the site was continuously occupied during this period. The orientation and plan of these buildings were relatively similar and no gap was observed in the occupational phases of this period (Sardari *et al*., 2011). The foundation of these buildings was pebble stones and the walls were made of mudbrick. In general, the architectural remains have been described as complex buildings with a big central unit that was confined by other smaller units (Sardari, 2011). Gypsum was used to plaster the mudbrick walls of these buildings but in some cases, they were decorated by different colours, such as dark brown and green (Sardari, 2011,2013). Overall, extensive excavations at Lapui deposits provided the first firm evidence on the nature and function of architecture during the 4th millennium BC in Northern Fars. Based on the radiocarbon evidence, the beginning of this period is dated to 3900 B.C. and its end to about 3500 B.C (Sardari *et al*., 2011; Sardari, 2013). Lapui samples were recovered from six stratigraphic and horizontal trenches including E5 (eighteen samples), F10 (seven samples), J12 (five samples), F11 (three samples), G (three samples) and D11 (one sample). The archaeobotanical samples from this phase mostly represent material from secondary deposits of domestic areas. The overall density of the Lapui assemblage was relatively low and the richest sample (J12 35) produced only 6.3 items per liter of sediment. A total of 1264 items of plant remains, corresponding to 24 plant taxa and types, were recovered from this assemblage, and they consisted of charred grains and seeds, chaff as well as legumes, nutshell fragments and wild taxa (Table 8.2). The identified cereals were emmer wheat grains and chaff (*Triticum dicoccum*), einkorn wheat grains (*Triticum monococcum*), bread wheat rachis (*Triticum aestivum*), indeterminate wheat grains (*Triticum* sp.) and hulled barley grains (*Hordeum vulgare*). In addition, few cereal grains that were unidentifiable to genus or species level were also present among the samples and these were classified as Cerealia. Both glume wheat and barley grains occurred in seven samples (19%) in low numbers

(Table 8.3). The identified cereal chaff including emmer spikelet forks and glume bases as well as bread wheat rachis were present in only one sample (5%). In the pulses group lentil (*Lens* sp.), bitter vetch (*Vicia ervilia*), vetch/pea (*Pisum/Vicia*) and indeterminate large legumes (Fabaceae) were present. In this category, lentil and bitter vetch were relatively frequent, present in eight samples (21%) and seven samples (19%) respectively. Nutshell fragments of pistachio (*Pistacia* sp.) and almond (*Amygdalus* sp.) comprised the main component of the Lapui assemblage. Among nuts, almond was the most frequent taxon found in 27 samples (70%), followed by pistachio present in 17 samples (45%). Pistachio nutshells were mostly recovered fragmented however, whole fruits of pistachio also occurred in some of the samples, and in few cases the remains of kernel was still present inside the shell (Fig 8.2). The shape and size of pistachio nuts resembled modern specimens of *Pistacia atlantica*; the nuts were laterally flattened, elliptical in cross section, with rounded apex tapering in a small point and smooth surface. The endocarp shell was approximately 0.5 mm thick. In total 35 intact pistachio nuts were recovered among the samples that were tentatively identified as *Pistacia* cf. *atlantica*. The dimensions of the pistachio nutshell remains are presented in Table 8.4. Three *Pistacia* species naturally occur in Iran including *P. vera, P. khinjuk* and *P. atlantica*, the latter has three subspecies (*mutica, kurdica* and *cabulica*) (Mozaffarian, 2009; Pazuki *et al*., 2010; Khatamsaz, 1988). Shrubs and trees of two species, *P.atlantica* and *P.khinjuk,* grow in the Fars province, however *P.atlantica* is more common as it is able to tolerate most soil conditions, desert heat and will survive with no irrigation (Mozaffarian, 2009; Negahdarsaber and Fattahi, 2003; Rezaeyan *et al*., 2009; Nejabat *et al*., 2017). Wild pistachio (*P. atlantica*) is one of the most economically important species of this region with several industrial, medicinal and culinary uses (Bozorgi *et al*., 2013). The fruit of wild pistachio (Baneh, بنه) is an important source of food, used raw, roasted or cooked (Mosaddegh *et al*., 2012). The resin of wild pistachio (Saqez, سقز) has a variety of industrial and traditional uses, including in food and medicine (Pourreza *et al*., 2008). The leaves of pistachio trees are eaten by animals and the wood of wild pistachio trees is regarded as a suitable source of fuel for heating and cooking (Mosaddegh *et al*., 2012; Miller, 1982). In the nut/fruit category, almond nutshells were the most numerous plant remains and were found mostly fragmented. In Iran, the genus *Amygdalus* includes two subgenera: subgen. *Amygdalus* with 15 species as of tree or shrubs divided into two sections, sect. *Amygdalus* and sect. *Spartioides*. The following species are reported from the Fars region: *A. reticulata, A. elaeagnifolia* and *A. hussknechtii* (sect. *Amygdalus*) and *A. glauca* and *A. scoparia* (sect. *Spartioides*) (Khatamsaz, 1992; Mozaffarian, 2009; Khalily, 2008; Vafadar, *et al*., 2010). The second subgen. *Dodecandra* includes six species that are shrubs with thick spines occurring in steep, rocky slopes and semi-arid habitats in Iran (Browicz 1969; Khatamsaz, 1992). From this subgen *A. eburnean* grows in Fars (Vafadar, *et al*., 2010). According to the modern distribution area of wild almond species growing in the Fars region *A. scoparia* with 10 vegetation types is the dominant species occurring in stony to sandy slopes, dry valleys and steppe-forest communities (Khalily, 2008). In the regional survey carried out by Miller (1982, p 194) this species was observed in both pistachio-almond forest and on the lower slopes of the oak forest. In the Fars region charred shell remains of *A. scoparia* were attested in the archaeobotanical assemblage of Malyan (3rd millennium B.C) and the fresh examples were descried as ʻʻ dropped shape with rounded base, point at distal end, reticulate in cross section, smooth surface, and thickness of shell 0.8 mmʼʼ (Miller, 1982, p 196). To identify the recovered almond nutshells from Mehrali an attempt was made to compare them with the *Amygdalus* species reported from Fars. Full description of endocarps of six *Amygdalus* species growing in the region is available in Table 8.5. In the Lapui assemblage, different parts of *Amygdalus* endocarps (apex, hilum plate, middle and side) were observed among the fragmented remains (Fig 8.3-8.5). All nutshell fragments were pitted and had short to long grooves on the surface. The shell thickness varied between 0.8 mm to 1.1 mm. The whole *Amygdalus* fruits (19 in total) were ovate in shape, laterally more or less compressed with obtuse apex. Their surface pattern was composed of small pits and grooves, they had rounded base, oval hilum plate, elongated grooves around the keel and deeper grooves near the hilum plate (Fig 8.4). The dimensions of the recovered *Amygdalus* nutshell remains are presented in Table 8.4. Based on the morphological comparison of the Mehrali *Amygdalus* remains with the six potential species, *A*. *elaeagnifolia* and *A*. *hussknechtii* are the most probable matches of the recovered *Amygdalus* endocarps. In Iran, the oil of wild almond (majak, مجک) is widely used for industrial, medical and food purposes (Sedaghat and Pazhuahnmehr, 2014). The findings from a study on the quantity and chemical composition of oil extracted from wild almond species (*A. reticulata, A. elaeagnifolia, and A. scoparia*) growing in the Fars province show similarities to sweet almond (*A. communis*), indicating their potential high economic value in food, pharmaceutical and cosmetic industries (Amanzadeh *et al*., 2016). Local people consume wild almond fruits after soaking the seeds in water and roasting them to reduce the bitter taste. The leaves and stems of *A. scoparia* are used to treat snakebites and the branches for making baskets (Amin, 2005; Mosaddegh *et al*., 2012; Amanzadeh *et al*., 2016).

The wild plant assemblage of the Lapui phase included 12 taxa mostly occurring in low numbers. The most frequent wild plants belong to the Cyperaceae and Brassicaceae families representing 16% of the assemblage. To provide insights into plant processing/consumption activities within the Lapui buildings, the archaeobotanical content of excavated units along other available archaeological evidence from the same space were assessed. Among 18 archaeobotanical samples retrieved from the residential phase of Trench E5, two samples (E5 10, E5 13) represent material recovered from the ash content of an internal fire installation, two samples (E5 34, E5 43) from a large disposal pit and fourteen samples from the general room fill deposits. The archaeobotanical content of the fire installation included a single emmer grain, one lentil and a few pistachio nutshells, most probably the remains of cooking/consumption episodes, accidentally burnt in the fire (Table 8.2). Samples taken from the disposal pit contained a relatively higher amount of almond and pistachio nutshells as well as two seeds of bitter vetch. This disposal pit is marked as an important feature of Trench E5 found in the southern part of the residential buildings containing large amount of ash, burnt clay, bone fragments, pottery remains and charcoal. Due to the large size, location and the content of this feature it has been suggested that this place might have been used to dispose habitation debris over a long time (Sardari, 2011). Room fill deposits of this area also contained a relatively high proportion of pistachio and almond nutshells, followed by cereal grains and chaff, pulses and a low number of wild taxa from a variety of habitats. It is important to note that wood fragments of almond and pistachio also dominated the wood charcoal assemblage of this residential area. Almond and pistachio endocarps were found whole and fragmented, however the fragmentation was higher in the case of pistachio remains. The majority of the nutshell fragments had smooth borders possibly indicating that fragmentation happened before carbonisation and deposition in the sediments. The concentration of nutshell remains (particularly the fragmented ones) recovered from these buildings is likely to represent food residue, burnt as part of fuel after consumption. However, considering the frequent presence of both taxa in the wood charcoal samples of the same area it is also possible that some of the nuts have entered through branches/twigs used directly as fuel. Archaeobotanical samples recovered from the residential phase of Trench F10 (seven samples) and Trench J12 (5 samples) also presented the same picture of a mixture of food plants (cereals, pulses and nuts) as well as low numbers of wild taxa. The identified wild taxa of these samples were a mixture of arable/ruderal, grasslands and wet-loving species, possibly originating from different routes. The fire installations found in this space were described as rounded features with compact heated floors and mudbrick walls possibly used for domestic purposes (cooking/heating). It has been also suggested that these fire installations might have been also used for preparing red ocher (Sardari, 2011). Sample (J12 35) taken from the ash content of one of these features yielded a relatively higher quantity of material, including cereal grains, pulses, nuts, wild taxa as well as wood charcoal fragments of almond and pistachio (Table 8.6). Therefore, based on the archaeobotanical evidence it seems that this fire installation has been used, at least partly, for some food processing and cooking activities. In addition, the presence of *Amygdalus* and *Pistacia* charcoal fragments in the same context indicates the type of fuel used for domestic purposes. It is important to note that although livestock dung would have been also available to be used as a source of fuel, no such evidence was observed in any of the analysed samples. Another important aspect of the Mehrali assemblage (Bakun and Lapui phases) was the almost complete absence of cereal chaff in the samples. Out of 44 samples only one room fill sample (E5 75) contained the remains of few emmer spikelet forks, glume bases and bread wheat rachis mixed with other plants (pulses, nutshells and a few arable/ruderal wild taxa). In the same sample, however, no cereal grains were present. The absence of cereal chaff among the samples could be partly due to taphonomic factors. For example, according to charring experiments, cereal chaff have less chance of surviving in the fire than grains (Boardman and Jones, 1990). Therefore, the presence of both glume wheat and free-threshing rachis in this context could indicate their exposure to the optimal charring temperature. However, it must be stressed that the rarity of cereal chaff remains was continuous throughout the sequence and within the spaces, therefore other reasons should be taken into account. Considering the fact that the majority of the archaeobotanical samples come from internal spaces (room fill deposits, fireplaces, etc.) one hypothesis that can be put forward is that cereal processing practises may have taken place outside these buildings, and consequently there would have been less chance for these products to be exposed to domestic fires.

8.4 Wood charcoal remains

In total 7 flotation charcoal samples amounting to 270 wood charcoal fragments were analysed from the Lapui phase of Mehrali. The list of identified charcoal taxa, absolute fragment counts, charcoal weights, volume of floated sediment and contextual information of the samples are presented in Table 8.6. The raw/percentage fragment counts and ubiquity (sample presence) are available in Table 8.7. The analysed charcoal assemblage (270 fragments, 48.228 g) represents material recovered from 4 room fill deposits (J12 35, E5 69, E5 36 and F11 37), 2 pits (E5 34, G22 11) and 1 fire installation (D11 12) dated to the Lapui phase. The Mehrali charcoal assemblage comprised 5 different taxa, including almond (*Amygdalus*), pistachio (*Pistacia*), ash (*Fraxinus*), willow/poplar (Salicaceae) and buckthorn (*Rhamnus*). *Amygdalus* was the most common taxon (100% ubiquity) followed by *Pistacia* which was present in 6 out of 7 samples (Table 8.7). The other identified taxa, such as *Fraxinus, Rhamnus* and Salicaceae, had lower frequencies and appeared only sporadically (Table 8.6, Fig 8.6). *Amygdalus* and *Pistacia* were the most abundant taxa (making up approximately 98% of the assemblage). The Mehrali charcoal assemblage had relatively higher density of wood charcoal in comparison to the other two sites under study and most of the samples contained >4 mm fragments (Table 8.6). The overall state of charcoal preservation was good as indicated by the very low number of unidentifiable fragments (Fr/Pr index, Table 8.6). No significant difference was observed in the composition of wood taxa recovered from different contexts, such as room fills, domestic fire installation and disposal pits. As there was no evidence of a burnt structure in any of the occupation phases of the site, it is assumed that the analysed charcoal fragments are likely to represent the remains of fuel originating from different burning episodes. Overall, based on these results, it seems that *Amygdalus-Pistacia* woodland was routinely exploited by the Lapui inhabitants of the site as a source of fuel wood. The presence of taxa such as *Fraxinus* and Salicaceae also points to the existence and occasional exploitation of riparian vegetation near the site (see also discussion in Chapter 9).

Mehrali	**Trench**	**J12**	**J12**	**D11**	**D11**	**D11**	**F10**	**J12**	**J12**	**J12**
	Locus	**46**	**47**	**45**	**47**	**64**	**90**	**4**	**7**	**19**
	Phase	**BA**	**BA**	**BA**	**BA**	**BA**	**BA**	**LA**	**LA**	**LA**
	Context	**Fill**	**Fill**	**Pit**	**Pit**	**Pit**	**Fill**	**Ash**	**Ash**	**FI**
	Volume (L)	**30**	**30**	**17**	**25**	**11**	**40**	**18**	**30**	**27**
	Items per/L	**0.6**	**0.06**	**1.29**	**3.8**	**0.27**	**0.27**	**0.11**	**0.83**	**0.4**
Cereals										
Triticum monococcum grain										
Triticum dicoccum grain										
Triticum dicoccum spikelet fork										
Triticum dicoccum glume base										
Triticum cf. *aestivum* rachis										
Triticum sp. grain										2
Hordeum vulgare grain			2	3						1
Cerealia										
Pulses										
Lens sp.								2		
Vicia ervilia									2	
Pisum/Vicia										
Fabaceae										
Fruit/Nuts										
Pistacia cf. *atlantica* (whole)									2	
Pistacia sp. (frg)		5		10	14	2			4	6
Amygdalus sp. (whole)										
Amygdalus sp. (frg)		13					7		2	2
Wild taxa										
Chenopodiaceae							2			
Brassicaceae					6					
Silene sp.				2						
Cyperaceae					61	1	2			
Carex cf. *divisa*				7	14				8	
Trigonella cf. *astroites*										
Astragalus sp.									2	
Gramineae										
Polygonum sp.									5	
Rumex sp.										
Galium sp.										
Hyoscyamus sp.										
Total		**18**	**2**	**22**	**95**	**3**	**11**	**2**	**25**	**11**

Table 8.2. Plant remains from the Bakun and Lapui levels of Mehrali, BA= Bakun, LA= Lapui, FI= fire installation, frg= nutshell fragment

Mehrali	**Trench**	**J12**	**J12**	**F10**	**F10**	**F10**	**F10**	**F10**	**F10**	**F10**
	Locus	**31**	**35**	**21**	**23**	**36**	**41**	**47**	**50**	**56**
	Phase	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**
	Context	**Ash**	**Fill**	**Fill**	**Fl**	**Fl**	**Fl**	**Fill**	**Floor**	**Ash**
	Volume (L)	**30**	**25**	**45**	**30**	**15**	**30**	**65**	**18**	**32**
	Items per/L	**0.43**	**6.36**	**0.77**	**0.4**	**0.26**	**0.3**	**0.41**	**2.7**	**0.18**
Cereals										
Triticum monococcum grain			2	2						
Triticum dicoccum grain		9	25	2	3		6	2		
Triticum dicoccum spikelet fork										
Triticum dicoccum glume base										
Triticum cf. *aestivum* rachis										
Triticum sp. grain				2				5		
Hordeum vulgare grain			2	3	2		1	4		
Cerealia			8	5						
Pulses										
Lens sp.				1						
Vicia ervilia							1		2	
Pisum/Vicia			1					1		
Fabaceae					4					
Fruit/Nuts										
Pistacia cf. *atlantica* (whole)			1	1						
Pistacia sp. (frg)			6			4				
Amygdalus sp. (whole)										
Amygdalus sp. (frg)				3					48	6
Wild taxa										
Chenopodiaceae										
Brassicaceae			3	4			1	6		
Silene sp.										
Cyperaceae		2		5				3		
Carex cf. *divisa*			108							
Trigonella cf. *astroites*			2	5				6		
Astragalus sp.					3					
Gramineae										
Polygonum sp.				2						
Rumex sp.		2								
Galium sp.										
Hyoscyamus sp.			1							
Total		**13**	**159**	**35**	**12**	**4**	**9**	**27**	**50**	**6**

Table 8.2. Continue

Mehrali	**Trench**	**E5**	**E5**	**E5**	**E5**	**E5**	**E5**	**E5**	**E5**	**E5**
	Locus	**75**	**40**	**69**	**29**	**33**	**13**	**10**	**34**	**67**
	Phase	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**
	Context	**Fill**	**Ash**	**Fill**	**Fill**	**Fill**	**Fl**	**Fl**	**Pit**	**Fill**
	Volume (L)	**40**	**60**	**28**	**45**	**55**	**35**	**60**	**54**	**30**
	Items per/L	**1.52**	**0.31**	**2.89**	**0.08**	**0.12**	**0.02**	**0.1**	**0.03**	**0.13**
Cereals										
Triticum monococcum grain										
Triticum dicoccum grain								1		
Triticum dicoccum spikelet fork		10								
Triticum dicoccum glume base		4								
Triticum cf. *aestivum* rachis		2								
Triticum sp. grain										
Hordeum vulgare grain										
Cerealia				2						
Pulses										
Lens sp.		2		1				1		
Vicia ervilia		1							2	
Pisum/Vicia			1							
Fabaceae		4								
Fruit/Nuts										
Pistacia cf. *atlantica* (whole)		4	2				1			
Pistacia sp. (frg)		10	14	2				6		
Amygdalus sp. (whole)		2	2	1						
Amygdalus sp. (frg)		14		68	4	7				4
Wild taxa										
Chenopodiaceae		2								
Brassicaceae		2								
Silene sp.				1						
Cyperaceae										
Carex cf. *divisa*										
Trigonella cf. *astroites*										
Astragalus sp.				5						
Gramineae		1		1						
Polygonum sp.										
Rumex sp.										
Galium sp.		2								
Hyoscyamus sp.		1								
Total		**61**	**19**	**81**	**4**	**7**	**1**	**8**	**2**	**4**

Table 8.2. Continue

Mehrali	Trench	E5	E5	E5	E5	E5	E5	E5	E5	E5
	Locus	**54**	**63**	**44**	**32**	**48**	**43**	**56**	**51**	**36**
	Phase	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**
	Context	**Fill**	**Fill**	**Ash**	**Ash**	**Fill**	**Pit**	**Ash**	**Fill**	**Fill**
	Volume (L)	**45**	**35**	**75**	**30**	**54**	**30**	**65**	**30**	**48**
	Items per/L	**0.04**	**0.2**	**1.8**	**5.5**	**0.5**	**3**	**1.4**	**1.16**	**1.04**
Cereals										
Triticum monococcum grain										
Triticum dicoccum grain										
Triticum dicoccum spikelet fork										
Triticum dicoccum glume base										
Triticum cf. *aestivum* rachis										
Triticum sp. grain			2							
Hordeum vulgare grain					1					
Cerealia										
Pulses										
Lens sp.					1			2		
Vicia ervilia								2		3
Pisum/Vicia										
Fabaceae								2		
Fruit/Nuts										
Pistacia cf. *atlantica* (whole)				13		8	3	2		
Pistacia sp. (frg)				20		17				
Amygdalus sp. (whole)				3	1	2	2	1	2	3
Amygdalus sp. (frg)			2	99	160		95	85	33	44
Wild taxa										
Chenopodiaceae										
Brassicaceae										
Silene sp.										
Cyperaceae			2							
Carex cf. *divisa*										
Trigonella cf. *astroites*										
Astragalus sp.										
Gramineae		2								
Polygonum sp.					2					
Rumex sp.										
Galium sp.										
Hyoscyamus sp.										
Total		**2**	**6**	**135**	**165**	**27**	**100**	**94**	**35**	**50**

Table 8.2. Continue

Mehrali	Trench	D11	G11	G22	G20	F11	F11	F11
	Locus	**12**	**14**	**11**	**19**	**37**	**35**	**46**
	Phase	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**
	Context	**FI**	**Ash**	**Ash**	**Ash**	**Fill**	**FI**	**Fill**
	Volume (L)	**30**	**30**	**7**	**18**	**30**	**60**	**45**
	Items per/L	**0.56**	**0.36**	**1.42**	**0.33**	**0.23**	**0.81**	**0.22**
Cereals								
Triticum monococcum grain								
Triticum dicoccum grain								
Triticum dicoccum spikelet fork								
Triticum dicoccum glume base								
Triticum cf. *aestivum* rachis								
Triticum sp. grain			1	1			2	
Hordeum vulgare grain								
Cerealia		1	4	1				
Pulses								
Lens sp.				2				
Vicia ervilia								
Pisum/Vicia								
Fabaceae								
Fruit/Nuts								
Pistacia cf. *atlantica* (whole)								
Pistacia sp. (frg)		15					4	3
Amygdalus sp. (whole)								
Amygdalus sp. (frg)			6		6	7	43	4
Wild taxa								
Chenopodiaceae								
Brassicaceae				1				
Silene sp.								
Cyperaceae		1						3
Carex cf. *divisa*								
Trigonella cf. *astroites*				2				
Astragalus sp.				3				
Gramineae								
Polygonum sp.								
Rumex sp.								
Galium sp.								
Hyoscyamus sp.								
Total		**17**	**11**	**10**	**6**	**7**	**49**	**10**

Table 8.2. Continue

Phase		Early Chalcolithic			Late Chalcolithic	
Number of samples		**6**			**37**	
Soil volume (L)		**153**			**1404**	
Number of identified taxa		**8**			**24**	
	Ubiquity	**Sum**	**Max per sample**	**Ubiquity**	**Sum**	**Max per sample**
Cereals						
Triticum monococcum grain	-	-	-	5%	4	2
Triticum dicoccum grain	-	-	-	19%	48	25
Triticum dicoccum spikelet fork	-	-	-	5%	10	10
Triticum dicoccum glume base	-	-	-	5%	4	4
Triticum sp. grain	-	-	-	19%	15	5
Triticum cf. *aestivum rachis*	-	-	-	5%	2	2
Hordeum vulgare grain	25%	5	3	19%	14	4
Cerealia	-	-	-	16%	21	8
Pulses						
Lens sp.	-	-	-	21%	12	2
Vicia ervilia	-	-	-	19%	13	3
Pisum/Vicia	-	-	-	8%	3	1
Fabaceae	-	-	-	8%	10	4
Fruit/Nuts						
Pistacia sp.	50%	31	14	45%	148	27
Amygdalus sp.	25%	20	13	70%	761	153
Wild taxa						
Chenopodiaceae	12%	2	2	2%	2	2
Brassicaceae	12%	6	6	16%	17	6
Silene sp.	12%	2	2	2%	1	1
Cyperaceae	37%	64	61	16%	16	5
Carex cf. *divisa*	25%	21	14	5%	116	108
Trigonella cf. astroites	-	-	-	10%	15	6
Astragalus sp.	-	-	-	10%	13	5
Gramineae	-	-	-	8%	4	2
Polygonum sp.	-	-	-	8%	9	5
Rumex sp.	-	-	-	2%	2	2
Galium sp.	-	-	-	2%	2	2
Hyoscyamus sp.	-	-	-	5%	2	1
Total		**151**			**1264**	

Table 8.3. Ubiquity and abundance for each plant taxon and type in Mehrali plant assemblage

Taxa	**Number**	**Length**	**Breadth**	**Shell thickness**
Amygdalus	19	Max: 17 mm Min: 15 mm	Max: 12 mm Min: 11 mm	Max: 1.1 mm Min: 0.8 mm
Pistacia	35	Max: 5.2 mm Min: 4.8 mm	Max: 6.3 mm Min: 5.5 mm	Max: 0.5 mm Min: 0.4 mm

Table 8.4: endocarp dimensions of almond and pistachio nuts recovered from the Mehrali assemblage

Amygdalus species	Section	Persian name	Endocarp dimensions	Shell thickness	Description
A. hussknechtii	*Amygdalus*	بادام زاگرسی	L Max: 27 mm , L Min: 13 mm W Max: 16 mm , W Min: 10 mm	Max: 1.2 mm Min: 0.7 mm	Elliptic-ovate, laterally compressed, obtuse or mucronate apex, pits and small grooves on surface, elongated grooves along the keel,
A. elaeagnifolia	*Amygdalus*	بادام برگ سنجدی	L Max: 23 mm , L Min: 16 mm W Max: 15 mm , W Min:7 mm	Max: 2.1 mm Min: 0.7 mm	Ovate, round base, acute to round apex, pits near the base, indistinctly sulcate.
A. reticulata	*Amygdalus*	بادام مشبک	L: 16 mm W:10 mm	0.7 mm	Elliptic to ovate in shape with pits near the base, distinct reticulate surface pattern in the lower part.
A. glauca	*Spartioides*	بادام شیرازی	L Max: 17 mm, L Min: 14 mm W Max: 14 mm, W Min: 9 mm	Max: 1.3 mm Min: 0.2 mm	Ovate, oblong ovate, slightly compressed, pointed apex, indistinct furrows on surface.
***A. scoparia* ***	*Spartioides*	بادام کوهی	L Max: 17 mm, L Min: 10 mm W Max: 10 mm, W Min: 8 mm	Max: 0.7 mm Min: 0.2 mm	Oval, pointed apex, small hilum scar, sharp keel, smooth surface or superficial grooves.
A. eburnean	*Dodecandra*	بادام عاجی	L Max: 14 mm, L Min: 12 mm W Max: 10 mm, W Min: 9 mm	Max: 1.5 mm Min: 0.4 mm	Ovate, ovate-globular, hilum slightly sulcate, rarely reticulate-sulcate no surface pits.

Table 8.5. Morphological characteristics of wild almond species growing in Fars, ***** all species are endemic to Iran except *A. scoparia,* **L**: Length, **W**: Width

Sources: Sorkhe *et al*., 2009; Mozaffarian, 2009; Khatamsaz, 1992; Browicz and Zohary 1996; Mozaffarian, 2006; Khalily, 2008; Vafadar, *et al*., 2010; Martinoli and Jacomet, 2004.

Fig 8.2. *Pistacia* cf. *atlantica*

Fig 8.3. *Amygdalus* nutshell fragment with keel

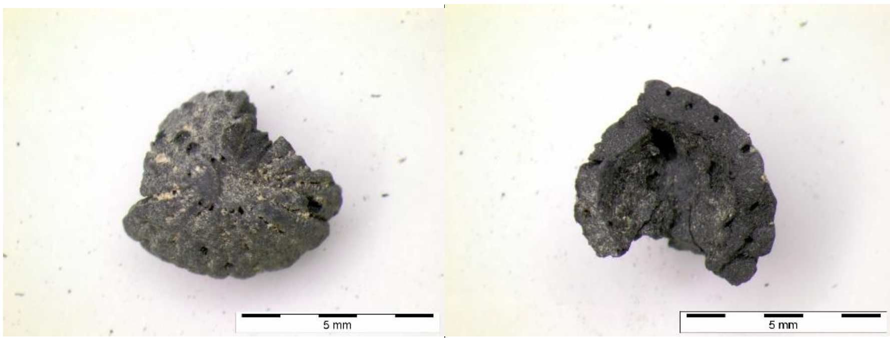


Fig 8.4. *Amygdalus* nutshell fragment with hilum plate

Fig 8.5. *Amygdalus* cf. *hussknechtii/elaeagnifolia*

Trench	J12	E5	E5	E5	D11	F11	G22	Total CH
Context no	**35**	**69**	**36**	**34**	**12**	**37**	**11**	
volume	**25**	**28**	**48**	**54**	**30**	**30**	**7**	
Description	**Fill**	**Fill**	**Fill**	**Pit**	**FI**	**Fill**	**Ash**	
Time period	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	**LA**	
Total charcoal weight:	14.708	9	7.644	3.224	6.916	5.457	1.278	48.228
4 mm weight:	0.93	3.423	2.949	0.495	2.173	1.629	0	11.599
2 mm weight:	13.615	5.579	4.695	2.729	4.743	3.828	1.278	36.467
Charcoal density	0.58	0.32	0.15	0.05	0.23	0.18	0.18	0.21
Fr/Pr Index	0	0	0	0	0	0	0.03	0.003
Amygdalus	18	47	8	32	16	11	27	**159**
Pistacia	12	2	32	27	14	19		**106**
Rhamnus							1	**1**
Salicaceae		1		1				**2**
Fraxinus							1	**1**
Indet.							1	**1**
Total	30	50	40	60	30	30	30	**270**
Total (- indet.)	30	50	40	60	30	30	29	**269**

Table 8.6. List of wood taxa identified in the Mehrali charcoal assemblage, **CH** = Chalcolithic, **LA**= Lapui phase**, Fr/Pr**= Fragmentation/Preservation index (In Asouti's assemblages, an index of <0.5 was used to indicate overall good preservation, 0.6-0.9 moderate to high proportions of indeterminate fragments and 1-5 very high proportions of indeterminate fragments showing poorly preserved fragments (Asouti, 2003: p. 1193).

Phase	**Chalcolithic**		
Taxa	**C**	**%**	**U**
Amygdalus (almond)	159	59	7
Pistacia (pistachio)	106	39	6
Salicaceae (willow/poplar)	2	0.74	2
Fraxinus (ash)	1	0.37	1
Rhamnus (buckthorn)	1	0.37	1
Total	270	100	(n=7)

Table 8.7. Quantified anthracological data from Mehrali, **C**= Absolute fragment count, **%** = Percentage fragment count, **U**= Ubiquity

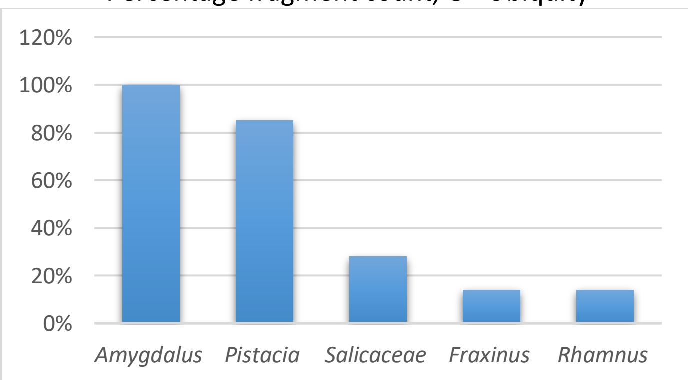


Fig 8.6. The percentage presence scores of the main taxa represented in the Mehrali charcoal assemblage (n=7)

Chapter 9

Discussion

The first section of this chapter briefly reviews the results of seed and charcoal analysis of the sites under study according to occupational phases. In the following part, the results are compared with other available archaeobotanical evidence in Fars to observe any changes or continuity (similarities/differences) in the plant management strategies at regional level over time. In order to have a broader understanding of the subsistence strategies of these settlements, along with archaeobotanical data, other available lines of evidence including bioarchaeological, other archaeological, ethnographic and ecological/environmental information are considered. The last section of the chapter discusses woodland management and fuel choice strategies based on the anthracological data.

9.1 Overview of the results from the sites under study (seed and charcoal)

A detailed discussion on the composition of samples, frequency of taxa, the use of space and possible sources of plant remains from each site is provided in Chapters 6, 7 and 8. The overall comparison of the results showed that despite differences in the size of plant assemblages and variations in the relative proportions of recovered plant remains at each site, the same range of taxa were present throughout the occupational phases across the three sites under study (Fig 9.1). Considering taphonomic biases, the relative proportion of taxa could be used only as a tentative indicator of the importance of the plant material. It has been argued that carbonised plant assemblages usually consist of a relatively limited range of plant species, including cereal grains, cereal chaff, pulses, nutshells, stones of fruits and wild plants (Van der Veen, 2007). Comparison of carbonised plant assemblages with waterlogged or desiccated remains showed that the former only represent a small proportion of plant remains originally present and discarded in archaeological sites (Van der Veen, 2007; Jacomet, 2012). Under charring conditions, some seeds and grains are more likely to be preserved in archaeological contexts, as fire is required in their processing or preparation (e.g. parching to free cereal grains from their spikelet, cooking of cereals and legumes before consumption, roasting of nuts, and use of some wild plants as fuel). Other plants, such as vegetables, fruits, condiments and oil-rich species are much less likely to become charred (e.g. Dennell, 1976; Hillman, 1981; van der Veen, 2007; Livarda, 2019). However, despite limitations of carbonised plant assemblages in terms of reconstructing food consumption and diet, they provide valuable information especially regarding past agricultural practices (van der Veen, 2007).

As discussed in Chapters 6, 7 and 8, the recovered charred plant remains from the sites under study might have originated from a variety of sources, however, it was observed that they mostly represent domestic cooking and consumption debris mixed with fuel. Some of the plant remains, such as cereal chaff, nutshell remains and wild taxa could have been used as part of the fuel intentionally, while others (cereal grains and pulses) were possibly burnt accidentally during food preparation. Burning of animal dung as fuel was also considered as another possible route of entry for some of the remains such as the small sized or hard- coated wild seeds, but the available evidence was not very convincing. Overall, archaeobotanical evidence from the sites under study indicated exploitation of cultivated crops as well as wild plant resources from the earliest occupation phase to the later periods. It seemed that glume wheats, such as emmer and einkorn (predominantly emmer), as well as barley constitute the main agricultural production in the Neolithic and Chalcolithic periods. The appearance of free-threshing wheats (*Triticum aestivum/durum*) was first observed in the Late Chalcolithic phase of Mehrali in very low numbers (Table 9.2). The absence or limited presence of free-threshing species must be considered with some caution, as they have fewer chances of being preserved in comparison to glume wheats (different processing requirement, lower survival rate of free- threshing chaff). The occurrence of lentil, grass pea and bitter vetch from the Neolithic period onward also points to the cultivation of pulses. Although the remains of wild fruits (*Amygdalus*, *Pistacia*) were present from the earliest phase, their importance may be overestimated due to the high fragmentation of the nutshells. However, due to their high ubiquity, it can also be suggested that collecting wild fruits/nuts was an important part of the plant economy of the inhabitants of Fars since the earliest occupation phase.

Table 9.1 presents the preliminary results of anthracological data from the sites under study ordered by chronological phase to assess their taxonomic representation. As shown in table 9.1, *Amygdalus* and *Pistacia* were the dominant wood taxa consistently present across time and space. The available anthracological evidence from these sites indicates that steppe-forest woodland (*Pistacia*, *Amygdalus*, and *Quercus*) constituted an important and sustainable source of fuel wood. Furthermore, the presence of riparian vegetation taxa, such as ash, willow/poplar, tamarisk and elm, also points to the diversity of wood catchments exploited during the Neolithic and Chalcolithic periods. The different proportions of the identified taxa in these sites may be an indicator of local strategies in wood collection and use. It is difficult to draw any firm conclusion based on the available quantified data, but it appears that a relatively wide range of taxa were used as fuel or building timber during both the Neolithic and Chalcolithic periods. Moreover, a pattern of continuity in the utilisation of taxa such as *Amygdalus* and *Pistacia* was observed through time, which is also supported by the seed data. In the following section, the results of the seed and charcoal analysis from this study along with other available archaeobotanical and bioarchaeological evidence from this region will be discussed in conjunction to understand the main characteristics of the subsistence economy and the environment of these settlements from the Aceramic to the end of the Chalcolithic period.

9.2 Agriculture and plant use patterns in prehistoric Fars through time

Reconstructing subsistence strategies of prehistoric settlements has always been one of the main objectives of the archaeological research undertaken in this region. In particular, discussions have been centred on whether the emphasis was on agricultural or pastoral activities. Previous archaeobotanical studies in Fars come from the following sites: Tall-e Mushki (Neolithic), Tall-e Jari (Neolithic), Tall-e Bakun (Chalcolithic) and Tall-e Malyan (Bronze Age) in the Kur River Basin, Tol-e Bashi (Neolithic) in the Ramjerd plain and the Early Holocene Cave site TB75 (Epipalaeolithic and Proto Neolithic/Aceramic) in Tange Bolaghi. The results of these studies have provided a greater understanding on the subsistence and plant economy of the prehistoric Fars. Plant remains analysed in the current study can make a significant contribution to the existing dataset by adding material from three prehistoric sites in Northern Fars with multi occupational phases. In order to observe the general trends in the exploitation of plant resources and agricultural practices at a regional level over a long sequence of occupation, the results of this study will be compared with the other archaeobotanical studies in Fars. Taphonomic factors shaping this dataset will be considered in the interpretations of the data.

9.2.1 Aceramic Neolithic (Late 8th millennium B.C.)

Currently the earliest archaeobotanical record of the region comes from the Early Holocene Cave TB75, containing Epipalaeolithic and Proto Neolithic/Aceramic layers (18000-8000 B.C.). The Aceramic occupation of this cave located above the Epipalaeolithic layers is dated to the late 10th mid-8th millennium B.C. (Tsuneki *et al*., 2007; Tsuneki and Zeidi, 2008; Tsuneki, 2013). Its archaeobotanical assemblage yielded remains of wild legumes (*Astragalus*/*Trigonella*), wild grasses (*Stipa*) and nutshells (*Prunus*/*Amygdalus*) with no evidence of domesticated plants (Tanno, 2008). It must be noted that the size of the plant assemblage was very small with poor state of preservation. The results of the analysis of the faunal assemblage from TB-75 showed the exploitation of wild animals, such as gazelle (predominant in the Epipalaeolithic layers), wild goat, sheep and a small number of wild pig and cattle. An increase in the proportion of wild sheep and particularly goats was observed in the proto-Neolithic period (Hongo and Mashkour, 2008). Moreover, in the archaeological surveys undertaken in this region a number of bedrock mortars were reported near the Pleistocene/early Holocene cave sites that might have been used for plant processing (Conard *et al*., 2006), although this does not necessarily imply their full domestication. Overall, based on the current available bioarchaeological data, a subsistence economy based on hunting and foraging has been suggested for the early Holocene communities of the region (Tanno, 2008; Hongo and Mashkour, 2008; Tsuneki, 2013; Weeks, 2013b).

To date, Rahmatabad is the only excavated tell site in the region containing multi occupational phases from the Aceramic to the later cultural phases (Late 8th to 5th B.C.) providing a rare opportunity to understand the earliest Neolithic communities of this region. The plant remains recovered from the first season of excavation at Rahmatabad were analysed as part of the present study and material from the second season of excavation were studied by Tengberg and Azizi (2016). In total seven samples corresponding to 61 litres of sediment (525 items) were analysed from the Aceramic (Pre-Pottery Neolithic) deposits of Rahmatabad in the second season of excavation. These deposits were reported as ash layers containing relatively high densities of plant remains (Tengberg and Azizi, 2016, p 138-139). The identified plant remains from these samples included a single grain of hulled barley, few emmer/einkorn spikelet forks, a few indeterminate cereal grains as well as a larger number of nutshell remains and wild taxa (Tengberg and Azizi, 2016, p 140, Table 2). It has been noted that small seeds of wild pulses (e.g. *Astragalus*) and seeds of the sedge family (Cyperaceae) constituted the main components of the wild assemblage, particularly in the early periods. Comparison of this study and the one included in this work showed some minor differences, for example while no barley grain, cereal chaff and nutshell fragments were found in the five samples analysed in this work, their presence was observed in the assemblage recovered from the second season of excavation. As discussed previously (see Chapter 4), the absence of these plant remains in the samples of the current study could be the result of taphonomic and other factors (e.g. assemblage size, preservation issues and the type of sampled contexts). The common aspect of both assemblages was the relatively higher proportion of wild taxa in comparison to the crop remains. However, in both studied assemblages the proportion and frequency of the wild taxa decreased from the Aceramic phase to the later occupational phases. Tengberg and Azizi (2016, p 143) noted that while plants of the sedge family were well represented in the Aceramic and Neolithic phase, they were absent in the Chalcolithic samples. Based on this evidence it is suggested that "their disappearance might reflect either a change in agricultural practices or an evolution from a more humid climate in the Early Holocene to more arid conditions" (Tengberg and Azizi, 2016, p. 143). It is also noted that the frequent occurrence of wild pulses in the earlier levels might reflect the persistence of plant practices based on foraging (as evident in the Cave TB75) alongside domesticated crops (Tengberg and Azizi, 2016, p. 144). Due to the small size of the Rahmatabad archaeobotanical assemblage analysed for the present study, it is very difficult to make a reliable statement regarding these changes through time. Overall, the archaeobotanical evidence from the Aceramic phase of this site (12 analysed samples in total) showed that alongside cultivated crops, the exploitation of wild plant resources was an important part of the plant subsistence economy. One important aspect of the carbonised plant assemblages of this region (from the Early Holocene to the later cultural phases) is the frequent occurrence of nuts and other wild plant taxa, particularly small wild legumes. In contrast to wild nuts, such as *Pistacia* and *Amygdalus* that are more likely to have been gathered for consumption, the use of small seeded legumes as food is not very clear and other routes of entry were considered (see Chapter 6). The appearance of domestic type of cereals in the analysed assemblages provided the first evidence of agricultural practices in the Aceramic period of this region. It is important to mention that no wild crop progenitors, such as wild barley or wheat, were found in the Aceramic samples of Rahmatabad. The cereal spikelet remains recovered from the second season of excavation were identified as "the domestic type (tear-off scar) with no sign of a local domestication process of either wheat or barley" (Tengberg and Azizi, 2016, p 144). Based on the results of this study, it is suggested that crops are more likely to arrive at the site in an already domesticated form from other sites or regions (*ibid*), an interpretation that is also supported by the current study.

Unlike the central Zagros region and the south-western lowlands (Ilam, Khuzestan), where several early Neolithic sites were found and investigated, our knowledge of the earliest Neolithic communities of Fars is very limited (Weeks, 2013b). The evidence of domesticated crops is attested from 8th millennium B.C. from the PPN sites in central Zagros and the south-western lowlands of Iran (Table 9.3). Archaeobotanical analysis from Sheikh-e Abad (the oldest Neolithic settlement in central Zagros) indicates the appearance of domesticated cereals from the later phases of the site dated to 7900 B.C. (Whitlam *et al*., 2018). The results of this study demonstrated that at the earliest phase (from 9800 B.C.) the site's inhabitants exploited a diverse range of locally available wild plants that were not wild progenitors of crops, indicating that domesticated crops were introduced to the site's inhabitants possibly from an external source (*ibid*). Evidence for the cultivation of crop progenitors (barley, wheats, lentil, large seeded pulses) before the appearance of domestication was present at the earlier levels of Chogha Golan (9700-7600 B.C.) located in the low foothills of the southern Zagros (Riehl *et al*., 2012, 2015; Weide *et al*.,2015, 2017). The earliest appearance of domesticated emmer at this site was recorded in the AHII phase dated to 7800-7600 B.C. (Riehl *et al*., 2012, 2015; Weide *et al*., 2015). Archaeobotanical data from other early Neolithic sites in these regions showed the widespread emergence of farming during the late 8th and early 7th millennium B.C. (Table 9.3). In general, it is noted that in most areas of Iran the early Neolithic communities displayed a well-established and integrated economy of plant and animal husbandry that is more likely to represent agricultural dispersal rather than independent agricultural origins (Weeks, 2013a, p 67). The emergence of farming communities in Fars is proposed to have started from the late 8th millennium B.C. with a subsistence economy based on herding and cultivation (Weeks, 2013b, Fig 9.2). The results of the archaeobotanical analysis on plant remains from the Aceramic phase of Rahmatabad is consistent with the model proposed for this region. It is important to note that the faunal assemblage of Rahmatabad is still under study, however, the initial observations on the animal bone remains by M. Mashkour also showed the presence of domesticates, which further support this argument (Weeks, 2013b).

9.2.2 Ceramic Neolithic (6th millennium B.C.)

The available archaeobotanical dataset from the Neolithic period of Fars comprises 70 samples recovered from the following prehistoric sites: Tal-e Mushki (6300-6100 B.C.) and Tal-e Jari (6000 B.C.) in the Kur River Basin, Tol-e Bashi (6100-6000 B.C.) in the Ramjerd plain, Rahmatabad (6000 B.C.) in the Kamin plain and Nurabad (6000 B.C.) in the Mamasani district (Table 9.2). It is important to note that in terms of number, samples from Bashi and Nurabad make up the majority of the current dataset (53 out of 70). All flotation samples recovered from the Neolithic deposits of Nurabad were fully analysed as part of the current study. Archaeobotanical data from Bashi, however, are based on the analysis of 20 flotation samples out of 142 recovered samples (Kimiaie, 2010). The Neolithic archaeobotanical assemblages of other sites were either small or not fully analysed yet. Factors such as variations in assemblage size, differences in the nature of archaeological contexts and site formation processes do not permit any direct comparison between these assemblages. However, the published archaeobotanical data of the region was explored for some general observations on the crop spectrum of this period. The results of these studies demonstrated the presence of the following crops: barley (*Hordeum vulgare*), emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*), bread/hard wheat (*Triticum aestivum/durum)*, lentil (*Lens*), pea (*Pisum* sp.) and vetch (*Vicia* sp.). In the cereal category, barley grains were attested in all five assemblages. The presence of barley rachis was less frequent. Glume wheats, such as emmer and einkorn, also occurred in most of the assemblages in both forms of grain and chaff. The evidence of bread/hard wheat (*Triticum aestivum/durum*) was also observed in the archaeobotanical assemblage of Tol-e Bashi and Tall-e Jari A (Table 9.2). Although the identified crop remains at each individual site were mostly restricted to barley and glume wheats, the overall picture indicated cultivation of a relatively wider range of crops by the Neolithic inhabitants of the region. Analysing more samples would allow more insights into the preferences of the major crops across the Neolithic settlements of Fars. Overall, according to the available archaeobotanical data, it appears that glume wheat species (particularly emmer) and barley played an important part in the agricultural and culinary regime during the Neolithic period of Fars. In addition to the cereal remains identified in the carbonised plant assemblages, the use of agricultural by-products was attested in the Neolithic ceramics and constructional remains of this region (Fukai *et al.,* 1973; Alden *et al.,* 2004; Weeks *et al*, 2009; Pollock *et al*., 2010; Weeks, 2013). The significance of crop cultivation for the Neolithic communities of Fars was also suggested according to the analysis of stone artefacts used for processing of cereals (Pope, 2010; Pollock *et al*., 2010; Nishiaki *et al*., 2013; Abe and Azizi, 2014). In addition, stone tool objects related to processing of grains (grinding, pounding) were found within the excavated units of these sites indicating the importance of crops in the subsistence economy (Egami *et al.,* 1977; Fukai *et al*., 1973; Saeedi and Pollock, 2010; Potts *et al*., 2009; Azizi *et al*., 2014). Analysing the wild plant assemblage of this period also showed the presence of potential arable weeds (e.g. *Eremopyrum, Aegilops*, *Avena*, *Galium*, *Lolium*, and *Vaccaria)* that are more likely to have been brought to the site with harvested crops.

It is important to mention that although pulses, such as lentil, peas and vetches, were absent in three of these plant assemblages, they are well attested in the plant assemblage of Nurabad. A few indeterminate pulses were also observed in the archaeobotanical assemblage of Jari. Assessing the role of taphonomic filters (e.g. the origin of plant remains, crop processing) and analysing an adequate number of samples are regarded crucial for the interpretation of crop spectra (Charles, 2007). As indicated in Table 9.2, the total number of analysed samples in three of these sites was less than 10 and the identified crops were mostly barley and glume wheats, whereas assemblages with a larger number of analysed samples showed a relatively broader range of crops. Therefore, it could be suggested that the small size of assemblages might have partly contributed to the observed pattern. Pulses, for example, are reported as common finds at prehistoric sites of the Near East (Zohary and Hopf, 2000). In Iran, they usually accompany cereals as part of agricultural economies of the Neolithic and Chalcolithic sites (Miller, 2003). However, they seemed to be absent or rarely present at some of these sites. This might be either due to the limited number of analysed samples (similarly to the cereals) or the preservation issues. As shown in Table 9.2, the presence of pulses was attested in the assemblages with larger number of analysed samples. In addition, it must be noted that due to processing requirements of pulses these are less likely to be exposed to fire in comparison to cereals. To explain the rare presence of lentil at Abdul Hossein for example, Hubbard (1990) noted that ''their haulms are too valuable as animal fodder to be burned and the seeds are only liable to be burnt during cooking accidents'' (Hubbard, 1990, p. 218). Overall, it appears that legumes (lentil, peas and vetches) also seemed to have been available, possibly as a supplementary source of food. Pulses constitute a rich source of plant protein and along with cereals they provide a complementary diet (Zohary and Hopf, 2000; Valamoti *et al*., 2011). Rotation of pulses and cereals is also important for maintaining soil fertility in small-scale intensive farming (Halstead 1987; Bogaard, 2005) and this may have been an option for the inhabitants of Fars too.

In addition to the food crops, nutshell remains of *Pistacia* and *Amygdalus* were found in all assemblages (Table 9.2). The ubiquitous occurrence of nutshell remains at these Neolithic sites points to their important role in rural economy. The significant role of wild fruits/nuts as gathered food resources during the Aceramic and Neolithic periods in Fars and the Zagros region has been addressed by several researchers (Tanno, 2008; Miller and Kimiaie, 2006; Kimiaie, 2010; Tengberg and Azizi, 2016; Van Zeist *et al*., 1984; Riehl *et al*., 2015; Whitlam *et al*., 2018; Hubbard 1990). The wild fruits of pistachio and almond are highly nutritive, containing a valuable source of vegetable fat (Van Zeist *et al*., 1984). Ethnobotanical observations in Eastern Anatolia showed that roasted and ground fruits of *Pistacia khinjuk* or *Pistacia atlantica* are used to preserve meat and for flavouring foods made from cereals (Hubbard, 1990). The fruits of wild almond can also be consumed after soaking the seeds in water and roasting to reduce the bitter taste (the culinary value of wild *Pistacia* and *Amygdalus* is also discussed in Chapter 8). The steppe-forests with *Amygdalus*, *Pistacia* and *Quercus* are available near these sites, providing reliable and predictable food/fuel resources that require relatively little time and labour.

From the Neolithic crop "package" (Zohary, 1996), flax was not found in the archaeobotanical assemblages of this region from the early Neolithic to the Bronze Age period (over 300 analysed samples). Two possible explanations can be put forward for the absence of flax seeds: A) preservation issues, as the oil-rich seeds of flax have low chances of survival through charring; B) cultivation of this crop was not part of the agriculture (or it was a minor crop), possibly due to its high maintenance and water requirements. Miller (2011, p 3) notes that flax is more likely to be a summer or spring irrigated crop. Cultivation of flax was attested at Tepe Sabz (6th millennium B.C.) as well as Sharafabad (3rd millennium B.C.) in the Deh Luran Plain (Table 9.3). Seeds of wild flax were also encountered in the samples of the Mohammad Jaffar phase (Neolithic) in Ali Kosh. It is suggested that flax cultivation in the arid environment of Deh Luran would have been based on irrigation (Helbaek, 1969; Miller, 2011). Overall, the assessment of the existing data recorded from the Neolithic phase of Fars, if regarded as representative, suggests cultivation of crops that are more suitable for the marginal environment of this region. Barley, for example, is more drought tolerant than wheat and well adapted to poorer soils (Zohary and Hopf, 2000, p. 59). Hulled wheats are also known for being resistant to poor soil conditions while their thick glumes protect the grains in the field and in storage (Nesbitt and Samuel, 1996). Storing glume wheat and hulled barley in their glumes and hulls would protect the grains from insect attack (Hillman, 1981; Nesbitt and Samuel, 1996). This would also allow dehusking the grains in smaller quantities prior to consumption as needed (Jones *et al*., 1986).

All these sites are part of the climate zone that extends south of the Zagros Mountains in which annual precipitation reaches 300-400 mm (between the months of October and May). The only exception is Mamasani (Nurabad) which is in receipt of considerably more rainfall than most areas in Fars with an annual average of 570 mm (Alizadeh, 2006: Pollock *et al*., 2010; Roustaie *et al*., 2009). The geographical location of the sites included in the current study (easy access to river, suitable pastures, fertile soil and forests) are regarded as important factors for their long sequence of human occupation (Azizi *et al*., 2014; Sardari, 2013; Potts *et al*., 2009). Based on the systematic archaeological surveys undertaken in the region some hypotheses have been put forward in relation to the nature of farming during the Neolithic period. For example, the Kur River Basin which is a broad plain of some 3400 km^2 situated about 1600 m above sea level with annual rainfall ranging from 350 mm in the northwest to 200 mm in the southeast, allows dry farming of winter crops (Alizadi, 2006; Sumner, 1977, 1994). It has been suggested that in the Mushki phase (6300-6100 B.C) crops depended on rain-fed agriculture and small-scale irrigation from nearby springs, while from the Jari phase (6100 B.C) canal-based irrigation from the rivers was practised (Sumner, 1990, 1994). It is argued that the development of this system allowed expansion of settlements in the Central part of the Kur River Basin in the later cultural phases (*Ibid*).

Analysis of the faunal remains from these sites also provided further insights into the subsistence strategies practised by the Neolithic inhabitants of Fars. The available zooarchaeological evidence from the ceramic Neolithic period comes from Mushki and Jari (Payen, 1991; Mashkour *et al*., 2006), Bashi (Mashkour and Bailon 2010) and Nurabad (Mashkour, 2009). Comparison of these assemblages revealed some major differences in the faunal spectra of the earliest periods of occupation at regional level (Mashhour, 2009). For example, while the faunal assemblage from Mushki was dominated by hunted species (equids, gazelle and aurochs) there was a sharp decrease in their presence in the later ceramic Neolithic sites. In Jari and Bashi, domestic caprids (sheep and goat) constituted the majority of the faunal assemblage, and other species, such as cattle, gazelle, aurochs and equids, were observed with lower frequencies (Mashkour *et al*., 2006; Mashkour and Bailon 2010). Mashkour (2009) notes that comparison of the Nurabad faunal assemblage with data from these contemporaneous sites in the region demonstrated a completely different picture. At Nurabad, caprids (sheep and goat) were the most important taxa exploited in the Neolithic phase with no evidence of hunting gazelle and equid, revealing clear economic differences at regional scale (Mashkour, 2009, p 138). Overall, it is noted that the faunal material from this period indicated ''a progressive change in subsistence through time and the uniformisation and specialisation of the meat economy around caprine and to lesser extent, bovine exploitation'' (Mashkour, 2009, p. 138). In general, archaeological and bioarchaeological evidence from this region showed diversity/flexibility in subsistence strategies practised by the Neolithic communities (Mashkour, 2009; Weeks, 2013). For instance, at Mushki while archaeobotanical evidence attested to the exploitation of domesticated cereals, such as barley, emmer and einkorn (Miller and Kimiaie, 2006), the faunal assemblage indicated reliance upon hunted species (Mashkour *et al*., 2006). Based on these results, a unique ''hunter-cultivator'' subsistence adaptation has been proposed for this site (Weeks, 2013, Fig 9.2). However, it has been suggested that new excavations at other Mushki period sites in the region might reveal a different mode of animal exploitation (*ibid*). The faunal assemblage of Rahmatabad has not been analysed yet. However, the recent zooarchaeological study of Qasr-e Ahmad provided important information on the process of caprine domestication in Fars. It has been reported that goat was the most exploited animal during the Aceramic and ceramic Neolithic phases at this site. The presence of domesticated sheep was also observed however represented a limited contribution to the subsistence economy at the site (Kamjan *et al*., 2018, p 27).

It is important to note that different assumptions regarding the origin of charred plant remains from these sites has created different interpretations. For example, animal dung burnt as fuel was considered as the main source of entry for charred seed remains recovered at Mushki, Jari, Bakun and Malyan. It has been argued that archaeobotanical evidence from these sites are directly relevant to pastoral economy and indirectly to the human subsistence economy. Consequently, the focus of these studies was centred around discussion on foddering and pasturing practices as well as fuel selection (Miller, 1982, 2011, 2013; Miller and Kimiaie, 2006). The analysed archaeobotanical samples from Mushki (five samples) and Jari (three samples) and Bakun (4 samples) were treated as a single temporal unit and for comparison purposes archaeobotanical data from Tall-e Malyan was used as instructive (Miller and Kimiaie, 2006, p 112-113). It is noted that most of the recovered charred seeds originated from dung burnt as fuel, therefore the proportions of wild seeds to charcoal were used to infer the relative contribution of wood to dung fuel. The higher wild seed (count) to charcoal (weight) ratios in Mushki, Jari and particularly Bakun assemblages compared to Malyan were taken to indicate higher use of dung as fuel in the earlier periods, possibly reflecting a less forested environment (Miller and Kimiaie, 2006, p 112 and Table 8, P. 116-118). Moreover, based on the higher ratios of the wild seed versus cereal grains (wild: cereal ratio combined with barley: wheat ratio) it was suggested that animal grazing was more important than foddering in earlier times than at Malyan (Miller and Kimiaie, 2006, p 112). The wood charcoal assemblages of these sites have not been analysed as yet. However, the archaeobotanical samples from these sites contained wood charcoal fragments in variable amounts. In the Mushki assemblage, one particular sample (oven/feature 4) was reported rich in charred wood remains (3.57 g charcoal >2mm) with very few seeds, indicating a wood fueled fire (Miller and Kimiaie, 2006, p 108).

The findings of the current study, however, demonstrated that the charred seeds could have derived from various activities/sources including crop processing, food preparation/consumption and fuel (including dung). No animal dung pellets were observed among the analysed samples recovered from the second season of excavation at Rahmatabad (Tengberg and Azizi, 2016). Moreover, due to the good preservation state of the chaff remains it is suggested that they were exposed to fire directly without passing through the digestive tube of animals. Therefore, these chaff remains probably represent the discarded by-product from cereal cleaning (Tengberg and Azizi, 2016, p 142). The results of phytolith analysis on samples from the interior spaces of Bashi also showed evidence of cereal storage/processing in the residential buildings (Hassan, 2010). The phytolith samples of the fire installations of this site also indicated the use of various flora resources (wood and grassy types with the latter most likely present in dung) as fuel (*ibid*). Although no dung pellets were observed in these Neolithic carbonised plant assemblages, this route of entry has been considered as a possibility for some of the recovered wild taxa. High exploitation of domesticated animals (predominantly sheep and goat) was indicated by the zooarchaeological studies of this period, therefore, livestock dung would have been available to be used as a source of fuel. However, careful consideration of the samples' composition, preservation status and other lines of evidence showed that dung burnt as fuel was not a major source of the plant material in the current study. Other methods including micromorphological analysis of sediments from these sites could provide complementary insights into the use of dung and more detailed interpretations.

Overall, the available archaeobotanical data from the Neolithic settlements of this region show that agricultural products were part of the subsistence economy, however it must be considered that differences in preferences of cultivated crops is also linked to several factors (e.g. population density, arable land and labour availability, intensity of animal husbandry and other cultural choices). The quantity and quality of the available archaeobotanical datasets from this period are very uneven, however, the available evidence points to regional variety and flexibility in subsistence strategies practised by the Neolithic inhabitants of this region. More archaeobotanical data and interdisciplinary studies are required to establish a reliable picture of the Neolithic subsistence economies and a better understanding of the regional patterns.

9.2.3 Chalcolithic (5th- 4th millennium B.C.)

Previously the archaeobotanical record of this period was limited to the four analysed samples from Tall-e Bakun A and B (Miller and Kimiaie, 2006). The new archaeobotanical evidence recovered from three multi-phase sites (Rahmatabad, Nurabad and Mehrali) added a significant glimpse to the existing Chalcolithic dataset and provided further insights into the plant use patterns of this period. Furthermore, since the plant remains derived from large-scale excavations in the residential areas, they provided the first direct evidence of food related activities/domestic life of the Chalcolithic settlements. Archaeobotanical samples from the early Chalcolithic period of this region (defined as Bakun Period) are available from the following sites: Rahmatabad (20 samples), Nurabad (11 samples), Mehrali (6 samples) and Tall-e Bakun (4 samples). Archaeobotanical data from the late Chalcolithic phase (Lapui) is only available from Mehrali (37 samples). In the Chalcolithic archaeobotanical samples, barley (2-row and 6-row) and glume wheats (predominantly emmer) were the most frequently encountered crops. Glume wheat chaff was found in larger numbers in comparison to free-threshing rachis in most of the assemblages. As noted previously, glume wheat chaff may be over-represented due to taphonomic factors (piecemeal processing, higher survival chance in fire). However, the abundance and frequency of the glume wheat and barley grains in comparison to the free threshing grains might reflect their importance in crop production. Although the presence of free-threshing wheats (grain and rachis segments) is relatively more frequent from this period onwards; however, glume wheats (particularly emmer) remained consistent through time (Table 9.2). The presence of free-threshing wheat at different sites in Iran, particularly in arid environments, was attributed to the practice of irrigation (Helbaek, 1969; Miller, 1999, 2003,2011). Other crops included lentil, bitter vetch, and peas that were found in lower quantities.

Overall, in these multi-period sites (Rahmatabad, Nurabad and Mehrali), comparison of the plant remains recovered from the Neolithic and Chalcolithic layers did not show any significant difference in terms of crop patterns, possibly indicating continuity in crop usage and presence throughout the sequence.

Archaeobotanical studies of the Chalcolithic samples (5th-4th millennium B.C) in south western Iran also indicated that barley, emmer and lentil were the most common crops (Table 9.3). At Musiyan E (4500-4000 B.C.), the presence of flax, lentil and hexaploid wheat was attributed to irrigation (Helbaek, 1969).

In the archaeobotanical assemblages of this period, the most common nuts appeared to be *Amygdalus* and *Pistacia*. In addition, a fragment of the inner part of acorn (*Quercus* sp.) was attested in the Chalcolithic samples of Rahmatabad (Tengberg and Azizi, 2016). It is important to note that oak was not identified in the wood charcoal assemblage of Rahmatabad; however, this might be due to the limited number of analysed samples. Completing the anthracological analysis of this site would allow the presence/absence of oak (*Quercus*) to be verified with certainty. The presence of oak, however, was observed in the wood charcoal assemblage of Nurabad throughout the whole sequence. Overall, the frequent occurrence of these nuts/fruits indicated the continuous exploitation of woodlands with *Quercus*, *Pistacia* and *Amygdalus* by the Chalcolithic inhabitants of Fars. In the Zagros region, local people commonly use these woodland resources for animal grazing, fodder, fuel and seed collection (Salehi, 2010). Acorn, for example has been mentioned as an important source of the diet of nomadic pastoralist and agricultural communities of the Zagros region (Alizadeh, 2006; Hole *et al*., 1969; Salehi, 2010). Acorns have variable fat content and are relatively high in carbohydrates; they can be eaten raw/roasted as snack food or ground into flour for making bread. The local villagers also collect acorns (*Q. persica*) and oak leaves to feed animals (mostly goats) in the winter. Gathering acorns is highly seasonal as oaks have a good production of acorns every two years (Elahi and Rouzbehan, 2008; Salehi, 2010). It is noted that the rare presence of acorns in archaeobotanical assemblages might be related to preservation conditions (carbonisation would usually destroy the thin walled shells of acorns) or the location of acorn processing (Lev *et al*., 2005; Salkova *et al*., 2011). The simultaneous presence of wild fruits/nuts with cultivated crops in these plant assemblages testifies to the significant role of these gathered resources in the plant economy.

Another important finding of this period was the presence of animal dung remains in the Chalcolithic samples of Rahmatabad, indicating the use of livestock dung as a source of fuel. The results of the faunal analyses from Bakun (Mashkour *et al*., 2006), Nurabad (Mashkour, 2009) and Mehrali (Sheikhi, 2008) demonstrated the intensive exploitation of sheep and goat during the Chalcolithic period, therefore livestock dung would have been available as a source of fuel. In the archaeobotanical assemblage of Tall-e Bakun (four analysed samples), animal dung remains were also attested in two samples (BB27, Sq38) recovered from a large trash deposit (Miller and Kimiaie, 2006, Table 8, p 118). While the animal dung remains found in one of these samples was reported as being uncharred (>2 mm, 0.03 grams), the second sample contained 0.01 g of charred dung remains >2 mm (Miller and Kimiaie, 2006, Table 8, p 118). Both of these samples are also reported rich in terms of plant remains, containing a mixture of cereal grains and chaff (barley, hard/bread wheat, emmer, einkorn), pulses (cf. *Pisum*), nutshells and a higher proportion of wild taxa (sedges, grasses, small seeded legumes). In sample square BB27 the presence of silicified awns of grasses and amorphous charred material was also attested that looked like digested masses of cereals (Miller and Kimiaie, 2006, p 108). Similar to the archaeobotanical remains recovered from Mushki and Jari, most of the charred seed remains from this site are reported to be derived from animal dung burnt as fuel (Miller and Kimiaie, 2006, p 112).

As discussed in Chapter 6, in Rahmatabad some whole and fragmented dung remains (charred) were also found in three samples retrieved from the Chalcolithic phase. However, in the case of Rahmatabad, it was suggested that the co-occurrence of dung remains and other plant material was the result of post depositional mixing. The plant material embedded in these dung pellets (sheep/goat) was very fragmented and badly damaged with no visible seed or grain, whereas the overall state of other plant remains found in physical association to dung pellets was good with no evidence of dung material adhering to them. The content of these sheep/goat dung pellets however, showed that cereal chaff (at least partly) was used as fodder. Cereal foddering might have been practised as part of animal feeding regime; however, this was not possible to infer based on the available data from Rahmatabad. It has been argued that crops could have been grown both for human food and as fodder for animals, however distinction of "food" and "fodder" grains based on mainstream archaeobotanical evidence (species of crops, thoroughness of crop processing, crop purity, method or context of storage) is unpromising as the boundaries between food and fodder tend to be highly flexible in mixed farming economies (Jones, 1998, p 97-98). As indicated by experimental studies, the survival rates of cereals (wheat and barley) vary based on the animals' digestive system, however the chance of cereal grains surviving intact is very low (Wallace and Charles 2013; Valamoti and Charles 2005; Anderson and Ertug-Yaras 1998). In addition to preservation biases imposed by the animals' digestive system, manufacturing of dung cakes also imposes additional biases complicating this picture (Wallace and Charles 2013). Therefore, in reconstructing animal diet based on the range of plant remains within dung-related samples, careful examination of these taphonomic biases is necessary (*ibid*). In the case of Rahmatabad, some of the identified wild species were considered as potentially dung derived material, which could have been grazed by animals or collected and brought to the site as fodder.

The presence of taxa associated with agricultural disturbance was observed in all plant assemblages of this period. However, the small size of these plant assemblages and the sporadic occurrence of these wild taxa made it difficult to establish a clear chronological pattern. A general comparison of the Chalcolithic wild plant assemblage with the earlier periods, however, showed an overall decrease in the presence of small seeded legumes and sedges. In the current study, as well as in the archaeobotanical study of material from the second season of excavation at Rahmatabad (Tengberg and Azizi 2016), these arable weeds are more likely to have arrived on the site with harvested crops and discarded in fire during postharvest processing.

The arable weeds could also represent plants grazed by livestock, incorporated into the assemblage through animal dung used as fuel (Miller and Kimiaie, 2006). Therefore, the proportional increase in the occurrence of arable weeds might indicate differences in land use and changes in the source of livestock diet through time (*ibid*). Regardless of differences in the sources of plant remains (e.g. derived from animal dung or harvested with crops), the more frequent occurrence of arable weeds in these archaeobotanical assemblages is further evidence for the importance of agricultural production in the Chalcolithic period.

Archaeobotanical analysis on the plant material recovered from the Lapui occupational phase of Mehrali also showed similar plant use patterns to the Bakun period. Archaeobotanical data from this site indicated the exploitation of cereal grains, such as emmer, einkorn and barley, hard/bread wheat and pulses, such as lentil and bitter vetch. The presence of glume wheat grains and chaff as well as barley in the archaeological deposits of domestic buildings testifies that these species were part of the Mehrali agriculture. The site is located on a fertile plain close to the Balengan River and some permanent springs, and therefore, sufficient water would have been available for crop cultivation (Sardari, 2013). It was also observed that the exploitation of steppe-forests for food, fuel and possibly fodder was still an important part of the plant economy during the 4th millennium B.C. The study of the faunal assemblage from Mehrali also demonstrated that sheep and goat were the most important taxa exploited throughout the sequence (Sheikhi, 2008). Archaeological investigations at this site also showed several similarities in management mechanisms, construction and the subsistence strategy during both the Bakun and Lapui phases (Sardari, 2013).

In contrast to the Neolithic period of this region, the Chalcolithic period (5th millennium B.C.) of Fars has received less attention and there are still many unanswered questions regarding cultural developments and subsistence practices, human behaviour and so on (Weeks *et al.*, 2006, 2010; Petrie, 2013). The Bakun period is regarded as the most intensive phase of prehistoric settlement in Fars and witnessed a number of major social, economic and political transformations (Sumner 1988, 1994, 2003; Petrie, 2011, 2013). However, there are different opinions between the scholars of this period over a number of issues, such as the development of settlements, population growth, stratigraphy of phases and cultural material. While some scholars believe that cultural and technological transformations and complexity in the Bakun period were the result of two millennia of progressive experience of village-based Neolithic societies, suggesting local cultural continuity (Sumner, 1990, 1994; Weeks *et al*., 2010; Petrie, 2013), others emphasise the influence of nomadic pastoralist groups that migrated into the region (Alizadeh, 2003, 2006). The validity of the second hypothesis has been debated, in particular the form of proposed pastoralism, i.e. “fully fledged nomadic pastoralists” (Abdi, 2003; Potts, 2008; Weeks, 2010; Petrie, 2013; Potts, 2014). As a result, there are different interpretations regarding the subsistence economy of this period. While some characterise this phase as a period of settled communities involved in a mixed agro-pastoral subsistence system based on agricultural production and herding (Weeks *et al.*, 2010; Petrie, 2013; Sumner 1990, 1994), others claim that subsistence economy focused on pastoral production generated by mobile pastoralist communities (Alizadeh, 2003b; 2006). Similarly, there are different hypotheses regarding the settlement developments and subsistence strategies during the 4th millennium B.C. defined as Lapui phase (see discussion in Chapter 2).

In general, agropastoral societies have been described as groups of people who practice both farming and herding as appropriate to their social and natural environment in which climate plays an important role in decision-making (Miller,2011,2013). Therefore, adjusting subsistence strategies according to environment allows substantial flexibility over space and time. It has been argued that in agropastoral systems, at one end the higher ratio of wild plants versus cultivated cereal grains and high proportions of sheep/goat compared to cattle and pig are signatures of a subsistence economy focused on pastoral production. At the other end, low wild/cereal ratios along with high proportions of cattle, pig, and hare indicate an economy more focused on agriculture (Miller *et al*., 2009; Miller,2011; Miller, 2013). In the Kur River Basin, an agropastoral economy with emphasis on pastoral activities has been suggested for the Chalcolithic occupation of Bakun (Alizadeh, 2006). In general, the available bioarchaeological evidence from the sites included in this study points to the close integration of crop cultivation and livestock management in the Chalcolithic period. The overall picture also indicates that agriculture was practiced alongside livestock herding and exploitation of other wild plant food resources, hinting at a broad subsistence economy. Comparison of the archaeobotanical assemblages recovered from the Neolithic and Chalcolithic periods of the sites under study also demonstrated a degree of continuity in crop usage and agricultural practises throughout time. It is important to note that archaeological investigations at these sites also showed a high degree of continuity in settlement population and size during this period (Petrie *et al.*, 2009; Petrie, 2013; Sardari, 2013). The intensity of agricultural and pastoral activities could be subjected to regional, cultural and climate variables; therefore, these results cannot be extrapolated to explain prehistoric subsistence strategies of the whole region. In order to establish a more reliable picture of the subsistence economies practised at a regional level and addressing wider socio-economic aspects of this period more bioarchaeological analyses and interdisciplinary studies are required.

9.2.4 Bronze Age (3rd- 2nd millennium B.C)

Although discussion on the archaeobotanical evidence of this period is beyond the scope of the current study, it is briefly reviewed here to give a broader picture of agricultural practices and plant management strategies through time. Currently, the only published archaeobotanical data from this period come from Malyan covering mainly two occupational phases, Banesh and Kaftari (Miller, 1982). The general density of charred seed remains of this site is reported low (Miller and Kimiaie, 2006, p 112) "in total 189 seeds were recovered from 1200 litres of the Banesh deposits (99 samples) and 2473 seeds from 1200 litres of the Kaftari deposits (90 samples)". Most of the recovered carbonised seeds were considered as constituents of dung and due to the larger number of seeds found in the Kaftari period it was suggested that there was an increase in the use of animal dung as fuel (Miller, 1982). In the Malyan archaeobotanical assemblage the following plant remains were present: cereals (predominately barley, emmer, einkorn, bread wheat) in both forms of grain and chaff, pulses (lentil, pea) as well as nuts/fruits (*Pistacia*, almond, hackberry, grape, fig, date). It is important to note that at Malyan relatively large quantities of recovered grape and fig seeds and all hackberries were preserved in mineralised form. Miller (1982, p.242) noted that "the grapes were most probably cultivated and their culture implies significant investment in labour and land for a crop that does not bear fruit for a number of years". The appearance of two date pits in the Kaftari samples was considered as evidence for economic interaction with other regions, as the closest date growing region is about 150 km from the site. Regarding the absence of acorn in the seed assemblage of Malyan the following suggestions were put forward: "A) herds were not pastured in the area of oak forests, despite the close distance to the site; B) the oak forests were utilised only for wood" (Miller, 1982, 245). Overall, a mixed economy based on wheat and barley agriculture and sheep and goat herding has been suggested for Bronze Age Malyan (Miller, 1982).

9.3 Woodland vegetation and fuel exploitation

The previous anthracological and palynological studies undertaken in Fars have provided important insights on climate history and human impacts on natural vegetation during the Late Holocene (Miller, 1982, 1985, 2013; Djamali *et al*., 2009,2016; Jones *et al*., 2015). However, our understanding of prehistoric human-vegetation interactions from earlier periods mainly comes from the studies of carbonised seed assemblages. Previously, the only anthracological record of this region was from Tal-e Malyan in the Kur River Basin covering the Bronze Age period (Miller, 1982, 1985, 2013). In addition, the earliest palynological investigation of Fars comes from Lake Maharlou around 150 km from the study area with the pollen record starting around 5700 cal BP and terminating at 400 cal BP (Djamali *et al*., 2009).

Palaeoenvironmental/palynological investigations on the vegetation and climate history of the Early Holocene period are available from the north, north-western and central parts of the Zagros Mountains (van Zeist and Bottema, 1977; Wasylikowa and Witkowski, 2008; Stevens *et al*., 2001; El-Moslimany, 1986, 1987; Djamali *et al*. 2008, 2010, 2011). It is important to note that the palynological evidence from the Zagros region comes from lake sediments or archaeological sites that are around 900 km away from the area under study. Furthermore, it has been argued that the picture of vegetation reflected in these pollen diagrams is partly biased due to the absence or under-representation of some autogamous or entomophilous plants (e.g. Fabaceae, Plumbaginaceae, Rosaceae) and the over-representation of other anemophilous groups (e.g. Artemisia, Chenopodiaceae) in the pollen rain (Djamali *et al*., 2009, 2011). Due to the limited number of archaeobotanical studies in this region, there is a considerable shortage of data with which to propose hypotheses concerning the relationship between prehistoric communities and their environment during the Early Neolithic and Chalcolithic periods. Therefore, in addition to the non-wood archaeobotanical analysis, the application of wood charcoal analyses can significantly enhance our understanding of prehistoric human-vegetation interactions in Fars. The new anthracological data from the site under study provided important insights into woodland exploitation practices and fuel selection of the Early Neolithic and Chalcolithic period of Fars. However, it must be considered that several taphonomic factors/processes might have affected the preservation and composition of the analysed wood charcoal remains. Potential filters include: (a) human selection of fuel wood species and variation in hearth types and functions, (b) the differential destruction of different wood taxa during combustion, and (c) depositional and post depositional processes (e.g. Chabal, 1999; Asouti and Austin, 2005; Smart and Hoffman, 1988; Thery-Parisot *et al*., 2010a; Thery-Parisot *et al*., 2010b; Chrzazvez *et al*., 2014; Lancelotti *et al*., 2010). Furthermore, due to the small size of the examined charcoal dataset, any suggestions regarding possible shifts in wood acquisition strategies (and from these inferences about past vegetation) are by necessity tentative at this stage. Due to the lack of comparative data from this period in Fars, the results of this study are compared at a broader regional context with the available anthracological and palaeoclimatic studies in the Zagros region. Table 9.4 presents the comparison of wood taxa present in the current study with other available anthracological evidence in the Fars and the Zagros regions.

As shown in table 9.1, *Amygdalus* and *Pistacia* are the dominant charcoal taxa consistently present in the wood charcoal assemblages of the sites under study from the Aceramic to the Late Chalcolithic periods. In the Zagros region, the earliest evidence of *Prunus* cf. *amygdalus* has been reported from the wood charcoal assemblage of Kaldar Cave (Khorramabad Valley, western Iran) dating to the Middle and Upper Palaeolithic (Allué *et al.,* 2018). It is noted that the charcoal fragments retrieved from this cave represent the use of wood as fuel and identification of charcoal remains of *Prunus*, *Prunus* cf. *amygdalus* indicated the presence of these trees and shrubs in the environment even during climatically cold periods (*ibid*). The frequent occurrence of *Pistacia* and *Amygdalus* has also been attested in the wood charcoal assemblages of other Aceramic and Early Neolithic sites in the Zagros region including Chogha Golan (Riehl *et al.*, 2015), Ganj Dareh (van Zeist *et al.*, 1984) and Abdul Hossein (Willcox, 1990). The results of wood charcoal analysis at Chogha Golan indicated the presence and continuous exploitation of the *Pistacia-Amygdalus* woodland throughout the long habitation of the site from the earliest phase dated to the last phase of the Younger Dryas to the 8th millennium B.C. (Riehl *et al.*, 2015). The new archaeobotanical evidence from two Early Neolithic sites (Sheikh-e Abad and Jani) in the Central Zagros also demonstrated exploitation of *Pistacia-Amygdalus* woodland for nuts. Both assemblages also contained wood charcoal remains in variable amounts indicating the use of wood as a source of fuel (Matthews *et al*., 2013, Whitlam *et al*., 2013, 2018). Both *Pistacia* and *Amygdalus* also made up a large percentage of the wood charcoal assemblage of Abdul Hossein, indicating that there was no lack of fuel in the natural vegetation during the mid-seventh millennium BC. (Willcox, 1990). At this site, charcoal remains of *Pistacia* were present in all analysed samples, however, several large fragments of this taxon were found in one of the trenches (trench 9-G 12032), and were thought to represent the remains of beams used in roof construction (*ibid*). In the same assemblage charcoal from *Amygdalus/Prunus* type was present as smaller fragments and Willcox (1990, p.225) notes that '' the wood produced by this group in the semi-arid environment is generally rather gnarled and rarely of usable length, it is, however a good firewood''. At Ganj Dareh also, a higher proportion of *Prunus* (*Amygdalus*) type charcoal was found in features like fire pits, ovens and kilns, indicating deliberate selection of firewood (van Zeist *et al.*, 1984). The less frequent presence of *Pistacia/Celtis* wood types in these features, was interpreted as an indication that they might have been spared from cutting because of their valuable nuts and fruits. *Pistacia* nutlets were commonly present in the archaeobotanical assemblages of Ganj Dareh (*ibid*). Overall, no significant shift/change was observed in the exploitation of the wood resources throughout the occupational levels of this site (van Zeist *et al.*, 1984). The presence of both taxa is also reported from the pollen sequences of this period from the Zeribar and Mirabad lakes (van Zeist and Bottema, 1977). However, it is noted that *Pistacia* and *Amygdalus* are poor pollen producers and therefore might be under-represented in pollen diagrams (Willcox, 1990). Several researchers have stressed the significance of on-site palaeoenvironmental data (charred seeds and wood) in providing vital information on taxa that are likely to be underrepresented in off-site sequences (e.g. poor pollen dispersers, or insect-pollinated taxa) (Willcox, 1990; Asouti, 2003, 2005,2013; Asouti and Austin 2005; Asouti and Kabukcu, 2014; Matthews *et al*., 2013; Djamali *et al*., 2009, 2011). Palynological investigations at the Lake Maharlou in Fars indicated the presence of woodland with *Quercus*, *Pistacia* and *Amygdalus* at least since the mid-Holocene (Djamali *et al.* 2009). Wood charcoals of *Pistacia* and *Amygdalus* were also frequently present in the anthracological assemblage of Malyan during the Bronze Age period (Miller, 1985, 2013). The available evidence from the Aceramic phase of Rahmatabad (including wood charcoal and seeds) also points to the existence of the semi-arid *Pistacia-Amygdalus* woodland near the site and its exploitation for nuts and firewood by prehistoric communities of this region. *Amygdalus* and *Pistacia* are the two dominant genera of the open woodlands or steppe-forests in this region and both taxa are regarded as good firewood (Miller, 1982, 2013).

In addition, riparian woodland taxa (*Tamarix, Fraxinus* and Salicaceae) were also present among the examined samples from the sites under study throughout the sequence, in lower frequencies. Regarding the scarcity of wood taxa such as poplar/willow in the anthracological assemblage of Ganj Dareh it was suggested that '' this charcoal type is rather soft which may unfavourably have affected its preservation '' (Van Zeist *et al.*, 1984, p. 222). By contrast, *Amygdalus* wood is hardy with higher chances of preservation even in adverse depositional and post-depositional environments (Asouti, 2005; Asouti and Kabukcu, 2014; Asouti *et al*., 2015). Riparian taxa (*Salix*/*Populus* sp. and *Tamarix*) have also been reported from the anthracological and palynological records of the Zagros region (Table 9.4). The presence of *Salix* in both the anthracological and palynological records of Caldar Cave indicated that there were active water sources or flows (Allué *et al.,* 2018). It is suggested that the wood of poplar or willow might have been used for construction purposes at Ganj Dareh and Abdul Hossein (Van Zeist, *et al.*, 1984; Willcox, 1990). Wood remains of *Fraxinus* and *Populus* were also present in the anthracological assemblage of Malyan in Fars (Miller 1985, 2013). Today, poplar and willow are the primary woods used for roof beams in the villages of this region as the wood can be obtained in long straight trunks, which are suitable for timber (Miller 1982, pp. 186-187; Miller 1985). The archaeological evidence for the use of poplar for beams was reported from a burnt building dating to around 400 years after the Kaftari phase of Malyan (1200 B.C.) where large chunks of poplar charcoal were found in association with other roofing material (grass or reed stems from matting) (Miller 1985, p. 13). It has been suggested that there were some similarities between archaeological and contemporary construction techniques in the region. The traditional construction technique is described as ''made of sun-dried mud bricks, with wooden beams covered with mats, brush and layers of hard-packed mud'' (*ibid*). The use of this construction technique has been also suggested for the residential buildings of Rahmatabad in the Chalcolithic phase (Bernbeck *et al*., 2005b). At this site, several clay pieces in different forms of concave, cross section and T-shaped with reeds impressions were found from the room fill deposits, and it was hypothesized that wood might have been used in some cases to block, strengthen or support walls and corners (*ibid*).

Since the origin of charcoal remains in the archaeological deposits (e.g. room fills, pits and ash deposits) is uncertain they could not provide direct information on the use of wood for construction purposes. Nevertheless, some of the recovered charcoal remains from the sites under study might represent the wood taxa used as building material. For example, in Nurabad, relatively large numbers of *Fraxinus* charcoal were found only in two contexts (C 509, C 511) from a room fill deposit, which might have originated from the burning and/or discard of structural timbers. In the Chalcolithic phase of Rahmatabad, wood charcoals of *Fraxinus*, *Tamarix* and Salicaceae (*Salix*/*Populus*) were also found in room fill deposits. Therefore, in addition to the possible use of these taxa as fuel, they might also have been used for construction purposes in the sites under study.

Other identified taxa (*Acer, Ulmus,* and *Rhamnus*) in the studied samples appeared only sporadically (Table 9.1). *Acer* was also present in the anthracological assemblages of Chogha Golan and Malyan (Table 9.4). Miller (1982, p. 196) notes: “It [maple] was mentioned by villagers of Malyan as suitable for firewood’’. In the wood charcoal assemblage of Nurabad, a single fragment of *Ulmus* (elm) was also found in a Neolithic fill deposit (D 1047) while wood charcoal of the elm family (Ulmaceae) was also identified in the anthracological assemblage of Malyan (Table 9.4). A single *Rhamnus* charcoal fragment was found in the Chalcolithic ash deposits (G 22) of Mehrali; the presence of this taxon was also recorded in the anthracological assemblages of Ganj Dareh and Malyan (Table 9.4). The sporadic occurrence of some less frequent wood taxa in the current assemblage might relate to their contexts of origin, possibly representing the remains of short-term, episodic fuel wood use.

The only significant difference observed in the examined samples from these sites was the presence of *Juniperus* (juniper) and *Quercus* (oak) wood charcoal at Nurabad (Table 9.4). In the anthracological assemblage of this site, juniper was observed in two samples (C508 and C509) dated to the Late Bakun period, indicating the presence of juniper trees in the region and the use of juniper wood as fuel and (possibly) timber. In Fars, this taxon is also attested in the wood charcoal assemblage of Malyan, identified as *Juniperus* *excelsa* on phytogeographic grounds (Miller 1982, 1985, 2013). Anthracological analysis at Malyan showed a continuous decline in the presence of juniper through the different cultural phases (Banesh and Kaftari, 3400-1600 B.C). It has been inferred that juniper might have been replaced by faster growing trees once it cut down as it is not a source of edible fruits and it and grows very slowly (Miller 1985, 2013). In Iran, juniper has a long history of uses, mainly as fuel and building material such as timber and fencing (Pirani *et al*., 2011). However, due to its extensive use as fuel and timber and its exceedingly slow growth the total surface of juniper forests of the country has dramatically decreased in the last 100 years (Zare 2001).

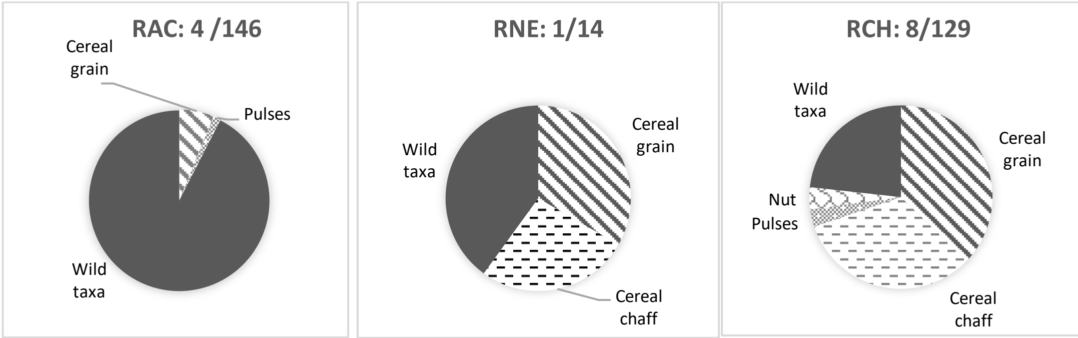
Another important finding of the current study was the continuous presence of oak in the anthracological assemblage of Nurabad (Table 9.4). Nurabad (1000 m a.s.l) in the Mamasani District lies across the heart of the southwestern Zagros where *Quercus brantii* is commonly present in the area. Today, in the Nurabad area, trees and shrubs of *Quercus brantii* and *Pistacia atlantica* are reported growing in lower elevations and *Amygdalus orientalis* and individual trees of *Juniperus polycarpus* in higher elevations ranging from 800-1400 m a.s.l (Taleshi and Maasumi Babarabi, 2013).

Oak, however, seems to be absent or scarcely present in the anthracological and palynological records of the Zagros during the Early Holocene. Palynological evidence Zeribar and Mirabad showed the scarcity of oak pollen during the Early Holocene, suggesting that the establishment of the present-day Zagros oak forest belt took place around 6000 cal BP (van Zeist and Bottema, 1977). According to the pollen record from Lake Maharlou, *Quercus brantii* woodland and *Pistacia–Amygdalus* scrub dominated the area during the late Holocene (Djamali *et al*., 2009). It has been suggested that the expansion of Zagros oak woodland in the Fars region might have occurred later than 6000 cal BP (Miller and Kimiaie, 2006; Djamali *et al*., 2009). The new anthracological data analysed as part of this study, however, indicated the presence and exploitation of oak trees from as early as 6000 BC (i.e. around two thousand years earlier than previously suggested by palynological analyses). The results of palynological analysis on samples from Kaldar Cave also indicated the presence of evergreen *Quercus* (Allué *et al*., 2018).

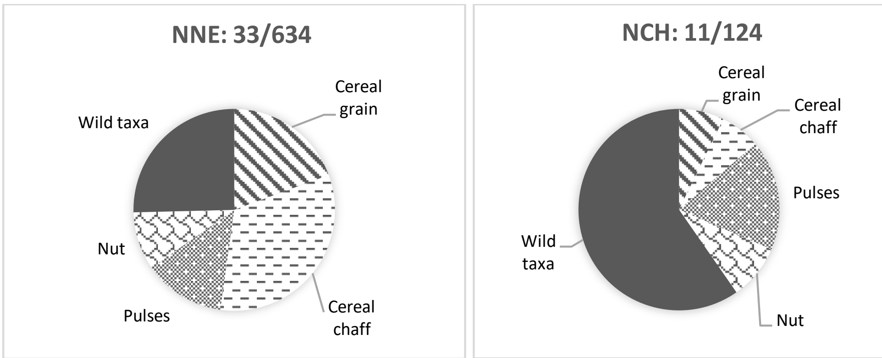
In general, it is argued that following the end of Pleistocene, there was a delay in the expansion of semi-arid deciduous oak woodland in the Irano-Anatolian region and the likely causes of this delay have been widely discussed (Van Zeist and Bottema, 1977; Van Zeist and Bottema, 1991; Roberts, 2002; Roberts and Wright, 1993; Hillman, 1996; Stevens *et al*., 2001, 2006; Asouti and Kabukcu, 2014). Asouti and Kabukcu (2014) have argued that at the start of the Holocene deciduous *Quercus* formed only a minor component of the semi-arid grassland vegetation across the hilly flanks of the Irano-Anatolian region and the postglacial expansion and establishment of deciduous *Quercus* woodlands was not completed until mid-Holocene times. According to this study, the gradual increase of *Quercus*-dominated woodlands in this region was the result of Neolithic human activities, such as increasing destruction of grassland habitats by grazing, cultivation, settlement expansion and woodland management strategies during the 9th–7th millennia BC. The anthracological records from the Konya Plain of Central Anatolia also demonstrated that during the first millennia of the Holocene *Quercus* wood use by Neolithic communities was very sporadic and its increase was recorded during the early-mid Holocene (Asouti and Kabukcu, 2014; Asouti *et al*., 2015).

Notably, *Quercus* was absent in the wood charcoal assemblages retrieved from the Aceramic deposits of Rahmatabad (current study) as well as other Early Holocene sites located in the Zagros region such as Chogha Golan (Riehl *et al*, 2015), Ganj Dareh (van Zeist *et* al, 1984) and Abdul Hossein (Willcox, 1990). The results of wood charcoal analysis from Nurabad indicated the presence and exploitation of oak trees from the earliest occupational phase dated to the 6th millennium BC. It is important to note that a single charcoal was also tentatively identified as *Quercus* from the Neolithic deposits (Ash layer, B 47) of Tol-e Bashi (Kimiaie, 2010). A fragment of the inner part of an acorn was also found in the archaeobotanical assemblage of Rahmatabad dated to the Chalcolithic period (Tengberg and Azizi, 2016). Although the current anthracological data from Fras are rather limited, the available evidence shows the use of *Quercus* wood from the Ceramic Neolithic period (mid-Holocene). Notably, the presence of *Quercus* substantially increased in the available anthracological and palynological records of Fars during the Late Holocene (Djamali *et al*., 2009; Miller, 1982, 1985, 2013).

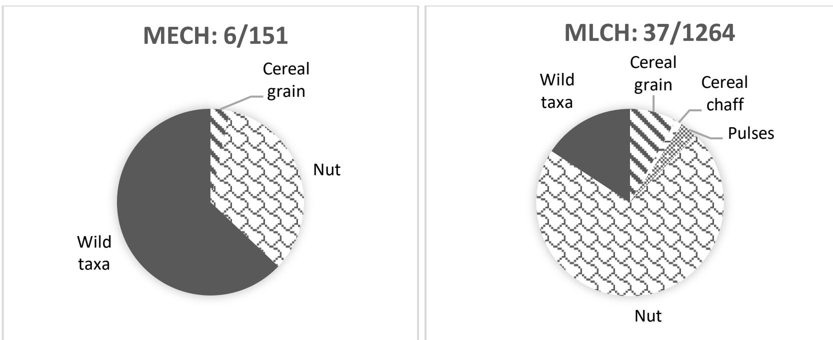
Overall, the results of the current study demonstrate the exploitation of the *Pistacia-Amygdalus* steppe forest by the prehistoric inhabitant of Fars for fuel from the late 8th millennium BC and deciduous oak woodland from 6th millennium BC. They also indicate the existence of a vegetation mosaic including riparian gallery forests with *Fraxinus* (ash), Salicaceae (willow/poplar), *Ulmus* (elm), *Ace*r (maple) and *Tamarix* (tamarisk), demonstrating the diversity of wood resources exploited during the Neolithic and Chalcolithic periods. Further work on the charcoal assemblages of these sites as well as sampling from other Early Neolithic and Chalcolithic settlements in the region would substantially improve our understanding of local vegetation, climate patterns and regional variation in the use of wood resources.



Rahmatabad



Nurabad



Mehrali

Fig 9.1: Relative proportion of plant remains (MNI) from the sites under study in chronological order (the headings indicate the number of samples/the number of remains), RAC= Rahmatabad Aceramic, RNE= Rahmatabad Neolithic, RCH= Rahmatabad Chalcolithic, NNE= Nurabad Neolithic, NCH= Nurabad Chalcolithic, MECH= Mehrali Early Chalcolithic, MLCH= Mehrali Late Chalcolithic.

Hunting and foraging economy in the Epi-Palaeolithic period (*ca*. 18,000-10,000 BC)
↓
Hunting and foraging economy with increasing emphasis upon future animal domesticates (herd management?) in the "Proto-Neolithic" period (*ca*. 10,000-8000 BC)
↓
farming communities (herder-cultivators) in the "Aceramic Neolithic" (*ca*. 7100 BC)
↓
Hunter-cultivators in the Mushki period (*ca*. 6300-6100 BC)
↓
Sedentary farming communities (herder-cultivators) exploiting domesticated plants and animals in the Bashi, Jari and Shams Abad periods (*ca.* 6100-5000 BC).

Fig 9.2. The proposed sequence of subsistence practises in prehistoric Fars (Weeks, 2013b, p. 102)

Period	AC	NE	ECH		LCH	
Site	Rahmatabad	Nurabad	Rahmatabad	Nurabad	Mehrali	
No. analysed samples	2	6	6	5	7	
Method of recovery	F	F	F	F	F	
Taxa	**#**					**U N=26**
Amygdalus (almond)	13	49	77	15	159	24
Pistacia (pistachio)	36	3	47	1	106	15
Quercus (oak)	-	12	-	23	-	9
Fraxinus (ash)	2	-	18	78	1	7
Salicaceae(willow/poplar)	5	-	4	7	2	7
Tamarix (tamarisk)	1	-	25	-	-	4
Juniperus (Juniper)	-	-	-	8	-	2
Acer (maple)	-	1	-	-	-	1
Ulmus (elm)	-	1	-	-	-	1
Rhamnus (buckthorn)	-	-	-	-	1	1
Total ID fragment count	57	66	171	132	269	

Table 9.1: Anthracological assemblage of sites under study based on chronological order, **#** = Absolute fragment counts, **U**= number of flotation samples in which taxon was present, **N**= Total number of analysed flotation samples, **F**= Flotation, **AC**= Aceramic, **NE**= Neolithic, **ECH**= Early Chalcolithic, **LCH**= Late Chalcolithic

Table. 9.2	Aceramic		Neolithic						Early Chalcolithic					Late Chalcolithic	Bronze Age	
	Late 8th B.C.		Late 7th - 6th B.C.						5th B.C.					4th B.C.	3rd - 2nd B.C.	
	Rahmatabad	Rahmatabad *	Rahmatabad	Rahmatabad *	Nurabad	Bashi	Mushki	Jari	Rahmatabad	Rahmatabad *	Nurabad	Mehrali	Bakun	Mehrali (Lapui)	Malyan (Banesh)	Malyan (Kaftari)
Number of analysed samples	5	7	1	8	33	20	5	3	8	12	11	6	4	37	99	90
Cereals																
Hordeum vulgare grain		+	+	+	x	+	+	+	+	+	+	+	+	+	x	x
Hordeum vulgare rachis				+	+		+	+	+	+	+		+		+	x
Triticum monococcum grain				cf	+	+	+			cf	+		+	+	+	+
Triticum monococcum sf		+				+	+			+			x		+	+
Triticum dicoccum grain	+		+	+	+				+	+	+		+	+	+	+
Triticum dicoccum sf			+	x	x			+	x	x	+			+	+	+
Triticum dicoccum glume bases			+		x				x		+			+	+	+
Triticum dicoccum/monococcum sf		x		x	+	+	x	+		x			x			
Triticum durum/aestivum grain						+				+			+			
Triticum durum/aestivum rachis								+						+	+	+
Triticum aestivum grain															+	+
Triticum sp.	+		+	+	+	+	+	+	+	+	+		+	+	+	+
Cerealia	+	+		x	+	+	+	+	+	x			+	+	x	x
Pulses																
Vicia/ Lathyrus					+				+		+					+
Pisum/Vicia					+					+	+			+		
Lens sp.					+						+			+	+	x
Pisum													cf			+
Vicia ervilia														+		
Pulse indeterminate	+							+					+	+		

	Aceramic			Neolithic							Early Chalcolithic						Late Chalcolithic		Bronze Age	
	Late 8th B.C.			Late 7th - 6th B.C.							5th B.C.						4th B.C.		3rd - 2nd B.C.	
	Rahmatabad	Rahmatabad *		Rahmatabad	Rahmatabad *	Nurabad	Bashi	Mushki	Jari		Rahmatabad	Rahmatabad *	Nurabad	Mehrali	Bakun		Mehrali (Lapui)		Malyan (Banesh)	Malyan (Kaftari)
Number of analysed samples	5	7		1	8	33	20	5	3		8	12	11	6	4		37		99	90
Nuts and fruits																				
Pistacia sp.						+					+	+	+	+	+		x		x	x
Pistacia atlantica/khinjuk							+													
Pistacia cf. *atlantica*																	x			
Amygdalus sp.					+	+	+				+	+	+	+			x		x	x
Amygdalus cf. *scoparia*																			x	x
Amygdalus cf. *hussknechtii/elaeagnifolia*																	x			
Quercus sp.												+								
Prunus sp.								+							+					
Nutshell indeterminate		x			x		+	+	+			x			+					
Ficus carica																			+	+
Phoenix dactylifera																				+
Cf. *Rubus*																				+
Celtis sp.																			+	+
Vitis vinifera																			+	x

Table 9.2: Presence of archaeobotanical material in Fars from the Aceramic to the Bronze Age period (**+** = Presence, **x** = common, **cf**. uncertain determination, **sf**= spikelet forks, ***** = material from the second season of excavation at Rahmatabad) **References:** *Rahmatabad (Tengberg and Azizi, 2016), Bashi (Kimiaie, 2010), Mushki, Jari, Bakun (Miller and Kimiaie, 2006), Malyan (Miller, 1982; 2003).

Site	Date (B.C)	No. samples	Barley	Einkorn	Emmer	Bread/hard wheat	Lentil	Pea	Vetch	Grass pea	Flax	Comments
Chogha Golan	9700-7600	45	R		+		+	x	x	x		*AH II phase onward (7800-7600 B.C).
Sheikh-e Abad	9800-7600	41	+	+	+		+	+	+	+		*Tr. 3 (7900 B.C)
Chia Sabz	8500-7600	4			Cf.		x		x	x		
Ganj Dareh	8240–7840	122	+				+	R				From the Level E to Level A
Abdul Hossein	8300–7800	50	+		+		R					*Early 7^{th} B.C
Chogha Bonut	7500-6800	24	x	+	x		Cf.	+	+	+		*From the Archaic phase
Chogha Mish	Archaic-protoliterate	33	+				x	x	x			*From the Archaic phase (7000 B.C)
Guran	6800-6400	?	+									
Ali Kosh (AK)	6500	13	x	R	x		R					
Ali Kosh (MJ)	6000-5600	13	x		+		R					Wild flax
Tepe Sabz	6^{th} B.C	?	X	+	+	X	X				X	Irrigation
Bendebal	Late 5^{th} – early 4^{th} mill.B.C	6	+	Cf.								
Musiyan E	4500-4000	2	x	+	x	+	+			+	+	Evidence of irrigation
Jaffarabad	4^{th} mill. B.C	36	x	+	x		x		+			
Farukhabad	4^{th} - 3^{rd} mill. B.C	8	x	+	+	+	+					
Sharafabad	3^{rd} mill. B.C	15	x		x		+				+	Evidence of irrigation
Godin VI	3^{rd} mill. B.C	10	xx	+	xx	xx	xx					Evidence of irrigation, Wine residue,

Table 9.3. The appearance of founder crops in the archaeobotanical assemblages of west and south-west of Iran from the Aceramic to the Bronze Age period (*: indicates the phase/layer that domesticated cereals appeared, **AK**= Ali Kosh phase, **MJ**= Mohammad Jaafar phase, **R**= rare, **+** = presence, **x** = common, **xx**= high concentration, **cf**. uncertain determination). **References:** Riehl *et al*., 2012, 2015; Weide *et al*., 2015, 2017,2018 ; Whitlam *et al*., 2013, 2018; Van Zeist *et al*., 1984; Hubbard 1990; Helbaek, 1969; Woosley, 1996; Meldgaard *et al*., 1963; Michel *et al*., 1993 ; Miller, 1981, 1983, 1985, 1990, 2003 , 2011, (Table modified after Miller 2003 and Charles 2007).

	Zagros Region				Fars					
Site	**Kaldar**	**Chogha Golan**	**Ganj Dareh**	**Abdul Hossein**	**Rahmatabad**		**Nurabad**		**Mehrali**	**Malyan**
Period	**PL**	**AC**	**AC**	**AC**	**AC**	**CH**	**NE**	**CH**	**CH**	**BA**
Prunus/ Amygdalus	**cf**	**+**	**+**	**x**	**+**	**+**	**+**	**+**	**x**	**x**
Pistacia		**x**	**x**	**x**	**+**	**+**	**+**	**+**	**x**	**x**
Quercus							**+**	**+**		**x**
Fraxinus					**+**	**+**		**+**	**+**	**+**
Salicaceae	**+**	**+**	**+**	**+**	**+**	**+**		**+**	**+**	**+**
Tamarix		**+**		**+**	**+**	**+**				
Juniperus								**+**		**x**
Acer		**+**					**+**			**+**
Ulmus							**+**			**+**
Rhamnus			**+**						**+**	**+**
Number of analysed samples	6	45	76	20	2	6	6	5	7	142

Table 9.4: Comparison of wood taxa present in the current study with other anthracological assemblages in the Fars and Zagros regions from the Palaeolithic to the Bronze Age (**+** = presence, **x** = frequent, **cf**, uncertain botanical identification, **PL**= Palaeolithic (Middle/Upper), **AC**= Aceramic Neolithic, **NE**= Ceramic Neolithic, **CH**= Chalcolithic, **BA**= Bronze Age) (sources: Miller, 1982, 1985, 2013; Willcox, 1991; van Zeist *et al*., 1984; Allué *et al*., 2018; Riehl *et al*., 2015).

Chapter 10

Conclusion and Final Remarks

The chapter summarises the main issues that have been addressed in this thesis. It also discusses the next steps for further research. The main objective of this study was to advance our understanding of the key aspects of the human-plant relationship (particularly food production and fuel use) from the Early Neolithic to the end of Chalcolithic period in the province of Fars, Iran. This goal was achieved by analysing new archaeobotanical material (seed and charcoal) recovered from three multi-occupation sites in the region, namely Rahmatabad, Nurabad and Mehrali. In addition, the results of the current study were combined and compared with the relevant bioarchaeological, ethnographic, ecological and archaeological evidence to reconstruct the main characteristics of the subsistence economy and the environment of prehistoric settlements of Fars. Overall, despite the limitations of the archaeobotanical assemblages of the sites under study, they vastly expanded the existing dataset of this region. This research included both seed and wood charcoal analysis from three archaeological sites in Fars, covering a long sequence of occupation (from the late 8th millennium B.C. to the late 4th millennium B.C.). Therefore, it has provided reliable information on subsistence practices, woodland exploitation and fuel collection of the prehistoric societies through a long sequence of time. Moreover, it allowed the evaluation of significant changes or continuities in the use of plants through the occupational phases of these sites.

10.1 Key findings:

The key findings of this research were as follows:

- Archaeobotanical data from the Aceramic phase of Rahmatabad provided important evidence in our knowledge and understanding of the plant economy between the Early Holocene hunting and foraging communities of Fars and the Pottery Neolithic settlements for which a subsistence economy based on farming and herding has been suggested (see also Tengberg and Azizi, 2016). The archaeobotanical evidence from this site indicated that Rahmatabad's plant economy was based on the cultivation of crops (glume wheats and barley) and the exploitation of wild plant resources, particularly nuts (*Amygdalus* and *Pistacia*) during the Aceramic period. Furthermore, there was no sign of any local cereal domestication event and the available evidence showed that domesticated crops were likely to have been introduced from other sites or regions (see also Tengberg and Azizi, 2016). The emergence of farming communities in Fars is hypothesised to have started from the late 8th millennium B.C. and the results of Rahmatabad's archaeobotanical analysis is consistent with this model (see Chapters 6 and 9).

- Analysis of the charred macrobotanical assemblage from Nurabad provided a greater understanding on the subsistence and plant economy of the Neolithic period. The available evidence showed that agricultural products (e.g. barley and glume wheat species) were an important part of the subsistence economy during this period. Taphonomic and contextual considerations of the plant remains from this site indicated on-site processing and preparation for human consumption. One of the important findings of this site was the presence of pulses such as lentil, peas and vetches that seemed to be absent or rarely present at the other Neolithic sites of Fras. Therefore, the new analysed archaeobotanical data from this site showed the utilization of a relatively broader range of crops. The exploitation of other wild food plants (almond and pistachio) alongside cultivated crops also suggested the importance of various locally available resources in the subsistence economy. Comparison of the bioarchaeological data from Nurabad with other contemporaneous sites highlighted several similarities but also differences pointing to regional variety and flexibility in subsistence strategies practised by the Neolithic inhabitants of this region. The overall results of this study are in agreement with the suggested subsistence model for the village-based Neolithic societies of Fars according to which there was a mixed economy based on farming and herding (see Chapters 7 and 9).

- The analysed archaeobotanical material recovered from the Chalcolithic phase did not show any significant changes compared to the Neolithic period, indicating continuity in crop usage and presence throughout the sequence. Moreover, the analysed plant remains of the sites under study provided important evidence on domestic activities, such as crop processing and food preparation during this period. Therefore, new light was shed on food related activities and the domestic life of the prehistoric inhabitants of this region. The overall picture indicated the cultivation of cereal grains, such as emmer, einkorn and barley, hard/bread wheat and pulses including lentil, peas and vetches. It was also observed that the exploitation of steppe-forests for food, fuel and possibly fodder was still an important part of the plant economy during the 5th and 4th millennium B.C. The fact that the data employed in this study represent settlements with long and continuous occupational phases supports the reliability of the findings. Furthermore, the archaeological investigations at these sites also showed a high degree of continuity in settlement population and size during this period. The available bioarchaeological evidence from these sites pointed to the close integration of crop cultivation and livestock management in the Chalcolithic period (see Chapters 6, 7, 8 and 9).

- Review and comparison of data from the sites under study also highlighted the crucial importance of careful assessment of the nature of the evidence and of the formation processes for the accurate interpretation of charred plant remains (see Chapters 4 and 9).

- The results of wood charcoal analysis on material from the sites under study provided the first anthracological record from the Aceramic to the end of the Chalcolithic period. Hence, the new charcoal evidence from these sites significantly enhanced our understanding of prehistoric human-vegetation interactions, woodland management practices and fuel selection in Fars. The results of the charcoal analysis showed that the range of wood taxa utilised was relatively stable through time. The overall results pointed to the existence of *Pistacia-Amygdalus* steppe forests near the sites and their continuous exploitation for firewood by prehistoric communities of this region. This pattern of continuity in the utilisation of these taxa through time was also supported by the seed data. Furthermore, the presence of riparian vegetation taxa, such as ash, willow/poplar, tamarisk, ash and elm, also showed the diversity of wood catchment areas exploited for fuel or building timber during the Neolithic and Chalcolithic periods. The anthracological data from Nurabad provided new insights into the arboreal cover in this area during the Neolithic and Chalcolithic. The results of wood charcoal analysis from this site indicated the presence and exploitation of oak trees since 6000 B.C. Moreover, the identification of *Juniperus* in the anthracological assemblage of Nurabad suggested the presence of this tree in the region at least since the Chalcolithic period and the use of its wood as fuel and possibly timber by the inhabitants of the site. Overall, based on the analysed archaeobotanical data it appeared that wood (mostly *Pistacia* and *Amygdalus*) was the preferred choice of fuel. However, it appeared that wood was used in conjunction with other complementary fuel sources, such as animal dung (e.g. Rahmatabad), as well as the by-products of crops and other wild plants for different purposes (see Chapters 6, 7 , 8 and 9).

10.2 Future research

This research provided an important archaeobotanical record for the Neolithic and Chalcolithic periods of Fars and significantly contributed to the understanding of the past human-plant relationships. Further investigations of more archaeobotanical data from other prehistoric sites of Fars would enhance our knowledge of the plant subsistence strategies of this archaeobotanically under-represented region. To address wider socio-economic aspects of the Neolithic and Chalcolithic periods at region level more bioarchaeological analyses and interdisciplinary studies are required. In the following section, some suggestions are proposed for future research.

- As noted in Chapter 4, it has not been possible to verify the degree of damage caused by the high or low alkalinity of the soil on the preservation of charred plant remains recovered from the sites under study. Therefore, measurements, such as of the soil pH, from different deposits in the future would allow us to have better understanding of the sites' formation processes.

- Micromorphological analysis on archaeological deposits of these sites could provide complementary information on the range of plant remains or material that are usually underrepresented in carbonised plant assemblages. Applying such analysis in the future studies holds great potential to address these issues.

- Completing the wood charcoal analysis of the recovered samples from the sites under study as well as sampling from other prehistoric sites in the region could substantially improve our understanding of local vegetation, climate patterns and regional variation in using wood resources.

- Future analysis on the stone tool objects (for grinding, pounding) found in the sites under study could provide more direct evidence related to crop processing and food preparation.

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