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Early evidence of *Prunus* and *Prunus* cf. *amygdalus* from Palaeolithic sites in the Khorramabad Valley, western Iran

Évidences anciennes de Prunus *et* Prunus *cf.* amygdalus *dans des sites paléolithiques de la vallée de Khorramabad, dans l'Ouest de l'Iran*

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A B S T R A C T

Along with the early age obtained for the cultural remains attributed to anatomically modern humans from Kaldar Cave, the archaeological assemblages recovered from both Kaldar and Gilvaran Cave located in the Khorramabad Valley (Iran), have yielded charcoal remains that allow the identification of *Prunus* spp. These remains correspond to the Middle and Upper Palaeolithic, which are the earliest finds attesting to the presence of this taxa in the area. Our anatomical observation of the samples revealed the presence of *Prunus* spp. (plums) and *Prunus* cf. *amygdalus* (cf. almond). This also reflects specific plant communities in the area, characteristic of open forest growing in cool, dry conditions. These results provide new insights into the arboreal cover in this area during an Upper Pleistocene period. Furthermore, anthracological evidence together with other contextual materials provides new clues to assess how Neanderthals and early modern humans adapted to their surrounding landscape, and their relationship with their environment in this region and beyond.

R É S U M É

En même temps que l'âge précoce obtenu pour les restes culturels attribués aux humains anatomiquement modernes de la grotte de Kaldar, les assemblages archéologiques récupérés à la fois dans les grottes de Kaldar et de Gilvaran, situées dans la vallée de Khorramabad (Iran) ont donné des restes de charbon qui permettent l'identification de *Prunus* spp. Ces restes correspondent au Paléolithique moyen et supérieur et sont les premières découvertes attestant la présence de ces taxons dans la région. Notre observation anatomique des échantillons a révélé la présence de *Prunus* spp. (Prunes) et *Prunus* cf. *amygdalus* (cf. l'amande). Ceci reflète également la présence, dans la région, de communautés végétales spécifiques, caractéristiques des forêts ouvertes se développant dans des

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conditions fraîches et sèches. Ces résultats apportent un nouveau regard sur la couverture arborescente présente dans cette zone au Pléistocène supérieur. En outre, les résultats anthracologiques ainsi que d'autres obtenus sur d'autres matériaux contextuels fournissent de nouvelles indications permettant d'évaluer comment les Néandertaliens et les premiers humains modernes se sont adaptés à leur environnement, et quelles ont été leurs relations avec leur environnement dans cette région et au-delà.

1. Introduction

The genus *Prunus* includes a large number of species that are distributed throughout the northern hemisphere (Kurtto, 2009). This genus is part of the Rosaceae family and the Amygdaloideae subfamily. *Prunus* spp. is referred to several synonyms including *Prunus*, *Amygdalus* and *Cerasus*. In this work, to avoid confusion between the different accepted nomenclatures, we use *Prunus* spp., which includes all three-mentioned genus names accepted in the Flora europaea (Kurtto, 2009). *Prunus* spp. is an entomophilous flowering tree or shrub with edible fruit (e.g., plums) or edible seeds (e.g., almonds). This genus includes 200 species of plums, almonds, peaches, apricots and cherries. Iran is the centre of origin of some of these species and a global center of nowadays world production (Gharaghani et al., 2017; Vafadar et al., 2010). Iran's geographical characteristics allow these species to spread in various tree communities under semi-arid conditions, such as Pistachio-almond communities, edges of the oak forests, open steppe forests, and steppe-like communities (Heshmati, 2007; Kashki and Amirabadizadeh, 2011; Pourmoghadam et al., 2013).

Past evidence of *Prunus* includes palaeobotanical records, which involve pollen, travertine imprints, charcoal, and seeds. Palynological records only permit identification to family level, i.e. Rosaceae, and pollen is usually absent or underrepresented due to the entomophilous character of this family (Djamali et al., 2008). According to Vafadar et al. (2010) *Amygdalus* L. (syn. *Prunus*) pollen grains from Iranian species are tricolporate and symmetric isopolar monads with a predominantly striated exine. According to these authors, the shape of the pollen grains allows different subgenera to be distinguished, whereas other features such as the exine show no differences. However, when the pollen is preserved in the archaeological record, it can only be identified as cf. *Prunus* (cf. *Amygdalus*) (Djamali et al., 2008; Vafadar et al., 2010). In Iran, there are several palynological sequences providing palaeoecological evidence from the upper Pleistocene to the Holocene (Bottema, 1986; Djamali et al., 2008, 2009a, 2009b, 2012; El-Moslimany, 1987; Miller et al., 2013; van Zeist, 1967). These sequences have yielded information on the arboreal cover in which Rosaceae is rarely present. Leaf imprints have preserved evidence of *Prunus*, but there have been very few records identified in natural environments in a diatomite deposit, suggesting that they were present from 1.2 Ma (Ollivier et al., 2010). Charcoal and seeds in archaeological contexts are the most abundant evidence of this genus. *Prunus* stones from several species have been identified from the Upper Palaeolithic, usually burnt and related to wild fruit gathering (Martinoli and Jacomet, 2004; Zohary and Hopf, 1993). There are 26 species of almond that include two eco-geographical groups: one is adapted to Mediterranean environments and the other occupies steppe forests or steppe-like environments (Zohary and Hopf, 1993). Archaeological evidence of this plant has been identified in Mesolithic and Neolithic layers in the Levant (Martinoli and Jacomet, 2004; Zohary and Hopf, 1993). The earliest evidence from Iran is from the Late Neolithic Tepe Musyan (Zohary and Hopf, 1993). Plums and cherries grow in temperate parts of Europe and Turkey, in woods and on cleared hills, and have been identified from the Neolithic. Some differences in the stones allow certain species to be distinguished, such as *Prunus spinosa*, and some types of almond have been recorded from Upper Palaeolithic deposits (Allué et al., 2010; Martinoli and Jacomet, 2004; Mason and Hather, 2002).

Until now charcoal macro-remains have provided the largest dataset of *Prunus* evidence, most of this from archaeological sites in various contexts. As charcoal is related to the use of wood for combustion, most records are from the upper Pleistocene to Holocene, whereas earlier evidence, where there is scarce evidence of fire, is rare. Charcoal analysis (or anthracology) is based on the taxonomic identification of charred wood remains recovered from archaeological sites. Anthracology is aimed at recognising past vegetation and its evolution through time, as well as understanding human behaviour in relation to the use of vegetal resources, particularly as fuel (Chabal et al., 1999). The significance of charcoal analysis as a tool for palaeoecological reconstruction has been demonstrated and its interpretation is based on the ecological characterisation of the species depending on the climatic conditions and their diachronic evolution. Also charcoal remains from domestic fires allow us to understand the uses of wood as a raw material for fuel, manufacturing objects, and as a building material (Chabal et al., 1999).

In the Near East, studies of archaeobotanical remains (fruits, seeds and charcoal) have been focused on tracing evidence of early agriculture, yielding excellent evidence for the study of past vegetation and plant uses (e.g., Asouti, 2003, 2013; Asouti and Kabukcu, 2014; Asouti and Fuller, 2013; Emery-Barbier and Thiébault, 2005; Mashkour and Tengberg, 2013; Miller, 1985, 2003; Miller and Marston, 2012; Miller et al., 2011; Willcox, 1999, 2002; Zohary and Hopf, 1993). In Iran, these studies mainly focus on seeds and charcoal remains from Neolithic and Bronze Age archaeological sites (Mashkour and Tengberg, 2013; Miller, 1985, 2003; Miller et al., 2011; Riehl et al., 2012; Tengberg, 2012; Willcox, 1990). In contrast, Palaeolithic records within the country are very scarce, with the exception of the Middle Palaeolithic site of Qaleh Bozi in central Iran, where charcoal analysis was carried out (Biglari et al., 2009). Preservation problems and lack of adequate sampling and excavation could be the main reason for the absence of charcoal remains from Iranian Palaeolithic sites. The importance of this region is focused on its important role for deciphering the Middle to Upper Palaeolithic transition related to the dispersal of Anatomically Modern Humans in terms of chronology and archaeological evidences (Bazgir et al., 2017; Becerra-Valdivia et al., 2017).

The aim of this work is to report the evidence of *Prunus* and *Prunus* cf. *amygdalus* yielded from the Palaeolithic sites of Gilvaran and Kaldar Caves. This evidence allows us to discuss palaeoenvironmental issues with regard to the presence of arboreal cover in the area during periods in which the region was occupied by culturally different human populations. These results are particularly important due to the scarcity of data from this period in the area, more specifically for providing new valuable evidence for the study of the Iranian Palaeolithic.

2. Site description

As a goal-oriented study with a regional and wide-ranging perspective, the Khorramabad research programme began in 2009. After a comprehensive field survey, in 2011–2012 we carried out an extensive excavation programme at the Palaeolithic localities including Gilvaran and Kaldar Caves (Fig. 1).

2.1. Gilvaran Cave

Gilvaran Cave is situated in the north-western part of the Khorramabad valley and located at 48° 18′ 56″ E longitude, 32° 28′ 12″ N latitude, at about 1225 m a.s.l. (Fig. 1). Excavation in Gilvaran involved two 2 × 2 m trenches, one near the cave dripline (trench A8) and the other about 20 m outside the cave entrance. Test pit AY1 exposed 4.8 m section of sedimentary deposit and is characterised by 5 main levels (Fig. 2). Level 1 consists of ashy blackish-green sediment with angular stones. It varies in thickness from 5 to 20 cm. This is the most recent level and contains an assemblage of Islamic materials. Level 2 consists of fine, light grey sediment with few angular stones. It varies in thickness from 28 to 84 cm and includes a Historical and Bronze Age record. Level 3 consists of grey, coarse sandy sediment that varies from 60 to 110 cm in thickness and which contains mixed evidence of Chalcolithic and Neolithic potsherds and lithic industries. Level 4 varies in thickness from 39 to 62 cm and consists of dark grey sediment with a large number of limestone blocks of different sizes. It contains an Upper Palaeolithic assemblage. Level 5 is a reddish brown deposit with many large limestone blocks. It increases in depth from the northern section towards the south, varying from 2.45 to 2.85 m in thickness. It includes two sub-levels that do not vary in colour. Evidence of Middle Palaeolithic industry is found in level 5, with mixed Middle and early Upper Palaeolithic/Baradostian industries in its sub-level 2 (Bazgir, 2013; Bazgir et al., 2014).

2.2. Kaldar Cave

Kaldar Cave is situated in the northern part of Khorramabad Valley at 48° 17′ 35″ E longitude, 33° 33′ 25″ N latitude, and an elevation of 1290 m a.s.l. It is 16 m long, 17 m wide, and 7 m high (Fig. 1). Its great potential was realised during our 2011–2012 test excavation. During the 2014–2015 excavation season at Kaldar, we enlarged the excavation area, focusing on gaining a better understanding of the stratigraphy and obtaining samples for dating. We dug a 3 × 3-m trench near the entrance and kept a 50-cm bulk sample from the previous test pit (squares E5, E6, E7, F5, F6, F7, G5, G6 and G7) (Fig. 3). The excavation was conducted using 5 cm spits within each archaeostratigraphic unit, as well as 3D recordings of all findings. The excavated trench exposed an approximately 2 m (195 cm) section of sedimentary deposit, which is characterised by five main layers. Layers 1 to 3 (including sub-layers 4 and 4II) consist of blackish-green ashy sediment containing both thick and thin angular limestone clasts. These layers vary in thickness from 60 to 90 cm and contain many phases dated as Holocene, i.e. the Islamic and Historical eras, Iron Age, Bronze Age, Chalcolithic, and Neolithic. However, due to the presence of some bioturbation in these layers, the phases were recognised only by a preliminary study of the potsherds, metal artefacts, and some diagnostic lithic artefacts from the lower layers. Layer 4 (including sub-layers 5, 5II, 6 and 6II) consists of a silty but compact dark-brown sediment with cultural remains from the Upper and Early Upper Palaeolithic. In the uppermost parts of this layer, two fireplaces made of clay were recovered and dated through thermoluminescence as 23,100 ± 3300 BP and 29,400 ± 2300 BP (Bazgir et al., 2017). The dates obtained show that these fireplaces were made or re-used from existing older sediment from the upper part of this layer in the later stages of the Upper Palaeolithic. AMS radiocarbon dates of 38,650–36,750 cal BP, 44,200–42,350 cal BP, and 54,400–46,050 cal BP have been obtained from charcoal material located below this layer (Bazgir et al., 2017; Becerra-Valdivia et al., 2017). Layer 5 (including sub-layers 7 and 7II) consists of an extremely well-cemented, reddish-brown sediment with some small angular limestone blocks and Middle Palaeolithic artefacts (Fig. 3). To date, no radiometric data are available for this layer (Bazgir et al., 2017). Charcoal remains included in this study belong to layers 4 and 5.

3. Materials and methods

The charcoal study is based on materials recovered from the 2011–2014 field seasons at Gilvaran and Kaldar Caves (Bazgir, 2013; Bazgir et al., 2014). Charcoal remains were handpicked and the sediments when possible were water sieved on the spot. At Gilvaran Cave, charcoals were recovered from Level 4, yielding positive results. The charcoal samples recovered from Level 4 are attributed to the Upper Palaeolithic, showing a clear association with other archaeological material (lithic remains and bones). The remains from Kaldar Cave came from two layers, Layer 4 belonging to the Upper Palaeolithic and Layer 5 belonging to the Middle Palaeolithic (Bazgir et al., 2017).

Fig. 1. Map of the area showing the location of the sites. The geographic position of the Khorramabad Valley and the position of the localities excavated in 2011–2012 field season indicated on an aerial photograph (Source of the original map: https://commons.wikimedia.org/wiki/File:Iran_relief_location_map.jpg (under the license of Creative Commons Attribution-Share Alike 3.0 Unporte). Modified by E. Allué. Original license pages: https://en.wikiedia.org/wiki/Creative Commons – https://creativecommons.org/licenses/by-sa/3.0/deed.en).

Fig. 1. Carte de la région, montrant la situation des sites. Position géographique de la vallée de Khorramabad et position des endroits creusés pendant la campagne 2011–2012 et indiqués sur la photo aérienne (Source : voir légende en anglais).

Fig. 2. Left, general view of Gilvaran Cave; middle, stratigraphic profile of Gilvaran cave; right, detail of the stratigraphy.

Fig. 2. À gauche, vue générale de la grotte de Gilvaran ; au milieu, profil stratigraphique de la grotte de Gilvaran ; à droite, détail de la stratigraphie.

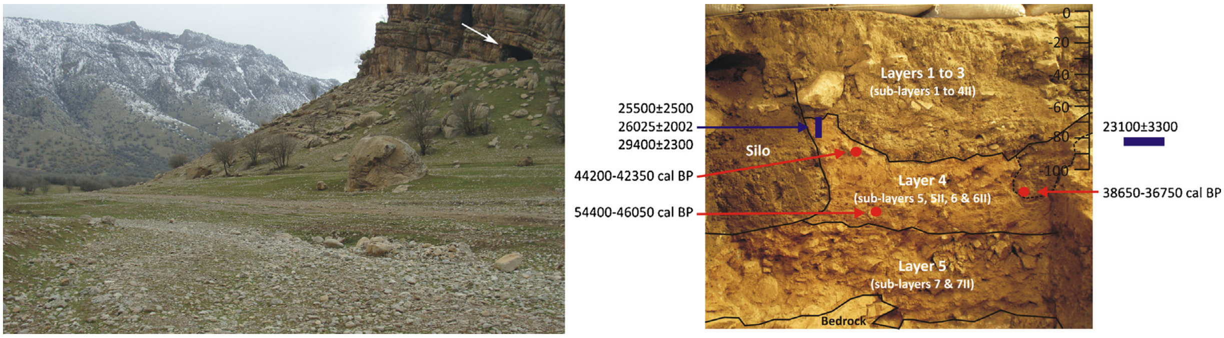

Fig. 3. Left, general view of Kaldar Cave; right, stratigraphy (eastern section) of Kaldar with location and results of the dated samples (created by A. Ollé and B. Bazgir. Modified from Bazgir et al., 2017).

Fig. 3. À gauche, vue générale de la grotte de Kaldar ; à droite, stratigraphie (coupe orientale) de Kaldar avec la localisation et les résultats des échantillons datés (créé par A. Ollé et B. Bazgir. Modifié d'après Bazgir et al., 2017).

For charcoal identification, the remains were fragmented by hand in order to obtain the three wood anatomy sections. This permitted a description of the cell structure. The charcoal fragments were observed using a metallographic reflected light microscope with dark and light fields, at ×50, ×100, ×200, and ×500 magnifications (Olympus BX41). The identification was supported with various wood anatomy atlases (Fahn et al., 1986; Parsapajouh et al., 1987; Schweingruber and Landolt, 2005). Charcoal analysis does not always permit a species-level identification due to factors such as size of the charcoal piece, anatomy defects produced by combustion or post-depositional processes, low degree of anatomical variability among species, or the absence within the fragment of all the characteristics needed to define a species. The identification categories used in charcoal analysis are genus, family, type, and occasionally species. Quantification of charcoal assemblages is usually based on the number of fragments or the presence/absence of the different taxa. Furthermore, depending on the number of fragments a statistical approach can be taken. Usually a minimum number of fragments should be studied in order to obtain a valid data set. A commonly agreed-upon and widely accepted standard among authors is that between 250 and 500 fragments per level are required to validate a sample (Chabal et al., 1999). At Gilvaran and Kaldar Caves, the number of remains is small; we will, therefore, take into account the presence of taxa to explain our results.

The palynological analysis was based on 12 samples 6 from Gilvaran Cave and 6 from Kaldar Cave. Samples were treated following a modified Goeury and de Beaulieu (1979) methodology by Burjachs et al. (2003), including hydrochloric acid (HCl), followed by KOH digestion, concentration using Thoulet heavy liquid, and finally silicate removal with hydrofluoric acid (HF). Fossil pollen was identified using published keys and a modern pollen reference collection (Moore et al., 1991; Reille, 1992, 1992).

4. Results

Gilvaran Cave Level 4 (Upper Palaeolithic) yielded 30 charcoal fragments belonging to *Prunus* sp. Kaldar Cave yielded 30 charcoal fragments from two archaeological layers. Layer 5 yielded 17 fragments including *Prunus*, *Prunus* cf. *amygdalus*, *Salix* and a few undetermined fragments. The Middle Palaeolithic Layer 4 yielded 13 fragments showing the presence of *Prunus* and *Prunus* cf. *amygdalus*, as well as a few undetermined fragments (Table 1).

Table 1
Number of charcoal fragments from Kaldar and Gilvaran Caves.
Tableau 1
Nombre de fragments de charbon extraits des grottes de Kaldar et de Gilvaran.

	Kaldar		Gilvaran
Taxa	Layer 4	Layer 5	Level 4
Prunus	2	5	30
Prunus cf. *amygdalus*	5	1	
cf. *Prunus*		2	
Salix		2	
Angiosperm	3	2	
Undetermined	2	8	
Total	**13**	**17**	**30**

Prunus is the only recurring taxa in the results from the 60 remains from Kaldar and Gilvaran Caves. This genus includes different subgenera among which *Prunus* (e.g., *P. divaricata*, *P. spinosa*), *Amygdalus* (e.g., *A. fenzliana*, *A. communis*, *A. scoparia*), and *Cerasus* (e.g., *C. incana*, *C. mahaleb*) are the most common species in Iran. *Prunus* wood anatomy commonly shows a diffuse to semi-ring distribution of the pores in the transversal wood section (Schweingruber and Landolt, 2005). *Amygdalus* show a ring-porous distribution of vessels, whereas the wood of other types, such as *Cerasus* and *P. spinosa*, has diffuse porosity. Ray cells are uniseriate to 3- and 7-seriate depending on the species. Vessels show spiral thickenings with simple perforation plates. Three different types of *Prunus* can be regrouped according to the wood anatomy (Allué, 2016; Heinz and Barbaza, 1998; Ntinou, 2002). *Prunus* type 1 rays does not have more than 2 cells; *Prunus* type 2 contain between 3 and 4 cells per ray; and *Prunus* type 3 has more than 5 cells. Each type corresponds to different groups, for example type 1 includes *Prunus avium/padus* (cherry/European bird cherry), type 2 is *Prunus spinosa/mahaleb* (blackthorn/mahaleb cherry), and type 3 is *Prunus spinosa/amygdalus* (blackthorn/almond tree). Ntinou (2002) also uses three groupings according to the species currently present in Greece. Group I includes *P. armeriaca*, *P. dulcis*, *P. persica*, and *P. webbii*. When the

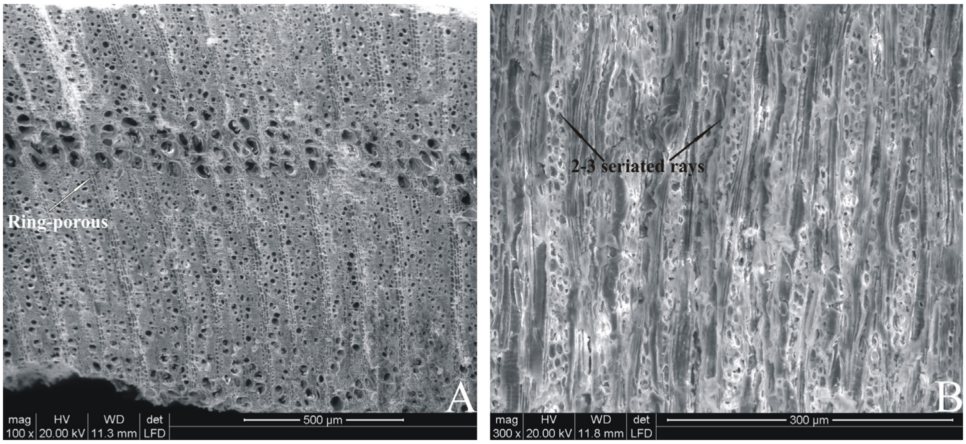

Fig. 4. A. Transversal section of *Prunus* cf. *amygdalus* from Kaldar showing a ring-porous Distribution. B. Tangential section of *Prunus* sp. showing 2 to 3 seriated ray cells.

Fig. 4. A. Section transversale de *Prunus* cf. *amygdalus* de Kaldar montrant une répartition annulaire poreuse. B. Section tangentielle de *Prunus* sp. montrant deux à trois cellules en rayon sérié.

rays were 7- or 8-seriated with ring-porous wood they were identified as *Prunus* cf. *amygdalus*. Group II with diffuse-porous wood and 2 to 7 cell rays (an average of 5) includes *P. domestica*, *P. padus*, *P. mahaleb*, *P. spinosa* and *P. cerasifera*. Group III with semi ring-porous wood to diffuse-porous wood and with 2 to 4 ray cells includes *P. avium* and *P. cerasus*.

The samples from Gilvaran are woods with a diffuse porosity distribution; 5 to 7 cells in rays, ruling out a possible identification as *Amygdalus* type. In contrast, some of the samples from Kaldar Cave have the anatomical characters of *P.* cf. *amygdalus*, showing ring porous wood (Fig. 4).

5. Discussion

The study of the charcoal remains from Kaldar and Gilvaran Caves shows the presence of *Prunus* and *Prunus* cf. *amygdalus* during the Middle and Upper Palaeolithic. This evidence, together with other palaeoenvironmental proxies (microvetebrates and macromammals) at Kaldar Cave, suggests temperate "interglacial" environmental conditions (Bazgir et al., 2017). The presence of *Salix* in both the anthracological and palynological records indicates that there were active water sources or flows, and steppe-like or open forests areas in which *Prunus* spp. could grow. Other data records from Kaldar Cave show the presence of herpetofauna, as well as macro and micromammals, suggesting open wooded areas and dry steppe areas indicating mild conditions. The poor palynological record from here shows, however, the presence of temperate taxa as *Corylus* or evergreen *Quercus*.

Species belonging to the genus *Prunus* are distributed among different plant communities in the Iranian region. They form the undergrowth of oak forests, the Pistachio-almond steppe, or stands in open areas (Heshmati, 2007). The Pistachio-almond steppe is present throughout the area and is characterised by dominance of *Pistacia* and *Amygdalus* cf. *scoparia*. This type of vegetation has been interpreted at the Qaleh Bozi Palaeolithic site as well, where two taxa were identified, *Salix/Populus* and *Pistacia*, underlining the presence of open steppe-forests and riverside formations (Biglari et al., 2009). Evidence from the early Holocene/early Neolithic suggests that Pistachio-almond vegetation was spread throughout Iran, Turkey and other neighbouring regions (Asouti, 2003; Miller, 2011). The evidence obtained from Gilvaran and Kaldar Caves shows the presence of two different taxa: *Prunus* cf. *amygdalus* and *Prunus* spp. According to the archaeological context, the charcoal remains belong to the anthropic assemblage that includes lithic and faunal remains. Despite of the lack of structured hearths, the scattered charcoal are probably related to the use of wood as fuel.

Evidence of *Prunus* in an archaeological context has been identified at a number of sites showing significant values during the Late Glacial (ca. 13–11 kyr BP) (Allué et al., 2010, 2012a; Bazile-Robert, 1980; Henry et al., 2013) (Fig. 5, Table 2). In earlier periods, the *Prunus* spp. communities were probably more important than assumed. The Azokh Cave layer II charcoal record, dated back to ca. 100 ka, shows high values (80%) of *Prunus*, mostly *P. spinosa*, and *P. mahaleb* types (Allué, 2016), and is interpreted as a pioneer vegetation succession or pre-forest formation in an open woodland. Several sites in Greece show the presence of *Prunus* (*Prunus* type *spinosa* group and *Prunus* cf. *amydalus*) and there were particularly high numbers of remains in Theopetra Cave from MIS 6 to MIS 3 (Ntinou and Kyparissi-Apostolika, 2016). The *Prunus* identified in that sequence belonged to the *P. spinosa*, *P. mahaleb* and *P. prostrata* types and the authors relate the dominance of *Prunus* and *Juniperus* to unstable climatic conditions in an open steppe-like environment (Ntinou and Kyparissi-Apostolika, 2016). In both sequences at Azokh and Theopetra, *Prunus* is interpreted as part of the pioneer vegetation in the glacial and interglacial vegetation cycles (Allué, 2016; Ntinou and Kyparissi-Apostolika, 2016).

Throughout MIS 3 and MIS 2, several western European records from Iberia, SE France, Italy and Greece show evidence of *Prunus* (Allué et al., 2007, 2012a, 2012b, 2017; Bazile-Robert, 1979; Bazile-Robert, 1980; Fiorentino and Parra, 2015; Maspero, 2004; Ntinou, 2002, 2010, 2016; Ros, 1987). According to these charcoal studies, *Prunus* was

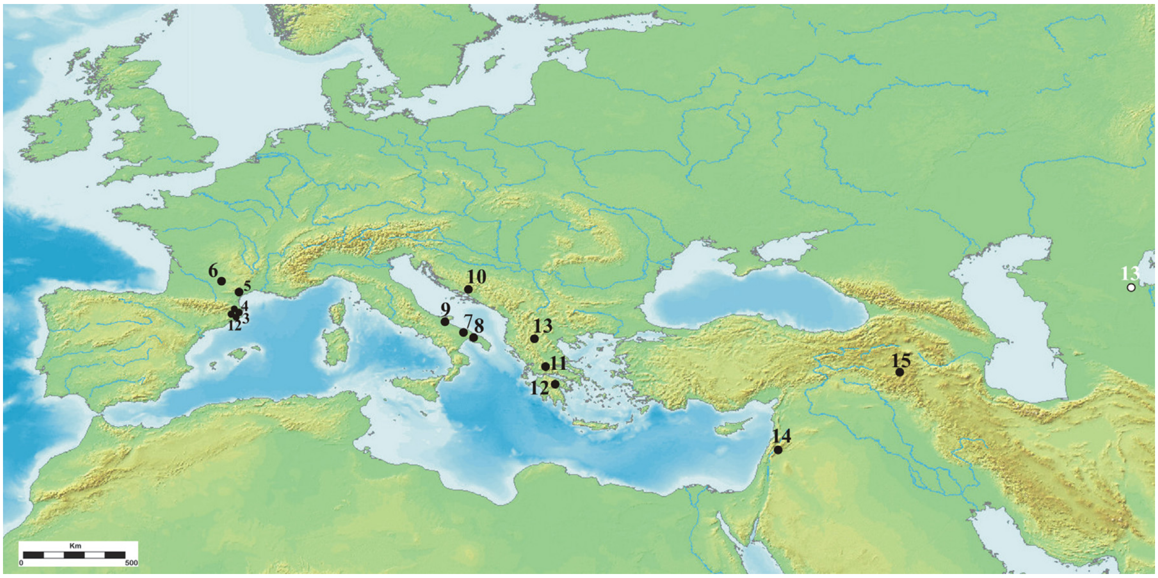

Fig. 5. Distribution of sites and areas mentioned in the discussion refering to *Prunus* anthracological evidences. (1) Balma del Gai; (2) Molí del Salt; (3) Arbreda; (4) Abric Romaní; (5) Salpetriere; (6) Coudoulous II; (7) Grotta delle Mura; (8) Grotta S. Maria D'Agnano; (9) Grotta Paglicci; (10) Konispol; (11) Klissoura; (12) Lakonis; (13) Theropestra Cave; (14) Manot Cave; (15) Azokh Cave. https://commons.wikimedia.org/wiki/Category:Maps_of_Eurasia#/media/File:Eurasian_mass.jpg User:Koba-chan, compiled by PHGCOM–Commons topographical maps File:Topographic30deg N0E60.png modified by E. Allué. Original license pages: https://en.wikiedia.org/wiki/Creative Commons.
Fig. 5. Distribution des sites et zones mentionnés dans la discussion se référant aux preuves anthracologiques de *Prunus*. (1) Balma del Gai ; (2) Moli del Salt ; (3) Arbreda ; (4) Abric Romani ; (5) Salêtriere ; (6) Coudoulous II ; (7) Grotta delle Mura ; (8) Grotta S. Maria D'Agnano ; (9) Grotta Paglicci ; (10) Konispol ; (11) Klissoura ; (12) Lakonis ; (13) grotte de Theropsetra ; (14) grotte de Manot ; (15) grotte d'Azokh. Source : voir légende en anglais.

present throughout MIS 3 and MIS 2 in Western Europe, but montane pine forests were the dominant arboreal cover. *Prunus* was increasingly represented in the woodlands during the Late Glacial and in general at the beginning of the Holocene, related to climatic improvement (Allué et al., 2012a, 2012b) (Fig. 5). Its increase is usually related to the development of pre-forest communities growing under milder climatic conditions. The good adaptation of the different *Prunus* species enabled them to resist cold and dry conditions, and they were pioneer plants during the Pleistocene glacial and interglacial cycles overall from Greece to western Asia. There was an important spread of this taxa during the Late Glacial and its archaeological remains are related to its use as fuel, as well as fruit gathering as food (Allué et al., 2012a; Filipović et al., 2010; Heinz and Barbaza, 1998; Henry et al., 2013). The presence of *Prunus* in the eastern Mediterranean and western Asia (Central Asia) might be also related to the development of open forests more adapted to cold and dry climates, lacking montane pine components. This fact might be linked to general biogeographical (e.g., Mediterranean peninsulas, mean altitudes of mountain ranges) and climatic conditions (higher precipitation rates in western Asia than in the Mediterranean peninsulas) in these different areas since the Pliocene, as part of the disjointed distribution of species between the different areas (Ribera and Blasco-Zumeta, 1998; Willis, 1996).

As mentioned earlier, the absence of *Prunus* in palynological sequences due to its entomophilous dispersal means it is difficult to obtain comparable records from continuous natural deposits. Palynological deposits from Iran show that during the last Pleniglacial and Late Glacial the dominant vegetation was characterised by steppe-forest with predominant herbaceous components including *Artemisia* and Chenopodiaceae (syn. Amaranthaceae) (Djamali et al., 2012). This vegetation is typical of open, dry steppe landscape with little arboreal cover. *Hippophae rhamnoides* spread throughout MIS 3, being the most significant arboreal cover along with riverside species (Djamali et al., 2012). In the case of Gilvaran Cave, all the samples analysed from Pleistocene levels were sterile.

The results of Kaldar Cave samples are slightly more decisive but insufficient to carry out a palaeoenvironmental reconstruction except in the samples related to the Holocene levels. Even so, in Level 4 there has been identified the presence of evergreen *Quercus*, *Corylus* and *Salix* in relation to the arboreal vegetation. The rest of the identified pollen spectrum corresponds to herbaceous plants among which there are wild grasses (Poaceae), Asteraceae, Apiaceae, Centaureae and hygrophytes Cyperaceae. At Level 5 only evergreen *Quercus* has been identified as representative of the arboreal stratum and the herbaceous plants identified are Poaceae, Asteraceae, and Apiaceae.

The palynological record from Kaldar, although very poor, suggests, however, that in these environments with mesic, thermophilous and riparian taxa; the presence of *Prunus* is consistent with this. Furthermore, according to Rajaei et al. (2013) the presence of *Gnofarmia*, a species of insect, during the Late Glacial Maximum indicates the presence of the host plants: *Prunus scoparia* and *Prunus felziliana*. Rajaei et al. (2013) also suggest that the presence of these host plants could indicate that the area acted

Table 2
Synthetical table of Lower to Upper Pleistocene sites with *Prunus* remains.
Tableau 2
Tableau synthétique des sites du Pléistocène inférieur à supérieur contenant des restes de *Prunus*.

MIS	Chronoculture	Name of the site	Location	Layer	Taxa	Values	Reference
MIS 2	Upper Paleolithic	Konispol	Albania	42–36	*Prunus* cf. *amygdalus*	80–100%	Ntinou and Kyparissi-Apostolika, 2016; Hansen, 2001; Ntinou and Kyparissi-Apostolika 2016; Hansen, 2001
		Theropestra cave	Greece		*Prunus* cf. *spinosa*	0–10%	
		Grotta Paglicci	Italy		*Prunus* cf. *amygdalus*	20–40%	Maspero, 2004
		Balma del Gai	Spain	I (140–150)	*Prunus*	10–30%	Allué, 2007
		Molí del Salt		Asup	*Prunus*	40–50%	Allué et al., 2010
				B1		10–30%	
				B2		10–30%	
		Salpetrière	France	107	*Prunus* cf. *amygdalus*, *Prunus*	< 1%	Bazile-Robert, 1980
MIS 3	Early Upper Paleolithic	Klissoura	Greece	IV	*Prunus* cf. *amygdalus*/*Prunus* cf. *spinosa*	50%	Ntinou, 2010
		Manot Cave	Israel	Areas A–G	*Prunus* cf. *amygdalus*	Presence	Barzilai et al., 2016
		Grotta Paglicci	Italy		*Prunus* cf. *amygdalus*	30%	Maspero, 2004
		Grotta S. Maria D'Agnano			*Prunoideae*	10–30%	Fiorentino and Parra, 2015
		Grotta delle Mura			*Prunus* cf. *spinosa*, *cf.maheleb*	20–40%	
		Arbreda	Spain	H I	*Prunus*	10–30%	Maroto, 1994
	Middle Paleolithic	Abric Romaní	Spain	M & O	*Prunus* sp.	< 1%	Allué et al., 2017
		Lakonis	Greece		*Prunus* sp.	Presence	Ntinou and Kyparissi-Apostolika, 2016; Panagopoulos, 2004; Ntinou and Kyparissi-Apostolika 2016
		Theropestra cave			*Prunus* cf. *spinosa*	60%	
MIS 4	Lower Paleolithic	Azokh	Nagorno-Karabagh	II	*Prunus*	80%	Allué, 2016
MIS 5		Coudoulous II	France	7a1, 7a2	*Prunus spinosa*	3–14%	Thery-Parisot et al., 2008
		Theropestra cave	Greece		*Prunus* cf. *spinosa*	0–5%	Ntinou and Kyparissi-Apostolika, 2016; Ntinou and Kyparissi-Apostolika 2016
MIS 5e						10–50%	
MIS 6-5	Lower Paleolithic					50–70%	

as a refuge during cold periods. Based on the data from Gilvaran and Kaldar Caves, the presence of *Prunus* could be tracked to earlier periods and confirm the presence of these taxa during the Pleistocene. The precise dating at Kaldar cave was carried out using *Prunus* and *Prunus* cf. *amygdalus* fragments, demonstrating their presence in MIS 3.

The most complete palynological sequence from Lake Urmia indicates that in the north-western part of Iran, the last glacial landscape was dominated by *Artemisa*, Chenopodiaceae (syn. Amaranthaceae), and other steppe grasses. There was more arboreal cover than in previous glacial periods and this was characterised by higher numbers of *Hippophae rhamnoides* (Djamali et al., 2008). According to these authors, winter temperatures were lower than today and there was very little arboreal cover (Djamali et al., 2008; van Zeist, 1967). Data obtained from the Damavand volcano (northern Iran) also suggests steppe-like vegetation in the Late Glacial; however, the increase of tree taxa in several samples suggests the occurrence of some wetter periods (Sharma et al., 2014). The presence of at least two species from the genus *Prunus* and the presence of *Salix* in Kaldar and Gilvaran Caves suggest that there was arboreal tree cover during the interstadial periods in the Late Glacial. Additionally, the palaeoecological evidence from palynological record, including the presence of *Corylus*, evergreen *Quercus*, *Salix* and Cyperaceae, among other taxa, and from micromammals (*Microtus* gr. *socialis*, *Ellobius* cf. *lutescens*, *Ellobius* sp., *Meriones* spp., *Apodemus* cf. *flavicollis* among others) and macro-mammals (*Sus scrofa*, *Capreolus*, *Cervus elaphus* among others) from Kaldar Cave, supports this interpretation of interstadial conditions (Bazgir et al., 2017).

Taking into account the older dates obtained for the modern human occupation at Kaldar Cave and adding the charcoal evidence to the other cultural remains recovered from this locality, we are able to assess an important climatic moment that provides information for reconstructing the relationship between the environment and human occupation in this region. The dates obtained from the lower part of the Upper Palaeolithic sequence at Kaldar Cave are among the oldest attributed to a lithic industry that traditionally has been associated with anatomically modern humans (AMHs) in western Asia (Goring-Morris and Belfer-Cohen, 2003; Otte et al., 2012; Mellars, 2006). From an archaeological and anthropological point of view, the timing of modern human emergence and demise of the Neanderthals has been always a pivotal issue. Moreover, data on the climatic conditions during this crucial moment necessary data to the understanding the role of humans and their relationship with the surrounding environment. Therefore, enlarging the datasets, along with the high potential of the Palaeolithic deposits in the region, would certainly provide a great opportunity to better understand human occupation and adaptation in this region and beyond.

6. Conclusions

The identification of charcoal remains of *Prunus* from Kaldar and Gilvaran Caves shows that these trees and shrubs were probably important in the environment even during climatically cold periods. The wooded vegetation was probably characteristic of an open steppe. These results and the results obtained using other proxies from the sites excavated in the Khorramabad Valley, allow us to identify this area as a suitable region where resources were available and in which humans were probably well adapted. Charcoal evidence from Palaeolithic sites is generally scarce; hence, new evidence is always important to enlarge the datasets for the study of past vegetation and plant use. Therein lies the importance of the well-dated Kaldar Cave–a key archaeological site–in the region where there are large number of caves and rock shelters that could strength these datasets for understanding more about Neanderthals and early modern human occupation in respect to their adaptation with climatic condition from further studies.

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