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ORIGINAL ARTICLE

Crop cultivation in the Talayotic settlement of Son Fornés (Mallorca, Spain): agricultural practices on the western Mediterranean islands in the first millennium BCE

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Abstract

The Balearic Islands were colonised around the transition from the Chalcolithic to the Bronze Age, not earlier than 2300 cal BCE and certainly much later than any central or eastern Mediterranean islands. The number of archaeobotanical records is low and consists mainly of cereals and a few pulses. We present here new results of our long-term study of Son Fornés, an archaeological site on Mallorca which was occupied since the beginning of the Iron Age Talayotic period (~ 850 cal BCE) and until Roman times (123 BCE onwards), in the Balearic Islands. In the Talayotic period of Son Fornés *Hordeum vulgare* var. *vulgare* (hulled barley) and *Triticum aestivum/durum/turgidum* (free-threshing wheat) were the main cereals grown and *Vicia faba* (broad bean) was the main pulse, while *Avena* sp. (oats) is considered to have been a weed but was nonetheless consumed and was probably in an early phase of being domesticated. For the subsequent post-Talayotic (ca. 550 – 250 BCE), Classic I and Classic II, the Republican Roman occupation period (from 123 BCE onwards) the databases are weak, displaying hulled barley as the main crop and broad bean as the main pulse. The archaeobotanical records of *Ficus carica* (fig), *Olea europaea* (olive) and *Vitis vinifera* (grapevine) represent wild or cultivated and domesticated forms. *Prunus dulcis* (almond) and *Pinus pinea* (stone pine) were found on Eivissa (Ibiza), pointing to a Phoenician introduction to the islands, while *Phoenix dactylifera* (date palm) and *Castanea sativa* (chestnut), found on Menorca, might have been brought in by the Romans. The number of crops being used on the Balearic Islands was limited when compared to sites of similar periods on the European mainland or the central and eastern Mediterranean islands. According to carbon isotope results of $\Delta^{13}C$, hulled barley grew under damper conditions than free-threshing wheat. The high $\delta^{15}N$ values indicated that both crops were well-manured with animal dung during the entire occupation period.

Keywords Balearic Islands · Iron Age · Talayot · Isotopic results · Archaeobotanical data · Agricultural development

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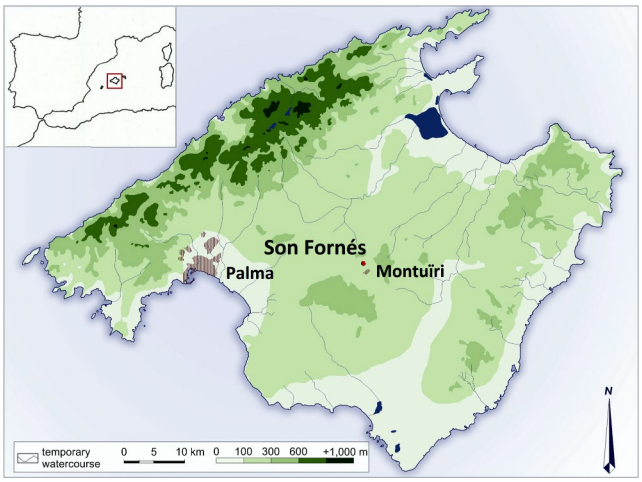

Fig. 1 Location of Son Fornés on the island of Mallorca and (inset) the Mediterranean Basin (drawing by ASOME-UAB)

Introduction

The archaeological site of Son Fornés is located in the centre of Mallorca, in a landscape typical of the rural lowlands of the island, 2.5 km to the north of Montuïri urban centre (Fig. 1). Fieldwork there started in 1975 in the area with the highest density of archaeological remains and it has continued until today (Fig. 2), under the coordination of Vicente Lull and his research team (Grup d'Arqueologia Social Mediterrànea, Universitat Autònoma de Barcelona, ASOME-UAB) (Gasull et al. 1984; Lull et al. 2001). The area excavated up to now is less than one third of the whole site, which has been estimated as 3 ha. Nevertheless, it displays a noteworthy case of the monumental architecture typical of Balearic archaeology, which lacks close parallels on the mainland (Lull et al. 2014).

In this paper, we present the results of a long-term systematic sampling for archaeobotanical remains from well-preserved floor levels of each one of the occupation periods at Son Fornés, as well as carbon and nitrogen isotope results from the main cereals recorded, *Hordeum vulgare* var. *vulgare* (hulled barley) and *Triticum aestivum/turgidum/durum* (free-threshing wheat). The full discussion of each specific context with the integration of other elements of the archaeological record is beyond the scope of this paper. Our purpose here is thus to benefit from the use of the same fieldwork methodology and laboratory procedures for just one site, which was occupied throughout the first millennium BCE, in order to present a comprehensive review of agricultural practices there, as well as the relative importance of the different staple crops.

The most recent review of the prehistoric archaeobotanical results of the Balearic Islands outlines the state of agriculture between the 3rd and the 1st millennium cal BCE (Pérez-Jordà et al. 2018). The results from the Son Fornés excavations add a large number of plant identifications, especially for the Talayotic period. These new results derive from the flotation of 4,578.5 L of sediment from various archaeological contexts.

Environmental background

Mallorca, an island of approx. 3,650 km², is part of the Illes Gymnèsies (Gymnesian Islands) consisting of Mallorca and Menorca, which are the largest islands of the Balearic Archipelago, in the western Mediterranean basin (Ginés et

Fig. 2 Aerial photo of Son Fornés in 2022 showing outlines of square buildings and round talayots (photo by ASOME-UAB)

al. 2012). In the north-west of the island is the mountainous region of Serra de Tramuntana reaching over 1,000 m with its highest peak, Puig Major, at 1,445 m a.s.l. In the east of the island there is another mountain range, the Serra de Llevant, which is lower, with a maximum height of 560 m. In between these mountains lies El Pla (the plain), fertile land with a large number of prehistoric settlements such as Son Fornés. Due to a geology with limestone, dolomite and marl, many karst solution caves can be found all over the island.

The climate of Mallorca is typically Mediterranean, with hot dry summers and mild wet winters. In Montuïri the annual average temperature is 18.8 °C, but it is lower in the higher mountain regions. The average annual rainfall is about 401 mm (climate-data.org 2023), and the highest precipitation falls in the Tramuntana highlands with 1,400-1,500 mm per year (van Strydonck 2014). Maps displaying average rainfall, altitude and vegetation categories for the whole island are given by Servera-Vives et al. (2022). At the site of Son Fornés the natural vegetation would be an evergreen hardwood forest with Mediterranean shrubs intermixed.

Archaeological background

According to the current state of research, colonisation of the Balearic Islands took place rather late, by ca. 2400 cal BCE (Alcover 2008; Ramis 2014). The oldest dates are found in Mallorca, while in the rest of the islands the earliest stable occupation is no earlier than the early Bronze Age, ca. cal 2200 BCE. The earliest human communities lived in caves and rock shelters, some of which were occasionally used as burial places, or in small open-air settlements with huts built mostly of perishable materials and occupied seasonally. Neither fish nor shellfish seem to have been important in the prehistoric diet, as isotope analyses have shown (van Strydonck et al. 2005), except in Formentera (Ramis 2018). Hunting was also unimportant, as the only endemic mammal formerly found in Mallorca and Menorca, *Myotragus balearicus* (goat antelope), predates human colonisation (Bover et al. 2016).

For the period ca. 2000 – 1500 cal BCE most of the archaeological record comes from funerary contexts. Dozens of primary burials were deposited following the same rites over many centuries, in caves, rock-cut chambers (*hypogea*) and dolmens. These collective traditions, with similar offerings and treatment of the bodies but in very different types of cemeteries, were characteristic of the Bronze Age. By ca. 1600 cal BCE human occupation had spread to all areas, including to islets and other coastal areas with very limited arable land (Calvo et al. 2011; Anglada et al. 2017). New megalithic structures were built both for the living and the dead. Long boat-shaped houses, either isolated or in loosely distributed clusters, are associated with evidence of many activities connected with crafts including metallurgy, stone and bone artefacts, pottery for food consumption and storage, querns for processing grain, as well as large assemblages of food waste with mostly domestic animal bones. By about 1200 cal BCE there were fewer of these boat-shaped houses and villages started to display a compact urban organisation.

Deep ideological and social changes marked the beginning of the Talayotic period (early 1st millennium BCE). It meant the end of almost all funerary practices which can be recognised archaeologically and the construction of hundreds of talayots, large watchtowers with an inner chamber and a central column used for public purposes (Lull et al. 2013; de Cet et al. 2017). Settlements emerged around these monumental buildings in Mallorca and Menorca, while they are non-existent in Eivissa (Ibiza) and Formentera, which were colonised by Phoenicians and Punic people (Carthaginians) and had a very different course of development during the Iron Age. Compared with earlier times, the Talayotic period reveals a remarkable absence of products and raw materials from elsewhere, demonstrating the isolation of these areas from the growing tensions elsewhere in the Mediterranean basin at this time (Lull et al. 2014).

Son Fornés was first settled in the Talayotic period (ca. 850 – 550 cal BCE), and had three talayots, together with eight domestic buildings which have been excavated so far (ESM Fig. S1). The archaeological record of this early period in Son Fornés is unusually extensive and well preserved. Its analysis has helped to define economic reciprocity as the hallmark of social and political relations in an Iron Age context. Talayotic communities, however, experienced a deep crisis all over the islands and came to a violent end ca. 550 cal BCE, when all the settlements investigated were destroyed by fire. In Son Fornés this event has been noticed in the final Talayotic occupation layers, but its chronology cannot be precisely determined by radiocarbon dating because of the Hallstatt plateau (Micó 2005). Nevertheless, the site has provided key stratigraphic and material evidence to date this general collapse at ca. 550 cal BCE (Lull et al. 2008).

In the following post-Talayotic period (ca. cal 550 – 250 BCE), also called Balearic in the most recent literature, there was a profound reorganisation of the settlements, since the talayots were no longer in use. The settlements have strong fortifications and are of very different sizes, organisation and content of houses, as well as showing a growing importance of imports. In the cemeteries, the individualisation of grave goods of high social value also suggests economic and political inequalities. In Son Fornés, the former village

was abandoned for a while and the settlement moved further north (ESM Fig. S2), where fortification structures were built (Amengual and Gelabert 2022). A few generations afterwards, the old Talayotic settlement area was re-occupied and there was a new economic and political organisation which was not based any longer on reciprocal relations. Five domestic buildings with different degrees of preservation have been excavated. Their interior space was re-arranged around a central courtyard and they differ in terms of storage capacity, production and consumption. Feasting was again an important feature of these new supra-domestic structures, traditionally called sanctuaries because of a supposed ritual dimension. Two of these buildings have been excavated so far (Amengual et al. 2012, 2013). They can be classified as public buildings, as is also the case with complete refurbishment of Talayot 3 that was accomplished in this period (ESM Fig. S1, Amengual et al. 2010).

The conflicts among the Mediterranean states had deep consequences in the local communities. After ca. 450 BCE the islands fell under the control of Carthage and Eivissa (Ibiza). Together with the growing importance of Italic amphorae, which occurred earlier, in the 3rd century, is a clear prelude of the loss of political autonomy. In Son Fornés by ca. 250 BCE there are further architectural changes and an increase of Punic and Italic imports that mark the beginning of the Classic I period. The Roman conquest of Mallorca and Menorca in 123 BCE (Classic II) meant the formal end of their political autonomy and the beginning of the colonisation period, although long-standing local traditions such as the cyclopean-megalithic architecture, stone tools and hand-made pottery survived under Roman rule until the end of the 1st c. BCE.

In Son Fornés both sanctuaries were extensively remodelled, but remained used as public buildings in the Classic period. The living quarters include the remains of eighteen buildings which are very varied in their sizes, structures and material records, indicating a much more complex settlement with specialised workshops and stores, as well as some scattered burials (ESM Fig. S3).

Materials and methods

The excavations at Son Fornés have produced an exceptional archaeobotanical record from the three occupation periods. For the Talayotic period, 76 samples have been analysed from 21 excavation contexts with a total sampled sediment volume of 2,501.5 L. For the post-Talayotic period, 37 samples were analysed from 18 contexts and a volume of 935 L. Finally, for the Classic period (Classic I, pre-Roman conquest 250 – 123 BCE; Classic II, Roman Republican, 123-1 BCE), the analysis includes 68 samples from 26 contexts with a volume of 1,142 L (further details in ESM).

The archaeobotanical samples were collected between 1981 and 2017 as part of the excavations in several excavation seasons. At the Museu Arqueològic de Son Fornés, the charred plant remains were extracted from the excavated sediments by flotation (basically an immersion of the soil samples in water, Jacomet and Kreuz 1999). The floating light fraction was washed through a set of sieves with mesh sizes of 2, 1 and 0.5 mm, then dried and stored until analysis. Laboratory analysis followed standard archaeobotanical methodology (Stika 1996, pp 18–20) (further details in ESM).

The analysis of stable isotopes in archaeobotanical remains is nowadays a normal method for reconstructing past agricultural practices and their interrelations with the prevailing environment (Bogaard et al. 2013; Araus et al. 2014; Ferrio et al. 2020; Knipper et al. 2020). As sub-products of plant tissues, charred seeds preserve physiological signals in their relative abundance of the stable isotopes of carbon (^{13}C, ^{12}C) and nitrogen (^{15}N, ^{14}N). The former is routinely used for deriving information about the water available for crops during the time of grain filling (Ferrio et al. 2005), while the latter provides hints on soil fertility and management practices (Aguilera et al. 2008). Despite the abundance of isotopic data on the origin and expansion of Near Eastern and eastern Mediterranean agriculture (Ferrio et al. 2020), these techniques have not been used on material from the Balearic Islands so far, in part due to the scarcity of crop remains traditionally recovered from archaeological sites there. Here we present carbon and nitrogen isotope values from a representative set of hulled barley and free-threshing wheat grains from each of the three occupation periods at Son Fornés (further details in ESM).

Results

In Table 1 the finds of cereals and other crops (but not wild plants) are listed for their respective settlement phases (Talayotic, post-Talayotic and Classic) and their ubiquity of appearance in single samples is given. Additional plant lists including all finds of wild plants from the sampled features are given in the ESM (Table S1, Talayotic; Table S2, post-Talayotic; Table S3, Classic).

The botanical names follow WFO Plant List (2023), with the exception of the cereals, which follow traditional nomenclature (Körber-Grohne 1994). A total of 87 different taxa have been identified, of which 74 could be determined to genus and 27 to species or subspecies level.

For the Talayotic period a total of 78,461 plant remains were found in 76 individual samples from 21 excavation

Table 1 Sums and ubiquities of finds of cereals and other crops for the three periods at Son Fornés

	Talayotic (800 – 550 BCE) 4,578.5 L	Ubiquity (76 samples)	Post-Talayotic (550 – 250 BCE) 935 L	Ubiquity (29 samples)	Classic (250-1 BCE) 1,142 L	Ubiquity (76 samples)
Avena sp., grain	2,858	63%	62	67%	18	35%
Avena sp., chaff	381	27%	2	11%		
Hordeum vulgare, grain	19	3%	24	33%	36	23%
H. vulgare, chaff	8	1%	1	6%	1	4%
H. vulgare var. *nudum*, grain	1,919	43%			11	12%
H. vulgare var. *vulgare*, grain	41,327	76%	102	67%	1,034	77%
H. vulgare var. *vulgare*, chaff	98	3%			2	4%
Triticum aest./durum/turgid., grain	26,499	65%	54	28%	49	42%
T. aest./durum/turgid., chaff					1	4%
T. cf. *dicoccum*, grain	123	27%	2	11%		
Fabaceae cult., seed	13	15%	4	6%		
Ficus carica, pip	160	43%	13	33%	18	27%
Linum usitatissimum, seed			1	6%		
Olea europaea, fruit stone	2	1%			1	4%
cf. *Pisum sativum*, pea	1	1%				
Vicia faba, bean	249	20%	4	17%	8	8%
Vitis vinifera, pip			3	6%		
Sum of cereals	75,206		349		1,274	
Sum of other crops	424		25		27	

contexts. Grains of *Hordeum vulgare* var. *vulgare* (hulled barley) are dominant (41,327/76% ubiquity) followed by *Triticum aestivum/durum/turgidum* (free-threshing wheat) with 26,499 grains in 65% of the individual samples, and *H. vulgare* var. *nudum* (naked barley) with 1,919 grains in 43% of the samples (ESM Table S1). *T. dicoccum* (emmer) is represented only by 123 grains in 27% of the samples. 2,858 grains and 381 glume fragments from *Avena* sp. (oats) were identified, although it is not known whether they represent domesticated or wild oats.

Grain finds make up 95.1% of the total plant finds from this archaeological phase. In addition to cereals, *Vicia faba* (broad bean) with 249 seeds, *Ficus carica* (fig) with 160 pips, *Olea europaea* (olive) with two fruitstone fragments, as well as 13 fragments of cultivated Fabaceae and one cf. *Pisum sativum* (probably pea) were identified.

In one building (HT6), 12 different grain accumulations were found (> 100 grains are assessed as an accumulation). 75,206 grain finds with only 611 remains of chaff classify these contexts as threshed and well-cleaned storage finds. In building HT6, three samples were collected in closed association with large pots (ESM Fig. S4), while a fourth accumulation appeared inside what seemed to have been a wooden box (photos of hulled barley, naked barley and free-threshing wheat grains in ESM Fig. S5), badly degraded but still in situ (ESM Table S4). The three accumulations from pottery jars contained hulled barley grains; in one of them oat grains were also mixed in. The sample from the wooden box consisted of free-threshing wheat grains, one sub-sample with some hulled barley grains added, one with subdominant naked barley and fewer hulled barley grains intermixed. All these accumulations contained only very few chaff remains and single seed finds of broad bean and pips of fig as well as a few weed seeds.

For the post-Talayotic period, a total of 762 plant remains were found in 37 individual samples deriving from 18 excavation contexts. Only 309 grains and three remains of chaff could be identified. Cereal remains represent 45.8% of the total plant finds. *H. vulgare* var. *vulgare* is dominant in the number of finds (102 grains) and ubiquity (in 67% of the samples), followed by 62 grains of *Avena* sp. (oats), which might derive from wild or domesticated plants, as well as *T. dicoccum* (19 grains) and free-threshing wheat (nine grains). *Vicia faba* (broad bean) (four beans) and one seed of *Linum usitatissimum* (linseed/flax) were also found. Fruit finds are represented by *Ficus carica* (12 pips and one fruit) as well as *Vitis vinifera* (grapevine) (two berry fragments and one pip).

For the Classic (I, II) period, 68 individual samples yielded a total of 1,669 plant remains from 26 different excavation contexts. An accumulation of grains was found in each of the houses HR11 and HR18. The total number of cereal remains amounts to 1,274 items and represents 76.3% of the total plant finds of this phase. Only four remains are from chaff. *H. vulgare* var. *vulgare* is absolutely dominant (1,034 grains), while *T. aestivum/turgidum/durum* is represented only by 49 grains. Other cereals include 18 grains of *Avena* sp. (oats), and 11 grains of *H. vulgare* var. *nudum* (naked barley). Other crops are 18 pips of *Ficus*, eight beans

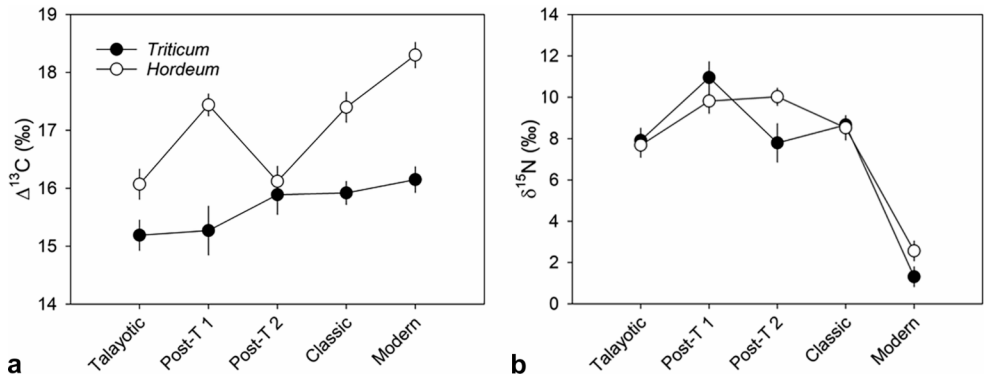

Fig. 3 **a**, Mean carbon isotope discrimination ($\Delta^{13}C$) values (± standard error) of charred *Hordeum vulgare* var. *vulgare* and *Triticum* spp. grains, corresponding to the different settlement phases and compared to $\Delta^{13}C$ values from modern barley and wheat grown near the site; **b**, mean nitrogen isotope composition ($\delta^{15}N$) values (± standard error) of charred *H. vulgare* var. *vulgare* and *Triticum* spp. (free-threshing wheat) grains, corresponding to the different settlement phases and compared to $\delta^{15}N$ grain values from modern hulled barley and bread wheat (*T. aestivum*) grown near the site

of *Vicia faba*, four seed fragments of cultivated Fabaceae, as well as one fruitstone of *Olea*.

The results of the isotopic analyses of hulled barley and free-threshing wheat grains are given in Fig. 3 and ESM Table S5. Overall, the $\Delta^{13}C$ measurements of hulled barley show significantly higher values than those of free-threshing wheat, including the modern samples, with the exception of the late post-Talayotic phase (Fig. 3a). This result points to more favourable growing conditions for barley than for wheat at Son Fornés. The $\delta^{15}N$ values of charred seeds had consistently positive values (higher than 6‰; Fig. 3b), which were similar for the different periods and cereal types. In comparison, the modern samples showed values that were insignificantly different from zero (*Triticum*) or close to zero (*Hordeum*). The high positive values of charred grains suggest that crop management involved the application of manure and the use of very fertile soils.

Discussion

Son Fornés

For the Talayotic period, the majority of the grains were identified as hulled barley and free-threshing wheat, with both crops displaying a very high ubiquity of appearance in features and single samples (ESM Table S1). In many samples, there were also small amounts of grains from naked barley mixed in. Only in one storage sub-sample (wooden box), naked barley was subdominant in a storage context mainly of free-threshing wheat grains. Oat finds were more common and frequent than naked barley and they were mostly found in connection with large accumulations of hulled barley, but these oats were significantly smaller than the other cereal grains. It can be suggested that oats occurred at Son Fornés as a weed in the hulled barley crops, but they were at least partly used for consumption and were probably at the beginning phase of becoming domesticated. *Triticum dicoccum* is recorded in several samples, but was most probably not grown on its own in separate fields. The almost complete absence of chaff remains is noticeable in all samples. Most probably, the stored cereals had been threshed, winnowed and sieved near the fields directly after the harvest and brought into the settlement as pure grains.

Many finds from building HT6 come from the floor level, including two accumulations stored in situ, one in a complete *pithos* (storage jar) and the other one in a wooden box, as well as two further accumulations associated with large, partly preserved pottery jars (ESM Table S4, Fig. S4). The main crops were hulled barley and free-threshing wheat, while free-threshing barley was a minor crop. The few finds of wild plants indicate a typical weed flora, such as *Fallopia convolvulus*, *Malva* sp., *Plantago* sp., *Rumex* sp. and *Silene* sp. as well as various grasses (*Festuca* sp./*Lolium* sp., *Phalaris* sp., *Poa* sp.).

Fruit trees are represented by finds of fig and olive, and both of these were probably cultivated and domesticated, a process which might have started in the Bronze Age (Stika and Heiss 2013). However, the finds themselves gave no morphological hints for discriminating between wild or cultivated forms. Broad beans were detected in Son Fornés as well as an unidentifiable cultivated Fabaceae and probably a pea. The numbers and frequencies of finds of pulses are less than those of cereals, but might still have been important crops, especially broad bean.

For the post-Talayotic period, a comparatively smaller amount of grains was found and there have been no storage finds so far (ESM Table S2). Mainly hulled barley and oat grains were identified, which suggest that weedy oats were growing in the fields of hulled barley. Although only several

grains were found, the ubiquity is very high at 67% (hulled barley) and 67% (oats). Fig and grape as well as broad bean and flax were also found. Based on morphological criteria, it can be suggested that figs had been dried before carbonisation. The grape finds might derive from domesticated vines but they could be of wild origin too, since wild grapevines have been identified in the Balearic Islands (Pérez-Jordà et al. 2018).

In the last settlement period of Son Fornés, most specifically in Classic II, when the islands fell under the domination of the Roman Republic in 123 BCE, hulled barley continued to be the most common cereal (81.2% of all seed/fruit finds) while grains of free-threshing wheat make up only 3.8% of all plant finds (ESM Table S3), and broad bean and olive were also identified.

According to the $\Delta^{13}C$ results, hulled barley grew in wetter (but rainfed) conditions than free-threshing wheat, as the corresponding values for *Hordeum* were almost consistently higher. This result is expected, since barley usually fills its grains earlier than wheat during spring, provided that both cereals are managed in a similar way with the same sowing time and manuring. In practice, this means that wheat is more exposed than barley to drought stress, which is typical of late spring and early summer (May-June) in the western Mediterranean basin. The consistency of the $\Delta^{13}C$ differences across periods (with the exception of the late post-Talayotic phase) suggests that there were no significant changes in amounts of precipitation in spring over the first millennium BCE, as also shown for the eastern Iberian Peninsula by Aguilera et al. (2012). However, the absolute differences in carbon isotope values between cereals are unusually high, over 1.5‰ in some instances and considerably higher than the differences reported by Aguilera et al. (2012). This finding suggests some preferential cultivation for barley (i.e. use of best arable lands) or (most likely) reflects different sowing periods, with barley being sown earlier in the growing season (e.g. autumn vs. winter). The very high $\Delta^{13}C$ values found from modern crops grown near the archaeological site, especially barley, are unusual in Mediterranean dry farming (Voltas et al. 1999; Ferrio et al. 2005), but in this particular case they can be attributed to particularly wet springs which repeatedly flooded the nearby arable land because the old drainage systems were no longer working. With regard to $\delta^{15}N$, the values of ancient barley and wheat were very high (in some cases exceeding 10‰), while modern grains from the surroundings of Son Fornés show low enrichment in ^{15}N. These results suggest that the prehistoric fields of both crops were efficiently manured with (heavily-enriched) animal dung (Aguilera et al. 2008; Fraser et al. 2011; Dreslerová et al. 2021), in comparison with modern fields in which chemical fertilizers are commonly used, with a N isotopic signature close to zero.

Other sites on the Balearic Islands

Compared to the mainland of Europe, the spectrum of crops for the Balearic Islands is narrow. *H. vulgare* and *T. aestivum/compactum/durum* were the main prehistoric crops, while *T. spelta* (spelt), *Secale cereale* (rye) and *T. timopheevii* (new glume wheat) (Czajkowska et al. 2020) never arrived there in prehistory, and the first finds of *Panicum miliaceum* (broomcorn millet) appeared late (early Iron Age) compared to the Bronze Age in mainland Europe (Stika and Heiss 2013). In the early and middle Bronze Age in Spain and southern France, the hulled wheats *T. dicoccum* and *T. monococcum* (einkorn) were subdominant, apart from barley and free-threshing wheat (Stika and Heiss 2013). The geographical isolation of the Balearic Islands and their limited external contacts during the Talayotic period, as well as the successful specialisation in barley cultivation there as indicated by the isotopic results, might explain the continued absence of crops such as emmer and einkorn even after the Roman conquest.

The number of excavated archaeological sites in the Balearic Islands with archaeobotanical analyses is quite low, as shown by a review on archaeobotanical results from there (Pérez-Jordà et al. 2018). The evidence from the first occupation of these islands in the late Chalcolithic and early Bronze Age (ca. 2300 – 1900 cal BCE) is limited to two cave sites. While the site of Coval Simó on Mallorca produced only one grain of barley, Cova des Riuets on Formentera, provided 27 barley grains (of which two could be classified as naked barley), three of free-threshing wheat and one seed of *Lathyrus cicera/sativus* (Table 2).

For the subsequent period, the Middle and Late Bronze Age (1600 – 1000 cal BCE), Mallorca produced only one grain of barley from the site of S`Hospilalet Vell (Ramis and Salas 2014) and an imprint of naked barley from Cap de Barbaria on Formentera (Sureda et al. 2017). Three sites on Menorca produced a considerable amount of hulled and naked barley grains, as well as a few emmer finds (Moffett 1992; Stika 1999; Arnau Fernández et al. 2003).

For the Talayotic period, there are several sites contributing to the understanding of crop cultivation and consumption. The archaeological site of Biniparratx Petit on Menorca produced hulled barley (38 grains) from the earliest Talayotic settlement phase (1000 – 800 cal BCE) and hulled barley (seven grains) and free-threshing wheat (one grain) from the later Talayotic phase (770 – 480 cal BC) (Antolín 2011). From the talayot of Son Fred on Mallorca, hulled barley (975 grains) and free-threshing wheat (243 grains) were found (Pérez-Jordà 2009). From the Talayotic phase of the settlement of Ses Païsses, hulled barley (six grains) and free-threshing wheat (five grains) as well as emmer (two grains) were found (Picornell-Gelabert and Carrión

Table 2 Finds of cultivated plants from the Balearic Islands summed up for several periods and quantitatively compared against the new data from Son Fornés

	Balearic Islands (after Pérez-Jorda 2018)			Son Fornés		
	Chalcolithic (2300-1900 BCE)	Bronze Age (1600-1000 BCE)	Iron Age (900-123 BCE)	Talayotic (800-550 BCE)	Post-Talayotic (550-250 BCE)	Classic (250-1 BCE)
Avena sp., grain				2,858	62	18
Avena sp., chaff				381	2	
Hordeum vulgare, grain	26	1,446	7	19	24	36
H. vulgare, chaff				8	1	1
H. vulgare var. *nudum*, grain	2	1,987		1,919		11
H. vulgare var. *nudum*, chaff		9				
H. vulgare var. *vulgare*, grain		2,800	2,668	41,327	102	1,034
H. vulgare var. *vulgare*, grain		55		98		2
Triticum aest./durum/turgid., grain	3		277	26,499	45	49
T. aest./durum/turgid., chaff						1
T. cf. *dicoccum*, grain		219	2	123	2	
T. cf. *dicoccum*, chaff		21				
Panicum miliaceum, grain			4			
Ficus carica, pip		24	20	160	13	18
Lathyrus cicera/sativus, seed	1					
Lens culinaris, seed			2			
Linum usitatissimum, seed					1	
Olea europaea, fruit stone		2	4	2		1
cf. *Pisum sativum*, pea				1		
Prunus dulcis, fruit stone			1			
Vicia faba, bean			1	249	4	8
V. sativa, seed			12			
Vitis vinifera, pip, fruit	1	3	19		3	
Sum of cereals	31	6,537	2,954	75,206	153	1,439
Sum of other crops	1	29	63	424	15	37

Marco 2017). The Talayotic samples from Son Fornés also included a huge amount of free-threshing wheat. Not only was there a storage find with many thousands of free-threshing wheat grains in a wooden box, but also its ubiquity in the samples (65%) was nearly as high as that of hulled barley grains (76%). This confirms that free-threshing wheat is the second most frequent cereal after hulled barley, at least for Mallorca. As no rachis fragments of free-threshing wheat were found, it remains unclear whether tetraploid or hexaploid free-threshing wheat or both were grown on the Balearic Islands during the Talayotic period. Naked barley was identified frequently from Son Fornés, but always in lower numbers than free-threshing wheat and hulled barley.

The Talayotic samples of Son Fornés yielded a large number of oat grains in many samples. Because of their small size, these are thought to have had a weedy character, most probably having grown among hulled barley. However, as the oats were found from storage contexts this shows that they were most probably consumed. Their first appearance and abundance in the Talayotic period suggest that oats were in the transition phase to becoming a cultivated crop. For millets, the database is weak for the Talayotic period, but from Pati d'Armes, Eivissa (Ibiza), *Panicum miliaceum* and *Panicum* sp./*Setaria* sp. are listed (Pérez-Jordà et al. 2018).

Of the crops other than cereals, *Vicia faba* was the most important crop in Talayotic Son Fornés with 249 finds from 52% of the analysed complexes. In other Talayotic settlements, broad bean has been detected only once, in Son Fred (Pérez Jordà 2009), together with 11 seeds of *Vicia sativa* (vetch) and three seeds of *Vicia/Lathyrus*. In Ses Païsses, another seed of *Vicia/Lathyrus* and a fruitstone of olive is listed for the Talayotic phase (Picornell-Gelabert and Carrión Marco 2017). Two olive stone fragments appeared in Talayotic layers of Son Fornés. Morphologically the olive finds could not be specified if they represent cultivated and domesticated or wild olive. Pips and one whole fruit of *Ficus carica* were found from Son Fornés and some fig pips from Pati d'Armes on Eivissa (Ibiza) (Pérez-Jordà et al. 2018). There is no morphological evidence whether these were wild or cultivated-domesticated. The olives and figs may have been either wild or domesticated in the 1st millennium BCE. Their cultivation and domestication might have started in the Bronze Age (Stika and Heiss 2013) and could have been brought to the Balearic Islands through contacts with the Phoenicians (Pérez-Jordà et al. 2018) or much later, with the Roman conquest of Mallorca and Menorca in 123 BCE.

The post-Talayotic period is represented in the settlement of Ses Païsses on Mallorca. Large amounts of hulled barley (1,537 grains) have been reported from the early phase there and 88 grains from the late phase. Free-threshing wheat is represented by only 12 grains for the early phase and by one grain for the late post-Talayotic phase (Picornell-Gelabert and Carrión Marco 2017). There are only a few records of

other crops from settlements of the post-Talayotic period. Single seeds of *Vicia*/*Lathyrus* and *Vicia*/*Lens* are listed from Ses Païsses and *Vicia*/*Lens* from Puig des Molins (Pérez-Jordà et al. 2018). In Son Fornés only broad bean could be detected. As in Son Fornés, in Puig des Molins figs were found. Olive finds appeared in Ses Païsses (Picornell-Gelabert and Carrion Marco 2017) and Puig des Molins (Pérez-Jordà et al. 2018) and *Prunus dulcis* (almond) and *Vitis* were recorded from the latter. Son Fornés also provided evidence of grapevine and additionally one seed of *Linum*.

The Classic period of Son Fornés is represented by 68 archaeobotanical samples which have provided only a short list of crops, despite the large volume of floated sediment (1,142 L). Hulled barley is dominant in both the number of finds (1,034 grains) and its ubiquity (in 77% of the samples), followed by free-threshing wheat (49 grains in 42% of the samples) and there were only a few finds (11 grains) of naked barley. Oats play a much more marginal role when compared to previous periods when it seems to have been an additional food source. Besides a few broad beans and fig pips, only olive is reported.

Summing up, in the Talayotic period ca. 800 – 550 cal BCE, two main cereals were grown in the Balearic Islands, hulled barley and free-threshing wheat. Both of these were grown on well-manured fields as shown by the isotopic analyses. Oats, either wild or domesticated, were grown in combination with barley and appear for the first time as an additional food source. Pulses, especially broad bean, were also grown in the Talayotic period, but they were unknown during the Bronze Age. These new results suggest that Talayotic farming was characterised by a variety of crops grown on well-manured fields with sufficient moisture.

Following the current state of research, for the second half of the 1st millennium BCE, hulled barley seems to have been the only main crop and broad bean was the most important pulse. After the Roman conquest of the islands, oats ceased to be grown for food and even wheat became a marginal crop. How far this development was a consequence of Roman colonisation and a change to cash crop production would require the investigation of more large-scale and long-term archaeobotanical records from other settlements. Several fruit taxa, fig, olive and grapevine, were found and these could have been cultivated and domesticated from wild stands on the Balearic Islands or from cultivars that were brought in from elsewhere. *Prunus dulcis* (almond) and *Pinus pinea* (stone pine) were found from Eivissa (Ibiza) (Pérez-Jordà et al. 2018), while *Phoenix dactylifera* (date palm) and *Castanea sativa* (chestnut) are listed for Menorca (Stika 1999). All four fruit trees might have been brought to the Balearic Islands by the Phoenicians or Romans, but stone pine might have originated there.

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