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ORIGINAL ARTICLE

New insights about economic plants during the 6th–2nd centuries BC in Sardinia, Italy

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Abstract
A research project carried out in Santa Giusta lagoon, Sardinia, since 2005 has revealed the presence of Phoenician and Punic waterlogged archaeological contexts of exceptional importance. Several transport amphorae, together with Punic coarse pottery and materials typical of funerary and votive contexts have been recovered. Two principal deposition phases have been distinguished, the first one dated to the 6th–5th century BC and the second dated to the 3rd–2nd century BC. The waterlogged conditions favoured the preservation of plant remains such as *Citrullus lanatus, Corylus avellana, Juglans regia, Juniperus oxycedrus, Lagenaria siceraria, Olea europaea, Pinus pinea, P. halepensis, Prunus dulcis, P. domestica, P. spinosa* and *Vitis vinifera*. Many amphorae contained ovine/caprine bones with slaughter or butchering marks, associated with grapes and other juicy fruits that have been interpreted as possible ingredients used as meat preservatives. This study provides information on the management of plants of economic importance for the Phoenician and Punic communities in Sardinia.

Keywords Archaeobotany · Phoenician and Punic · Othoca · Waterlogged remains

Introduction

Agricultural issues have occupied an important position in the development of Phoenician and Punic (Carthaginian) archaeology in recent years. In modern historiography, Punic agricultural prosperity has often been highlighted, and a significant place has been given to Mago and his 28 volume agricultural treatise which was translated into Latin by the Roman Senate as a proof of his renowned agrarian excellence (Domínguez Petit 2004). Leaving aside whether the fame of Punic agriculture is really mirrored in Mago's work or, as has been suggested, its purpose enters into more philosophical and political realms (Krings 2007, 2008), it is remarkable that over the years so little attention has been paid to the analysis of plant remains as direct evidence of plant cultivation and the large amount of information that can be drawn from this.

Phoenician and Punic archaeobotany is still in its infancy. Apart from the seminal works of Van Zeist et al. (2001) and Kroll (2007) in Carthage and recent research still unpublished by López and Cantero (personal communication), work in Tunisia at the site of Althiburos (López and Cantero 2016) and some preliminary reports from the Iberian Peninsula (Chamorro 1994; Catalá 1999; Iborra et al. 2003; Pérez

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Jordà 2007; Pérez Jordà et al. 2017), research into the role of plants in Phoenician and Punic subsistence has been limited.

In Sardinia, plant remains are also scarce due to the lack of systematic recovery there. Except for a few cases (Wetterstrom 1987; Bakels 2002), proper sampling and the application of suitable recovery techniques have started to be applied only recently (Del Vais and Sanna 2009, 2012; Pérez Jordà et al. 2010; Buosi et al. 2014; Sabato et al. 2015; Ucchesu et al. 2015a, 2017a), producing results that can inform on the use of plants there in the past. Although the datasets are reduced, plant remains from the Phoenician and Punic periods in Sardinia have been studied from sites such as Ortu Comidu (Wetterstrom 1986), Pinn'e Maiolu (Bakels 2002), Nora (Marinval and Cassien 2001; Miola et al. 2009) and Truncu'e Molas (Pérez Jordà et al. 2010), demonstrating the presence of cereals (free-threshing wheats and barley), legumes (broad beans and lentils) and fruits (grapes).

The main objective of this work is to explore the range of plants used during the Phoenician and Punic periods and to contribute to the development of archaeobotany in Sardinia.

Archaeological context

The lagoon of Santa Giusta is located in central-west Sardinia, on the Gulf of Oristano (39°521′57546″N, 8°35′21798″E). It has a circular shape, with a maximum area of 900 ha and a depth ranging from 0.4 to 1.5 m (Fig. 1). The waterlogged site there has been excavated since 2005 by the archaeological authorities, Soprintendenza Archeologia belle arti e paesaggio per la città metropolitana di Cagliari e per le province di Oristano e Sud Sardegna, and the University of Cagliari (Del Vais and Sanna 2009, 2012). This area is close to the ancient city of Othoca, located on the north-east side of the lagoon (Del Vais 2010).

The areas of highest concentration of the archaeological material were identified by systematic exploration of vast tracts of the north-eastern part of the lagoon. Under the mud, Del Vais and Sanna (2009) detected two main contexts dating from the 6th and the 2nd century BC called Area A and Area B. In Area A which is discussed here (Fig. 1), a large amount of pottery was discovered, especially transport amphorae containing animal remains and seeds, mixed with branches, wood fragments and wooden objects. The majority of transport amphorae were found almost intact and contained animal bones with traces of slaughter (Del Vais and Sanna 2009, 2012; Portas et al. 2015). The amphorae from the most ancient context appear to be related to either type T-1.2.1.2. (Ramon Torres 1995), dating to the first two-thirds of the 6th century BC, or type T-1.4.4.1., dated to the 5th century BC (Del Vais and Sanna 2009, 2012). Among the late Punic amphorae, there is a prevalence of those with an elongated cylindrical body of type T-5.2.2.1., with a sloping shoulder and indistinct edge externally, and of type T-5.2.1.3., with a more pronounced shoulder and distinct edge, both dating to the 3rd–2nd century BC (Del Vais and Sanna 2009, 2012).

Most of the transport amphorae seem to have been locally produced as proved by the archaeometric analysis conducted

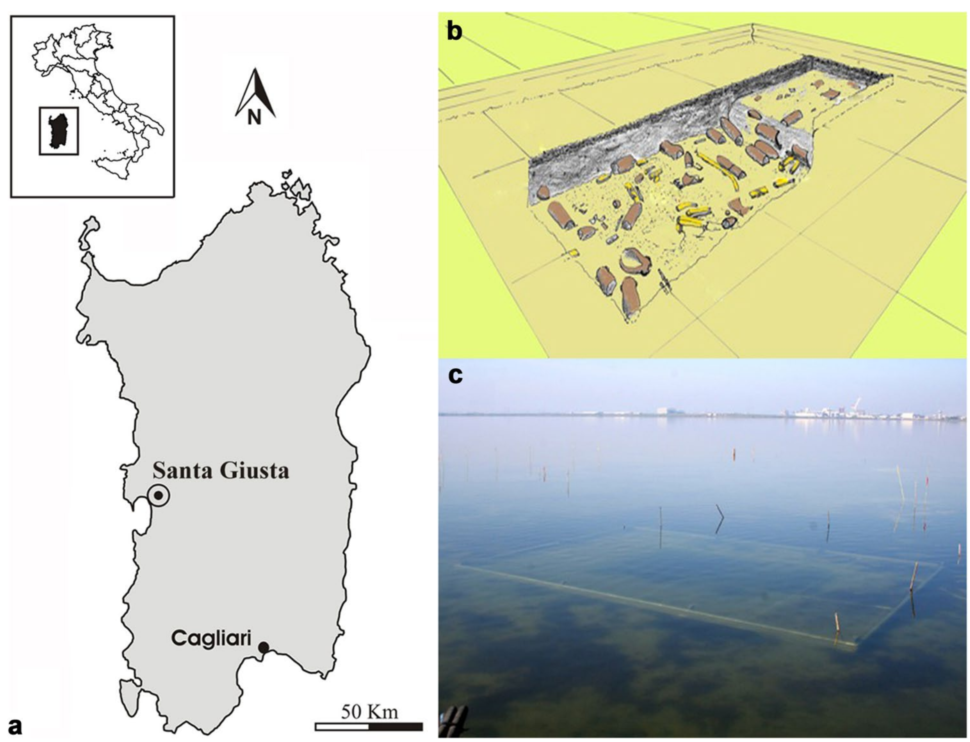

Fig. 1 **a** Location of Santa Giusta lagoon; **b** plan of the excavation area; **c** excavation area and submerged metal enclosure

in collaboration with the University of Urbino (Amadori et al. 2016). Much of this pottery was still intact and preserved the original content, which is an important indicator of the economic activity that took place during the Phoenician and Punic periods in the territory of the city of Othoca. Food processing activities carried out at the site included the use of food preservatives needed to transport perishable foodstuffs in ships.

Almost all the amphorae were used for transporting meat, from domestic species: *Ovis aries* (sheep), *Capra hircus* (goat) and *Bos taurus* (cattle) (Portas et al. 2015).

Materials and methods

During the excavation, the use of a large submerged metal fence for the protection of the excavation area and the sieving of the sediments using filters of different sizes allowed recovery of a total of 31 sediment samples that were collected from inside the amphorae and another 51 samples from the deposition layers using a sub-aquatic pump (Del Vais and Sanna 2009, 2012).

Among the amphorae, 13 were dated to the 6th–5th centuries BC and 18 to the 3rd–2nd centuries BC. Regarding the samples collected from the deposition layers, 11 were attributed to the 3rd–2nd centuries BC. Due to the difficulty of ascribing the soft silt layers to specific chronologies, the other 40 deposition layers were not classified into a specific period. It is likely we are dealing with part of the amphorae contents which were spread around due to breakage in antiquity.

The samples were water sieved during the excavation with a coarse mesh of 2 mm, according to the excavation methods being used then. The waterlogged material was kept in distilled water and stored in a fridge at + 5 °C at the Sardinian Germplasm Bank (BG-SAR) of the Hortus Botanicus Karalitanus. Identifications were carried out using a Leica M165C binocular microscope and a magnification range of 73× to 120× and with the reference collection of the BG-SAR.

Results

The samples provided more than 3,512 macro-remains that were found to be in an excellent state of preservation (Table 1). A wide range of plant taxa was identified (Figs. 2, 3) including *Olea europaea* (olive), *Prunus domestica* (plum), *Prunus dulcis* (almond), *Prunus spinosa* (sloe), *Vitis vinifera* (grape), *Juniperus oxycedrus* (prickly juniper), *Corylus avellana* (hazelnut), *Juglans regia* (walnut) and *Pinus pinea* (pine nut). The latter specimen was found also as a complete pine cone together with cones of *P. halepensis* (Aleppo pine) (Fig. 3). Furthermore, two seeds of *Citrullus lanatus* (watermelon) and a single seed of *Lagenaria siceraria* (bottle gourd) were identified. The majority of the taxa were found in the amphorae and in deposition layers dated to the 3rd–2nd century BC, and most of them were identified in both types of deposit. A large number of seeds of the aquatic *Potamogeton* sp. (pondweed) were also recorded in all samples.

Discussion

The biological remains analysed in this paper are mainly composed of plants of economic importance, of which fruits are the dominant category. The absence of small wild or cultivated seed or fruit remains is probably related to the use of a 2 mm mesh during the sieving process. A new protocol has been agreed with the archaeologists for future analyses.

There are no significant differences between the samples from amphorae and depositional layers. Cereals and legumes are probably absent as waterlogging does not favour their preservation. The most abundant taxon is *Vitis* (grape), which has been recovered from all contexts and periods. Due to the high concentration of remains in some of the vessels, particularly in the oldest material, some of the amphorae might have contained grapes or dried raisins.

Many of the amphorae contained remains of ovine/caprine bones suggesting the trading of pieces of meat from sheep or goat. Meat was preserved using an unknown method, but probably using various additives; this could explain the presence of grape pips.

In addition, textual evidence points to the role of wine as an ingredient in many foods such as meat marinades, fish sauces, cheeses and desserts (McGovern 1999). Grapes as well as other fruit such as plums and perhaps sloes (identified among the archaeobotanical remains) may have played a role in meat preservation. Sampels (2013) emphasized the antioxidant capacity of many fruits, spices and berries such as plums and grapes due to their content of phenols, anthocyanins and ascorbic acid. Furthermore, the modern food industry uses plum products and grape seed extracts in food processing for improving the colour of finished meat (Karre et al. 2013). Other plant parts such as the strong-scented berries of *Juniperus oxycedrus* (prickly juniper), which have been found at the site and grow widely in Sardinia, were used as additives to improve wine flavour (Atzei 2003). Similar examples of grape pips associated with ovine/caprine bones are also known from amphorae from Nora (Poplin 1980; Marinval and Cassien 2001). Furthermore, a 10th century AD recipe reported from Didimo in Geoponica Book 19th 9.5 suggests the use of grape pressing residues without separating the skin from the berry, to preserve salted meat of sheep, goat and deer (Meana et al. 1998). The remains found at Nora were interpreted this way (André 1981). For

Table 1 List of seeds and fruits identified from Santa Giusta lagoon

Context	Layers	Layers	Amphorae	Amphorae	Total
Century BC	6th–2nd	3rd–2nd	6th–5th	3rd–2nd	
Number of soil samples	40	11	13	18	82
Citrullus lanatus seed	1	–	–	1	2
Corylus avellana nut	–	–	–	5	5
Corylus avellana nut fragment	–	–	2	–	2
Juglans regia endocarp fragment	2	–	–	1	3
Juniperus oxycedrus seed	3	2	6	3	14
Lagenaria siceraria seed	–	1	–	–	1
Olea europaea endocarp	29	9	7	11	56
Olea europaea endocarp fragment	16	1	2	–	19
Pinus halepensis cone	3	–	–	1	4
Pinus pinea cone	–	1	–	1	2
Pinus pinea pine cone fragment	21	14	–	–	35
Pinus pinea shell	6	6	–	6	18
Pinus pinea shell fragments	46	60	2	6	114
Potamogeton sp. seed	75	–	1,362	664	1,437
Prunus domestica endocarp	4	–	1	5	10
Prunus domestica endocarp frag	1	–	–	–	1
Prunus dulcis endocarp	2	–	–	8	10
Prunus dulcis endocarp fragments	8	3	–	5	16
Prunus spinosa endocarp	34	6	5	1	46
Prunus spinosa endocarp fragments	8	–	–	–	8
Prunus sp. endocarp	8	–	4	4	16
Quercus sp. nut	1	–	–	–	1
Quercus sp. nut fragments	1	–	–	–	1
Vitis vinifera seed	140	27	1,240	273	1,680
Indeterminate (wild plants)	11	–	–	–	11
Total items					3,512

Santa Giusta, this could be also the case, at least for some of the grape pips found. Such a practice would have found a use for the grape pressing waste produced in the numerous wineries active in the area (Pérez Jordà et al. 2010). Grape pollen was recorded in the 5th century BC levels and later in Tharros (Acquaro et al. 2001) and again at the transition from the Middle Bronze Age to the Punic period (approx. from 3,500 to 2,500 cal BP) in Lago de Mistras (Di Rita and Melis 2013). Grape pollen and pips have been found in huge amounts in the same area since the Bronze Age (Lovicu et al. 2011; Orrù et al. 2013; Ucchesu et al. 2015b).

Grape pips may also have come from amphorae, which contained wine as, in antiquity, wine could include grape residues such as pedicels, skins and pips. It remains unclear whether their variable presence in the archaeological record represented different grades of wine quality. Apart from grape pips, none of these remains have been reported from Santa Giusta.

In some of the amphorae, there is evidence of a coating with pitch to reduce their permeability (Del Vais and Sanna 2009, 2012). One of the commonest materials used for vessel coating was pine resin, which as well as waterproofing the pottery also added a pleasant flavour to the wine. It also helped to preserve the wine by preventing oxygen from entering through the pores of the clay and therefore avoiding the bacterial activity responsible for the conversion of wine into vinegar. It has been suggested that it also contributed to lessen unpleasant taste or odour (McGovern et al. 1996). Pliny, in his Natural History (Rackham and Jones 1975), described the use of pine pitch for lining storage jars. Pine resin from Aleppo pine has been traditionally used in Greece to produce retsina, a popular resinated wine (McGovern at al. 1996).

Several pine cones were found, from two different species, *P. halepensis* and *P. pinea* from which seeds have also been identified. Their presence in the samples is difficult to interpret. In antiquity, pine cones sealed with clay were used as stoppers in amphorae (Twede 2002), while being steeped in the wine they helped to avoid the wine becoming vinegar. However, to enhance the flavour and aroma of wine, additives other than resin were also used, from fruits, berries, spices, herbs, honey, etc.

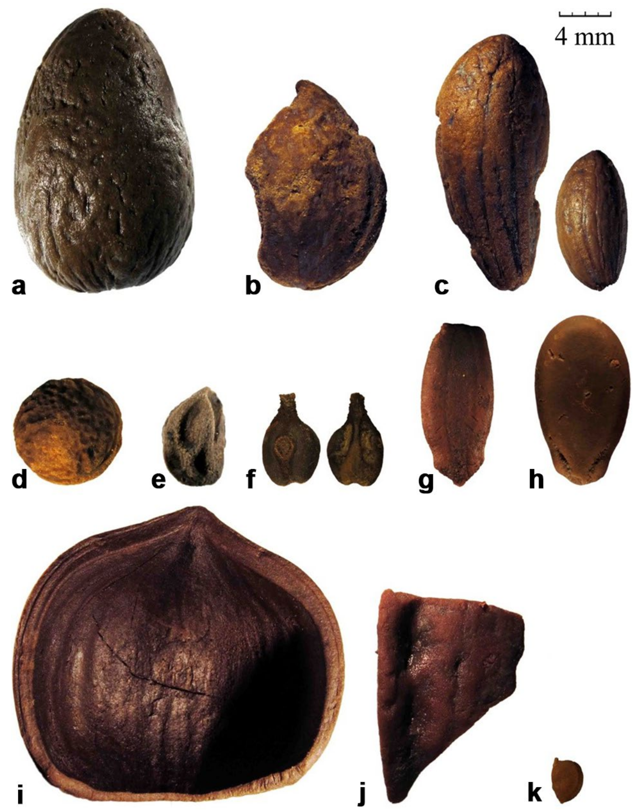

Fig. 2 Waterlogged remains from Santa Giusta lagoon; **a** *Prunus dulcis* endocarp; **b** *Prunus domestica* endocarp; **c** *Olea europaea* endocarp; **d** *Prunus spinosa* endocarp; **e** *Juniperus oxycedrus* seed; **f** *Vitis vinifera* seed; **g** *Lagenaria siceraria* seed; **h** *Citrullus lanatus* seed; **i** *Corylus avellana* nut; **j** *Juglans regia* endocarp fragment; **k** *Potamogeton* sp. seed

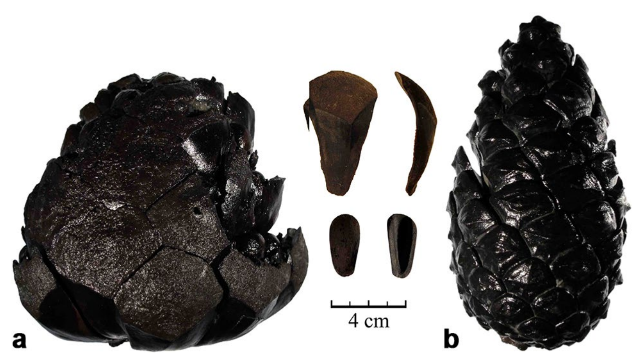

Fig. 3 Waterlogged remains from Santa Giusta lagoon; **a** *Pinus pinea* cone, bract scale and pine nut; **b** *Pinus halepensis* cone

The presence of walnuts, hazelnuts, almonds and pine nuts amongst the remains suggests that nuts were also part of the traded items. Although hazelnut and walnut are considered to be introduced plants in Sardinia (Podda et al. 2012), pollen of *Corylus* and *Juglans* is present in the same area from at least 5,300 BP (Di Rita and Melis 2013) and evident in the 5th century BC (Acquaro et al. 2001). *Juglans* is considered to be an indicator of human activities (Di Rita and Melis 2013). In northern Italy *Corylus* is recorded from the Mesolithic-Neolithic transition (Biagi et al. 2008; Boccacci and Botta 2009; Rottoli and Castiglioni 2009). As for the pine cones, *P. halepensis* (Aleppo pine) and *P. pinea* (stone pine) could have grown locally, although nowadays pines only thrive naturally in two restricted areas in the southwest, Porto Pino and Portixeddu-Buggerru (Mossa 1990). Walnuts, hazelnuts and pine nuts identified in Punic Carthage have been interpreted as exotic foods, since these plants do not grow naturally in that area (van Zeist et al. 2001). Thus, it is yet unclear whether these taxa were present in Sardinia before the Phoenician colonization or if the colonists introduced them.

Prunus endocarps have been found in small numbers in both amphorae and deposition layers. According to Ucchesu et al. (2017b), *P. domestica* remains from Santa Giusta match varieties currently cultivated in Sardinia, representing the oldest find in Italy from this period. Plums have also been recorded from Huelva, southern Spain, in Phoenician contexts dated to the late 9th century BC (Pérez Jordà et al. 2017), suggesting a link with Phoenician presence there.

The olive stones were of various shapes and sizes, perhaps representing different varieties belonging to cultivated and/or wild trees. The record of olives in Sardinia goes back to at least the Middle Bronze Age, 1800–1300 BC. Olive stones were identified at the site of Duos Nuraghes (Bakels 2002) and *Olea* pollen appears in Tharros (Acquaro et al. 2001) and in the Mistras pollen diagram (Di Rita and Melis 2013), where moderate frequencies (up to 5%) are detected between 5,300–1,600 BP, indicating that olive trees were growing in the surroundings of the site. Bearing in mind the enormous importance of the olive in the Mediterranean, it is surprising that olive cultivation was not a common practice in Sardinia (Di Rita and Melis 2013) according to the archaeobotanical data. The association of olive stones with amphorae remains open to various possibilities. On the one hand, olives or olive oil could have been traded, and on the other it is also possible that olives were ingredients of the meat dressing being transported.

Lagenaria (bottle gourd) was recorded in the latest phase, in a deposition layer dated to the 3rd–2nd century BC. It represents the oldest record from this area. Its presence might be related to its traditional use as a water container, a practice still common today in Sardinia and Africa and widespread during Roman times (Schlumbaum and Vandorpe 2012). However, since only a single seed was discovered, any hypothesis on its use is speculative. Similarly, the record of *Citrullus* (watermelon) is based only on two seeds and it is, at present, the oldest record of this taxon from the western Mediterranean. Recently, Paris (2015) has published a detailed review of ancient watermelon records, pointing out that the origin and domestication of dessert watermelon is probably located in north-eastern Africa and that it reached the Mediterranean basin around 2,000 years ago. Most of the oldest records and representations come from Egypt (Germer 1988; Hepper 1990; Janick et al. 2007), Libya (van der Veen 2011) and Sudan (van Zeist 1983). Wasylikowa and van der Veen (2004) suggested the possibility that some Egyptian seeds may have been erroneously identified as other *Citrullus* species. Further remains of watermelon seeds dated to the 1st millennium BC have been reported from the site of Raybun, in southern Arabia (Cox and van der Veen 2008; Levkovskaya and Filatenko 1992), Samos, Greece (Kučan 1995) and Israel (Schultze-Motel 1974). For Europe, but also for northern Africa, remains have been retrieved from several sites dated to the Roman period (Castelletti at al. 2001; Rinaldi et al. 2013); for further details see Cox and van der Veen (2008) and Paris (2015). It is likely that watermelon, as well as bottle gourd, were known to the people of Carthage and their colonies in North Africa, although the lack of evidence before the classical period suggests that the spread of this plant probably occurred at a later stage.

Concerning the other wild plants, seeds of pondweed were probably within the sediment that filled the amphorae when they were deposited. This water plant thrives in shallow fresh water, but some species such as *Potamogeton pectinatus*, which is common in Santa Giusta lagoon, have shown some salinity tolerance (van Wijk et al. 1988).

Conclusions

Waterlogged plant remains from various amphorae used for the transport of goods and dated to two different periods, the 6th–5th and the 3rd–2nd centuries BC, were discovered in the seabed of Santa Giusta lagoon. Plant composition was similar in both assemblages, suggesting some continuity in the use of the plant taxa identified. However, many remains were also retrieved from deposition layers which are not easily attributable to either of the two phases. Taxa such as walnuts, hazelnuts and pine nuts were probably part of trade in specific categories of products with high commercial value. The relatively large size of the fruits suggests a strong selection of the best specimens.

The occurrence of juicy fruits, such as grapes and plums, together with animal bones with clear slaughter marks can be interpreted as evidence of a way of preserving meat as suggested by similar finds from other sites.

The discovery of two cucurbits, watermelon and bottle gourd, represents their oldest records in the western Mediterranean area. It is unlikely that these crops were locally cultivated since their introduction occurred only later, but they were probably known in North Africa.

The analysis of plant remains from Santa Giusta lagoon has allowed exploration of aspects of Phoenician and Punic trade in the Mediterranean basin. This is especially important because archaeobotanical data from these periods is rather scarce, not only in Sardinia but also in the rest of the Mediterranean. The data set discussed in this paper is a small part of the total available, so further research will certainly contribute to clarify many of other issues raised here and to improve our knowledge about Phoenician and Punic agriculture and diet.

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