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Agricultural dynamics in southwestern Mediterranean France
from the end of the Iron Age to the early Middle Ages

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Abstract

In the north-western Mediterranean, the rural world underwent major economic, social and cultural changes between the end of the Iron Age and the beginning of the Middle Ages, with a decisive impact on the evolution of agricultural production, practices and landscapes. Roman expansion first led to the spread of *villae* during the 2nd and 1st c. BC, leading to a new structuration of rural areas and the development of a speculative agriculture, which strongly favoured wine production. By the end of the Roman period, new changes are observed: while certain Roman *villae* are still occupied, the appearance of a new network of rural settlements reveals the emergence of a new form of rural economy. Although these changes are increasingly well documented by archaeology, their impact on the agrarian production and practices remains little explored. The multiplication of archaeobotanical investigations in southwestern Mediterranean France allows us to present a first review of farming practices and their evolution during this key period. The study of 30 rural sites provides new data concerning local agriculture between the 2nd c. BC and the 8th c. AD (cultivated plants, prevalence of certain species, associated farming practices, exploited landscapes) and attempts to detect potential specificities / evolutions over time such as changes in staple crops, diversification, exploitation of new “terroirs”.

Keywords

Archaeobotany · Crops · Farming practices · Fruit cultivation · Southern France

1. Introduction

In the north-western Mediterranean, the rural world underwent major economic, social and cultural changes between the end of the Iron Age and the beginning of the Middle Ages (Wickham 2006), with a decisive impact on the evolution of agriculture. In Mediterranean France (*Gallia Narbonensis*), the Roman conquest led to the spread of a new type of rural settlements, the *villae*, during the 1st c. BC, which led to a restructuring of the countryside, in conjunction with the rise of speculative agriculture favouring wine production (Favory *et al.* 1998; Buffat 2011). Although these settlements tended to become rarer from the 3rd c. AD onwards, some of the *villae* founded during the High Empire extended well into the first centuries of the Middle Ages (Schneider 2010). At the same time, from the 4th-5th c. onwards, the creation of a new network of rural settlements reveals the emergence of a new form of rural economy which lasted at least until the 7th-8th c. (Schneider 2010; Ros *et al.* 2020a, b).

Although these changes are increasingly well documented by archaeology, their impact on agrarian production and practices remains little explored. In the past decades, this part of the Mediterranean has seen a significant increase in archaeobotanical approaches to the ancient and medieval periods, particularly in southern France (*e.g.* Ruas 2005; Bouby 2014; Ros 2020; Tillier 2023) and Catalonia (*e.g.* Alonso Martinez 2005; Buxó 2005). These successive contributions to the agrarian history of the north-western Mediterranean have highlighted the importance of both a diachronic and regional approach to understanding agricultural dynamics over the long term, especially in a changing socio-economic context. In particular, it seems important to assess the role of the evolution of global and local socio-economic contexts on eventual changes in cultivated plants, practices and agro-pastoral systems.

In this sense, the increase of archaeobotanical investigations in southwestern Mediterranean France allows us to present a first review on farming practices and their evolution during this ever-changing period. Based on the study of 30 rural sites, we aim to document the agricultural characteristics of this region between the 2th c. BC and the 8th c. AD (cultivated plants, prevalence of certain species, associated farming practices, exploited habitats) and to detect likely specificities or evolution over the long term (changes in the staple crops, diversification, exploitation of new “terroirs”).

1.1. Regional setting

This study covers the coastal plain of the Roussillon and the mountainous regions of Vallespir and Conflent (Pyrénées-Orientales, France). The Roussillon plain is surrounded by the Corbières’ hills and the lagune of Salses (north), the Pyrenees mountains (west), the Albères’ hills (south) and the Mediterranean Sea (east) (Fig. 1). The geological substrate is largely the same everywhere in the plain but limestone tend to be dominant in the north, while schists abound in the south (Servant 1970). The vegetation of the study area includes elements from the thermo-, meso- and supramediterranean levels (Gausson 1926, 1934). The natural vegetation is dominated by mixed evergreen (*Quercus ilex*) and pubescent (*Q. pubescens*) oak forest. Several sub-sectors can be distinguished according to the average annual rainfall, notably the rather dry coastal fringe (averages below 600 mm) and the inland area, which experiences higher rainfall (subhumid type). On the coastal strip, in addition to evergreen oak formations, there are Aleppo pine (*Pinus halepensis*), lentisk (*Pistacia lentiscus*) and kermes oak (*Quercus coccifera*) formations, and, mixed with pubescent and pedunculate oaks on deep soils, cork oak (*Q. suber*) forests. Inland, where the above species are absent, pubescent oak is more frequently mixed with evergreen oak.

Regarding the hydrological network, the plain is crossed by four west-east oriented coastal rivers of unequal size and regime: the Agly, the Têt, the Réart and the Tech. The history of these rivers is closely linked to the history of the human populations that lived in the plain. Archaeological and geomorphological surveys, as well as medieval written sources, show that this prevalent hydrography has varied over the millennia, particularly during the medieval and modern periods, but the valleys were pretty stable during Roman antiquity and the early Middle Ages (Marichal *et al.* 1997; Calvet *et al.* 2002; Puig *et al.* 2007; Carozza *et al.* 2009). These researches also document the existence in the past of a greater quantity of wetland areas in the plain, that were largely drained between the end of the medieval and the beginning of the modern period. During the Early Middle Ages, notably during the 6th-8th c., these wetlands attracted settlements occupied in fishing, hunting and the exploitation of plant resources (Puig *et al.* 2007; Ros *et al.* 2020a). However, their role in the local Roman economy remains obscure.

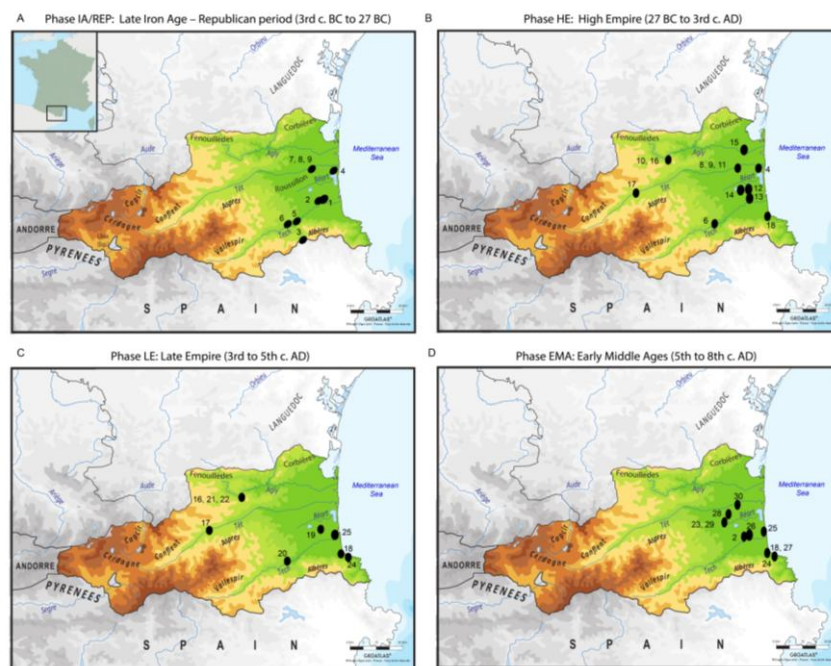


Fig.1: Studied area and location of sites taken into account (black dot = archaeological site). Site numbers correspond to those shown in Table 1.

1.2. Historical and archaeological setting

Settlement dynamics between the end of the Iron Age and the Early Middle Ages are closely linked to the global and local evolution of socio-economic factors.

At the end of the Iron Age, the Roussillon territory was under the influence of urban-type settlements (*Ruscino, Illiberis, Pyréné*), while a strip of rural occupations developed from the Aspres massif to the coast. The palaeoenvironmental data allow us to reconstruct a fairly dense agrarian occupation, favoured by the existence of alluvial soils (Dunyach 2018). Dispersed settlements composed of small mud dwellings and scattered agricultural areas characterised this open, hilly landscape. *Pyréné* (Collioure) and *Illiberis* (Elne) were the most active settlements in Roussillon from the second half of the 4th c. to the 3rd c. BC. For reasons that are still unclear, many rural settlements were abandoned during the 3rd c. BC. Some archaeologists interpret this drop in the number of sites as resulting from a break in the occupation of the Roussillon plain (Ropiot and Mazière 2007). Between the end of the 3rd and the beginning of the 2nd c. BC, changes suggest a progressive but rapid Romanisation of the region, accompanied by Iberian imports on the northern Pyrenean margins (Kotarba and Castellvi 2014). In the course of the 2nd c. BC, the region is mentioned by Latin authors (Pomponius Mela, Avienus) as the territory of the Sordes people. The year 118 BC was marked, under the impetus of the consul Cnaeus Domitius Ahenobarbus, by the foundation of the Roman colony of Narbonne, located about 50km north of the Roussillon plain, as well as the construction of the *Via Domitia*, commercial route that crossed the plain, connecting Roman Gaul and Roman Iberia.

The beginning of the Roman conquest is characterized by the fast development of farms of modest size, which appeared a little before the end of the 2nd c. BC (Comps and Kotarba 1997). These farms were regularly distributed, in the plain as well as on the slopes and hillsides. Their expansion was such that "enormous territories" were apparently converted to agriculture (*Ibid.*). However, the vast majority of these farms disappeared very quickly, probably before 70 BC, when new rural establishments were created, especially near the Roman city of Ruscino and at the foot of the Albères (*Ibid.*). These new and larger establishments, known as *villae*, developed between the Augustan period and the second half of the 1st c. AD. They were equipped with cellars, wine presses and, from 20 BC onwards, with basins with paving bricks and central cupule, testifying to the production of wine and olive oil (Kotarba *et al.* 2007; Beauchamp *et al.* 2017). The first production of local wine *amphorae* is also recorded, notably at Petit Clos (Perpignan), Font del Mas (Ponteilla) and Llupia (Thuir) (Kotarba *et al.* 2007); the excavation of underground silos of great volumes should also be mentioned. The majority of these farming establishments created in the second half of the 1st c. BC also disappeared between the second half of the 1st c. AD and the first half of the 2nd c. AD. Only the large-scale establishments remained throughout Late Antiquity

(3rd-4th c.); the disappearance of the city of Ruscino seems to have led to a redistribution of settlement areas towards the south of the plain and the town of Elne (known as *Castrum Helenae*, *Helena*, *Elna*). Despite the absence of large *villae* in the immediate vicinity of Ruscino, archaeology reveals the permanence of habitat and even the creation of small settlements in the Têt valley, by the end of the 4th c./beginning of the 5th c. (Passariius *et al.* 2008).

Between the 5th and the 8th centuries, the plain underwent a great change, with the emergence of short-lived settlements, made out of perishable material (Ros *et al.* 2020a). These sites are considered to be rather large and, above all, include fairly dense areas of activity (*e.g.* storage, farming, craft areas) (*Ibid.*). For the moment, it is not possible to determine whether these areas belonged to the same family or administrative entity, or whether they were occasional dwellings of the same community, moving over the same area on a time scale too short to be apprehended by archaeology (*i.e.* every 20/30 years). Some authors consider this new settlement dynamic as related to social and economic changes (Catafau 2007). Afterwards, the 8th-9th centuries saw the appearance of new settlements, whose relationship with the previous ones cannot be ascertained (Catafau 2007).

2. Material and methods

Archaeobotanical data from 30 sites, mostly excavated in the framework of rescue archaeology, have been examined (Tab. 1, Fig. 1). The sites are mainly located on the alluvial plain, but also by the coast and on the slopes of the Pyrenees (Tab. 1, Fig. 1). A total of 238 archaeobotanical samples from 103 archaeological features was analysed. They mainly concern secondary deposits from 'open' features, such as storage pits (silos), ditches, living spaces (*e.g.* houses) and livestock pens, rubbish dumps and wells. Radiocarbon and/or pottery analyses date the layers from the 3rd c. BC to the 8th-10th c. AD. The data was grouped and analysed according to four phases:

Phase IA/REP: Late Iron Age – Republican period (3rd c. BC to 27 BC) (47 samples),

Phase HE: High Roman Empire (27 BC to 3rd c. AD) (60 samples),

Phase LE: Late Roman Empire (3rd to 5th c. AD) (26 samples),

Phase EMA: Early Middle Ages (5th to 8th c.) (109 samples).

The database is chronologically biased, with far fewer samples for the Late Roman Empire in comparison with the Early Middle Ages, because of the focus of existing archaeological research within the study area.

Samples were processed using various methods. During earlier excavations (1980's and 1990's) samples were sometimes coarse sieved and archaeobotanical material sorted by non-specialists. Fortunately, these samples are a minority in the corpus (Tab. 1). The remaining samples were manually floated and the archaeobotanical remains recovered in sieves with mesh sizes of 2 and 0.5 mm, the volume of samples taken ranging from 2 to 400 litres, with an average of around 10 litres per sample. However, due to the different sample processing methods, samples are subject to variable degrees of recovery bias and representativeness, especially in relation to plant species with small seeds that may be underrepresented in some cases.

The nomenclature in this article follows the French 'Inventaire National du Patrimoine Naturel' (Museum National d'Histoire Naturelle, Paris). To interpret the results, the remains were quantified, either as entire specimens or as fragments. As the abundance of plant remains varies according to sampling methods, the frequency of occurrence of cultivated taxa was calculated per sample / phase. Only well dated samples were selected for analysis and those overlapping two chronological periods were discarded. A comparison of the edaphic preference of wild plants identifiable at a species level allowed us to characterise agrarian practices and the soil types exploited, as proposed by Neveu *et al.* 2021. Two ecological databases provided the majority of the information: Julve (Julve, 1998) and Try¹ (collaborative database); further information derives from Jauzein (1995) and Pignatti (2005).

N°	Site	Locality	Type of settlement	Century	Number of studied features (samples)	Total studied volume (L)	Methods of extraction	Total of plant remains	Researcher/publication
1	Rue des Corbieres	Elne	urban context	225-0	7 (7)	167	water sieving : 0,5	113	Benezet <i>et al.</i> 2012
2	Pujals	Omalls	rural settlement	200-100 BC / 300-800 AD	4 (11)	74	water sieving : 0,5	6,708	Ros <i>et al.</i> 2020a
3	Camp de la Torre	Le Perthus	rural settlement	200-75 BC	3 (6)	80	water sieving : 0,5	35	Ros unpubl
4	Parg del Braja I	Canet-en-Roussillon	rural settlement	175-75 BC / 80-150 AD	5 (22)	651	at sight and water sieving : 0,5	1,249	Ros 2020
5	Pla de Moltes	La Boulou	rural settlement	150-100 BC	2 (9)	510	at sight and water sieving : 0,5	88	Ros 2020
6	Las Tumbes	Céret	rural settlement	150-100 BC / 75-100 AD	2 (2)	20	water sieving : 0,5	2	Ros unpubl
7	Mas de la Maddeïme I	Peppignan	rural settlement	150-75 BC	1 (1)	10	water sieving : 0,5	2	Ros 2020
8	Mas Coste	Peppignan	rural settlement	120 BC-60 AD	8 (13)	700	at sight and water sieving : 0,5	156	Ros 2020
9	Mas Delfau	Peppignan	rural settlement	100-50 BC / 1st AD	2 (3)	8	water sieving : 0,5	3,208	Ros 2020
10	L'Hato	Caramany	rural settlement	40-20 BC / 300-600 AD	5 (5)	70	water sieving : 0,5	19	Ros unpubl
11	Petit Clos	Peppignan	rural settlement	20 BC-150 AD	7 (15)	576	at sight and water sieving : 0,5	8,094	Ros, Ruas 2017
12	Mas Raig	Théza	rural settlement	10-30 AD	1 (2)	40	at sight and water sieving : 0,5	33	Ros, Ruas 2017
13	Maison Philippon	Elne	urban context	1st AD	1 (1)	20	at sight	6	Ros 2020
14	Mas Savay	Villeneuve-de-la-Raho	rural settlement	60-120 AD	2 (2)	35	at sight	74	Ros, Ruas 2017
15	Sant Jaume del Crest	Claira	rural settlement	75-150 AD	1 (1)	18	water sieving : 0,5	1	Figuera unpubl
16	Pla de l'Aigo	Caramany	rural settlement	50-350 AD	7 (7)	180	water sieving : 0,5 and 2mm	30	Ros unpubl
17	Rue de la Basse	Prades	rural settlement	1st-5th c. AD	7 (24)	213	water sieving : 0,5	4,444	Ros unpubl
18	Taxo-les-garrettes	Argelès-sur-Mer	rural settlement	1st-5th AD	4 (4)	340	water sieving : 0,5	35	Ros unpubl
19	Aspra del Paradis	Comella-del-Vercol	rural settlement	375-450 AD	1 (1)	26	water sieving : 0,5	223	Ros, Ruas 2017
20	Bente Farine	Céret	rural settlement	350-400 AD	3 (4)	20	at sight and water sieving : 0,5	11	Ros, Ruas 2017
21	Ternofort 268	Caramany	rural settlement	370-450 AD	1 (1)	20	water sieving : 2	1	Ros unpubl
22	Les Coudoumines 541	Caramany	rural settlement	370-500 AD	2 (2)	64	water sieving : 0,5	9	Ros unpubl
23	L'GV Baguettes	Ponteilla	rural settlement	400-800 AD	3 (9)	53	water sieving : 0,5	3,977	Ros <i>et al.</i> 2020a
24	Chateau Royal 16	Cullouere	rural settlement	450-550	3 (6)	38,2	water sieving : 0,5	5,506	Ros unpubl
25	Las Xinetes	Saint Cyprien	rural settlement	5th-6th AD	2 (5)	120	water sieving : 0,5 and 2mm	150	Ros <i>et al.</i> 2020a
26	Le Plianol	Elne	urban context	5th-7th AD	1 (1)	20	water sieving : 0,5	4,306	Ros unpubl
27	Taxo-l'ompergie	Argelès-sur-Mer	rural settlement	6th-9th AD	2 (2)	20	water sieving : 0,5	181	Ros unpubl
28	Manresa	Canohès	rural settlement	600-700	11 (68)	1645,5	water sieving : 0,5	17,207	Ros <i>et al.</i> 2020a
29	Camps de la Ribera 42	Ponteilla	rural settlement	600-800 AD	1 (1)	10	water sieving : 4	12	Ruas 2011, Ros <i>et al.</i> 2020a
30	Ruscino	Peppignan	rural settlement	600-1000 AD	5 (7)	= 40	at sight and water sieving : 0,5	16,745	Ros, Ruas 2014
					Total of features (samples):			Total of plant remains:	72,625

Tab. 1: Corpus of archaeological sites including a carpological study (2th c. BC – 8th/10th c. AD)

¹ Website : <https://www.try-db.org/TryWeb/Home.php>

3. Results

A total of 72,625 carpological remains were sorted out. Some samples provided very few remains, at times less than 10 (Tab. 1). Despite the scarceness of the remains in some sites, which limits the information on the actual farming practices, the inclusion of all available data for this region and period provides a comprehensive picture of the exploited crops, both annual and perennial. Taxa include 30 cultivated/gathered plants corresponding to 5 cereals, 5 pulses, 2 oil/textile plant, 17 cultivated/gathered fruits and 1 aromatic/ornamental tree (Fig. 2, see Appendix 1).

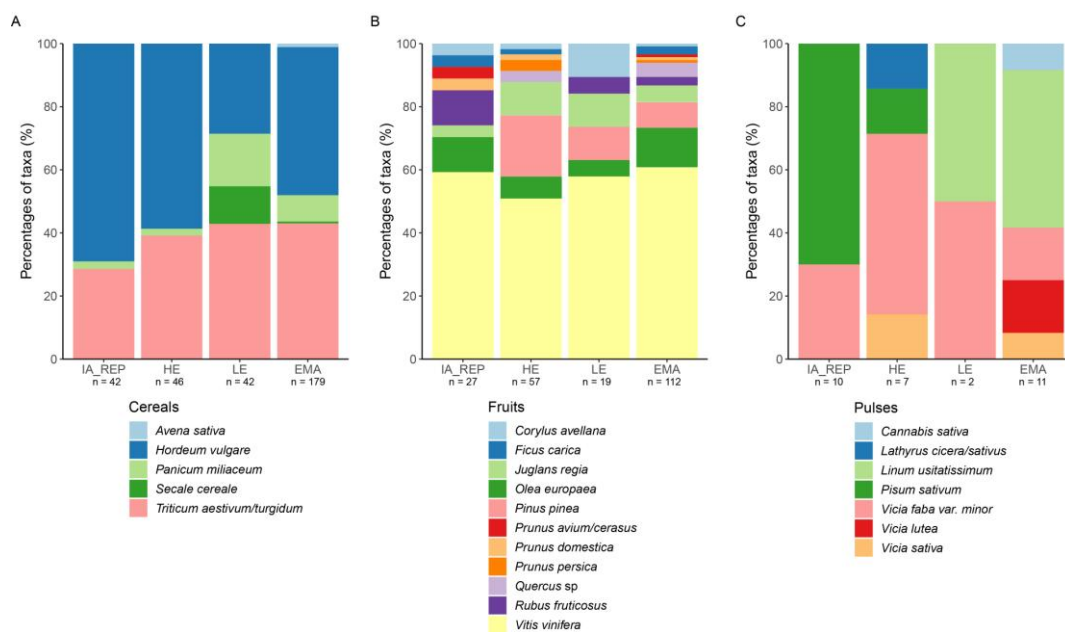


Fig. 2: Frequencies of cultivated/exploited plants within the corpus. (n is the total number of samples in which the plant group appears per period. The percentage per species is calculated on the number of times the species appears in n). Taxa identified in a single context of a single site are not presented in the histogram, such as *Arbutus unedo*, *Crataegus monogyna*, *Cupressus sempervirens*, *Pistacia lentiscus*, *Prunus dulcis*, *Prunus spinosa*, *Pyrus sp.*

Cereals

Throughout the all periods, *Hordeum vulgare* and *Triticum aestivum/turgidum* are the most common and abundant cereal species (Fig. 2). In terms of frequency, hulled barley appears to be the leading cereal, followed by naked wheat. During the Late Empire, naked wheat was slightly more frequent, but fewer samples are available for this phase (26 samples). Nonetheless, naked wheat seems to get relatively more frequent after the 1st c. AD. In regard to the former diversity of these two cereals, a geometric morphometric study confirmed the use of *Hordeum vulgare* subsp. *distichum* in the region during the High Empire (site n°11, Petit Clos), and its presence during the Early Middle Ages is also a possibility (site n°28,

Manresa) (Ros *et al.* 2014). Concerning naked wheat, the identification of rachis segments at Petit Clos (site n°11) and Manresa (site n°28) confirmed that the hexaploid type was cultivated during the peak of the Empire and the Early Middle Ages (Ros *et al.* 2017, 2020a). *Panicum miliaceum* is the third most frequent cereal in Roussillon. It is recorded during the Late Iron Age in the plains, then only in the hinterland during the High Empire. Findings increase again in the lowlands from the Late Empire onwards. *Secale cereale* appears in the samples from the 1st and the 3rd c. AD, but only in the hinterland. Its cultivation in the plains is documented from the 5th c. onwards, but mentions are sparse, whereas its production is well recognised at the same period in the highlands of the Pyrenees (Ruas 2007). Remains of *Avena* comprise mainly grains and very few chaff. Nonetheless, preserved spikelet bases from site n°22 (Les Coudoumines 541) indicate the presence of the cultivated species (*Avena sativa*) during the 6th-7th c. *Setaria italica*, *Triticum dicoccum*, *T. monococcum* and *T. spelta* are absent from the Roman and Early Middle Ages samples.

Pulses

Pulses remains are less frequent, and never found in large quantities (Fig. 2, see Appendix 1), with two notable exceptions: hundreds of seeds of *Pisum sativum* were found in a sample from site n° 2 (2nd c. BC.), while hundreds of mixed *Vicia sativa* and *V. lutea* seeds were found in a sample from site 2 (Pujals, 8th c. AD). Among pulses, *Vicia faba* var. *minor* is the “most frequent”, although attested in only 10 samples. It is the only one present throughout all phases while the others (*Pisum sativum*, *Lathyrus cicera/sativus*, *Vicia sativa*) only appear sporadically.

Oil / textile plants

As plant remains were preserved by charring, oil seeds are generally rare and in a poor state of preservation. The presence of flax (*Linum usitatissimum*) was detected at one site (n°19, Aspra del Paradis) dated from the Late Empire and four sites from the Early Middle Ages (sites n° 2, Pujals, 23, LGV Baguères, 27, Taxo l’orangerie, and 30, Ruscino), but never in great quantities (Fig. 2). Only two seeds of hemp (*Cannabis sativa*) were recovered (site n°2, Pujals). Currently, it is not possible to know whether these flax and hemp seeds were being used for food or for sowing; the question of whether these plants were mainly cultivated for technical purposes (seed oil, fibre) or as food also remains unanswered.

Fruits and aromatic/ornamental tree

Vitis vinifera is by far the most frequent (124 samples) and abundant fruit plant in the corpus throughout all phases (Fig. 2). It is mainly recorded as pips, but in some samples from the High Empire and the Early Middle Ages we noted the presence of abundant flesh fragments, epicarps, pedicels and stalks (Ros *et al.* 2016, 2020a). The olive tree (*Olea europaea*), the umbrella pine (*Pinus pinea*) and the walnut tree (*Juglans regia*) are other frequent taxa, but much less common than grapevine (15 to 22 samples). The olive tree is present throughout all phases, and its occurrence seems to increase from the 6th c. onwards. *Pinus pinea* appears from the High Empire (1st c. AD) onwards, particularly in the Roman villa of Petit Clos (site n°11), its presence in the Late Empire and Early Middle Ages is more occasional and discreet. *Juglans regia* is found as shell fragments in all phases, but never in large quantities. Other fruits appear very irregularly (2 to 7 instances), in variable quantities, some throughout the all phases (*Ficus carica*, *Corylus avellana*, *Quercus* sp., *Rubus fruticosus*, *Prunus avium/cerasus*, *P. domestica*), others (*Prunus dulcis*, *P. persica*) from the High Empire onwards. It is also interesting to note that some of the fruits were recorded in only one sample (*Arbutus unedo*, *Crataegus monogyna*, *Pistacia lentiscus*, *Pyrus* sp.). It is also remarkable that cypress (*Cupressus sempervirens*) is identified for the first time in this part of *Gallia Narbonensis* at the Roman villa of Petit Clos (site n°11), although the tree does not quite fall into the category of fruit trees (aromatic role of the seeds, ornamental tree).

Although 17 different fruit taxa have been identified, this number seems relatively low when compared with other areas of *Gallia Narbonensis* (e.g. Bouby *et al.* 2011; Bouby 2014; Figueiral *et al.* 2010, 2015; Tillier 2023). The absence of waterlogged contexts excavated so far in Roussillon may explain these trends.

Wild plants

Among the recognized wild taxa, 63 were identified to species level, thus providing information concerning soil characteristics (humidity, acidity, content of nutrients) (Fig. 3).

The list of wild taxa recorded during the Early Middle Ages is larger, reflective of the number of samples available for this phase. The species identified are considered to represent arable weeds, ruderals and grassland plants. Before going into the details of the edaphic preferences by phase, we would like to underline the fact that, overall, no major ecological differences from one phase to another was observed.

When considering soil humidity, general trends reveal the abundance of mesoxerophilous to mesohydric taxa (more than 60% of taxa in each phase) (Fig. 3). Although present in the four phases, the frequency of hydrophilous/hydrophilic taxa seems higher during the Iron

Age/Republican period and the Early Middle Ages, suggesting the exploitation of humid or even submerged soils. The frequency of xerophilous taxa seems higher during the High Empire.

Soil pH preferences revealed the abundance of taxa related to alkaline soils (pH over 7.5), and their frequency seems to increase over time (from 50% during the Late Iron Age to 70% during the Early Middle Ages) (Fig. 3). However, plants associated with acidic soils were also recorded, especially for the earliest and latest phases (up to 20%).

The most abundant weeds were the nitrophilous taxa, *i.e.* those linked to nitrogen-rich soils, which increased after the High Empire. However, the presence of taxa associated with nitrogen-poor fields was also recognized (Fig. 3). The frequencies of nitrophilous plants may suggest fertility maintenance practices undertaken at the exploited land plots. The proportion of oligotrophic taxa during the Late Iron Age and its increasing frequency during the Late Empire and Early Middle Ages is harder to interpret, but indicate that different areas and soils were exploited (naturally poor soils, nutrient-depleted agricultural soils?).

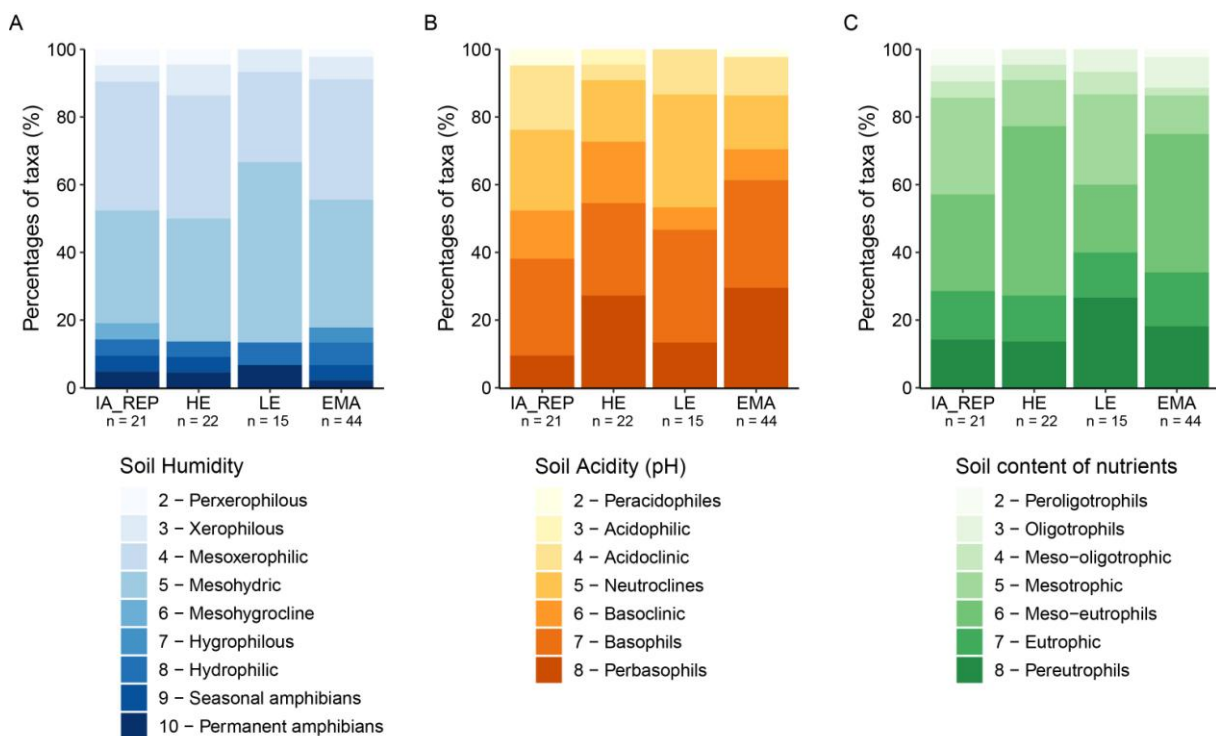


Fig. 3: Frequency of soil preferences encountered in each phase, based on wild taxa identified to species level (n is the total number of identified wild plant species in each phase; the values are based on Appendix 2)

4. Production and farming practices: first overview

Influence of Romanisation on agro-horticultural systems: before and after

Although data from the Iron Age is still scarce (Bénézet *et al.* 2012; Ros 2020), they provide a basis for reconstructing agriculture in Roussillon before the Roman conquest. The local agricultural system was based on cereal diversity, already dominated by naked wheats, hulled barley and grapevine, followed by millets (*Panicum miliaceum*, *Setaria italica*), hulled wheats (*Triticum dicoccum*, *T. monococcum*, *T. spelta*), associated with pulses (*Lathyrus cicera/sativus*, *Lens culinaris*) and native fruit trees (*Olea europaea*, *Ficus carica*, *Quercus* sp., *Corylus avellana*) (Ros 2020). Wild plants provide evidence of the exploitation of a variety of soils, dry and humid/submerged, alkaline and acidic, rich to very poor.

The Roman conquest had a decisive impact on agriculture on the plain, as early as the 2nd c. BC, with the disappearance of hulled wheats and foxtail millet, and the appearance of new fruits (*Prunus avium/cerasus*, *P. domestica*, *Juglans regia*) (Fig. 4). This rapid disappearance of hulled wheats is remarkable, given that they are still present in the farming systems of neighbouring regions during Roman times (Alonso Martinez 2005; Buxó 2005; Bouby 2014; Tillier 2023). An even more remarkable change took place during the 1st c. AD, with the appearance of the *villae*: cereal production in the plain became totally dependent on hulled barley and naked wheat, while grapevine cultivation experienced a major boom. Furthermore, new perennial “exotic” species such as umbrella pine, almond, peach and cypress appeared for the first time (Fig. 4), implying a major change in agrarian landscapes’ physiognomy. This period also corresponds to a slight increase in the frequency of basophilic and eutrophic/meso-eutrophic weeds in the samples, possibly as a sign of the cultivation of lands that were highly suitable for the agricultural productions favored by the Roman economic system, such as naked wheat. Vegetables and pulses are identified only sporadically for this period, although horse beans (*Vicia faba* var. *minor*) are regularly noted, while *Beta vulgaris* (potentially cultivated?) and garlic (*Allium* sp.) are recorded for the first time. In the hinterlands, the situation seems more nuanced. The agricultural production remained diversified, with the presence of common millet and the very first recorded occurrence of rye. However, this discovery, a single caryopsis, does not confirm that rye was cultivated in the region from the 1st c. AD onwards, and its status is still debated. In the Iberian Peninsula, recent data show the earliest macroremains of rye between the 3rd c. and the first half of the 1st c. BC, in assemblages dominated by spelt and other cereals, rye likely acting as a weed (Seabra *et al.* 2023). In southeastern France, Rye is present in Bronze Age and Iron Age sites, certainly as a crop weed (Bouby 2014). Its occurrence increases during the Roman period, both in terms of abundance and frequency (Tillier 2023), and the question of whether it was tolerated, favored or even cultivated, arises as early as the High Empire. As far as fruit trees

are concerned, there are no exotic taxa introduced by the Romans in the hinterland during this period.

During the Lower Empire (4th-5th c.), new changes take place, in the hinterland first, with the rise of rye cultivation, then in the plains with the reappearance of common millet and the very first signs of flax and rye cultivation (Fig. 4). Millet cultivation is indicated at settlements located on the slopes, on the plain as well as along the coast line, which suggests that this reappearance occurs at a large scale over the entire study area. The reason of these new cereal cultivation practices has been the subject of some debate. One hypothesis is that a colder and damper Post-classical climate² made it difficult to grow the cereals favored during the High Empire (naked wheat, hulled barley), leading to the rise of more rustic species, such as rye (Squatriti 2019). However, our results show that the rise of rye and millet was not at the expense of wheat and barley, which remain the most frequent and abundant cereals both in the plain and hinterland settlements. Our belief is that by the end of the 3rd c. AD, the hinterlands redirected part of their production towards a subsistence economy, favoring crops that were less demanding in terms of human labor, more rustic, and ensured greater food security (millet's role as a spring cereal), partially disassociating themselves from the Roman economic model that dominated the plain. At this stage, it is difficult to determine whether this shift was caused by local anthropogenic or environmental parameters.

During the Early Middle Ages, the agricultural production strategies are similar to that of the High and Low Empire, both for cereals and fruit trees: hulled barley, naked wheat and grapevine are still the main productions, millet and the new fruits introduced during the High Empire are still exploited, and the cultivation of rye and flax spread throughout the plain. Among cereal crops, we note the absence of hulled wheats and foxtail millet, present in neighboring regions throughout Antiquity and into the early Middle Ages (Buxó 2005; Ruas 2005; Alonso 2008). Given the large number of sites and samples studied in Roussillon for the Early Middle Ages, this absence can be considered a genuine choice on the part of local farmers, rather than a sampling bias. In addition, new produce includes cultivated oat and hemp, but their actual expansion is difficult to track due to taphonomy (identification problem for *Avena*, conservation problem for *Cannabis sativa*). Wild plants remains indicate the use of a variety of soils, dry and humid/submerged, mainly alkaline but also acidic, rich to very poor. It is difficult to assess whether certain soils played a particular role in the cultivation of particular taxa, e.g. the richest and most humid soils for millet and flax, while the poorest and

² Late Antique Little Ice Age.

most acidic soils could have been exploited for rye, or possibly oats and barley. However, it is clear that the early medieval period, just like the late Iron Age, favored a polycultural system based on a wide variety of cereal and fruit crops, and that they made the most of a variety of soils.



Fig. 4: Presence/absence of the main cultivated/exploited taxa from 400 BC to 1000 AD

The rise of Roman wine and olive oil production and its evolution in the Early Middle Ages

In Roussillon, evidence of the consumption of grapes for their fruit is regular from the Neolithic onwards (Ros *et al.* 2018), but it is only between the 1st c. BC and the 1st c. AD that evidence of more extensive exploitation of grapevine is observed alongside indicative of its cultivation for winemaking. For this period, *Vitis vinifera* is the third most frequent and abundant species in carpological samples, after barley and naked wheat; remains recovered,

such as flesh fragments, epicarps, pedicels and stalks, are interpreted as corresponding to winemaking by-products (Ros *et al.* 2016). Other material remains also register the rapid development of structures linked to probable winemaking (wine presses, basins, dolia, cellars) between 20 BC and 20 AD (Kotarba *et al.* 2007). However, the very occasional presence of these wine by-products in the High Empire carpological samples raises the question of their possible reuse. Since fire is necessary for their conservation in an aerobic archaeological context, the question arises whether their rarity should be interpreted as being linked to their use in agricultural activities (fertiliser, fodder, litter) that did not favour contact with fire? The Low Empire, less well documented by field archaeology, shows no sign of the weakening of the exploitation of the grapevine, and *Vitis* remained the most frequent and abundant fruit species in the carpological samples between the 3rd and 5th c. AD. During the Early Middle Ages (6th-8th c.), in addition to the frequent remains of consumption, certain concentrations of berries, pedicels, pips and epicarps are interpreted as wine by-products. As no built structures, such as crushing basins or presses, have been found, we can envisage the existence of wooden structures such as vats and barrels, that were not preserved archaeologically (Kotarba *et al.* 2007). The most significant remains of wine-making (site n°18, Taxo-les-gavarettes, 28, Manresa) were found in agrarian areas, located on the settlements' outskirts. The presence of these types of remains suggests a local wine production, though the extent and destination of this produce cannot be identified. (*i.e.* domestic, regional or extra-regional).

The exploitation of the olive tree also has strong evidence in the archaeobotanical record: fruit consumption, use of the wood as fuel in domestic, funerary, symbolic and ritual contexts (Beauchamp *et al.* 2017). However, oil production is more difficult to demonstrate. It is well known that the *Gallia Narbonensis* region benefited from dynamic commercial networks with Betica (Spain) and the importation of oil from this region was particularly developed. E. Garrote pointed out the existence of numerous wrecks off the Roussillon coast, in particular the one known as "Port-Vendres II", sank in 41 or 42 AD, whose cargo was made up of four types of amphorae, essentially destined for the transport of olive oil; all had the same Betic origin (Garrote 1996). Chemical analyses carried out on vat levels at Mas Delfau (1st AD, site n°9) suggest local production, but its scale is difficult to determine (domestic consumption?) (Beauchamp *et al.* 2017). The concentration of olive stones and fragments from Pujals (6th-8th c., site n°2) are considered as pressing residues, but does not allow debate relating to the scale of production. We can but envisage a local domestic production, in parallel with the consumption of the fruit. It should, however, be noted that the frequency of olive plant

remains in early medieval Roussillon is remarkably high when compared to other regions of Mediterranean France and Catalonia (Ruas 2005; Peña-Chocarro *et al.* 2019).

Feeding the livestock: the role of agricultural products and by-products

A final point to raise is the discovery of samples whose composition appear to be related to fodder. At Mas Delfau (1st AD, site n°9), one of the analysed samples contained thousands of meadow plants / small Fabaceae (*Medicago lupulina*) seeds, and, to a lesser extent, cereal grains (*Hordeum vulgare*, *Triticum aestivum/turgidum*), grape pips and crop weed seeds (such as *Lolium temulentum*, *Schoenoplectus lacustris*). Here, the preservation of *Medicago* pods and seeds was excellent; combined with the presence of grass and cereal caryopses and the absence of carbonised organic matter that might represent burnt manure or dung residues, the hypothesis of fodder inputs was put forward (Ros 2020). Additional agropastoral residues were discovered in sites from the Low Empire and even more so for the Early Middle Ages: cereal by-products (husking, threshing), sometimes in exceptionally large quantities, cereal grains, small grasses and Fabaceae seeds (*Medicago* spp., *Trifolium* spp., *Vicia lutea*³), seeds and stem fragments of wetland taxa as well as by-products of wine making (Ros *et al.* 2019, 2020a). The discovery of goat excrement in several samples implies that these mixed plant remains were the remains of fodder, as sheep and goats played a central role in the plain pastoral agrosystem at that time (Ros *et al.* 2020a). At Manresa (7th c., site n°28), the discovery of both mineralised plant remains (favoured by the presence of excrement) sometimes in significant concentrations, and of a mud-built enclosure, supports the hypothesis of assemblages related to livestock raising (Ros *et al.* 2020a). In that respect, beyond the simple recourse to cereal products and by-products to feed/manage livestock, the populations of early medieval Roussillon also remobilised by-products from different production chains (such as wine), suggesting that these residues were available and could be reused *in situ* as soon as they were produced. The importance of wetland plants also suggests the exploitation of lands on the edge of fresh water ponds or rivers.

Conclusion

Although this study is based on a chronologically irregular corpus, agricultural variations are already clearly noticeable in the long-term trends. The archaeobotanical corpus demonstrates

³ The status of *Vicia lutea* is hard to assess; its seeds have been found in great quantities mixed with *Vicia sativa* seeds. It might have been cultivated for fodder or be present in the sample as a (tolerated/favored?) weed of *Vicia sativa*.

similarities between the Late Iron Age and the Early Middle Ages characterized by a greater agricultural diversity. This stands in contrast with the Roman period, which saw the emergence of a form of agrarian specialization, at least for cereals. The agriculture practices of the Iron Age and the Early Middle Ages seem to be based on the search for food security, possibly linked to a degree of autonomy of farmers and the preponderance of small and medium-sized farms. In fact, basing the agrarian system on a large diversity of species, particularly cereals, reduces risks in the event of poor harvests, with spring-sown crops (*e.g.* millets, potentially oats and barley) serving as a backup resource. Conversely, Roman agriculture, which was part of a larger network and subject to a more global economy, favored hulled barley, naked wheat and grapevine, to the detriment of the diversity or security of crops and agricultural practices. This phenomenon, which is particularly marked on the Roussillon plain, is not an isolated case, is observed over a large part of the western Mediterranean plains (Wickham 2006). It can be explained by the greater self-reliance of Iron Age and early Middle Ages farmers when compared to the Roman peasant world, more subservient to the overarching socio-economic will of the State and the elites.

This initial summary constitutes a milestone, and the questions raised by our results will need to be re-examined following future the carpological research and comparing them thoroughly with zooarchaeological and anthracological data. Beyond these “classical” approaches, our work opens new perspectives. The abundance of olive stones and grape pips will allow us to further explore the diversity and evolution of these two plant species using geometric morphometrics (Bonhomme *et al.* 2021; Terral *et al.* 2021), making it possible to highlight the possible introduction of new varieties following the Roman conquest, and document the evolution of fruit diversity as the Roman economic model weakened.

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Appendix 2. Soil preferences for each wild taxa identified to species level, based on Julve (Julve, 1998) and Try (collaborative database); further information derives from Jauzein (1995) and Pignatti (2005)

Species	Humidity	Soil	Nutrients	Meaning of the values-Humidity
<i>Agrostemma githago</i>	4	8	6	1 : hyperxérophiles (sclérophiles, ligneuses microphylls, révisivescentes)
<i>Amaranthus blitum</i>	4	7	8	2 : perxérophiles (caulocrassulescentes subaphylles, coussinets)
<i>Anagallis arvensis</i>	5	6	7	3 : xérophiles (velues, aiguillonnées, cuticule épaisse)
<i>Anthemis arvensis</i>	5	4	6	4 : mésoxérophiles
<i>Anthemis cotula</i>	4	4	5	5 : mésohydriques (jamais inondé, feuilles malacophylles)
<i>Arrhenatherum elatius</i> subsp. <i>bulbosum</i>	4	4	4	6 : mésohygroclines, mésohygrophiles
<i>Asperula arvensis</i>	4	8	6	7 : hygrophiles (durée d'inondation en quelques semaines)
<i>Asperula cynanchica</i>	3	8	3	8 : hydrophiles (durée d'inondation en plusieurs mois)
<i>Avena fatua</i>	5	7	7	9 : amphibies saisonnières (hélrophytes exondés une partie minoritaire de l'année)
<i>Avena sativa</i> subsp. <i>sterilis</i>	4	8	6	10 : amphibies permanentes (hélrophytes semi-émergés à base toujours noyée)
<i>Beta vulgaris</i>	4	8	8	11 : aquatiques superficielles (0-50 cm) ou flottantes
<i>Buglossoides arvensis</i>	4	7	6	12 : aquatiques profondes (1-3 m) ou intra-aquatiques
<i>Bunias erucago</i>	4	8	7	
<i>Bupleurum tenuissimum</i>	4	8	3	Meaning of the values-Soil
<i>Chenopodium album</i>	5	5	7	1 : hyperacidophiles (3,0<pH<4,0)
<i>Cistus monspeliensis</i>	4	3	4	2 : peracidophiles (4,0<pH<4,5)
<i>Coincya cheiranthos</i>	4	5	5	3 : acidophiles (4,5<pH<5,0)
<i>Ecballium elaterium</i>	5	8	7	4 : acidoclines (5,0<pH<5,5)
<i>Echinochloa crus-galli</i>	6	8	8	5 : neutroclines (5,5<pH<6,5)
<i>Eleocharis palustris</i>	8	5	5	6 : basoclines (6,5<pH<7,0)
<i>Fallopia convolvulus</i>	5	6	6	7 : basophiles (7,0<pH<7,5)
<i>Galium aparine</i>	5	5	8	8 : perbasophiles (7,5<pH<8,0)
<i>Galium tricorutum</i>	4	8	6	9 : hyperbasophiles (8,0<pH<9,0)
<i>Heliotropium europaeum</i>	4	8	6	
<i>Humulus lupulus</i>	7	7	7	Meaning of the values-Nutrients
<i>Hyoscyamus niger</i>	5	7	8	1 : hyperoligotrophiles (≈100 µg N/l)
<i>Lithospermum arvense</i>	4	7	6	2 : peroligotrophiles (≈200 µg N/l)
<i>Lolium temulentum</i>	5	7	6	3 : oligotrophiles (≈300 µg N/l)
<i>Lysimachia arvensis</i>	5	6	7	4 : méso-oligotrophiles (≈400 µg N/l)
<i>Malva parviflora</i>	5	7	7	5 : mésotrophiles (≈500 µg N/l)
<i>Malva sylvestris</i>	4	7	8	6 : méso-eutrophiles (≈750 µg N/l)
<i>Medicago lupulina</i>	4	8	3	7 : eutrophiles (≈1000 µg N/l)
<i>Medicago minima</i>	3	8	2	8 : pereutrophiles (≈1250 µg N/l)
<i>Medicago polymorpha</i>	3	7	5	9 : hypereutrophiles (≈1500 µg N/l)
<i>Persicaria lapathifolia</i>	8	7	8	
<i>Plantago lanceolata</i>	5	5	6	
<i>Polygonum aviculare</i>	5	5	8	
<i>Polygonum persicaria</i>	8	7	8	
<i>Portulaca oleracea</i>	2	7	7	
<i>Prunella vulgaris</i>	5	6	6	
<i>Raphanus raphanistrum</i>	5	4	6	
<i>Rapistrum rugosum</i>	4	8	6	
<i>Reseda lutea</i>	4	7	6	
<i>Rumex acetosella</i>	4	2	2	
<i>Schoenoplectus lacustris</i>	10	6	5	
<i>Schoenoplectus tabernaemontani</i>	9	7	6	
<i>Sherardia arvensis</i>	4	7	6	
<i>Silene gallica</i>	4	4	6	
<i>Silene vulgaris</i>	4	7	5	
<i>Solanum nigrum</i>	5	7	8	
<i>Sparganium erectum</i>	9	7	7	
<i>Stellaria media</i>	5	6	8	
<i>Teucrium scorodonia</i>	5	4	4	
<i>Thalictrum flavum</i>	7	8	6	
<i>Thalictrum minus</i>	4	8	3	
<i>Trifolium arvense</i>	3	2	3	
<i>Trifolium pratense</i>	5	5	6	
<i>Trifolium repens</i>	5	5	6	
<i>Urtica urens</i>	5	6	8	
<i>Valerianella ramosa</i>	4	7	6	
<i>Vicia angustifolia</i>	5	5	6	
<i>Vicia lutea</i>	4	7	6	
<i>Vicia tetrasperma</i>	5	4	5	