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ORIGINAL ARTICLE

Seeds of knowledge: paving the way to integrated historical and conservation science research

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Abstract

Recognition of the importance of protecting agrobiodiversity is not a new phenomenon. Crossing different sciences is often pinpointed as a relevant contributor to its successful protection. This paper proposes an integrated research approach in history and conservation science by opening new paths for using written historical sources in biodiversity inventories. It discusses some conceptual and methodological challenges raised by historical research regarding the diversity and distribution of wild and cultivated edible plants. The possibilities of using historical sources for compiling plant lists that can be integrated into biodiversity databases are also explored. Arguing that interdisciplinarity and transdisciplinarity are crucial, enabling a wide range of vernacular sources from several centuries to be cross-referenced, the paper aims to draw attention to written historical sources and their importance in deepening knowledge about past biodiversity patterns.

Keywords Agrobiodiversity · Historical research · Biodiversity databases · Transdisciplinarity

Introduction

This paper discusses the role of knowledge about the past in the conservation sciences concerning wild and cultivated edible plant species. It intends to pave the way for integrated research in history and conservation science, drawing attention to written historical sources and their importance in identifying past patterns of biodiversity. Underlining the importance of crossing knowledge about plants produced by past testimonies with different viewpoints and interests, we propose an approach to include historical information in conservation research projects.

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Although this paper proposes a methodology that can be applied on a large scale to a panoply of historical sources, the examples discussed below stem from the research developed under the ReSEED project.[1] This project brings fresh data to examine agrarian and food changes in Europe related to the transcontinental movements of seeds and their local environmental and social impacts. One of the specific goals of the project is to examine the 'new seeds', which arrived in Europe from the *Mundus Novus* since the fifteenth century, and understand their impacts on the cultivation of 'old seeds' through the Iberian Peninsula (IP). This approach allows to better understand how the so-called Columbian exchange transformed landscapes from early modern times. The IP is a particularly interesting case study because it was a gateway for products and crops from the 'new worlds' to Europe. From the fifteenth century onwards, the overseas travels led by Portuguese and Spaniards accelerated the circulation and dissemination of seeds previously unknown by Europeans. However, groundwork is still needed to evaluate these changes

[1] ReSEED—Rescuing seed's heritage: engaging in a new framework of agriculture and innovation since the eighteenth century: https://reseed.uc.pt/

accurately. An inventory of what has been cultivated over time is necessary. In other words, the European past agrobiodiversity dynamics must be assessed.[2]

The paper starts with a brief discussion about the importance of history to access past patterns of biodiversity, focusing on material historical sources. Considering how written historical documents have traditionally been undervalued in this context, the paper then proposes a methodology to use them to monitor agrobiodiversity trends. Finally, taking the ReSEED project as a starting point, different typologies of written historical sources are analysed to trace the diversity of wild and cultivated plants in the IP.

While highlighting how these sources can help us understand the diversity of wild and cultivated edible plants over the centuries, the paper argues that interdisciplinarity and transdisciplinarity are crucial, allowing us to cross-apply a wide range of vernacular sources from different time periods. This is an exploratory paper. Rather than showing precise and specific results, it intends to present a research approach. It discusses some conceptual and methodological challenges raised by historical research regarding the diversity and distribution of edible wild and cultivated plants and the possibilities of using historical written sources for compiling plant lists that can be integrated into biodiversity databases.

The past of biodiversity

In recent decades, the use of concepts such as biodiversity and sustainable development has increased. The recognition of the importance of protecting biological diversity is not new (Chape et al. 2003) and has been growing as its fundamental role in sustaining life on Earth and the role of humans in its destruction is acknowledged (Sala et al. 2000; Hilton-Taylor 2000). In 1995, it was estimated that extinction rates for the next 100 years would be 1000 times higher than those revealed in fossil records (May et al. 1995).

The 1993 Convention on Biological Diversity,[3] signed by nearly 200 countries, is the most relevant international legal instrument for the conservation and sustainable use of biological diversity. This convention represents a broad global commitment to study ecosystem services and biodiversity conditions and trends, promoting their sustainable use. History can play a vital role in this mission since assessing trends implies accumulating knowledge about biodiversity over a long time span; this means acknowledging the history of how species have changed over time.

It has already been recognised that natural-history collections in museums[4] can provide relevant information for biodiversity conservation by describing the distribution of species across space and time (Ponder et al. 2001; Graham et al. 2004; Paknia et al. 2015; Figueira and Lages 2019; James et al. 2018; O'Connell et al. 2004; Nelson and Ellis 2019; Suarez and Tsutsui 2004; Alberch 1993). As repositories of extensive sets of specimens of current or extinct species and knowledge about the diversity of the natural world, these collections also play an important role in assessing trends in biodiversity. They are 'sentinel observatories of life on earth', allowing the monitoring of changes in ecosystems (Krishtalka and Humphrey 2000, 617). Through the study of collections, it is possible to understand what was destroyed in a particular place. They are 'reference tools, just as necessary as the books in a library, which are not in continuous use yet must be available when needed' (Mayr and Ashlock 1991, 326). Natural-history collections are thus crucial material historical sources for assessing the biodiversity of the past.

The diversity of agricultural plants is also a source of concern. The social and economic consequences and risks of decreasing plant genetic resources have become relevant issues in addressing current food security challenges. Agrobiodiversity is essential to eradicate hunger and ensure sustainable consumption and production patterns (Hammer et al. 2003; Thrupp 2000; Jackson et al. 2007; Bocci 1970; Wood and Lenné 1997; Biasi et al. 2015). So, it is not only important to acknowledge the state of ecosystem services related to 'wild biodiversity', i.e., undomesticated and uncultivated, but also to recognise biodiversity related to agriculture, specifically, the diversity of cultivated plants. For instance, attempts have been made for the Red Listing of Agricultural Crop Species, Varieties, and Landraces (Joshi et al. 2004). Moreover, analysing agrobiodiversity historically is fundamental since agriculture issues have had a major influence on spatial planning and biodiversity.

A large scope of knowledge on the most important world crops (like vine, wheat, or maize) has already been collected. Yet historical knowledge of these crops, particularly of their diversity and geographical distribution, is scant. For certain species, such as tomatoes, grain legumes, and cabbages, historical data is also scarce, even though they are extensively used. They belonged mainly to the private sphere, i.e., were cultivated in kitchen gardens for family consumption and were therefore not usually included

[2] Agrobiodiversity, in its broadest sense, 'includes the full diversity of organisms living in agricultural landscapes, including biota for which function, in the human utilitarian point of view, is still unknown'. In some studies, agrobiodiversity is defined in a stricter sense, as the 'planned agrobiodiversity", i.e., "the biodiversity of the crops (…) chosen by the farmer' (Jackson, Pascual, and Hodgkin 2007, 197). This latter concept is expanded in this paper to encompass what was being eaten: edible plants, cultivated or wild, which could, at a certain moment, become cultivated.

[3] https://www.cbd.int/ (accessed on 30 July 2021).

[4] Including historical herbaria collections.

in official records. Historical knowledge about these species remains poor, probably due to their low economic and political value.

The available material historical sources, like the previously mentioned, are not so useful regarding agrobiodiversity. Museums and herbarium collections are frequently limited in their scope (Ward 2012). Wild and undomesticated flora is often depicted, but crops, landraces, and, particularly, species cultivated in kitchen gardens are often neglected by naturalists during their field trips.[5] This may be due to the fact that most species grown in kitchen gardens are common and widespread. They are used and consumed daily and are therefore not considered relevant enough to be collected and integrated into natural-history collections.[6]

Nevertheless, other kinds of historical sources can help overcome these constraints (Stöckli et al. 2011; Zettler and Daunys 2007; Geri et al. 2016). It is possible to find some data related to cultivated plants in different written sources of varied origins. They may be of extreme importance, especially when studying plants with little or no evidence of introduction or presence in archaeological records,[7] and in which, therefore, written documents are fundamental. Written sources contain information on cultivated plants, but the basic work, as the inventory of this agrobiodiversity data, has yet to be done. How can written sources be used for surveying past biodiversity in order to monitor trends and changes? This paper will now review their usefulness and limitations in addressing agrobiodiversity trends from a *longue durée* perspective.

The written sources

One of the current challenges in the conservation sciences is to provide a historical perspective, preferably in the *longue durée*, and to include the variety of crops that were important in the daily lives of common people. On the one hand, historical data on agrobiodiversity seems to be scarce. From the mid-nineteenth century onwards, documentary and material sources are abundant. Since the twentieth century, oral sources are also relevant. But how can we go back to the sixteenth century? On the other hand, how can researchers go beyond 'scientific' or erudite sources like floras or herbaria to study everyday life and agricultural and food practices? For the period before the nineteenth century, information from nonexperts is essential. But how can data from different sources be compared?

Source selection

What written sources can be used to grasp the historical agrobiodiversity dynamics? As mentioned, the ReSEED project aims to acknowledge what has been cultivated and eaten in the IP from the fifteenth century onwards. The historical sources already known show that several plants were used in different ways. Some were consumed as food, others as medicine. Some were cultivated, and others grew spontaneously and were gathered in the wild. Different social activities were thus carried out with diverse kinds of plants and their fruits or seeds. In this context, written documents help to understand how these plants were embedded in past societies. A detailed analysis of available historical sources has shown that various typologies of books focused on plants are very useful for understanding the dynamics of agrobiodiversity. These books, published between the fifteenth and eighteenth centuries, not only describe plants but also shed light on how they were connected to socially relevant activities and knowledge. Source selection methodology sought to encompass the socioeconomic and cultural heterogeneity within the IP, consequently covering a wide range of agroecological variability.

Seeking to capture these varied social uses of plants and to have a broader view of the biological diversity of edible plants, the approach presented in this paper was built on six carefully selected books divided into three categories: agricultural treatises (Herrera 1818a, b, 1819; Garrido 1749), food regime books (Aviñón 1885; Henriques 1721), and culinary books (Martínez Montiño 1790; Rodrigues 1683) . These are consolidated book typologies, each one with roots in classical antiquity, updated over time and explored by different historiographical perspectives (Bray and Métailié 2001; Freire 2020; Gentilcore 2015; Rodrigues 2016; Willan and Cherniavsky 2012). Particularly since the fifteenth century onwards, the authors of these types of books reveal influences from local or regional practices and the knowledge closest to them. In each category, one Spanish and one Portuguese book were analysed to look at the Iberian Peninsula's regional agrobiodiversity. The selected books were written between the fifteenth and eighteenth centuries, exploring wild and cultivated edible plants. Even though they were written for different purposes and different audiences, together, they express changes in perceptions about nature and access to plants in everyday life.

While diverse in length and degree of detail, the agriculture books analysed describe the best practices to optimise

[5] On the study of agrobiodiversity using herbarium specimens, see Mazzola, Raimondo, and Schicchi (2003)

[6] More recently, since the Second World War, germplasm banks have been built to safeguard crop seeds (Peres 2016).

[7] On the one hand, plants such as legumes, due to the dispersion of their pollens, are underrepresented. On the other, because archaeological studies focus on periods well before the eighteenth century, or rather, the analyses cover a period of hundreds or thousands of years, this does not allow an annual assessment for periods so close to ours (Peña-Chocarro et al. 2019).

agricultural and livestock production. Aiming to advise farmers, these treatises expressed common regional views by describing crops, discussing the best times of the year for cultivation, the most appropriate soils or suitable agrarian techniques, as well as the most effective ways to combat some pests. Subjects on veterinary medicine, pastures, beekeeping, hunting, or the relationship between food and health are also often discussed in these treatises. Since Alonso Herrera's pioneer book, first published in 1513 (Herrera 1818a, b, 1819), does not mention the cultivated species brought from the 'new worlds', the analysis of works published in later periods, by comparison, will help us to understand how these were being disseminated across the territory. Nonetheless, the book is rich in the description of varieties, namely crops that had already become well integrated into Spanish agriculture, probably for centuries. In the first half of the eighteenth century, Garrido (1749) demonstrates how crops brought from the Americas were part of regional Portuguese agrarian routines but is less detailed in the descriptions of species and varieties. These books thus provide complementary insights into agricultural practices and knowledge in the IP.

Although they mainly express the elite's preferences, cookbooks have been considered an important historical source (Freire 2020) as they record the common consumption of specific foods and the arrival of others. They introduce us to kitchen practices (what was eaten, cooked, and sometimes even cultivated), as well as to the circulation of certain foods. The first editions of the culinary books analysed in this research date back to the seventeenth century: the Spanish (by Francisco Martínez Montiño) was published in 1611, and the Portuguese (by Domingos Rodrigues) in 1680. Data from culinary books usually have no ecogeographic or temporal references. Information on plant species and their varieties are sometimes brief, as they are simply necessary ingredients. They seem to have such common usage that they need no further explanation. These sources may also be interesting in identifying the dissemination of some exotic products and crops. Relevant evidence can be captured, such as Francisco Martínez Montiño's preference for pumpkins (from Central America) and the importance given by Domingos Rodrigues to oranges from China, the sweet species that the Portuguese were bringing from Asia.

Similarly, the selected food regime books do not focus on the description of recipes to cure diseases but rather on the medical attributes of certain daily consumption foods. In a long tradition dating back to antiquity, even in the eighteenth century, there was still no separation between food and medicine, plants being the cornerstone for both. This means that pharmacopoeias or diet regime books worked as treatises on food (Gentilcore 2015). These books are therefore an important source to understand the food consumption patterns of the elites and what was being cultivated. For example, in the fifteenth century, *Sevillana Medica* was written with the purpose of presenting the healthy foods of the city of Seville (Spain), informing everyone about 'all the things that exist in it to sustain human life, the quality and physical characteristics these had and how they were used and how they should be kept for the health of its inhabitants'[8] (Aviñón 1885, 6). Three centuries later, the distinguished Portuguese doctor Francisco da Fonseca Henriques, who assisted King D. João V, continued to stress the links between health and food and already included many of the new crops that were arriving from other continents (Henriques 1721).

These books were selected for four main reasons. Firstly, they were the first books published in each of these categories in Portugal and Spain, becoming influential and being reprinted over the following centuries. Secondly, being based in the kingdoms that pioneered the exploration of the 'new worlds', these sources show how the authors and the communities they belonged to were abandoning the authority of the Latin classics and/or integrating the novelties brought from overseas territories since the fifteenth century. Thirdly, historiography has been identifying, characterising, and exploring the typologies of books analysed, allowing them to be included in the concerns and debates that crossed Europe in those centuries. Finally, precisely for those reasons, the methodology and analysis developed in this paper can be replicated, exploring the data provided by books on these typologies from other European regions.

While other historical sources are useful for accessing the biodiversity of the past, such as the aforementioned herbaria, to understand the various dimensions of this issue, it is necessary to cross-reference sources from multiple origins. Data from written sources help to gather detailed information about plants grown and consumed in a specific place and time. These are indeed precious indications. Furthermore, the possibility of deepening access to the background allows us to recognise the knowledge of specific communities or social groups and their changing relations or visions about nature. This is crucial to explain the spatiotemporal dynamics of agrobiodiversity, building plausible interpretations of the past that can be more useful to current conservation strategies.

We contend that exploring these different typologies of written sources requires an inter and transdisciplinary approach. This means that it is not only important to call on several disciplines (e.g., bringing together historians and biologists) to the analysis of complex problems such as agrobiodiversity and its past, but also that we should look

[8] '(…) todas las cosas que ay en ella para sustentar la vida humana, qué calidad y complexión tengan y el modo de usar dellas, y cómo se deuen conservar en salud los habitantes en ella (…)'.

at diverse historical sources, from various disciplines, from many areas of knowledge, including nonacademic or non-expert sectors, to have a broad understanding of past plant species.[9] Pluralising the sources of information enriches the views on wild and cultivated edible plants. Different forms of knowledge and plant use allow a more inclusive landscape reconstruction.

Having explored these selected historical books, the following sections will provide a more detailed overview of the information on the designation and geographic distribution of different wild and cultivated edible plant species from the past.

Historical data

Written historical sources contain data on plant species, cultivated seeds, crops, or edible plants. Specifically, historical written sources have data on:

1) species diversity;
2) genetic diversity (varieties);
3) spatiotemporal patterns.

Species diversity

Recognition of edible, wild, and cultivated plants over time is challenging. A key problem is identification and nomenclature, as plants are identified differently in diverse sources. Some designate species according to their scientific names, while others use only vernacular names. To be able to use historical data in global biodiversity databases, we should be careful when using vernacular names (Kull et al. 2015; Turreira-García et al. 2020; Tengö et al. 2017; Bouchet and Strong 2010). Scientific names are the only reliable way to compare different sources and use them to understand changes and trends across time and space.

Similar problems arise in anthropological and sociological studies that use local ecological knowledge. It is necessary to use 'a common taxonomic language (…) to merge biodiversity monitoring data from multiple sources' (Turreira-García et al. 2020). Scientific names are the 'common taxonomic language'. Written sources offering data about everyday life, like the ones described in this paper, can be seen as the local informants for anthropology or sociology. Information regarding plant identifications by local informants may not be easily incorporated into scientific assessments of biodiversity due to difficulties in establishing links between Folk and Linnaean taxonomies (Turreira-García et al. 2020). The same can be said for vernacular names in historical sources. Nevertheless, these data remain valuable. In fact, in germplasm banks created to conserve the genetic variety of local populations of a given species, vernacular names are also taken into consideration and registered.[10]

Several challenges arise when trying to associate vernacular and scientific names. The identification of a species is indeed complex due to constant cases of polysemy, synonymy, and local names. Historical sources frequently include vernacular names taken from various regions without a scientific name. This means that one term may refer to many different species or even varieties within the same species. Establishing two-way correspondence can become a complex task. Most of the time, this diagnosis results from the interpretation of uses, virtues, shapes, growth cycles, ecological requirements, and places where the plant was present. This information is not always described in the sources. Therefore, it is essential to cross-reference information from sources produced for different purposes. Interdisciplinarity is fundamental.

The challenges that vernacular names pose to researchers have already been identified in several studies (Zhao et al. 2016; Wilkie and Saridan 1999; Turreira-García et al. 2020; Berlin 1973). While scientific names are univocal, vernacular names can be ambiguous. This means that the same name can refer to different species or that one species can have a panoply of vernacular names. Still, as Zhao et al. (2016, 2) states, 'some vernacular names do show a one-to-one correspondence with scientific taxa'. In some cases, a single folk taxon corresponds to a single scientific species; in other cases, more than one folk taxon refers to a single scientific species; and sometimes, a single folk taxon refers to more than one scientific species (Berlin 1973). However, as Wilkie and Saridan (1999, 1466) noted, 'vernacular names are often the only means of communicating with local people and can provide some direction in trying to identify a species when no other information is available'. Like with local people, in historical research, vernacular names are sometimes the only way to communicate with the past. As Delêtre et al. (2012, 27) mentions, 'comprehensive lists of accepted, synonymous, and vernacular names are very valuable and needed to retrieve comprehensive datasets on species occurrence'. This is also a goal of the ReSEED project: compiling a list of synonym and vernacular names for cultivated and edible plants in the IP. This thesaurus intends to overcome the limitation of *longue durée* historical approaches that, by using a wide and diversified range of sources, have to deal with 'nomenclatural challenges', i.e., the same 'objects' are frequently nominated in different ways.

[9] For a discussion on multi, inter and transdisciplinarity see, for example, McGregor (2014).

[10] See, for instance, the international platform GRIN-Global, a tool for organising, managing and providing information on Genetic Resources: https://www.grin-global.org/ (accessed on 30 July 2021).

Despite these difficulties, cross-referencing different sources can allow a rigorous approach between vernacular and scientific names. For example, agricultural treatises can help to validate cookbooks or other sources that do not use Linnaean taxonomy. Complementarities across different sources may help to find correspondences between vernacular and scientific names. Associating vernacular and scientific names is a complex and longstanding task, but it is crucial.

In summary, to compare different sources and/or use them in international biodiversity conservation initiatives, it is necessary to start by standardising the information. This means associating each of the plants mentioned with a scientific name. Nevertheless, in some cases, it is not possible to know rigorously which species is mentioned in the sources. For instance, thistles (*cardos*), sweet herb (*herva doce*), mustard (*mostarda*), or pumpkin (*abóbora*), among others, may refer to several different species.

Some species raise another kind of challenge, such as turnips. All the sources analysed for this paper mention turnips. However, Herrera linked turnips with two Latin names, *napi* and *rapa*. Is Herrera referring to two different species or two diverse varieties? Considering there are currently two species, *Brassica napus* and *Brassica rapa*, one could presume Herrera is distinguishing the two. This is, actually, the interpretation of naturalists in the nineteenth-century edition of Herrera. Interestingly, this distinction does not appear in any of the other sources. In Flora Ibérica,[11] the vernacular name 'turnip' (*nabo*) is only associated with *Brassica napus*. Could Herrera really be referring to two species? In the other analysed sources, are two distinct species being designated by the same name? Or is one species mentioned in some cases and in others a different one, using the same vernacular name? Is it a case of under-differentiation, as Berlin (1973) puts it?

Genetic diversity

Safeguarding biodiversity, or agrobiodiversity, implies not only protecting different species but also different varieties within the same species (genetic diversity). The agrobiodiversity of varieties, i.e., the biodiversity of landraces or folk varieties, is at risk with the intensification and industrialisation of agriculture (Renna et al. 2019). Thus, to identify the biological diversity described in each historical source, several scales of analysis must be considered.

For these reasons, the research discussed in this paper focuses not only on species diversity but also on genetic diversity, here meaning infra-specific diversity, i.e., the variety of different phenotypes within the same species, which are considered here as defined by Emperaire (2005, 35)[12]: 'a set of individuals considered sufficiently homogenous and sufficiently different from other groups of individuals to receive a specific name and be the object of a set of practices and knowledge throughout its cycle or a particular stage within it.'

Thus, variety is not necessarily as strictly defined as a species is. A variety is rather the 'local perception of the diversity of varieties (…) the smallest unit of perception and management of agricultural diversity' (Emperaire and Peroni 2007). In actual fact, as Hammer et al. (2003, 243) point out, 'for research on cultivated plants and for the utilisation of the diversity of plant genetic resources for food and agriculture, measurements of the extent of variation, i.e., polymorphism, can easily be made by observing plant phenotypes. If clear-cut qualitative traits such as colour, morphology, or enzyme variants are used for characterisation, genetic diversity is reflected to a high degree (…)'.

The historical sources analysed in this paper frequently describe varieties as a function of colour, shape, sweetness, or smoothness. Cloves of garlic, chard, cabbages, onions, lettuce, gourds, cucumbers, melons, and eggplants, among many others, are associated with different phenotypes. Agronomic characteristics, such as precocity, are sometimes also used. For instance, there are references to round and large pumpkins (*calabaza larga*, *calabaza redonda*), black carrots (*acenorias negras*), or black chickpeas (*garvanzos negros*). Regarding sweetness, the sources mention sour apples *(peros agrios)*, sour oranges (*laranjas azedas*), sour lemons (*limões azedos*), and sweet oranges (*laranjas doces*). The varieties of melon mentioned in the nineteenth-century edition of Herrera are paradigmatic examples: smooth; rugged; deeply furrowed; with designated slices; compact and united; green peel; thin and thick rind; white rind; yellow peel; striped shell; mottled and nuanced rind; shell with spots of various colours; white flesh; yellow flesh; green flesh; of reddish flesh; orange flesh; smelly flesh; scentless flesh; tasteless; watery in taste; of vinous flavour; sweet taste; sugary flavour; spicy in taste; round figure; oval in shape; flatness; late maturing; early maturing; of much endurance after the fruits are perfected; of little endurance after the fruits are perfected; compact in consistency; soft in consistency; stringy in consistency (Herrera 1819).

Some varieties are associated with particular places: Chinese oranges (*laranjas da China*) or Corinth raisins (*passas de Corinto*). In some cases, it is unclear whether the geographical reference associated with a plant species concerns the origin of the variety or if the plant or fruit was imported from the region referred to, such as in the case of Genoa plums (*ciruelas de Génova*). In a few cases, varieties are associated with particular names. In the Portuguese culinary book *Arte de Cozinha,* for instance, four different varieties of

[11] http://www.floraiberica.es/ (accessed on 30 July 2021).

[12] Translation in Emperaire and Peroni (2007)

pears are mentioned: *Bom Cristão*; *Virgulosas*; *Bergamotas*; *Verdiais*.

The strong link between varieties and local or personal perceptions makes the task of following varieties across space and time more difficult. Various authors may perceive the same varieties in diverse ways or may designate different varieties with similar names. However, because the concept of variety is very much associated with a place and with certain agricultural or social practices, this is crucial for agrobiodiversity conservation. In fact, as discussed in the context of the ReSEED project, each variety synthesises the triangle of factors on which agriculture is based: environmental conditions, human action, and the seed (biology). How can we overcome this limitation? On the one hand, it is possible to analyse and compare local sources, which may tend to be more homogeneous. On the other hand, historical data may require further investigation; i.e., historical data can be used as a clue to understanding if and how these perceptions have changed over time.

Spatiotemporal patterns

Although data are dispersed in time and space, they are important markers that allow us to understand more about the spatiotemporal dynamics of biodiversity and agrobiodiversity.

Data on location, provided by historical sources, can be difficult to access, which is a major constraint to the aim of using historical data in global biodiversity databases (Delêtre et al. 2012; Yesson et al. 2007; Hill et al. 2009). Firstly, names and topography may change over time, which makes georeferencing a difficult task. Secondly, data are not frequently georeferenced. Textual descriptions are often the only information available, being frequently imprecise and unsystematic. When describing Borage (*Borrago officinalis L.*), the Spanish agricultural treatise states that the species can be found 'in many parts of Spain'; lettuce (*Lactuca sativa* L.), for instance, could be seen 'with abundance in Madrid's surroundings' (Herrera 1819, III:60, 178). In *Sevillana Medicina*, regarding asparagus (*Asparagus officinalis* L.), one can only conclude that "those from Carmona are better than those from Seville" (Aviñón 1885, 95). In a few cases, however, the information is more precise. In *Ancora Medicinal…* for example, the 'famous melons of Vilariça', a small village in the Trás-os-Montes region (northeast of Portugal), are mentioned (Henriques 1721, 225). So, it is possible to follow this data through time and figure out if and how these melons were described over the years.

The aim of this paper is not to discuss how limitations regarding descriptive geographical data can be overcome; other authors have already approached these problems (Delêtre et al. 2012; Wieczorek et al. 2004; Chapman 2005; Hill et al. 2009; Feeley and Silman 2011; Guralnick et al. 2006; Graham et al. 2004; Hortal et al. 2008; Funk and Richardson 2002).[13] Even so, spatially explicit data are needed to establish causal relationships between agrobiodiversity, environmental variables, and local socioeconomic variables. Only a very wide range of sources can overcome this limitation, including the analysis of handwritten local or regional historical registers of civil and religious organisations, private letters or several documents expressing personal viewpoints, and other typologies of historical books. Collecting information from a variety of local and regional historical sources is precisely another path the ReSEED project is currently exploring, aiming to establish more robust perspectives on changes in agrobiodiversity based on geographical and long-term data.

Temporal patterns are evaluated by considering the date (year) when the source refers to the observation or use of a particular plant. When this date is not explicit, the publication date of the book is used. This is a plausible date since, as already explained, the authors express knowledge built in their experience or observation. Besides some limitations, it is interesting to note that important data can be revealed when comparing different editions of the same book. In many cases, they show some differences, namely the reference to some plants of the 'new worlds'. For example, in Herrera's agricultural treatise, in the nineteenth-century editions, products such as sorrel, sweet potato, asparagus, spinach, strawberry, bean, potato, pepper, tomato, watermelon, corn, or saffron are mentioned. The nineteenth-century edition mentions a sum of 145 plant species, 72 more than those mentioned in the first edition of the book (1513). Comparing different editions but also different sources may give us an idea of the timeline of new plant integration or, at least, the periods when those species became more popular in these diverse areas of knowledge (such as agriculture, medicine, or culinary).

Quantitative analysis

Data collected from the selected historical books about species diversity, genetic diversity, and spatiotemporal patterns (location and date (year)) were summarised in a table (Fig. 1). Each accession was associated with its current scientific name. Additionally, other relevant information to species identification was also registered. Each plant species was associated with a crop class. The classification used was the one employed by the Food and Agriculture Organisation (FAO) in the World Programme for the Census of Agriculture 2020 (FAO 2015).[14] These pre-established categories were used to facilitate the systematic analysis of a wide set

[13] On temporal bias, see Tessarolo et al. (2017)

[14] Cereals; fruit and nuts; vegetables and melons; leguminous crops; root/tuber crops with high starch or inulin content; oilseed crops and oleaginous fruits; stimulant, spice, and aromatic crops; sugar crops; other crops.

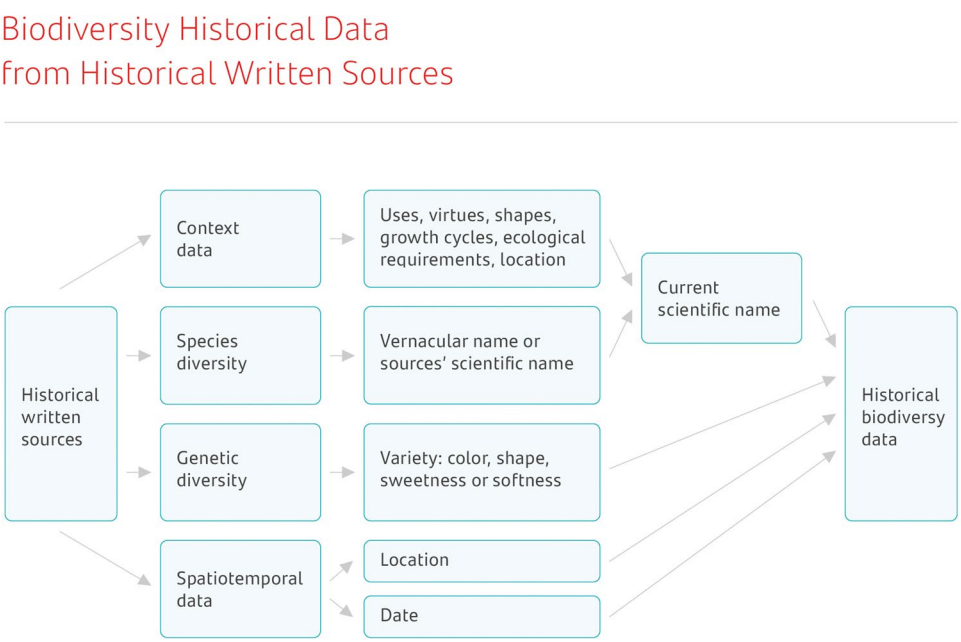

Fig. 1 Schematic representation of information on historical biodiversity provided by written historical sources

Table 1 Number of plant species mentioned in each source

Med_PT	Med_SP	CUL_SP	CUL_PT	AGR_PT	AGR_SP
84	68	75	56	62	73

MED_PT, Portuguese medicine book; *MED_SP*, Spanish medicine book; *CUL_PT*, Culinary Portuguese book; *CUL_SP*, Culinary Spanish book; *AGR_PT*, Agriculture Portuguese book; *AGR_SP*, Agriculture Spanish book

Table 2 Number of species by number of sources where they are mentioned

1	2	3	4	5	6
54	29	10	15	18	21

of data, such as the one analysed. However, in the determination of any categories, some degree of subjectivity is inherent. Other categories could have been defined. FAO categories were chosen considering the objectives of the ReSEED project and a prior survey of the sources to be analysed. Moreover, the use of internationally established categories is meant to facilitate comparison with other research case studies.

Despite the methodological challenges previously mentioned, a general overview of what was cultivated and eaten in the IP between the fifteenth and eighteenth centuries could be accessed. A list of 147 plant species was compiled. The number of plant species mentioned in each source varies between 56 and 84 (see Table 1), being quite constant throughout different sources.

When trying to acknowledge the plants that appear in the highest number of sources, in other words, when trying to determine the overlaps among the wild and cultivated edible plants named in the six sources, it is understood that the variation is high (see Table 2).

The collected information shows that 37% of plant species are mentioned in just one source, and only 14% are included in the different sources analysed. This lack of overlap may be due to several factors. Species composition from a variety of sources is determined by the interaction of various features: tastes, food culture, local customs, agricultural policies, and market forces. Each source typology reveals the different interests of diverse disciplines or areas, enlightening the dynamics that link botany, cultivation, and consumption and uncovering new landscape aspects, thus emphasising the importance of pluralising sources.

Similar to data analysis in ecology, an analogy between sources and habitats was made to uncover co-distribution trends in the plant species mentioned in each source. A principal components analysis, using R version 3.6.1 (2019–07-05), was performed for dimensionality reduction to identify new vectors (the principal components) that explain the variance in species presence across sources.

Species mentioned in only one source were excluded from the analysis because they could have a large effect on the data variance reduction and mask the variation patterns of meaningful species. The choice to plot just the two most important axes was made as they explain a large percentage of the variability and are clearly linked to easily identified factors. The first and the second axes explained 32 and 23.5% of the variance (Fig. 2).

Axis 1 clearly separates culinary (CUL_SP and CUL_PT) sources from the other types of sources. Species like *Satureja* sp., *Origanum majorana* L., *Cynara scolymus* L., or *Laurus nobilis* L. play a major role. This may be due to the specificity

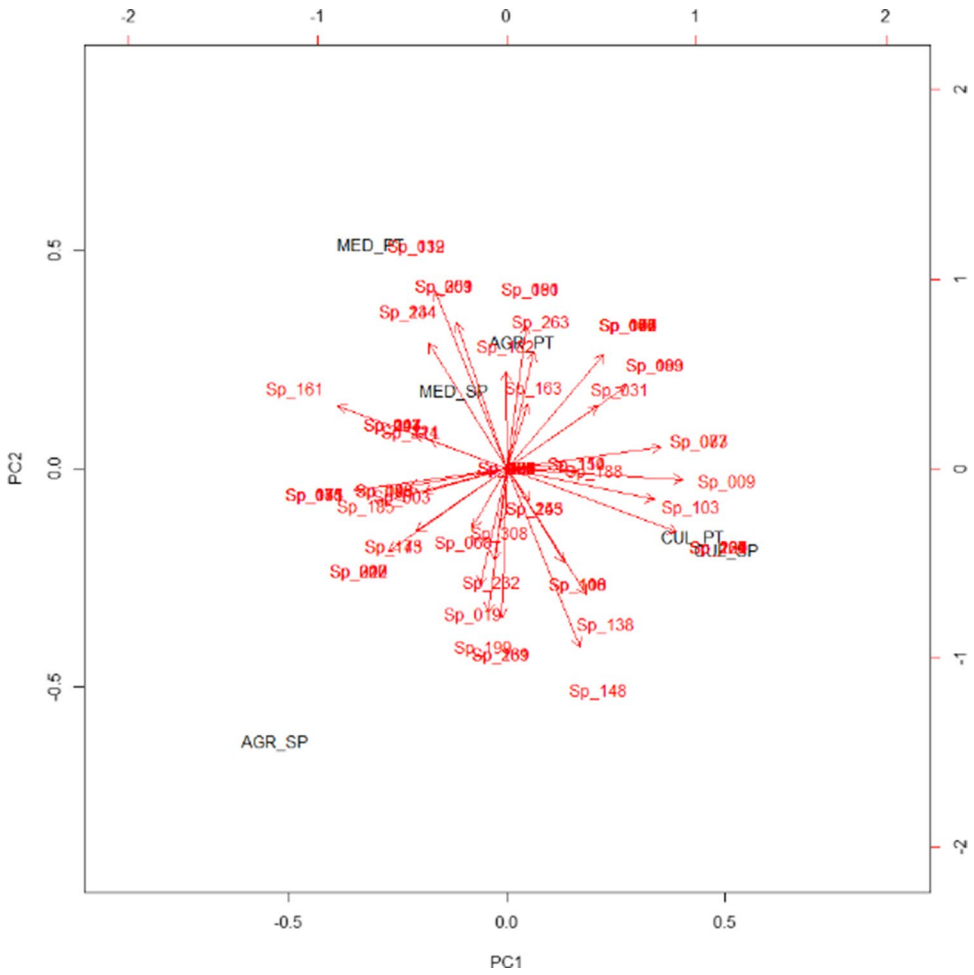

Fig. 2 Principal component analysis of the six historical sources

of culinary books, which detail diet, in particular the diet of the elites. Furthermore, plants are more related to consumption but not necessarily to cultivation, or at least to cultivation on a larger scale. They may refer to plant species cultivated only in royal gardens for their kitchens. These sources may also be useful in revealing the introduction of some exotic products into the diet of the elites of the IP, but may not be representative of what the general population was eating or cultivating. This 'makes us question the validity of relying on certain historical categories in our analysis and realise that these categories derive from a particular background', and each one can give us different information (De Vos 2017). Axis 2 seems to separate Herrera's *Agricultural Treatise* (AGR_SP). This may be due to the high degree of detail in this Spanish agricultural book.

If one analyses only crop classes usually associated with the cultivation in kitchen gardens,[15] culinary sources still feature a distinct list of species. Nevertheless, there seems to be a marked separation between Portuguese and Spanish sources that may be driven by regional differences (Fig. 3). The main 'ecological' trend (indicated by Axis 1) in plant species distribution among the sources was connected to species like *Allium* sp., *Cichorium* sp., or *Crocus sativus* L. A secondary 'ecological' trend (indicated by Axis 2) is associated with *Portulaca oleracea* L., *Spinacia oleracea* L., or *Capparis spinosa* L. This may be due to local customs or localisms (species or varieties that actually grow just in one country or region) or to synonyms that make the identification of the same species problematic. These challenges illustrate the difficulties of understanding global trends in biodiversity using terminologies developed in local backgrounds (De Vos 2017). Nevertheless, there is no doubt that to understand global landscape change, local histories must be integrated. So, different scales must be analysed and combined.

This kind of analysis, linking ecological methods to written historical sources rather than giving us straight answers, allows us to raise new questions that would not otherwise usually be asked by a conservation scientist unfamiliar with historical sources. At the same time, it

[15] In other words, species included in four crop classes: vegetables and melons; leguminous crops; stimulant, spice, and aromatic crops; root/tuber crops with high starch or inulin content.

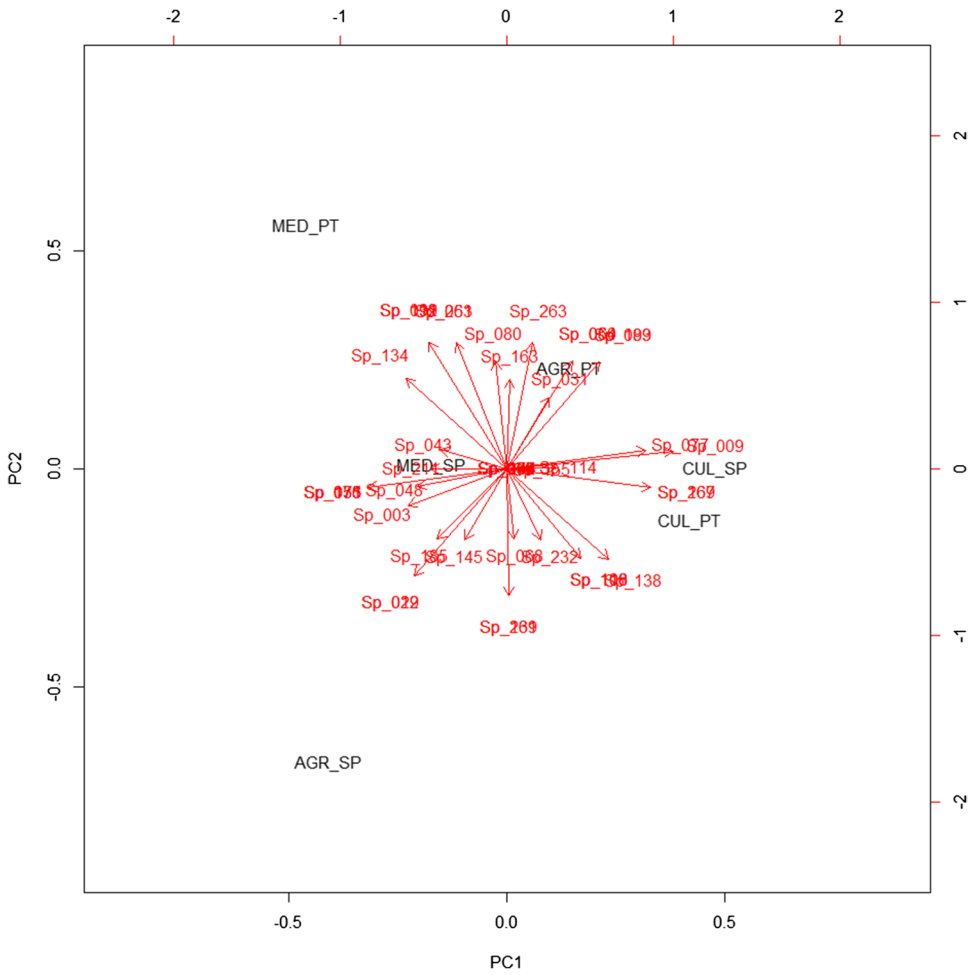

Fig. 3 Principal component analysis of the six historical sources counting only species included in four crop classes: vegetables and melons; leguminous crops; stimulant, spice, and aromatic crops; root/tuber crops with high starch or inulin content

encourages historians to understand trends that would not otherwise be revealed.

Final remarks

Historical sources contain data that may inform decisions regarding the safeguarding of biodiversity. By identifying and/or describing species, both across time and space, these sources are particularly important to access the species composition at a given location over time. Historical material sources, like herbarium specimens, have already been recognised as important assets to evaluate biodiversity patterns. However, an in-depth discussion of written historical sources had not yet been undertaken. Notably, this paper provides a holistic picture of written sources as a tool to access the agrobiodiversity of the past, which is crucial to provide more opportunities to use these sources for biodiversity conservation. The paper illuminates how written sources can help us to understand the diversity of wild and cultivated edible plants. Despite the limitations and methodological challenges discussed in this paper, written sources may indeed help gather data on the biological diversity of the past, providing an opportunity to obtain at least a reasonable assessment and outline of what was cultivated and eaten.

This research analysed historical sources, written between the fifteenth and eighteenth centuries in different contexts and for different audiences, to trace the diversity of wild and cultivated plants in the IP. The information was systematised in a table, associating vernacular names with scientific names, which enabled us to compare the different sources. In some cases, it was possible to associate particular plant species with specific places or regions, suggesting changes in agricultural crops over time.

Transdisciplinarity and the inclusion of different sources of knowledge, academic and nonacademic, are fundamental in order to have a comprehensive view of ecosystems and to effectively and successfully implement biodiversity conservation management plans. This paper highlights the importance of extending the concept of transdisciplinarity to historical sources. Their variety, linked to different perspectives of resource use and exploitation, allows for a broader perception of plant species of the past by grasping ancient local knowledge:

what, when, where, and how particular seeds, crops, plants, and varieties were cultivated or consumed. It is fundamental to bring history to ecological assessments, gathering historians, biologists, and local communities. Besides, to acknowledge the past, a wide and transdisciplinary set of sources should be considered. Each type of source embraces particular plant species. Collectively, different sources give an in-depth and broader picture of past landscapes.

Once more, it is important to note that this is a preliminary study that assesses the kind of information that may be gathered when analysing written sources. The data gathered allows for the development of new research inquiries, i.e., the sources induce new questions that will allow for a better understanding of ecosystem dynamics. In other words, the historical data provide a basis for further research, namely, analysing the causes of current changes and challenges.

The approach proposed in this paper will need to be expanded since only with a large amount of historical data will it be possible to assess trends and changes in species composition. Further research will help build a vision of the changing geography of historical agrobiodiversity in the IP; reveal the associations between plant species and their phenotypes with environmental and social conditions; and provide a better understanding of the links between vernacular and scientific names, essential for the extensive integration of different kinds of historical sources into global biodiversity datasets.

Despite the limitations of the sources, which should not invalidate but rather bind the use of historical data, and although there is still much data collection work to be done, alongside linguistic, archaeobotanical, and genetic approaches, projects like ReSEED may provide a better comprehension of the past of edible seeds and plants, their diversity, and distribution in regional landscapes.

In the words of De Vos 2017, 232) , who was involved in compiling the Nahua pharmacopoeia, 'does this [difficulties] mean that we need to give up these investigations, (…)? (…). Just because we may not have access to perfect understanding (…) does not mean that what we find is not valuable. (…) We may not be able to know everything about [what was cultivated in the past], but we can know something about it'.

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Declarations

Ethics approval This paper reflects only the authors' views. The European Commission and European Research Council Executive Agency are not responsible for any use that may be made of the information it contains. This research did not involve human participants or other nonhuman animals.

Conflict of interest The authors declare no competing interests.

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