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Cross-cultural and historical traceability of ethnomedicinal Asteraceae. Eastern Morocco and Eastern Andalusia: Two sides of a sea in 20 centuries of history

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ABSTRACT

The aim of the study is to analyse the sharing and dissimilarities of current popular knowledge on the medicinal uses of plants in two neighbouring areas of the Western Mediterranean with a shared historical background: Eastern Morocco and Eastern Andalusia (Spain), focusing on the most important botanical family in both territories, the Asteraceae. Data on the Moroccan traditional use of the plants were gathered in an ethnobotanical field research. For comparison, a database was developed containing these data and those from the reviews of the ethnobotanical literature from Eastern Andalusia, and three historical important herbals. Statistical analysis was performed using clustering hierarchical analysis and Jaccard's similarity index. Results show that in Morocco, 10 taxa of the family are used to treat 45 medical conditions of 10 pathological groups. The whole database reached 380 use records to treat 64 conditions across time and both cultures. The consensus of current ethnobotanical knowledge in the two studied territories is high, as 35.5% of uses are practised in both territories. Among coincident uses in the 5 information sources, most are currently accepted-approved through phytotherapeutical and ethnopharmacological studies. Nearly 70% of the uses included in Ibn al-Baytar's codex are of previous unknown origin. The high coincidence in the current use in both territories seems to be influenced by: 1. the shared historical context and medical traditions for several centuries and 2. the validity and pharmacological effectiveness of the plants: well ethnopharmacologicaly studied uses are transmitted both through time and territories or cultures.

1. Introduction

The Asteraceae Berchtold & J. Presl, *nom. cons.* (also known as Compositae Giseke, *nom. cons. et nom. alt.*) is the larger botanical family of vascular plants in the world, with some 25,000 species in more than 1500 genera (Funk et al., 2005; Stevens, 2018). Phylogenetically it can be subdivided in 12 modern subfamilies (Stevens, 2018). Asteraceae were originated in the mid Eocene, and are dated to some 42–36 m.y. (Kim et al., 2005), although more recent research date them back to the transition of late Cretaceous to Paleocene, about (74.4-) 64.7(-55.1) m.y. (Panero and Crozier, 2016).

As the major family of plants in the world, it is also the major one in the European Flora (about 1616 species taking into account those in apomictic taxa in Webb 1978). In the Mediterranean flora, it is also the major family, containing 278 genera, 4337 species and 2384 additional subspecies (Greuter, 2008). The flora of Morocco with some 4200 species is the richest of any North African country and one of the most diverse of the Mediterranean region (Valdés et al., 2002). The Flora of the country reaches 5211 plant taxa: 3913 species, 426 subspecies and 872 additional subspecies (Fennane and Ibn Tattou, 2012), with 550 species of Asteraceae. In north Morocco, a total of 338 species of Asteraceae from 114 genera have been quoted (Valdés et al., 2002). On the other hand, the flora of the Iberian Peninsula includes 1003 Asteraceae species, representing the 14.2% of the total vascular flora, with 824 species in mainland Spain (Aedo et al., 2013). The endemicity is high within this family: 131 species in Morocco and 203 in Spain (14.8% of the total ones) with up to 8 endemic genera (Buira et al., 2017). Eastern Andalusia has 415 Asteraceae species in 126 genera, being also the major family and the one with most endemic taxa, 60 (Cueto et al., 2014).

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1.1. Importance in Mediterranean traditional medicine

The Asteraceae plant family is well known as widely used in phytotherapy and ethnomedicine.Of course, it is clear that as the major family of plants in the world, and as one of the main botanical families in the local floras of most of the world, it high traditional utilization is not surprising. Moreover, it is also well-known that the family is characterized by the presence of active secondary metabolites, such as chlorogenic acid, flavonoids, pentacyclic triterpene alcohols, terpenoid essential oils, alkaloids, a variety of fatty acids in the seeds, tannins, iridoids and polyacetylenes (Stevens, 2018; Yaoita et al., 2012, Konovalov, 2014).

Because of both its high diversity in species number and chemical composition, the Asteraceae is the main used family in several ethnobotanical surveys in different areas of the world, including Africa (e.g. Erasto et al., 2005; Simbo, 2010; Tsobou et al., 2013; Yemele et al., 2015), Asia (specially western Asia: e.g. Sargin et al., 2013; Ong et al., 2018; Maleki and Akhani, 2018), Europe (Rigat et al., 2007; Benítez et al., 2010; Dei Cas et al., 2015; Mazzei et al., 2018) and America (Heinrich et al., 1998; Leonti et al., 2003; Tene et al., 2007; Leitão et al., 2009; Trojan-Rodrigues et al., 2012). In fact, the family tend to be overused in the holartic territories (Moerman et al., 1999). Several researches have focused on the ethnobotany, chemistry and pharmacology of several plants of the family (e.g. Hayat et al., 2009; Hulley et al., 2010; Chagas-Paula et al., 2012; Medeiros-Neves et al., 2018).

1.2. Historical and cross-cultural studies on medicinal plants

The study of the knowledge transmission regarding drugs and *materia medica* through history is a fundamental topic for medicinal plant research (Leonti, 2011; Touwaide and Appetiti, 2013), and the relevance of the historical methods in the context of ethnobotany, ethnopharmacology and phytotherapy has been previously highlighted (Heinrich et al., 2006; Leonti et al., 2010). Several papers have deal with this topic, focusing on historical important texts (f.i., Leonti et al., 2009; de Vos, 2010; Leonti, 2011; Staub et al., 2016; Van Andel et al., 2018; Rivera et al., 2017; 2019). In this case, we have focused on 3 historical herbals, detailed in the methods. We aim to know if each use was previously known by ancient physicians, and what differences can we see on the described uses and properties among them.

On the other hand, apart from the historical perspective, a cross-cultural one may also offer variations and patterns with regard to the traditional knowledge. As previously stated, "without cross-cultural comparison, we could not talk or write about what may be universal and variable about human cultures, and we could not discover why the variation exists" (Ember and Ember, 2009). Cross-cultural studies on medicinal plants are not scarce (f.i., Ceuterick et al., 2008; González-Tejero et al., 2008; Saslis-Lagoudakis et al., 2011; Molander et al., 2012; Benítez et al., 2018) and can offer light to nearly universal or "extended in space" remedies for certain conditions, or interesting variability patterns. It is a fact that "medicinal plant products have been successfully administered both externally and internally in several different forms for a wide range of health problems cross-culturally since prehistoric times" (Halberstein, 2005).

1.3. Aim of the study and research questions

With this contribution we aim to: 1. obtain and compile ethnobotanical knowledge of Eastern Morocco about the medicinal use of the Asteraceae, with a field-study; 2. compare the current traditional uses of this family in this region with the ones still practiced in Eastern Andalusia with the same species (cross-cultural synchronic comparison); 3. compare the uses in both territories with classical works on medicinal plants, trying to cover different historical periods but focused in this geographical context (historical comparison); 4. analyse if the scientifically assessed and validated pharmacological properties of some uses of these plants can be an unaware reason determining a high use coincidence in both territories or across time.

With the cross-cultural comparison we also aim to analyse the consensus in the use of medicinal plants and the possible links and level of knowledge-sharing between these two neighbouring and historically related territories. This is based on an ethnobotanical review of the previously known works in the area for comparison: eastern Andalusia. With the historical comparison we aim to deepen in the knowledge of the historical consensus, extension, evolution or changes of the known current uses, i.e., what in other disciplines is so-called the traceability. This is based on a literature review of some important codices and works dealing with medicinal plants and uses. Both parts are detailed in the methods section.

1.4. Testable hypotheses

We selected this study area because, as it was previously stated (El-Gharbaoui et al., 2017), Southern Spain and Northern Morocco have a shared cultural past spanning more than seven centuries (Watt, 1967). Muslims occupied the Iberian Peninsula in the eighth century creating the Al-Andalus Kingdom, lasting from 711 to 1492. Nevertheless, despite the high current cultural contact, economical exchange and migrants in each territory, cultural, religious, and socio-economic distances make a clearly different lifestyle in the two territories. And, as was previously demonstrated (El-Gharbaoui et al., 2017), these differences can be also reflected in the traditional use of plants. While Andalusian traditional phytotherapy seems to be quite developed with a number of publications, the Eastern part of Morocco needs more ethnobotanical field studies (some previous ones are Jamila and Mostafa, 2014 or Hayat et al., 2020), thus more field work in Morocco was needed to obtain a dataset suitable for comparison.

We therefore will analyse the Asteraceae in this context to test the hypotheses: 1. due to the historical past and the centuries of shared culture and language, as well as a similar flora and vegetation, there must be a high overlap in plant use between these geographically close territories which are currently socio-culturally distant. And 2. since the used herbals had a great influence on the traditional medicines of both territories, there must be a high plant-use overlap between these texts and the current uses in Morocco and Andalusia.

2. Material and methods

2.1. Study area and ethnobotanical field methods

A field study was performed in Eastern Morocco, including the districts of Driouch, Nador, Berkane, Oujda-Angad, Guercif, Taourirt, Jareda, and Figuig (see Fig. 1., with main surveyed localities), covering a total area of about 82,820 km^2 between the Mediterranean Sea and Algeria (about 11% of Morocco's area).

Surveys were conducted in order to preselect informants, together with conventional methods of informant location, such as the snowball method and participant observation. Surveys were focused on marketed plants, a matter already described and discussed on previous works (El-Gharbaoui et al., 2017; this work can be consulted for more data on the informants and socio-cultural description of the study area, for a deeper description of the field methods used to gather ethnobotanical data, and more data on the used Andalusian ethnobotanical works for comparison). Data on the use of plants were gathered by open and semi-structured interviews performed in *Darija*, the Moroccan Arabic dialect, usually individually (although group discussions and team interviews were also performed). Informants gave their prior verbal informed consent. Amongst them there were farmers, shepherds, medicinal plants sellers (locally *Fkih*), wise women (popularly known as *Kablat*), and men known as wizards. In total 153 persons were interviewed.

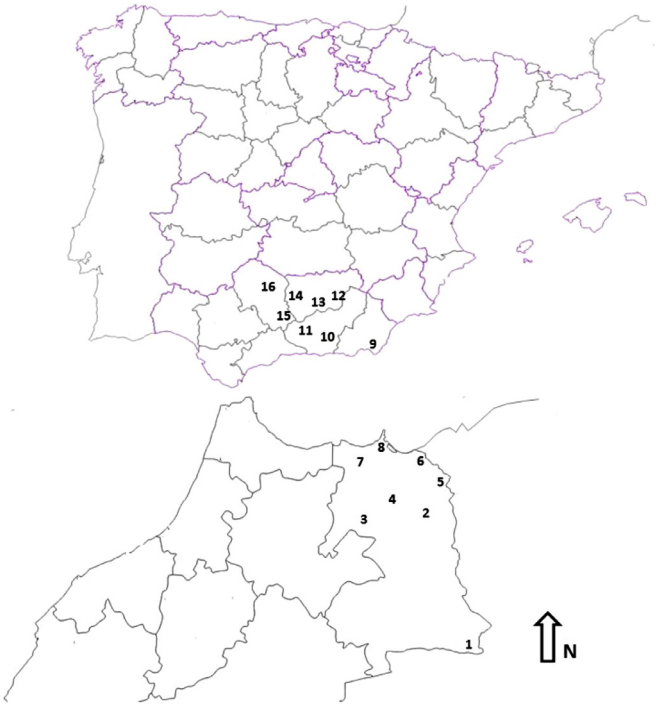

Fig. 1. Map of the study area in East Morocco and the East Andalusian territories used for bibliographical comparison. Numbers 1–8: main localities for the field study. 1. Figuig, 2. Yerada, 3. Guercif, 4. Taourirt, 5. Oujda, 6. Berkhane, 7. Driouch, 8. Nador. Numbers 9–16: Andalusian territories for bibliographical comparison. 9. Martínez-Lirola (1993), 10. González-Tejero (1989), 11. Benítez (2009), 12. Fernández-Ocaña (2000), 13. Guzmán-Tirado (1997), 14. Casado-Ponce (2003), 15. Triano et al. (1998), 16. Galán-Soldevilla (1993).

With regard to the plant material, it is comprised by dry plant material (mostly from markets) which was donated by our informants or directly bought in markets while performing the interviews. In all cases we obtained all the needed structures for the proper identification of the species: leaves, calices, corollas, etc. using local floras in order to identify the plant material (Fennane et al., 1999, 2007, 2014; Valdés et al., 2002; Castroviejo, 1986,2015). Vouchers were deposited in the University of Tétouan Herbarium, and codes are included in the results. General standards and recommendations for ethnopharmacological studies were followed (Martin, 1995; Alexiades, 1996; Weckerle et al., 2018).

2.2. Ethnobotanical review of Eastern Andalusian works

For the cross-cultural comparison, in order to compare current uses of this family in Eastern Morocco with the ones still practiced in Eastern Andalusia, we performed a review of the ethnobotanical works of this area. It includes all the ethnobotanical field works performed in the Spanish provinces of Granada, Almeria, Jaen and Cordoba (González-Tejero, 1985, 1990; Martínez-Lirola, 1993; Galán Soldevilla, 1993; Guzmán Tirado, 1997; Triano et al., 1998; Fernández Ocaña, 2000; Casado Ponce, 2003; Benítez, 2009; eight of them are PhD dissertations). Covered territories can be seen in Fig. 1. Most of these works were performed using the same data gathering methods and within the same research group (except Galán Soldevilla, 1993; Triano et al., 1998; Casado Ponce, 2003). Thus, any new field work was performed in Andalusia, and data for this territory come from this literature review.

2.3. Historical use of plants: literature review

With the obtained data we performed a database on Microsoft Access® containing several data sources: ethnobotanical fieldwork in Morocco, literature review of Andalusian ethnobotanical works (for the cross-cultural comparison), and literature review of important historical works on the medicinal use of plants for the covered territory. With this review we aim to know to some extent the history of the use of every known traditional use in both territories. For this historical comparison, we have reviewed 3 different works offering information on 4 different authors and 4 different historical periods:

Quer (Q): José Quer y Martínez (1695–1764). He started the work *Flora española o Historia de las plantas que se crían en España* (finished later by his disciple Casimiro Gómez Ortega; 1741-1818). The flora, in 6 volumes (Quer, 1762a, 1762b, 1762c, 1764, and Gómez Ortega, 1784a, 1784b) is the first attempt to perform a Spanish flora and was performed as a catalogue, using the polynomial Tournefortian names of the species, with all the known synonyms (Gómez Ortega also added the Linnaean binomials). It includes descriptions of the species but also valuable information on the use of medicinal plants, citing Laguna, Matthioli, Galen and others, and adding his own commentaries on these time uses in Spain. Therefore, it contains valuable information on the use of medicinal plants in this historical moment. The work comprises information for 2602 species in 649 genera, somehow the 28% of the current Spanish flora (Aedo et al., 2017 this reference can be consulted for more biographic data).

Laguna's Dioscorides (DL). Andrés Laguna de Segovia (1499–1559) was a Spanish physician, who worked as doctor for Pope Julius III and later for the Spanish Kings Carlos I and Felipe II. Several papers deal with his biography and bibliography (e.g. Lahiff, 2012; Morales, 2015; Andretta and Pardo-Tomás, 2017), but his most known work was the commented Spanish translation of Dioscorides' *Materia Medica* (Laguna, 1555). It was only few years after Matthioli's first one in Italian (Matthioli, 1544). Several ethnobotanical historical studies focused on Matthioli's work (Leonti et al., 2009; Leonti et al., 2010; Leonti, 2011; Staub et al., 2016), but Laguna's heritage is still partly unknown. For the purpose of this study, we have considered that this work contains two different information sources: the original one from Dioscorides, historically framed in the 1st century A.D., perfectly differentiable from the second: Laguna's comments (clearly in a different format through the book), historically framed in the XVI century.

Ibn al-Baytar (IB). *Diya al-Din Abu Muhammad Abdullah Ibn Ahmed Ibn al-Baytar* (1197–1248), was a physician, pharmacologist and botanist born in Malaga (South Spain). He studied in the Islamic school of the Nasri Kingdom of Granada, and focused on botany and pharmacology as complementary disciplines for medicine (Cabo-González, 1999). After this, he travelled through the Islamic world learning the use of medicinal plants and compiled in Damascus, where he died, the most important Compendium of medicinal plants of his age. The *Compendium*, entitled *Kitab al-Yami' li-mufradat al-adwiyawa-l.-aghdiya* (the Compendium of Simple Medicaments and Foods) is one of the major works in Arabic on this issue (Álvarez-de-Morales, 1986). A detailed study of the botanical work of Ibn al-Baytar has not been performed, although several studies deals with it content (f.i., El-Gharbaoui et al., 2017, where more data on his biography and bibliography can be found) as well as with the relation between this work and the current use of medicinal plants, especially in North Africa (Bellakhdar, 1978, 1997). For the analysis we mainly used the French translation (Leclerc, 1877–1883) with the author's comments providing information on the correlation of mentioned plants with scientific and French vernacular names. In order to clarify some paragraphs, other editions were also consulted, including a complete modern Arabic version (Ibn al-Baytar, 1992) and several partial Spanish translations (Cabo-González, 1996, 2009, 2011, 2012; Cabo-González and Merino, 2010; Navarro, 1997). More data about this author can be found in general Islamic Medicine books (Sankary, 1984, 1991; Sterpellone and El sheikh, 1995; Bellakhdar, 1997; Guardi, 1999).

2.4. Data treatment

This comparative study is focused on the Asteraceae, but the inclusion criteria for the analysis was that the plants may: 1. be present in both territories, and 2. have at least one traditional medicinal reported use it in each territory. Therefore, not all included plants were mentioned in the reviewed literature cited in Section 2.3.

With the data coming from the related sources, i.e., ethnobotanical fieldwork in Morocco, ethnobotanical review and historical review, we performed a database in Microsoft Access ®. It contains scientific names and families, the most known vernacular names, vouchers (for plant material gathered during the interviews), part used, medicinal uses and pathological groups, and preparation forms.

For data analysis and graphs we used Microsoft Excel, with XLSTAT. As standard classifications are a valid tool for cross-cultural comparisons (Staub et al., 2015), we performed the analysis following the International Classification of Primary Care (ICPC-2) (http://www.who.int/classifications/icd/adaptations/icpc2/en/). For the comparisons (cross-cultural and historical) we have considered a similar medicinal use when the same plant part was referred for the same condition or symptom according to the ethic names of conditions and the ICPC-2 classifications of diseases. Next section deals with the possible bias regarding vernacular or scientific names of the included plants. When an ethnomedicinal use (i.e., in this study, a part of a plant used to treat a certain condition) is cited in 2 or more information sources, we have considered them to be related, and try to explain at least the most important cases for us in the discussion. We cannot analyse the origin of extension of most uses which are only cited in one of the sources.

The generated matrix of uses and references was analysed with clustering analysis (hierarchical cluster analysis) using XLSTAT 2014.5.03. Jaccard's similarity index was generated in order to compare the similarity and diversity of the data, as some other comparative ethnobotanical analyses (e.g. González-Tejero et al., 2008; El-Gharbaoui et al., 2017) according to the formula

$$JI = (C/(A + B - C)) \times 100$$

where A is the number of taxa of the sample A, B is the number of taxa of the sample B, and C is the number of taxa common to A and B. The index can range from 0 (no coincidence) to 100. It was generated for comparing the 5 information sources (two ethnobotanical ones, tree historical texts), comparing the coincidence of the use of a certain species for any condition of each pathological group, without considering the specific condition for which the plant is used in the pathological group.

2.5. Nomenclatural and taxonomical comments and bias

As previously stated by several scholars, the correlation of the current scientific names with ancient Latin, Arabic or other languages is not easy (Holmes, 1888; De Vos, 2010; even Leclerc, 1877–1883). As ethnopharmacological research needs to refer unambiguously to a scientific valid and correct name (Rivera et al., 2014; Bennett and Balick, 2014), we have preferred to state a more conservative correlation of vernacular-scientific names in old sources using the name of the genus (following De Vos, 2010 and our previous work, El-Gharbaoui et al., 2017). This occurs in 2 of our 10 included plants: genera *Artemisia* and *Carthamus*. We have taken into account that for these genera, the used species in Morocco and Andalusia are not the same, but we have also considered that the reliability of the association of scientific names and vernacular names in the historical sources is not always high (especially in our cases, with Leclerc, 1877-1883). As for previous comparisons, particular species should not always be the same through times or in neighbouring territories, but uses can be properly compared for the genus, especially if the comparison includes classical texts where this correlation problem is evident. All scientific names included in the results were updated using theplantlist website (http://www.theplantlist.org/).

Another possible bias that deserves to be commented is the sampling in the cross-cultural comparison (Ember and Ember, 2009). As the ethnobotanical data from Morocco come from a single field work, and those from Andalusia come from the review of several field works (see Fig. 1), it is expected that the number of uses for the included species is bigger in Andalusia, since a higher number of informants have been considered.

Finally, some differences regarding how inhabitants of Andalusia and Morocco obtain and use their medicinal plants should also be highlighted. In the Andalusia, it is common the personal or familiar gathering of resources from the wild and the ethnobotanical field research has focused on the gathered medicinal plants (without forgetting non-native or purchased medicinal plants). On the other hand, in Morocco it seems to be more common their obtainment from local markets or small herbs shops (where most of the plants used in traditional medicine can be found) and where is not uncommon that it is the seller himself who acts as a transmitter of this knowledge, recommending the plants for a certain condition.

3. Results

3.1. Ethnobotanical fieldwork in Morocco

Although this fieldwork was not focused on Asteraceae, it is the second family with the highest number of plants included, 10 taxa, after the Lamiaceae (see El-Gharbaoui et al., 2017). A total of 45 medicinal uses have been recorded in the study area for them, serving to treat 26 afflictions or symptoms from 10 pathological groups (detailed in Table 1), outstanding digestive ones (13 uses) and endocrine/metabolic/nutritional ones (7 uses). *Artemisia arborescens* L. is the taxa for which we gather more medicinal uses in Morocco (7), followed by *Matricaria chamomilla* L. and *Centaurea calcitrapa* L. (see Fig. 2).

Our informants were Arabs (75%) and Berbers (25%, specially ethnicities Zenete from Nador and Isenhájen from Figuig). We interviewed a higher proportion of females (54%), and informants were mostly people over 40 (30% more than 60, 47% 40 to 60, 13% 30 to 40, and 10% under 30) with a poor educational background (45% illiterate). According to the RGPH (2004), the poverty rate in the region was 24.8% in rural areas and the illiteracy rate is 42.9%, with women affected to a greater extent than men.

3.2. Bibliographical comparison

Considering the bibliographical comparison with modern ethnobotanical sources for Andalusia and the works of Ibn al-Baytar, Laguna and Quer, the 10 Asteraceae taxa reach 380 use records. They are or were used to treat 64 conditions of 15 pathological groups (Table 1), with a total amount of 237 entries of use, i.e., a plant for one medicinal use in at least one of the sources. We performed a hierarchical cluster dissimilarity analysis for the 5 sources for all uses (Fig. 3) as well as Venn diagrams for coincident uses among sources (Fig. 4).

Uses are sorted by pathological group in Table 3 for the 5 sources of information used. As in the case of the Lamiaceae (El-Gharbaoui et al., 2017), the number of total references of the medicinal uses of these plants is higher in the included areas of Andalusia than in those of Morocco, due to the high number of reviewed works in Andalusia compared to a single field ethnobotanical study in Morocco (85 vs. 45 uses, see Table 3).

With regard to the pathological group, we can extract from Table 3 than digestive conditions are the most frequently cited to be treated by our included plants not only in Morocco, but in all the comparison sources. Skin conditions and general/unspecified conditions or

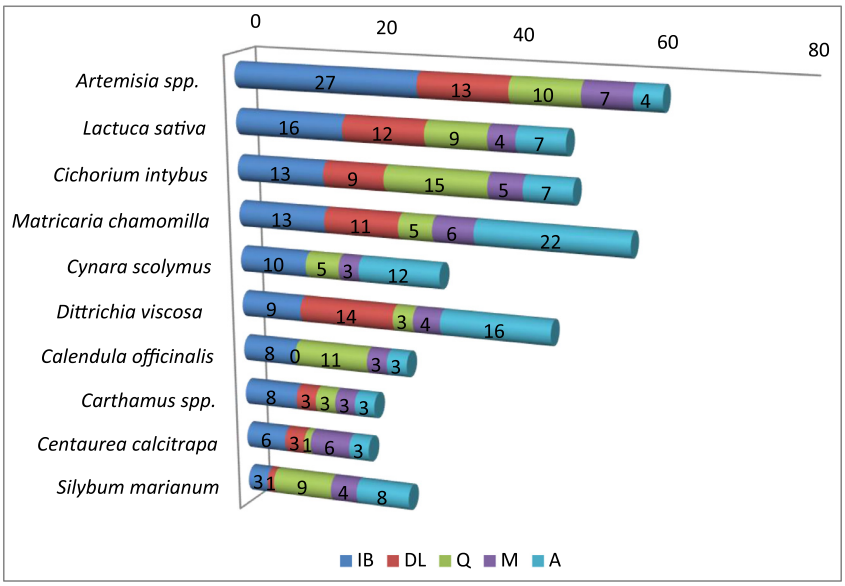

Fig. 2. Number of medicinal uses for the included Asteraceae species in Ibn al-Baytar's work (IB), Laguna's version of Dioscorides (DL), Quer's Flora Española (Q), the studied area of Morocco (M), and East Andalusia (A).

symptoms (including fever, pain and infectious diseases, included in other categories in other classifications) are also important. To analyse the use similarities in the pathological groups, we calculated Jaccard's index (Table 4). To know the pharmacological evidence, we reviewed the plants included in Eur. Pharm., and selected important references on medicinal plants and phytotherapy (Table 2), analyzing separately the pharmacological evidence for uses preserved along time (cited in all sources or in at least 4 of them; Fig. 5). These points are discussed below.

4. Discussion

4.1. General comparison between sources

Despite our inclusion criterion (see sect. 2.4) was based on the presence of the species in both Eastern Morocco and Andalusia with at least one traditional medicinal use it in each one, most of the plants were also cited in the 3 bibliographical sources, with two exceptions: *Calendula officinalis* and *Cynara scolymus* not mentioned by Dioscorides.

With the aim to compare data from Table 1 within the 5 data sources, we performed the hierarchical cluster dissimilarity analysis (Fig. 3). The clustering shows a higher dissimilarity for Ibn al-Baytar, probably due to the big amount of information which this source contains, with lots of uses not repeated in other sources. As previously stated, the value of his work is manifold, and he added 300–400 new simple medicaments to the previously known pharmacological works (El-Gharbaoui et al., 2017). Andalusia is also clustered separately from the rest sources, which form a node with minor dissimilarities (containing Quer, Dioscorides and Morocco). This means that in this model, ethnopharmacological knowledge in the Eastern region of Morocco is more related to Dioscorides than to Ibn al-Baytar. The high similarity of the information in Quer and Laguna's Dioscorides is also clear, although as commented in the introduction, several other authors were also cited in this work regarding the medicinal uses of the included plants.

Fig. 5 shows three Venn diagrams with the number of specific uses and shared uses between data sources, comparing the main groups of sources: historical, modern ethnobotanical ones, and each modern one with the 3 historical. With respect to the modern uses at both sides of the Mediterranean and the cross-cultural analysis, the 35.5% (16 of 45 total ones) of Moroccan uses are also cited for Andalusia. In fact, the consensus on the current ethnobotanical knowledge in these two territories for the Asteraceae is high, but less than the obtained for the Lamiaceae (64%; El-Gharbaoui et al., 2017). This can reflect that current uses for the Asteraceae may have been influenced by the evident cultural differences of the territories, as well as by the different medicinal traditions. Considering this 35.5% of use overlap for Asteraceae a notable overlap in the plant traditional use (and the 64% for Lamiaceae), we can state that our first hypothesis is confirmed.

In the historical analysis, the higher coincidence was obtained for Ibn al-Baytar and Dioscorides (34 uses, representing 30% of the total uses included in Ibn al-Baytar for the studied Asteraceae). Coincidences in Quer-Dioscorides and Quer-al-Baytar were also high (28 uses each). These high coincidences of Ibn al-Baytar and Quer with Dioscorides can be explained since both authors included in their texts the information complied in the *Materia Medica*. We cannot forget that Dioscorides´ treatise was a reference book in medical matters for more than 1500 years (Reeds, 2008) until the Renaissance in Europe. Nevertheless, the contribution of the Oriental and Arab-Islamic traditions in the work of Ibn al-Baytar must have been important for both the higher amount of contained information and its originality.

It is also surprising that the work of Ibn al-Baytar is more related with Andalusia than with Morocco (as was previously found for the Lamiaceae; El-Gharbaoui et al., 2017). It is known that Ibn al-Baytar was born and studied in Andalusia, but since 1219 he travelled to the Islamic world to collect plants and improve his own knowledge reaching Anatolia, Syria, Palestine and Arabia. Thus, the expected results were higher similarities with current ethnopharmacological knowledge in Morocco than Andalusia, since Morocco has kept the cultural tradition since these times but Andalusia has change important cultural issues (e.g. language or main religion). It is also surprising the big amount of medicinal information that Ibn al-Baytar's Compendium contains (113 uses for only 10 taxa), as was previously reported for the Lamiaceae (193 uses for 14 taxa; El-Gharbaoui et al., 2017). By the other hand, in Laguna's version of the *Materia Medica* 66 uses were found for the plants, nearly than in Quer with 71.

In fact, as shown in Figs. 3, 4 also reveals a higher proximity for Morocco with Dioscorides (17 shared uses; 38%) than with Ibn al-Baytar (13; 28%). This result is quite surprising, since one may expect a higher similarity of Moroccan current uses with those related in the

Table 1
Data set with scientific names of the plants used in the study area, specifications of the possible different names in quoted in the consulted bibliographical works, voucher number and parts used. Vernacular names [original transcription in diferent alphabet], pathological groups, conditions and citations in the five data sources. Conditions in bold coincide for at least four sources. Acronyms: A: Andalusian vernacular name (literature review; see text); DL: Laguna´s Dioscorides, with book and chapter in Laguna (1555); E: English vernacular name; IB: Ibn al-Baytar, with number of chapter in Leclerc (1877-1883); M: Moroccan vernacular name (this study); NM: not mentioned; Q: Quer, with book and page number (see text for references). Pathological groups are according ICPC-2.

Scientific name (s), Vouchers (Part used)	Vernacular names	Pathological group	Condition	IB	DL	Q	M	A
Artemisia spp.	E: wormwood.	A. General and Unspecified	Weakness/tiredness general	+	-	-	-	-
M: Artemisia arborescens L. MP-Ast-001	M: chîba [شيبة].		**Fever**	**+**	**+**	**+**	**+**	-
A: Artemisia absinthium L.	A: ajenjo, asensio, hierba santa, artemisia.		Dropsy/ascites	-	+	+	-	-
IB: Artemisia arborescens L.; *A. absinthium* L.	IB: (n° 113, 759, 957, 1942):		Measles	-	-	-	-	+
(Leaves and steams)	afsantîn, damsîsa, khatraf, kochût rûmî, dohn afsantîn [نالأفسنتين أفسنتين،دمسيسة،خطرف،كشوثرومي،ده].	B. Blood, Blood Forming Organs and Immune Mechanism	Spleen disease	+	-	-	-	-
	DL: (III, ch.24): apsínthion [ἀψίνθιον]	D. Digestive	Gallbladder disease/ cholecystitis/ cholelithiasis	+	-	-	-	-
	Q: (II, 142): agenjo.		**Stomach disorders/pain/dyspepsia**	**+**	**+**	**+**	**+**	**+**
			Intestine disorders	+	-	-	-	-
			Teeth/gum disease	+	+	-	-	-
			Liver diseases	+	+	+	-	-
			Anal fissure	+	-	-	-	-
			Flatulence/gas/belching	+	+	-	-	-
			Helminthiasis/ other intestinal parasites	+	+	-	+	-
			Jaundice	+	-	-	-	-
			Nausea/ vomiting	-	-	-	+	-
		F. Eye	Eye inflammation/eyelids/ ophthalmia	+	+	-	-	-
		H. Ear	Ear pain/ earache/otitis	+	+	-	-	-
		K. Cardiovascular	Hemorrhoids	+	-	-	-	-
			Inflammation/ swollen of the extremities /ankles	+	-	-	-	-
		L. Musculoskeletal	Joint signs/symptoms/pain/ rheumatism	+	-	-	-	-
		N. Neurological	Sciatica	-	-	+	-	-
			Paralysis / tongue /other members	+	-	-	-	-
		P. Psychological	Alcohol abuse / drunkenness	+	+	-	-	-
		R. Respiratory	Throat symptom/ pharynx / tonsils	+	+	+	-	-
			Pectoral pains/ pleura/ cold / cough	+	-	-	-	-
		S. Skin	Alopecia	+	-	-	-	-
			Animal/insect bites	+	-	+	-	-
			Burns	-	-	+	+	+
		T. Endocrine/ Metabolic and Nutritional	**Anorexia/Loss of appetite**	**+**	**+**	**+**	**+**	**+**
		U. Urological	Kidney disease	+	-	-	-	-
			Diuretic	+	-	-	-	-
		X. Female Genital	**Menstruation disorders**	**+**	**+**	**+**	**+**	-
Calendula officinalis L.	E: pot marigold.	A. General and Unspecified	Cancer/ tumor/malignant diseases	**-**	**-**	**-**	**-**	**+**
MP-Ast-002	M: ej-jâmra [**حمرة**].		Scrofulosis	+	-	+	-	-
(Flowers)	A: caléndula, flor de todos los meses, flor del muerto		Plague (pest)	-	-	+	-	-
			Sweating problem	-	-	+	+	-
	IB: (n° 30): adryûn [**أدريون**].		Consumption	-	-	+	-	-
	DL: NM	B. Blood, Blood Forming Organs and Immune Mechanism	Spleen disease	-	-	+	-	-
	Q: (III, 376): calendula, flor de todos los meses.	D. Digestive	Teeth/gum disease	+	-	-	-	-
			Liver diseases	-	-	+	-	-
			Nausea/ vomiting	+	-	-	-	-
		F. Eye	Eye inflammation/eyelids/ ophthalmia	-	-	+	-	-
		K. Cardiovascular	Hypertension	-	-	-	+	-
			Palpitations/awareness of heart	+	-	-	-	-

(*continued on next page*)

Table 1 (*Continued*)

Scientific name (s), Vouchers (Part used)	Vernacular names	Pathological group	Condition	IB	DL	Q	M	A
		N. Neurological	Headache	-	-	-	-	+
		P. Psychological	Sexual desire reduced/ aphrodisiac	+	-	-	-	-
		S. Skin	Wounds / ulcers / sores / vulnerary	-	-	-	-	+
			Animal/insect bites	+	-	+	-	-
		U. Urological	Diuretic	-	-	+	-	-
		W. Pregnancy, Childbearing, Family Planning	Pregnancy/abortive	+	-	-	-	-
			Feminine infertility	+	-	-	-	-
		X. Female Genital	Affections of the matrix	-	-	+	-	-
			Menstruation disorders	-	-	+	+	-
Carthamus spp.	E: safflower.	A. General and Unspecified	Colic	+	-	-	-	-
M: Carthamus tinctorius L. MP-Ast-003	M: ôsfor [**عصفر**].	D. Digestive	Liver diseases	-	+	+	-	-
A: Carthamus lanatus L.	A: cardo cuco, pincho cambrón.		Constipation	-	+	+	+	-
IB: Carthamus tinctorius L.	IB: (n° 23, 370, 939, 1548, 1761, 2119): ihrîdh, behrem, 'usfur, murrîk, qurtum,		Flatulence/gas/belching	+	-	-	-	-
(Flowers and seeds)	behremân, khirrî' [**إحريض،بهرام،عصفر،مريق،ق مرطم،بهرمان،خريع،دهنالقرط**].	F. Eye	Eye inflammation/eyelids/ ophthalmia	-	-	-	+	-
	DL: (IV, ch. 89): knikelaion [κνικέλαιον].	P. Psychological	Sexual desire reduced/ aphrodisiac	+	-	-	-	-
	Q: (IV, 51): alazor, simiente de papagayos.	R. Respiratory	Throat symptom/ pharynx / tonsils	-	-	-	-	+
			Pectoral pains/ pleura/ cold / cough	-	+	+	-	-
		S. Skin	Abscess/ tumor/ boils/ cutaneous infection	+	-	-	-	-
			Corn/callosity	-	-	-	-	+
			Erysipelas	+	-	-	-	-
			Wounds / ulcers / sores / vulnerary	+	-	-	+	+
			Impetigo	+	-	-	-	-
			Freckles / skin blemishes	+	-	-	-	-
Centaurea calcitrapa L.	E: purple starthistle.	A. General and Unspecified	**Fever**	**+**	**-**	**-**	**+**	**+**
MP-Com-004	M: bû- neggâr [**نقاربو**].	D. Digestive	Stomach disorders/pain/dyspepsia	-	-	-	-	+
(Whole Plant)	A: calcitrapa, cardo estrellado, abrojos, abrepuños, pincho, azotacristos, clave-		Liver diseases	+	-	-	-	-
	litos, estrella del sol.	F. Eye	Eye inflammation/ eyelids/ ophthalmia	-	-	-	+	-
	IB: (n° 2106) murrâr, murrîr, derderîya, chouka meghila [**دردرية،مرير،مرار**]							
	Berber: [**مغيلةشوكة**].	K. Cardiovascular	Circulatory disorders	+	-	-	-	-
	DL: NM.	N. Neurological	Headache	-	-	-	+	-
	Q: (IV, 23): cardo estrellado.	R. Respiratory	Pectoral pains/ pleura/ cold / cough	+	-	-	-	-
		S. Skin	Wounds / ulcers / sores / vulnerary	-	-	-	+	-
		T. Endocrine/ Metabolic and Nutritional	Pruritus	+	-	-	-	-
			Scabies	+	-	-	-	-
			Anorexia/ loss of appetite	-	-	-	+	-
		U. Urological	Kidney disease	-	-	-	-	+
			Diuretic	-	-	+	+	-
Cichorium intybus L.	E: common chicory.	A. General and Unspecified	Weakness/general tiredness	-	-	+	-	+
MP-Ast-005	M: bû-aggâd [**عقادبو**], hîndab [**هنداب**], tîfaf [**تيفاف**].		Fever	+	-	+	-	-
(Aeral part)	A: achicoria, chicoria, chicoreta, endivia, camarroja, mamporrina.		Inflammation	-	-	+	-	-
	IB: (n° 2263): hindabâ, ântûbya, âmayrûn, hindabâ chami, hindabâ hachimi [**شامي, هندباهاشمي هندبا،أنطوبيا،الأميرون،هندبا**]	B. Blood, Blood Forming Organs and Immune Mechanism	Spleen disease	+	-	-	-	-
	DL: (II, ch. 121): seris [σέρις]	D. Digestive	Gallbladder disease /Cholecystitis/ cholelithiasis	+	-	-	-	-
	Q: (IV, 246): achicoria silvestre.		**Stomach disorders/pain/dyspepsia**	**+**	**+**	**+**	**-**	**+**
			Teeth/gum disease	-	-	+	-	-
			Liver diseases	**+**	**+**	**+**	**-**	**+**
			Constipation	-	+	+	-	+
			Jaundice	**+**	**+**	**+**	**+**	-
			Nausea/ vomiting	+	-	-	-	-
		F. Eye	Eye inflammation/eyelids/ ophthalmia	-	+	+	-	-
		K. Cardiovascular	Blood purifier	+	-	+	-	-
			Hypertension	-	-	-	+	-

(*continued on next page*)

Table 1 (*Continued*)

Scientific name (s), Vouchers (Part used)	Vernacular names	Pathological group	Condition	IB	DL	Q	M	A
			Palpitations/awareness of heart	+	+	-	-	-
		R. Respiratory	Throat symptom/ pharynx / tonsils	+	-	-	-	-
			Pectoral pains/ pleura/ cold / cough	-	-	+	-	-
		S. Skin	Abscess/ tumor/ boils/ cutaneous infection	+	-	-	-	-
			Animal/insect bites	+	+	-	-	-
			Erysipelas	-	+	-	-	-
		T. Endocrine/ Metabolic and Nutritional	Anorexia/ loss of appetite	-	-	+	+	+
			Diabetes	-	-	-	+	-
			Hyperuricemia	-	+	+	-	-
		U. Urological	Kidney disease	+	-	-	-	+
			Diuretic	-	-	+	+	+
			Urinary infection	-	-	+	-	-
Cynara scolymus L.	E: artichoke.	A. General and Unspecified	Depurative	-	-	-	-	+
MP-Com-006	M: khorchef (**خرشف**), i-gerni' (**لقرنيع**).	D. Digestive	Gallbladder disease /cholecystitis/ cholelithiasis	-	-	-	-	+
(Roots)	A: alcaciles, alcochofa, alcochoferas, alcancil, alcaucil, cardo.							
	IB: (n° 524, 658, 659, 1976): djenah en-Nesr,herchef, scoloumos, lassif, harchef bostany, kenarya, kenguer [**اني،كنكر،سقلومس،لصيف،حرشفبستجناحالنسر،حرشف،قنارية**]. Berber: fezan (**فزان**).		Stomach disorders/pain/dyspepsia	-	-	+	+	-
			Diarrhea	+	-	-	-	-
			Liver diseases	-	-	-	-	+
			Flatulence/gas/belching	+	-	-	-	-
	DL: NM.		Jaundice	-	-	+	-	-
	Q: (IV, 301): alcachofera.		Nausea/ vomiting	-	-	-	-	+
		K. Cardiovascular	Hemorrhoids	+	-	+	-	+
			Hypertension	-	-	-	+	-
		L. Musculoskeletal	Joint signs/symptoms/pain/ rheumatism	-	-	-	-	+
		R. Respiratory	Pectoral pains/ pleura/ cold / cough	+	-	-	-	-
			Asthma	+	-	-	-	+
		S. Skin	Pediculosis / lice / nits	+	-	-	-	-
			Pruritus	+	-	-	-	-
		T. Endocrine/ Metabolic and Nutritional	Anorexia/ loss of appetite	-	-	+	-	-
			Diabetes	-	-	-	-	+
			Hypercholesterolemia	-	-	-	+	+
			Hyperuricemia	-	-	-	-	+
		U. Urological	Kidney disease	+	-	-	-	+
			Bladder symptom	+	-	-	-	-
			Diuretic	+	-	+	-	+
Dittrichia viscosa (L.) Greuter	E: false yellowhead.	A. General and Unspecified	Cancer/Tumor/malignant diseases	-	+	-	-	-
MP-Ast-007	M: tirreklane [**تركلان**], terrkil [**تركل**].		Colic	-	+	-	-	-
(Whole plant /leaves)	A: altabaca, olivarda, matamosquera, belesa, flor de árnica.		Pain	+	-	-	-	-
	IB: (n° 413, 1448): thobbaq, quniza (**طباق،قونيزة**). Berber: terhelán, tarhelá (**ترهلان،ترهلا**).		Fever	+	+	-	-	-
			Bleeding/haemorrhage	-	-	-	-	+
	DL: (III, ch.130): kónyza megál [κόνυζα μεγάλη].	D. Digestive	Stomach disorders/pain/dyspepsia	-	-	-	-	+
	Q: (VI, 472): olivarda, yerba peluquera.		Diarrhea	-	-	-	+	-
			Teeth/gum disease	-	-	-	-	+
			Liver diseases	+	-	-	-	-
			Jaundice	-	+	-	-	-
			Peptic ulcer	-	-	-	+	+
		K. Cardiovascular	Hemorrhoids	-	-	-	-	+
		L. Musculoskeletal	Sprains	-	-	-	-	+
			Bone fracture	+	-	-	-	+
			Joint signs/symptoms/pain/ rheumatism	-	-	-	+	-
		N. Neurological	Headache	-	+	-	-	-
			Epilepsy	+	-	-	-	-
			Nervous disorders	-	+	-	-	-

(*continued on next page*)

Table 1 (*Continued*)

Scientific name (s), Vouchers (Part used)	Vernacular names	Pathological group	Condition	IB	DL	Q	M	A
		R. Respiratory	Pectoral pains/ pleura/ cold / cough	-	-	-	-	+
		S. Skin	Corn/callosity	-	-	-	-	+
			Contusion	-	+	-	-	+
			Dermatitis/atopic eczema	-	-	-	-	+
			Erysipelas	-	-	-	-	+
			Wounds / ulcers / sores / vulnerary	-	+	-	+	+
			Pediculosis / lice / nits	-	+	+	-	-
			Animal/insect bites	+	+	+	-	-
			Pruritus	+	-	-	-	-
			Chilblains/erythema	-	-	-	-	+
			Scabies	+	-	+	-	-
		U. Urological	Dysuria/strangury	-	+	-	-	-
		W. Pregnancy, Childbearing, Family Planning	Pregnancy/abortive	-	+	-	-	-
		X. Female Genital	Female genital infection	-	+	-	-	+
			Menstruation disorders	+	+	-	-	+
Lactuca sativa L. MP-Ast-008 (Leaves)	E: lettuce. M: lkhâss [**خس**], chlada [**شلاظة**]. A: lechuga. IB: (n° 792): khass [**خس**]. DL: (II, ch. 75): thridax emeros [θρίδσξ ήμερος]. Q: (V, 293): lechuga comun.	D. Digestive	Gallbladder disease/ cholecystitis/ cholelithiasis	+	-	-	-	-
			Stomach disorders/pain/dyspepsia	**+**	**+**	**+**	**-**	**+**
			Liver diseases	-	+	+	-	-
			Constipation	**+**	**+**	**+**	**+**	**+**
			Jaundice	+	-	-	-	-
		F. Eye	Eye inflammation/eyelids/ ophthalmia	+	+	-	-	-
		L. Musculoskeletal	Sprains	+	-	-	-	+
		N. Neurological	Headache	+	-	-	-	-
			Nervousness	-	-	+	-	-
		P. Psychological	Anaphrodisiac	+	+	-	-	-
			Delirium	+	-	-	-	-
			Sleep disturbance	**+**	**+**	**+**	**-**	**+**
		R. Respiratory	Pectoral pains/ pleura/ cold / cough	+	-	-	-	+
		S. Skin	Skin conditions / Emollient	-	-	-	+	-
			Alopecia	-	-	-	-	+
			Wounds / ulcers / sores / vulnerary	-	+	+	-	-
			Animal/insect bites	+	+	-	-	-
		T. Endocrine/ Metabolic and Nutritional	**Anorexia/ loss of appetite**	**+**	**+**	**+**	**+**	-
			Excessive thirst	**+**	**+**	**+**	**+**	-
		U. Urological	Bladder symptom	+	-	-	-	-
			Diuretic	+	-	+	-	+
		W. Pregnancy, Childbearing, Family Planning	Galactogen	-	+	-	-	-
		X. Female Genital	Menstruation disorders	-	+	-	-	-
Matricaria chamomilla L. MP-Ast-009 (Flowered aeral parts)	E: chamomille. M: bâbounj [**بابونج**], ûqhuwàn [**أقحوان**]. A: manzanilla. IB: (n° 121, 1767) ûqhuwàn, babonj, kerkâch, parthenion, chjarat maryem, chjarat el kafor, quorras, kafouriya [**ر،قراص،كافورية،يون،شجرةمريم،شجرةالكافورأقحوان،بابونج،كركاش،فرتان**] DL: (III, ch. 147): anthemís [άνθεμίς] Q: (V, 405): matricaria.	A. General and Unspecified	Pain	-	+	-	-	-
			Fever	-	+	-	+	-
			Dropsy/ascites	-	-	+	-	-
			Obstruction	+	-	-	-	-
			Sweating problem	+	-	-	-	-
		D. Digestive	Gallbladder disease / cholecystitis/ cholelithiasis	-	-	-	-	+
			Stomach disorders/pain/dyspepsia	+	-	-	+	+
			Teeth/gum disease	-	-	-	-	+
			Liver diseases	-	+	-	+	+
			Constipation	-	-	-	-	+
			Flatulence/gas/belching	-	+	-	+	+
			Halitosis	-	-	-	-	+
				-	-	+	-	-

(*continued on next page*)

Table 1 (*Continued*)

Scientific name (s), Vouchers (Part used)	Vernacular names	Pathological group	Condition	IB	DL	Q	M	A
			Helminthiasis/ other intestinal parasites					
		F. Eye	Eye inflammation/eyelids/ ophthalmia	-	+	-	-	+
		K. Cardiovascular	Hemorrhoids	-	-	-	-	+
			Hypertension	-	-	-	-	+
			Circulatory disorders	-	-	-	-	+
		N. Neurological	Headache	-	-	-	-	+
			Neurological symptom	+	-	-	-	-
		P. Psychological	Depression / melancholy	+	-	-	-	-
			Sexual desire reduced/aphrodisiac	+	-	-	-	-
			Sleep disturbance	+	-	-	-	+
		R. Respiratory	Throat symptom/ pharynx / tonsils	-	-	-	-	+
			Pectoral pains/ pleura/ cold / cough	-	-	-	-	+
			Asthma	+	-	-	-	-
		S. Skin	Wounds / ulcers / sores / vulnerary	-	-	-	-	+
			Burns	-	-	-	-	+
		T. Endocrine/ Metabolic and Nutritional	Anorexia/ loss of appetite	+	-	-	-	+
		U. Urological	**Kidney disease**	**+**	**+**	**+**	**-**	**+**
			Bladder symptom	-	-	-	+	-
			Diuretic	**+**	**+**	**+**	**-**	**+**
		W. Pregnancy, Childbearing, Family Planning	Pregnancy/abortive	-	+	-	-	-
			Childbirth difficulties	-	+	-	-	-
		X. Female Genital	Affections of the matrix	+	+	-	-	+
			Menstruation disorders	**+**	**+**	**+**	**+**	**+**
Silybum marianum (L.) Gaertn. MP-Ast-010 (Flowered aeral parts/ Leaves and roots)	E: milk thistle. M: chouk jmel [**حملشوك**]. A: cardo mariano, cardo borriquero, cardencha. IB: (n° 1357, 1574) uqûb, chouk eddemen [**الدمنشوك, عكوب**]. D: (IV, 160): silubon [σίλλυβον]. Q: (IV, 19): cardo lechero.	A. General and Unspecified	Weakness/tiredness general	-	-	-	+	-
			Flank pain	-	-	+	-	-
			Fever	-	-	-	-	+
			Malta fever	-	-	-	-	+
			Dropsy/ascites	+	-	+	-	-
			Bleeding/haemorrhage	-	-	-	-	+
		D. Digestive	Gallbladder disease / cholecystitis/ cholelithiasis	+	-	-	-	+
			Emetic	+	+	-	-	-
			Liver diseases	-	-	+	+	+
			Jaundice	-	-	+	-	-
		K. Cardiovascular	Blood purifier	-	-	-	-	+
			Hypertension	-	-	-	+	-
		R. Respiratory	Pectoral pains/ pleura/ cold / cough	-	-	+	-	+
		S. Skin	Skin conditions / emollient	-	-	+	-	-
			Herpes	-	-	-	-	+
		T. Endocrine/ Metabolic and Nutritional	Anorexia/ loss of appetite	-	-	+	-	-
		U. Urological	Kidney disease	-	-	+	-	-
			Diuretic	-	-	+	+	-

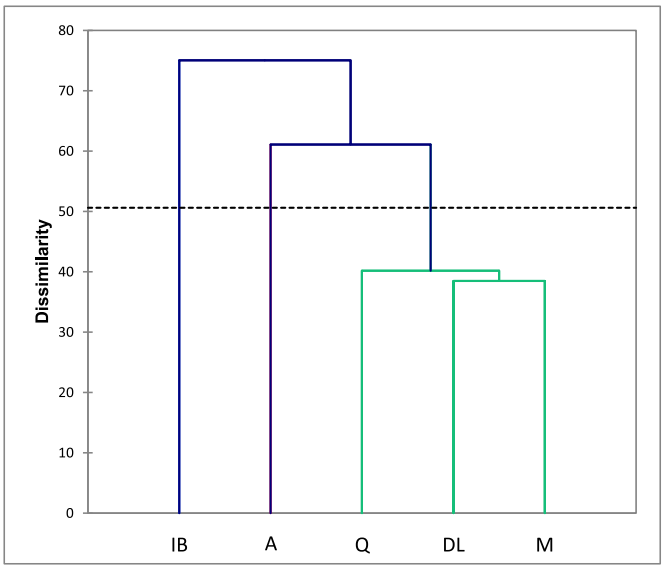

Fig. 3. Hierarchical cluster dissimilarity analysisfor the 5 sources for all uses from Table 1.

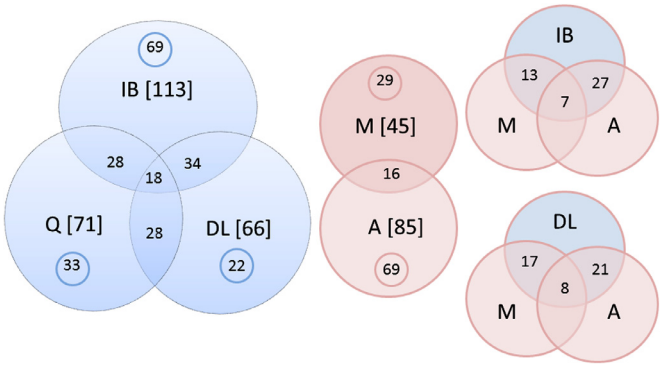

Fig. 4. Venn diagrams for coincident uses in the historical sources (blue), modern ethnobotanical sources (pink), and al-Baytar and Dioscorides with Morocco and Andalusia. Numbers in brackets are total uses of the source. Numbers in circles represent non-shared uses (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

Arab-Islamic tradition (here analysed with Ibn al-Baytar), and not with the Classical Greek-Roman one. But, as commented above, in Morocco there are currently lots of street markets and small shops where most of the plants used in traditional medicine are offered and it is the seller himself who, in many cases, acts as a transmitter of this knowledge, whose origin may come from Dioscorides through Arabic translators. On the other hand, Andalusia is closer to the uses described in Ibn al-Baytar (27 shared uses; 32%) than with Dioscorides (21; 25%; see Fig. 4). In conclusion, despite the fact that coincidences have not been as we expected (*M* more related to IB and *A* more related to *D*, but just the opposite), it has been proven that there is a high overlap between historical sources and both territories, as our second hypothesis suggested.

4.2. Comparison between sources within pathological groups

Jaccard's index value in ethnopharmacology has been questioned (Weckerle et al., 2018) but we find it valuable as a numerical comparison tool to analyse the primary data of our research (in this case, the use of the species in any condition of a certain pathological group among the used data sources). According to the Jaccard's index (Table 4), the highest similarity in the quotation of medicinal uses in the 5 sources was found for digestive conditions but, unexpectedly again, not for Ibn al-Baytar and Morocco, but for Dioscorides and Morocco (87.5), what is in concordance with the exposed in the previous section. In fact, Ibn al-Baytar's work has the same 80 Jaccard's index with Morocco, Andalusia and Quer. Similarities in the use of these plants for skin conditions are also high, especially for Andalusia and Quer, and strikingly low for Andalusia and Dioscorides, maybe reflecting than the uses of these plants have change with time, maybe because there are other preferred plants for these conditions in Andalusia. It is also surprising one index of 100 for Morocco and Quer in female genital system, because *Artemisia* spp., *Calendula officinalis* L. and *Matricaria chamomilla* L. are quoted in both sources for menstruation disorders, and not for other female conditions (see Table 1). This data will be discussed more in depth below.

4.3. Uses preserved along time and pharmacological evidence

Most of these Asteraceae are well-known medicinal plants (Table 2), with a long tradition of use and more or less in-depth phytochemical and pharmacological studies assessing their properties. Six of them appear in the 9th Edition of the European Pharmacopoeia (2016) as well as six in the commission *E* monographs (Blumenthal et al., 2000), five in the ESCOP monographs (ESCOP, 2003, 2009) and eight are considered medicinal plants in a phytoterapy vademecum (Vanaclocha and Cañigueral, 2010), works which can be consulted for a detailed phytochemical and pharmacological information.

Some uses can be said to be "preserved along time" (highlighted in bold in Table 1) since they were mentioned in the 3 historical sources reviewed, and were also recorded in the ethnobotanical field works on Morocco (5 uses in Table 1), Andalusia (6 uses), or both of

Table 2
Plants included in Eur. Pharm., and selected important references on medicinal plants and phytotherapy.

	Pharm. Eur. 9.7	ESCOP	Commission E monographs (Blumenthal et al., 2000)	Phytotherapy (Vanaclocha and Cañigueral, 2010)
Artemisia spp.	*Absinthii herba*	*A. absinthium*	A : Wormwood	*A. absinthium*
Calendula officinalis L.	*Calendulae flos*	*C. officinalis*	A : Calendula flower, I : Calendula herb	*C. officinalis*
Carthamus spp.	*Carthami flos ; Carthami oleum raffinatum*			*C. tinctorius*
Centaurea calcitrapa L.				*C. calcitrapa*
Cichorium intybus L.			A : Chicory	*C. intybus*
Cynara scolymus L.	*Cynarae folii extractum siccum ; Cynarae folium*	*C. scolymus*	A : Artichoke leaf	*C. scolymus*
Dittrichia viscosa (L.) Greuter				
Lactuca sativa L.				
Matricaria chamomilla L.	*Matricariae aetheroleum, Matricariae extractum fluidum, Matricariae flos*	*M. chamomilla*	A : Chamomile flower, German	*M. chamomilla*
Silybum marianum (L.) Gaertm.	*Silybi mariani extractum siccum raffinatum et normatum, Silybi mariani fructus*	*S. marianum*	A : Milk Thistle fruit, I : Milk Thistle herb	*S. marianum*

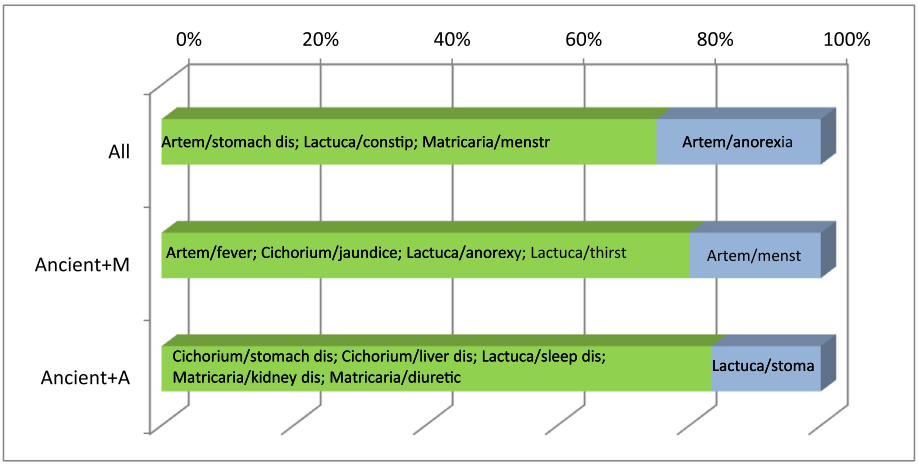

Fig. 5. Pharmacological evidence for uses preserved along time. Green: uses with demonstrated evidence; blue: uses with probable evidence (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

them (4 uses). In this section we discuss theses uses and the pharmacological evidence for them.

Special mentions deserve uses recorded in the 5 data sources for which a higher consensus through time and territory was obtained. These old uses transmitted through time are still being practised in both sides of the Mediterranean: *Artemisia* spp. to treat stomach disorders (including dyspepsia) and anorexia (or loss of appetite), chamomile against menstruation disorders, and lettuce to treat constipation. All of these medicinal uses have been surveyed through ethnopharmacological studies. Although *Artemisia absinthium* is cited as appetite stimulant and to treat dyspepsia in the literature (Blumenthal et al., 2000) the first use should be better studied, since Baghban Taraghdari et al. (2015) found no positive and dose-related effects on appetite of rats. Sharifi et al. (2014) and Maleki-Saghooni et al. (2018) related chamomile consumption with a relieve of the intensity of pre-menstrual syndrome associated symptomatic psychological pains, and Mirabi et al. (2014) stablished promising evidence supporting the use of chamomile tea for primary dysmenorrhea. With regard to lettuce and constipation, it can be explained on the high dietary fiber content of the vegetable (Kim et al., 2016).

Cichorium intybus L. is cited through historical sources to treat jaundice and liver disease, coinciding with current ethnomedicinal uses in Eastern Morocco and Eastern Andalusia respectively (Table 1). Jaundice is a symptom for several possible medical causes (pre-hepatic, hepatocellular, post-hepatic jaundice), related to several liver diseases, including hepatitis (hepatocellular jaundice), hepatotoxicity, cirrhosis, etc. Thus, it is clear that the demonstrated anti-hepatotoxic and hepatoprotective effect of *C.intybus* (Ahmed et al., 2003; Li et al., 2014) can serve to treat this symptom. Another coincidence was found for Morocco and the historical texts using lettuce against anorexy or appetite loss and to treat excessive thirst. Historically, the Romans ate a lot of lettuce, generally after the meal to promote sleep, but occasionally before it to stimulate the appetite (Bynum and Bynum, 2016). This well-studied vegetable with good nutritional value has shown anti-inflammatory, cholesterol-lowering, and anti-diabetic activities through *in vitro* and *in vivo* studies (Kim et al., 2016). We have not found any study dealing with its supposed properties to treat the mentioned conditions, but some of its chemicals could point to shallow explanations of these uses: its beta-carotene content (Kim et al., 2016) may have a role in the suppression of appetite loss. Lower beta-carotene in the adipocytes is related with obesity (Östh et al., 2014), thus it is feasible to think that an increase in the intake of beta-carotene can influence the appetite. Moreover, the micronutrient density of a diet influences the experience of hunger (Fuhrman et al., 2010), and lettuce is rich in some of them, since commonly found vitamins in lettuce include folate, and vitamins *C* and *E* (Kim et al., 2016). With regard to thirst, it is well-known the effect of salts in it apparition, as well as the low salt concentration in lettuce. The use of chiba, *Artemisia arborescens* L. in Morocco is frequent, mainly as a complement to flavour mint-tea. Its use against menstrual disorders was already cited in Dioscorides, Ibn al-Baytar and Quer. Containing mainly chamazulene, camphor, β-thujone, myrcene and α-pinene in the essential oil and 15 flavonoids (Costa et al., 2016), its use in menstrual disorders has not been pharmacologically assessed. Nevertheless, other species of the genus are used to treat this condition elsewhere (e.g. *Artemisia absinthium* L. in Morocco or *Artemisia herba-alba* Asso in Jordan; Ziyyat et al., 1997; Alzweiri et al., 2011).

Some more historically preserved medicinal uses can be highlighted for Eastern Andalusia as, f.i., the use of lettuce against sleep disturbances and stomach disorders or dyspepsia. It is known that the *lactucarium* (milky fluid) from lettuce was used to induce sleep (frequent use in Roman times; Bynum and Bynum, 2016) and it was included in several historical herbals (e.g. Dioscorides, see Table 1) and dispensatories (as the King's American Dispensatory, Felter and Lloyd, 1898), mainly achieved from wild lettuce (*Lactuca virosa* L.). Lettuce is rich on the

Table 3
Uses included in each pathologic group. IB: Ibn al-Baytar; DL: Dioscorides; Q: Quer; M. Morocco; A: Andalusia.A: general/unspecified; B: blood/blood forming organs/immune mechanism; D: digestive; F: eye; H: ear; K: circulatory; L: musculoskeletal; N: neurological; P: Psychological; R: respiratory; S: skin; T: endocrine/metabolic/nutritional; U: urinary system; W: pregnancy, childbearing, family planning; X: female genital system; Y: male genital system; Z: social problems.

Pathological group	A	B	D	F	H	K	L	N	P	R	S	T	U	W	X	Total
IB	11	2	28	2	1	7	3	4	9	8	18	4	10	2	4	113
DL	8	0	18	4	1	1	0	2	3	2	9	4	4	4	6	66
Q	12	1	18	2	0	2	0	2	1	4	8	7	10	0	4	71
M	5	0	13	2	0	4	1	1	0	0	5	7	4	0	3	45
A	9	0	22	1	0	6	4	2	2	7	14	6	8	0	4	85
Total	45	3	99	11	2	20	8	11	15	21	54	28	36	6	21	380

Table 4
Jaccard's index for pathological groups analysing the use of a given species for a given condition in the 5 sources. Indexes over 60 are marked in bolds.

		D: Digestive				
		IB	**DL**	**Q**	**M**	**A**
S: Skin	**IB**		**70**	**80**	**80**	**80**
	DL	50		**66.67**	**87.5**	**66.67**
	Q	44.44	28.57		**77.7**	60
	M	62.5	50	42.86		**77.78**
	A	50	22.22	**71.43**	50	
		A: General/ unspecified				
		IB	**DL**	**Q**	**M**	**A**
U: Urinary system	**IB**		50	**62.5**	**62.5**	**66.67**
	DL	14.29		28.57	50	37.5
	Q	50	25		**66.67**	50
	M	28.57	40	57.14		50
	A	**66.67**	33.33	**71.43**	50	
		P: Psychological				
		IB	**DL**	**Q**	**M**	**A**
R: Respiratory	**IB**		40	20	0	40
	DL	14.29		50	0	33.33
	Q	25	50		0	50
	M	0	0	0		0
	A	33.33	14.29	25	0	
		K: Circulatory				
		IB	**DL**	**Q**	**M**	**A**
N: Neurological	**IB**		20	40	50	12.5
	DL	25		50	25	0
	Q	50	0		50	20
	M	0	0	0		33.33
	A	20	0	0	0	
		T: Endocrine/metabolic/nutritional				
		IB	**DL**	**Q**	**M**	**A**
X: Female genital	**IB**		50	33.33	33.33	40
	DL	**75**		60	60	40
	Q	50	40		**66.67**	50
	M	50	40	**100**		50
	A	**66.67**	50	25	25	

sesquiterpene lactone lactucin (red romaine: 361.50 μg/g of extract, green romaine: 1071.67 μg/g of extract), involved in the increase in the sleep duration at low and high doses of seed and leaf extracts derived from romaine lettuce (Kim et al., 2017). On the other hand, the relation of lettuce with dyspepsia has not been properly studied, although it is one of the foods less related with dyspeptic symptoms in studies with patients suffering functional dyspepsia (Carvalho et al., 2010; Filipović et al., 2011). In fact, lettuce was probably originally cultivated for its medicinal properties, although culinary use followed (Bynum and Bynum, 2016).

Other interesting uses with consensus on the historical herbals and Andalusia are chamomile as diuretic and against kidney disease. As Cemek et al. (2008) pointed up, chamomile is also used as diuretic in Turkish traditional medicine, and its pharmacological value was studied *in vivo* on the basis of its antihyperglycemic and antioxidative potential. Its use in kidney diseases was found to be effective, as well as in diabetic complications (Kato et al., 2008). The use of chicory against stomach disorders and dyspepsia was also cited in all the historical sources, is still practised in Andalusia, and is pharmacologically validated in the modern phytotherapy literature (e.g. Blumenthal et al., 2000).

Therefore, most of the current ethnomedicinal uses for these plants with a high historical consensus, have ethnopharmacological evidence: 75% of the cited in the 5 information sources, 80% of the cited in the 3 historical sources plus current Moroccan ethnobotany, and 83% of the historical plus Andalusia (see Fig. 5). Nevertheless, we should add that the proportion of conserved uses for all the information sources is less than expected (only 4 of the 380 use records).

4.4. Comments on other pharmacologically demonstrated uses

Apart from the above commented uses, some other well-known phytoterapeutical uses of the included Asteraceae deserve to be commented. For instance, use of the milky thistle, *Silybum marianum* (L.) Gaertn. to treat liver diseases seems to be firstly quoted in our review by Quer. This use is strongly pharmacologically supported by the presence on its fruits (the only approved part in Blumenthal et al., 2000; Table 2) of silibinin, silydianin, and silychristin, particularly for toxic liver damage and supportive treatment in chronic inflammatory liver disease and hepatic cirrhosis. Ethnobotanical records were found for the use, as to be traditionally performed and transmitted currently in both Eastern Andalusia (Benítez et al., 2010) and Eastern Morocco. Curiously, Ibn al-Baytar mentioned it use in gallbladder disease, which was also recorded in Andalusia but not in Morocco, Dioscorides or Quer, and was also slightly pharmacologically studied, but is currently unapproved in Blumenthal et al. (2000) "disorders of liver and gallbladder" for milky thistle herb.

Concerning chamomile, some of its approved phytoterapeutical uses in Blumenthal et al. (2000), or Vanaclocha and Cañigueral (2010) are not mentioned in our work as, f.i., externally for bacterial skin diseases. We have references for its use in burns and wounds in Andalusia, similar to the proposed (Blumenthal et al., 2000) to treat skin and mucous membrane inflammations. More or less the same can be said for the Andalusian traditional use in throat symptom and pectoral pains, cold or cough, similar to the official use of the plant for inflammations and irritations of the respiratory tract. Its phytoterapeutical use in gastrointestinal spasms and inflammatory diseases could support our (emic standpoint) references in stomach disorder or pain and dyspepsia recorder for Andalusia and Morocco, as well in Ibn al-Baytar, or in flatulence (recorded in both territories and Dioscorides).

4.5. Ethnobotanical uses not cited in the historical texts and vice versa

A total of 59 uses recorded in the studied territories were not cited in the historical texts (Table 1). These uses have an unknown origin for us. Innovation, empirical new findings, extrapolation from another plant or any other origin may be possible. Nevertheless, we know that a bigger review with other herbals of both European and North-African traditions could enrich this analysis. Just two of them are cited in both Andalusia and Morocco, and deserve to be commented: artichoke (*Cynara scolymus* L.) against hypercholesterolemia, and *Dittrichia viscosa* (L.) Greuter against peptic ulcer. The first use has been studied and is pharmacologically validated (see Bundy et al., 2008; Mocelin et al., 2016). But the use of *Dittrichia* against peptic ulcer could be explained as a result of it use as substitute for *Arnica montana* L. in Andalusia. *Arnica* is a highly valuated anti-inflammatory plant, reputed as wound-healing in all Europe and Spain, where is also used to treat peptic ulcers in some territories (Villar and Bonet, 2014). The reputation of arnica has led to a number of substitutes through the Spanish ethnobotanical literature, especially in territories where *Arnica montana* does not naturally grow; the list of substitutes includes up to 10 Asteraceae in North Spain (Palacin et al., 1984), and 32 species from 6 botanical families (mainly Asteraceae) in the Iberian Peninsula and Balearic Islands (Obón et al., 2012). As *Dittrichia viscosa* is a popular substitute for *Arnica*, it may have been used not only as it substitutes for external anti-inflammatory use but also to internally treat peptic ulcers. *Dittrichia viscosa* has demonstrated gastroprotective and anti-ulcerogenic action (Martin et al., 1988; Alarcón de la Lustra et al., 1993).

For other shared uses in Morocco and Andalusia the first known written reference of the use is Quer: *Artemisia* on burns, chicory as diuretic and to avoid anorexia (cited in Blumenthal et al., 2000), and the previously commented use of the milky thistle in liver diseases. This reflects that, even containing a less amount of information on the medicinal use of plants (as commented in the introduction this

publication is a Spanish Flora and not a work on medicinal plants), some of the cited uses seem to have this historical value of being new or "these-times modern" uses of unknown previous origin, which seem to have been practiced in these times and orally transmitted to current times.

On the other hand, 32% of uses were cited in at least one of the historical texts but not in the ethnobotanical surveys in the studied territories. Nevertheless, only 3 uses were cited in all the historical texts and not in the ethnobotanical studies (*Artemisia* for liver disease and throat symptom, and *Dittrichia viscosa* for animal/insect bites). As these uses were cited in other Spanish or Moroccan territories (e.g., first ones by Obón et al., 2014 and Roldán et al., 2018), it is possible that they have been locally forgotten.

The importance of Ibn al-Baytar's Compendium could be highlighted again on the basis that for 113 uses included on this book for the studied plants, 79 were not cited in Dioscorides' *Materia Medica*, representing that nearly 70% of the uses included must have come from different previous physicians 'treaties, or from his own learning with other contemporary ones.

5. Conclusions

Morocco is a territory with a long and wide tradition in the use of medicinal plants, as demonstrated in this paper: 10 taxa of the family are traditionally used to treat 26 afflictions or symptoms from 10 pathological groups. Considering the bibliographical comparison with modern ethnobotanical sources in Andalusia and three historically important works, the 10 Asteraceae taxa reached 380 use records. They are or were used to treat 64 conditions of 15 pathological groups. Our first hypothesis was proven, and the overlap in plant use between the studied territories exists. The coincidence of current ethnobotanical knowledge for the Asteraceae in the two studied territories is high, as 35.5% of uses for these 10 taxa are practised in the same way in both territories. Nevertheless, it is not as high as expected and smaller than the obtained for the Lamiaceae (El-Gharbaoui et al., 2017). The historical background, recent cultural exchanges and information flow, and the influence of the consulted historical herbal texts in both traditions may have influenced this coincidence, but in a minor extent that for the Lamiaceae. The origin of the ethnobotanical knowledge could explain some of these differences: as commented, in Morocco the existence of small shops offering plant remedies for traditional medicine is usual even in the smallest populations, with herbalists recommending uses and spreading the tradition. This is much less common in Andalusia, where in rural areas it is common to collect plants from natural populations and to use them following the oral familiar or local tradition.

Throughout time, the tradition of writing herbal treatises usually includes the mention (or plagiarism) of uses that were associated to a certain plant by previous authors with recognized prestige. Nevertheless, the similarities between ancient sources are not always high since Ibn al-Baytar includes much more data on the use of most of plants, and many more medicinal simples. This was proved again, as nearly 70% of the uses included in his Compendium for the studied Asteraceae are of previous unknown origin. But besides differences between authors, medical schools, or traditions, we have seen a high overlap in plant-use between the selected historical texts and the current uses in both Morocco and Andalusia. Thus, we also consider that and our second hypothesis has been proven.

As the dataset used in this analysis is not so big (10 taxa, 380 uses in 5 information sources), we can deepen on the ethnopharmacological knowledge on the most interesting uses (e.g., those preserved through times, or shared in-between territories). A wider dataset could better explain how the cultural traditions have evolved since ancient times in both territories and the loss and introduction of plants or uses. But on the other hand, it would not be plausible for an ethnopharmacological analysis of the most interesting uses. In this sense, it is remarkable that among uses with a greater coincidence in the analysed sources (particularly those coincident in the 5 sources), most are currently recommended in clinical phytotherapy and accepted-approved through phytotherapeutical and ethnopharmacological studies and cited in popular phytotherapy books. This reinforces the idea that medicinal uses which are effective tend to be more propagated, either by the oral tradition or by specific books. Thus, the importance of comparing the current ethnobotanical knowledge with both the written history on the use of herbs and the ethnopharmacological literature is highlighted again as valuable tools for the better understanding of why and how people use plants, and what for.

Declaration of Competing Interest

None.

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