



Research article

Ethnobotanical knowledge in Calabria (southern Italy): A summary review

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ARTICLE INFO

Keywords:

Mediterranean basin
Ethnobotany
Biodiversity
Cultural heritage
Endemic species
Food plants
Medicinal plants

ABSTRACT

This paper presents a comprehensive overview of ethnobotanical knowledge in Calabria, southern Italy. The diverse plant uses and knowledge in the region stem from the cultural contributions of various populations that have inhabited the area since ancient times. To achieve the stated objective, an in-depth review of 16 bibliographic sources published between 1950 and 2024 was conducted, and data on ethnobotanical uses was extracted. The data were then analyzed using various indices, including CI, CV, FC, PPV, RFC, RI, and UV, to determine the most relevant species, families, and plant parts. A total of 4873 records were collected. The analysis shows that the Asteraceae family is the most used, while *Urtica dioica* L. and *Sambucus nigra* L. are the most frequently used species according to the CV index. Medicinal and alimentary purposes are the most common types of use. This study could serve as a foundation for further detailed research, contributing to the valorisation of the ethnobotanical heritage of this region.

1. Ethnobotanical knowledge: A wealth to be enhanced

As defined by Prance [1], ethnobotany is the study of the relationships between plants and people, including their uses, beliefs, management systems, classification, and language. It also encompasses the aquatic and terrestrial ecosystems associated with them. Prance posits that human existence be unfeasible without plants. In their study, Gilani & Rahman [2] put forth the proposition that herbs and plants have been integral to the human experience since the earliest periods of recorded history.

The studies conducted by Harshberger [3] and Balée [4] demonstrated the strong correlation between cultural practices and the utilization of plants. The studies indicate that plants were not merely material resources, but also held significant symbolic and spiritual meaning for indigenous societies. Subsequently, ethnobotanical studies have developed to integrate cultural understanding with scientific methodology.

The practice of ethnobotanical knowledge among indigenous communities can be traced back to the earliest periods of human civilization and has remained largely unchanged over time [5–7]. The field of ethnobotany is highly regarded for its vast repository of knowledge, as evidenced by numerous scientific contributions [8–11]. In the past, it was common practice for people to utilize wild plants in the preparation of medical remedies, including treatments for animal diseases. This was likely due to the isolation or inaccessibility of certain areas [12,13]. It is noteworthy that even in the present day, certain populations continue to consume seasonal foods derived from wild (or uncultivated) plants that are capable of self-sustainability without direct human intervention [14–16]. Furthermore, these plants are recognized for their high fiber content and bioactive compounds [17–19]. In the field of medicine, plants

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continue to play a crucial role in the development of new drugs [1,20,21], as they tend to produce minimal side effects and are naturally assimilated by the body [22–24].

The significance of plants in Europe, particularly in the Mediterranean region, is well documented. They constitute a fundamental element of the Mediterranean diet, as evidenced by numerous studies [25,26]. Italy, the country of origin of this dietary pattern, has been the subject of numerous studies investigating the beneficial effects of these dietary habits on human health [27,28].

The Italian region of Calabria has attracted considerable interest from ethnobotanists. A substantial body of research has been conducted on this subject [29–44], with studies highlighting the region's cultural stratification, shaped by various peoples including Greeks, Romans, Byzantines, Arabs, Normans, and Albanians. This has resulted in both linguistic and biological diversity [42]. Furthermore, Calabria is still home to rural communities where subsistence farming is practiced, and some archaic customs are still observed. It is therefore imperative that research be concentrated on this region, which is rich in living knowledge [31].

The objective of this study is to synthesize and examine all documented traditional plant uses in Calabria, with the aim of creating a digital database of the region's ethnobotanical heritage. Furthermore, it is essential to ensure the preservation and, more crucially, the promotion of this endangered cultural asset.

2. Materials and methods

2.1. Study area

The area under consideration is the Calabria region (Fig. 1), which spans approximately 15,222 km². Calabria is bordered to the east and south by the Ionian Sea, to the west by the Tyrrhenian Sea, and to the north by the region of Basilicata. The Strait of Messina forms a natural boundary between Calabria from the island of Sicily.

The region is predominantly mountainous, with approximately 90 % of its surface area occupied by two sections of the Apennine chain. These include the southern Apennines, which encompass the Pollino Massif, and the predominantly siliceous Calabrian Apennines, which consist of the Coastal Range, Sila Massif, Serre Calabre and Aspromonte Massif [45]. As stated by Pesaresi et al. [46], the Calabria region exhibits a Mediterranean bioclimate, displaying considerable mesoclimate fluctuations influenced by factors such

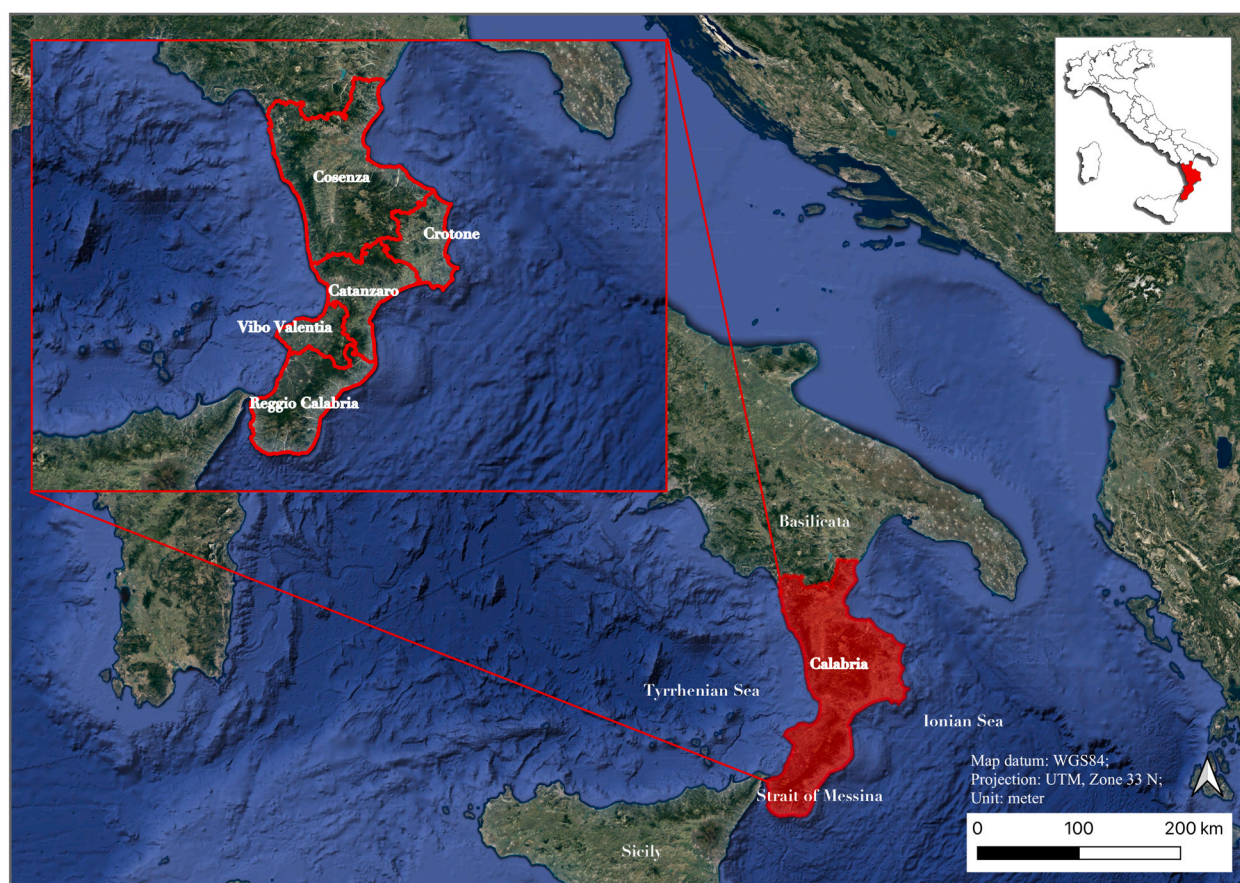


Fig. 1. Calabria region (Southern Italy). In red are the boundaries of the five provinces of the region: Catanzaro, Cosenza, Crotona, Reggio Calabria and Vibo Valentia (adapted from Google© 2024).

as altitude, topography, and proximity to the sea.

2.2. Data collection

To gather information, a variety of online and printed bibliographic sources were consulted. The keywords “Ethnobotany” AND “Calabria” were employed in online searches on the Scopus (last accessed February 20, 2024) and Google Scholar (last accessed February 20, 2024) platforms, with the objective of locating scientific articles pertinent to ethnobotanical studies. The search yielded a total of 13 results on Scopus and 409 results on Google Scholar. All available sources were subjected to a rigorous evaluation process to ascertain their potential inclusion in the database. Furthermore, an exhaustive examination of printed books from a range of libraries was conducted. Following a robust selection process, 13 scientific articles, two books and one master’s thesis were selected for inclusion, as they addressed the specific topic of ethnobotanical uses in Calabria. All other sources that did not directly relate to ethnobotanical uses or focus solely on one species or the region were excluded from further consideration.

The data on the species’ uses were extracted from the bibliographic sources and compiled into a digital database using Microsoft Office Access® software.

The database is structured as follows:

- bibliographic source consulted;
- province;
- municipality;
- locality;
- family;
- taxon (scientific name);
- common name;
- synonyms;
- dialectal name;
- life form and growth mode;
- chorological type;
- origin (native, alien - or allochthonous - and cryptogenic);
- type of use (food, medicinal, craft, recreational, domestic, etc.);
- purpose;
- disease group (for medicinal uses);
- part of the plant used;
- mode of preparation;
- mode of use.

For updated scientific nomenclature (including both scientific binomials and family names), Bartolucci et al. [47] was used for native species, while Galasso et al. [48] was referenced for alien species. The origin of alien taxa was also based on Galasso et al. [48]. The life form of the taxa is classified in accordance with Raunkiaer’s [49] system, while the chorological classification is based on Pignatti [50] approach. The data on medicinal uses were organized in accordance with Cook’s classification system [51].

2.3. Data analysis

In order to quantify the significance of the species within the study area, a series of indices were employed:

- *Cultural Importance Index (CI)* (1) [52,53] which is the sum of the percentage of informants who mention the use of each species and is calculated as follows:

$$CI = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}/N \quad (1)$$

where:

- UR_{ui} is the number of types of use for each species;
- N is the total number of informants.
- *Cultural Value (CV)* (2) [54] which calculates the cultural value of the species as follows:

$$CV = \frac{U_s}{U_{tot}} * \frac{FC}{N} * \left[\sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}/N \right] \quad (2)$$

where:

- U_s is the number of uses for species 's';
- U_{tot} is the total number of potential uses of a species considered in the study;
- FC is the number of respondents mentioning the species;
- N is the total number of informants;
- UR_{ij} is the sum of all Use Reports (UR) of the species, i.e. the sum of the number of respondents who mentioned each use of the species, divided by N.
- *Frequency of Citation (FC)* [55], which refers to how frequently a taxon is cited by informants.
- *Family Importance Value (FIV)* (3) [21], which represents the number of times a botanical family is mentioned by informants. The FIV index is calculated as follows:

$$FIV = \frac{FC_{(family)}}{N} \quad (3)$$

where:

- FC (family) is the number of informants citing family;
- N is the total number of informants.
- *Plant Part Value (PPV)* (4) [56], used to identify the most commonly utilized part of the plant during the interviews, calculated using the following this formula:

$$PPV = \frac{RU_{plant\ part}}{RU} \quad (4)$$

where:

- $RU_{plant\ part}$ is the sum of records with that plant part;
- RU is the total of records with all plant parts.
- *Relative Frequency of Citation (RFC)* (5) [52], which has the same function as the FC index but is relative to the total number of informants, with a value ranging between 0 and 1:

$$RFC = \frac{FC}{N} = \frac{\sum_{i=1}^{iN} UR_i}{N} \quad (5)$$

where:

- FC is the number of informants mentioning the species;
- N is the total number of informants.
- *Relative Importance Index (RI)* (6) [52] was used to calculate the relative importance of each species and is determined using the following formula:

$$RI = \frac{RFC_{(max)} + RNU_{(max)}}{2} \quad (6)$$

Table 1

List of all the bibliographic sources with the year of publication, the Calabrian provinces (according to Fig. 1) and the types of use documented.

N°	Bibliographic sources	Years of publication	Calabrian provinces	Types of documented use
1	Barone [29]	1963	CS	ME
2	Leporatti and Pavesi [30]	1989	CS, CZ, RC	CO, DO, ME, VE
3	Passalacqua et al. [31,32]	2006; 2007	CS, CZ, KR, RC	AG, AL, CO, DO, FO, HA, LU, MA, ME, RE, VE
4	Nebel et al. [33]	2006	RC	AL
5	Leporatti and Impieri [34]	2007	CS	ME
6	Tagarelli et al. [35]	2010	CS, CZ, KR, RC, VV	ME
7	Siviglia [36]	2011	VV	AL
8	Bellusci [37]	2017	CS	CO, ME, VE
9	Lupia et al. [38]	2017	CS, CZ, KR, RC, VV	AG, AL, CO, DO, FO, HA, LU, MA, ME, OR, RE, VE
10	Maruca et al. [39]	2018	CZ	AG, AL, CO, DO, FO, HA, LU, MA, ME, RE
11	Musarella et al. [40]	2019	VV	AG, AL, CO, DO, HA, MA, ME, OR, RE, VE
12	Mattalia et al. [41,42]	2020a,b	CS	AL, CO, DO, ME
13	Gentile et al. [43]	2022	VV	AG, AL, CO, DO, FO, HA, LU, MA, ME, OR, RE
14	Patti et al. [44]	2024	RC	AG, AL, CO, DO, FO, HA, LU, MA, ME, OR, RE

Calabrian provinces: CS: Cosenza; CZ: Catanzaro; KR: Crotona; RC: Reggio Calabria; VV: Vibo Valentia. Ethnobotanical uses: AG: Agropastoral; AL: Alimentary; CO: Cosmetic; DO: Domestic; FO: Forage; HA: Handicraft; LU: Ludic; MA: Magic; ME: Medicinal; OR: Ornamental; RE: Religious; VE: Veterinary.

where:

- $RFC_{(max)}$ is the Relative Frequency of Citation over the maximum, obtained by dividing FC by the maximum value in all species [$RFC_{(max)} = FC/\max(FC)$]
- $RNU_{(max)}$ is the Relative Number of Use Categories over the maximum, obtained by dividing the number of uses of the species by the maximum value in all species in the survey [$RNU_{(max)} = NU/\max(NU)$].

The CI and RI indices were calculated using RStudio software, version 2023.9.1.494 [57], with the EthnobotanyR package (version 0.1.9), developed by Whitney [58], in accordance with the guidelines set forth by Tardío & Pardo-de-Santayana [52]. In contrast, the CV, FC, FIV, PPV, RFC and UV indices were calculated using the Microsoft Excel® software.

3. Traditional uses found in Calabria

A total of 16 bibliographic sources were consulted, comprising 13 scientific articles, two books and one master's thesis. These sources contain information on all the Calabrian provinces (Table 1).

For each Calabrian province, the specific study areas referenced in the published literature were identified, along with the relevant species records and their documented uses (Fig. 2). Fig. 2 illustrates the distribution of publications and known records across the five Calabrian provinces. It is noteworthy that the table in the bottom right corner indicates that the province of Cosenza has the highest number of publications (8) and records (2241). This is likely due to the presence of rural populations in the region who possess extensive ethnobotanical knowledge across a broader territory. The province of Reggio Calabria has been the subject of study in both the Ionian strip (Graecanic area) and in the Tyrrhenian strip, with a total of five publications and 822 records. The provinces of Vibo Valentia and Catanzaro each have four publications. The province of Crotona has been the subject of fewer studies than other provinces, with only two publications and 88 records.

The existence of numerous studies in a single region indicates a particular interest in the preservation of traditional knowledge pertaining to the utilization of plants.

A total of 4873 records were obtained from the bibliographic sources consulted, providing detailed information on the uses of 517 taxa belonging to 97 families and 318 genera. The full list of families, along with the number of taxa in each, the number of records, the FC index (family) and the FIV index (%) (3), is provided in Table 2.

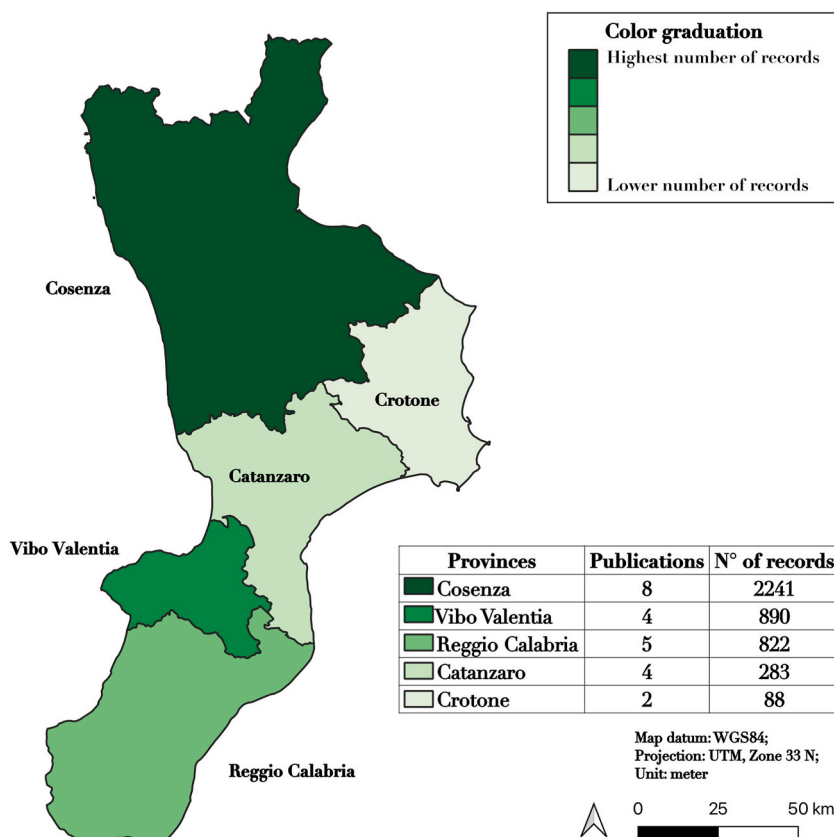


Fig. 2. Distribution of ethnobotanical knowledge documented in the literature across the five Calabrian provinces (adapted from Google© 2024).

According to Table 2, the families with the highest number of records are Asteraceae (679), Lamiaceae (408), Rosaceae (394), and Apiaceae (261). The Family Importance Value (FIV) 3 confirms the importance of these families in the region: Asteraceae, Lamiaceae and Rosaceae each have an FIV value of 100 %, meaning that they are mentioned in all 16 bibliographic sources consulted. Apiaceae, mentioned in 14 bibliographic sources, has an FIV of 87.50 %.

A total of 517 taxa were recorded, including 51 subspecies and 12 genera. The three most common life forms were Hemipterophytes (33 %), Phanerophytes (22 %), and Therophytes (21 %). These life forms reflect the typical characteristics of many species in the Calabrian territory and are adaptations to different ecological conditions [59–62]. It is important to note that other life forms, although present in smaller percentages, contribute to the significant ecological diversity among the species considered (Fig. 3).

In terms of chorological types (Fig. 4), the most representative group comprises 38.2 % of the species observed in Calabria. This group belongs to the Mediterranean chorotype *sensu lato*. Within this category, the Mediterranean chorotype is further subdivided into three types: Stenomediterranean (19 %), Eurimediterranean (19 %), and Mediterranean-Mountain (0.2 %). This division highlights the significant presence of species typical of Mediterranean and Mediterranean-Mountain environments in the region. This distribution is consistent with the regional bioclimate [46]. The Eurasian chorotype follows, with 25 % of the taxa. Notably, there is also a significant presence of cultivated taxa (12 %) and a smaller percentage of alien taxa (5 %). These results highlight the remarkable heterogeneity and complexity of the Calabrian flora, with dynamic interactions between native, alien and cultivated taxa [63].

In terms of origin, taxa were classified as native (N), alien (A) and cryptogenic (C), where each category is split into cultivated and wild (Fig. 5). As shown in Fig. 5, native taxa dominate (80.6 %) with 79.3 % of wild native and 1.4 % cultivated native taxa: this highlights the significant ethnobotanical importance of native species in the region. Alien taxa represent 17.8 %, with 10.3 % of this group consisting of cultivated and 7.6 % of wild taxa. Cryptogenic taxa represent only 1.5 % of the entire regional ethnobotanical flora.

Among other data, the plant parts used for ethnobotanical purposes, as reported in publications, were also recorded (Fig. 6). The most used parts are the leaves (1452 records), followed by the fruits (819) and aerial parts (664).

The Plant Part Value (PPV) index highlights the most frequently used plant parts by comparing the records for each part (RU_{plant part}) with the total number of records (4873): Table 3 shows the most frequently used plant parts according to the PPV index.

As shown in Fig. 6 and Table 3, the most frequently used plant parts are the leaves (1452 records and PPV 0.298), followed by the fruits (819 records and PPV 0.168) and the aerial parts (664 records and PPV 0.136). Almost all parts of the plant are used, depending on the intended use. For example, the leaves of *Malva sylvestris* L. are consumed as food (in salads and in main dishes) [36], while the flowers of the same plant are used in infusions and medicinal decoctions [43].

3.1. Types of use

Plants are used for a variety of purposes, and those recorded for the Calabria region are summarized in Fig. 7. The figure shows different types of plant use, organized by the number of records and the number of taxa used for each specific purpose.

The most common uses are medicinal (2588 records and 277 taxa) and food (1764 records and 299 taxa), which are often more common than other uses because they form the basis of human survival [64,65]. Since ancient times, people have relied on local plants for food and natural remedies for ailments. Less common are uses related to daily life, such as domestic uses (135 records and 62 taxa), which include purposes such as cleaning dishes and preparing perfumes and soaps. Equally important is the category “handicraft” (119 records and 53 taxa), which includes the professional manufacture of items such as chairs, baskets and spoons.

The data collected from the bibliographic sources were classified by types of use, and Fig. 8 illustrates the composition of these sources according to the number of records for each type of use.

Fig. 8 shows that some publications focused exclusively on medicinal uses [29], while others focused on food uses [33]. In any case, these two types of uses are present in almost all the studies and represent the most significant uses in terms of the number of records.

Domestic use (highlighted in yellow) is also well represented in several publications, confirming the importance of plants in everyday life. Although ludic, magical, ornamental, and religious uses are less frequently mentioned, but still provide valuable insights that will be discussed in more detail later.

In order to highlight the most important, versatile and widely known taxa, several indices were calculated on the basis of the collected data. Table 4 lists some of the species from the publications, ranked by decreasing Cultural Value (CV) index. The full list of taxa, including information on common names, dialect names, life forms, chorological types, origins, uses, purposes, and associated indices, can be found in Supplementary Material 1.

According to the CV index (2), the most relevant species is *Urtica dioica* L. (CV 2.920). A total of 115 records (UR) were collected for this taxon, and it also has a high value for the CI (7.188), RFC (0.813), RI (0.717) and UV (0.500) indices. This species is used for six different types of uses (U_s), including agropastoral, handicrafts, food (e.g. omelettes and pasta dishes), cosmetics, household and medicinal uses, especially for its diuretic and hypotensive properties. *Urtica dioica* is widely used in different regions of Italy [66–71] and is a common species, as evidenced by numerous publications worldwide [72–75].

Another important species is *Sambucus nigra* L. (CV 1.969), which is well known and widely used in Calabria. It appears in almost all the publications consulted (14 out of 16) and has the highest RFC index (0.875) among the species recorded. Other indices also confirm its importance in the region (CI 6.750; RI 0.582; UV 0.333). *Sambucus nigra* is mainly used in four categories, but the most common uses are in the food and medicinal fields. Elderflower, locally known as “*fiuri i maju*”, is often used to flavour omelettes, side dishes, and to stuff “*pitta chijna*” (Vibo Valentia) [36,43], and in the medicinal field to prepare decoctions for anti-inflammatory purposes, such as the treatment of skin inflammations, reddened eyes, or wounds [29,40,43].

Opuntia ficus-indica (L.) Mill., an invasive neophyte plant species, has “colonized” the regional territory over time [76,77], adapting to drier environments where it competes with native plants typical of the Mediterranean belt. In Calabria, this species has found a place

Table 2

Comprehensive list of recorded families in alphabetical order, including the number of taxa in each family, the number of records, the FC index (family) and the FIV index (%) (3).

N°	Family	Number of records	Number of taxa	FC (family)	FIV %
1	Acanthaceae	1	1	1	6.25
2	Aizoaceae	2	2	1	6.25
3	Amaranthaceae	40	6	9	56.25
4	Amaryllidaceae	111	9	11	68.75
5	Anacardiaceae	14	2	6	37.50
6	Apiaceae	261	17	14	87.50
7	Apocynaceae	10	2	5	31.25
8	Aquifoliaceae	3	1	2	12.50
9	Araceae	4	2	2	12.50
10	Araliaceae	10	1	6	37.50
11	Arecaceae	4	3	2	12.50
12	Aristolochiaceae	1	1	1	6.25
13	Asparagaceae	107	8	13	81.25
14	Asphodelaceae	17	4	5	31.25
15	Aspleniaceae	7	1	4	25.00
16	Asteraceae	679	77	16	100.00
17	Berberidaceae	3	1	1	6.25
18	Betulaceae	25	5	5	31.25
19	Boraginaceae	95	6	14	87.50
20	Brassicaceae	138	27	13	81.25
21	Cactaceae	62	1	12	75.00
22	Campantulaceae	2	1	1	6.25
23	Cannabaceae	12	3	6	37.50
24	Capparaceae	38	1	6	37.50
25	Caprifoliaceae	10	1	2	12.50
26	Caryophyllaceae	20	7	8	50.00
27	Cistaceae	2	2	1	6.25
28	Convolvulaceae	22	6	6	37.50
29	Coralliaceae	2	1	1	6.25
30	Cornaceae	1	1	1	6.25
31	Crassulaceae	16	6	6	37.50
32	Cucurbitaceae	27	6	5	31.25
33	Cupressaceae	13	2	4	25.00
34	Dennstaedtiaceae	6	1	4	25.00
35	Dioscoreaceae	4	1	2	12.50
36	Dipsacaceae	11	4	4	25.00
37	Dryopteridaceae	3	2	2	12.50
38	Ebenaceae	1	1	1	6.25
39	Equisetaceae	28	2	10	62.50
40	Ericaceae	47	2	9	56.25
41	Euphorbiaceae	22	7	9	56.25
42	Fabaceae	190	31	16	100.00
43	Fagaceae	88	10	15	93.75
44	Gentianaceae	9	2	5	31.25
45	Heliotropiaceae	4	1	4	25.00
46	Hypericaceae	22	2	7	43.75
47	Iridaceae	8	5	3	18.75
48	Juglandaceae	74	1	14	87.50
49	Juncaceae	5	2	3	18.75
50	Lamiaceae	408	40	16	100.00
51	Lauraceae	120	1	12	75.00
52	Linaceae	1	1	1	6.25
53	Loranthaceae	3	1	2	12.50
54	Lythraceae	29	2	8	50.00
55	Malvaceae	167	4	11	68.75
56	Moraceae	123	3	12	75.00
57	Myrtaceae	71	4	14	87.50
58	Oleaceae	53	4	12	75.00
59	Onagraceae	7	2	3	18.75
60	Orchidaceae	1	1	1	6.25
61	Orobanchaceae	2	1	1	6.25
62	Oxalidaceae	8	3	3	18.75
63	Papaveraceae	55	5	12	75.00
64	Passifloraceae	3	1	1	6.25
65	Phytolaccaceae	2	1	2	12.50
66	Pinaceae	30	5	6	37.50
67	Piperaceae	2	1	1	6.25

(continued on next page)

Table 2 (continued)

N°	Family	Number of records	Number of taxa	FC (family)	FIV %
68	Plantaginaceae	41	8	12	75.00
69	Plumbaginaceae	2	1	2	12.50
70	Poaceae	169	18	13	81.25
71	Polygonaceae	34	11	7	43.75
72	Polypodiaceae	3	3	3	18.75
73	Portulacaceae	37	1	12	75.00
74	Primulaceae	5	3	3	18.75
75	Pteridaceae	23	1	4	25.00
76	Ranunculaceae	63	6	12	75.00
77	Resedaceae	4	1	2	12.50
78	Rhamnaceae	20	2	5	31.25
79	Rosaceae	394	31	16	100.00
80	Rubiaceae	10	5	3	18.75
81	Rutaceae	88	7	10	62.50
82	Salicaceae	22	6	7	43.75
83	Santalaceae	14	2	4	25.00
84	Sapindaceae	3	2	2	12.50
85	Scrophulariaceae	65	7	9	56.25
86	Smilacaceae	16	1	3	18.75
87	Solanaceae	76	10	12	75.00
88	Tamaricaceae	3	2	2	12.50
89	Thymelaeaceae	8	1	3	18.75
90	Typhaceae	5	2	3	18.75
91	Ulmaceae	6	1	4	25.00
92	Urticaceae	221	5	15	93.75
93	Valerianaceae	18	4	6	37.50
94	Verbenaceae	16	2	5	31.25
95	Viburnaceae	115	2	14	87.50
96	Violaceae	7	3	5	31.25
97	Vitaceae	19	1	6	37.50
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*Corallinaceae are a family of red algae.

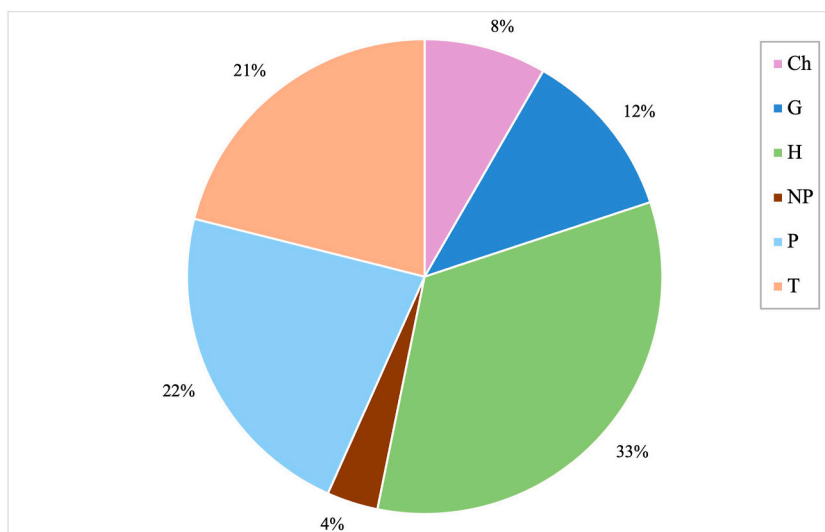


Fig. 3. Life spectrum of ethnobotanical taxa detected in Calabria (Southern Italy). Ch- Chamaephytes; G- Geophytes; H- Hemicryptophytes; NP- Nanophanerophytes; P- Phanerophytes; T- Therophytes [49].

in local ethnobotany [29,30,32,33,35,38–44]. It has 62 records and is used for five different types of use. Its indices are quite high (CI: 3.875; CV: 1.211; RFC: 0.750; RI: 0.484; UV: 0.417), indicating how people have adapted to environmental changes and integrated this plant into their practices.

3.1.1. Medicinal uses

The most common use category is medicinal, with 2588 records and 277 different taxa (Fig. 7). Within this category, numerous

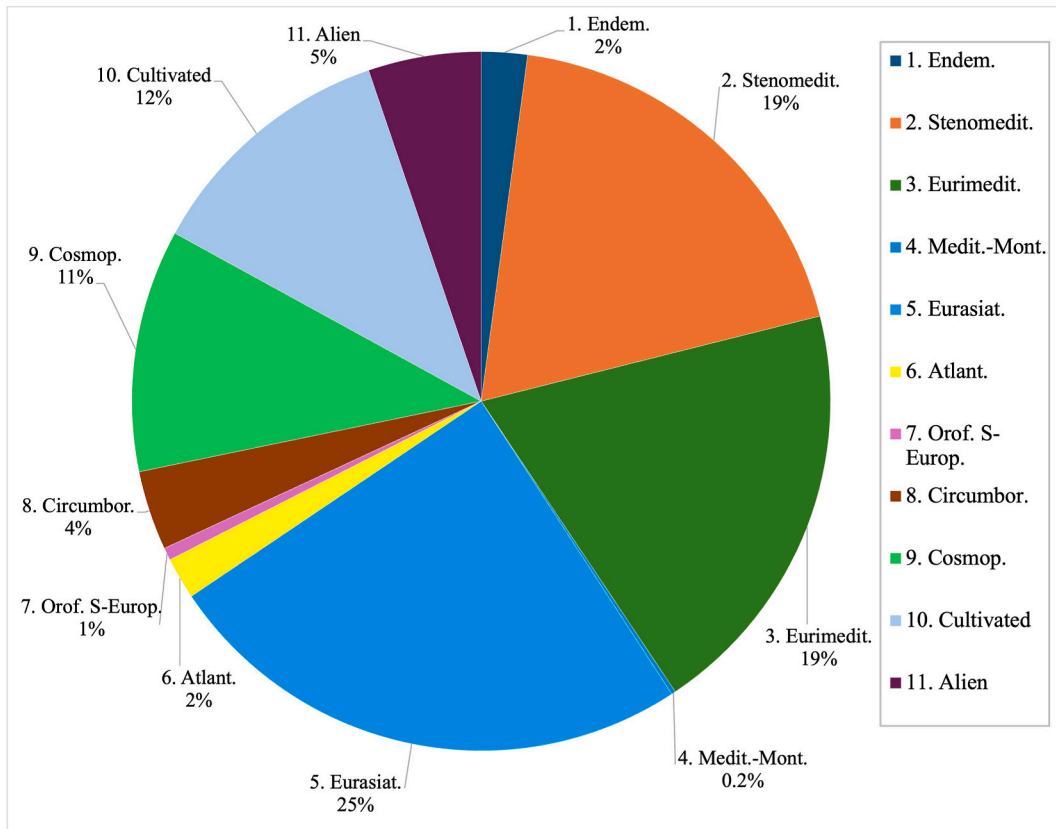


Fig. 4. Chorological spectrum of ethnobotanical taxa use detected in Calabria (Southern Italy) according to Ref. [50].

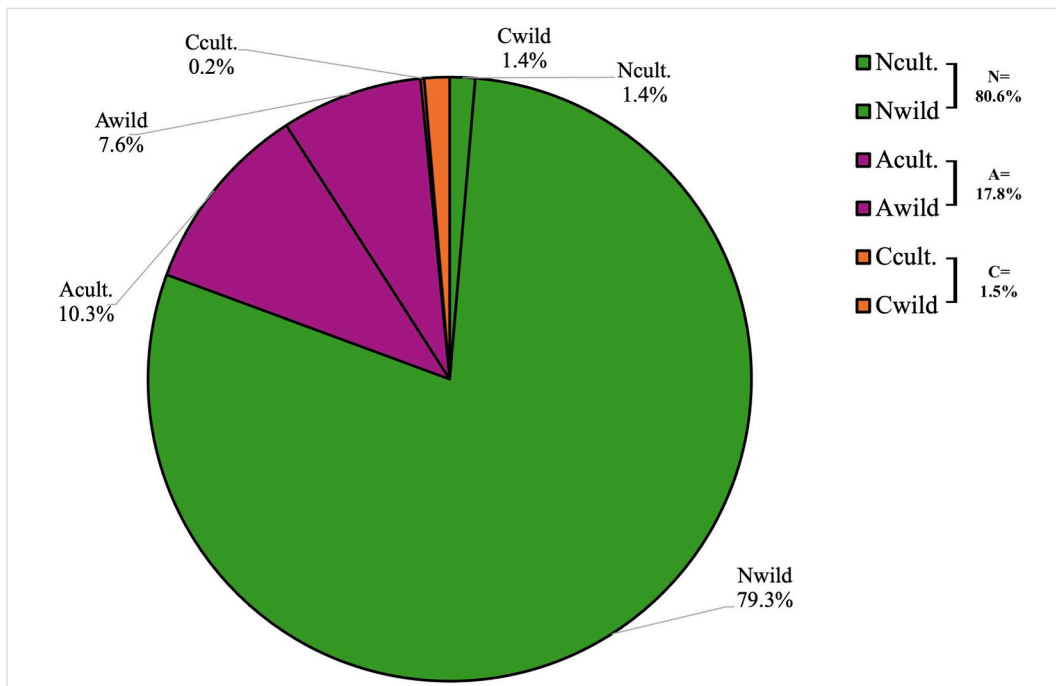


Fig. 5. Origin of ethnobotanical taxa detected in Calabria (Southern Italy) in accordance with [48]. Acult. – Alien cultivated; Awild – Alien wild; Ccult. – Cryptogenic cultivated; Cwild – Cryptogenic wild; Ncult. – Native cultivated; Nwild – Native wild.

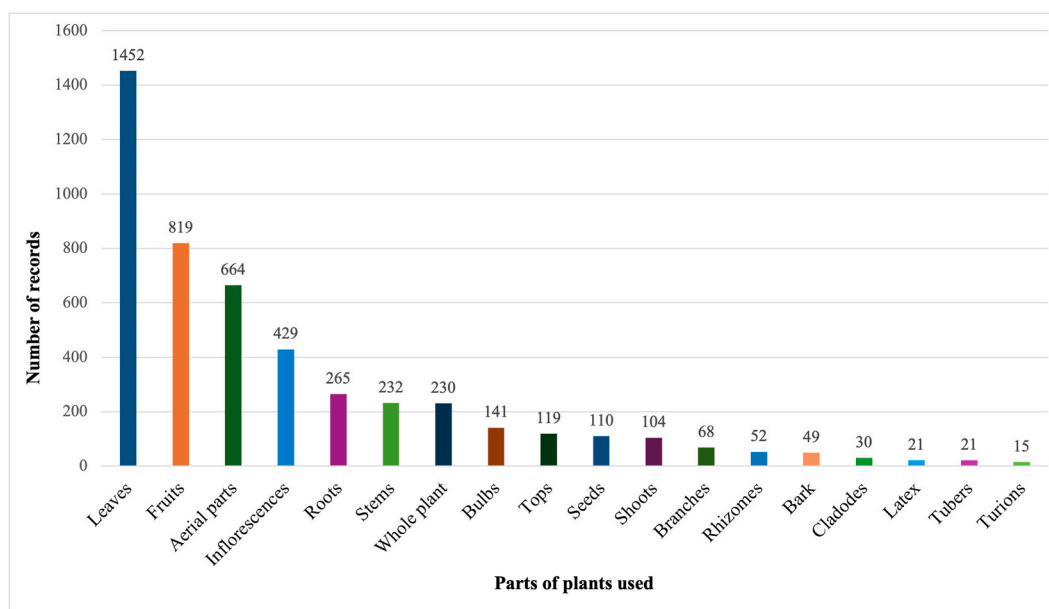


Fig. 6. Plant parts most used for ethnobotanical purposes in Calabria (Southern Italy).

Table 3

Most frequently used plant parts for ethnobotanical purposes in Calabria (Southern Italy) ranked by Plant Part Value (PPV) index (4).

Parts of plants used	$RU_{\text{plant part}}$	PPV
Leaves	1452	0.298
Fruits	819	0.168
Aerial parts	664	0.136
Inflorescences	429	0.088
Roots	265	0.054
Whole plant	232	0.048
Stems	230	0.047
Tops	141	0.029
Bulbs	119	0.024
Seeds	110	0.023
Shoots	104	0.021
Branches	68	0.014
Rhizomes	52	0.011
Barks	49	0.010
Cladodes	30	0.006
Tubers	21	0.004
Latex	21	0.004
Turions	15	0.003

subcategories cover different health problems. For example, the subcategory “1-Digestive system disorders” includes treatments for digestive tract disorders, tracheitis and dental problems (Fig. 9). This subcategory stands out with the highest number of records (659) and the largest number of taxa (167) used to treat these ailments.

The second most common medicinal category is “2-Skin, ear, hair, and wounds”, with 657 records and 154 different taxa. This is followed by the third category, “3-Systemic diseases”, which includes diseases that affect the whole organism, such as fever, with 318 records and 89 different taxa.

Table 5 shows the most frequently used taxa within the medicinal use category, together with the number of disease groups for which they are used.

According to Table 5, the most frequently used medicinal plant in Calabria is *Malva sylvestris*, with 143 records and applications in 8 different groups of ailments. It is widely used for gastrointestinal inflammation (1-Digestive) by preparing an infusion or decoction of the aerial parts, which is consumed hot to relieve abdominal pain. The aerial parts are also used as an anti-odontal agent: a paste is made and applied to the teeth to relieve pain. It also has healing properties, useful for treating small wounds (2-Skin). Its roots are used to treat bronchitis and to suppress coughs (5-Respiratory) by hot infusion or decoction. The aerial parts also have sedative properties (6-Nervous). *Malva sylvestris* is not only widespread in Calabria, but also in other Italian regions [31,66,67,78–82]. Phytochemical

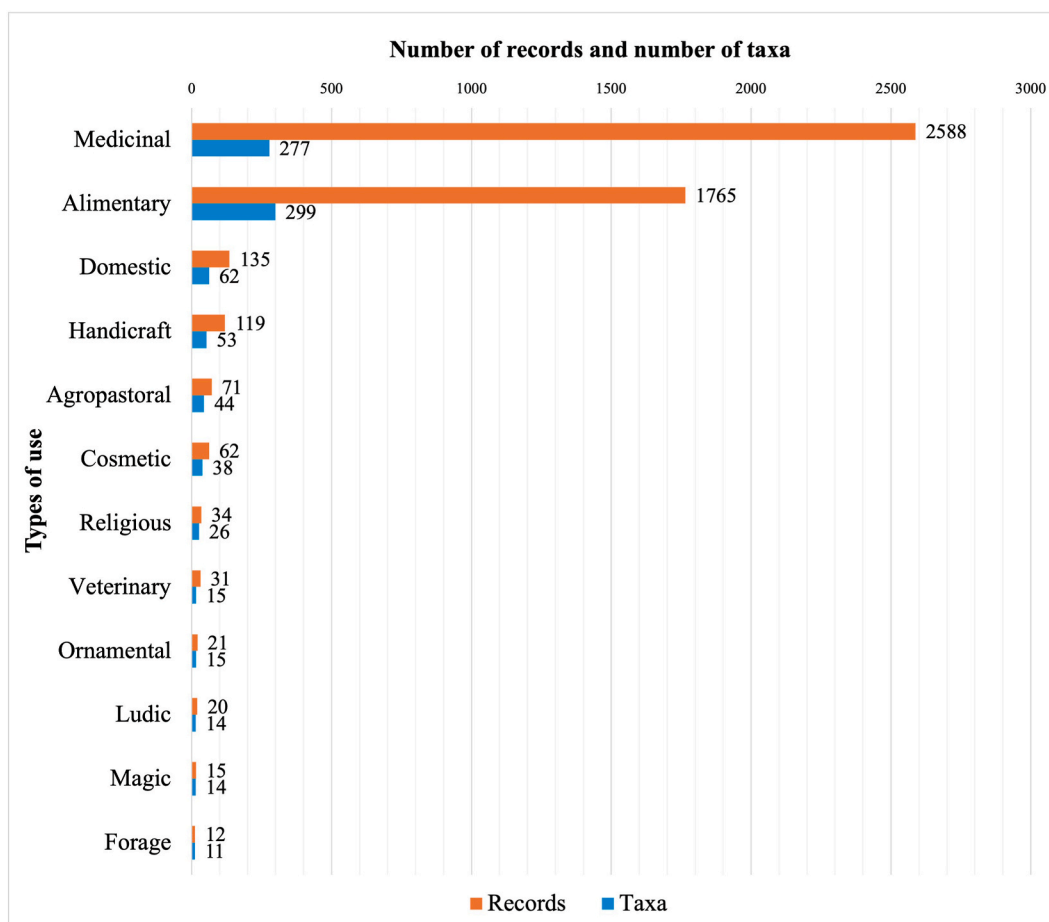


Fig. 7. Types of ethnobotanical use of taxa detected in Calabria (Southern Italy), sorted according to the number of records and taxa for each use.

studies also confirm the presence of bioactive compounds with various medicinal effects [83–85].

The second most used medicinal taxon is *Laurus nobilis* L. with 83 records for 8 different disease categories. Laurel is typically used in infusions and decoctions for abdominal pain and digestive problems (1-Digestive), menstrual pain (4-Genito-urinary) and as a mild sedative (6-Nervous). In Calabria, *L. nobilis* is often cultivated in gardens due to its widespread medicinal use. This plant is well known in the regions surrounding Calabria, such as Basilicata [85–88] and Sicily [67,89–91] as well as in other Italian regions, including Campania [92–95], Latium [96,97], Liguria [81,98], Lombardy [99,100], Marche [101], Piedmont [68], Apulia [102], Sardinia [103–107], and Tuscany [66,82,108].

A notable taxon is *Cynodon dactylon* (L.) Pers., a native species that commonly infests cultivated fields but has considerable medicinal value. It is mentioned 56 times in 6 different disease categories, mainly for its antispasmodic (1-Digestive), antipyretic (3-Systemic), and diuretic (4-Genito-urinary) properties. Decoctions made from its aerial parts or rhizome are commonly administered. This taxon is widely recognized for its medicinal applications in several Italian regions, including Basilicata [87,88], Campania [93,94,109], Latium [96,97], Liguria [110], Lombardy [100], Molise [111], Apulia [112], Sardinia [102], Sicily [67,89,113–115], and Tuscany [66,81,82,98].

Some taxa primarily known for their culinary use have also shown medicinal properties. *Salvia rosmarinus* Spenn and *Allium sativum* L. are two species that are widely used in cooking but also have medicinal interest. *Salvia rosmarinus* has 39 records for 6 different medicinal purposes; its aerial parts are mainly used to treat skin inflammations and wounds, including cuts, scratches, abscesses and sores. Methods of preparation include decoctions for topical application or the preparation of ointments from powdered aerial parts mixed with olive oil. The medicinal use of this plant is well documented, with studies highlighting its therapeutic potential [116–118]. *Allium sativum* has 40 records for 7 different disease groups. It is used mainly as a laxative (1-Digestive), either by boiling the bulb and drinking the water, or by eating it raw. Garlic bulbs are also used as a callifuge (2-Skin) by making a poultice with minced garlic and olive oil. It also has hypotensive (6-Nervous) and anti-rheumatic (8-Muscul.) properties. Numerous studies confirm the medicinal properties of *A. sativum* [119–121].

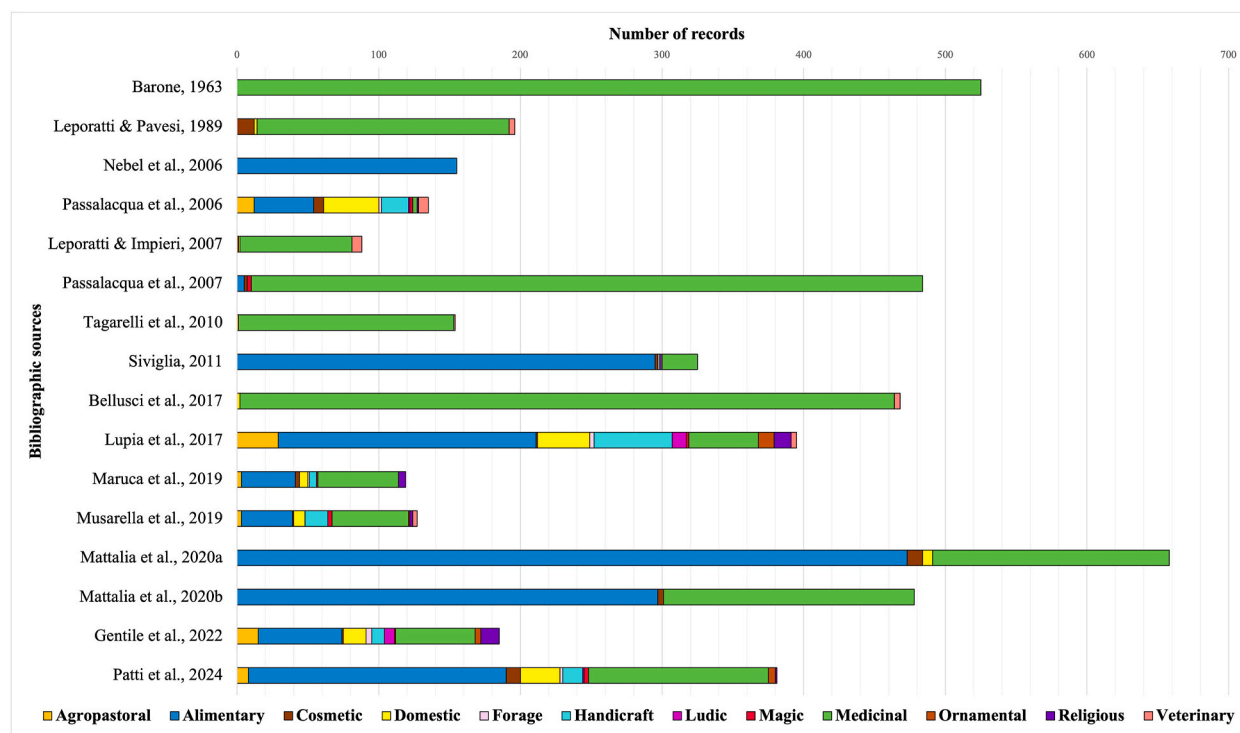


Fig. 8. Composition of the bibliographic sources analyzed, categorized by the number of records for each type of use of the taxa surveyed in Calabria (Southern Italy).

3.1.2. Food uses

The food category is defined as any substance that is used as food. This review subdivides the different food uses into categories, with the objective of identifying the most commonly occurring ones. The resulting categorization is illustrated in Fig. 10. The categories with the greatest significance are those related to soup preparation (269 records and 98 different taxa) and side dishes (236 records and 90 taxa). In Calabria, boiled vegetables are a common ingredient in soups and side dishes. They are often cooked with oil, salt, garlic and other spices [122].

The plants are widely used as a snack (234 records and 71 taxa), with the fruit often consumed directly from the plant. Examples of this include the fruits of *Arbutus unedo* L. (10 records) and *Ficus carica* L. (22 records).

Seasoning is also a common food use, with 206 records and 61 taxa. In this context, plant parts such as leaves, flowers, or twigs are added to dishes with the intention of enhancing their aroma or flavour. Notable examples include *Allium ursinum* L. (7 records), *Salvia officinalis* L. subsp. *officinalis* (6 records), *Salvia rosmarinus* (7 records) and *Anethum piperitum* Ucria (48 records). The latter is the most cited taxon within the food category with 71 records. Other frequently cited taxa include *Rubus ulmifolius* Schott (50 records), *Juglans regia* L. (43 records) and *Borago officinalis* L. (40 records).

The practice of preparing salads using a variety of plant species, typically consumed raw, is widespread (13 records and 93 taxa). The most frequently utilized species within this subcategory is *Portulaca oleracea* L., with 14 records. The raw aerial parts are consumed, and the plant is rich in antioxidant compounds, such as omega-3, which are essential for human health [123–125].

The preparation of omelettes and fritters with plants is a typical practice in Calabria, with 128 records and 54 different taxa. Leaves, shoots, young shoots, or flowers are incorporated into eggs and cheese mixtures (for omelettes) or (for fritters), which are then fried. The most frequently utilized taxon for this preparation is *Asparagus acutifolius* L. (15 records), with young shoots being incorporated into egg mixtures. Another frequently utilized taxon is *Clematis vitalba* L. (13 records), wherein shoots are boiled and subsequently incorporated into egg preparations.

The beverage category encompasses preparations related to the production of liqueurs and other alcoholic and non-alcoholic beverages, with a total of 126 records and 50 taxa. The most frequently utilized taxa are *Juglans regia* (12 records), *Myrtus communis* L. (12) and *Fragaria vesca* L. subsp. *vesca* (11). The fruits of *J. regia* employed in the production of “nocino”, a traditional liqueur. This is made by macerating the nuts in alcohol, filtering the resulting mixture, and then combining it with water and sugar. Additionally, the berries of *M. communis* and the conocarps of *F. vesca* subsp. *vesca* are also employed in the production of liqueurs through a comparable process.

3.1.3. Domestic uses

This category encompasses a variety of purposes related to home care and cleaning, with 143 records and 66 different taxa (Fig. 7),

Table 4

The most relevant taxa of ethnobotanical use in Calabria sorted according to Cultural Value (CV) index (2).

TAXON	BASIC VALUE			INDEXES					RANKING	
	FC	Us	UR	CI	CV	RFC	RI	UV	CV	RFC
<i>Urtica dioica</i> L.	13	6	115	7.188	2.920	0.813	0.717	0.500	1	4
<i>Laurus nobilis</i> L.	12	5	120	7.500	2.344	0.750	0.678	0.417	2	7
<i>Sambucus nigra</i> L.	14	4	108	6.750	1.969	0.875	0.582	0.333	3	3
<i>Juglans regia</i> L.	14	5	74	4.625	1.686	0.875	0.524	0.417	4	2
<i>Malva sylvestris</i> L.	11	3	150	9.375	1.611	0.688	0.667	0.250	5	13
<i>Opuntia ficus-indica</i> (L.) Mill.	12	5	62	3.875	1.211	0.750	0.484	0.417	6	6
<i>Borago officinalis</i> L.	14	3	79	4.938	1.080	0.875	0.430	0.250	7	1
<i>Parietaria judaica</i> L.	12	4	68	4.250	1.063	0.750	0.449	0.333	8	11
<i>Spartium junceum</i> L.	10	9	34	2.125	0.996	0.625	0.613	0.750	9	17
<i>Matricaria chamomilla</i> L.	11	3	84	5.250	0.902	0.688	0.447	0.250	10	12
<i>Olea europaea</i> L.	10	6	45	2.812	0.879	0.625	0.483	0.500	11	20
<i>Myrtus communis</i> L.	12	4	54	3.375	0.844	0.750	0.402	0.333	12	8
<i>Castanea sativa</i> Mill.	9	6	46	2.875	0.809	0.563	0.487	0.500	13	24
<i>Salvia officinalis</i> L. subsp. <i>officinalis</i>	10	4	59	3.688	0.768	0.625	0.419	0.333	14	19
<i>Cynodon dactylon</i> (L.) Pers.	12	2	64	4.000	0.500	0.750	0.324	0.167	15	9
<i>Salvia rosmarinus</i> Spenn.	9	3	56	3.500	0.492	0.563	0.353	0.250	16	25
<i>Arundo donax</i> L.	9	4	42	2.625	0.492	0.563	0.362	0.333	17	27
<i>Lavandula angustifolia</i> Mill.	7	5	39	2.438	0.444	0.438	0.408	0.417	18	41
<i>Arbutus unedo</i> L.	9	4	37	2.312	0.434	0.563	0.346	0.333	19	23
<i>Taraxacum</i> sp.pl.	8	3	54	3.375	0.422	0.500	0.347	0.250	20	30
<i>Cichorium intybus</i> L.	12	2	52	3.250	0.406	0.750	0.284	0.167	21	5
<i>Rubus idaeus</i> L. subsp. <i>idaeus</i>	5	3	34	5.000	0.391	0.313	0.433	0.250	22	73
<i>Clinopodium nepeta</i> (L.) Kuntze subsp. <i>nepeta</i>	10	3	38	2.375	0.371	0.625	0.293	0.250	23	18
<i>Anethum piperitum</i> Ucria	6	2	89	5.562	0.348	0.375	0.408	0.167	24	45
<i>Cynara cardunculus</i> L. subsp. <i>cardunculus</i>	9	3	36	2.250	0.316	0.563	0.287	0.250	25	22
<i>Ruscus aculeatus</i> L.	10	4	23	1.438	0.299	0.625	0.299	0.333	26	16
<i>Papaver rhoeas</i> L. subsp. <i>rhoeas</i>	9	3	34	2.125	0.299	0.563	0.280	0.250	27	26
<i>Anethum foeniculum</i> L.	7	2	65	4.062	0.296	0.438	0.328	0.167	28	37
<i>Asparagus acutifolius</i> L.	9	3	33	2.062	0.290	0.563	0.277	0.250	29	21
<i>Portulaca oleracea</i> L.	12	2	37	2.312	0.289	0.750	0.234	0.167	30	10

*Basic Value: Frequency of Citation (FC), Number of types of use (Us), Use Reports (UR); Indexes: Cultural Importance Index (CI) (1), Cultural Value (CV) (2), Relative Frequency of Citation (RFC) (5), Relative Importance Index (RI) (6), Use Value (UV).

which demonstrates the continued prevalence of domestic traditions in Calabria. One of the most common practices is the utilization of plant-based substances for the cleansing of textiles and culinary items. For example, the epicarps of the fruits of *Solanum lycopersicum* L. fruits are employed as a cleansing agent for dirty dishes. It is noteworthy that this particular application has not been documented in other Italian regions or in foreign publications. Similarly, the aerial part of the plant *Parietaria judaica* L. is used for cleaning dishes, cutlery and glasses by rubbing it to polish and clean them. A comparable usage is documented for the related species *Parietaria officinalis* L. in Liguria [98], Tuscany [82], and Marche [101], whereas *P. judaica* is employed for this purpose in Latium [97] and Umbria [126]. Four distinct taxa are traditionally utilized for the cleansing of textiles: the seeds of *Phaseolus vulgaris* L., the leaves of *Saponaria officinalis* L., and the aerial parts of *Spinacia oleracea* L. and *Urtica dioica*. Of these, *S. officinalis* is the only species documented for which documentation exists in other regions, including Campania [93] and Latium [97].

Another significant domestic application involves the dyeing of fabrics. The plant materials were subjected to boiling, whereby the coloured pigments were released into the boiling water and subsequently employed for the purpose of dyeing fabrics. In Calabria, the species used for dyeing include *Isatis tinctoria* L. (entire plant), also reported in Abruzzo [127–129], Campania [95], Latium [130], and Sicily [115]. Additionally, other species employed in dyeing processes include the barks of *Quercus pubescens* Willd. subsp. *pubescens* and *Rhamnus alaternus* L. (Sardinia [131]), the roots of *Rubia peregrina* L. (Sardinia [131,132]; Sicily – [131]) and the fruits of *Sambucus nigra* (Italy [133]; Latium [97]; Marche [101]) and *Solanum melongena* L. No other publications were identified for *Q. pubescens* subsp. *pubescens* and *S. melongena* with the same purpose.

3.1.4. Handicraft uses

This category encompasses all activities in which plants are utilized to create professional-level products, comprising 119 records and 53 distinct taxa (Fig. 7). Typically, plant parts, primarily stems or small branches, are employed in the fabrication of a range of items, including furniture such as chairs and tables, baskets, and cutlery. The most frequently utilized species in this category is *Arundo donax* L. (10 records), an archaeophyte that is primarily employed in the manufacture of baskets, broom handles, and the “*camicciata*”, a traditional support used for sun-drying tomatoes. These applications have been documented in other Italian regions, including Basilicata [134], Latium [97], Apulia [112] and Sicily [67,90,114,115,135], as well as in other European countries, such as Spain [136,137].

Spartium junceum L. is another plant that has been widely used for handicraft purposes, with 13 documented records. This species has a long history, with the name “*Spartium*” deriving from ancient Greek (Σπαρτον = rope), reflecting its traditional use in the production of textile fibres. These fibres were employed by the Phoenicians, Romans, and Greeks to make sails [102]. In Calabria, the

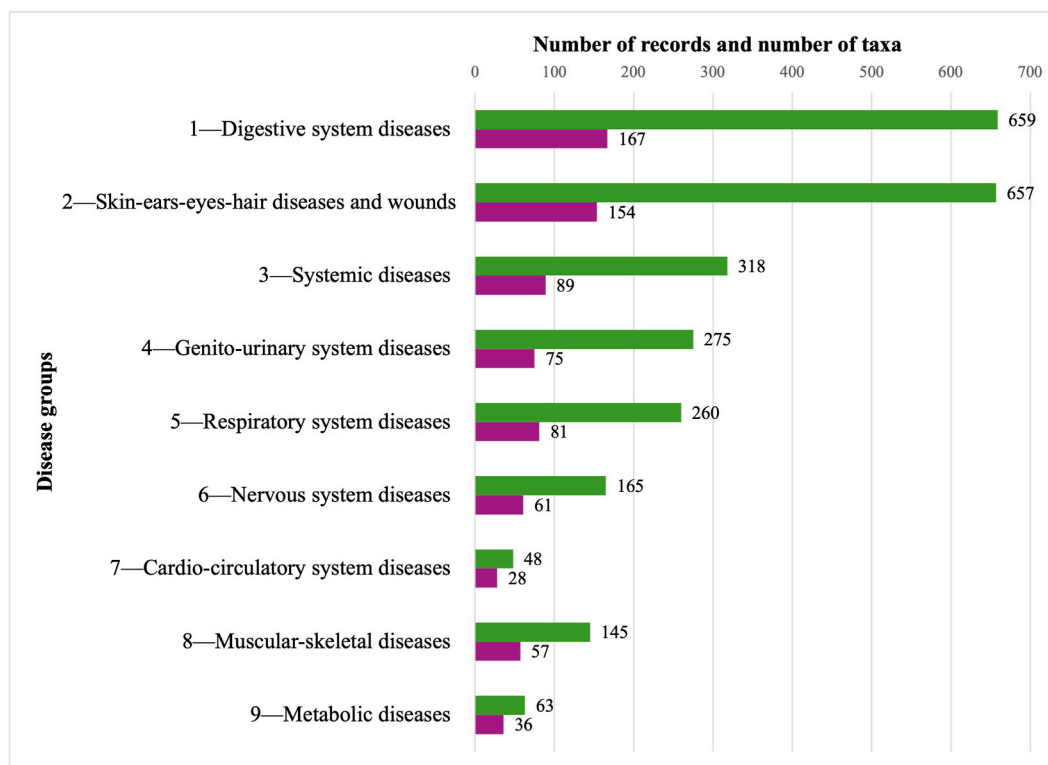


Fig. 9. Number of records and taxa divided categorized by to medicinal purposes. The medicinal categories follow the classification by Cook [51].

Table 5

List of the most used taxa within the medicinal category, ordered by number of records.

Taxa	Number of citations	Number of disease groups
<i>Malva sylvestris</i> L.	143	8
<i>Laurus nobilis</i> L.	83	8
<i>Matricaria chamomilla</i> L.	81	7
<i>Urtica dioica</i> L.	79	8
<i>Sambucus nigra</i> L.	70	7
<i>Cynodon dactylon</i> (L.) Pers.	56	6
<i>Parietaria judaica</i> L.	53	7
<i>Ficus carica</i> L.	43	5
<i>Achillea millefolium</i> L.	40	8
<i>Allium sativum</i> L.	40	7
<i>Salvia rosmarinus</i> Spenn.	39	6
<i>Borago officinalis</i> L.	38	9
<i>Salvia officinalis</i> L. subsp. <i>officinalis</i>	38	6
<i>Clinopodium nepeta</i> (L.) Kuntze subsp. <i>nepeta</i>	35	3

branches of *S. junceum* were collected for the fabrication of textiles utilized in the manufacture of mattresses, blankets, clothing, and even undergarments. The process entailed softening the material in a stream and subsequently drying it in the sun for a several days. Once the branches had been dried, they were subjected to manual treatment or processing with stones or wooden sticks in order to separate the fibrous components from the non-fibrous materials, such as the pith. Once the fibres had been cleaned, they were collected and woven into fabrics using community looms. This traditional method, though exhibiting variations in its specific execution, represents an ingenious and sustainable approach to utilize local plant resources for textile production. Furthermore, the utilization of *S. junceum* for textile purposes has been documented in other regions worldwide, including Lebanon [138], Marche [101] and Apulia [112]. Furthermore, the branches were employed directly in the production of rope, a use that has been well documented [66,115].

3.1.5. Agropastoral uses

A total of 71 records and 44 different taxa were identified in the agropastoral uses category (Fig. 7). These encompass a range of activities related to the care of cultivated land and pastures, including the application of natural fertilisers or repellents, as well as the use of plants for the creation of bedding for animals. One of the most frequently utilized species is *Ampelodesmos mauritanicus* (Poir.) T.

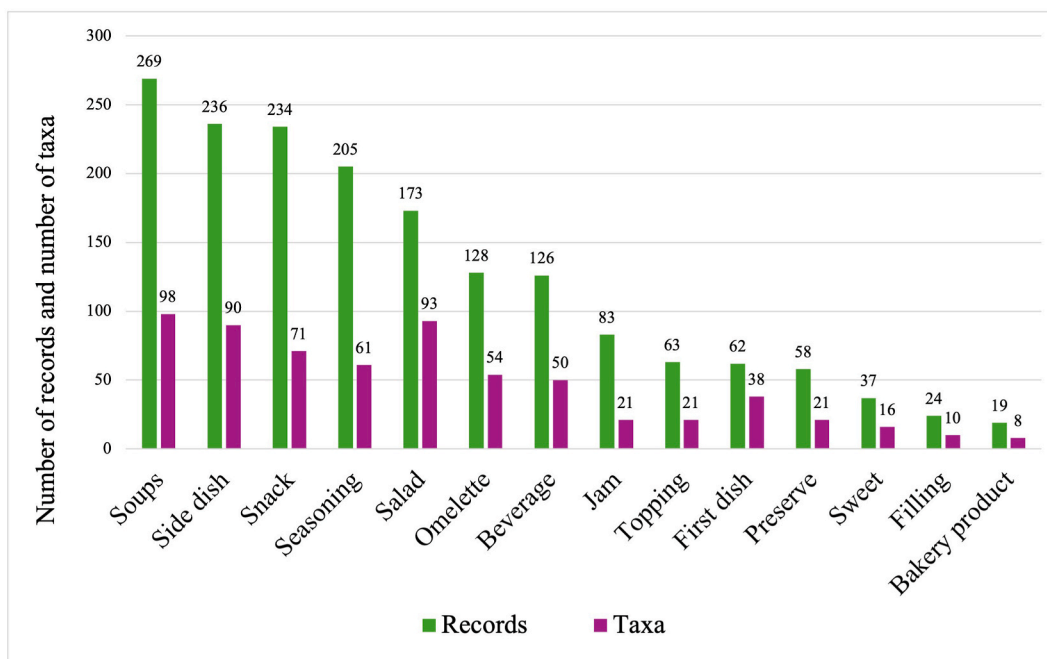


Fig. 10. Food purposes ordered by decreasing number of records and number of taxa.

Durand & Schinz, whose branches are employed in the fabrication of ties for crops or ropes for livestock. This use has been documented in other Italian regions, including Basilicata [134], Campania [93,94,139,140], Marche [101], Apulia [112] and Sicily [114,115,135], as well as in Spain [137].

Another noteworthy species is *Daphne gnidium* L., whose roots were historically employed in poaching. The roots were submerged in waterways to stun eels, which, due to the plant's toxicity, would rise to the surface. Furthermore, this practice has also been documented in Apulia [112], Spain [137,141], Sicily [90,135] and across Italy [9].

3.1.6. Cosmetic uses

The category of cosmetic uses encompasses applications related to aesthetic care and personal hygiene, including the formulation of body creams and facial and hair masks (62 records and 38 different taxa) (Fig. 7). Of particular note among the species identified in Calabria for this category is *Urtica dioica*, which is primarily utilized for hair care. The aerial parts were pulverised to create a paste-like mask, which was then applied to the hair to soften and strengthen it. This use has been documented in other Italian regions, including Campania [94], Emilia Romagna [142], Lombardy [21], Marche [101], Molise [111,143], Piedmont [144] and Tuscany [82,108], as well as in foreign countries such as Albania [145] and Algeria [146]. Furthermore, numerous ethnobotanical studies have documented the use of *U. dioica* in addressing hair loss [6,68,90,98,100,101,106,129,142,144], treating dandruff [93,95,101,106], and even colouring dark hair [81].

3.1.7. Religious uses

The category of religious uses encompasses activities where plants are incorporated into votive rites, prayers, or religious celebrations that are linked to traditions (34 records and 26 different taxa) (Fig. 7). For example, *Hypericum perforatum* L. and *Hypericum perforatum* L. were historically employed on St. John's Day (June 24th) to strengthen a religious bond between individuals. Women would gather bouquets of St. John's wort flowers and exchange them with a close friend, linking their little fingers while reciting a phrase to seal an indissoluble bond of friendship. From that moment on, the two women became "flower wives".

Pseudodictamnus mediterraneus Salmaki & Siadati subsp. *mediterraneus* was employed as a votive lamp, where the flowers being lit like as wicks in the home, especially during the "novena" period.

The inflorescences of *Daucus carota* L., *Spartium junceum*, and *Helichrysum italicum* (Roth) G.Don subsp. *italicum* were scattered as religious offerings during the Corpus Christi procession.

3.1.8. Veterinary uses

Veterinary uses refer to the use of plant parts for the treatment of animals (31 records and 15 different taxa) (Fig. 7). Among the most used plants for this purpose are *Helleborus foetidus* L. subsp. *foetidus* and *Helleborus viridis* L. subsp. *bocconei* (Ten.) Peruzzi, both of the Ranunculaceae family, used mainly for pain relief in cattle by placing the root on the affected area to alleviate discomfort [66]. *Dittrichia viscosa* (L.) Greuter was used as a pesticide: the whole plant was inserted into the rectum of donkeys to eliminate intestinal parasites. For flea control, *Lupinus albus* L. was used by rubbing the plant on the body of chickens as an anti-flea treatment. In addition,

the stems of *Triticum aestivum* L. were burned to produce ash, which was mixed with olive oil to make a paste that was applied to wounds and inflammations.

3.1.9. Ornamental uses

Ornamental use refers to the utilization of plants for purposes of home and garden beautification, as evidenced by 21 records and 15 different taxa (Fig. 7). The species commonly utilized for decorative purposes include *Acanthus mollis* L., *Antirrhinum majus* L., *Arbutus unedo*, *Cestrum parqui* L'Hér., *Convolvulus soldanella* L., *Hedera helix* L. subsp. *helix*, *Helichrysum italicum* subsp. *italicum*, *Verbascum sinuatum* L. and *Vinca major* L.

3.1.10. Ludic uses

The ludic category encompasses all uses where plants were employed for the fabrication of small toys or the enactment of social games (20 records and 14 different taxa) (Fig. 7). One of the most utilized species is *Avena barbata* Pott ex Link, which features in two distinct games. In one game, children would collect the spikelet and throw it onto other individuals' clothing to determine the number of romantic partners based on how many spikelets stuck. In the other, the plant was used to fashion small nooses, which were then used to catch lizards and take them for a walk. Another species employed in children's games was *Convolvulus silvaticus* Kit. Its flowers were closed in a manner akin to a balloon and burst on children's foreheads. Concurrently, a nursery rhyme, "cuccu, cuccaritu, dimmi a quale via mu mi maritu" with the intention of predicting the future spouse's location based on the flower's direction after bursting [43]. Furthermore, the explosive capsules of *Ecballium elaterium* (L.) A.Rich. were utilized as a source of play, with children throwing them at each other to trigger an explosion.

3.1.11. Magic uses

The category of magical uses includes all purposes involving plants in spells or rituals, such as those meant to ward off the evil eye (15 records and 14 different taxa) (Fig. 7). The most used taxa for the purpose of protection against the evil eye include *Olea europaea* L., *Phoenix dactylifera* L. and *Capsicum annuum* L. In the case of *O. europaea*, a common ritual involved the preparation a dish with water and the addition of drops of oil, accompanied by the recital of a prayer and a magic formula with the intention of dispelling the evil eye. Another protective use of this species involved the preparation of small bags containing three pieces of olive leaves, three pieces of *P. dactylifera* leaves, a pinch of salt, and some sand, which were taken in front of a consecrated church. Such bags were subsequently attached to children's clothing in order to provide protection from negative influences. Regarding *C. annuum*, its fruits were simply retained in a pocket with the intention of warding off negative energies.

The branches of *Spartium junceum* were employed in a magical ritual for the removal of warts. This involved tying a branch behind the back of the individual concerned, with the number of knots corresponding to the number of warts. Subsequently, the branch was provided to an individual who would conceal it in an area that the person with the warts did not regularly frequent. It was believed that the warts would fall off the person's body as if by magic when they passed by the location where the branch was hidden [44].

3.1.12. Forage uses

The forage category encompasses all plants utilized as animal fodder, comprising 12 records and 12 distinct taxa (Fig. 7). The most commonly utilized species belong to the Fabaceae family, including *Genista monspessulana* (L.) L.A.S.Johnson, *Medicago sativa* L., *Robinia pseudoacacia* L., *S. junceum*, *Sulla coronaria* (L.) B.H.Choi & H.Ohashi, *Trifolium repens* L. and *Vicia faba* L. These species are primarily utilized for the nourishment of rabbits and sheep, offering indispensable nutrition for these animals within agricultural and pastoral contexts.

4. Concluding remarks and future perspectives

The objective of this review was to synthesize the ethnobotanical knowledge of the Calabria region, elucidating the region's profound history and cultural heritage pertaining to plants. Over centuries, local communities have developed a sophisticated understanding of the nutritional, therapeutic, ritual, and cultural significance of plants, reflecting a strong connection between local biodiversity and daily practices. However, this knowledge is fragmented, with some provinces receiving minimal study, thereby increasing the risk of this valuable cultural and biological heritage at risk of being lost due to socio-economic changes and time. It is of the utmost importance to preserve and promote this heritage in order to safeguard biodiversity and recover local traditions. The data obtained from this review could inform scientific research and the development of new pharmaceutical, food, and cosmetic products, thereby bridging the gap between local culture and scientific progress.

Further research is required to enhance comprehension of the ethnobotanical applications in Calabria, with a particular emphasis on the involvement of local communities in the collection and dissemination of data. An integrated approach that combines traditional knowledge with modern scientific methods is essential for the sustainable management of natural resources and for maintaining the profound connection between people and their environment. This approach promises to enhance both biodiversity conservation and the well-being of local communities, thereby paving the way for a more sustainable and culturally vibrant future.

CRedit authorship contribution statement

Miriam Patti: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Investigation, Formal analysis, Data curation. **Carmelo Maria Musarella:** Writing – review & editing, Visualization, Validation, Supervision, Resources,

Methodology, Investigation, Data curation, Conceptualization. **Giovanni Spampinato**: Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Data availability statement

The datasets generated and/or analyzed during the current study are available in the file [SUPPLEMENTARY MATERIAL 1](#). Other materials can be asked to the corresponding author.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Miriam Patti reports financial support was provided by National Operational Program (PON). We declare that the corresponding author Carmelo Maria Musarella is Associate Editor of the section Plant Biology in that journal. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was funded by the National Operational Program (NOP) “Research and Innovation” 2014–2020 n. CCI2014IT16-M2OP005, Thematic Area Action IV.5 “Additional PhD scholarships on green topics”.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2025.e42050>.

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