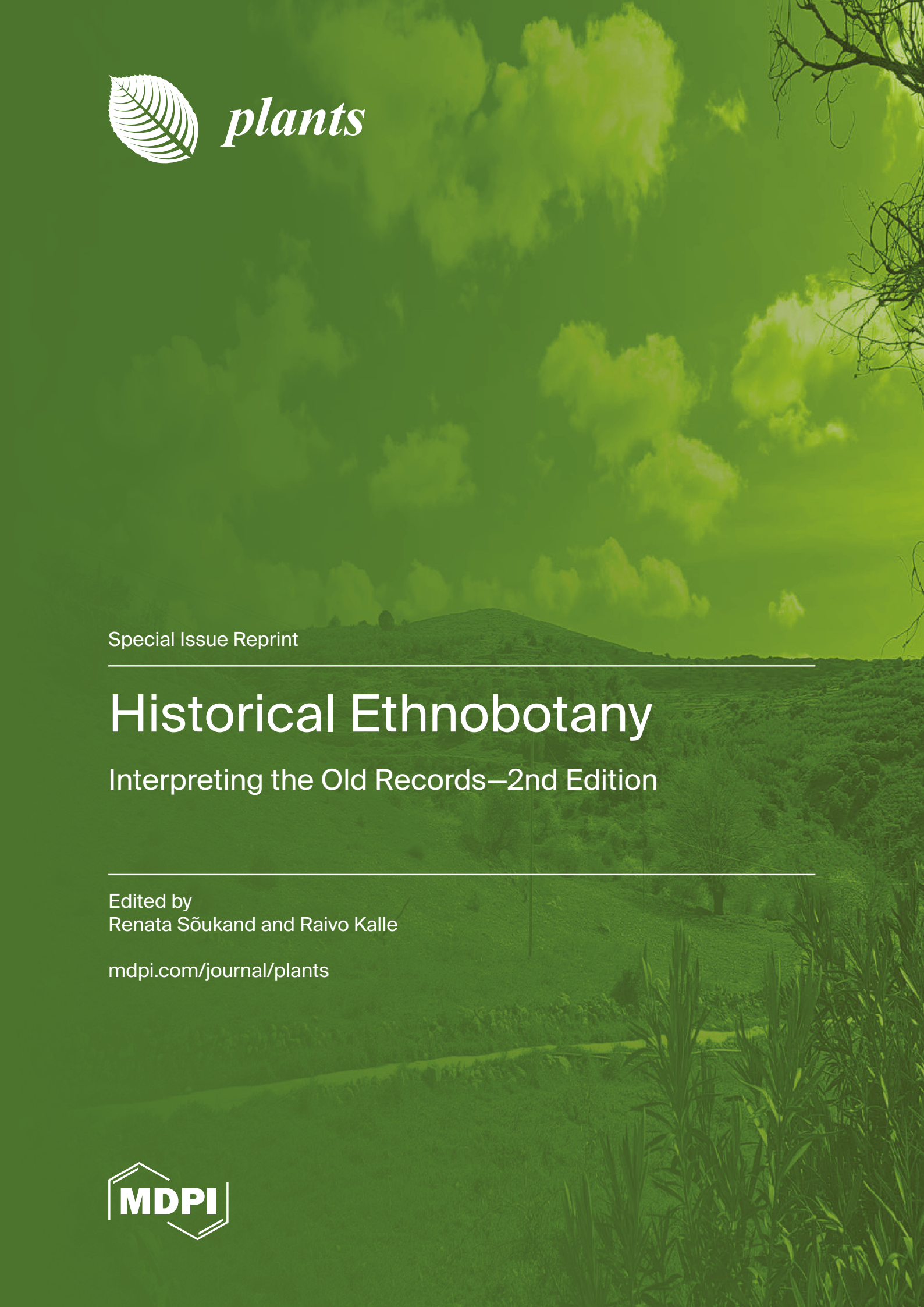


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Special Issue Reprint

Historical Ethnobotany

Interpreting the Old Records—2nd Edition

Edited by
Renata Sõukand and Raivo Kalle

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Historical Ethnobotany: Interpreting the Old Records—2nd Edition

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Guest Editors

Renata Sõukand
Raivo Kalle

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About the Editors

Renata Sõuknad

Renata Sõuknad is Associate Professor of ethnobotany at Ca' Foscari University in Italy. Her main research interests include current and historical ethnobotany of Europe, biocultural diversity, environmental history and ecosemiotics (with a focus on the relationships between humans and nature). Her ethnobotanical and anthropological field experience in over twenty countries has allowed her to observe, compare and reflect upon the inextricable link between sustainability and all aspects of biocultural diversity.

Raivo Kalle

Raivo Kalle is a senior researcher at the Estonian Literary Museum in Estonia. He studies the use of wild plant resources—for food, medicine and veterinary medicine. He has published research on the specifics of the natural cultures and food cultures of small ethnic groups. More broadly, his research has focused on the mechanisms and transformations of the transmission of both oral and written knowledge; socio-ecological systems; agroecology, including the topic of semi-natural areas; the impact of agricultural subsidies on pastoralists; human–nature relationships and reciprocity; natural vocabulary and its changes; natural and cultural heritage; the history of science; and the history of ethnobiology.

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Editorial

Time Travel Within the History of Ethnobotany

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Currently, science is increasingly being influenced by artificial intelligence (AI). Although AI can be used to write content for articles quickly and conveniently, there is also a dark side: this tool is being used more and more to "produce" articles with fictitious content. Thus, what remains permanent is history: the periods when human scientists authored articles, books and articles were published in print, manuscripts were written with pen and paper, and notes were made by hand in fieldwork diaries.

We initially thought that artificial intelligence would not significantly affect ethnobotanical research, but we were mistaken. We have encountered situations, even during the review process, where the content of an article was too good to be true. When checking the original sources, it became apparent that these were empty references, as the cited articles had never been published and the information attributed to them did not exist; these spurious references were created by AI. Therefore, references that have historically appeared in print or have been preserved in manuscripts are stable and reliable—i.e., permanent—if they were archived in the pre-AI era. That is why we, as editors, are drawn to historical ethnobotany: it is based on physically existing notes that can be reinterpreted from different perspectives again and again in light of new knowledge, yielding answers to new questions that arise.

However, a historical manuscript or book on plant use is definitive, as it remains as it was originally written. Researchers who read it in the modern day can no longer question or clarify the contents. In many cases, these scarce earlier records are the only available data, requiring researchers to interpret and reconstruct the records' contexts. To do this, it is necessary to look at broader cultural-historical sources and cultural changes, the natural conditions of the region and their transformations, and the specific features of the written language. Even then, it is always possible to err, make false assumptions, and draw erroneous conclusions. Such errors may arise from fragmented data, intentional omissions, or prior misinterpretations of the data—whether accidental [1] or deliberate [2]—that have been carried forward for decades or even centuries [3].

It was over two years ago in November 2023 when the first edition of this Special Issue was published in print [4]. At that time, the collection was fairly popular, and thus we received numerous contributions, 13 of which made it to publication. This success revealed that the topic was popular among researchers. Even as we were closing the previous Special Issue, we still received inquiries about whether it would be possible to submit manuscripts. We discussed this with the editor-in-chief of the section and he suggested creating a new Special Issue. Since history, cultural history, and plants and their use have been of interest to us for a long time, we accepted the task of editing this new Special Issue. We have now received the requisite number of contributions for publication. It brought us great

pleasure to receive manuscripts from all over the world on a range of interesting topics. This Introduction will outline the submissions that deal with the earliest periods of plant use, dating from a few thousand years ago and to the mid-20th century.

The first to take us back to the distant past Huan Wu, Xiaofeng Long, and Yanfei Geng [5] from Guizhou University, College of Tea Science. They chose Guizhou Province, China, as their research area. Tea bushes have probably been grown on forest terraces in China for thousands of years. According to archeological findings, Chinese tea culture dates back 10,000 years. Initially, the leaves of *Camellia sinensis* were collected from bushes growing naturally in forests to make tea. With the beginning of cultivation, this environment also began to be reshaped, and, over its long history, it was observed that some trees and shrubs were more suitable for co-existing with tea bushes by supporting them in their growth or protecting them from many hazards. Terraces, therefore, became the most common form of cultivation for tea bushes in that region. Forest tea gardens were only defined as agroforestry systems in 2022. According to this definition, they must contain at least 10% other species (in addition to *Camellia* spp.), must be over 0.5 hectares and over 5 meters high, and the forest must be managed in a traditional way. The authors not only examined 21 ancient written sources to determine how tea forests were described, but also conducted fieldwork in eight traditional tea forests to assess which plant species grow alongside tea bushes today. The authors found that, in early sources, tea bushes were recorded as growing together with 24 species of companion plants (including 12 tree species and 7 shrub species). The data collected during their fieldwork show that tea bushes grew alongside 81 species of plants (including 40 woody plants and 10 shrub species) on terraces, but also that there were as many as 234 species around tea bushes grown in forests (including 64 tree species and 98 shrub species). Tall trees provide shade for tea bushes, enrich the soil with nitrogen, and improve the water regime. However, the literature mentions that *Albizia chinensis* (Osbeck) Merr. is necessary because it attracts flies that would otherwise harm tea bushes. Fruit trees and vegetables are also grown between tea gardens. The authors found that people were inspired by the original tea forests to find suitable companion plants for tea bushes in established tea gardens and terraces. This knowledge also aids in the transition to agroecological agriculture because the cultivation of tea bushes growing on terraces changed in the second half of the 20th century when agrochemicals began to be widely used, which polluted the soil and water, and thus alternative solutions are now being sought.

Wendy L. Applequist, who works at the Missouri Botanical Garden, takes us on an exciting journey to Africa with the most famous botanist of his time, Ibn al-Baytar (1197–1248) [6]. Ibn al-Baytar compiled the Arabic knowledge of plants from that time and supplemented it with personal experiments and observations. His most important work included over 2300 entries, in which he described the uses of 1400 substances. Applequist provides a comprehensive overview of how Ibn al-Baytar's legacy has been recorded and studied in the past. Additionally, in the introduction to her article, she provides examples of how and by whom plant use in historical sources have been compared with modern practices. She also discusses the people known as Berbers, from whom Ibn al-Baytar acquired and recorded plant knowledge during his lifetime. Applequist relies on articles based on fieldwork conducted among Berbers in modern times, as well as reference books for comparative research. She identifies 46 plant names in Ibn al-Baytar's work that were associated with Berbers; however, as is typical with historical sources, she was not able to identify all the names, and thus only 38 species remained in the final selection, 28 of which (or 61%) are still in use among Berbers today. Appelquist concludes that, since Berbers were largely illiterate with no written language to support the preservation of plant use,

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oral traditions of plant use remained uninterrupted for about 750 years. This reveals that these plants had therapeutic effects, which could become a basis for current research into the active ingredients of medicinal plants.

Next, we move to the other side of the globe to South America. Verónica S. Lema of the Institute of Anthropology of Córdoba studied *Anadenanthera colubrina* (Vell.) Brenan var. *cebil* (Griseb.), a tree native to the southern Andes, locally called *vilca* or *cebili* [7]. This tree is known throughout the Indigenous population of this mountainous region for its psychoactive properties. Archaeological evidence suggests that the seeds of *Anadenanthera* sp. have been used in pipes for psychoactive purposes for 4000 years, and this tradition continues today. Lema reviewed the prior literature and conducted fieldwork in urban and suburban markets, interviewing vendors of this plant. For shamans, inhaling powdered seeds or smoking them in a pipe was essential to achieving visions, healing, and communicating with spirits. The seeds were also used in ethnomedicine to alleviate various ailments. Placing the seeds in amulets and wearing them as jewellery was believed to protect the owner from the evil intentions of witches. Consuming the seeds as a ritual beverage was also thought to offer protection against diseases and evil spirits. In addition, the bark of this tree was used both for tanning leather and in ethnoveterinary medicine; the leaves have also been used in ethnoveterinary medicine. Since the 19th century, all parts of the tree have been used as therapeutic agents. The use of the seeds also expanded after the arrival of the Spanish. Today, this tree holds great cultural significance, and the associated cultural practices are vibrant.

We continue our travels in the Andean region. Matteo Sartori and Julia Prakofjewa from Ca' Foscari University studied the uses of the species *Otholobium glandulosum* (L.) J.W.Grimes, native to Chile [8]. Historically, this plant was known in that region as *Culén*. The period selected for study spans from 1646 to 1810. The authors reviewed the prior literature discussing the local population's knowledge regarding this plant and how its use was reflected in Europe. It proved to be the case that *O. glandulosum* was a popular medicinal plant among the local population and was used both to treat skin diseases and as an infusion for digestive problems. In Europe, however, this plant was mainly advertised as a recreational tea. The authors point out that, under the influence of colonization, Indigenous knowledge and the local name of this plant were pushed aside and replaced by scientific knowledge.

Next, we move to the Atlantic coast of South America, specifically to Brazil. Plant use in that region has been selected for study by Natalia Hanazaki from the Department of Ecology and Zoology at the Federal University of Santa Catarina [9]. Hanazaki structures her article as a flowing narrative, and her qualitative research shows how even the smallest coincidences and the fates of individual ordinary people can lead to significant changes. This historical adventure begins in November 1793 when a merchant ship with a crew of sixteen men set off from northern Japan to deliver goods to the central part of the country. The voyage was expected to last only a few weeks, but due to a strong storm, the ship drifted at sea for over five months, eventually reaching the Aleutian Islands, which then belonged to Russia. From there, the shipwrecked crew were taken to central Siberia, where they were detained for almost seven years. They were not sent back to Japan because, at that time, Japan had a strict policy of isolation and forbade contact with the outside world. In 1803, the Russian Tsar decided to establish relations with Japan, and four Japanese shipwrecked crew members were taken along to help smooth relations. On the way from St. Petersburg to Japan, there was only a single stop of about 45 days in southern Brazil. After unsuccessful diplomatic negotiations with the Japanese government, the four shipwrecked men were handed over to Japanese officials in April 1805. Because of Japan's strict isolation

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policy, the men were then thoroughly interrogated. The records of this interrogation were the first reports and descriptions of the flora and fauna of Brazil for the Japanese people. Several books were subsequently published about the crewmen's journey, which later influenced the emigration of Japanese people to Brazil in the early 20th century. Hanazaki provides fascinating examples of how the shipwrecked men described both the localplant species and the cultural and ecological conditions of Brazil.

The article that follows is authored by Szabolcs Kis and Attila V. Molnár [10], who work in the Department of Botany at the University of Debrecen. They reviewed the historical literature (including newspapers aimed at a wide audience) and archival sources in Hungary from 1721 to 1943 that deal with the distribution and popular use of the highly poisonous *Cicuta virosa* L. The distribution of this plant in Hungary has significantly decreased compared to the past. The folk name of this plant varies significantly in different regions of Hungary. Overall, three major folk name areas can be distinguished for this plant, but, in total, i has been known by eight folk names throughout history. New locations where this plant used to be found were also discovered in historical sources. This shows that earlier manuscripts and written sources in the national language are an important source for both ethnobotany and biogeographical data. The authors provide a comprehensive overview of the history of poisoning cases caused by this plant in Hungary. There have been many accidents, especially involving children who mistook this poisonous plant for an edible one. However, the plant has sometimes been used deliberately to poison and kill people. There have also been numerous reports in Hungary of livestock deaths caused by *C. virosa*. Its toxicity is also one of the reasons it was removed from farmland in the past and why its distribution has decreased.

Next, we arrive in the 20th century. A large team of authors, including eight scientists from Zhejiang Agricultural and Forestry University, China, led by Ke Shi and Shuai Liao from the South China Botanical Garden, studied the legacy of Scottish plant collector George Forrest (1873–1932) in China [11]. Forrest visited China seven times between 1904 and 1932. During this time, he amassed a remarkably large collection of plant specimens, which are now kept in 31 herbaria around the world. Shi and his co-authors undertook the major task of reviewing all these digital herbaria and recorded a total of 38,603 plant specimens that Forrest collected in China. These specimens belong to 233 plant families, 1395 genera, and a total of 5426 plant species. The authors organized and harmonized the disparate data by date, region, and elevation. They used this information as a source to reconstruct each of Forrest's expeditions to China. Shi and his co-authors subsequently wrote a compelling descriptive story, which will be a significant aid to modern scholars for understanding the history of Chinese plant research at that time. Although Forrest's achievements as a plant collector stand out in many respects, his work not only advanced botany, but also had a profound impact on the fields of horticulture, ecology, and plant conservation. He made a particularly significant contribution to the introduction of Rhododendron species to Europe. However, the authors also pay attention to the negative aspects of his work, noting that such a colonial attitude towards collecting natural resources in another country is inconsistent with today's ethical norms. The authors also point out that Forrest, in his passion for collecting plants, did not really care about the local natural environment, as they cite the case of his cutting down a Rhododendron tree that was important to locals and taking its logs back to England.

Next, we come to the 1970s. A large team of authors, including eleven scientists from six different research institutions, led by Andrea Pieroni from the University of Gastronomic Sciences, studied the use of medicinal plants by people living in the Susa Valley in the Italian Alps [12]. The people living in this valley are heavily dependent on the tourist

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seasons of summer and winter (ski tourism); during other periods, there are few permanent residents living in the area. A prior comprehensive study on the use of medicinal plants in this region was conducted in 1970 (the use of 96 plant species was documented), while a comparative study was conducted in 2018 (the use of 36 plant species was documented). A comparison between periods revealed a significant decrease over time regarding the knowledge and use of medicinal plants. This can be attributed to the socio-economic, cultural, and potentially even environmental changes that have occurred over the past half century. In addition, the authors point out that, due to the current trend of functional foods, these plants can also be used in the food industry to develop regional products (e.g., seasoning salts). This could represent one solution for keeping local plant traditions alive.

The same time period—although in this instance covering an overseas territory—was studied by an international team of authors led by Renata Sõukand from Ca' Foscari University and Andrea Pieroni [13]. Their work describes the resilience and transformation of the biocultural heritage of wild greens foraged among the Arbëreshë, an ethnolinguistic minority, in the Argolis and Corinthia regions of Greece. Compared with historical ethnobotanical records from the 1970s, this fieldwork, conducted in 2025, not only documents previously unrecorded linguistic labels, but also new plant species. However, current Arbëreshë ethnobotanical heritage has undergone profound linguistic and cultural assimilation, with the majority of folk plant names being of Greek origin and the remainder being Albanian or a hybrid. However, the tradition of using foraged plants in boiled mixed greens (*lakra* in Arbëreshë, *chorta* in Greek) remains central to local cuisine. The authors highlight the urgent need for recognizing and supporting the continuity of this minority's remaining linguistic and ethnobotanical diversity. They suggest that the changes that appeared in the past fifty years have been driven by the ecological availability of the plants, socio-cultural transformations, and changing taste preferences.

And so we finally arrive at the 21st century. An international group of authors, including eight researchers from six institutions, led by Raivo Kalle from the Estonian Literary Museum, examined the use of medicinal plants among Karelians and Finns living in Northern Karelia, Finland [14]. This region is interesting because the majority of former settlements of one ethnic group, the Karelians, are occupied today by the Russian Federation. However, after World War II, when this border was closed, a significant number of Karelians moved from Russia to live in Finland. A total of 67 semi-structured interviews were conducted, and the current use of 31 medicinal plants was recorded. The plant names were mainly in Finnish, with only a few wild berries, one tree, and some weeds recorded in Karelian. Overall, the use of medicinal plants has significantly decreased today compared with the historical data gathered in the 19th century. Also, most knowledgeable respondents were of mixed Finnish-Karelian origin, drawing on both ancestral (and historical) knowledge. Factors such as resettlement from Russia to Finland, which resulted in the loss of contact with their traditional ancestral lands and difficulties in adapting to the new environment, may have contributed to the small number of plants reported by people with purely Karelian origin. The official health system, which did not favor the use of medicinal plants, also played a role in hindering the continuation of this tradition. Understanding all these factors could help to better preserve traditional knowledge when future decisions are made.

Saint Augustine (354 AD–430 AD), who contemplated the concepts of "long time" versus "short time" thousands of years ago, concluded, "But in what sense is that long or short, which is not? For the past, is not now; and the future, is not yet. Let us not then say, 'it is long'; but of the past, 'it hath been long'; and of the future, 'it will be long.'" [15], p. 235. All our actions today are already history tomorrow. Therefore, with our data on

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plant uses published today or collected in archives, we point the direction to tomorrow's scientists so that they can say "it hath been long", just as we rely on past scientists to make decisions for the future.

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Article

Companion Plants of Tea: From Ancient to Terrace to Forest

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Abstract: China is one of the origins of ancient tea gardens, with a long history of tea culture and tea cultivation. Guizhou Province is an important tea production place in southwest China with rich forest tea resources. The purpose of this study is to obtain historical information on companion plants in historical tea gardens and provide a theoretical basis for the sustainable development of forest tea gardens in Guizhou Province. We conducted a statistical analysis and comparison of plant species among ancient tea gardens, terrace tea gardens, and forest tea gardens from a diachronic perspective, based on 21 ancient tea literature studies, 116 terrace tea garden documents, and 18 sampled plots of forest tea gardens in Guizhou. A total of 24 companion plants species belonging to 16 families and 22 genera were found in ancient tea gardens, 81 species were found in terrace tea gardens belonging to 37 families and 74 genera, and 232 species were found in sample plots of forest tea gardens belonging to 90 families and 178 genera. Companion plants can be divided into three categories. Most of the plant families recorded in the literature also appeared in the forest tea garden we surveyed. In ancient tea gardens, terrace tea gardens, and forest tea gardens, Poaceae, Fabaceae, and Rosaceae were the most dominant families, respectively. The intercropping of tea gardens has been practiced since ancient times. Companion plants in natural forest tea gardens not only provide important insights into intercropping of terrace gardens but also hold significant implications for the conservation of existing forest tea gardens and the sustainable development of tea gardens.

Keywords: companion plants; forest tea gardens; ancient literature; sustainable development

1. Introduction

Tea has a long history in China. Tea plants originate from forests. They are one of the characteristic and important tree species of subtropical evergreen broad-leaved forests. In a stable plant community structure, they are found as tall trees or shrubs in the understory of the forest. According to legends, Shennong, an ancient Chinese ruler, tasted various herbs and encountered seventy-two toxic substances in a single day but was healed by tea (神农尝百草，一日遇七十二毒，得荼而解之), which was believed to be the main function of tea in ancient China. In the Ming Dynasty, Shen Yang's "Dan Qian Record" (the year 1547) states that "tu 荼 is the ancient word for tea 茶. Additionally, Yu Lu's "The Classic of Tea" (the year 780) from the Tang Dynasty mentioned that tea originated from the Shennong family 茶之为饮，发乎神农氏. According to Gu Ban's "White Tiger Tongyi" (the year 79) in the Eastern Han Dynasty, the Shennong period was the primary agricultural stage of China's Urgesellschaft. At present, archaeological discoveries have revealed that the Shennong period began over 10,000 years ago, and it can be inferred that the history of tea might also extend over 10,000 years [1].

Chinese tea culture has a rich and extensive history, dating back to the Pre Qin period, appearing also in the literature of the Jin Dynasty and Han Dynasty, and thriving in the Tang Dynasty and Song Dynasty. "The Classic of Tea" (the year 780) written by Yu Lu marks the formal establishment of Chinese tea culture and also allows the study of Chinese tea culture to enter the academic field of vision [2]. The emergence of the "The Classic of Tea" (the year 780) led to the rise of the tea literary works, such as Tingyun Wen's "Tea

Picking Record" (the year 860), Ran Jiao's "Cha Jue" 茶诀 (the year 784), Wen Fei's "Cha Shu" 茶述 (the years 811–813), etc. During the Song and Yuan Dynasties, the trend of drinking tea flourished day by day, and tea was an indispensable drink in the daily lives of the people from the emperor to the countryside. Moreover, there were stunning verses such as " Tea is for civilian use, equivalent to rice and salt, and cannot be consumed without it for a day" in Anshi Wang's "Yi Cha Fa" 议茶法 (the year 1059) of the Song Dynasty, and "those what are indispensable every day are firewood, rice, oil, salt, sauce, vinegar and tea", recorded in Zimu Wu's "Dream of Liang Lu" (the year 1274) of the Song Dynasty. In addition, tea-drinking customs such as tea parties, tea competitions, and tea banquets are also quite popular, and this further illustrates the important position of tea at that time [3,4].

The cultivation of tea plants in China also has a long history. Chaosheng Wang [5] inferred that the tea planting by ancient people in China has a history of at least 2000 years through his understanding of the two ancient tea literatures "Huayang Guo Zhi" (the years 348–354) and "Sichuan General Records" (the year 1816). The earliest records of tea tree cultivation techniques in China can be traced back to "Guang Zhi" (the year 270), which was written in the Western Jin Dynasty. There are also numerous pieces of literature from later dynasties that record the cultivation of tea plants. Lin Luo's "Cha Jie" 茶解 (the year 1609) of the Ming Dynasty recorded the method of preserving tea seeds to facilitate planting in the coming year. "Dongxi Shi Cha Lu" (the years 1049–1054) and "Da Guan Cha Lun" (the years 1107–1110) of the Song Dynasty recorded "Tea is suitable for the shade of high mountains, but prefers the early morning of the sun". "Beiyuan Bie Lu" (the year 1196) and "Cha Jie" (the year 1609) of the Song and Ming Dynasty recorded "where was better place for tea plantation, and what were good companion trees to tea".

During the Ming and early Qing dynasties in China, the Tea culture was a stage of stable and sustainable development, but in the end of Qing Dynasty, it was a stage of abnormal development followed by rapid decline [6]. In the Ming Dynasty, not only did the cultivation of tea plants expand but later Ming treasure voyages spread Tea culture further. Moreover, there was a big improvement in tea cultivation techniques with the emergence of tea seedling transplanting methods and tea garden intercropping practices. In the early Qing Dynasty, the area of tea plantations continued to expand, and asexual propagation methods of tea branch cutting and layering were invented [7,8]. There have also been further improvements in tea garden management, such as tea tree pruning, weeding, and fertilization. From the late Qing Dynasty to the establishment of the People's Republic of China, Chinese tea farming entered a period of decline [9–12].

After the establishment of the People's Republic of China, the tea economy developed gradually. During this period, great efforts were devoted to developing terrace tea gardens, from learning methods to improve terrace tea garden management to increasing investment in labor, funds, fertilizers, and pesticides in terrace tea gardens. As a result, the area of terrace tea gardens was expanded, and the yield of terrace tea gardens was significantly increased nationwide. For example, from 1954 to 1965, the terrace tea garden in Yuhang Tea Experimental Field increased its area by 153.3 hectares, with an average yield of 1200 kg per hectare [13]. According to the data from the China Tea Marketing Association, the total area of China's terrace tea gardens reached 3.165 million hectares in 2020. Although the development of terrace tea gardens in this way can play a great role in the economy, there are serious problems such as ecosystem instability caused by single planting, ecological environment destruction, pesticide residues, and chemical fertilizer residues [14–17].

In December 2022, Professor Shengji Pei defined a Forest Tea Garden as "it is a tea community of the genus *Camellia* (sect. Thea, including *C. sinensis* var. *sinensis*, *C. sinensis* var. *assamica*, *C. sinensis* var. *dehungensis*, *C. taliensis*, *C. crassicolumna*) of family Theaceae, managed in a traditional way, meeting the green and organic planting standards, with the goal of producing ecological tea and an area of more than 0.5 hm^2, accompanied by at least one other wild or cultivated woody plant that forms a canopy over 10% and reaches a height of over five meters" [18]. Guizhou Province is an important tea production area in Chinese history, and it was also one of the eight major tea regions in China during the Tang and Song dynas-

ties, known as the "Qianzhong Tea Region" [19]. Records of forest tea in Guizhou could be traced back to Yu Lu's "The Classic of Tea". It was written that the taste of "Du Ru Gao Shu Tea" (also known as Wu Chuan Da Shu Tea) was highly enjoyable. Tingjian Huang of the Song Dynasty also praised the Du Ru Gao Shu Tea of Qianyang, which had a bitter taste and helped to relieve the dizziness in his "Jian Cha Fu" (the years 1057–1061). Guizhou Province is rich in wild tea forest resources. According to the survey, Fanjingshan Nature Reserve in Tongren City alone has an area of 13,700 hm^2 of wild tea forest [20].

The purpose of this study is to conduct a diachronic comparison of the similarities and differences in companion plants among ancient tea gardens, terrace tea gardens, and forest tea gardens by analyzing ancient tea literature and terrace tea garden literature, as well as a sample plot survey. Also, it aims to provide a theoretical basis for the sustainable development of forest tea gardens in Guizhou Province.

2. Materials and Methods

2.1. Review of Ancient Literature in China before the Late Qing Dynasty

In this study, 21 pieces of ancient tea literature including articles, books, and poetry written before the end of the Qing Dynasty of China were selected using the keywords "ancient", "tea garden", "companion plants", and "intercropping" (Figure 1). The author's name, literature name, the year of completion, the Chinese name of companion plants, and reference fragments regarding companion plants of ancient tea literature were summarized (Table 1).

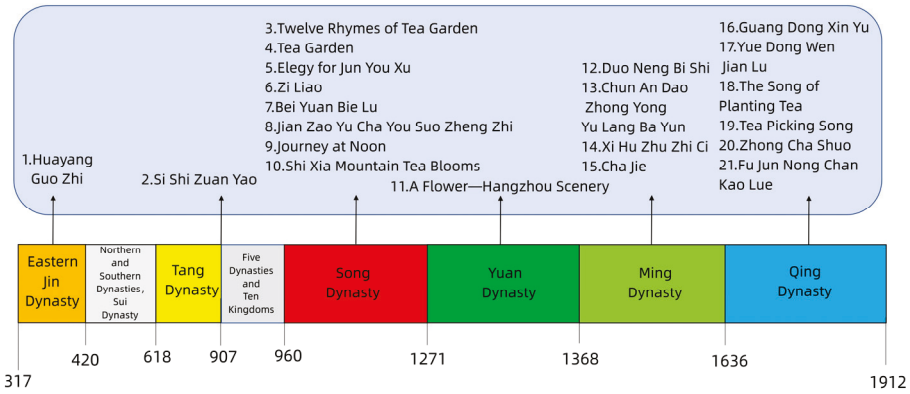


Figure 1. Historical records of major ancient tea literature.

Table 1. A summary of companion plants in ancient tea literature.

Serial Number	Ancient Tea Literatures Names	Author	The Year of Completion	Chinese Name of Companion Plants	Reference Fragment
1	Huayang Guo Zhi 华阳国志	Qu Chang	Eastern Jin Dynasty (348–354)	Mo Yu	There are fragrant konjac and fragrant tea in the garden. 园有芳蒟、香茗
2	Si Shi Zuan Yao 四时纂要	E Han	Late Tang and five Dynasties (Around 900)	Sang, Zhu, Su, Ji, Ma	Under the mulberry trees and bamboo shades, any place is suitable for planting… There is no restriction on planting ramie, millet, and barley. 桑下竹阴地种之皆可……面不妨种雄麻黍稷等
3	Twelve Rhymes of Tea Garden 茶园十二韵	Yucheng Wang	Song Dynasty (997)	Cong	Green onions share a garden. 青葱共一园
4	Tea Garden 茶园	Yuanchong Liu	Song Dynasty (1081)	Mei	The winter plum has not yet bloomed. 天寒梅未花
5	Elegy for Jun You Xu 徐君猷挽词	Shi Su	Song Dynasty (1083)	Liu, Zhu Zi	Alone, I came to plant willows after the snow. Through the bamboo grove, I walk once more to gather tea. 雪后独来栽柳处，竹间行复采茶时
6	Zi Liao 自料	Zi Zhang	Song Dynasty (1153–1221)	Sang	Planting tea should be done in a shaded area with mulberry trees 植茶要是依桑荫

Table 1. *Cont.*

Serial Number	Ancient Tea Literatures Names	Author	The Year of Completion	Chinese Name of Companion Plants	Reference Fragment
7	Bei Yuan Bie Lu 北苑别录	Ruli Zhao	Song Dynasty (1196)	Tong	Tung wood remains, and the prosperity of tung wood is compatible with tea. 桐木则留桐木之兴与茶相宜
8	Jian Zao Yu Cha You Suo Zheng Zhi 监造御茶有所争执	Ji Xu	Song Dynasty (1162–1214)	Tong	The beautiful tung tree forest has tea trees under its shade. 修修桐树林，下荫茶树低
9	Journey at Noon 午行即事	Zengbo Li	Song Dynasty (1198–1265)	Mei, Song	A few white branches emerge from plum tree in the bamboo gate, and a few stacks of green trees lie horizontally on the pine outside the mountain. The people gradually pick tea on the hills of Longfu, while many households brew rice wine for sale at market. 竹门梅出数枝白， 松外山横几叠青。人渐采茶登陇阜，家多酿秫市邮亭
10	Shi Xia Mountain Tea Blooms 石峡山茶盛开	Fengchen Fang	Song Dynasty (1221–1291)	Huo Shu	I am not alone while Phoenix Tree is under sunshine. 火树生阳我不孤
11	A Flower—Hangzhou Scenery 一枝花·杭州景	Hanqing Guan	Yuan Dynasty (1220–1300)	Dao	Tea Garden and Rice Paddy Path. 茶园稻陌
12	Duo Neng Bi Shi 多能鄙事	Ji Liu	Ming Dynasty (1311–1375)	Ma, Su Zhu Ma	When the tea plants are not yet matured, it can be planted with “Ma, Suand Zhu Ma” next to it 茶未成时其傍种麻、粟、苧诸不宿根布蔓之物皆可
13	Chun An Dao Zhong Yong Yu Lang Ba Yun 淳安道中用渔梁坝韵	Minzheng Cheng	Ming Dynasty (1446–1499)	Mai	The sparse plum trees stand on the bamboo bank, and the fine wheat embraces the tea garden 疏梅临竹岸，细麦拥茶园
14	Xi Hu Zhu Zhi Ci 西湖枝词	Zhideng Wang	Ming Dynasty (1535–1612)	Mei	Plant plum blossoms above and tea below 上种梅花下种茶
15	Cha Jie 茶解	Lin Luo	Ming Dynasty (1609)	Mei, Xin Yi, Gui, Yu Lan, Song, Zhu Zi	Such as osmanthus, plum, Xin Yi, magnolia, green pine, and emerald bamboo, and the like. 惟桂、梅、辛夷、玉兰、苍松、翠竹之类
16	Guang Dong Xin Yu 广东新语	Dajun Qu	Qing Dynasty (1630–1696)	Ku Ding Cha Shu	In the present day, people in the mountains often grow tea, occasionally complemented by Kudingcha tree. 今山中人率种茶,间以苦荬
17	Yue Dong Wen Jian Lu 粤东闻见录	Qu Zhang	Qing Dynasty (1686–1740)	Ying Shu	In Xiqiao, most people grow tea, and in the tea Beds, there are Yingshu. 西樵多种茶，茶畦有蝇树
18	The Song of Planting Tea 种茶子歌	Tingdong Cao	Qing Dynasty (1699–1785)	Da Mai	Then he mixed it with barley. 下子继以大麦掺
19	Tea Picking Song 采茶曲	Bingkun Huang	Qing Dynasty (1832–1904)	Hu Ma	Drunk and fallen into seasame land, holding a pipa (a Chinese musical instrument). 醉倒胡麻抱琵琶
20	Zhong Cha Shuo 种茶说	Jingfan Zon	Qing Dynasty (1874)	Shu, Dou	When the tea tree is not yet lush, you can plant Shu and Dou next to it 茶树尚未茂盛之时，旁下空土犹可栽薯种豆
21	Fu Jun Nong Chan Kao Lue 抚郡农产考略	Gangde He	Qing Dynasty (1903)	Lan, Ju	Under the tea, fragrant orchids and graceful chrysanthemums can be planted, creating a clear and delightful aroma. 其(茶)下可植芳兰幽菊清芬之物

2.2. A Survey of Companion Plants in Terrace Tea Gardens after the Establishment of the People's Republic of China

One hundred and sixteen Chinese documents regarding companion plants in terrace tea gardens were found in the CNKI database (www.cnki.net, accessed on 16 August 2023) using the keywords “tea garden”, “intercropping”, “companion plants”, “ecological benefit”, “terrace tea garden”, and “tea growth”. The types of publications were articles and reviews, and the period of publication was 1957 to 2022.

2.3. Forest Tea Garden Survey

2.3.1. Overview of the Survey Area

(1) Puding County (longitude 105°27′ E to 105°58′ E and latitude 26°26′ N to 26°31′ N) is located northwest of Anshun City in the middle of Guizhou Province (Figure 2). It has a subtropical monsoon humid climate.

(2) Sandu (longitude 107°40′ E to 108°14′ N and latitude 25°30′ N to 26°10′ N), located southeast of Qiannan Buyi and Miao Autonomous Prefecture in Guizhou Province, is the only autonomous county of Shui nationality in China (Figure 2). It is located in the hinterland of "Moon Mountain and Leigong Mountain". It has a temperate subtropical monsoon climate.

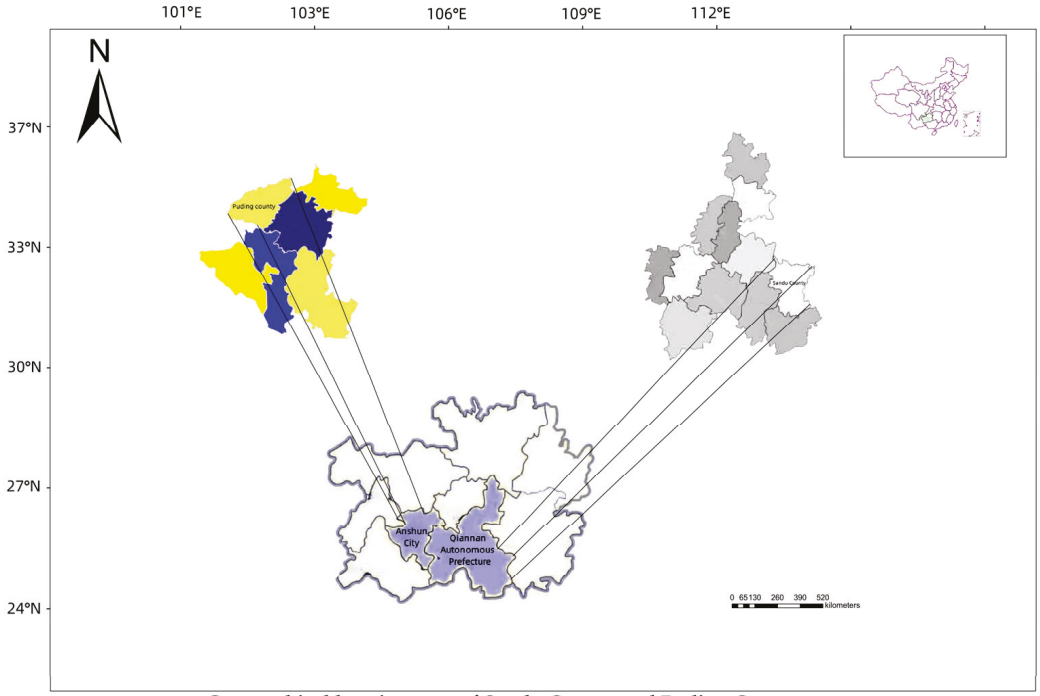


Figure 2. Location of the forest tea gardens in Guizhou Province, China.

2.3.2. Sample-Plot Survey

Eighteen sample plots were chosen in the forest tea gardens located in Sandu County and Puding County, Guizhou Province (Table 2, Figure 3a). The specific details of another 10 plots in Sandu County could be seen in our previous study [21]. Each sample plot covered an area of 20 m by 20 m and trees with a diameter at breast height exceeding 5 cm were recorded. Additionally, four middle squares (5 m by 5 m) were established along the diagonal of each sample plot to examine the shrubs. Furthermore, four smaller plots (1 m by 1 m) were arranged in the center of each shrub layer sample to study the herbaceous plants [22].

Table 2. Specific information of the sample plots in Puding County.

Region	Sample Plot Number	North Latitude	East Longitude	Altitude/m	Slope Aspect	Slope/°	Total Coverage/%
Puding County	DB	26°14′8.35″	105°34′24.58″	1287	SE	66	92
	CJ01	26°14′51.06″	105°34′28.47″	1301	E	69	95
	CJ02	26°14′48.33″	105°34′18.13″	1265	SW	65	96
	CJ03	26°14′50.17″	105°34′13.84″	1243	SW	69	98
	SZ01	26°13′53.68″	105°34′18.55″	1383	NE	77	93
	SZ02	26°14′26.45″	105°35′14.39″	1353	E	67	98
	SZ03	26°14′46.77″	105°35′15.74″	1370	SE	77	95
	XF	26°14′29.39″	105°34′17.11″	1307	N	76	92



(**a**) (**b**)

Figure 3. The comparison of forest tea gardens and terrace tea gardens in Guizhou, China. (**a**) Forest tea garden. (**b**) Terrace garden.

3. Results

3.1. Diversity of Companion Plant Species in Three Different Types of Tea Gardens

In this study, a total of 24 companion plant species belonging to 16 families and 23 genera were found in ancient tea literature, including 12 species of tree plants, 7 species of shrub plants (with 5 species of them being both trees and shrubs), and 10 species of herbaceous plants (Table 3).

Table 3. Companion plants in ancient gardens and terrace tea gardens.

Serial Number	Scientific Name	Family	Chinese Name	Life Form	Types of Tea Garden *
1	*Mangifera indica* L.	Anacardiaceae	Mang Guo	Tree	Terrace
2	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Tang Jiao Shu	Tree	Terrace
3	*Ilex Latifolia* Thunb.	Aquifoliaceae	Ku Deng	Tree	Ancient
4	*Pinellia ternate* (Thunb.) Breit.	Araceae	Ban Xia	Herbaceous	Terrace
5	*Areca catechu* L.	Arecaceae	Bing Lang	Tree	Terrace
6	*Hemerocallis citrina* Baroni	Asphodelaceae	Huang Hua Cai	Herbaceous	Terrace
7	Asteraceae sp.	Asteraceae	Ju	Herbaceous	Ancient, Forest
8	*Atractylodes macrocephala* Koidz.	Asteraceae	Bai Shu	Herbaceous	Terrace
9	*Artemisia argyi* Lévl. et Van.	Asteraceae	Ai Hao	Herbaceous	Terrace
10	*Alnus nepalensis* D.Don.	Betulaceae	Ni Bo Er Qi Mu	Tree	Terrace, Forest
11	*Raphanus sativus* L.	Brassicaceae	Luo Bu	Herbaceous	Terrace
12	*Brassica rapa* var. *glabra* Regel	Brassicaceae	Bai Cai	Herbaceous	Terrace
13	*Brassica napus* L.	Brassicaceae	You Cai	Herbaceous	Terrace
14	*Dioscorea alata* L.	Convolvulaceae	Shu	Herbaceous	Ancient, Terrace
15	*Cornus officinalis* Sieb. et Zucc	Cornaceae	Shan Zhu Yu	Tree, Shrub	Terrace
16	*Cunninghamia lanceolata* (Lamb.) Hook.	Cupressaceae	Shan Mu	Tree	Terrace
17	*Vatica mangachapoi* Blanco	Dipterocarpaceae	Qing Mei	Tree	Terrace
18	*Diospyros kaki* Thunb.	Ebenaceae	Shi Zi	Tree	Terrace
19	*Eucommia ulmoides* Oliv.	Eucommiaceae	Du Zhong	Tree	Terrace, Forest
20	*Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg.	Euphorbiaceae	Xiang Jiao Shu	Tree	Terrace, Forest
21	*Ricinus communis* L.	Euphorbiaceae	Bi Ma	Shrub	Terrace
22	*Triadica sebifera* (L.) Small	Euphorbiaceae	Wu Bai	Tree, Shrub	Terrace
23	*Vernicia fordii* (Hemsl.) Airy Shaw	Euphorbiaceae	You Tong Shu	Tree	Terrace, Forest
24	*Albizia chinensis* (Osbeck) Merr.	Fabaceae	Ying Shu	Tree	Ancient
25	Fabaceae sp.	Fabaceae	Dou	Herbaceous	Ancient, Terrace
26	*Medicago sativa* L.	Fabaceae	Zi Hua Mu Xu	Herbaceous	Terrace
27	*Trifolium repens* L.	Fabaceae	Bai San Ye	Herbaceous	Terrace

Table 3. *Cont.*

Serial Number	Scientific Name	Family	Chinese Name	Life Form	Types of Tea Garden *
28	*Astragalus sinicus* L.	Fabaceae	Zi Yun Ying	Herbaceous	Terrace
29	*Glycine max* (L.) Merr.	Fabaceae	Huang Dou	Herbaceous	Terrace
30	*Cassia rotundifolia* (Pers.) Greene	Fabaceae	Yuan Ye Jue Ming	Herbaceous	Terrace
31	*Indigofera spicata* Forssk.	Fabaceae	Pu Di Mu Lan	Herbaceous	Terrace
32	*Senna siamea* (Lam.) H. S. Irwin & Barneby	Fabaceae	Tie Dao Mu	Tree	Terrace
33	*Zenia insignis* Chun	Fabaceae	Ren Dou	Tree	Terrace
34	*Acacia richii* A. Gray	Fabaceae	Tai Wan Xiang Si Shu	Tree	Terrace
35	*Arachis hypogaea* L.	Fabaceae	Luo Hua Sheng	Herbaceous	Terrace
36	*Delonix regia* (Boj.) Raf.	Fabaceae	Huo Shu	Tree	Ancient
37	*Kummerowia striata* (Thunb.) Schindl.	Fabaceae	Ji Yan Cao	Herbaceous	Terrace
38	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Yin He Huan	Tree	Terrace
39	*Macroptilium lathyroides* (L.) Urban	Fabaceae	Da Yi Dou	Herbaceous	Terrace
40	*Pisum sativum* L.	Fabaceae	Wan Dou	Herbaceous	Terrace
41	*Phaseolus calaratus* Roxb.	Fabaceae	Zhu Dou	Herbaceous	Terrace
42	*Vicia faba* L.	Fabaceae	Can Dou	Herbaceous	Terrace
43	*Vicia sativa* L.	Fabaceae	Ye Wan Dou	Herbaceous	Terrace
44	*Vigna radiata* L. Wilczek	Fabaceae	Lv Dou	Herbaceous	Terrace
45	*Vigna unguiculata* (L.) Walp.	Fabaceae	Gang Dou	Herbaceous	Terrace
46	*Castanea mollissima* Blume	Fagaceae	Ban Li	Tree	Terrace, Forest
47	*Ginkgo biloba* L.	Ginkgoaceae	Yin Xing	Tree	Terrace, Forest
48	*Cinnamomum camphora* (L.) Presl	Lauraceae	Zhang Shu	Tree	Terrace, Forest
49	*Litsea cubeba* (Lour.) Pers.	Lauraceae	Shan Ji Jiao	Tree, Shrub	Terrace
50	*Ocimum basilicum* L.	Labiatae	Luo Le	Herbaceous	Terrace
51	*Perilla frutescens* (L.) Britt.	Labiatae	Zi Su	Herbaceous	Terrace
52	*Agastache rugosa* (Fisch. & C. A. Mey.) Kuntze	Labiatae	Huo Xiang	Herbaceous	Terrace
53	*Salvia japonica* Thunb.	Labiatae	Shu Wei Cao	Herbaceous	Terrace
54	*Allium sativum* L.	Liliaceae	Da Suan	Herbaceous	Terrace
55	*Allium fistulosum* L.	Liliaceae	Cong	Herbaceous	Ancient
56	*Punica granatum* L.	Lythraceae	Shi Liu	Tree, Shrub	Terrace
57	*Firmiana simplex* (L.) W. Wight	Malvaceae	Wu Tong	Tree	Ancient
58	*Yulania denudate* (Desr.) D. L. Fu	Magnoliaceae	Yu Lan	Tree	Ancient, Forest
59	*Yulania liliiflora* (Desr.) D. L. Fu	Magnoliaceae	Xin Yi	Shrub	Ancient
60	*Toona sinensis* (A. Juss.) Roem	Meliaceae	Xiang Chun	Tree	Terrace
61	*Morus alba* L.	Moraceae	Sang	Tree, Shrub	Ancient, Terrace, Forest
62	*Musa acuminata* Colla	Musaceae	Xiang Jiao	Herbaceous	Terrace
63	*Morella rubra* Lour.	Myricaceae	Yang Mei	Tree	Terrace, Forest
64	*Osmanthus fragrans* Lour.	Oleacea	Gui	Tree, Shrub	Ancient, Terrace
65	Orchidaceae sp.	Orchidaceae	Lan	Herbaceous	Ancient, Terrace
66	*Sesamum indicum* L.	Pedaliaceae	Hu Ma	Shrub	Ancient
67	*Pinus elliottii* Engelm.	Pinaceae	Shi Di Song	Tree	Terrace
68	*Pinus* sp.	Pinaceae	Song	Tree	Ancient, Terrace, Forest
69	*Pinus taeda* L.	Pinaceae	Hou Ju Song	Tree	Terrace
70	*Bambusoideae* sp.	Poaceae	Zhu Zi	Herbaceous	Ancient, Forest
71	*Hordeum vulgare* L.	Poaceae	Da Mai	Herbaceous	Ancient
72	*Oryza sativa* L.	Poaceae	Dao	Herbaceous	Ancient, Terrace
73	*Saccharum officinarum* L.	Poaceae	Gan Zhe	Herbaceous	Terrace
74	*Lolium multiflorum* Lamk.	Poaceae	Duo Hua Hei Mai Cao	Herbaceous	Terrace
75	*Paspalum notatum* Flugge	Poaceae	Bai Xi Cao	Herbaceous	Terrace
76	*Panicum miliaceum* L.	Poaceae	Ji	Herbaceous	Ancient
77	*Setaria italica* var. *germanica* (Mill.) Schred.	Poaceae	Su	Herbaceous	Ancient
78	*Sorghum bicolor* (L.) Moench	Poaceae	Gao Liang	Herbaceous	Terrace
79	*Zea mays* L.	Poaceae	Yu Mi	Herbaceous	Terrace
80	*Secale cereale* L.	Poaceae	Hei Mai	Herbaceous	Terrace
81	*Eriobotrya japonica* (Thunb.) Lindl.	Rosaceae	Pi Pa	Tree	Terrace, Forest
82	*Malus pumila* Mill.	Rosaceae	Ping Guo	Tree	Terrace
83	*Prunus mume* Siebold & Zucc.	Rosaceae	Mei	Tree, Shrub	Ancient, Terrace, Forest
84	*Prunus salicina* L.	Rosaceae	Li	Tree, Shrub	Terrace, Forest
85	*Crataegus pinnatifida* Bunge	Rosaceae	Shan Zha	Tree	Terrace
86	*Prunus* sp.	Rosaceae	Ying Tao	Tree	Terrace
87	*Pyrus bretschneideri* Rehd.	Rosaceae	Li Shu	Tree	Terrace
88	*Citrus reticulata* Blanco	Rutaceae	Gan Ju	Tree, Shrub	Terrace, Forest

Table 3. *Cont.*

Serial Number	Scientific Name	Family	Chinese Name	Life Form	Types of Tea Garden *
89	*Populus* sp.	Salicaceae	Yang Shu	Tree	Terrace, Forest
90	*Salix* sp.	Salicaceae	Liu	Tree	Ancient
91	*Dimocarpus longan* L.	Sapindaceae	Long Yan	Tree	Terrace
92	*Lucuma nervosa* A.DC.	Sapotaceae	Dan Huang Guo	Tree	Terrace
93	*Paulownia fortunei* (Seem.) Hemsl	Scrophulariaceae	Bai Hua Pao Tong	Tree	Terrace, Forest
94	*Capsicum annuum* L.	Solanaceae	La Jiao	Herbaceous	Terrace
95	*Laportea* sp.	Urticaceae	Ai Ma	Tree, Shrub	Ancient
96	*Boehmeria* sp.	Urticaceae	Zhu Ma	Tree, Shrub	Ancient
97	*Vitis vinifera* L.	Vitaceae	Pu Tao	Herbaceous	Terrace, Forest

* Note: If the companion plants presented here also existed in forest gardens, then it was also marked with "forest" in the last column.

The companion plants found in terrace tea gardens include 81 species belonging to 37 families and 74 genera, including 40 species of tree plants, 10 species of shrub plants (with 9 species of them exhibiting dual life forms), and 40 species of herbaceous plants (Table 3). According to the selected articles, intercropping economic trees (apples, mulberry trees, etc.) in tea terrace gardens demonstrated favorable strategic selection, while young terrace tea gardens (1–4 years old) were generally intercropped with leguminous plants (peanuts, peas, etc.).

The companion plants found in forest tea garden sample plots include 232 species belonging to 90 families and 178 genera, including 64 tree species, 98 shrub species, and 111 herbaceous species (Table 3, Table A1). In the sample plots of forest tea gardens we surveyed, the total vegetation coverage exceeded 92.44%. The JQ02 plot (Altitude 877 m) situated in Sandu County exhibited the highest species richness with 43 recorded species, while the CJ01 plot (Altitude 1301 m) located in Puding County presented the lowest species count of 25.

3.2. The Categories of Companion Plants

The companion plants could be divided into three categories. The first type was companion plants that have ecological value. For instance, tall trees such as *Firmiana simplex* (L.) W. Wight and *Morus alba* L. can provide shade for the tea plant, as tea plants prefer shade. Also, some companion plants could be multi-purpose (nitrogen fixing, fly attracting, water storage for tea, and so on). There was a multi-purpose tree written in several pieces of ancient literature named *Albizia chinensis* (Osh.) Merr, which not only can provide shade for tea but also attracts flies to avoid the gathering of flies around tea and contaminating the tea leaves. At the same time, it can also help regulate the soil moisture in the tea garden. The second type referred to aromatic plants, such as *Osmanthus* fragrans Lour. and *Yulania liliiflora* (Desr.) D. L. Fu. The third type included companion plants that have economic value (fruits and economic crops). In the terrace tea gardens, fruits trees like *Prunus salicina* L., *Mangifera indica* L., and *Punica granatum* L. were often used to provide shade for tea while economic crops like *Vicia faba* L., *Zea mays* L., and *Sorghum bicolor* (L.) Moench were often planted to change the microclimate of tea gardens and obtain economic benefits.

3.3. Dominant Family of Companion Plants in Three Different Types of Tea Gardens

According to ancient tea literature, a greater diversity of companion plant species was documented within the families of Poaceae, Urticaceae, and Fabaceae in ancient tea gardens. In terrace tea gardens, higher species diversity was observed in the families Fabaceae, Rosaceae, and Poaceae. Meanwhile, the predominant families were Rosaceae, Asteraceae, and Dryopteridaceae in sample plots of forest gardens in Guizhou (Figure 4). The findings demonstrated the prevalence of the Rosaceae family within both terrace and forest tea gardens, while the Poaceae and Fabaceae families exhibited dominance in ancient tea gardens and terrace tea gardens.

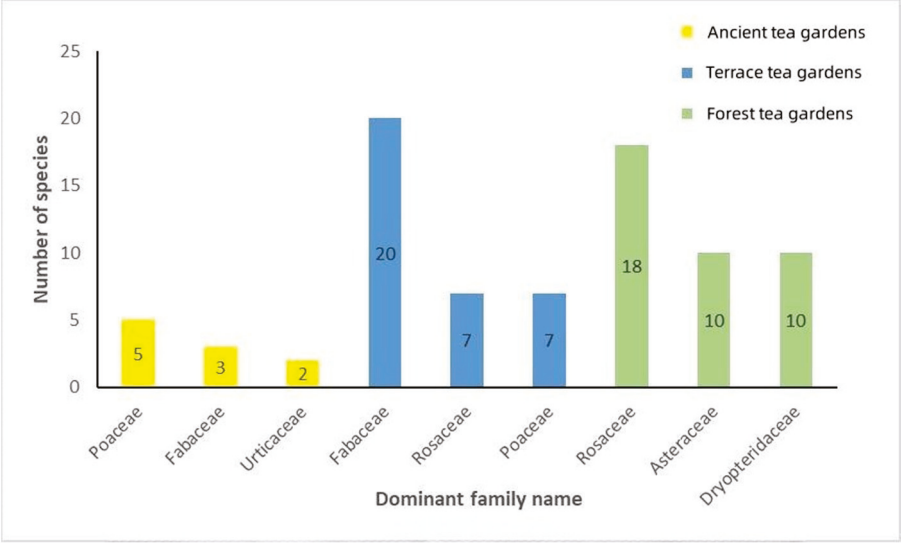


Figure 4. Families with many companion plant species appear in tea gardens.

3.4. The Common Family of Companion Plants in Three Different Types of Tea Gardens

The highest affinity in terms of companion plant species at the family taxonomic level was observed between ancient tea gardens and terrace tea gardens (Jaccard Index, JI = 0.23), and a high resemblance also occurred between terrace tea gardens and forest tea gardens (JI = 0.22), whereas the lowest similarity was detected across all three garden types (JI = 0.07). The level of similarity between ancient tea gardens and forest tea gardens fell within an intermediate range (JI = 0.12).

4. Discussion

Tea plants thrive beneath the canopy of arboreal vegetation in the forest and have evolved over an extended period of systematic cultivation to acquire distinctive genetic traits associated with shade endurance, temperature and humidity preferences, and the ability to efficiently harness diffused light [23]. Our research shows that the companion plants found in forest tea garden sample plots include 232 species belonging to 90 families and 178 genera, and there is a rich diversity of plant species in the Guizhou forest garden. It is found that as early as the Tang Dynasty in China, ancient people discovered that companion plants in tea gardens are beneficial to tea plants [24]. Appropriate plant diversity can improve the microclimate of tea gardens, improve the physical and chemical properties of soil, and increase beneficial insects in tea gardens [25–28], which further proves the importance of companion plants in tea gardens.

Currently, there are still serious issues that need to be addressed in the terrace tea garden. Primarily, commencing from the latter half of the 20th century, certain terrace tea gardens have employed substantial quantities of agrochemicals (pesticides, fertilizers) with the intention of achieving heightened tea yields. Regrettably, this practice has engendered soil microbiota, the dissipation of vital nutrients, and disruption to the ecological equilibrium of terrace tea gardens, thereby exerting a significant influence on the biodiversity of indigenous plant species [29,30]. In congruence with existing research findings, it has also come to our attention that a few forest tea gardens have suffered artificial degradation [31–33]. These gardens are susceptible to pests and diseases, resulting in suboptimal rates of tea plant resource utilization.

The intercropping of tea gardens has been practiced since ancient times and most of the intercropping plants in terrace tea gardens were fruits trees (pomegranate, loquat, and pear), economic trees (chestnut and rubber tree), legumes (broad bean, mung bean, and cowpea), and grain (corn and sorghum). In our research, we also found that only a small number of companion shrub plants were intercropped in terrace tea gardens. The reason for this may be that the tea planted in terrace tea gardens was mostly shrub tea plants, and there was a competitive relationship between shrubs. The intercropping of shrub species might lead to competition between them and tea plants for nutrient elements, which is unfavorable for tea growth

and development [34]. Introducing intercropping practices encompassing clover, straw, and other herbaceous species offers a pragmatic method for diminishing soil erosion in terrace tea gardens, concurrently upholding soil element stability [35,36], and intercropping trees such as magnolia and chestnut in the middle of terrace tea gardens can contribute to the moderation of microclimatic conditions, fostering a cooler and more humid environment that benefits tea vegetation [37,38].

The Rosaceae family exhibits a relatively higher diversity of companion plant species within both terrace tea gardens and forest tea gardens. This phenomenon could be attributed to their considerable economic significance, expansive geographical distribution, and high endurance to climate change [39].

Comparing the three garden types, the family-level similarity is lowest among the companion herbaceous plants (which possess relatively greater species richness in forest tea gardens), while companion trees exhibit the highest level of similarity. This disparity could be attributed to the fact that certain companion herbs in forest tea gardens may be got rid of as weeds in terrace tea gardens, whereas certain companion trees play a favorable role in tea plant growth and garden development. The majority of the families observed in ancient tea gardens and terrace tea gardens can also be found in the forest tea gardens we investigated. These findings suggest that the inspiration for planting companion plant trees in ancient tea gardens and terrace tea gardens might have originated from natural forest tea gardens, which demonstrates the feasibility of promoting the vigorous development of forest tea gardens.

5. Conclusions

Our study indicates that the utilization of companion plants in tea gardens has been prevalent since antiquity, showcasing a diverse array of companion plant species. Notably, Poaceae, Fabaceae, and Rosaceae emerge as the most prevalent botanical families. These diverse companions can confer distinct advantages to tea cultivation. During the establishment of tea gardens, it is recommended to deliberate on approaches that ensure the preservation of the ecological balance and the optimal utilization of companion plant resources. This will facilitate the attainment of sustainable progress across a spectrum of tea garden contexts.

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Data Availability Statement: Data is contained within the article and Appendix A.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Companion plants in forest tea gardens in Puding County, Guizhou Province, China.

Serial Number	Scientific Name	Family	Chinese Name	Life Form
1	*Alternanthera philoxeroides* (Mart.) Griseb	Amaranthaceae	Kon Xin Lian Zi Cao	Herbaceous
2	*Toxicodendron vernicifluum* (Stokes) F. A. Barkl.	Anacardiaceae	Qi Shu	Tree
3	*Aralia echinocaulis* Hand. Mazz.	Araliaceae	Chi Jin Song Mu	Tree
4	*Artemisia carvifolia* Buch.-Ham. ex Roxb.	Asteraceae	Qing Hao	Herbaceous
5	*Artemisia lavandulifolia* DC.	Asteraceae	Ye Ai Hao	Herbaceous
6	*Conyza sumatrensis* (Retz.) Walker	Asteraceae	Su Men Bai Jiu Cao	Herbaceous
7	*Erigeron acer* L.	Asteraceae	Fei Peng	Herbaceous
8	*Eupatorium coelestinum* L.	Asteraceae	Po Hua Cao	Herbaceous
9	*Gnaphalium hypoleucum* DC.	Asteraceae	Qiu Shu Qu Cao	Herbaceous
10	*Senecio scandens* Buch.-Ham. ex D. Don	Asteraceae	Qian Li Guang	Herbaceous
11	*Blumea balsamifera* (L.) DC.	Asteraceae	Ai Na Cao	Herbaceous
12	*Sphaeranthus africanus* L.	Asteraceae	Dai Xinh Cao	Herbaceous
13	*Athyrium otophorum* (Miq.) Koidz	Athyriaceae	Guang Ti Gai Jue	Herbaceous
14	*Betula luminifera* H. Winkl.	Betulaceae	Guang Ye Hua	Tree

Table A1. *Cont.*

Serial Number	Scientific Name	Family	Chinese Name	Life Form
15	*Catalpa bungei* C. A. Mey.	Bignoniaceae	Qiu	Tree
16	*Pachysandra axillaris* Franch.	Buxaceae	Ban Deng Guo	Shurb
17	*Lonicera fulvotomentosa* Hsu et S. C. Cheng	Caprifoliaceae	Huang He Mao Ren Dong	Shurb
18	*Lonicera hypoglauca* Miq.	Caprifoliaceae	Gu Xian Ren Dong	Shurb
19	*Viburnum fordiae* Hance	Caprifoliaceae	Nan Fang Jia Mi	Shurb
20	*Cerastium fontanum* Baumg.	Caryophyllaceae	Con Sheng Juan Er	Herbaceous
21	*Stellaria vestita* Kurz.	Caryophyllaceae	Jing Gu Cao	Herbaceous
22	*Cornus macrophylla* (Wall.) Sojak	Cornaceae	Lai Mu	Tree
23	*Capsella bursa-pastoris* (L.) Medic.	Cruciferae	Ji Cai	Herbaceous
24	*Dioscorea bulbifera* L.	Dioscoreaceae	Huang Du	Herbaceous
25	*Cyrtomium caryotideum* (Wall.) Presl	Dryopteridaceae	Chi Ci Guan Zhong	Herbaceous
26	*Cyrtomium fortunei* J. Sm.	Dryopteridaceae	Guan Zhong	Herbaceous
27	*Dryopteris championii* (Benth.) C. Chr.	Dryopteridaceae	Kua Ling Ling Mao Jue	Herbaceous
28	*Dryopteris setosa* (Thunb.) Akasawa	Dryopteridaceae	Liang Se Ling Mao Jue	Herbaceous
29	*Polystichum xiphophyllum* (Baker) Diels	Dryopteridaceae	Jian Ye Er Jue	Herbaceous
30	*Elaeagnus pungens* Thunb.	Elaeagnaceae	Hu Tui Zi	Herbaceous
31	*Hylodesmum podocarpum* (Candolle) H. Ohashi & R. R. Mill	Fabaceae	Chang Bin Shan ma Huang	Shurb
32	*Castanopsis chinensis* (Sprengel) Hance	Fagaceae	Zhui	Shurb
33	*Clinopodium chinense* (Benth.) O. Ktze.	Labiatae	Feng Lun Cai	Herbaceous
34	*Clinopodium gracile* (Benth.) O. Ktze.	Labiatae	Xi Feng Lun Cai	Herbaceous
35	*Stauntonia* sp.	Lardizabalaceae	Niu Teng	Herbaceous
36	*Cinnamomum bodinieri* H. Lév.	Lauraceae	Hou Zhang	Shurb
37	*Phoebe zhennan* S. K. Lee & F. N. Wei	Lauraceae	Nan Mu	Shurb
38	*Ophiopogon japonicus* (L. f.) Ker-Gawl.	Liliaceae	Mai Dong	Herbaceous
39	*Stenoloma chusanum* Ching	Lindsaeaceae	Wu Jue	Herbaceous
40	*Palhinhaea cernua* (L.) Vasc. & Franco	Lycopodiaceae	Chui Sui Shi Song	Herbaceous
41	*Toona sinensis* (A. Juss.) Roem.	Meliaceae	Xiang Chun	Shurb
42	Broussonetia papyrifera (L.) Vent	Moraceae	Hou Shu	Herbaceous
43	*Ficus heteromorpha* Hemsl.	Moraceae	Yi Ye Rong	Shurb
44	*Humulus scandens* (Lour.) Merr.	Moraceae	Lv Cao	Herbaceous
45	*Morus australis* Poir.	Moraceae	Ji Sang	Shurb
46	*Camptotheca acuminata* Decne.	Nyssaceae	Xi Shu	Shurb
47	*Osmunda japonica* Thunb.	Osmundaceae	Zhi Qi	Herbaceous
48	*Oxalis corniculata* L.	Oxalidaceae	Chu Jiang Cao	Herbaceous
49	*Plantago asiatica* L.	Plantaginaceae	Che Qian Cao	Herbaceous
50	*Arthraxon hispidus* (Trin.) Makino	Poaceae	Jing Cao	Herbaceous
51	*Eremochloa ciliaris* (L.) Merr.	Poaceae	Wu Gong Cao	Herbaceous
52	*Heteropogon contortus* (L.) P. Beauv. ex Roem. et Schult.	Poaceae	Huang Mao	Herbaceous
53	*Microstegium nodosum* (Kom.) Tzvel.	Poaceae	Xiu Zhu	Herbaceous
54	*Miscanthus sinensis* Anderss.	Poaceae	Mang	Herbaceous
55	*Fagopyrum dibotrys* (D.Don)Hara	Polygonaceae	Jin Qiao Mai	Herbaceous
56	*Fallopia multiflora* (Thunb.) Harald.	Polygonaceae	He Shou Wu	Herbaceous
57	*Pteris cretica* L.	Pteridaceae	Feng Wei Jue	Herbaceous
58	*Pteridium aquilinum* (L.) Kuhn	Pteridiaceae	Jue	Herbaceous
59	*Ranunculus sieboldii* Miq.	Ranunculaceae	Yang Zi Mao Geng	Herbaceous
60	*Agrimonia pilosa* Ldb.	Rosaceae	Long Ya Cao	Herbaceous
61	*Duchesnea indica* (Andr.) Focke	Rosaceae	Shei Mei	Herbaceous
62	*Pyrus pashia* F. Schmidt	Rosaceae	Ci Li	Shurb
63	*Cerasus pseudocerasus* (Lindl.) G. Don	Rosaceae	Ying Tao	Tree, Shurb
64	*Rosa cymosa* Tratt.	Rosaceae	Xiao Guo Qiang Wei	Shurb
65	*Rubus multiflora* Thunb.	Rosaceae	Ye Qiang Wei	Shurb
66	*Rubus coreanus* Miq.	Rosaceae	Cha Tian Pao	Shurb
67	*Rubus ellipticus* var. *obcordatus* (Franch.) Focke	Rosaceae	Zai Yang Pao	Shurb
68	*Rubus pectinellus* Maxim.	Rosaceae	Huang Pao	Shurb
69	*Rubus swinhoei* Hance	Rosaceae	Mu Mei	Shurb
70	*Rubia cordifolia* L.	Rubiaceae	Qian Cao	Herbaceous
71	*Evodia fargesii* Dode	Rutaceae	Shu Ye Wu Yu	Shurb
72	*Populus adenopoda* Maxim.	Salicaceae	Xiang Ye Yang	Tree, Shurb
73	*Populus tremula* var. *villosa* Carr.	Salicaceae	Bai Yang	Tree, Shurbs
74	*Koelreuteria paniculata* L.	Sapindaceae	Luan Shu	Tree
75	*Houttuynia cordata* Thunb.	Saururaceae	Zhe Er Geng	Herbaceous
76	*Selaginella tamariscina* (P. Beauv.) Spring	Selaginellaceae	Juan Bai	Herbaceous
77	*Onychium japonicum* (Thunb.) Kunze	Sinopteridaceae	Ye Zi Jin Wei Fen	Herbaceous
78	*Solanum virginianum* L.	Solanaceae	Huang Guo Qie	Shurb
79	*Cryptomeria fortunei* Miquel	Taxodiaceae	Liu Shan	Tree, Shurb
80	*Cunninghamia lanceolata* (Lamb.) Hook.	Taxodiaceae	Shan Mu	Tree, Shurb

Table A1. *Cont.*

Serial Number	Scientific Name	Family	Chinese Name	Life Form
81	*Cyclosorus acuminatus* (Houtt.) Nakai	Thelypteridaceae	Jing Jian Mao Jue	Herbaceous
82	*Phegopteriis decursive-pinnata* (Ven Hall) Fée	Thelypteridaceae	Yan Yu Luan Guo Jue	Herbaceous
83	*Cryptotaenia japonica* Hassk.	Umbelliferae	Ya Er Qing	Herbaceous
84	*Debregeasia orientalis* C. J. Chen	Urticaceae	Shui Ma	Shurb
85	*Gonostegia hirta* (Bl.) Miq.	Urticaceae	Luo Mi Tuan	Herbaceous
86	*Pilea notata* C. H. Wright	Urticaceae	Len Shui Hua	Shurb
87	*Urtica fissa* E. Pritz.	Urticaceae	Qian Ma	Shurb
88	*Viola philippica* Cav.	Violaceae	Zhi Hua Di Ding	Herbaceous
89	*Cayratia japonica* (Thunb.) Raf.	Vitaceae	Wu Lian Mei	Herbaceous

Note: If the companion plants in forest gardens were already listed in Table 3 (marked with "forest"), then no duplication was presented in Appendix A (Table A1).

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Persistence of Use Among Amazigh People of Medicinal Plants Documented by Ibn al-Baytar (Early 13th Century CE)

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Abstract: The long-term stability of orally transmitted ethnopharmacopoeias is of interest, but difficult to study for lack of information on plants used by a specific past culture. Similarities between modern Italian ethnopharmacopoeias and Dioscorides' classical text have been proposed to derive from modern replacement of traditional practices with those from published translations of Dioscorides. Ibn al-Baytar produced the best compendium of medicinal substances in medieval Islamic science. He gave "Berber" common names for some plants, which were presumptively used by North African Amazigh people. Since Amazigh traditional knowledge was largely transmitted orally, with little access to medieval literature, this allows comparison of historic (>750 years ago) practices and modern practices that are unlikely to be causally derived. Presumptive identities for Ibn al-Baytar's plants with Berber names were obtained from key references. Recent ethnomedicinal publications from Amazigh-populated areas in North Africa were surveyed for reports of those species and homologous common names. Of 46 historically used plants, an estimated 60.9% are still used in Amazigh regions, 78.6% with homologous common names. This is likely to underestimate persistence of species use across the entire local pharmacopoeia. Second, emulating a published analysis of Dioscorides, plants reported by three large recent studies in Amazigh regions were compared with plants recorded by Ibn al-Baytar and in a comprehensive modern Moroccan reference. Between 58.2% and 73.8% of species included in individual studies were recorded by Ibn al-Baytar; of the 46 shared among all three, 82.6% were recorded by Ibn al-Baytar and 100% by the modern reference. An historical compilation may be more likely to mention plants that are widely used today simply because a thorough author could document most plants that were widely used at the time; use of such data to assess causality should take that effect into consideration.

Keywords: Algeria; Berbers; Jamal Bellakhdar; historical ethnobotany; Islamic medicine; Lucien Leclerc; medicinal plants; Morocco; North Africa

1. Introduction

A question of interest in ethnobotany is the degree of change in indigenous medicinal knowledge, which is usually orally transmitted, and practice over long times. It is obvious and uncontroversial that change occurs in any culture, but also that some transmission of useful knowledge between generations is essential to survival. Many cultures or regions have been repeatedly studied by ethnobotanists in the modern era, so that surveys taken a generation or two apart may be compared. Relatively few studies address the more difficult question of how closely a culture's present body of medical knowledge might resemble knowledge from the much more distant past, centuries or millennia ago. It is increasingly acknowledged that oral traditions can preserve some culturally important knowledge, not

necessary for daily survival, for several thousand years or more, e.g., [1–3]. How long might people continue to hand down knowledge of medicinal plants? Most medicinal plants are unlikely to be preserved in archaeological sites, and when found, their interpretation is often disputable (even regarding their status as artifacts if they are not in a preserved container [4]). In regions with a long history of indigenous or colonial literacy, a more fruitful approach can be to compare modern ethnobotanical surveys to information from historical literature (including unpublished documents and herbarium specimens).

1.1. Studies Utilizing Colonial Records

Certainly one of the most substantial studies to use colonial records is Bussmann and Sharon's comparison of extensive modern ethnomedicinal data from Peru and Ecuador, with equally substantial data published by the Spanish colonial author Martínez de Compañón in 1780 [5]. Of 526 plants historically used in Peru, 73% were sold in markets or found to be used locally. Conversely, 42% of the species sold in modern markets, which included many post-colonial introductions, had been recorded by Martínez de Compañón. Similarly, Van Andel et al. compared 228–242 Surinamese plant species recorded as useful in Daniel Rolander's diary, which he kept in 1754–1756, with plants in modern use [6]. About 208 (at least 86%) were still considered useful in Suriname at present, and 54%, especially crop, timber, and ornamental species, had at least one modern use corresponding to a historical use. In Brazil, Alcantara-Rodriguez et al. [7] reported that 80% of the 256 species described as useful in the *Historia Naturalis Brasiliae* (1648) had similar uses recorded in recent literature. This represents a knowledge survival period of ca. 280–360+ years (since the earliest reference Alcantara-Rodriguez et al. used as a source of "recent" traditional knowledge began publication in 1926).

Data from herbarium specimens have also been used to document historical use. Van Andel et al. analyzed the Hermann Herbarium, a bound collection of 51 Surinamese useful plant specimens probably made around 1687 [8]. Forty-eight species were represented, almost all known today as useful; all included medicinal plants were still in use, though commonly for different purposes. Similarly, Soelberg et al. [9] located herbarium specimens from 1695–1697, 1799–1803, and 1817 that recorded medicinal plant uses by the Fante, Ga, and Ashanti people, respectively, all of whom reside in modern Ghana. For all three collections combined, at least 75% of the species were still used, though only 31% of specific uses persisted. In both studies [8,9], 52–59% of common names persisted into modern times. A caveat for both is that small collections of useful plants may disproportionately represent well-known species, whose names and use would be most likely to persist.

Limitations of historical comparative studies include the facts that some plants in older literature will not be identifiable and that ethnobotanical surveys can rarely document all current knowledge. Both would result in underestimation of the proportion of species that persist in use. Studies of this nature, conducted in countries where most local knowledge transmission over the relevant time frame would have been oral, demonstrate that substantial preservation of an ethnopharmacopoeia over a period of at least several generations is common. However, studies of time periods over 200 to 300 years are rare.

1.2. Historical Comparisons Involving Dioscorides

Literate scholarship in some regions is of such antiquity as to create the possibility of exploring changes in plant use over much longer periods. The longest time horizon for European studies was established by Leonti et al. [10,11] who examined the proportion of currently used species or genera in various Italian datasets that had been documented in Dioscorides' *De Materia Medica*, a massive compilation of medicines known in the Ro-

man empire over 1900 years ago. (Of note, a recent study involving some of the same authors [12] similarly compares Dioscorides to selected Central European references from the medieval, Renaissance, and modern eras).

Leonti et al. [10] first compared current medicinal plant lists from Sardinia and Sicily, two Italian islands, with each other and with Dioscorides. Introduced species were excluded from analyses; of the native medicinal species, 170 were used on both islands, while 247 species found on both islands were known to be used only on one. According to plant identifications in Berendes [13], Dioscorides mentioned 62% of the 170 shared species and the genera of another 28%, and reported many of the modern uses for the most-cited 15 species on both islands. He was much less likely to mention the species or genera of plants used on only one of the islands.

The statistical analysis of Leonti et al. [10] rejected the null hypothesis that the 170 plants used on both islands were selected randomly on each "from a pool of 1573 (potential medicinal) species" [10] (p. 265), which is the total number of plant species found on both islands. They concluded that the high proportion of shared medicinal species reflects "common cultural knowledge or selection criteria" [10] (p. 265). More controversially, they suggested that those criteria were neither shared antique tradition nor actual benefits, but a more recent uncritical adoption of plants from printed editions of De Materia Medica: "the medicinal plant knowledge in Sicily and Sardinia is a shallow stereotype of… De Materia Medica" [10] (p. 265).

This interpretation may be questioned. First, the number of species not mentioned by Dioscorides supplies evidence that many modern practices derive from other sources. Second, plants are rarely if ever used at random. In addition to observing benefits directly, users may prescreen plants using characters such as flavor and odor that suggest bioactivity, e.g., [14–16]. Likewise, plants that are rare, locally endemic, or inaccessible are less likely to be tested, adopted, then used for long periods. Rarer species might also be less useful, for example, if superior chemical content might help a species to flourish or if past human populations have dispersed useful plants, e.g., [17–19]. Many native species would not have been considered suitable for medicinal use. Leonti et al. [10] noted that the 170 shared species could have been shared at random if independently selected from a population of 477 to 539 *medicinal* species (higher than the 417 medicinal species actually present on both islands).

Third, Leonti et al. were surely right to say that writing "revolutionized the transmission of knowledge" [10] (p. 265) and "accentuated the homogenization of medicinal plant use" (p. 266). However, Dioscorides' creation of a written record of medicines already in use would not have immediately or automatically terminated ongoing oral transmission of folk knowledge of them, and little is known about oral transmission in various time periods. The coexistence of two effective routes of knowledge transmission makes assessment of their relative influence challenging, as suggested by Köhler [20] in a study of the writings of Polish botanist Józef Rostafiński (1850–1928). Rostafiński also came to believe, after observing overlap between Polish folk medicine and the writings of Dioscorides and Pliny the Elder, that 19th-century folk medicines were not survivals from pagan culture. Instead, he concluded that they had been introduced after Christianization in written herbals that influenced first the literate nobility and by further dissemination their servants, then finally rural commoners, whose descendants preserved the introduced practices after the upper classes abandoned them. Köhler observed that Rostafiński had overlooked a possible alternative explanation: that the two bodies of knowledge had a common origin, both descending from the folk knowledge that existed before the scholarly works were written.

In a second paper, Leonti et al. [11] compared the current ethnopharmacopoeia of Campania in southern mainland Italy with those of Sardinia and Sicily and with plants reported by Dioscorides, as copied in a book by the well-known physician and botanist Pietro Andrea Mattioli or Matthioli that also discussed additional species [21]. This work, termed in brief I Discorsi, was first published in Italian in 1544 [22] and was the major pharmacological text in Italian universities until the 18th century. Use categories were recorded separately from Dioscorides' text and Matthioli's commentaries. Of 120 native species used medicinally in Campania, Sardinia, and Sicily, all but five were identifiable as Dioscoridean plants, which again was viewed as evidence of Dioscorides' influence.

Leonti et al. [11] conducted a Bayesian inference-based analysis of use reports for 27 frequently-cited species that concluded that 19.7% of their uses were derived from Matthioli as a causal correlation. This analysis assumed that if species mentioned in a use category by Matthioli are more likely than others to be mentioned in that category today, Matthioli should be treated as a causal influence. Further, the causal effect was considered higher for uncommon plants and uses. An expanded follow-up study [23] analyzed use reports for 87 taxa commonly used in all three Italian regions and sought to detect causal influence of both Dioscorides and a second classical authority, Galen, on modern use. In their model, Dioscorides was estimated to have an average 27.6% (15.1–51.7%) causal effect on plant uses in the three regions, while Galen's causal effect was estimated at 36.4% (14.3–66.2%). Relative local accessibility of Galen's and Dioscorides' work in recent centuries was not discussed.

Such analyses may be vulnerable to bias if many remedies actually work. The finite number of remedies that are most effective for each purpose should be more likely to be adopted, passed on, or rediscovered if once abandoned. Leonti et al. noted that De Materia Medica "generally includes widespread species… and commercialized plant products" [10] (p. 265). Though Dioscorides' work was magisterial, most of the plant uses he described were not his own discoveries or inventions, but documentations of already-existing professional and folk medical practices in the eastern Mediterranean. If those traditions had discovered a large majority of the indigenous plants that were bioactive and plentiful enough to be worth using by professionals, and Dioscorides' investigations were thorough, he could have recorded most native genera that multiple modern populations from the region would consider useful, even if his opinions had had no direct influence on theirs at all (that being the extreme case of Köhler's [21] alternative explanation for shared knowledge).

The opposite question, of how many of the plants recorded by Dioscorides persisted in use to the modern era, is one that cannot be answered fully for two major reasons. First, it is never possible to identify all plants in classical literature. Classical descriptions were often very poor or incomplete, and errors could be introduced by hand-copying. Hence, one purpose of early European herbarium collections was to provide definition for the application of names in classical literature [24]. Folk taxa incorporating multiple species can legitimately be treated as entities with persisting use, but it is sometimes not possible to determine even what genus was described. Second, if the interest is in unbroken transmission of knowledge over long periods, which group(s) are the inheritors of recorded knowledge, within which its "persistence" should be checked for? The plants listed by authors such as Dioscorides were not all used within any single region or culture, and large classical compilations seldom provide adequate information about where plants grew or were used to permit expected descendant cultures to be identified.

The studies by Leonti et al. [10,11] showed that many of the native plants considered useful today in southern European datasets were also recorded by Dioscorides' great clas-

sical compilation. However, their belief that that history was for many species broken by an unspecified, but presumably centuries-long, lacuna rejects the assumption that these species could be said to have a 2000-year history of use. Therefore, to demonstrate persistence of plants' use in folk medicine over very long periods may require a context in which literate scholarship has existed for several centuries, yet ordinary people in later generations did not place enough value on its products that they could be thought likely to have abandoned traditional knowledge for it.

1.3. Ibn al-Baytar's Treatise on Simples

Information of the kind necessary to demonstrate long-term oral knowledge transmission from a forward-looking perspective, starting from the historical document, may be available for small subsets of plants treated by the great Andalusian physician, pharmacist, and botanist Diya' al-Din Abu Muhammad Abdullah Ibn Ahmad al-Malaqi, commonly called Ibn al-Baytar, who lived from ca. 1197 to 1248 CE. Born in Malaga, Ibn al-Baytar studied with the famed botanist Abu al-Abbas al-Nabati, then traveled widely in North Africa and the Middle East, gathering information on medicines from practitioners along his route. He is known to have authored 11 works, not all of which survive [25]. One of his two major works, known briefly as the *Jami' al-mufradat* (Treatise on Simples), was a compilation of text about medicinal plants, animals, and minerals from dozens of classical and medieval Arabic sources, supplemented by personal experiments and observations from his field research. The work included over 2300 alphabetically organized entries; because many substances were given multiple entries for different names and others were unintentionally treated repeatedly, an estimated 1400 substances were included [25].

An authoritative discussion by Bellakhdar [26,27] highlights that Ibn al-Baytar was among the most important authors whose medical works were studied in Islamic universities during the flowering of Islamic science. At that time, all books were hand-copied. Eighty-six handwritten copies of the Treatise have survived, which preserved portions of several earlier Arabic works that would otherwise have been entirely lost to history [25]. Printed copies of the Treatise were published in 1874 and 1992, the former with many errors [25]. There was also a 1990 edition published in Beirut, which may be more scholarly. All are very rare outside their region of origin, though Bellakhdar [27] reports that scholarly practitioners of herbal medicine in modern Morocco often possess copies.

Lucien Leclerc published a scholarly French translation in 1887–1883, omitting most of the lengthy text copied from Dioscorides [28]. Earlier translations into modern European languages had been partial, of dubious quality, or both [25,28]. Leclerc's translation included annotations discussing his and some previous European scholars' opinions on the identity of many substances. A facsimile with minor omissions was produced in the late 20th century by the Institut du Monde Arabe (Paris), but is no longer sold. Google Books currently makes all three volumes available [29]. There is still no English translation.

Bellakhdar [26,27] published a comprehensive survey of the modern Moroccan traditional (or folk) pharmacopoeia based on years of field research. As part of his analyses of this very large ethnobotanical dataset, he searched five key medieval Arabic reference works for possible citations of each substance and included notes on such citations. This analysis was similar to Leonti et al.'s [10,11] later backward-looking studies, with more diverse historical sources targeted, but with a time gap less than half as long. The expanded third edition of his work [27] described 759 substances in current use, which included a total of 1118 species or individual non-biological products. Only 31.4% of these were considered not to appear in Ibn al-Baytar's Treatise, which was the most comprehensive of the five. The 239 substances not mentioned included 14 compounded formulas, 25 later-

developed industrial products, and 50 species introduced later from other geographic regions. Of the 576 currently used plant species or species groups, 163 were definitely not mentioned in the Treatise and 15 only dubiously mentioned, leaving 67.4% as presumptively mentioned by Ibn al-Baytar, at least in generic categories [27].

El-Gharbaoui et al. [30] analyzed the overlap between use records of Lamiaceae species in modern eastern Morocco and eastern Andalusia and those from Ibn al-Baytar's Treatise (referred to there briefly as the Compendium). Fourteen taxa were recorded in current use, with *Thymus* spp. treated as a single taxon as they are used interchangeably. All 14 taxa had been described by Ibn al-Baytar, who recorded 195 uses for them. Ibn al-Baytar had recorded 44% of the 95 specific uses recorded in modern Morocco and 28% of the 257 uses from modern Andalusia.

Based on the reported citation by Ibn al-Baytar of many currently used species investigated in those works and three others, Alami Merrouni & Elachouri [31] have recently argued that "a large part of modern traditional knowledge [in Morocco] originated from ancient Arabic-Islamic medieval medicine" [31] (p. 8). Similarly to Leonti et al. [10,11] but more extreme in interpretation, they described El-Gharbaoui' et al.'s [30] article as indicating that "43% of plant uses may have [been] acquired straight from Ibn al-Baytar text" [31] (p. 8). Their implication is that all modern uses corresponding to a historical use should be assumed to be derived from historical authors, though later generations may have transmitted this knowledge orally. This ignores the prior existence of the folk knowledge that was merely documented by elite authors. These authors demonstrate an evident bias in favor of crediting the scholars of the "Arabic-Islamic Golden Age" for knowledge generation; their schema for the origins of modern knowledge in Morocco depicts North African and African medicine as being influenced by Arabic-Islamic medicine, but not the reverse.

A very recent publication by Mir et al. [32] provides brief comments on a comparison of Ibn al-Baytar's work to current knowledge in northeastern Morocco. These authors had recently published an ethnobotanical dataset based on surveys of 1177 people in three provinces, both "Berber" (Amazigh) and Arab [33]. While analyzing this dataset primarily in comparison to other modern Moroccan datasets, they also compared it to a list of 363 taxa believed to have been treated by Ibn al-Baytar and identified as being extant in Morocco. They reported that 221 of 241 taxa mentioned by their interviewees had been cited by Ibn al-Baytar. Those 221 taxa were noted to be "15.78% of Ibn al-Baytar's simples" [32] (p. 5) [assuming precisely 1400 products were included], but they represented 60.9% of his simples that were believed to be found in Morocco. However, 18% of the 241 taxa mentioned by interviewees had no medicinal use reported, so it was not clear what percentage of relevant simples cited by Ibn al-Baytar were documented as medicines in the investigated region. No further details of methods or results were given.

Names Ibn al-Baytar used or cited included Arabic, classical Greek and Latin, and less often regional (Persian, Berber, or Spanish) vernacular names. Though Ibn al-Baytar mentioned a few substances only briefly without detailing their medicinal uses, his clear intent in writing the Treatise was to document substances of medicinal value ("simples", or individual medicaments). He was not writing a general botany or zoology text, nor did he seek to provide exhaustive lists of common names for included species. Given the nature and intent of his research, his use of a vernacular name from a regional language provides good reason to believe that people from that region were a source of information on the substance's use, even if, as was often the case, he did not explicitly say so. He thereby supplied us with some ethnobotanical data for those cultures, which provides, to a limited extent, another means of asking a forward-looking question: how many of a group of

species reasonably presumed to be used in the 13th century CE, by a specified culture, are still used today by the culture's descendants?

1.4. The Amazigh People and Medical Traditions

Among these, Ibn al-Baytar recorded "Berber" common names for a few dozen substances, almost all plants, often as the only name known for the substance. "Berber" refers to a group of largely North African ethnicities, tribes, or nations, believed to have derived from at least three separate waves of migration [27], some of whose ancestors have lived in northwestern Africa for up to 15,000 years, despite many later invasions and migrations [34–38]. The umbrella term by which present-day groups reportedly prefer to be known is Amazigh (or Imazighen, a plural), which was adopted in part to assert a collective identity for political reasons, and the preferred collective term for their group of languages is Tamazight [39,40]. Most modern ethnobotanical publications continue to use "Berber" for the people and languages, presumably because of the term's familiarity from past literature. However, it is a term utilized by outsiders and it may be considered derogatory; though its derivation is disputed, it closely resembles Greek and Arabic words for "barbarian". In this paper, "Berber" refers only to text in historical works that used that term; when the present-day people or language are discussed, "Amazigh" or "Tamazight" will be used.

The Amazigh have for millennia included large settled agricultural communities, as well as nomadic groups. In Ibn al-Baytar's time, North Africa was largely Muslim, having long since been conquered by the Arabs [40–42], but many Amazigh remained culturally distinct. Today there are many "Arabized" Amazigh who are fluent in Arabic and often identify themselves as "Arab" even if that is not their actual ancestry [42,43]. Conversely, Bellakhdar observes that much Moroccan Arabic culture has been strongly influenced by "berbère" culture, so that the mixture of the two cultures is "indissociable et non réductible" (inseparable and not reducible) in his country [27] (p. 34).

Traditional Amazigh culture reportedly was primarily oral (despite having an indigenous alphabet, Tifinagh, used for inscriptions and short messages [44]), and until recently Amazigh communities tended to have low literacy rates, e.g., [43,45]. Medicinal knowledge in many communities is transmitted mostly by women, who have traditionally had particularly low literacy rates [43]. Fakchich and Elachouri [46] and Ouhaddou et al. [47] reported 32.3% and 52% of their interviewees, respectively, to have had no formal education. Eddouks et al. [48], in their large ethnobotanical survey that included 1616 people from the Tafilalet area, asked interviewees where they obtained knowledge about plants; though 83.4% had at least primary school education, only 6.75% said "reading", while most indicated "heritage", learning from others, or personal experience. In an Algerian Amazigh population surveyed by Bendif et al. [49], 73% of those using herbal medicine were women, and 60.27% were illiterate; only 2% of medicinal plant use was reported to derive from "reading", vs. 89% from "experience of their predecessors".

Bellakhdar [26,27] considers it certain that there has been an unbroken tradition of oral instruction in healing practices ("une chaine ininterrompue", an unbroken chain [27], p. 71) in Morocco, formerly parallel to a literate scholarly track, and later completely replacing it so far as transmission of Arabo-Islamic medicine was concerned, with one result being the loss of much theory and doctrine. To be clear, he does not suggest that no rural North African Amazigh knowledge holders in more recent centuries ever possessed or read key medieval scholarly texts, only that their access to them was too limited to be the major influence upon what plants people continued to use. The scholarly information regarding Amazigh ethnobotany in Ibn al-Baytar's book was derived from traditional

knowledge already held by the people among whom he traveled. Had large portions of that knowledge later been abandoned by the Amazigh, their respect for oral tradition and the limited physical accessibility of Ibn al-Baytar's work (or lesser works of other medieval Arabic authorities) to rural Moroccans make it implausible to assume that that literature would have been sufficiently available, at any time in the past few centuries, to bring about its popular restoration. The importance of these facts is that, if a substantial number of medicines from the "Berber" pharmacopoeia of 750 years ago were found to appear in the Amazigh pharmacopoeia of today, the most plausible explanation for the majority of that similarity would not be abandonment of those plants followed by their relatively recent uncritical adoption from Ibn al-Baytar or some other work of medieval Islamic medicine, but the persistence of indigenous, orally transmitted traditional knowledge for ca. 750 years.

In this paper, plants with Berber common names documented by Ibn al-Baytar will be compared to modern ethnobotanical literature dealing with traditional medicine among Amazigh-descended populations to estimate the proportion of those plants that are still in use today, as well as the proportion that still have similar Tamazight common names. (It seems particularly unlikely that common names would ever be revived from medieval literature, had they dropped out of use and been replaced by others, so homologous common names can be assumed to exist through an unbroken history of use). Additionally, species lists from a selected set of three large ethnobotanical surveys from these populations, and the list of species shared among all three, will be checked for inclusion in Ibn al-Baytar's work (and that of Bellakhdar, the local modern equivalent) to see whether patterns of greater documentation in historical scholarly literature of plants more widely used today, similar to those found by Leonti et al. [11], may be observed.

2. Materials and Methods

2.1. Comparison of Historical Berber Data to Modern Amazigh Ethnobotanical Data

Medicinal substances for which Ibn al-Baytar reported Berber names were enumerated, with numbered entries cross-referenced in Leclerc's French translation [28] as being applicable or partly applicable to each. For some, Bellakhdar [26,27] identified additional entries believed to pertain to the same species or group that were not indicated by Ibn al-Baytar as such; these numbers were not included. Substances that were stated to occur in North Africa were not recorded if Berber names were not mentioned because of the possibility that they were used primarily by Arab populations. Special note was made of a few substances without specified-Berber names that were said to come from Berber lands, but they were not included in the main analysis in order to maintain a consistent criterion. Because modern publications generally deal only with botanical medicines, one fungus, one beetle and one bird were excluded (though one lichen was included). Leclerc noted some Berber names to have been doubtfully recorded or written differently, possibly by copyist error, in different manuscripts. All listed variants of such names were recorded.

Presumptive identifications for Ibn al-Baytar's names were those proposed by Bellakhdar [26,27], or by Leclerc if Bellakhdar did not mention an historical name. Synonymies were confirmed as needed using major taxonomic databases [50,51]. Bellakhdar [26,27] often identified historical names more precisely than Leclerc and identified and corrected a few misattributions by Leclerc with citations of recent literature. Where Leclerc and Bellakhdar [27] definitely and substantially differed on the identity of a name, both proposed identities were recorded so that modern usage and common names pertaining to both suggested identities could be compared, with the expectation that these would demonstrate

more support for Bellakhdar's identifications. In one case, a differing opinion in a nomenclatural reference by Trabut was also recorded [52].

A large group of recent journal articles presenting ethnobotanical data appearing relevant to Amazigh populations, as well as one book, were surveyed for references to the species or genera with which Bellakhdar (or Leclerc) identified historically used plants. Accessible literature was mostly Moroccan, with a lesser portion Algerian. Most regions of both countries having largely Amazigh populations do also have residents of Arab ethnicity, though as Bellakhdar [27] notes, those cultures have mutually influenced one another. Studies from regions reported to have high Amazigh ethnic populations, especially if they reported common names derived from Tamazight languages, were considered relevant regardless of whether interviewees' ethnic backgrounds were reported. This survey could not be exhaustive, but it was considered that the large number of accessible recent references would almost certainly include any species having frequent use. In a few cases, when the ethnic background of interviewees was unclear, papers were used as evidence of Tamazight names but not Amazigh use data. Publications providing relevant data included [33,46–49,53–75].

If no Amazigh region-specific use data were found for a species or species group, major reference works on Moroccan and Algerian ethnobotany [26,27,76] and two recent publications on locally marketed Moroccan medicines [77,78] were checked for national-level citations of the plant's use, especially associated with Tamazight common names. Bellakhdar [27] occasionally mentioned a specific region, of known Amazigh population, in which he had observed a species to be used. However, it was not counted as Amazigh use if he cited Amazigh regions only as a source of Tamazight common names.

When species or species groups (folk taxa) identified with historically used plants were mentioned in those references, any documented common names that were similar to those in Ibn al-Baytar's compilation were recorded. If the taxa were not found to be in use or only unrelated common names were seen, the historical Berber common names were searched for without taxonomic restriction in a major compilation of North African common names [52] and in ethnobotanical sources that had provided substantial lists of species with apparently Tamazight common names. A few Berber common names were given by Ibn al-Baytar only in Arabic translation of the meaning, so that possible homologues could not be recognized (at least by this author). If a current common name was located that appeared homologous or similar to a historical name, the plausibility of identifying the historical medicine as the species known by that name was considered.

Common names were recorded exactly as printed in original publications, except that for a few of Ibn al-Baytar's names from Leclerc, vowel marks were added following his own instructions for correct orthography. Leclerc provided a francophone transliteration of names in the Arabic alphabet (e.g., "ch" was used for ش) and used multiple symbols for some letters (especially غ, a "gh" sound sometimes rendered as "r"), while frequently using "k" for both ك and ق. Recent publications vary substantially in practice, e.g., using a wide variety of diacritical marks. Many of Ibn al-Baytar's Berber names begin with a double alif (اا), which Leclerc stated to be a definite article in the Berber language; this is generally not seen in recent publications. Likewise, the "t" (ت) with which some historical names began was indicated to be a feminine prefix. Although some modern Tamazight common names are variable in spelling and pronunciation (or are variably recorded), many modern publications reported common names only in the Latin alphabet and may have variably rendered identical names. When spelling of modern common names varies among references, all observed variants were recorded.

Two quantitative questions were asked of the resulting data set: (1) Using the best available identifications, what proportion of plants with Berber common names reported by Ibn al-Baytar appear still to be in use in Amazigh traditional practice, or to be in use regionally? (2) What proportion of the plants in use have modern common names homologous to historical names?

2.2. Comparison of Modern Amazigh Ethnobotanical Data to Historical Data

A separate analysis was made to determine what percentage of the species recorded in three selected current ethnobotanical studies involving primarily Amazigh populations, and what percentage of the species that were recorded in all three studies, were mentioned by Ibn al-Baytar, or belonged to species groups or genera that were mentioned. For this analysis, there was no requirement that Ibn al-Baytar should have reported the species to be used by Berbers or even in North Africa. This was intended to be comparable to Leonti et al.'s [10,11] comparison of modern data from multiple Italian regions to the species in Dioscorides' De Materia Medica, which had similarly been derived from knowledge gleaned over a wide area.

The three datasets chosen for comparison were those of Fakchich and Elachouri [46], Ouhaddou et al. [47], and Teixidor-Toneu et al. [63], which represented three geographically distinct regions of Morocco. Fakchich and Elachouri [46] supplied data from 3151 people in multiple communities of eastern Morocco, reporting 148 medicinal plants. Ouhaddou et al. [47] interviewed 400 people in 13 districts of the southwestern province of Agadir Ida Ou Tanane, reporting 110 medicinal species (including two subspecies of one). Teixidor-Toneu et al. [63] conducted an in-depth study of a single ethnically Ishelhin, Tashelhit-speaking rural commune in the High Atlas mountains (hence, this was an entirely non-Arabized Amazigh group); they reported 151 common names and 159 plants, 153 of them identified at least to genus.

Bellakhdar's [26,27] assessments of whether each of those taxa were mentioned by Ibn al-Baytar (individually or as part of a species group), not mentioned, doubtfully mentioned, or mentioned only in a generic category or lumped in with a similar species, were recorded, and numbers in each category were tallied. Most of these were extracted from his first edition [26] because it had a complete table of products with specific information; species not included in that work were checked for updates in the third edition [27]. Because preferred nomenclature has changed for some species, the cited online nomenclatural databases [50,51] were used to confirm some synonymies. Where a plant in recent studies was only identified to genus, if multiple species of that genus were reported by Bellakhdar [26,27] to be used interchangeably, it was presumed that the species observed was part of that group.

If a species from the regional datasets was not listed by Bellakhdar as being used in Morocco, a note was made regarding whether other species of the genus were listed in that work, and whether any of those species were recorded as being mentioned by Ibn al-Baytar. Species or genera that were not documented by Bellakhdar, except for exotic taxa that Ibn al-Baytar could not have seen, were looked up in Leclerc [28] to determine whether he associated any of Ibn al-Baytar's species with those names or well-known 19th century synonyms.

3. Results

3.1. Ibn al-Baytar's Berber Names

When entries referring to the same species or folk taxon are combined, Ibn al-Baytar reported Berber common names for 46 plants (Table 1). Leclerc [28] remarked upon "Berber"

usage or provided "Berber" names for a few other plants, but his added information was not considered as historical because its sources were unclear and it could have been derived from late-19th-century CE scholarship. Eight of the 46 plants had no meaningful identity supported by either Bellakhdar [27] or Leclerc; one of those (no. 1167, *Afersak*) was a fern but otherwise unknown. None of their common names could be identified with common names in current use in Morocco or Algeria, and none had sufficient descriptive text to identify them as species in use. This result was unsurprising, as Bellakhdar would surely have identified them had that been easily done.

Table 1. Species for which Ibn al-Baytar recorded Berber names, with numbers and Arabic-alphabet and transliterated names from Leclerc [28]; suggested botanical identities, from Bellakhdar [27] unless otherwise noted; use reports for those taxa in studies from Amazigh regions (or, lacking those, in national references); and homologous or similar modern common names, with the species to which they were applied specified as needed. Where Leclerc and Bellakhdar substantially disagreed on the botanical identity of a historical name, both are listed on separate lines. IAB = Ibn al-Baytar.

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
2	*Aâthirîlâl* (أاطريلال)	Leclerc: *Ptychotis verticillata* Duby [=*Ammoides pusilla* (Brot.) Breistr.] (Apiaceae) Bellakhdar: *Ammi majus* L. (Apiaceae) (confused with *Ptychotis* since historic times; see also [6])	*P. verticillata* [=*A. pusilla*] [46]; *A. pusilla* [71] *A. majus* [33,70]	Aatrilal [70]; Āṭṛīlāl (آطريلال), Ṭṛīlān (طريلان), Ṭlīlān (طليلان) [abbreviation for âṭar îlâl, bird's foot] [27]
3, 542	*Aacoutsâr* (اأاكثار)	*Bunium* spp. (Apiaceae)	*B. bulbocastanum* L. [63]; *B. mauritanicum* (Boiss. & Reut.) Batt. [=*B. fontanesii* (Pers.) Maire] [60]	*B. fontanesii*, *B. incrassatum* (Boiss.) Amo [=*B. ferulaceum* Sm.?]: Ākuṯār (آكثار), Akṯīr (اكثير) [27]
4, 1607 in part	*Aarr'îs* or *Arghîs* (اارغيس)	*Berberis hispanica* Boiss. & Reut. [=*B. vulgaris* L. subsp. *australis* (Boiss.) Heywood]	*B. vulgaris* [60,70], *B. hispanica* [46]	*B. vulgaris*: Ârgîs [70], Elghris [58]. *B. hispanica*: أغريس [46], Ārġīs (أرغيس) [27]
5	*Aamilîlis* (اامليلس)	*Rhamnus alaternus* L. (Rhamnaceae)	*R. alaternus* [49,55,59,60,65,72,74,75]	M'liles [49]; Melilez [59]; Amliles [53]; Mlilles [71]; Amlilis [72]; Āmlīles (آمليلس), Mlīles (مليلس) [27], Mlilès, M'liless [55], Mlilis [74], Imliles [75]
6	*Aakcheroua* (اقشروا); also read اقشزواو and اقشرون	Leclerc: Chlora? Centaurée? [*Centaurium* or *Blackstonia* (includes *Chlora*) (Gentianaceae)?]	*Centaurium erythraea* Rafn [46,61,62,74,75]; *C. umbellatum* (Gilib.) Beck [55]; *Blackstonia grandiflora* (Viv.) Maire [75]. In Morocco, *C. spicatum* (L.) Fritsch [53]	*Chlora grandiflora* Viv. [≡*Blackstonia grandiflora*: Aqchera [52]

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
27, 86, 741	*Addâd* (أداد)—white chameleon (see 742)	*Atractylis gummifera* L. [≡*Carlina gummifera* (L.) Less.] (Asteraceae)	*C./A. gummifera* [46,47,55,57,59,63,72,74] *C. acaulis* [48]	*C./A. gummifera*: Addad [47,57,72,74]; Dâd, Dlagh [59]; Dad [70]; اداد [46]; Leddad [71]; Āddād (آداد), Ddād (داد) [27]; Adad [55] *C. acaulis*: الداد [48]
28, 440, 2321	*Adrîs* (ادريس), *Adriâs* (ادرياس)	*Thapsia transtagana* Brot. [=*T. garganica* L. subsp. *decussata* (Lag.) Maire] and *T. villosa* L. (Apiaceae)	*T. transtagana* [57]; *T. villosa* and *T. garganica* L. [incl. *T. decussata* Lag., = *T. transtagana*] [55]; *T. garganica* [61,72,74,75]	Wrak darrias [57]; Daryass [18]; Deryass [77]; Deryās (درياس), Āderyās (آدرياس) [27]; Aderys, Derias [55]; Adharyis [61]; Adaryes [74]; Aderiass [72]
35 [also see 2031]	Sheep's ear (الشاة اذان), gazelle's ear (اذان الغزال), [Arabic translations of Berber names]	*Cynoglossum officinale* L. (Boraginaceae)	In Morocco, *C. officinale* [27]	
56, 1145, 2041	*Ardjân* (ارجان), *Argân* (ارقان)	*Argania spinosa* (L.) Skeels (Sapotaceae)	*A. spinosa* [57,62,64,66,73]	Argan [53,57,64,66]; Argane [62]; Argan, ⵄⵔⴳⴰⵏ/آركان [73]; Ārgān (آركان) [27]
61bis, 717	*Azourd* (ازورد) or *Azrour* (ازرور)	*Melilotus* spp. (Fabaceae)	*M. officinalis* (L.) Pall. subsp. *alba* (Medik.) H. Ohashi & Tateishi [48]. In Morocco, *Melilotus* spp. [27]	*M. officinalis*: ازرود [48]. *Melilotus* spp.: Āzrūd (آزرود), Āzūrd (آزورد), Zrūda (زرود) [27]
250, 1170	*Ousserghînd* (اوسرغيند) or *Serghent* (سرغنت)	Leclerc: *Telephium imperati* L. (Caryophyllaceae)	*Telephium imperati* [46]	سرغينة [46,48], تاوسرغينت [48], Sarġīna (سرغين), Tasserġint (تسّرغنت) [27]; Serghine, Sarghina [62]; صرغينة (Sarġîna) [54], Serghina [53,77], Tasserghint [78]
		Bellakhdar: *Corrigiola telephiifolia* Pourr. (Caryophyllaceae)	*C. telephiifolia* [46,48,62]	
260, 390?	*Abou-immoût* ("the father is dead") (ابويّموت), *Boukichrem* (بوقشرم)	Unidentified; two species described		

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
280, 416, 442, 1891	*Techtiouân* (تشتيوان)	*Polypodium vulgare* L. (Polypodiaceae)	*P. vulgare* [27 (Azrou)]	Astīwān (استيوان), Aštīwān (اشتيوان), Taštīwān (تشتيوان) [27]; possibly Achtouane, Chtioual, Nechnaouane [76]
375	*Akankan* (اقنقن)	*Verbascum* spp. (Scrophulariaceae)	*V. sinuatum* [33,61,74]; *Verbascum* sp. [63]. In Morocco, 4 spp. [27], Amazigh names given	
398, 788	*Tafghaït* (تيغفات)	Leclerc: *Cynara acaulis* L. [≡*Rhaponticum acaule* (L.) DC. or *Leuzea acaulis* (L.) Holub] (Asteraceae)	In Morocco, *R. acaule* [78]	Tafgha [78]
		Bellakhdar: *Centaurea chamaerhaponticum* Ball [=*Centaurea acaulis* L.] (Asteraceae)	In Morocco, *C. chamaerhaponticum* [=*C. acaulis*] [27,77]	Tāfġā (اغفات) [27], Tafgha [77]
399, 1673	*Tacout* (تاكوت) or *Tanqout* (توقنات; see note 2296)	*Euphorbia resinifera* O. Berg, *E. echinus* Hook.f. & Coss. [≡*E. officinarum* L. subsp. *echinus* (Hook.f. & Coss.)] Vindt., and *E. beaumieriana* Hook.f. & Coss. [≡*E. officinarum* var. *beaumieriana* (Hook.f. & Coss.) Maire]]	*E. officinarum* subspp. *officinarum* and *echinus* [47,64]; *E. resinifera* [46,66]; *E.* spp. including *E. echinus* [65]; *Euphorbia*, 5 spp. [57]	*E. beaumierana*: Tikiūt or Tikiwt (تويكت) [27]. *E. officinarum* subsp. *echinus*: Tikiout [57]. *E. resinifera*: تويكت or تاوكت [46]. Tikhiout [64]. *E. officinarum*: Tikiout [47]
400, 1507	*Taghendest* (تدسنغات), *Tîkendest* (تدسنقيت)	*Anacyclus pyrethrum* (L.) Lag. and *A. depressus* Ball [=*A. pyrethrum*] (Asteraceae)	*A. pyrethrum* [2,46,48,59,60]	Tiguentest [59]; تسيطنكت [46]; تشيدنقاث [48]; Tiguendizt [77]; Tigentast (تسطنكت), Īgenṭas (اكطنس), Tigenthast [72], Genṭūs (كوسطن), Taġendest (تدسنغت) [27]

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
401, 2185	*Tamchaourt* (تامشاورت) (or *tamsaourt*, تامساورت)	Leclerc: *Meum*, possibly *M. athamanticum* Jacq. (Apiaceae)	In Morocco, *M. athamanticum* [77]	
402, 698	*Tassemmoumt* (تاسّمّمت) (read otherwise by error; feminine of *semmoum* or *assemmam*)	*Rumex* spp. (Polygonaceae)	*R. acetosa* L. [33,47,60,62,72]; *R. conglomeratus* Murray [61,74,75]; *R. vesicarius* L. [33,57]; *R. bucephalophorus* L. subsp. *gallicus* (Steinh.) Rech. [55]; *R. pulcher* L. [33]	*R. acetosa*: Tismoumine [47], Semmamout [72]. *R. vesicarius*: (?) Basmom, Wasmim [57]. *R. buecephalophorus*: Tasemumt, Tasmumt [55]. *R. conglomeratus*: Tassemumt [74], Thassemoumth Guezgaren [61], Tassemumt n yezgaren [75]. Group of 9 species: Tassemūmt (تمسّتس), Tassamam (ممسّت), Tissemumīn (نيممسّت), Smamun (نممس), Bassemūm (مومسّب) [27]
413, 1448	*Terhelân* (تانرهت), *Tarhelâ* (الرهت)	*Inula viscosa* (L.) Aiton [≡*Dittrichia viscosa* (L.) Greuter] (Asteraceae)	*I./D. viscosa* [33,46,48,49,55,61,66,72–75]	Tinirine, Terrhla [66], Terreklān (Tahraoui et al.), الهرات [48], Terhalā, Terahlā (الهرت) [27]
423, 2255 [323,329]	*Tifâf* (تفاف)	*Sonchus* spp. (Asteraceae)	*S. oleraceus* (L.) L. [55,61,72,74,75]; *S. tenerrimus* L. [73]; *S. asper* (L.) Hill, *S. tenerrimus*? [68].	*S. oleraceus:* Tifaf [53], Tifef [55], Thifaf [74,75], Thiffaf [61], Tilfef [72]. *S. tenerrimus*: فافيث [73] Group of 4 spp: Tifāf (تفاف), Tilfāf (تلفاف) [27]
539	*Tazr'et* (تزغت) [sic] or *Tarakht* (تتارخ); *Thamah* (طمح) or in 1 ms. *Thalah* (جلط) [sic]; includes 2 types	Leclerc: Sorbier? [*Sorbus* (Rosaceae)]	In Morocco, *Sorbus aria* (L.) Crantz [53]	
		Bellakhdar: IAB's *tazaġt* is *Rhus pentaphylla* (Jacq.) Desf. [≡*Searsia pentaphylla* (Jacq.) F.A. Barkley] (Anacardiaceae); IAB's *judar* is *R. tripartita* (Ucria) Grande [≡*Searsia tripartita* (Ucria) Moffett]	*R. pentaphylla* [33,47] *R./S. tripartita* [46,56,69,72]	*R. pentaphylla*: Tazaġt (تزغات[sic]) (plural Tizġā, اغزت), Tazâdt تزاضت), etc. [27]; Tizrah, Tazrah (ةغزيت) [52]; Tazzad, Azad [47]; Tizga (اتزك), Azad (أزاد), Tazadt (تازادت) [33]. *R. tripartita*: ةغزيت, تغزيت [46].

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
658	*Fezân* (فـزان) or *Kerân* (قران)?	Leclerc: Wild artichoke (Dioscorides citation *Cynara scolymus* L., Asteraceae) Bellakhdar: *Cynara humilis* L., with *C. scolymus* mentioned in same treatment	*C. scolymus* [33,46,47,73,74] *C. humilis* L. [62]	Possibly القرني [46], El-Qorni' (القرنيع) [33] (??)
742	*Addâd* (أداد)—black chameleon, *Ouahîd* (الـوهيد) [see no. 27]	Leclerc: *Carthamus corymbosus* L. [≡*Cardopatium corymbosum* (L.) Pers.]		
824	*[al-]Amîroun* (الـاميرون)	Leclerc: *Chondrilla* sp. (Asteraceae)		
826	*Tîglîch* (شيقليت) or *Tiglilîch*	*Asphodelus ramosus* L., *A. microcarpus* Salzm. & Viv. (Asphodelaceae)	*A. microcarpus* [53,55]; *A. ramosus* [47,67,74,75]	Possibly Āgellūs (أگلّوس) [27] (??)
842	*Aroûzi* (اروزى)	Leclerc: "Aspalathe" of Dioscorides: species of 3 genera of Fabaceae have been suggested		Unrelated species with somewhat similar names: *Warionia saharae* Benthem ex Benth. & Coss. (Asteraceae): Arouzzir [52]. *Coriaria myrtifolia* L. (Coriariaceae): Arouz [52], Ārwāz (ارواز) [27]
876, 1191	*Tafîfrâ* (تـفـيـفـرا or تـافـيـفـرا)	Bellakhdar: *Heracleum sphondylium* L. (Apiaceae) possibly due to IAB's confusion [27] Trabut: *Magydaris panacina* DC. [=*M. panacifolia* (Vahl) Lange] [52]	*Magydaris panacifolia* and *M. pastinacea* (Lam.) Paol. [33]	*M. panacina*, *M. tomentosa* (Desf.) W.D.J. Koch ex DC. [=*M. pastinacea*] and *Athamanta sicula* L.: Tafifra [52], Fafra (فـافـرة) [33]. Umbels including *H. sphondylium*, *M. panacifolia*, and *M. pastinacea*: Frīfra (فـريـفـر), Fīfra (فـيـفـر), Tafrīfra (تـفـريـفـر) [27]
1140	*Azemmor* (ازمّور)	*Olea europaea* L. (Oleaceae)	*O. europaea* [33,46,47,55,57,61–64,66,69,73–75]	Azmour [63,64], Azemour [74,75], Azemmour [47], Azemur [55], Āzemmur (آزمّر) [27]

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
1167	*Afersak* (افـرسق)	*Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae), treated with *Dryopteris filix-mas* (L.) Schott (Dryopteridaceae)	*P. aquilinum* [27,55,61,75], as *Pteris aquilina* L. [33]	Possibly Afersīn (افـرسيـن) and similar names [27] (??)
1179	*Tar'îr'ats* [sic] (تـارغـيـرغـث), *Kerrout* (كـروت), *Tarhîrhecht* [sic] (تـاغـيـغـشـت)	Leclerc: Struthion, perhaps *Cucubalus behen* L. or *Silene inflata* Sm. [both = *S. vulgaris* (Moench) Garcke] (Caryophyllaceae) Bellakhdar: *Silene* and *Saponaria* spp. (IAB cited by name, not number)	*Sil. vulgaris* [47,63,73–75]; *Sil. cucubalus* Wibel (=*Sil. vulgaris*) [55]; *Sil. abietum* Font Quer & Maire [48]; *Sap. vaccaria* L. [59]	*Sil. vulgaris*: Tigheghcht [77], Tighercht [47], Taghighasht [63], Tighighach [74], Tighighache [55], Thaghighachth [75], ⵜⵖⵉⵖⴰⵛⵜ/تـغـيـغـشـت [73]. *Sil. abietum*: تـغـيـغـشـت [48]. *Sap. vaccaria*: Tigheghechte [59]. *Silene* and *Saponaria* spp.: Tīġīġest (تـغـيـغـسـت), Tīġīġešt (تـغـيـغـشـت), Tāġīġešt (تـاغـيـغـشـت) [27]
1369, 1549	*Ou'ssâb* or *O'ssâb* (أعـصـاب)	Leclerc: *Lepidium*; *L. latifolium* L.? (Brassicaceae) Bellakhdar: *Plumbago europaea* L. (Plumbaginaceae), which is confused with *Lepidium*	*L. latifolium* [74]; *L. sativum* L. (equated with *L. latifolium*) [55]; *L. sativum* [46,73] In Morocco, *P. europaea* [27]	ʻUsṣāb (اعـصـاب), Laʻsṣāb (الاعـصـاب), Laʻsṣābat (الاعـصـابـت) [27]
1604	*Esfaghîgher*? (اصـفـغـيـغـر) or perhaps *Esghîfer* (اصـغـيـفـر)	Leclerc: Bois de serpent; unidentified, dubiously *Ophioxylon* (Apocynaceae)		
1654, 2286	*Ourdjâlouz* (ورجـالـوز), variant *Ourdjâlour* [ورجـالـور]	*Bryonia dioica* Jacq. [≡*B. cretica* subsp. *dioica* (Jacq.) Tutin] (Cucurbitaceae)	*B. dioica* [55]	
1655	*Mimoun* (مـيـمـون)	Leclerc: Taminier; *Bryonia alba* L.? (Cucurbitaceae)		

Table 1. *Cont.*

Number(s) [Leclerc]	Historical Berber Name(s) [Leclerc]	Suggested Identity	Species Reported in Amazigh Traditional Medicine	Homologous or Similar Modern Common Name(s)
1698	*Harmi* (ⵃⵔⵎⵉ) or possibly *Harri* (ⵃⵔⵉ)	*Xylopia aethiopica* (Dunal) A. Rich. (Annonaceae)	In Morocco, *X. aethiopica* [27]	
1717	*Amz*? (ⴰⵎⵣ)	Leclerc: Spondylium? Unidentified		
1878	*Tâzghallât* (ⵜⴰⵣⴳⵀⴰⵍⵍⴰⵜ or ⵜⵍⵖⴰⵣⴰⵜ)	*Ranunculus* spp. (Ranunculaceae)	In Morocco, 5 spp. of *Ranunculus* [27]	
1902, 2304	*Yakhsis* (يخصص)	*Smyrnium olusatrum* L. (Apiaceae)	*S. olusatrum* [48,61]	Īġsās (سسغ!), Īḫses (سسخ!), Yaḫsīs (سيسخي), Taḫsīs (سيسختـ) [27]
2015	*Tamert ou issoûn* (probably "ogre's beard) (ⵜⴰⵎⴰⵔⵜ ⵓⵏ ⵉⵙⵙⵓⵏ)	Leclerc: *Asplenium trichomanes* L. (Aspleniaceae)		Tamart ou içoun [52]
2047	*Irna* (ⵉⵔⵏⴰ)	Several *Arum* and *Arisarum* spp. (Araceae)	*Arisarum vulgare* O.Targ.Tozz. [33,55,61,71,73]; *Arum maculatum* L. [33,54]; *Arum italicum* Mill. [33,55,74,75]	*Arisarum vulgare*: إرني [73] *Arum maculatum*: Ayerna [54]. Multiple species of *Arum* and *Arisarum*: Īrnī (إرني), Ārnī (آرني), Yernī (يرني), Āyernī (آيرني) [27,33]
2106	*Choûka Meghîla* (ⵛⵓⴽⴰ ⵎⴳⵍⵉⵍⴰ) [Arabic translation of Berber name]	*Centaurea calcitrapa* L.? (Asteraceae); not *C. pungens* Pomel unless conflated with *C. calcitrapa*.	*C. calcitrapa* [74]; *C. pungens* [67,69]; in Morocco, *C. calcitrapa* and *C. maroccana* Ball [27]	
2188	*Asmâmin* (ⴰⵙⵎⴰⵎⵏ) or *Esmâqen* (ⴰⵙⵎⴰⵇⵏ)	Unidentified; the former name is used in the *'Umdat aṭ-ṭabīb* for *Rumex* spp., but the description does not match [27]		
2206	*Hormi* (ⵃⵔⵎⵉ) or *Aghroum* (ⴰⵖⵔⵓⵎ) [means "bread"]	Unidentified; Leclerc: possibly = no. 1698?		
2293	*Ouathmou* (ⵡⴰⵟⵎⵓ)	Unidentified		
2297 note	*A'cheba kîry* [عشبة ريڤي] [prob. Arabic translation], possibly *Ouendjehek* or *Ouendjehel* (ⵡⵏⴷⵊⵀⴽ or ⵡⵏⴷⵊⵀⵍ)	Unidentified		

Of the 38 plants with proposed identities, 28 of these species or species groups were reported to be in modern use in Amazigh populations. This count excludes no. 6 (*Aakcher-oua*), whose proposed identification, only by Leclerc, was very broad and tentative, so that the association of currently and historically used plants appeared dubious. It also excludes no. 1369 (*Ou'ssâb*), for which Leclerc proposed *Lepidium*; Bellakhdar corrected that identification to *Plumbago*, but though only *Plumbago* has homologous common names, only *Lepidium* has Amazigh-specific references. Contrarily, it includes no. 876 (*Tafîfrâ*), a name used for multiple umbels, for which only Trabut's [52] proposed identity was seen in an Amazigh reference. An additional five plants were reported to be in use at a national level but not specified to be used by Amazigh populations, one (no. 1369) having homologous common names.

Four plants that were at least marginally identified were not reported to be in current use in the region at all, one (no. 2015, *Tamert ou issoûn*) with a homologous common name. There are a couple of plants for which dubiously related common names may be in use for other genera than those referred to by Ibn al-Baytar. As for the eight unidentifiable plants, whose historical names are no longer in use, it is assumed that all are no longer used by the Amazigh. It is possible that some persist in use under different names, but it would be inappropriate for the purposes of this analysis to assume that. Thus, it is estimated that at a minimum 60.9% (28/46) of the plants for which Ibn al-Baytar reported Berber common names remain in use among the Amazigh; this figure would increase to 63% if no. 1369 were counted.

Of the 28 plants found in Amazigh-related datasets, at least 22 (78.6%) had reported common names that appeared etymologically related to the historical name, although some were rarely used. For example, it appears that modern Amazigh populations usually use the Arabic word *zeitoun* for olives, but variants of the historical name *azemmor* do persist. Some plants (nos. 826 [*Tîglîch* or *Tiglilîch*], 1167 [*Afersak*]) had common names whose homology was uncertain. Considering the 34 species listed in either Amazigh datasets or national references, 24 (70.6%) had homologous common names.

Bellakhdar's identifications were presumed to be more reliable given his greater first-hand knowledge of the North African flora and ethnobotany. Modern common names often, but not always, provide evidence in support of his interpretations (see Table 1; or, contrarily, might have influenced them). For nos. 2 (*Aâthirîlâl*), 250/1170 (*Ousserghînd* or *Serghent*), 539 (*Tazghet* (تزغت) or *Tarakht*), and 1369/1549 (*Ou'ssâb*), modern names homologous to the historical Berber name were recorded for Bellakhdar's identifications, but not for Leclerc's. For no. 398/788 (*Tafghaït*), which the two identified as different but rather similar plants, the same common name of *tafgha* is in use for both species, indicating a folk taxon that may well have commingled the two at the time of Ibn al-Baytar's writing. For no. 1654/2286 (*Ourdjâlouz*), no homologous common names were found. Finally, Leclerc identified no. 658 (*Fezân* or *Kerân*) as wild artichoke, *Cynara scolymus* L., whereas Bellakhdar identified it as the related *C. humilis* L., though saying that *C. scolymus* was mentioned in the treatment. The only dubiously homologous common names reported were applied to *C. scolymus*, not *C. humilis*.

Of substances that Ibn al-Baytar identified as coming from or used in some portion of North Africa, only five that did not have recorded Berber common names were stated to come specifically from the Berber country or the Berbers. These are the plants (or, in one case, a presumptive lichen) numbered 533, 535, 538, 559, and 1002 (Table 2). Two of those five substances were reported to be used today in Amazigh-related references and two in national references, but none appear in much of the literature. The historical Arabic common names reported for 533 and 535 (*Djouz ez-zendj* and *Djouz es-cherc*), now reported

by Bellakhdar to be used for unrelated species, are rather generic geographic names (*jawz* means "nut", which appears in many common names, and the associated adjectives reference the land of origin) so that a change of meaning would not be unreasonable.

Table 2. Species directly associated by Ibn al-Baytar (IAB) with the Berbers, but without Berber names.

IAB #	Classical Name, Ibn al-Baytar's Link to Berber People [28]	Suggested Identity	Current Species Used	Similar Modern Common Name(s)
533	*Djouz ez-zendj* (جوز الزنج); it is brought from the desert of the Berbers' country.	Leclerc: *Sterculia acuminata* P. Beauv. [≡*Cola acuminata* (P. Beauv.) Schott & Endl.] (Malvaceae) [28]		Jawzat az-zenj (جوزة الزنج) for *Xylopia* spp. (see no. 1698), also by some for *Aframomum melegueta* (Roscoe) K. Schum [27]
535	*Djouz es-cherc* (جوز الشرك); it is brought from the Berbers' country.	Leclerc: *Amomum grana paradisi* L. [=*Aframomum* sp.] (Zingiberaceae) [28]	In Morocco and Algeria, *Af. melegueta* (Roscoe) K. Schum. [27,52]. Bellakhdar: not mentioned by ibn al-Baytar [27]	Jawzat aš-širk (جوزة الشرك) for *Xylopia* spp. (see no. 1698) [27]
538	*Djouz djondom* (جوز جندم); the *Livre des Talismans* says that of the Berbers is the best and strongest.	Bellakhdar: *Lecanora esculenta* (Pall.) Eversmann (lichen) [27]	In Morocco and Algeria, *L. esculenta* [27,52]	
559	*Habb ez-zelm* (حب الزلم); it is brought from the Berbers' country.	Bellakhdar: *Cyperus esculentus* L. (Cyperaceae) [27]	*C. esculentus* [33,73]	Ḥabb ez-zalam (حَب الزلم) [27], Habb ez zelim (حب الزليم) [52]
1002	*Deneb es-seba'* (ذنب السبع); Abdallah ibn Saleh saw it used by Berbers near Fez.	Leclerc: "Cirsium. P."; prior authors suggested *Carduus tenuiflorus* Curtis (Asteraceae) [28]	*Cirsium chrysacanthum* (Ball) Jahand [63]	*C. chrysacanthum*: None similar *Dipsacus sylvestris* Huds. [possibly = *D. fullonum* L.] (Caprifoliaceae): Denb es sebaa (دنب الصبع) [52]

No. 1002 (*Deneb es-seba'*) may be another case in which common names suggest a misidentification by European scholars and Ibn al-Baytar himself. Leclerc [28] suggested it to be a thistle (Asteraceae), possibly a *Carduus*, based on Dioscorides' Cirsium; Bellakhdar [26,27] provided no identification. The entry included quotations of text from Dioscorides, who supplied a short description, and Abdallah ibn Saleh, who reported medicinal use by Berbers near Fez. Dioscorides' description is of a spiny plant with stems triangular beneath, leaves similar to bugloss but smaller, whitish but only moderately hairy, and apically borne heads with red appendices. An almost identical Arabic common name, given tolerance for misspelling, is used in modern Algeria for *Dipsacus sylvestris* Huds. (Caprifoliaceae), usually treated as a synonym or subspecies of *D. fullonum* L., fuller's teasel [52]. *Dipsacus* is prickly on all parts and has ridged stems and often dark pink to purple flowers borne in heads. Bellakhdar [27] recorded no usage of *Carduus* in Morocco and recorded *Dipsacus fullonum* as used only for non-medicinal purposes; he noted its mention by Ibn al-Baytar in several entries, but not 1002. Ibn al-Baytar recorded no personal

observations of no. 1002. Given the limitations of historical plant descriptions, it seems plausible that his entry could represent a conflation of Dioscorides' report of *Carduus* and North African reports of *Dipsacus*.

The three non-plant substances for which Ibn al-Baytar reported Berber common names were truffles (nos. 411 and 1964), cantharides beetles (no. 995), and the flesh of the *saqr* or *yanina* (a small falcon-like bird, no. 1404). Non-plant substances are seldom reported in modern ethnopharmacological papers, but Bellakhdar [26] reported modern use in Morocco of a substantial number, including all of these (if a cited reference to use of falcon skin in magic is counted); he reported homologous Amazigh common names for truffles and falcons.

3.2. Comparison of Modern Medicinal Species Lists to Ibn al-Baytar

Table 3 summarizes the appearance or non-appearance of species from three modern Moroccan ethnobotanical datasets, in the opinion of Bellakhdar [26,27], in the work of Ibn al-Baytar. Of Teixidor-Toneu et al.'s [63] 153 identifiable medicinal plants from a single High Atlas Amazigh community, 89 were considered to have been recorded as mentioned by Ibn al-Baytar. These include two plants identified to genus (*Cinnamomum* sp. and *Boswellia* sp.) for which several species can be used interchangeably and one, *Aristolochia paucinervis* Pomel, that probably represents the taxon Bellakhdar [26] called *A. longa* L. An additional six plants were considered to have been mentioned generically or lumped in with related species, and two to have been doubtfully so mentioned. One was considered to have been doubtfully mentioned in its own right, and three plants identified only to genus (*Verbascum* sp., *Juniperus* sp., *Linum* sp.) belong to genera which Ibn al-Baytar mentioned. Of the remaining 52 species, Bellakhdar specified that Ibn al-Baytar had not mentioned 26, while the final 26 were not recorded in Bellakhdar's work as useful. One of the former is suspected to have been an erroneous identification of an important species, and twelve of the latter had other members of their genera listed, at least in an obsolete taxonomy or in notes.

Table 3. Numbers of identifiable taxa reported in three recent Moroccan datasets [46,47,63]; the subgroup of species found in all three datasets considered by Bellakhdar [26,27] to have been mentioned by Ibn al-Baytar under individual species or species groups, possibly mentioned, at least possibly included in a generic treatment or lumped with other related species, or not mentioned, or not recorded as useful by Bellakhdar.

	Fakchich and Elachouri [46]	**Ouhaddou et al. [47]**	**Teixidor-Toneu et al. [63]**	**Shared Species**
Total # taxa	145	111	153	46
Mentioned	107 (73.8%)	73 (65.8%)	89 (58.2%)	38 (82.6%)
Possible mention	2 (1.4%)		4 (2.6%)	
Generic mention or possible mention	8 (5.5%)	8 (7.2%)	8 (5.2%)	2 (4.3%)
Not mentioned	22 (15.2%)	19 (17.1%)	26 (17.0%)	6 (13.0%)
Not listed in Bellakhdar	6 (4.1%)	11 (9.9%)	26 (17.0%)	

In Fakchich and Elachouri's [46] dataset, 148 medicinal plants were reported from eastern Morocco. Nomenclature in this paper was often erroneous. Three names were incomplete or invalid and could not be identified. Of the remaining 145, 107 were considered

by Bellakhdar [26] to have been mentioned by Ibn al-Baytar, with two others uncertainly in that category, four to have been included in a generic entry or with related species and three doubtfully so included, and 22 not to have been mentioned. Six were not recorded as useful by Bellakhdar; for four of those, other species of the genus were listed, sometimes several species, which, however, were not explicitly treated by Ibn al-Baytar.

In Ouhaddou et al.'s [47] dataset, 111 medicinal taxa were reported from southwestern Morocco; these included two subspecies of *Euphorbia officinarum* L., which had slightly different reported uses. Of these, 73 were considered by Bellakhdar [26] to have been mentioned by Ibn al-Baytar; five to have been included in a generic entry or with related species and two doubtfully so included, with a possible third dependent upon disagreement regarding taxonomy; and 19 not to have been mentioned. Eleven were not enumerated as useful by Bellakhdar; seven of these had other species of the genus mentioned. One of the others is *Carraluma europaea* (Guss.) N.E. Br. (under *Apteranthes*), to which Bellakhdar reports that a common name for useful species of *Euphorbia* is sometimes applied.

In these three individual datasets, 58.2% to 73.8% of reported plants were considered by Bellakhdar [26] to have been included in the work of Ibn al-Baytar. At most 46 species appear in all three datasets. That number involves the following presuppositions: the *Linum* sp. in Teixidor-Toneu et al. [63] is *Linum usitatissimum* L., the widespread, important species cited in the two other papers; the *Thymus* spp. in Fakchich and Elachouri [46] include *T. willdenowii* Boiss., cited in the two others as *T. pallidus* Coss. ex Batt.; and the *Eucalyptus torquata* Lehmann in Teixidor-Toneu et al. can be equated with the *Eucalyptus* sp. in the other two. In all three cases, homologous common names indicate that they are at least the same folk taxon. Of these, 38 (82.6%) were considered by Bellakhdar to have been mentioned by Ibn al-Baytar as individual species or species groups, two probably to have been included in a generic treatment or lumped into related species, and six (13.0%) not to have been mentioned at all. Of the three species reported as "sp." and presumptively equated with specific species in other datasets, one was in each of the three categories. If those had been excluded, 37 of 43 (86.0%) would have been mentioned by Ibn al-Baytar, and 5 (11.6%) would have been entirely unmentioned.

4. Discussion

4.1. Persistence of Historical Species

Probably ca. 61% of the medicinal plants reported by Ibn al-Baytar to have Berber common names are still found to be used in one or more North African regions having ethnically Amazigh populations, and most of those have homologous (but, importantly, not always identical) common names. Had the indigenous knowledge of this region's people been lost after it was documented by Ibn al-Baytar and other classical authors, including those whose writings he saved from oblivion, few Amazigh traditional knowledge holders in later generations would subsequently have had access to their works, much less used them as an authority superseding local tradition. Therefore, the most parsimonious conclusion is that over half of this group of plants (species or folk taxa) persisted in use among the Amazigh through unbroken oral tradition for some 750 years.

Ibn al-Baytar's inconsistent reporting of Berber names greatly restricts this analysis. He did not report Berber common names for the large majority of species from potentially relevant regions of North Africa, although many of them must surely have been used by Amazigh people. Modern ethnobotanical surveys in regions of high Amazigh ethnicity almost always find the most important plant family, in terms of number of species used, to be Lamiaceae, commonly with 14–20 species listed, e.g., [30,46,48,54,59,62]. El-Gharbaoui et al. [30] determined that Ibn al-Baytar had recorded 193 uses for 14 taxa (species or genera)

of Lamiaceae. Despite this, Ibn al-Baytar did not report a Berber common name for any species of Lamiaceae, though many have modern common names that are of Tamazight origin [27,76].

Those Lamiaceae are all species, or genera of which multiple species may be used interchangeably, that are broadly distributed in the Mediterranean. It is reasonable to presume that if Ibn al-Baytar and his educated audience were familiar with these plants under Arabic, and often Greek or Spanish vernacular names, he saw no reason to document local names that his readers would not need to use to obtain or identify medicines. He would not have reported Berber common names for plants that were widely used outside North Africa, unless he quoted an author who happened to mention the name. Such widely used plants, once adopted, might be less likely to fall out of use because their reputation, commercial availability, and, perhaps, superior efficacy could encourage continued use. If Ibn al-Baytar recorded Berber names mostly for species that were not already known to Mediterranean scholars, this dataset might be skewed towards lesser-known or endemic species whose use might more easily be lost, resulting in an underestimate of the persistence of species.

It is also the case that the number of species recorded to be used in Amazigh regions was dependent upon the number of primary literature sources examined. Several recent publications were seen that provided specific use data for a few species previously only recorded from national-level references. Thus, the percentage of species reported to be persisting would have been meaningfully lower had this work been completed just a few years previously. On the other hand, the fact that a few species were recorded in only one or two of numerous references emphasizes that no community preserves all the knowledge recorded by Ibn al-Baytar, which is not a surprise, since no single community ever possessed all that knowledge; it was amassed from multiple sources. Whether it is important that *some* descendants of the medieval Amazigh still recognize a certain plant as useful, if the vast majority do not, is an open question.

As for those that appear no longer to be used, Soelberg et al. [9] emphasize that the abandonment of a medicinal plant or specific plant use does not necessarily mean that it was concluded to be ineffective. They supply a list of alternative reasons for a plant's abandonment, including cultural changes (migration, ethnic change, urbanization, changing attitudes towards herbal medicine), reduced availability due to overharvest or habitat loss, increased availability of another medicine perceived as more effective, or reduced occurrence of the disease condition. However, the *persistence* of a plant's use over several centuries is, they argue, good evidence that it is perceived to be effective.

4.2. Documentation of Currently Used Plants in Ibn al-Baytar's Work

Bellakhdar [27] concluded that 365 of 576 plants then identified as used in Morocco nationwide, including exotics, might be found in Ibn al-Baytar's Treatise on Simples, or 67.4%. Thus, over two-thirds were already in use 740 years previously. In the present analysis of three recent ethnobotanical datasets from small regions of Morocco [46,47,63], which included a number of recently introduced exotic plants, 58.2% to 73.8% of plants recorded in single studies from small regions had been identified by Bellakhdar with plants treated by Ibn al-Baytar. However, of the 46 plants considered to be shared among all three datasets, 82.6% were identified with plants recorded by Ibn al-Baytar.

These numbers are lower than Leonti et al. [10,11] reported for native plants in Italian datasets. Leonti et al. [11] reported that 115 of 120 native plants found in all three of their selected Italian datasets, or 95.8%, could be associated with Dioscoridean plants. The greater overlap between currently widely-used plants and historically used plants in

that study, despite the longer time frame involved, can plausibly be attributed to the past availability of Dioscorides' (or perhaps Galen's) work in all three regions and the greater influence of academic scholars and literacy in general, as Leonti et al. propose. However, the substantial shared similarity in this study, where treating the historical literature as causal would not be equally plausible, identifies a "floor" for the level of similarity between widely-used plants from the modern ethnopharmacopoeia and an encyclopedic historical work that might be seen even if the historical work had had little influence on modern traditional knowledge holders. Even within "literate" societies, different cultures may vary greatly in the public's access to written elite scholarship and the authority they bestow upon it, and both should be taken into account in assessing possible influences on modern folk practices.

In fact, the use of Bellakhdar [26,27] as the primary identifying reference for this analysis provides a second demonstration of this effect. His authoritative compilation of medicinal plant data for Morocco is, for that country, the early-21st-century equivalent of Ibn al-Baytar's work. Many of his use reports came from his own field studies totaling 809 days in the field between 1969 and 2017 [27]. He obviously did not have a causal effect on the modern uses that he recorded. Contrarily, the fact that the large majority of species in the three large individual modern datasets compared, as well as many other recent publications, are listed in his work is evidence that he did a thorough job of seeking out existing usage. Each of those three datasets contained some fraction of plants that Bellakhdar had not documented. However, not a single species that was reported in all three datasets had been overlooked by Bellakhdar, all of them being recorded already in his 1997 first edition [26]. It is entirely logical that the more widespread a species' use is, the more likely a researcher is to have the opportunity to document it. The same would have been true for Ibn al-Baytar and, for that matter, Dioscorides.

4.3. Application of Common Names

Folk taxa that are defined by their general morphology and/or uses often persist with similar circumscriptions for many centuries. It is not uncommon for folk taxa to represent what a taxonomist would say was not a natural group, including species that are relatively distantly related while excluding more closely related species that have different properties. For example, the historical name "تاغيغشت" (*tāghīghesht*) was tentatively identified by Leclerc with two names in Caryophyllaceae that are synonyms of *Silene vulgaris* (Moench) Garcke, and modern homologues are usually associated with *S. vulgaris* or *S. abietum* Font Quer & Maire, e.g., [47,48,63,77]. However, Benlamdini et al. [59] identified "*tighighechte*" as referring to *Saponaria vaccaria* L. (Caryophyllaceae) [also known as *Gypsophila vaccaria* (L.) Sm. or *Vaccaria hispanica* (L.) Rauschert]. Bellakhdar [27] reported three minor variants of the name as being in current use for either *Silene* or *Saponaria* species and considered that Ibn al-Baytar had also treated them interchangeably. Ibn al-Baytar explicitly attempted, across several different entries, to recognize two distinct types of saponiferous plants, though neither Leclerc nor Bellakhdar seems to have fully respected his opinion on that point. Similarly, Ouarghidi et al. [78] report that "*serghina*" or "*tasserghint*" in commerce may refer both to *Corrigiola telephiifolia* Pourr. and to *Petrorhagia illyrica* (Ard.) P.W. Ball & Heywood, also both Caryophyllaceae.

Thus, in many complex genera, the possibility that the application of the name has changed over time cannot be excluded. It is appropriate to regard modern use as the persistence of the usage, and perhaps name, of a folk taxon, which may or may not be a single taxonomically defined species. These uses may represent simply inaccurate dissemination or inconsistent use of a common name across time and place, much as Americans in differ-

ent parts of the Midwest use the term "pigweed" for different species of Amaranthaceae s.l. However, they could also reflect a deliberate intention to treat the species as similar, an implicit assertion that they are of similar value. It would be of interest to determine whether such pairs or groups of plants in fact share similar bioactivities that are not shared by excluded congeners.

5. Conclusions

Over half of the historical medicinal plants for which Ibn al-Baytar provided Berber common names are used medicinally by modern populations with Amazigh ethnic or cultural backgrounds, and homologous Tamazight common names still exist for a large majority of them. This demonstrates that primarily oral transmission of traditional knowledge is capable of maintaining considerable stability in a pharmacopoeia for over 750 years. Furthermore, plants appearing in multiple recent ethnobotanical datasets were more likely to be included both in Ibn al-Baytar's work and in Jamal Bellakhdar's modern work than plants from any single dataset, indicating that plants with widespread current uses are more likely to be found in major historical reference works even if the reference work is unlikely to have been responsible for current use. Plants with a long history of continuous use are particularly likely to demonstrate useful bioactivities and should be prioritized by local scientific communities for clinical trials or other forms of biomedical research.

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Article

Contemporary Uses of Vilca (*Anadenanthera colubrina* var *cebil*): A Major Ritual Plant in the Andes

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Abstract: *Vilca* or *cebil* (*Anadenanthera colubrina* var. *cebil*) is a species known for its psychoactive properties and its widespread use among the pre-Hispanic peoples who inhabited the southern Andean area (southern Peru, Bolivia, northern Chile and northwest Argentina). Studies on this species, as well as on medicinal, psychoactive, or magical plants in general, tend to consider its use in post-Spanish conquest times to be scarce or irrelevant in the Andes of South America. However, based on an in-depth review of the existing literature and on ethnobotanical research conducted in markets in Argentina, Bolivia, and Peru, this paper provides an updated overview affirming the continuity of the use of this species. The results indicate a significant diversity in terms of usage types, plant parts used, treatments, and conditions in which it is applied, along with new records of vernacular names. This paper also offers an interpretation from the perspective of Andean logics, highlighting the current therapeutic effectiveness of the seeds of this plant, facilitated through a series of "movements" that aim to restore the affected person's health.

Keywords: Andes; medicinal plants; psychoactives; therapeutics

1. Introduction

1.1. Background

Globally, the American continent stands out for its vast array of plant species with psychoactive properties [1]. In South America specifically, a wide variety of plants and their preparations can alter human perception through their chemical components [2]. The knowledge about these plants in South America is also deeply rooted in history. The earliest evidence dates back approximately 4000 years, with archeological findings of *Anadenanthera colubrina* (Vell.) Brenan var. *cebil* (Griseb.) Altschul [synonym *Anadenanthera macrocarpa* (Benth.) Brenan; Fabaceae] seeds alongside pipes used for smoking them in northwest Argentina [3,4].

The genus *Anadenanthera* has an exclusively neotropical distribution from the West Indies to Argentina. *Anadenanthera* trees are feathery-foliaged; the leaves are bipinnately compound, with leaflets 9–8 mm. long. The trunks may be smooth or appended with mammillose projections. The flower heads are up to 20 mm in diameter and range from white or greenish white to orange–yellow. The pods are up to 35 cm long and up to 3 cm wide; they are more or less flat and unilocular, dehiscing along one suture only, brownish outside, containing 8–16 thin, flat orbicular and shiny brown or black seeds 10–20 mm in diameter. *Anadenanthera colubrina* primarily inhabits seasonally dry forests between 0 and 30 degrees south latitude. Known as *vilca* or *willka* in Peru, Bolivia, and Chile, and as *cebil* in Argentina, *A. colubrina* var. *cebil* has been extensively used over time. Similarly, its relative *A. peregrina*, known as *yopo*, *parica,* or *cohoba*, is found in Colombia, Venezuela, English Guyana, Brazil, and Paraguay. It was also introduced in pre-Hispanic times to the Greater Antilles [3,5,6].

The psychoactive effects of this genus of plants, regarded as visionary and entheogenic, are primarily due to the presence of dimethyltryptamine (DMT), 5-hydroxy-DMT or bufotenin, and 5-MeO-DMT, particularly in their seeds [2,3]. In the pre-Hispanic Andean world, *vilca* held significant cosmological, medicinal, and ritual importance. However, its use began to decline with the expansion of the Inca empire and was further suppressed by the Spanish conquistadors, leading to its near extinction, or very limited use, from the 18th century onward [7]. While this perspective is widely accepted, recent studies [8] suggest that the situation might be different than previously assumed.

This paper will present, on one hand, an exhaustive review of the existing literature for the Southern Andean Area—covering central and southern Peru, Bolivia, northern Chile, and northwest Argentina (Figure 1)—that documents the use of *vilca* or *cebil* from post-colonial times to the present (19th to 21st centuries). On the other hand, it will present the results of a survey conducted in various urban and peri-urban markets of northwest Argentina, Bolivia, and southern Peru to document the current uses of *Anadenanthera colubrina* var. *cebil*. Following the presentation of these results, the diversity of registered uses will be analyzed, culminating in a unified interpretation of the contemporary therapeutic applications of *vilca* or *cebil* seeds within the southern Andean cosmovision.

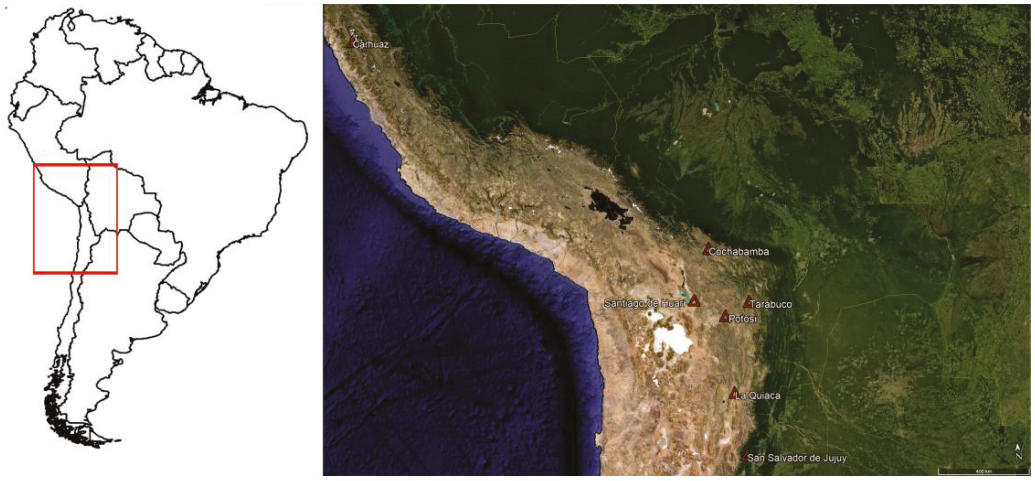


Figure 1. Map showing the Southern Andean Area and the countries it encompasses in South America (**left**), with traditional markets and fairs where *Anadenanthera* seeds were found during fieldwork (**right**).

1.2. The Use of Anadenanthera colubrina var. cebil in Pre-Hispanic and Colonial Times (16th to 18th Centuries) in the Southern Andean Area

After its earliest presence in pipes 4000 years ago, remains of *vilca* or *cebil* seeds have continued to be detected in South America in various artifacts, including pipes, enemas, and items associated with snuffing, such as leather bags, tubes, and trays. These seeds have also been found as macro remains or as an ingredient in alcoholic beverages like *chicha de molle* (*Schinus molle* L.-Anacardiaceae) and *aloja*, a fermented drink made of different *Neltuma* [Fabaceae] species [3,4,9–17]. All these findings are confined to the Andean area, in particular northern Chile, northwest Argentina, central and southern Peru, and Bolivia. The use of *vilca* has a continuous record throughout the pre-Hispanic period, except during the expansion of the Inca or *Tawantinsuyo* empire. For this period, there is no direct archeological evidence of *vilca* seeds use; although, the consumption of this plant is mentioned in early chronicles of the region [7,18]

In pre-Hispanic archeological sites in northwest Argentina, remains of *cebil* seeds have been recovered, along with wood, either unmodified or used as raw material for the production of snuff trays [18–21]. Cebil wood has also been identified as fuel in cremation funerary contexts in that area [22]. According to early chronicles, its wood was used in the manufacture of furniture and artifacts [23]. Some authors, such as Gade [7], suggest that its

wood may have been part of the ceremonial fire called *vilcanina*, used to offer sacrifices and oblations to the tutelary hills.

In the 17th century, several chroniclers of the central Andes—Cristóbal de Albornoz, Guaman Poma de Ayala, Bernabé Cobo, Polo de Ondegardo, and Ludovico Bertonio—documented the Inca customs of purging (oral and/or anal) with *vilca* seeds and its inclusion in *chicha* (fermented beverage), whether for medicinal, revitalizing, or visionary purposes [7,14,23].

Between the 16th and 18th centuries, the inhalation of *vilca* or *cebil* snuff was noted as a customary practice among the indigenous people of north central Argentina (provinces of Santiago del Estero and Córdoba), including its consumption during rituals to ask for rain [24]. During this period, there are also records of *cebil* seeds being collected as an indigenous tribute by a Spanish landowner in Santiago del Estero, as well as accounts of Spaniards and Creoles using these seeds in Córdoba during the early colonial period to forge alliances with indigenous chiefs [25–27]. In the 18th century, there are testimonies from Santiago del Estero of accusations of sorcery among indigenous women. One such account describes a remedy involving the ingestion of five ground *cebil* seeds in hot water to counteract an illness (*daño*) caused by one of them through *chicha* mixed with *chamico* (*Datura ferox* L.-Solanaceae) seeds [28].

These instances demonstrate the significant role of *vilca* or *cebil* in the pre-Hispanic and colonial history of the southern Andes. Therefore, the aim of this paper is, firstly, to examine whether this importance has been maintained since the 19th century by analyzing bibliographical background and conducting ethnobotanical fieldwork in traditional markets. Secondly, the aim of this paper is to offer a possible interpretation of the various uses of *Anadenanthera colubrina* var *cebil* seeds from the perspective of Andean therapeutic logics.

2. Materials and Methods

To survey the contemporary uses of *Anadenanthera colubrina* var. *cebil* in the Southern Andes (Figure 1), both an exhaustive literature review and ethnobotanical fieldwork in markets were conducted. The former focused on references to the use of *vilca* or *cebil* (including all recorded variants of both terms) [3,5] from the 19th century to the present. This step implied the use of various internet search engines and references to specialized books on plants used for medicinal, magical, and ritual purposes in the southern Andes. Ethnographic, anthropological, archeological, and ethnobotanical publications were explored, along with graduate and postgraduate theses from institutions in the countries within the study area. All recorded uses of the plant were documented, with a specific emphasis on those referring to the seeds. These uses were systematized according to the logics outlined by the original communities that utilize them, particularly focusing on traditional doctors and ritual specialists. Additionally, information from Wichí groups in the western sector of the Gran Chaco, close to the Andean area of northern Argentina, was included due to their widespread use of *cebil*. Other extra-Andean references were excluded, unless they documented a particular form of use not recorded in the primary area of interest for this paper.

The fieldwork was conducted between 2017 and 2019 in stalls selling medicinal products in Peru, Bolivia, and northwest Argentina (Figure 1). They are characterized by the sale of ingredients with traditional ritual and medicinal uses, including plants, animals, minerals, and various preparations made from these materials. The surveyed stalls are located in permanent markets and fairs held at different times of the year. The former include the Carhuaz Market (Ancash, Peru), Central Market, and Vicuñas Market in Potosi; Cochabamba Market and Tarabuco Market (Bolivia); and the old bus terminal market in San Salvador de Jujuy (Argentina). The fairs include the Manka Fiesta, usually held on the third Sunday of October in La Quiaca, Jujuy, Argentina, and the Holy Week Fair of Santiago de Huari in Bolivia. During these years, I also visited several markets and stalls in Tilcara (Jujuy, Argentina), Lima, Cusco, Huánuco, Trujillo, Chiclayo, Iquitos (Peru), San Pedro de Atacama (Chile), and Sucre (Bolivia), without finding *vilca* seeds alone or in preparations.

In each market or fair, all stallholders selling Anadenanthera, which are not usually many, were interviewed. In all cases, only one stall was found, except in the Central Market of Potosí, where there were two, and in the Santiago de Wari fair, where there were five. The number was obtained by direct observation of plant remains at the stalls and also by asking the local population who sell the plant (using the particular name given to the plant in each place and also showing its seed). However, it should be noted that both fairs and markets are dynamic and change from year to year, and the number of vendors may vary as well as the presence or absence of products, including *vilca*. No formal interviews were conducted, instead a friendly conversation was sought, explaining my research interests. In the course of the conversation, the name of the plant, the parts used, its place of origin, and its applications were discussed. The records from these visits were systematized and compared with the results obtained from the literature.

The results of the bibliographic research are presented below, followed by the findings of the fieldwork.

3. Results

3.1. Bibliographic Results

The inhalation of snuff made from *vilca* seeds was recently documented by Gili [8] as a healing practice performed by a descendant of the Mochica people of the northern coast of Peru. Among Wichí shamans, the inhalation and smoking of *cebil* seeds are established practices that enable them to obtain visions, perform healings, and communicate with spirits [29–35]. Field records from the 1970 decade among the 'Weenhayek (Mataco-Mak'á linguistic family) settled in the Boreal Chaco, on both sides of the border between Bolivia (Tarija) and Argentina (Salta) provide interesting information. The seeds are harvested once a year, dried (sometimes roasted), strung on a fine thread made from *Bromelia* [Bromeliaceae], and stored as "bracelets" (34 cm long). These "bracelets" are of considerable value and are traded to regions where the tree is rare (Figure 2a). When *hataaj* (wichí name for *cebil*) powder is needed, the dried seeds are roasted, ground and the powder is put directly into the nostrils. There are records from the 1930s of a clay container called *hataaj'wet* (meaning 'the cebil, its place') being used as a base for grinding and/or snuff inhalation (Figure 2b). Also recorded in that decade is the use of a gourd for grinding, from which shamans would then take "pinches" to inhale during ceremonies. The ground cebil is also mixed with tobacco to be smoked in pipes (Figure 2a) [32,33].

The Chorote shamans (Mataco–Mataguayo linguistic family) of eastern Salta also use the *cebil*, a practice they acquired from the Wichí. Particularly, female shamans (*aiewu-ki*), who have the chant of this plant, make women burn its fruits to ashes when they wish to kill another woman [36].

In the south of Peru and Bolivia, north of Chile and northwest Argentina, other uses exist, which will be detailed below. Notably, in northern Chile and Argentina, historical records and testimonies from decades ago refer to the *yungas* as suppliers of *cebil* or *vilca* [8,37,38]. These members of the Kallawaya ethnic group, recognized as itinerant healers, are also known as *yungueños* [39].

In addition to the uses detailed below and summarized in Table 1, *cebil* bark has been widely used in leather tanning from colonial times to the present in several parts of northwest Argentina, such as eastern Catamarca. Here, veterinary uses of the bark and forage uses of leaves and fruits (for animals introduced post-conquest) are reported along with artisanal and fuel uses of the wood [40–43]. Among the Wichí, the bark, rich in tannins, is also used to tan hides and dye fibers [3], and the powder of ground seeds is placed on the eyelids to cure conjunctivitis; care must be taken to ensure that the powder does not enter the eyes as it may damage them [35]. Additionally, there is a use of *cebil* seeds reported as "magical", where the victim of a dog bite can kill the aggressor animal by putting ground seeds in its food [44]. According to Suárez, "some seeds are ground and the powder is placed on the wound. This helps the wound to heal and at the same time the 'dog' that caused the wound becomes sick, completely inappetent and eventually dies" [35].

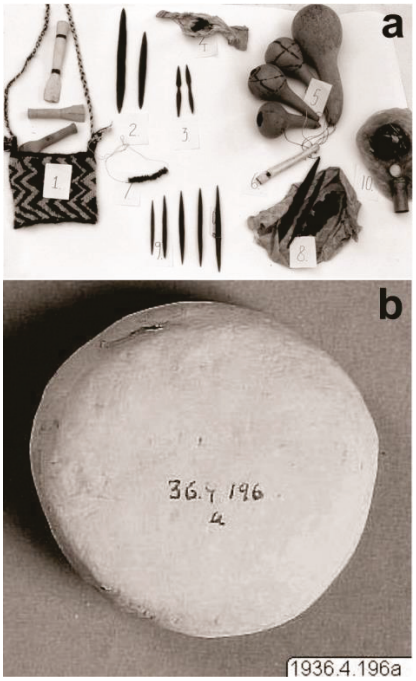


Figure 2. 'Weenhayek shaman's implements (**a**) 1—bag with ceramic and wooden pipes; 2—large vehicles for spirits; 3—small vehicles for spirits; 4—"secret"; 5—gourds; 6—heron's whistle; 7—cebil seed bracelet; 8—cebil seeds and large vehicles; 9—set of vehicles; 10—coca and a jar of bicarbonate ([33], Figure 6). (**b**) 'Weenhayek plate for inhaling cebil ([32], Figure 38).

In the vicinity of Cuzco, Lira mentions the administration of ground *willka willka* (*A. colubrina*) seeds in the food of dogs to make them fierce [45]. Cooper notes that the Piro and Catawishi (from the southern Amazonia in Peru) administer Anadenanthera, apparently as snuff, to hunting dogs to make them more alert and improve their vision [6]. Infusions made from *cebil* leaves are known to induce heat in cows [46], while consumption of the immature fruits can be abortive in large animals [43].

In eastern Salta (northwest Argentina), an infusion of *cebil* bark with other ingredients is used as an external bath to cure skin diseases and other "hot" conditions [47]. The Wichí also make a decoction of the bark for stomach pains and make enemas with unripe pods, sometimes adding leaves to treat headaches [1,3]. De Lucca and Zalles report that in Bolivia, a decoction of the leaves is consumed as an excellent tonic for the stomach and womb. A decoction of the bark, taken as a drink, is effective against diarrhea and is also used in lavages to stop bleeding. Additionally, both the bark and resin are utilized for treating lung ailments and bronchitis [46].

In the following sections, we will examine the documented uses of *Anadenanthera colubrina* var. *cebil* seeds in the context of human consumption.

Table 1. Preparation and administration methods of *Anadenanthera colubrina* reported for human consumption in the southern Andean area.

Plant Part	Preparation and Consumption	Combination with Other Substances	Chronology	Geographical Area	Bibliography
	Burnt ground (smoked)	*Nicotiana*, *Nicotiana tabacum* L. [Solanaceae]	Pre-Hispanic (ca 2000–0 BC)	Northwest Argentina	[4,13,26]
		Nicotiana tabacum, "aromo" (*Acacia* and *Vachellia* genus, Fabaceae)	Modern	Wichi, Salta and Formosa, Argentina; 'Weenhayek in Tarija, Bolivia and Salta, Argentina	[1,31–35]

Table 1. *Cont.*

Plant Part	Preparation and Consumption	Combination with Other Substances	Chronology	Geographical Area	Bibliography
Seed	Ground (inhaled)	*Nicotiana*	Pre-Hispanic (ca BC 1000–BC 1000)	Peru, Bolivia, northern Chile, and northwest Argentina	[3,10,12,15]
			Colonial 16th and 17th centuries	Lules from Santiago del Estero and Indians from Córdoba, Argentina	[24]
			Modern	Mochica in the northern Peruvian coast; Wichi in Salta and Formosa, Argentina; 'Weenhayek in Tarija, Bolivia and Salta, Argentina	[8,29,33–35]
	Ground (placed on the organ concerned)		Modern	Wichi, Salta, Argentina	[35]
	Ground in liquid suspension (enema)		Pre-Hispanic (ca. AD 500–1500)	Bolivia; northern Chile; Jujuy, Argentina	[14]
			Colonial 17th century	Reference to Inca customs	Guaman Poma 1615 in [14]
	Whole in fermented drink (beverage)	In "chicha de molle" (*Schinus molle*)	Pre-Hispanic (ca. BC 600–1000)	Southern Peru (Wari sites)	[16]
	Not specified whether whole or ground in fermented drink (beverage)	In "aloja" (fermented *Neltuma* pods)	Pre-Hispanic (1000–770 BC)	Northern Chile	[17]
		In chicha	Colonial 16th century	Peru	Bernabé Cobo 1563 and Polo de Ondegardo 1571 in [23]
	Not specified whether whole or ground in infusion (beverage)	In "Polipodio" (*Polypodium* fern) root decoction			Bernabé Cobo 1563 in [23]
	Ground in hot water (beverage)		Colonial 18th century	Santiago del Estero, Argentina	[28]
	Ground as infusion (beverage)	In "charcoal tea" (remains of smoked elements), with basil (*Ocimum basilicum* L.-Lamiaceae) or lemon balm (*Melissa officinalis* L.-Lamiaceae)	Modern	Salta, Argentina	[37]
	Ground in distilled spirit (beverage)	Corn kernels, wayluru (*Citharexylum herrerae* Mansf.-Verbenaceae) seeds, coca seeds, a couple of carnation flowers and two mineral fragments (all ground together into a mixture called *llampu*).	Modern	Ayacucho, Peru	[48]
	Not specified whether whole or ground in water (beverage)	With honey	Colonial 16th, 17th, and 18th centuries	Juli, Bolivia	Bertonio 1612 in [49], Guaman Poma 1615 in [14]
				Peru	Bernabé Cobo 1563 in [23]
				Santiago del Estero, Argentina	[28]
			Modern	Bolivia and Bolivia–Argentina border	[38,39,50–52]

Table 1. *Cont.*

Plant Part	Preparation and Consumption	Combination with Other Substances	Chronology	Geographical Area	Bibliography
	Whole (buried or burned)	On ceremonial "mesas" with multiple ingredients depending on the case	Modern	Ayacucho, Peru and Bolivia	[39,53–55]
	Whole (worn as a charm)	Alone or wrapped in wool		Cuzco, Peru; Bolivia; northwest Argentina	[8,28,39]
	Whole (chewed)		Colonial 17th century	Pampas and Huarpes, central western Argentina	Ovalle 1646 in [5,24]
Leaf	Decoction (drink or enema)		Modern	Bolivia	[46,51]
Bark	Decoction (beverage)			Bolivia. Wichi, Argentina	[3,46]
	Decoction (baths)	Together with bark and flowers of *Vachellia caven* (Molina) Seigler and Ebinger and plants of "mastuerzo" (*Lepidium didymum*L.-Brassicaceae)	Modern	Northwest Argentina	[47]
				Bolivia	[46]
Resin	Probably beverage		Modern	Bolivia	[46]
Pods	Burned (inhaled)		Colonial 18th century	Abipones, Formosa, Argentina	Dobrizhoffer 1784 in [5]
	Decoction of unripe pods (baths)	*A. colubrina* var *cebil* leaves	Modern	Wichi, Argentina	[1,3]

3.1.1. For Protection (*Contra*) and to Attract Good Luck

In the first half of the 20th century, testimonies from Santiago del Estero and Catamarca, Argentina, describe the use of *cebil* seeds as amulets and charms for protection (called *contra*) to ward off witch attacks [28,43]. Local testimonies indicate that wearing three seeds in the hem of trousers or a dress, or a necklace hidden in the clothing, was believed to prevent the influence of witchcraft [43]. In northern Chile, *vilca* seeds from Bolivia wrapped in *pante* wool (dyed fleece of ritual value) are also used as amulets [8]. In Bolivia, *Yungeño* traders sell *vilca* seeds for good luck and remedies for discomfort caused by envy [39]. According to records from the 1980s, Pellegrin noted the sale of *vilca* seeds on the border between La Quiaca (Argentina) and Villazón (Bolivia) [38]. These seeds are either carried (*se trajinan*) as amulets or made into an infusion to be drunk three times a day for good luck.

From Salta to Villazón, *cebil* seeds are used as amulets to counteract evils and attract luck or fortune. These elements, known as *cuti* in Andean culture, embody the idea of turning or changing direction. This concept involves redirecting negative forces rather than undoing them. Many *cuti* elements, including certain fruits, have a counterclockwise twist that stands for this idea [55–57]. *Cuti* includes various plant elements, such as *wuayruros* (usually *Ormosia coccinea* (Aubl.) Jacks. [Fabaceae] seeds) and *willcacuti* (*vilca* seeds), which must be used in specific numbers or proportions to be effective. They can function independently or be combined with other elements by ritual specialists. In the latter case, they can be bought in markets already prepared in small bags, glass containers, or *chuspas* (small traditional woven bags), which must be carried by the individual [57].

Gentile analyzed stalls selling traditional Andean talismans and amulets across various provinces in Argentina and in Sucre (Bolivia) [58]. According to Gentile, talismans are crafted to attract or obtain desired outcomes. They are made up of various elements and require preparation by a ritualist who "activates" them, endowing the talismans with their own will, requiring regular attention. Amulets, on the other hand, are unmodified animal, plant, or mineral parts that can be purchased or found.

Gentile highlights the predominance of plant elements in the creation of talismans, mainly *wuayruros*, followed by *mastuerzo* or *cuti* (*Strombocarpa strombulifera* (Lam.) A. Gray., Fabaceae) and *cebil* seeds. She describes a composite talisman acquired in Sucre in the 1990s intended to attract a loved one, which included multiple ingredients, including *vilca* seeds. Metraux also notes that in Bolivia, seeds of the *wilka* or *wilkacipa* legume, or the fruit of the *Prosopis strombolifera* (*Strombocarpa strombulifera*), known as *kutiwainito*, are drunk to counter curses and ailments like neck pain [50].

3.1.2. As Purge, Cleanser, and Medicine

The main chroniclers of the central Andes in the 17th century often mentioned the use of *vilca* as a purge, administered either as an enema or as a drink with *chicha*, due to its laxative and emetic properties (Table 1). *Vilca* was also used to cleanse the chest and stomach and to stimulate urination by drinking its seeds cooked with honey. Additionally, it was believed to enhance fertility in women [23]. Larraín explains that "to purge" meant to expel "bad humours", a practice achieved in the past, as it appears in early chronicles, through the inhalation and oral consumption of *vilca* for prophylactic therapeutic purposes [59]. This cleansing process facilitated the plant's stimulating and ritualistic effects, allowing the sacred to manifest within the individual, as *willka* also means "sacred". In this context, the effects of *vilca* are similar to those defined for entheogens [2].

The use of *vilca vilca* as a stimulant and aphrodisiac is documented in the 19th century *Callahuayan* pharmacopeia [60]. The cooked leaf, either in a decoction or enema, is used to cleanse the chest, stomach, and womb of parasites and mucus and to provoke menstruation. In [3], Yacovleff and Herrera 1934–1935 note that *cebil* seeds are sold as a laxative in Peruvian markets. In northern Chile, the seeds are currently used "as a remedy by women in the Salado river basin" [49]. In Bolivia, *vilca vilca* is used as an "aphrodisiac stimulant; it is taken as *mate* (infusion) to treat sterility and impotence, and to alleviate anger and melancholy" [51]. Karen Urcia of the Mochica people explains that the inhaled seed powder "is used for cleansing, as it is considered the strongest plant capable of expelling deep-seated evils" [8]. In San Pedro de Atacama, Chile, seeds wrapped in wool or red fleece are used to cleanse individuals suffering from illnesses [8].

According to Loza and Quispe, traditional Aymara midwives in Bolivia use *vilca* seeds, administered in liquid form, to facilitate loosening of the placenta [39]. These seeds are sold in markets in the city of La Paz (specifically on Santa Cruz and Linares streets) and in El Alto (in La Ceja area). They are marketed as an abortifacient and for inducing menstruation when prepared as a decoction [52].

3.1.3. To Cure *Susto* (*Susto* (Fright) Refers to a Disease Caused by the Loss of the Vital Principle, or *animu*, of the Person, Which Leaves the Body and Becomes Retained Somewhere) and Restoration of the Person's Vital Principle (The Cure for *Susto* Involves the Return of the Retained or "grabbed" *animu* to the Individual's Body)

Ethnographic records from the 1970s and 1990s in Molinos, Salta (northwest Argentina), document the use of *vilca* to cure *susto* in children [61]. The sick children are smoked (*se sahuman*) with palm, blessed cane, incense, and lamb's wool. Subsequently, the combustion residue is used to prepare an infusion, to which ground *vilca* is added. This preparation is typically conducted collaboratively by the "medicine woman" and the affected person's family.

Local testimonies inform additional methods for treating *susto*. One approach involves taking a fourth of a *vilca* seed, burning it alongside with a hummingbird's nest and a piece of condor feather. Furthermore, three drops of holy water and earth from the afflicted child's home are included. Alternatively, basil, lemon balm, and *vilca* ground with a spoon and a small, clean stone, are blended, strained, and administered to the frightened individual [37]. Moreover, in Molinos, *vilca* is combined with various ingredients to concoct infusions aimed at alleviating heart maladies attributed to bad wishes [62].

In the case of the Department of Ayacucho, in Peru, *willka* seeds are integral to various ritual bundles called *pagapu* (payments). These bundles, comprising several ingredients,

are buried in the place where the individual was "grabbed" by the earth or *Pacha*, often in a cemetery or a burial ground of *gentiles* (*Gentiles* refers to a pre-human generation associated with the underworld). This ritual is performed to compel the place to release the *animu* taken from the person, thereby curing them once this vital essence returns to their body [53]. Additionally, in Ayacucho, a handful of *willka* seeds is commonly used as an ingredient in *mesas* or *pagapus* to treat ailments believed to be caused by *Pacha.* These earth-related diseases may have various origins [63].

3.1.4. As an Ingredient in *Mesas* (Ritual Bundles)

As we have seen, *vilca* and *wuayruros* are *cutis* and often appear together, commonly featured in the so-called *black mesas*. According to Fernández Juárez, this type of *mesa* is used to cleanse, repel, and return the patient's affliction through a "decontaminating" preparation that involves "inversion movements" [54]. Rösing adds that these *mesas* with *kutis* operate a "change of direction" through both the ingredients used and the counterclockwise gestures performed by the specialist [55]. This practice aims to dispel sorrows and sadness while ensuring that sacred places receive the offering and reciprocate, a notion closely linked to the concept of Andean reciprocity. Consequently, protection and rejection are seen as exercises in the constant return of what arrives and must be sent away to make room for what is to be attracted.

Vilca seeds are used in various ritual *mesas*, along with many other ingredients, among the Aymara groups of the Bolivian Altiplano. During his travels in 1930 and 1931, Metraux documented their use in *saxra mesas*, which are employed against curses and to treat diseases caused by "the air" or "blows", as well as in *chywchy mesa* composed of *chywchys* (lead miniatures) and *wuayruru* seeds [64].

Fernández Juárez explains that *chiwchis* are lead and tin miniatures of domestic objects, people, animals, tools, crosses, and celestial bodies (such as stars and the moon), crafted from shiny papers, along with *willka* and *wuayruru* seeds [65]. These elements form the *chiwchi mesa* but they are also components of other *mesas,* like the *gloria mesa*, which is associated with celestial entities, such as virgins and saints or with lightning [65]. Nordenskiöld describes the objects buried when a house is built and mentions that, in addition to miniatures, *vilca* and *huayruros* seeds are acquired in the La Paz market for this purpose [66].

Among the Aymara ritual specialists of La Paz and El Alto, Bolivia, Loza and Quispe mention *vilca* seeds as part of the *castilla mesa*, which is associated with the conservation of life and protection against threats from evil entities inhabiting the cosmos [39]. In the Central Market of San Pedro de Cusco, Peru, *vilca* is sold for use in dispatch (*despacho)*, an offering incinerated to honor specific entities [8]. In Humamarca, Bolivia, *willka* seeds are included in the *saminchay* or "smoke offerings", along with incense, gold and pepper, coca seeds, and llama fat. These offerings are presented to sacred sites to release water for irrigating fields [67].

3.1.5. As a Ritual Drink

As previously discussed, the inclusion of *vilca* in *chicha* is mentioned by early chroniclers and has archeological antecedents in northern Chile and the Cuzco area. Torres explored this topic by examining the chemistry behind this combination as well as its historical trajectory and continued practice today [23]. Torres highlighted a unique case: "*cebil* wine" among the Wichí, referencing the ethnographic work of Califano [30]. Califano recounts a shamanic initiation where the individual visits the world of spirits, a place where the *jataj* or *cebil* seed is a wine that produces similar effects once the initiate drinks it. This narrative appears to be a case of perspectivism [68], which is frequent in several South American psychoactive plants [69,70], although it had not been previously noted in the case of *Anadenanthera*.

Another contemporary account is provided by Isbell. In her ethnography conducted in Chuschi (Department of Ayacucho, Peru) in August [48], she details the preparation of a

ritual drink called *llampu*, which includes *willca* seeds and is used for rituals associated with *herranza* (livestock branding). This drink, in addition to ground *vilca* seeds, incorporates pairs of pulverized ingredients: large-grain white corn kernels, *wayluru* seeds *(Citharexylum herrerae* Mansf., Verbenaceae), coca seeds, white carnation flowers, and fragments of minerals known as red and white *llampu*, along with "crude gold" and "crude silver". The term *llampu* seems to refer both to the reddish-colored drink and to certain minerals included in its preparation, as well as to the ground powder of the mentioned ingredients. This ground preparation, along with some of its ingredients, such as *vilca* seeds, are kept inside the ritual bundles and other paraphernalia for the *herranza* ceremony.

The drink is offered as payment (poured on the ground) to the *wamanis* (powerful mountains) and is consumed as a purifying agent for ritual preparation and as protection against contamination, capture, and disease caused by the *wamanis*. As Isbell states:

"When the *llampu* preparation was finished, our compadre poured *trago* into a shell and sprinkled *llampu* over the liquid, then a small quantity of *achita* (*Chenopodium pallidicaule*). He prepared an identical mixture in a horn cup and drank from both. We followed him by drinking the double concoctions in turn. He explained to us that the double shots would protect us from the *Wamani*" [48].

These two beverages are consumed by everyone who participates in the *herranza* ritual. In addition to the preparation of the drink, the ground *llampu* is essential when setting up the ceremonial *mesa* next to the corral:

"The larger cloth of red *llampu* was untied and the figurines, the *illas*, were carefully set upright in the *llampu.* Another cloth contained a sea shell filled with lighter-colored *llampu*, several fossil shells, and some red wool. Our compadre sprinkled three lines of *llampu* on the Poncho, then coca leaves were carefully scattered along the lines. The small knife was dipped in *llampu* and placed near the center line. The chunks of "crude gold" and "crude silver" were stationed on the other lines. Now the ceremonial *mesa* was complete" [48] (Figure 3).



Figure 3. Ritual bundle (*mesa*) during *herranza* rituals in Chuschi, Peru. Lines made of *llampu*, a ceremonial powder that includes *vilca* ([48], plate 12).

After arranging the *mesa*, the animals are brought into the corral. The rite officiant then sprays *llampu* into the air, tracing a counterclockwise path. Once the branding is complete and the animals leave the corral, they are also sprayed with *llampu* [48].

3.2. Fieldwork Results (2017–2019)

3.2.1. Names

Although the names given to *Anadenanthera colubrina* var. *cebil* seeds were briefly mentioned at the beginning of this paper, we will delve deeper into them in this section. During our fieldwork, we recorded several names that were not included in the existing bibliography (Table 2).

Table 2. Results from the fieldwork regarding *Anadenanthera colubrina* var cebil *seeds*.

Country	Place	Name	Uses	Preparation Mode of Seeds	Consumption Mode
Perú	Ancash (Carhuaz Market)	*liman*	protection of the house and livestock; to attract money and fortune	as part of a cross	hanging in the house or business
Bolivia	Potosi (Central Market)	*chi'j'pi*	cleanse oneself of all spiritual harm and dirt	ritual bundle	cleansing baths
	Potosi (Vicuñas Market)	*chipi*	to treat *susto* and womb disorders	powdered or loose seeds dissolved in one liter of boiled water	drunk three times a day
	Cochabamba (Cochabamba Market)	*chi'j'pi*	cleanse oneself of all spiritual harm and dirt	ritual bundle	cleansing baths
	Tarabuco (Tarabuco Market)	*chipi*	to treat *susto* and womb disorders	in warm water	drunk
	Santiago de Huari (Holy Week Fair)	*ch'ij'pi*	to treat *susto* and womb disorders	two seeds in water	drunk
Argentina	San Salvador de Jujuy (old bus terminal market)	*urilimpi*	for luck	ritual bundle	cleansing baths
	La Quiaca (Manka Fiesta fair)	*vilca*	as protection against spiritual harm	powdered to dissolve in water	drunk

Wilka, *Villca*, or *Vilca* is an Aymara word which, according to several chroniclers, refers to the ancient name of the sun before it was called *Inti*. It is also the name of certain idols and shrines and refers to sacred beings sometimes synonymous with *huaca.* Additionally, it is the name of a tree whose fruits are used as medicine or visionary vehicle, as previously mentioned [3,7].

Cárdenas, in his manual of economic plants in Bolivia [71], mentions other names for that species: *curupau* from the east, *yarisana* from the Yungas, *villca* from Peru, and *cebil* from Argentina. Altschul, in addition to *vilca* and *cebil* with their variants and *curupau*, also mentions *curupai* for Paraguay [5]. Oblitas Poblete also cites the name *bayan* [51].

In [39], Giraul 1988 says that the Aymara use the term *willka, chipa,* or *kipi*. The latter name resonates with *chipi*, recorded by Forgione in 1983 in the Villazón market, referring to Anadenanthera seeds from the Bolivian yungas [38]. During my fieldwork, I most frequently recorded the term *chipi*, albeit with different intonations: *chi'j'pi* in the Central

Market of Potosí, *chipi* in the Vicuñas Market of Potosí and in Tarabuco, and *ch'ij'pi* in the Santiago de Huari Fair.

In addition to the names mentioned above, there are others not found in the literature: *liman* in the Carhuaz Market (Peru) and *urilimpi* in the San Salvador de Jujuy Market (Argentina). In the Mercado Modelo of Chiclayo (Peru), whose sector of ritual and medicinal plants is known in tourist jargon as *Mercado de los Brujos* or *de las Huaringas* (the latter name alluding to some famous high Andean lagoons of great power), one of the vendors told me when I asked him about the *urilimpi* that they did not have it. They bring it from the jungle and sometimes they have it, but very rarely. Therefore, although I could not confirm its botanical identity, the vernacular name was recognized locally.

3.2.2. Source and Vendors

Regarding the sourcing of the seeds sold in markets and fairs, those in Potosí come from Cochabamba, Santa Cruz, or Argentina. In Tarabuco, they are brought from "the valleys", referring to the area of Tarija and Oruro. In San Salvador de Jujuy, the seeds come from Peru, enter Bolivia through Desaguadero, and then reach the province of Jujuy. These references to places of origin should not always be taken literally. Access to these seeds is closely linked to the figure of *yungas* or *Kallawaya* doctors. Referring to them or their area of residence as the source of the seeds adds value. Even in Molinos, Salta, people prefer seeds sold by the *yungas*, as they are considered more potent and effective than those they could collect themselves (Pochettino, personal report).

3.2.3. Uses

In the market of Carhuaz, Peru, I acquired a cross (Figure 4a) used both for protection of the house and livestock and to attract money and fortune. This cross is possibly made of *chonta* palm (*Iriartea deltoidea* Ruiz & Pav. or *Bactris gasipaes* Kunth., both of the Arecaceae family), which is used in the Andes to craft other powerful objects, such as ceremonial staffs. It is associated with jungle groups like the *Chunchos* in religious dances from Paucartambo, Cusco, to northern Chile [72]. This cross features *cebil* and *wuayruro* seeds, *mastuerzo* fruits—all of them *kuti* plants—along with a small horseshoe and metal studs. When I acquired it, the seller had me pass it through iron filings so that the stone magnet at its upper part would materialize the idea of attracting with my hand [58]. In the old market of San Salvador de Jujuy, I was told that the seeds are "for luck" due to their coin-like shape. They are part of a ritual bundle for cleansing baths, which also come from Peru via Bolivia and are sold in smaller quantities in Jujuy (Figure 4b).

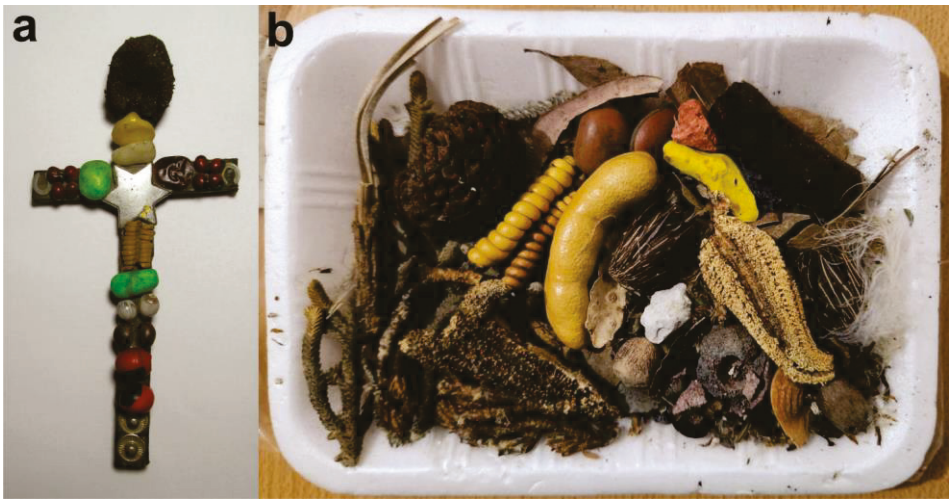


Figure 4. (**a**) Cross purchased in 2018 at the market of Carhuaz, Peru. (**b**) Ritual bundle for cleansing baths, bought in the old market of San Salvador de Jujuy, 2016. Photos taken by the author.

In the central market of Potosí, *vilca* seeds are sold individually or as part of the *contra mesa* (Figure 5a), which is used to wash and cleanse oneself of all spiritual harm and dirt. The residue must be discarded in an open place without looking back. This kit even includes an image of Saint James (*San Santiago*), a saint linked to the pre-Hispanic deity *Illapa*, associated with lightning and thunder, along with a brief prayer. In the Cochabamba market, a similar preparation with *vilca* seeds is sold for the same purpose; although, it is not referred to as *black mesa* (Figure 5b).



Figure 5. (**a**) *Contra mesa* purchased in the central market of Potosí, Bolivia, 2017; (**b**) similar bundle prepared in the market of Cochabamba, Bolivia, 2017. Photos by the author.

In Bolivia, at the Vicuñas Market (Figure 6a,b), *willka* is available either as loose seeds or as a powdered preparation meant to be dissolved in a liter of boiled water and consumed three times a day. This remedy is used to treat *susto* and womb disorders. Similarly, at the Holy Week Fair in Santiago de Huari, vendors sell *willka* seeds for the same purposes. According to one vendor, "you put a couple of seeds in water and the woman takes it".



Figure 6. (**a**,**b**) Vicuñas Market, Bolivia, 2017. (**c**–**e**) Manka Fiesta, Argentina, 2013. Photos by the author.

To summarize, in markets across Peru (Carhuaz), Bolivia (Cochabamba), and northwest Argentina (Manka fiesta) (Figure 6c–e), *vilca* seeds are sold as protection and *contra* or *kuti*. They are available alone, combined with other elements, or placed on supports like crosses. *Vilca* seeds are also sold to attract luck (*suerte*), cleanse from damage (*daño*) and spiritual evils, cure *susto*, and heal the womb (Table 2).

The relationship between all the uses of *vilca* seeds reported in this paper may initially appear confusing or unrelated. In the next section, I will delve into an argumentation that aims to elucidate the connections between the various reported uses of *vilca* seeds. Drawing from native explanations and Andean perspectives on the body, illness, and healing, I will elucidate how these seemingly unrelated uses are interconnected. This discussion will provide clarity on the cultural and traditional rationale behind the multifaceted therapeutic applications of *vilca* seeds across different Andean regions.

4. Discussion

The information gathered from the literature and ethnobotanical studies in south Andean markets revealed both commonalities and variations in the uses, names, and descriptions of *Anadenanthera* seeds. The diversity of applications and their seemingly unconnected nature can be attributed to Andean concepts of illness and the underlying dynamics at play. By considering these cultural perspectives, we can interpret the contemporary therapeutic uses of *vilca* or *cebil* in terms of "movements" as integral to the healing process.

Firstly, the use of *Anadenanthera* seeds reflects a fundamental concept of movement—specifically, the actions of releasing and attracting. These seeds are associated with purgative and abortive properties, indicating their ability to expel substances from the body, such as phlegm, mucus, the placenta, or to induce menstruation. This concept extends beyond physical purging; it also encompasses spiritual cleansing rituals, known as *limpias*, which aim to release evil energies held within a patient. Moreover, the idea of releasing is integral to dispatches made to entities in the landscape. These offerings seek to persuade those entities to release trapped waters for irrigating crop fields.

The treatment of *susto*, a condition where the patient's soul is trapped by a non-human entity, further exemplifies the need for releasing and attracting movements in healing. The goal is to release the trapped soul so that it may return to the patient's body. Attracting is crucial for healing processes, the aim is to attract desired elements—whether it be the patient's soul for healing or qualities like fortune, health, or love. This involves not only removing obstacles that hinder these qualities but also actively working to maintain their presence and prevent them from turning towards misfortune due to external human or non-human influences.

Secondly, we found the movements of stopping and returning, which underscores the use of *vilca* as *kuti* or *contra* to ward off harm. This practice involves redirecting damage back to its origin rather than attempting to nullify or eradicate it completely, as diseases and misfortunes emanate from a specific source, human or otherwise [55]. This approach acknowledges the kinetic nature of afflictions, where new sources of harm can continue to emerge or return. This also explains why *vilca* seeds act as protective amulets, playing a dual role: shielding the body to prevent the displacement of its spirit and embodying a continuous, rotation movement. This rotational motion compels incoming negativity to reverse its trajectory and to return to its point of origin. Many plant elements achieve this effect through counterclockwise twisting [56]. Although the shape of the *vilca* seed itself does not explicitly suggest twisting or turning, its shape significantly influences its therapeutic efficacy.

Lira describes *Anadenanthera* seeds, known as *Willka Willka*, pointing out the following:

"The center of the almond has a human footprint shape in some cases, and in others, the form of a horseshoe, a cow's foot, or a sheep's foot. In other cases, it has the shape of a field plot (*chacra*), a dog, or a road. Thus, the use of the almond depends on its shape. If it has the shape of a human foot, it is buried in the ground to prevent servants from leaving a household. The dog-shaped almond is buried at the entrance of a farm or farmhouse

to prevent any mastiffs from dying (. . .). The almond with a horseshoe shape is buried in the manger or in the horses' stall to protect them from death or theft. The same applies to almonds shaped like a cow's foot, a sheep's foot, or a *chacra*, which are arranged in the same way" [45].

Lira then describes how the seeds are buried along with coca leaves, fat, aromatic plants, and other vegetables. His work emphasizes the importance of the seed's shape and its fissural line, which helps to retain those entities (humans, animals, field plots) with morphological similarity and fend off (or return) potential harm. The implications of the seed's shape for its healing properties are uniquely detailed in Lira's work and were corroborated during field research.

For instance, in the former market of San Salvador de Jujuy, I was told that the *cebil* seed attracts luck due to its resemblance to a coin. This idea aligns with observations made by early chroniclers such as Bernabé Cobo, who likened it to a half-real, and Cristóbal de Albornoz, who compared it to a copper coin of Castile [23]. This resemblance to coins that entered America during colonization adds new significance to the *vilca* seed, which became part of the transactions between Spaniards or Creoles and indigenous chiefs in Argentina. Likewise, ancient coins are still used today in Kallawaya ritual bundles and are sometimes considered as *illas* [73], underscoring the enduring cultural and symbolic values of these seeds.

Lira mentions ritual bundles intended to change bad luck, which include ingredients such as *wilka* and *wuayruro* seeds, as well as "a small steel cross, three old silver half coins, seven *reales*, seven *pesetas*, and seven current half coins" [45]. Additionally, the fissural line inside the seed, which resembles a horseshoe, is linked not only to the hoof of many livestock animals but also to the horseshoe itself. This is another symbol known to attract or retain fortune. As noted, *vilca* seed is accompanied by a miniature metal horseshoe in the cross of Carhuaz, reinforcing its role as a powerful amulet.

5. Conclusions

Nine uses of *Anadenanthera colubrina* var *cebil* have been recorded in the southern central Andes from the pre-Hispanic past to the present: magical–religious, medicinal, veterinary, construction, fuel, fodder, dyeing, tanning, and artifact making. These uses span almost all parts of the tree, including seeds, fruits (pods), bark, wood, resin, and leaves. The records, which may be incomplete due to gaps in documentation across the extensive geographic region, reflect a broad and integrated utilization of the tree. The therapeutic use of the plant parts, apart from the seeds, is mostly modern (from the 19th century onwards). This intensification of the uses of *Anadenanthera* trees could be due to difficulties in accessing other traditional medicines under national legislation or it could also be the result of more detailed ethnobotanical and anthropological research in modern times.

In addition to this diverse and integral use, there is a significant variation in the preparation and administration of *vilca* or *cebil* seeds for therapeutic and psychoactive or visionary purposes, with this variety in seed preparation and administration expanding after the Spanish conquest. The records reported and analyzed in this work demonstrate the ongoing use of *vilca* or *cebil* and its centrality in contemporary south Andean therapeutics, highlighting the enduring ritual value of this plant.

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Article

Cultivating Environmental Ignorance: Non-Circulation of Ethnomedicinal Knowledge about *Culén* (*Otholobium glandulosum*) in the Atlantic World (1646–1810)

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Abstract: A growing body of literature recognises the importance of exploring the uses of plants in historical written sources. The Chilean native plant *culén* (*Otholobium glandulosum*) has a long history of medicinal use, with various parts of the plant, including its leaves, aerial parts, and roots, employed to treat numerous ailments. This study undertakes a Critical Discourse Analysis of historical sources, specifically books published between the 17th and early 19th centuries (1646–1810), focusing on the medicinal applications of *culén*. The research highlights the circulation of plant knowledge over time by adopting an interdisciplinary approach that bridges historical ethnobotany, environmental history, and the history of knowledge and ignorance studies. The study reveals how the evolution of the ethnobotanical and ethnomedicinal knowledge of *culén* reflects the broader environmental ignorance, wherein the scientific community excluded and oppressed the indigenous and local knowledge of the plant. This work underscores the importance of integrating historical studies into modern environmental and botanical research, emphasising the value of understanding past knowledge systems to inform contemporary conservation efforts and sustainable practices.

Keywords: *Otholobium glandulosum*; *culén*; medicinal plants; ethnobotany; ethnomedicine; Chile; Global South; botanical history; plant knowledge; knowledge circulation

1. Introduction

Studies on the evolution of the relationships between nature and people over the past centuries represent a growing field in ethnobotanical research [1,2]. Recent work by historians and ethnobotanists has particularly emphasised the importance of examining plant knowledge circulation in published sources and the current uses of native and introduced flora fostered by local communities. Investigating the changes in recorded plant uses offers critical insights into the evolving relationship between society and the environment [3,4]. Moreover, historical written sources documenting ethnomedicinal knowledge allow us to explore how records of plant use have transformed over centuries and what factors have influenced these changes [5]. By examining these historical sources, we gain an understanding of how local plant knowledge was interpreted and influenced by broader contexts [6].

In present-day Chile, *yerbateros* (herb sellers) continue selling various plant species along main streets and public squares. Among these, the leaves of *culén*, scientifically known as *Otholobium glandulosum* (L.) J.W. Grimes, a species in the Fabaceae family, is frequently offered [7]. The scientific name *O. glandulosum* was first formally published in 1990 in the *Memoirs of the New York Botanical Garden*. However, in 2023, this name was unplaced from the Plants of the World Online database, meaning its taxonomic placement is no longer recognised within that system [8]. Furthermore, *World Flora Online* currently lists this name as unchecked and is awaiting further taxonomic review [9].

Despite these recent developments, we continue to rely on the *Catalog of the Vascular Plants of Chile* (updated in April 2019) to identify this species [7]. This catalogue remains a widely accepted reference for Chilean flora and provides a stable basis for botanical nomenclature in our work. Nevertheless, this situation highlights the fluid nature of taxonomic classifications, where names and categorisations may shift as new research emerges. However, regional references like the Chilean catalogue often maintain practical authority.

In Concepción, Chile, herb sellers not only offer the leaves of *O. glandulosum* but also advise customers on their use, continuing a tradition that has persisted for centuries (Figure 1).



a) b)

Figure 1. (**a**) Some medicinal plants sold by a herb seller in the Plaza de la Independencia, the main square of Concepción (Chile). Credit by M.S. (2022). (**b**) The French botanist Claudio Gay (1800–1873) engraved in the background of a plant included in his *Atlas de la historia física y política de Chile* (Thunot: Paris, France, 1854, Vol. 1, Plate 48)—a man on horseback, defined as a herb seller, who is carrying some vegetables. Credit: Memoria Chilena (Available online: http://www.memoriachilena.gob.cl/602/w3-article-99629.html, accessed on 25 March 2023).

Chilean herb sellers often prepare *culén* leaves in tea bags, similar to products offered by a well-known Chilean company run by Mapuche, one of Chile's indigenous communities. Moreover, the Chilean Ministry of Health has authorised the medicinal use of *O. glandulosum* [10]. Notably, the most frequently cited sources in the Ministry's catalogue and more recent works on Chilean medicinal plants are the natural histories, travel reports, and descriptions of medicinal plants written during the Chilean colonial period before Chile's Independence in 1818. Like the herb-seller trade, the ethnomedicinal use of *culén* has endured for centuries. Today, Chilean herb sellers maintain this long-established tradition, fostering a tangible link between society, the Chilean environment, and the evolving practices surrounding *O. glandulosum* [11,12]. The evolution of historical records concerning this plant reveals the dynamic relationship between people and nature, which was shaped by the exchange between Chile and Europe.

The scope of this study is to explore the evolution of the historical, ethnobotanical records of *culén* (*O. glandulosum*) between the 17th and early 19th centuries (1648–1810). The study aims to (1) document the ethnobotanical uses of the plant in historical written sources, (2) trace the evolution of its uses over time, and (3) examine the documentation of local and indigenous practices related to *O. glandulosum* within historical written sources. As recorded in historical sources, the evolution of *culén* ethnomedicinal uses can provide insights into the changes and the influences underlying the ethnobotanical descriptions found in these historical records.

2. Results

2.1. The Evolution of the Ethnobotanical Uses of Culén

The evolution of *culén*'s uses can generally be divided into two main periods: before and after its spread in Europe by the Franciscan missionaries and later by Jesuits during the 18th century [13]. Previous research has established that the introduction of *culén* to Europe radically changed the recorded uses of this plant [14]. During the colonial period, Chilean indigenous communities used the juice of the leaves of *culén* to heal wounds. However, in the second half of the 18th century, descriptions of the studied species for wound care and general medicinal usage gradually diminished as the plant was introduced in Europe. At the same time, Chilean and European naturalists began recommending *culén* primarily as a recreational tea for European audiences, and the Latin binomial classification began to replace the plant's common name [14].

Despite these changes, naturalists continued to regard *culén* as a potential remedy throughout the 18th and early 19th centuries. Almost all scientists of the 18th century mentioned the use of *culén* leaves as a treatment for wounds in their writings. For instance, in 1798, the Argentine Jesuit Gaspar Juarez and the Italian abbot Filippo Luigi Gilii highly praised the use of *culén* leaves for healing skin lesions [15,16]. In books published between 1762 and 1810, scholars even recommended the studied plant for treating a broader range of diseases than in the previous period (Tables 1 and 2).

Table 1. Disease categories for which *culén* was recommended in historical records before and after its spread in Europe (see Supplementary Materials), according to ICPC-2.

Sources 1646–1732			Sources 1762–1810		
Skin	Bruise/contusion	S16	General	Pain general/multiple sites	A01
Skin	Skin injury, other	S19	General	Bleeding/haemorrhage NOS	A10
			General	Swelling	A08
			Digestive	Dyspepsia/indigestion	D07
			Digestive	Worms/other parasites	D96
			Digestive	Disease digestive system, other	D99
			Musculoskeletal	Rheumatoid/seropositive arthritis	L88
			Neurological	Headache	N01
			Ear	Ear pain/earache	H01
			Skin	Bruise/contusion	S16
			Skin	Skin injury, other	S19
			Psychological	Psychological disorders, other	P99

Table 2. The medicinal properties of *Culén* are mentioned in the works before and after the spread of that plant in Europe.

Sources 1646–1732	Sources 1762–1810
Emetic	Balsamic
Purgative	Emetic
Vulnerary	Digestive
	Purgative
	Vulnerary

Furthermore, the use of *culén* leaves in infusions was neither a European invention nor a result of the plant's spread in Europe. Even before the mid-18th century, Chilean military officer Pedro Pascual de Córdoba y Figueroa and the Spanish Jesuit José Sánchez

Lábrador, residing in Chile and Paraguay, respectively, documented the use of *culén* leaves in infusions. Similarly, around 1767, the Spanish Jesuit Miguel de Olivares reported that "*drinking the water from the culén infusion increases the desire to eat*". In 1774, the English Jesuit Thomas Falkner, who served in Argentina and Paraguay, also noted that the plant possessed the same virtues as tea, particularly as a remedy for indigestion [17].

In 1783, King Carlos III requested that native medicinal plants be sent to Spain. The chief Chilean physician, José Antonio Ríos, organised the expedition and included *culén* among the various species. Ríos recommended the infusion of *culén* leaves and bark to cure stomachache and indigestion. Historical written sources from the same period also documented that the Chilean local communities used the *culén* leaf infusion as a kind of tea for indigestion [18,19]. Thus, the spread of *culén*-based tea was not a result of the plant's arrival to European territory. However, it was a common practice in Chile even before the introduction of *O. glandulosum* in Europe. Moreover, 18th-century naturalists continued referring to *culén* using its scientific classification and local names [20]. To sum up, naturalists consistently reported the ethnomedicinal uses of *culén* and did not solely identify the studied plant only with its scientific classification (Figure 2).



a) b)

Figure 2. In the engraving (**a**), the Spanish botanist Joseph Quer recorded the *culén* in his *Flora española o historia de las plantas que se crían en España* (Ibarra, Madrid, Spain, 1784, 6, Plate 18) with both scientific and indigenous names. Credit: Biblioteca Digital del Real Jardín Botánico (https://bibdigital.rjb.csic.es). In the picture (**b**), the French botanist Luis Feuillée reported the scientific name he coined "*Barba Jovis triphilla, flore ex albo et caeruleo vario*", adding the indigenous name "*culen*".

2.2. The Documentation of Local and Indigenous Communities in the Historical Written Sources

During the early colonial period, Spanish chroniclers primarily described the studied plant, reporting its names as "*cuelen*" (likely a misspelling of the actual indigenous name *culén*) and "*albahaquilla*" (meaning "little basil" in Spanish). For instance, Francisco Núñez de Pineda y Bascuñán, a military man from Chillán, mentioned the studied plant in 1629 in his famous work *El Cautiverio feliz*, but without recording any plant use [21].

Generally, no ethnomedicinal information on *culén* (*albahaquilla)* circulated in print until the mid-17th century when Jesuit Alonso de Ovalle published his works in 1646. In his chronicle, Ovalle reported that the leaf juice could be used to heal wounds, citing an instance where a Spanish soldier used it to save his wounded dog. Additionally, Ovalle created a map of Chile for the Spanish King Philip IV, titled *Tabula geographica regni Chile*, in which he depicted a small tree, writing the name "*culén*" and describing it as a "*very healthy plant*" [22].

In the 18th century, French travellers Louis Feuillée and Amédée François Frézier published accounts of their travels in Chile, both of which gained significant attention [23]. Feuillée's work was translated into German, and Frézier's book was printed in the Netherlands, each with two editions. The publishing success was probably due to their detailed engravings and the first comprehensive descriptions of the ethnomedicinal uses of Chilean plants. Both French travellers mentioned *culén* in their travel accounts, noting its indigenous use for healing wounds. Frézier even used it to cure himself. Feuillée documented various uses of different parts of the herb by the indigenous communities. However, no authors from that period recorded the possible ethnomedicinal uses of the plant by local communities.

In the second half of the 18th century, scientists continued to report the Latin binomial classifications alongside the indigenous names. However, the local Spanish name "*albahaquilla*" was no longer used to identify the plant. For instance, in the second edition of the *Flora Española* [Spanish Flora], the Spanish physician and botanist Joseph Quer referred to the plant solely as *culén.* Similarly, priests Gilii and Juárez specified that Italians exclusively used the indigenous name. In early historical written sources, scholars documented the indigenous names and practices associated with the plant.

From the second half of the 18th century onwards, most naturalists began including an engraving of the *culén* in their descriptions. This innovation likely facilitated the plant's knowledge circulation as it spread throughout Europe. However, at the same time, authors increasingly omitted certain aspects of herbal medicinal preparation. The proportion of fragmented uses was higher than in the previous century, limiting the circulation of ethnomedicinal knowledge about the plant.

Moreover, Feuillée was the last to explicitly attribute the medicinal uses to the "*natives of the country*", referring to the indigenous communities [24]. In contrast, the naturalists of the second half of the 18th century did not acknowledge the indigenous origins of these medicinal uses; instead, they treated them as scientific knowledge or inherent properties of the plant. Additionally, many authors failed to report the ethnomedicinal indigenous and local knowledge of *culén* during this time. As a result, after the mid-18th century, indigenous and local knowledge began to disappear from published sources (Figure 3).

Even in the second edition of Molina's *Natural History of Chile*, the Chilean Jesuit did not fully detail the indigenous and local knowledge of *culén*. He noted that "*Araucanians* [as Mapuche communities were identified at those times] *consider it a panacea, and the Spanish peasants of Chile (. . .) use it in all their illnesses*" [25]. Despite this, he primarily emphasised the *culén* infusion as a powerful remedy against intestinal parasites, although he acknowledged that other treatments were often preferred for this condition [26].

In 1776, an anonymous work written by a group of Jesuits who had been expelled from Chile stated that "*the Indians (. . .) apply* [it] *to almost every kind of severe internal illness*" [27]. However, in both cases, the authors failed to specify which parts of the plant were used or for which specific disease the plant was employed. The scientists did not provide detailed instructions on how the indigenous and local communities utilised this remedy.

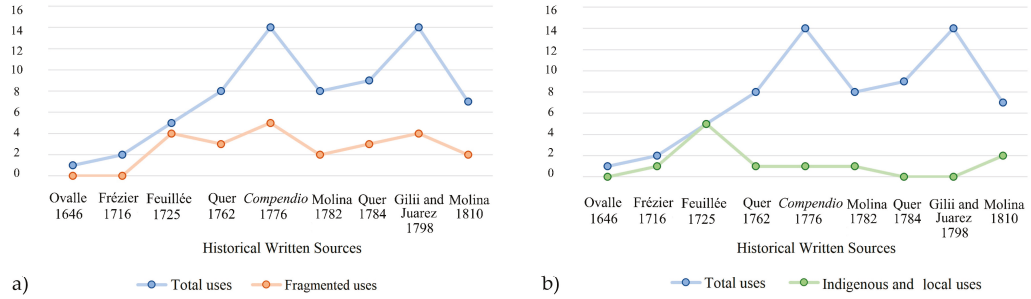


Figure 3. In graph (**a**), the *X*-axis shows the written sources that mentioned the medicinal uses of *culén* (see Supplementary Materials): Ovalle, A. de. *Historica Relatione del Regno di Cile*; Cavallo: Rome, Italy, 1646; Frézier, A.F. *Relation du voyage de la Mer du Sud aux côtes du Chily et du Perou, fait pendant les années 1712, 1713 & 1714*; Paris, Jean-Geoffrey Nyon, 1716; 24. Feuillée, L. *Journal des Observations Physiques, Mathematiques et Botaniques*; Giffart: Paris, France, 1725; Quer, J. *Flora española o historia de las plantas que se crían en España*; Ibarra, Madrid, Spain, 1762; *Compendio Della Storia Geografica, Naturale e Civile del Regno del Chile*; Stamperia di S. Tommaso d'Aquino: Bologna, Italy, 1776; Quer, J. Flora española o historia de las plantas que se crían en España; Ibarra, Madrid, Spain, 1784; Gilii, F.L.; Xuarez, G. *Osservazioni fitologiche sopra alcune piante esotiche introdotte in Roma*. Arcangelo Casaletti, Rome, Italy, 1798; Molina, J.I. *Saggio Sulla Storia Naturale del Chili*; Stamperia di S. Tommaso d'Aquino, Bologna, Italy, 1810. The *Y*-axis shows the total number of uses of the studied herb described in each historical text. The blue line represents the total medicinal descriptions, while the orange line corresponds to the partially described knowledge. In diagram (**b**), the *X*-axis represents the written records about the ethnomedicinal knowledge of *culén*. The *Y*-axis shows the total number of uses described in each historical written source. The blue line corresponds to the total medicinal records, while the green line shows the knowledge attributed to indigenous and local communities.

Therefore, like all authors of the studied period, the Jesuits did not fully recognise or give voice to the indigenous and local communities. They primarily emphasised the importance of the native Chilean species that were brought to Italy and the ethnomedicinal uses promoted by the scientific community. Generally, naturalists of the late colonial period prioritised scientific knowledge, documenting more detailed and comprehensive plant uses from a scientific perspective while providing less information on indigenous practices, which were often incomplete or fragmented (Figure 4).

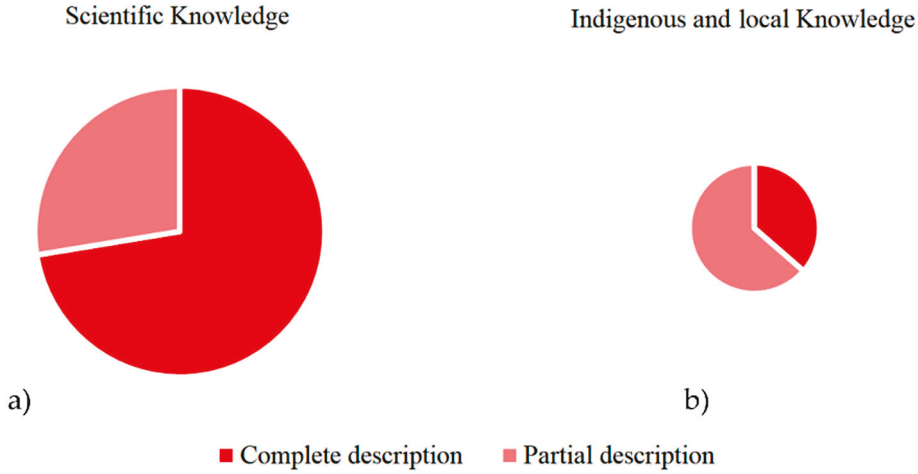


Figure 4. The dark red portions represent the complete records of ethnomedicinal uses of *culén* in naturalists' books about Chilean flora. The rose parts indicate the incomplete uses reported by the scientists in the historical written sources. The graphics show the fragmentation of the most extensive set of DURs related to scientific knowledge (**a**) and the smallest number of DURs pertaining to indigenous and local knowledge (**b**).

The authors of the 18th century supported the ethnomedicinal knowledge of *culén* but focused solely on scientific descriptions, giving little significance to the uses by indigenous and local communities. They limited the circulation of non-European practices, permanently fragmenting and excluding them. As a result, in the 18th and early 19th centuries, the records of ethnomedicinal knowledge about this plant contributed to the invisibilisation of indigenous and local cultures.

3. Discussion

The transformation of knowledge about *culén* into a non-medicinal, tea-like infusion, as mentioned in the introduction, was not the primary transformation that occurred in the public circulation of knowledge about the plant. Whether or not this change happened, and whether it succeeded or failed, the use of *culén* as tea symbolised the exclusion and invisibilisation of non-scientific knowledge. The tea made from its leaves was merely one expression of the coloniality of knowledge, the unbalanced relationship among different forms of knowledge (scientific, indigenous, local, and others) [28].

Overall, the results indicate that the evolution of the knowledge about *culén* is a much more complex phenomenon than just a change in use, a disappearance, or an appropriation of ethnomedicinal knowledge. The recorded practices of *O. glandulosum* were not entirely erased from the historical written sources. For instance, Molina continued to support many uses of that herb for various diseases, even in his last *Natural History of Chile* [25]. The evolution of *culén* ethnomedicinal knowledge was not a straightforward appropriation, as the infusion of the leaves was not directly linked to indigenous knowledge. The most recent use of *culén* leaves as a tea-like infusion may represent a scientific appropriation of local use. Nevertheless, the nearly simultaneous spread of this practice in Chile, Argentina, and Europe makes it difficult to establish clear causal or chronological correlations.

There was a gradual decline in the circulation of indigenous and local knowledge about *culén* throughout the 18th and early 19th centuries. Writers did not promote the non-European ethnomedicinal uses of the plant nor acknowledged the local and indigenous communities in their descriptions. Scientists progressively fragmented the ethnomedicinal knowledge about *culén* and generalised its use, often describing it as a valuable botanical species to cure any disease without explaining how.

One of the most striking findings is that the evolution of the historical ethnomedicinal records of *culén* demonstrates the epistemic exclusion and oppression of non-scientific knowledge. Epistemic oppression refers to the phenomenon that prevents and deprives a person or social group from being able to contribute, directly or indirectly, to the circulation of knowledge [29]. Naturalists of the 18th century did not give equal importance, dignity, or precision enough to the indigenous and local ethnomedicinal knowledge compared to scientific knowledge. This exclusion was not a temporary, isolated phenomenon, limited to a few authors or a scattered group of naturalists. It represented the common denominator of the entire scientific production of the 18th and early 19th centuries. Thus, it was not only a temporary exclusion of local and indigenous knowledge but fundamentally an act of epistemic oppression.

The findings highlight environmental ignorance as one of the consequences of the exclusion and oppression of indigenous and local knowledge in the Atlantic world [30]. A similar impact of coloniality can be observed in the evolution of the ethnomedicinal uses of other Chilean native plants, such as *cachanlagua/cachanlahuen* (*Centaurium cachanlahuen* (Molina) B.L. Rob.) and *canelo/boighe* (*Drimys winteri* J.R. Forst. & G. Forst.) [31]. The ethnomedicinal knowledge of these two plants circulated in published sources during the same period as *culén*. However, they were associated with *Cinnamomum verum* J. Presl and *Centaurium erythraea* Rafn, species familiar to Europeans and linked to related local ethnomedicinal knowledge. The first plant spread as a remedy for fever, while the second circulated as a cure for scurvy. In both cases, the error arose from the perceived similarity between species.

Overall, the circulation of ethnomedicinal knowledge regarding *cachanlagua/cachanlahuen* and *canelo/boighe* was fragmented and eroded, and this rendered the non-scientific uses invisible. According to our study, the Atlantic circulation of public knowledge about *culén* represented a continuous form of cultural oppression. Using *culén* leaves as a recreational tea, rather than as a remedy for wounds, served to exclude and oppress non-European knowledge. This was one of the ways in which indigenous and local communities were erased from scientific works. The overall changes in the ethnomedicinal knowledge of *culén* privileged the Western scientific knowledge, allowing it to prevail over the indigenous and local forms of knowledge.

The non-circulation of local and indigenous ethnomedicinal knowledge contributed to and reinforced a socio-environmental ignorance, which was rooted in a narrow interpretation of diverse knowledge forms. The heterogeneity between scientific and non-scientific medicinal uses of *culén* was not valued. Instead, it was implicitly subordinated and underestimated relative to non-European knowledge and knowers. During the colonial era, Europe became the place where the scientific ethnomedicinal knowledge of *culén* was granted importance and worth. Consequently, the formation of environmental ignorance around the studied species contributed to the formation of the geopolitics of knowledge, where the place of origin primarily and uniquely determined the intrinsic value of knowledge.

During the colonial period, scientists created a deep divide between their knowledge and local and indigenous communities. This divide contributed to the separation, distancing, and marginalisation of other knowledges. Scholars did not include, acknowledge, or integrate these diverse knowledge systems.

Scholars of the 18th century undermined the ethnomedicinal knowledge outside the scientific realm, limiting its diffusion, fragmenting it, and ignoring it. The circulation of public knowledge about Chilean native plants during colonial times was heavily influenced by naturalists' failure to appreciate any knowledge from outside Europe and any scientific forms as potentially valid and useful.

4. Materials and Methods

Plants have long been studied from an environmental history perspective. However, much of the literature has primarily focused on the introduction of species into new territories and the scientific names attributed to them, with an emphasis on flora introduced from Europe to other continents. Additionally, scholars often examine the medicinal properties of plant species without incorporating the knowledge and descriptions provided by local communities or considering the scientific uses of these plants [32–34].

The novelty of this study lies in its specific methodology, which centres on ethnomedicinal knowledge reported by various authors and employs an interdisciplinary approach. This approach integrates historical ethnobotany, environmental history, history of knowledge, and history of ignorance, all viewed from a decolonial perspective.

We examined the evolution of historical ethnomedicinal records of *culén* as a phenomenon that reflects societal shifts and represents the changing socio-environmental relationships in the Atlantic world. Our focus was on public knowledge, defined as the information communicated through media and disseminated, utilised, and transmitted via social relations. We explored the close connections between culture and society that develop in public arenas of knowledge, which are specific spaces where certain forms of knowledge are promoted, supported, and fostered. In contrast, others are hindered, fragmented, or rendered invisible [35].

Interpreting the circulation of knowledge as a non-linear process within an epistemic system, we concentrated on public circulation, examining how this knowledge fluctuated over time in various published works, which reported different forms of knowledge [36]. During the Chilean colonial period, multiple forms of knowledge coexisted, primarily indigenous, local, and scientific knowledge. In this context, indigenous knowledge refers to communities that have had historical continuity from pre-European colonisation. Local knowledge pertains to the knowledge of communities directly interacting with their sur-

rounding environments. Scientific knowledge refers to the literature written and cited by naturalists, scientists, travellers, botanists, and doctors.

In alignment with the "ignorance turn", we considered the coexistence, interaction, and interdependence of knowledge and ignorance. We focused on the fragmentation, erosion, and invisibilisation of knowledge [37]. Central to the decolonial perspective are two main processes that have occurred since the 16th century: the bright side of modernity, characterised by rationality, logic, and the development of scientific knowledge, and the coloniality, the dark side of modernity, in which non-European peoples, knowledges, and ways of being are disregarded by scientists as non-existent [38].

Due to the coloniality of knowledge, the access to, production, distribution, and reproduction of knowledge promoted by scientists and authors were not equal for all knowers. The circulation of knowledge during modern times followed a hierarchical, vertical structure in which specific knowledges were valued more critically than others. This meant that not all knowledge was afforded the same dignity, consideration, or opportunity to spread. During the colonial period, authors promoted this epistemic hierarchy in their writings, favouring some knowledge systems than others. Both the coloniality of knowledge and the epistemic hierarchy, like subterranean rivers, feed the socio-environmental relationship, often showing little visibility and remaining difficult to detect [39].

Recently, some ethnobotanists have shifted their focus toward examining the transformation of plant uses over time and turning to historical sources to highlight how totalitarian dynamics represent complex and articulated phenomena. Simultaneously, there has been a growing focus on environmental and ethnobotanical ignorance dynamics, both in contemporary and colonial contexts [40].

To date, however, research has often framed coloniality solely as a violent form of destruction or as a form of appropriation, sometimes referred to as bioprospecting, of non-European knowledge [41].

This study focuses on the colonial period, beginning from 1646, when Chilean Jesuit Alonso de Ovalle first introduced the knowledge of *Culén* in the Atlantic world, and concluding in 1810, when another Chilean Jesuit, Juan Ignacio Molina, published the second edition of his *Natural History of Chile*. Molina's book represents the last description of *culén.* Understanding the cultural patterns that influenced the circulation of knowledge about *culén* during the colonial period is crucial to grasping the mechanisms of coloniality of knowledge.

In the colonial descriptions of *culén*, authors did not always include the Latin name of the species, as binomial classification was developed only in the mid-18th century by Carl Linnaeus. However, all colonial authors indicated that they were describing the same herb mentioned by previous writers. Therefore, we considered all naturalists who described the same plant species.

For this research, we employed Critical Discourse Analysis (CDA) to explore the ethnomedicinal discourse surrounding *culén* (*O. glandulosum*) in colonial texts. Data were collected from available colonial sources (see Supplementary Materials) in their original languages, all of which included ethnomedicinal descriptions of *culén*. Nine sources, published between 1520 and 1818, were selected, and the information was compiled into a Microsoft Excel database. Each entry in the database represents a detailed report of the uses of *O. glandulosum* reported in the sources (see [42]). Each use was classified according to the different forms of knowledges reported (ethnomedicinal use, property, or mention), the source of information (books, scientific literature, and local and indigenous knowledge), and the form of information (current or historical usage, use/recommendation to use, and for which disease, classified according to the International Classification of Primary Care (ICPC-2) (updated March 2003)).

Through CDA, we assessed the fragmentation of knowledge by examining the extent to which the sources provided sufficient detail to support the medicinal use of the plant species. Knowledge was considered fully described when the authors provided details such as which parts of the plant to use, how to use them, and for which specific disease. In

contrast, knowledge was considered partial when essential details for the practical use of *culén* were missing—for example, when it was merely noted as a general medicinal plant or when only its properties were mentioned without further context.

5. Conclusions

This study highlights how the historical records of *culén* (*O. glandulosum*) reflect the dynamics of knowledge circulation and suppression during the colonial period. The fragmentation and marginalisation of indigenous and local knowledge by naturalists in favour of European practices reveal the coloniality of knowledge, contributing to the epistemic oppression of non-scientific traditions. The transformation of *culén* into a tea-like infusion for European consumption exemplifies how ethnomedicinal knowledge was appropriated while indigenous uses were disregarded.

Key scientific gaps remain, particularly regarding the full scope of indigenous and local practices associated with *culén* and other Chilean plants. Further research should prioritise recovering indigenous perspectives on *culén* and other native plants through collaboration with local communities and oral histories. It is crucial to explore how colonial knowledge systems shaped the trajectory of plant-based medicinal research, with an emphasis on decolonising this knowledge for modern application. By integrating local knowledge with scientific research, future studies can contribute to a more complete understanding of Chilean native plants and help bridge the historical gap between indigenous and scientific knowledge.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/plants13202861/s1.

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Abbreviations

DUR	Detailed Use Report
ICPC-2	International Classification of Primary Care
CDA	Critical Discourse Analysis

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Brazilian Environment and Plants as Seen by Japanese Eyes Two Hundred and Twenty Years Ago

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Abstract: In 2023, the Japanese migration to Brazil completed 115 years. However, the first time Japanese people arrived in Brazil and left a testimony of their experience was about two centuries ago. Their reports were registered in a historical document, handwritten during the Edo period when Japan was adopting a closed-door policy. The episode of their visit to Brazil is only a small part of the odyssey of these four Japanese sailors who departed from Ishinomiya to Tokyo at the end of the 18th century, but unexpectedly traveled around the globe. After a storm, they were adrift for six months until shipwrecking on the Aleutian Islands; from the Russian Aleutian Islands, they crossed the whole of Russia and boarded, in Saint Petersburg, on the first Russian expedition to circumnavigate the world. Their only stop in South America was at Santa Catarina Island, southern Brazil, and this is the first analysis of this episode from an ethnobiological perspective. Their reports described both the forest environment and the plants they observed and included at least 23 taxa of plants, mostly cultivated. These descriptions of plants and the environment are in contrast with other reports from the same period and to the current environment found in Santa Catarina Island, inspiring reflections on the construction of Brazil's image in Japan before the 20th century.

Keywords: historical ethnobiology; historical ethnobotany; Atlantic Forest; navigation

1. Introduction

Being a Brazilian with Japanese ascendants whose grandparents migrated from Japan to Brazil at the beginning of the 20th century, the issue of migrations and identities always caught my attention. Why did my four grandparents, on different occasions, decide to move to the other side of the Earth more than a hundred years ago? Brazil and Japan are antipodes, or points diametrically opposite on the Earth, which means that to Japan, there is no place geographically farther than Brazil. Apart from the strong governmental propaganda promising plenty of land and resources in abundance for people suffering from hunger and other mishaps, people who decided to sail across the ocean knew practically nothing about the place they were choosing to live. Even with some governmental support, these deliberate migrations had their own costs because people had to adapt to the new country, with a different society and environment, facing prejudice, and after one or two generations, changing their mother tongue to Portuguese. The official registers of Japanese migrations to Brazil started at the beginning of the 20th century with the arrival of the ship Kasato Maru in 1908, preceded by bilateral negotiations since the end of the 19th century [1]. Since then, approximately 250 thousand Japanese people have arrived in Brazil as migrants [2], forming the largest Japanese population outside Japan with approximately two million descendants today [3].

To my astonishment, it was only in 2021 that I saw an internet post about the visit of the Japanese ambassador to Brazil to a memorial monument for the sailors of Wakamiya Maru [4]. This was when I first heard about this incredible story of four Japanese sailors

who unwittingly traveled around the world more than a century before the massive Japanese migration to Brazil started. In addition, the one and only place in South America where they stopped was the exact city where I currently work and live. As I sought more information about this event, my surprise grew. This incredible story of these Japanese castaways, who crossed the whole Russian territory and, more than ten years after their shipwreck, returned to Japan aboard the first Russian expedition to circumnavigate the globe, departing from Saint Petersburg, is registered in a unique historical description: a manuscript from the Edo period, called *Kankai Ibun* (環海異聞, or exotic tales from) with 16 parts, first written ca. 1805 by Otsuki Gentaku and Shimura Hiroyuki [5].

Historical manuscripts such as these are rich sources for ethnobotanical investigations, even considering some imprecision. The oldest records (written in the usual languages of Western science) about the plants and the environment in Brazil are present in manuscripts written by European colonizers, which include documents such as Caminha's letter [6]—analyzed from a botanical perspective by the authors of [7]—and other more detailed (Gandavo [8], first published in 1576) or later better-known descriptions, such as those after the passage of Piso [9] published in 1658, Humboldt and Bonpland [10] in 1820 and even Darwin [11] in 1832 (published 1859). Ethnobotany in historical documents is an approach widely explored in relation to medicinal and food plants in historical records in Brazil (e.g., [12]) and elsewhere in the world (e.g., [13,14]). The contribution of historical documents, both via written sources and iconography, provides valuable ethnobotanical information about the plants described [15], but also about the observers who contributed to science and sometimes remained suppressed in history, such as female naturalists [16]. The approaches to the information on historical documents can be guided by a search about a given species (in most cases) or themes, or even analyzing the contents of a document to infer about plants [17] and are not restricted to the plant scope (e.g., [18]), including important registers about landscape changes [19].

Although some authors explored parts of the amazing history enclosed in *Kankai Ibun*, including the material testimony and legacy in one jacket used by one of the sailors [20], the description of an Earth Globe witnessed in Saint Petersburg [21], and a theatrical event watched by the Japanese castaways when invited by Emperor Alexander I [22], no further analysis was performed under an ethnobiological perspective. In this article, I explore the testimonies in the written registers of *Kankai Ibun* about the months these Japanese pioneers spent anchored in Santa Catarina, Brazil, and compare these descriptions with other historical sources about the environment and the ecosystem of this region in this period between the 18th and 19th centuries.

The oral reports of the first Japanese to circumnavigate the world were materialized in several versions of the *Kankai Ibun* [5], a handwritten document, as mentioned above. Otsuki Gentaku, the main author of *Kankai Ibun*, was a *rangaku* (Dutch learning) scholar [23], and he was assisted by other scholars who wrote this manuscript based on other Western documents they had available at the time. They were careful to separate the information from the oral reports of the castaways and their own observations.

According to Ramming [21], "this work, now rather rare, was at the beginning of the 19th century widely circulated throughout Japan and most eagerly read by all interested in foreign things". Such records often provide vivid descriptions of contemporary native societies with valuable historical, ethnographical, and anthropological data [24], and yet only a few scholars have analyzed these documents (mainly in Japanese publications but also in English, see [25]); their value remains much neglected simply as "curious tales" [24].

2. Results and Discussion

The odyssey of the castaways from Wakamiya Maru is described in several documents, both in Japanese [5] and summarized in English [21,26]. In Portuguese, in addition to Tomoko K. Gaudioso's translation of volume 12 of *Kankai Ibun* [27] and her analysis of the first Japanese in Brazil [1], there are scattered newspaper notes and internet websites

and a recent publication of a children's book about this episode [28]. Nevertheless, since this is a story quite unknown to the general public, a brief summary is presented here.

At the end of the 18th century, in November 1793, the small ship Wakamiya Maru, with sixteen crew members, departed from Ishinomaki (currently Miyagi prefecture) to Edo (currently Tokyo), transporting 1300 bales of rice and 400 pieces of wood [29]. What was planned as a trip of a few weeks took an unexpected direction: after a strong storm near the coast of Fukushima, the ship went adrift for over 165 days, or more than five months, finally shipwrecking at the Aleutian Islands in the North Pacific Ocean. After one year in Unalaska, an Aleutian island under the Russian domain, the castaways were transferred to Irkutsk, in the middle of Siberia, where they spent another seven years. When the new Russian emperor Alexander I decided to support a Russian expedition with an embassy to establish commercial ties with Japan, the Japanese castaways were summoned to quickly travel to Saint Petersburg, where after an arduous journey of more than 40 days, they had an audience with the emperor. At this time, three crew members of Wakamiya Maru had already died (the captain Heibei, the crew member Kichirōji, and the sailor Ichigorō) and another three members decided to stay in Russia due to a weak health condition (the sailors Sadayū, Ginsaburō, and Saizō). Of the ten who attended the hearing with the emperor, four decided to return to Japan, and six opted to stay in Russia and be converted to Christianity (the sailors Taminosuke, Shigejirō, Yasaburō, Zenroku, Tatsuzō, and Minosuke) [29].

An important reminder is that during this period, Japan was under a policy of strict isolation [25], with the *sakoku seisaku* (鎖国政策) or "closed door policy" under the Tokugawa shogunate. This policy prohibited all foreign contact except for trade conducted officially with the Netherlands and China via Nagasaki port [24] and to some extent with Korea and the Ryūkyū kingdom (currently Okinawa). Thus, not only were foreign ships mostly forbidden to dock in Japan, but Japanese citizens were also forbidden to leave the country.

The four people who decided to return to Japan by joining the Russian expedition on board the main ship Nadezhda, were the cook of Wakamiya Maru, Gihei, born in Higashimatsushima, and the sailors Tsudayū, Sahei, and Tajuro. Tsudayū and Sahei were born in Shiogama and were approximately 59 and 41 years old, respectively, at the time the Russian expedition departed in August 1803, approximately ten years after they left Japan. Tajuro was the youngest, approximately 33 years old, and was born in the same village as Gihei (at that time, approximately 42 years old). Zenroku, who had already converted to Christianity and became a Japanese teacher in Irkutsk, also joined the expedition with the role of interpreter [29] and disembarked in Russia prior to their arrival back in Japan in 1804.

The Russian expedition first docked in Copenhagen, then at Falmouth (England) and Canaries Islands. After crossing the Atlantic Ocean and the equator line, in December 1803, the expedition stopped in only one port in South America, Ekaterina Island, or Island of Santa Catarina (currently Florianópolis and Governador Celso Ramos municipalities). There, they spent approximately 45 days to restock provisions and fix damages in one of the ships (Neva).

After departing from Santa Catarina Island on 4 February 1804, the expedition passed through Cape Horn, Easter Island, and Nuku Hiva (French Polynesia). In Hawaii, the ships parted ways: since the Russian expedition supposedly had only the permit for one ship to land in Nagasaki, the Nadezhda headed to the Kamchatka peninsula and then to Japan to attempt the diplomatic mission—which was unsuccessful at the end—and the Neva headed to the Pacific coast in North America.

The Russian ship Nadezhda reached the Japanese coast in Nagasaki at the beginning of October 1804, but only after six months of slow negotiations under the strict rules of the Japanese government; and after the diplomatic mission failed completely, the four castaways Tsudayū, Sahei, Gihei, and Tajuro were delivered to the Japanese officials in April 1805. This seems to have occurred just before the departure of Nadezhda.

The anonymity of the castaways is remarkable in the books registering this trip, authored by Krusenstern [30], Langsdorff [31], and Lisiansky [32], and published in 1813 and 1814. They are usually described as "the Japanese". The commander of the expedition (Krusenstern) mentioned them as "the Japanese who in 1796 were captured in the Aleutic Islands" to be returned to Japan and to "secure the favor of the monarch [of Japan] and his ministers", together with other valuable presents [30], reflecting the role of the four castaways in the diplomatic negotiations intended with Japan. When listing the crew and passengers of Nadezhda, he solely registered "five Japanese", although he also described that "except MM. Horner, Tilesius, Langsdorff, and Laband, there were no foreigners on board either of the ships" [30]. They are mentioned by Krusenstern with words of disapproval, being "scarcely possible to imagine worse people than they were" (...) "lazy, dirty in their persons, always ill-humored", with the exception of "an old man of sixty years of age" [30], probably referring to Tsudayū. According to Krusenstern [30], the relationships between Tsudayū's group and Zenroku, the interpreter, were also hostile: "they lived in a continued state of warfare (...) because he [the interpreter] was rather more noticed by the ambassador than the others". The Russian Nikolai Reazanoff was the ambassador in charge of the diplomatic mission with Japan. His disappointment with the failed task of establishing commercial relations with Japan likely contributed to the start of the conflict between Russia and Japan on the Kuriles island a few years after the passage of the ship Nadezhda in Nagasaki. One remarkable episode registered by both Krusenstern [30] and Langsdorff [31] was when Tajuro tried to kill himself on 16 January 1805, supposedly due to the frustration of having arrived in Japan but being unable to disembark.

After being left in the care of Japanese officials, they were sent to the capital Edo (currently Tokyo), and were submitted to 40 days of a detailed inquiry [21]. During this period, with the closed-door policy, Japanese castaways drifting to other countries faced several obstacles to returning home, such as the possibility of being arrested upon returning, and those who returned were subjected to a detailed investigation about the nature of their experiences abroad. To maintain the closed-door policy, repatriated castaways were not allowed to relate their experiences freely to ordinary citizens [24]. The written document produced from this inquiry, known as *Kankai Ibun* [5], contains the first reports of how Brazil was viewed by Japanese eyes in the very first years of the 19th century.

Brazilian Environment and Plants through the Eyes of the Japanese Castaways

A disclaimer is necessary regarding this analysis through the eyes of the castaways: they reported what they saw to people who did not have experiences abroad and who interpolated their accounts with what was known in Japan during the Edo period. These accounts were transcribed many times and then translated. In other words, although the writers were careful to provide accurate descriptions, the original accounts from the castaways were filtered through these other lenses. These narratives were also burdened by the trauma of a trip lasting more than 10 years through unknown lands, by the uncertainty of returning to their home country, and by the uncertainty of knowing whether there would be freedom when they returned home. Additionally, Tajuro was the only one who disembarked whenever they had an opportunity to do so [26]. Tsudayū also disembarked in Santa Catarina [27]. However, after the attempt to end his own life months after his arrival at Nagasaki, Tajuro probably could not talk during the interrogatory. According to Oshima [26], after this incident, he never spoke again; although the captain of the Nadezhda reported that "after his wound had healed, he was frequently heard to say that the Russians were very good people, but himself a very bad man; and he wished his life might soon have an end" [30] (p. 282). Thus, it is possible that most accounts from the Brazilian land were probably told by Tajuro to their friends who stayed aboard most of the time and who then retold these accounts to their inquisitors.

Krusenstern's [30] and Lisiansky's [32] diaries registered the crossing of the equator on 16 November 1803. After that, they spotted the Brazilian coast in Cabo Frio (Rio de Janeiro state coast) on 12 December and anchored on Anhatomirim Island in Santa Catarina

Bay on 21 December 1803. In *Kankai Ibun* [5], several misinterpretations appear both in relation to dates and to places, despite the efforts of Otsuki and Shimura to be as precise as possible. Among the numerous notes added by Otsuki and Shimura to the accounts they were registering, there are several pages describing the attempts to equip the Japanese calendar with the one used by the Russians. In one of these notes, they mention that they must have landed in *Ekaterina* or *Ecaterína* (エカテリナ, or Santa Catarina Island), *Burajiri* (ブラジリ, Brazil), having stayed there for more than 70 days. Such confusion also reflects the limited knowledge available during the Edo period in Japan about these faraway parts of the world. For example, Otsuki and Shimura supposed that they harbored in a place that could be southern to Santa Catarina Island, at the mouth of the Plata River (which is between Argentina and Uruguay), although they raised doubts about this based on the observation that Brazil was part of the Portuguese (ポルトガリ, *Porutogari*) territory [5].

After crossing the equator, the castaways knew they were heading toward South America and commented "To the south, from that point on, we no longer saw either the North Star or the constellation of Ursa Major, so we were very amazed and commented about it" [27]. In this section, they commented, "Sailing on the high seas, we spent two or three days in places where the color of the water was different. The water had a dark reddish color" [27]. This fact was remarkable, as it was also reported in [30] and was investigated by the naturalist Langsdorff [31], who concluded that "this effect arose from an immense number of little crabs which floated upon the surface of the water". This phenomenon is caused by the final larval stage (Megalopa) of decapod crustaceans from the deep sea, which was described, for example, for *Moreiradromia antillensis* on the shelf break on the central coast of Brazil in 2002 [33].

One episode involving Japanese travelers aboard Nadezhda in South Atlantic waters was mentioned by Krusenstern [30]: "We caught but one shark, part of which was eaten, although it was not as good as a bonito. Our Japanese, however, ate the head and seemed to relish it much". Large sharks were much more abundant before the commercial exploitation of the South Atlantic seas [34].

As the expedition approached the Brazilian coast, the increased heat was perceived in their observations about the need for daily baths, sometimes two or three times a day [27]. Apart from the misregistered dates (probably due to the different calendars used at that time [27]), they reported that in November 1803, they docked in a large port called *Ekaterina* (エカテリナ), supposed to be one of the largest ports in South America. This observation reveals the scattered knowledge they had about the places they were passing through, both for the Japanese travelers and for the transcribers, Otsuki and Shimura. At the beginning of the 19th century, Santa Catarina was far from being an important port in Brazil when compared to other ports such as Salvador and Rio de Janeiro, well established since the 16th century (at the end of the 17th century, Santa Catarina Island was marked simply as "sterile and desert" in Coronelli's world globes). For Krusenstern, the choice for this port to restock provisions was due to the lowest fees when compared to major ports [30], cued by La Perouse [35], who navigated through these waters a few years before and mentioned the preference for Santa Catarina port instead of Rio de Janeiro to avoid the formalities of the large cities. Other chroniclers passing through Santa Catarina in the 18th century also commented on the convenience of this port due to the availability of wood and provisions for ships [36–38].

Then, they describe that the harbor was large but formed a very shallow bay, so large ships could not approach the shore. They also reported several small rivers flowing into this bay. These descriptions, although somewhat vague, reveal their perception of the North Bay of Santa Catarina Island and the wisdom at that time that already recognized the limitations of navigation. The submerged relief of the North Bay is a shallow bay, with an average depth of 5 m (in fact, this is a semiconfined system, as there is a connection with the South Bay in a constriction approximately 500 m wide, with greater depth, as well as its open connection to the ocean) [39].

A precious description of canoes is also found: "the natives' boats were as thin and long as bamboo leaves. Its bottom consisted of a board nailed to a tree trunk split in a half" [27]. Single-trunk canoe carving is a traditional vessel in many parts of the Brazilian coast, including the Santa Catarina coast. Several chronists and travelers observed and described these single-trunk canoes on Santa Catarina Island, some of them large enough to transport 50 people [38]. According to Souza-Sobrinho [40], at that time, these canoes were made of woods such as *Aiouea glaziovii* (Mez) R.Rohde, *Terminalia kleinii* (Exell) Gere and Boatwr., *Cedrela fissilis* Vell., *Ficus organensis* Miq., *F. christianii* Carauta, *F. insipida* Willd., and *Schizolobium parahyba* (Vell.) S.F.Blake. Building and maintaining single-trunk dugout canoes is an activity still found currently in this area [41], with registers of the contemporary use of *C. fissilis*, *Ficus* sp., *S. parahyba,* and species of *Nectandra* and *Ocotea*. De Paula et al. [42] found canoes about 200 years old in this same region; thus, some canoes currently found in this area date back to the beginning of the 19th century and are still in use. In other words, the oldest canoes currently found on the Santa Catarina coast could be contemporary to those witnessed by the Japanese castaways.

According to *Kankai Ibun*, Tajuro disembarked and observed a village with approximately a thousand houses. He probably visited the village of São Miguel, where the ships were restocked with potable water. The distance from the port as described in *Kankai Ibun* is probably misregistered (20 ri, an old Japanese measure of distance, which would be equivalent to approximately 80 km) because the distance to São Miguel village is no more than 8 km from where they were docked. Tajuro and his colleagues interpreted the places based on the knowledge they had at that time, such as describing the roof tiles as being made of cherry tree bark—a species absent in this region—which is reliable in accuracy only regarding the color of the traditional ceramic roof tiles when seen from a distance. Ceramic clay tiles with a frustum-conical shape have been used since Portuguese arrival in Brazil in the 16th century [43].

According to *Kankai Ibun* [27], they observed "an enormous number of trees on the hills. Among the familiar trees were bergamot and orange" (*Citrus* spp.). The abundance and quality of oranges, limes, and lemons at Santa Catarina Island is described by other travelers (e.g., [36,38]). Krusenstern, Lisiansky, and Langsdorff [30–32] all remarked in their registers on the luxuriant forests with an abundance of resources. These descriptions could be embedded in the romantic ideal of European naturalists and travelers of that time, who described picturesque and exotic landscapes but were also guided by their own subjectivity [44]. In *Kankai Ibun*, the luxuriant vegetation also attracted the attention of Japanese travelers. Indeed, these descriptions converge to the physiognomy of the original Atlantic Forest of Santa Catarina [45].

When the Russian expedition docked at Santa Catarina, provisions of staple foods, fruits, and wood from forests were reported as abundant, while few areas were cultivated. The registers of deforestation of the island started with the first reports of ships stopping at Santa Catarina Island for wood supply, dating back to 1526, when a Spanish expedition traveling to the Mollucas Islands stayed there for four months, the time needed to build a small vessel [46]. At that time, the use of the environment for cultivation was at a very small scale for manioc, corn, and cotton production by Carijo indigenous people [46]. The strategic location and the abundance of wood and supplies attracted the attention of navigators until the end of the 18th century and the beginning of the 19th century. Less than three decades after the Japanese visit to Santa Catarina, Duperrey [47] did not find an abundance of provisions and resources. According to Caruso [46], from 1748 onward, deforestation for agriculture increased with the settlement of Azorean migrants, and changes in forest cover were already perceivable in the first years of 1800 [46].

The availability of trees at that time was essential for the supply of wood for the construction of a new mast for Neva. Japanese travelers observed the arrival of the wood in the port, which they described as "a very hard wood with red and black parts mixed together. The Russians called it *karasunazeriwa*" (カラスナゼリワ, probably *krasnoye derevo* or *krasnaya drevesina*) or red wood. Also related to woods, they reported "They brought to the

ship exotic woods that are light red in color and have spots the color of egg yolk. The day we came to Nagasaki, several people told us that it was red sandalwood" [27]. They also reported that they heard that a wood called *suô* 蘇枋 (スオウ) was native to the region, but they did not see this wood, which was interpreted by Gaudioso [27] as the word referring to sappanwood (*Caesalpinia sappan* L., with occurrence in Asia) but in this case would be the South American equivalent brazilwood [27] (*Paubrasilia echinata* (Lam.) Gagnon, H.C. Lima and G.P. Lewis).

The identification of wood based only on color is very imprecise, and the descriptions can refer to several different genera. Other travelers at the end of the 18th century reported the abundance of trees used as high-quality wood but with scattered mentions of their color or other characteristics. Wood species from that time that could be identified based on occurrence and on Portuguese names include *Cedrela fissilis*, *Ocotea odorifera* (Vell.) Rohwer, and *Ocotea* spp. [37,38] (species identifications were based on [40]), and some of them are currently very rare in this area (e.g., *Ocotea catharinensis* Mez. [40]). In regard to brazilwood, other travelers mentioned the presence of "the Brazilian wood used for dyes" in Santa Catarina at the end of the 18th century and the beginning of the 19th [38,48].

Paubrasilia echinata was a heavily exploited resource until the middle of the 19th century [49]. Historical maps from the 16th century roughly depicted the presence of this species in the region, although precise information about the geographical distribution in these cartographies is hampered for two reasons: first, the need to show the precise localization and geographical accidents of the discovered lands; and second, the choice of not showing the distribution of resources of economic interest with both political and strategic purposes [50]. The accepted distribution of brazilwood is the Atlantic Forest further north of Santa Catarina [51,52]; however, these scattered registers of travelers and naturalists of the 18th and 19th centuries [38,48] inspire thoughts about the unsure possibility of a broader, albeit rare, distribution of this species.

Tsudayū also disembarked and observed a rice mill. Although we find few mentions of rice cultivation (*Oryza* sp.) on the island, other authors mentioned the rice mill powered by the aqueduct in São Miguel [47], in the continental area, close to the place where ships sought water supplies. Probably both Tajuro and Tsudayū could observe the village of São Miguel, but is uncertain if they disembarked in Nossa Senhora do Desterro as well. Lisiansky [32] described the abundance of cereals and staples and provided a list of provisions that could be purchased, including rice, wheat (*Triticum* sp.), corn (*Zea mays* L.), coffee (*Coffea arabica* L.), and manioc (*Manihot esculenta* Crantz). The castaways believed that people at Santa Catarina had corn as their main staple, and they observed the prohibition of eating rice [27]. However, what they described as the corn flour prepared with hot water to make a kind of glue was probably the first description of *beiju* or *tapioca* by Japanese eyes. The main staple at that time was manioc, usually prepared as flour mixed with hot water and eaten instead of bread [31]. For Langsdorff [31], corn and white bread were found only among the "very highest and richest of the people".

The Japanese travelers reported in *Kankai Ibun* several local products, such as "cabbages, turnips (thin, with no change in flavor), horseradish (round), Chinese melons, melons, watermelons, pumpkins, cucumbers, grapes, pepper (the fruits are small and the pepper trees grow like trees), oranges, walnuts (small), apples, sugarcane (the thick ones were the diameter of a fist" [27]). Travelers' reports since the 18th century mentioned the presence of a remarkable variety of oranges (*Citrus* spp.) [36,38,53], and melons, watermelons (Cucurbitaceae), sugarcane (*Saccharum officinarum* L.), and grapes (*Vitis vinifera* L.) [38,53]. Few products listed by Lisiansky as purchased by the expedition [32] were the same as described in *Kankai Ibun*: lemons (*Citrus* sp.), pumpkins (*Cucurbita* sp.), and bananas (*Musa* sp.). While some of these crops and fruits were expected to be present in Santa Catarina Island at that time, others could be reported as similar to fruits known in Japan.

Their description of coconuts (*Cocos nucifera* L.) is as follows: "There were some very large fruits. The outer shell was thick. When you removed it, you could see the very hard inner shell, part of which looked like a person's face. Its interior was full of oily meat, sweet like nuts". The enslaved people placed these fruits in a container and swam to the ship to sell them. They reported that when they tried these fruits, "we feel the freshness in our mouth and forget the intense heat, so we buy them and eat them several times" [27]. According to *Kankai Ibun* [27], Tsudayū had brought a shell-like object that he used as a water container, and the writers of *Kankai Ibun* concluded that it was indeed green coconut, or *kokkosu* (コッコス).

One of the richest descriptions is related to bananas (*Musa* sp.), as green plants that produce 20 to 30 bunches of long things, with three longitudinal edges, without seeds, which are green at the beginning but when mature turn yellow (Figure 1). They reported the harvesting of these fruits when green and taking two days to mature, being sweet and white in the interior, and considered it similar to akebi [27]. Akebi (*Akebia quinata* (Thunb. ex Houtt.) Decne.) is a fruit native to Japan with a sweet flavor. It is worth noting the slight changes in the representations of bananas in different versions of *Kankai Ibun* (Figure 1 [5,54–58]). These differences reveal the novelty in the knowledge about this fruit in 19th century Japan, probably mixed with the exotism of unknown lands and plants.

In addition to the plants among purchased products and goods, they also described the cultivation of cotton, which was "identical to that observed in Japan", but with larger leaves [27]. Frézier [53] described in detail the presence of cotton on the island, which he referred to as *Gossypium arboreum* L. or *Xylon* sp. [53]. At that time, cotton was reported by other voyagers as one of the main crops [38], and probably cultivated by Carijo indigenous people prior to European colonists [46]. There is an observation added by the writers of *Kankai Ibun*, Otsuki and Shimura, about the possibility of these cotton plants surviving for more than one year due to the warm weather.

Finally, *Kankai Ibun* also mentions several animals witnessed by the Japanese castaways' eyes. Among the domestic animals, they observed pigs, with tusks and fatty meat, and cattle, also with fatty meat; dogs similar to those in Japan, and tabby three-colored cats, similar to those in Japan but seemingly more ferocious [27]. They also mentioned the lack of fish and the availability of shrimp in abundance [27]. The lack of fish could be due to climatic conditions (usually with a lower productivity in summer, the period when they were docked at Santa Catarina), because other reports from the 18th century mention the abundance of fish [36,37,53], but this can also indicate the beginning of the decline of local fish stocks. One fish caught their attention, "with a square shell similar to that of a turtle", and with a skin similar to pufferfish (Figure 1), probably referring to *Sphoeroides testudineus*.

Non-domesticated animals include descriptions of long-tailed monkeys and "little birds with a very beautiful color, blue and with red beaks and nasal holes. They sing doing *kiu kiu*. When someone sticks out their tongue, they suck it with their beak" [27], probably referring to hummingbirds. They also described what is supposed to be the Procyonidae *Nasua nasua*, with whitish-gray fur, a long snout and striped tail, and a bad smell. Some of these animals were raised on the ship, but several died during the trip; one probably survived until they reached the port of Kamchatka. Oshima [59] presents excerpts of the diaries of other tripulants of the Russian expedition, such as Ratmanov and Levenstein (レーベンシュタイン, probably Lowenstern) describing other aspects of the animals found in this part of the expedition, including an episode on board with captured monkeys and the Japanese travelers.



Figure 1. Examples of different versions of the drawings in *Kankai Ibun* on the nature elements observed in Brazil. From left to right: bananas (*Musa* sp.), pufferfish (probably *Spheroides testudineus*) and caiman (*Caiman latirostris*). The sources are indicated with the [5,54–58] in the bottom right of each series of pictures.

At the end of the reports about the stay at Santa Catarina Island, the document presents a drawing (Figure 1) and a description of a caiman brought on board. It is described as a four-legged cub of an animal called *garukaruzeru* (ガルカルゼル). The animal had thick and dark skin, scales on its feet, and thorns on its tail. Its mouth was full of mismatched teeth, and above the eyes were things that looked like calluses. Each paw had three nails, and the Japanese castaways reported that they were told that "these calluses above the eyes turn into horns when they grow and that they live both in the sea and in the mountains and that they even hunt and devour men. Looking at the drawing of the dragon, we think it looks similar. We even commented that it was truly a baby dragon" [27]. Following the presented drawing, they concluded that it was a caiman, or crocodile (*kokojiru*, ココジル). They also reported that the animal was killed and preserved by the use of a white chemical substance, the removal of viscera and eyes, and the replacement of the eyes with spheres. Lisiansky [32] also reported this episode: "we caught a young one and sent it on board the Nadezhda to the naturalists, who have preserved the skin. Although this little monster was scarcely a yard long alligator". *Caiman latirostris*, or broad-snouted caiman, is distributed in the eastern part of South America and is easily found in wetlands and mangroves on Santa Catarina Island [60] until present day.

3. Materials and Methods

There were more than 30 manuscript copies of *Kankai Ibun* circulating in Japan's Edo period [25]. The full version of *Kankai Ibun* was also published in a printed version in Tokyo in 1986 [61] and in a collection of anecdotal stories of shipwrecked people under the title *Hyōryū kidan zenshu* [21]. In this essay, I used Tomoko Kimura Gaudioso's [27] Brazilian Portuguese translation of volume 12 of *Kankai Ibun* as a main textual source. Other versions were accessed and consulted for both text and images [5,54–58,61].

To triangulate information and to understand the context of the voyage at the end of the 18th and beginning of 19th centuries, I searched for historical documents with descriptions of the Russian expedition of Nadezhda and Neva ships and other documents describing the socioeconomic and environmental context of Santa Catarina Island (several of them compiled by Haro [62]). The main sources about the Russian circumnavigation used here were the reports of the Estonian captain of the expedition and commander of the main ship, Nadezhda, Adam Johann von Krusenstern [30], originally published in German in 1803; the diary of the Ukrainian commander of Neva, the second ship in the Russian expedition, Yuri Fyodorovich Lisiansky [32]; and the registers of one of the naturalists on board, the German doctor Georg Heinrich Freiherr von Langsdorff [31]. Ten years later, Langsdorff would return to Brazil as the consul general of Russia, in Rio de Janeiro, and after that, he would lead important naturalist expeditions in Brazil. Before joining the Russian circumnavigation expedition, Langsdorff practiced medicine in Lisbon, and thus was familiar with the idiom used in Brazil. His 1813 book includes one of the first written transcriptions of music in Santa Catarina, a "Brazilian Aria". Souza-Sobrinho [40] mentioned that Langsdorff collected more than 80 species of wood on his first travel to Brazil; unfortunately, Langsdorff described the loss of most of the botanical samples due to humidity [31] and published only descriptions of pteridophytes collected on this trip [63], but none of them could be related to the Japanese descriptions. Other written reports from the Russian circumnavigation, such as those registered by Wilhelm Gottlieb Tilesius von Tilenau, the main naturalist on board Nadezhda, were not used due to the lack of contextual data to allow relations to *Kankai Ibun* registers.

Botanical names mentioned in historical documents or in the literature were updated following Plants of the World Online [64] and World Flora Online [65].

4. Conclusions

Little is known about what happened to the four castaways after the interrogation in Edo. They supposedly returned back to their original towns, with the express prohibition to tell what they witnessed outside Japan. Tajuro and Gihei died a short time after return-

ing to their city, at 36 and 45 years old, respectively [29]. Tsudayū passed away at 70 years old, and Sahei passed away at 67 years old [29].

The reports of these four people's experiences around the world reveal pieces of information of places, plants, and animals that existed only in the imagination of Japanese people, or were otherwise places and plants never thought of before. The wide circulation of several copies of *Kankai Ibun* during the Tokugawa Shogunate period played a role in the construction of Japanese views on Brazil through the eyes of these four people, which certainly contributed profoundly to the future implementation of the friendship treaty signed between Japan and Brazil [1] that ultimately resulted in the migratory waves of the beginning of 20th century. These impressions and views may have also had subtle consequences in the building of the several identities of Japanese descendants in Brazil [66].

These registers are invaluable historical reports that may be read and interpreted with caution, filtered by all rich and dramatic context surrounding these events. In addition to the caution already mentioned in analyzing records made by third parties of facts stored in the memories of travelers, these reports may have incorporated distortions over time due to transcriptions and along successive translations. However, several treasures are still hidden behind these narratives. This amazing history of four people who unwittingly traveled around the world and almost from one pole to another certainly has much more to be explored under ethnobiological and ethnobotanical lenses. Beyond the Santa Catarina passage, rich reports about all other points of passage are included in *Kankai Ibun*. This is still a rich and underutilized ethnographic document, showing us "a glimpse of the world as it appeared to common Japanese sailors" [20].

Finally, in addition to testimonies related to biodiversity, historical records show different perspectives on environments and the world. They also help to understand how identities are built from the past to the present, with so many connections in a multicultural world.

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Content Analysis of Digital Archives Contributes to the Historical Distribution and Folk Knowledge of the Highly Toxic *Cicuta virosa* L. in Hungary

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Abstract: The northern water hemlock is an endangered species that has been severely diminished in Hungary due to water regulation and river control in the 18th and 19th centuries. We collected data on this highly toxic plant from Hungary using archival sources, including digitized databases of daily and weekly newspapers and books. By exploring historical digital archives, we identified 88 locatable occurrence records spanning 65 flora mapping grids, 52 of which represent new additions to its known distribution. Between 1721 and 1943, a total of 103 records were found relating to its vernacular names. The most widespread names were *csomorika* (predominantly used in the Berettyó-Sárrét and Hortobágy regions), *mételytorzsa* (Rétköz, Taktaköz, Ecsedi-láp), and *Kónyi gyökér* (Fertő-Hanság region). Human poisonings caused by this species were primarily due to confusion with parsley, celery, and, less frequently, parsnips or carrots, occasionally resulting in the deaths of entire families. Children, in particular, were at risk when they accidentally consumed it raw as a snack. There have also been instances of intentional homicidal use and unintentional fatalities associated with its ethnomedicinal application. The plant was primarily used to treat scrofula (a form of tuberculosis-induced lymphoma) and for abortion.

Keywords: Apiaceae; Central Europe; children's snack; ethnoveterinary; habitat loss; local ecological knowledge; Pannonian ecoregion; poisonous plants; wetlands

1. Introduction

Human-induced modifications to the landscape are a significant driver of biodiversity loss [1]. Such activities include the ploughing of grasslands, deforestation, and wetland drainage. A particularly noteworthy example is the profound transformation of the soil, hydrological, climatic, and ecological conditions of the Hungarian Great Plain resulting from river regulation [2]. Prior to the implementation of river regulation and drainage in the 18th century, a substantial portion of the Pannonian Basin was periodically or permanently covered by water [3]. In the valley of the River Tisza, the largest river regulation project in Europe led to the destruction of approximately 38,000 km^2 of wetlands. This significant landscape alteration resulted in considerable changes to both vegetation and fauna, including a dramatic 83% reduction in reedbed areas and the complete disappearance of floating islands [4].

As a result, this extensive landscape transformation has left us with limited information regarding the flora and vegetation of the former wetland habitats, further exacerbating the knowledge gap created by the river regulation efforts. To address this deficiency, the exploration of historical digital archives, which have previously proven effective in studying past wetland grazing [4], emerges as a promising solution.

For this purpose, we selected the highly toxic *Cicuta virosa* L. as a model species, hypothesizing that its toxicity may have played a significant role in folk life, a role that may be reflected in historical, printed sources contained within digital archives.

Northern water hemlock (*Cicuta virosa*) is the only European representative of the genus. It is a circumpolar species, distributed across Eurasia (from Western and Central Europe to Siberia, and the Korean Peninsula) and northwestern North America [5–8].

Cicuta virosa is a hemicryptophyte (hydro-helophytic) species. Its rootstock is multi-chambered, containing a yellowish oily liquid (Figure 1A) and emitting a characteristic smell of raw parsnip. The stem is thick and hollow (Figure 1B), and the petioles are inflated and hollow. The leaves are alternate, pinnately compound (two or three times) (Figure 1C), and may reach 30–120 cm in length. The leaflets are elliptic–lanceolate with acutely serrate margins. The generative shoots are hollow with clusters of foliage (Figure 1B). The umbellate inflorescence contains clusters of 30–50 flowers with white petals (Figure 1E). The schizocarp fruits are approximately 2 mm long and 3 mm wide, with a much longer pedicel (Figure 1F) [9,10]: 352.

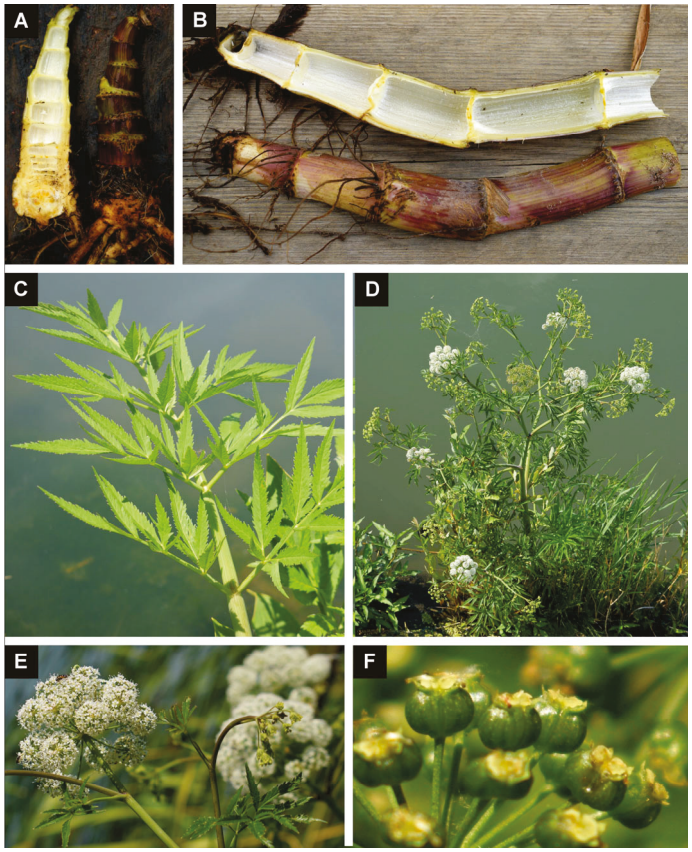


Figure 1. Morphological characteristics of *Cicuta virosa*. (**A**) Rhizome resembling celery and its longitudinal section with leaking yellowish, oily liquid; (**B**) hollow, articulate, generative stem with nodular adventitious roots and its longitudinal section; (**C**) leaf; (**D**) flowering individual; (**E**) inflorescence; (**F**) unripe fruits. Photo credits (**A**,**B**,**D**) by A. Molnár V.; (**C**,**E**,**F**) by Sz. Kis.

The entire plant is highly toxic, with its primary active compounds being C-17 polyacetylene-type substances that induce respiratory paralysis and death through GABAA receptor antagonism [11] and also inhibit potassium channels [12]. The most notable of these toxins is cicutoxin [13,14], which has historically been responsible for fatal poisonings among both humans and livestock [15]. The cicutoxin content in fresh plant material is approximately 1.5%, and in dried material, it can reach 3.5% [10]. It also contains 11 other

C-17 polyacetylene derivatives, the most important of which are oenanthotoxin, cicutol, falcarindiol, and isocicutol [14].

Currently, *Cicuta virosa* is listed as endangered (EN) in Hungary [16], the Czech Republic [17], and South Korea [8], and as vulnerable (VU) in Slovakia [18]. In Baden-Württemberg (Germany), the species is highly endangered, with its decline largely attributed to the conversion and overuse of water bodies [10].

Our work was based on the two following assumptions: (i) *Cicuta virosa* may have been much more widespread in Hungary before the river regulation and drainage works of the 19th century; (ii) reports of human and livestock poisoning cases may have appeared in archival, non-scientific sources, such as newspapers, magazines, and periodicals of the time, and these contemporary records may provide valuable insights into the former distribution and local knowledge related to the species.

2. Results

The studied Hungarian historical sources contain a wealth of information on *Cicuta virosa* (Figure 2).

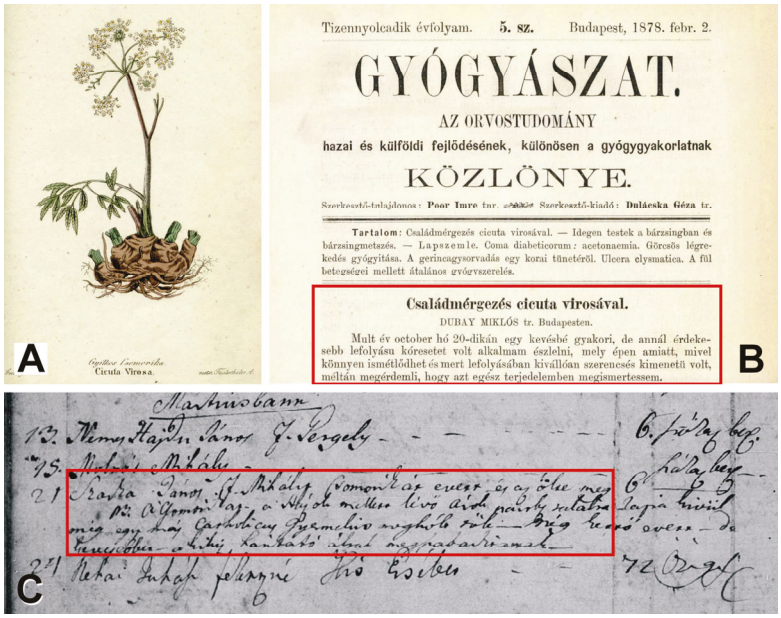


Figure 2. *Cicuta virosa* in archival sources. (**A**) Illustration of the species in the work of Á. Kubinyi [19] published in 1842; (**B**) "Family poisoning with *Cicuta virosa*": news on the cover of the journal *Gyógyászat* in 1878: "On the 20th of October last year, I had the opportunity to observe a case of a rather uncommon yet intriguing course of illness, which, precisely because it could easily recur and had an exceptionally fortunate outcome, rightfully deserves to be presented in its entirety" [20]; (**C**) death certificate of a 6-year-old boy who consumed *csomorika* in 1803, Szeghalom, Eastern Hungary: "The son of János Szarka, Mihály, ate the csomorika which caused his death. He found the csomorika by the bank of the ditch near their house, and in addition to him, one Catholic children perished, while two others ate less and were saved by means of vomiting.". (**C**): photographed by J. Éliás.

2.1. Historical Distribution of the Species

Currently, *Cicuta virosa* is a rare and endangered species in Hungary. The Vascular Plants of Hungary online database [21] documents its occurrence in 39 flora mapping grids. Through exploration of the historical digital archives, we identified 88 locatable occurrence records covering 65 flora mapping grids, 52 of which represent additional distribution points (Figure 3). By overlaying the hydrographic depiction of the Pannonian Basin's pre-regulation conditions onto the distribution data map derived from digital archives, it

becomes evident that the recently identified distribution points correspond to locations that were once covered by extensive wetlands, characterized by periodic or permanent flooding. From this, we can infer that nearly half of the previous *Cicuta virosa* populations have been lost due to the river regulation and drainage projects in the Pannonian Basin.

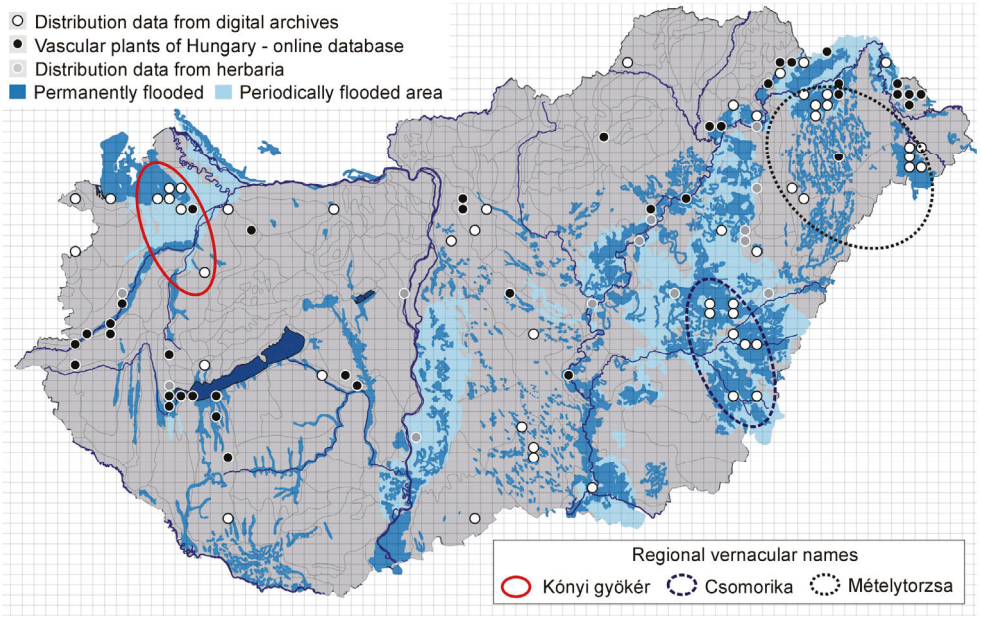


Figure 3. Three most common regionally used vernacular names and complete distribution of *Cicuta virosa* in Hungary, overlaid with the pattern of inundation. Areas that were permanently or temporarily covered with water in Hungary prior to river regulation are distinguished (according to the Hungarian Hydrographic Institute [3]). Full circles represent distribution data obtained from the *Vascular Plants of Hungary* online database [21].

2.2. Vernacular Names of Cicuta virosa

Between 1721 and 1943, a total of 103 records were found concerning the Hungarian vernacular names of the studied species (). The most widespread names and their variants, along with their localization, sources, and brief explanations, are listed in Table 1. The most common name, *csomorika*, is still used in official Hungarian nomenclature to designate the species and has been known since 1578 (*czomorika*) [22]. The four most common names were found in the sources studied from at least the late 18th to the early 20th century (Figure 4).

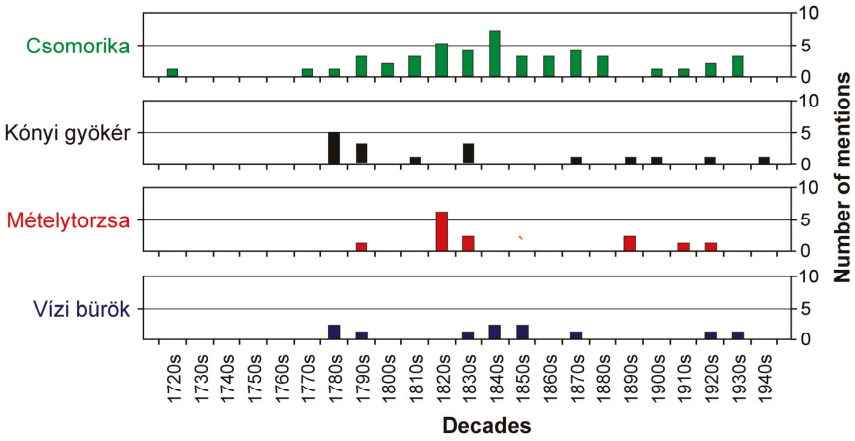


Figure 4. Temporal pattern of usage of the most common vernacular names for *Cicuta virosa*. The bars represent the number of mentions for each name (including variants) across decades in the studied literature.

Table 1. Frequency of use of various vernacular names, their geographical distribution, and brief explanations of the Hungarian terms.

Vernacular Name (Number of Mentions)	Region	Notes
Csomorika (22); *Csomorika fű* (3); *Gyilkos csomorika* (19), *Mérges csomorika* (3)	Berettyó-Sárrét region, Hortobágy (E-Hungary)	*Csomorika* is the most widespread and currently used name for the plant. The specific epithets (*gyilkos*, *mérges*) refer to toxicity of the plant (killer and poisonous, respectively).
Mételytorzsa (9), *Métel* (1), *Métely* (3), *Mételfű* (1).	Rétköz, Taktaköz, Ecsedi-láp (NE-Hungary)	The Hungarian word *torzsa* means a thick, fleshy plant stem. The word *métely* refers to the liver fluke (*Fasciola hepatica*, Platyhelminthes), a parasite of ruminants. In a general sense, however, the word *métely* means a pathogenic, harmful organism. *Megmételyezni* = to spoil, poison, influence in a negative direction.
Kónyi gyökér (15), *Konyer Wurzel* (1)	Hanság, Fertő (NW-Hungary)	*Kóny* is a village in north-western Hungary, where the plant was common in the early 20th century. The word *gyökér* means root.
Vízibürök (6), *Vízi mérgesbürök* (2) *Méregbürök* (4)	In several regions.	The word *bürök* is usually used to designate the species *Conium maculatum*, which also belongs to the Apiaceae family and is severely poisonous too. *Cicuta* is usually distinguished from *Conium* based on their habitats (*víz* means water, *vízi* is equivalent to aquatic).

2.3. Incidents of Poisoning

Diószegi Sámuel, a Reformed preacher and renowned botanist, wrote the following about *Cicuta virosa*: "The csomorika, among all plants, is the most wicked poison, particularly its root, which can kill both humans and livestock in a short period" [23]: 195.

2.3.1. Human Poisoning

Historical records indicate the consumption of approximately 60 wild plant species among Hungarian ethnic groups [24]. At least five species from the Apiaceae family were commonly consumed in Hungary as soup, a spice, refreshing drinks, or children's snacks (*Anthriscus cerefolium* (L.) Hoffm., *Daucus carota* L., *Heracleum sphondylium* L., *Pastinaca sativa* L., *Chaerophyllum bulbosum* L.; [24,25]). Available data show that *Cicuta virosa* was most commonly mistaken for parsley (seven cases) or celery (three cases), and less frequently for parsnip or carrot. In a detailed incident, an entire family was poisoned in 1878 by the root of *Cicuta virosa* mistaken for celery purchased at the local market [20]. In 1880, *csomorika* was cooked in soup, and the family later succumbed to poisoning [26]. "It has caused countless household poisonings, with its beautiful white umbellate flowers, leaves resembling celery, hollow roots mistaken for parsley, or its seeds, similar to aniseed" [27]: 108.

Many cases of poisoning have occurred among children who mistook it for other edible roots, often resulting in death [28]: 203. In 1787, a schoolboy in Losonc (now Lučenec, Slovakia) died after consuming the root, mistaking it for a carrot [19]. In 1796, three children on the outskirts of Pest died after consuming *Cicuta virosa* [29]. According to the Reformed Church registry in Szeghalom (March 1803), four children consumed a *csomorika* found on the banks of a ditch; two died, while two were saved after vomiting [30]. In 1816, a prayer was offered for a child who had eaten *csomorika* [31]: 201. In 1842, two boys and six girls ate *csomorika* root mistakenly identified as parsnip, and some died soon after [19]. Additionally,

children used the hollow stems to make whistles, unwittingly endangering themselves by putting them in their mouths [32].

In 1722, during a witch trial in Békés County, a man was killed by his wife, who prepared bath water with *Cicuta virosa* [33,34]: 22. The famous physician and naturalist János Földi wrote, "Many people still prepare murderous poison from it". He believed that instead of marking cultivation sites with prohibition signs, people should be informed about the plant's medicinal properties [29]. In a case in Dévaványa, a woman cooked *csomorika* leaves in a stew for her alcohol addict husband, leading to his death by evening [35]. The plant is also mentioned in a darkly humorous folk song, 'Ki az urát nem szereti, Csomorikát főzzön neki, Ha ma vele megeteti, Még estvére kiteríti' ("If she does not love her husband, cook him *Csomorika*. If she feeds him today, he will be dead by night") [36].

Although *Cicuta virosa* is not mentioned in Fäller's (1943) comprehensive work [37], historical sources suggest its use in folk medicine, primarily against tuberculosis (lymphatic gland inflammation) [38] and rheumatism [39]: 6. In Kiskunmaja, Kígyós, and Szank, it was used as an abortifacient. The root was washed and carefully inserted into the uterine cavity; it induced miscarriage after 3 h [40]: 296. In some cases, these practices resulted in fatalities, and records of criminal proceedings initiated thereafter have been preserved. In 1868, a market vendor in Hajdúszoboszló confessed to having cured a six-year-old girl suffering from tuberculosis by preparing a decoction of *Cicuta virosa* root in milk. The child died that evening in considerable suffering [38].

2.3.2. Poisoning Among Livestock

The majority of historical sources document cases of livestock mortality due to poisoning. Three examples of reports of poisonings caused by *csomorika* from different Hungarian regions during 18th century are listed in Table 2. Sometimes *Cicuta* caused significant damage; for instance, Pál Kitaibel reported that in 1799, it resulted in the death of twelve oxen near Pápa [41]. According to complaints from peasants in Szatmár County, "about one-third of the cattle are lost every four years, partly due to the *mételytorzsa*" [42]: 436.

Table 2. Examples of sources providing ethnobotanical data on livestock poisoning from the 18th century.

Region	Original Text	English Translation	Source
Nagy-Sárrét	'*A lapos és posványos hellyeken levő csomorika nevezetű fű a marhának olly veszedelmes, hogy ha azt megeszi, fél óra múlván elkelletik néki veszni. E miatt is marháinkban esztendőnként nagy kárt szenvedünk.*'	The herb, called *csomorika*, which is found in marshy places, is so dangerous to cattle that if they eat it, they are forced to die after half an hour. Because of this we also suffer a lot of damage to our cattle every year.	[43]: 331
Hajdúság	'*Egy nyáj juhot téli időben szénával éppen olyan rét aljon étettek, ahol az ilyen Tsomorikának torzsás gyökerei bőven találtattanak. Ezt a juhok még inkább rágták, mint a szénát (minthogy ezt édességének okáért különben is szeretik). De csakhamar kezdetiének is tőle számosan ledobbanni és megdögleni.*'	In winter, a flock of sheep was fed by hay at the bottom of a meadow where the roots of such "Tsomorika" were found in abundance. The sheep like it for its sweetness and chewed it even more than hay. But it soon began to cause many of them to fall and die.	[29]
Hanság	'*A' Hanyságbann is valamint a' Kónyi-tó mellett a' Vármegye szélén, bőven találtatik az úgy nevezett Kónyi-gyökér melly olly mérges, hogy ha a' marha meg találja enni, azonnal feldagad 's megdöglik.*'	In Hanyság as well as near Lake Kónyi on the edge of the county, there is plenty of the so-called Kónyi root which is so poisonous that if the cattle find it to eat, it swells up and dies immediately.	[44]: 805

In particular, in the Berettyó-Sárrét region (comprising the former Békés and Bihar counties), where pastures were scarce, residents grazed their animals in the marshes of the Nagy-Sárrét, where they often succumbed to poisoning. During the 18th and 19th centuries, the damage caused by *csomorika* was substantial [45]: 5. In the Hanság region, as in Berettyó-Sárrét, it caused poisoning in cattle grazing on pastures in many instances [46]. *Cicuta* could have entered the animals' diet either through hay used as winter feed for sheep or through grazing in marshes [29]. However, sources also indicate that cattle generally consumed *csomorika* only in times of scarcity (autumn and winter) or in swampy areas where other vegetation was unavailable [47,48]. Reports of livestock poisoning from *Cicuta* in Hungary include cattle, sheep, and horses. "It has often been observed that *csomorika* kills horses, cattle, and sheep when carelessly offered to them as food" [19]. The majority of poisoned livestock were cattle (35 cases), followed by horses (six cases) and sheep (four cases). However, Diószegi [23] noted that "it is said that the leaves of *csomorika* can be safely consumed by sheep". According to Greschik [49], larks and quails can pick the seeds of *Cicuta* without danger.

The course of poisoning is usually rapid; in cattle, it typically occurs within 5–6 h [48], a few hours [50], or even within half an hour [43]. Symptoms of poisoning include "inability to walk, muscle twitching, whitening and lividity of the tongue, cessation of mucus production (dry throat), and difficulty breathing" [50]. Kátai (1858) [51] described the effects as follows: "When consumed, it causes intense heat, pain, insatiable thirst, gastric ulceration, hiccups, spasms, dizziness, a sensation of drunkenness, convulsions, and ultimately death. After death, the abdomen swells to an enormous size, with the intestines and stomach distended due to inflammation, causing them to collapse, while the brain vessels swell with blood." According to Kiss [46], "It is such a poisonous plant that when cattle find its leaves mixed with other grasses, they become so bloated that their skin nearly bursts open, leading to death." Upon dissecting two steers that died from poisoning, it was reported that "the rumen was highly bloated with gases, the reticulum was dry and hard with locust leaves and root parts of the plant. The lungs were congested with blood and air was sparse. In both cases, the diaphragm was pressed tightly against the lungs. Other organs were intact. When the rumen was punctured during dissection, gas escaped with a trumpet-like rattle, similar to that of a drumstick".

Salt was considered the most effective antidote in ethnoveterinary for poisoning by *Cicuta*. In Füzesgyarmat, "salt is considered the best antidote. Therefore, if they notice early enough that the cattle have been poisoned, they vigorously rub their tongues with salt and administer water saturated with salt" [52]. In Sárrét (Bihar county), salt was also placed into the mouth of a sheep that had consumed *csomorika*, or, in the absence of salt, the shepherd would urinate into the sheep's mouth [53]. Tannic acid [54], milk, and fat were also mentioned as antidotes [55]: 786.

The rhizome is most commonly reported as the poisonous part of the plant (20 times), followed by the leaf (10 cases), and the stem and fruit (1–1 cases). It has also been noted that the evaporation of the plant's leaves can cause dizziness and fainting [28,46], and that a person could faint who is lying on a pillow with a *Cicuta* underneath [56]. Kubinyi [19] suggested that the poisonous sap of the plant could contaminate water, especially in areas where the plant grows abundantly.

Considering the damage caused to livestock and human lives, it is possible that the decline in *Cicuta virosa* (Apiaceae) may have been due to its toxicity, in addition to the draining of its habitats. Diószegi [23] stated, "it is only beneficial to eradicate it wherever it is found". Anonymous [57] noted, "*csomorika* weeds must be eradicated so that the crop of God may grow". In some provinces, the eradication of the *csomorika* is strictly ordered [19].

3. Discussion

The implementation of river regulation and drainage projects has profoundly impacted wetland habitats, leading to a significant reduction in species abundance and biodiversity, primarily due to alterations in hydrological conditions [58,59]. Our analysis of historical sources indicates that *Cicuta virosa* was far more prevalent in the Pannonian Basin prior to the initiation of river regulation and drainage. Subsequent drainage efforts have led to the disappearance or substantial modification of the species' habitats. Historical sources have provided considerable information on the vernacular names of the species, the symptoms, danger, and remedies used, and the extent of damage in cases of poisoning.

In a broader context, it is evident that plant poisonings among livestock and humans occur widely across both spatial and temporal dimensions. Numerous plant species, such as *Conium maculatum* L., *Equisetum palustre* L., *Colchicum autumnale* L., and *Datura stramonium* L., present a significant threat to grazing livestock due to their toxicity [60]. However, members of the genus *Cicuta* and related species are particularly implicated in a high number of severe poisoning cases. This has been observed in case of *Oenanthe crocata* L. in France [61] and the United Kingdom [62]. Comparable toxic effects have been associated with *Oenanthe aquatica* (L.) Poir., which has caused poisonings in grazing cattle in Sweden [63] and Poland [64].

Poisoning incidents linked to *Cicuta virosa* have been extensively documented, particularly in the northern regions of Europe [65]. Carl Linnaeus devoted considerable attention to *Cicuta virosa* in his travelogues, letters, and books [66,67]. The plant was one of 643 species studied for the food preferences of cows, goats, sheep, horses, and pigs [68]. Cases of poisoning in grazing animals, including dairy cattle, beef cattle, and ewes, continue to be reported in areas where *Cicuta virosa* is prevalent, especially in northeastern Germany [69]. Additionally, two closely related species, *Cicuta maculata* L. and *Cicuta douglasii* (DC.) Coult. & Rose, have been responsible for poisoning incidents in North America, affecting both swine and cattle. One such incident in northwestern Utah resulted in the deaths of nine Hereford cows after they ingested *Cicuta maculata* in a streamside habitat. Necropsy revealed stomach contents containing cicutoxin and two other cicutol-like compounds [70]. These observations underscore the continued relevance of plant toxicity in livestock management.

Reports of human poisonings attributed to *Cicuta virosa* have emerged in several countries, including Norway [71], The Netherlands [72], Poland [73], and Sweden [74]. Similarly, *Cicuta maculata* has been implicated in multiple human poisoning cases in North America. One tragic incident involved the fatal poisoning of a 14-year-old boy, who mistakenly identified *Cicuta maculata* as a 'wild carrot' [75]. Children appear to be particularly vulnerable, as evidenced by reports from various parts of the world, including Poland [73], France [76], and the United States [77]. The latter report described an incident in which 17 boys, aged 9 to 13, exhibited symptoms of poisoning. It was later revealed that five of the boys had consumed the root of *Cicuta maculata*, resulting in severe convulsions, while the remaining twelve had ingested only its leaves and flowers.

The lesson of our article is the importance of information in non-academic sources written in local languages (such as daily and weekly newspapers), whose accessibility is increasing dramatically with digitization. In particular, these sources can contribute important information about organisms that have played an important role in the life of humankind (e.g., species used as animal feed or human food or for handicraft production, and poisonous taxa). The challenges associated with processing articles written in national (non-English) languages present difficulties in preparing comprehensive scientific reviews [78]. The importance of non-English-language scientific articles in biological research has been acknowledged by several authors [79,80]. Furthermore, printed media

(e.g., newspapers) and online platforms occasionally contribute to raising awareness of various issues in conservation biology [81,82].

4. Materials and Methods

To investigate the former distribution and local folk knowledge of *Cicuta virosa*, we conducted content analysis using the digital archives of Arcanum [83], Hungaricana [84], and Szaktárs [85]. These archives contain digitized Hungarian-language journals, magazines, dailies, weeklies, courtesy letters, and books. The following search terms were employed: the scientific names of the species (*Cicuta*, *Cicuta virosa*, *Cicuta angustifolia*, *Cicuta linearis*), the official Hungarian name of the species (*gyilkos csomorika*), and various folk names of the species (*csomorika*, *csomorika fű*, *tsomorika*, *mételytorzsa*, *méregbürök*, *vízibürök*, *kony gyökér*, *konygyökér*, *kónyi gyökér*, *kónyigyökér*). For the results obtained, the following data were recorded in an Excel spreadsheet: locality, date, folk names, poisoning incidents, symptoms, number of fatal incidents, antidotes, ethnomedicinal or ethnoveterinary uses, and plant parts consumed or used. Distribution data refer to the records that could be identified with sufficient precision to be placed in the flora mapping grids of the Central European Flora Mapping System [86] and that were not included in the Vascular Plants of Hungary online database [21] and had no data in the collections of the four most important Hungarian herbaria (BP, DE, EGR, BPU) [87–90]. The taxon does not even seem to be reported by archaeobotanical research in Hungary (e.g., see Gyulai [91]).

5. Conclusions

Our study has confirmed our hypothesis that historical digital archives in Hungarian contain substantial information regarding the past distribution and knowledge of the highly poisonous species *Cicuta virosa*. Thus, it can be asserted that digital archives in non-English languages hold significant potential for enhancing ethnobiological and biogeographical knowledge of organism with significant economic and/or cultural significance.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/plants14030315/s1, Table S1: Distribution, ethnomedicinal, and ethnoveterinary information related to *Cicuta virosa* in the archival sources studied. For the complete reference list, please see the main text. References [92–151] are cited in the Supplementary Materials.

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What Was George Forrest's Plant Collection Journey like in China?

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Abstract: Since the 16th century, Western countries have conducted extensive plant collections in Asia, particularly in China, driven by the need to collect botanical resources and foster academic development. These activities have not only significantly enriched the Western botanical specimen collections but have also had a profound impact on the development of related disciplines such as botany, ecology, and horticulture. During this process, a large number of renowned plant hunters emerged, whose discoveries and contributions are still remembered today. George Forrest (1873–1932) was one of these distinguished plant hunters. From 1904 to 1932, he visited China seven times to collect plants and became famous for the regional distinctiveness of the species he collected. However, due to the lack of systematic collection, organization, and analysis of specimens collected by Forrest, only a few species, such as the species *Rhododendron*, are well-known among the many species he introduced to the West. Furthermore, the personal collecting characteristics and the characteristic species collected by Forrest are also not clear. This limits a comprehensive understanding of the specimen collection history and impact of Forrest in China. Therefore, systematic organization and analysis of Forrest's plant specimens collected in China are crucial to understanding his impact on botanical classification, *Rhododendrons* introduction, global horticulture, and plant propagation. This study aims to systematically organize and analyze the plant specimens collected by George Forrest in China to investigate the family, genus, and species composition of the collected specimens and the seven collection expeditions of Forrest in China, as well as the time and altitude of these collections. Furthermore, it seeks to discuss Forrest's scientific contributions to the global spread of plants, the widespread application of the *Rhododendron*, and his impact on the development of modern gardens, providing a theoretical basis and data reference for related research and professional development. To this end, we extensively consulted important historical literature related to Forrest and systematically collected data from online specimen databases. The conclusions drawn from the available data include 38,603 specimens, with 26,079 collection numbers, belonging to 233 families, 1395 genera, and 5426 species, which account for 48.24%, 32.63%, and 14.17% of the plant families, genera, and species in China, respectively. *Rhododendron* specimens made up 17.20% of the specimens collected in this study. The collection locations cover three provinces or autonomous regions, 11 prefecture-level cities, and 25 counties. Furthermore, we found that Forrest's collections were concentrated in spring and summer, mainly in high-altitude areas, with 135 species found below 1500 m and 3754 species at 1500 m and above. *Rhododendron* specimens were mostly found above 3000 m.

Keywords: specimen collection; *Rhododendron*; plant collection history; ethnobotany

1. Introduction

Western developed countries have extended their research on plant resources far beyond their own borders [1,2], making plant specimens from various national herbaria

important reference materials for botanical research. Plant specimen collection is closely related to ethnobotany, which is concerned not only with the classification and usage of plants but also with the interactions between plants and local cultures, traditional knowledge, and social practices. The collection and study of plant specimens provide an empirical basis for ethnobotany, enabling researchers to gain a deeper understanding of the history of plant usage and cultural significance in specific ethnic cultures and providing important research materials for understanding the corresponding local ethnic cultures. Airy Grasa et al. demonstrated the robustness of pharmaceutical ethnobotanical knowledge in the Catalan region by studying about 6000 plant specimens from the herbarium of Catalan pharmacist and naturalist Francesc Bolòs (1773–1844) and concluded that the historical herbarium is a relevant source of ethnopharmacological information [3]. Ingvar Svanberg et al. explored the folkloric botanical knowledge of Loptuq by studying the plant specimens collected by the Swedish explorer Sven Hedin (1865–1952) in the early 20th century, as well as demonstrating that historical herbarium is of great value in understanding the culture and history of Loptuq [4].

China is recognized as one of the countries with the richest biodiversity [5], and it has seen its plant resources highly valued and widely utilized in Western countries [6]. This phenomenon dates back to the 16th century when Western botanists and collectors began to explore China's abundant plant resources [7]. Over time, this botanical collection craze attracted many Western botanists and collectors to China, where they conducted extensive collection activities, significantly enriching Western botanical studies and making notable contributions to global garden landscapes and biodiversity [8–10]. This process has given rise to a number of renowned plant hunters whose discoveries and contributions are still remembered today [11–13].

George Forrest (1873–1932) was an outstanding botanist and plant hunter born in Falkirk, Scotland. He studied at Kilmarnock Academy and learned some medicinal knowledge of plants and the art of making herbarium specimens from a local pharmacist, which laid a solid foundation for his later work at the herbarium of the Royal Botanic Garden Edinburgh. Forrest played a significant role in the early 20th-century plant collection boom [14]. From 1904 to 1932, he made seven collecting expeditions in China, visiting areas in Yunnan Province, Sichuan Province, and the Tibet Autonomous Region, and over 100 species have been named after him [15], making him one of the most famous plant hunters in the 20th century. Forrest was renowned for collecting species with distinctive regional characteristics, such as those from *Rhododendron*, *Primula*, and *Gentiana*. These species, which have been continuously propagated and bred into new varieties in Western gardens, owe much to his extensive collections in China [16–18].

Forrest was not only a plant collector but also a practitioner of ethnobotany. During Forrest's plant collecting expeditions, he not only traveled deep into the mountains and rivers of Southwest China but also established good relationships with local residents. Through his interactions with them, Forrest not only learned about the local language and customs but also gained first-hand knowledge of the unique plant culture of Southwest China. He provided his local assistants with in-depth training in plant collection and classification, imparting botanical knowledge while assimilating local understanding and use of plants. Years of exploring China gave Forrest a deep insight into the natural geography, biodiversity, and ethnic cultures intertwined with them in Southwest China. The plant specimens he collected not only recorded the botanical diversity of Yunnan and its surrounding regions but also served as a valuable source of ethnobotanical research. These specimens not only reveal the biological characteristics of the plants but also contain a wealth of knowledge about the local people's perception, utilization, and conservation of these plants. Therefore, the study of Forrest's botanical specimens is of inestimable value to the in-depth understanding of botanical culture, history, and the role of plants in the local society in Southwest China.

Although Forrest's collecting activities hold a very important position in the history of botany, existing research on his plant specimen collections in China is scarce and mainly

based on historical literature, lacking substantial data sources for support. There is also a deficiency in research and analysis on factors such as the collection time and altitudes of the plant specimens, which affects the accuracy and comprehensiveness of the studies, limiting our understanding of Forrest's history and impact of plant specimen collection in China [19]. Therefore, there is a need to systematically collect, organize, and study the plant specimens of Forrest in China to fill the gaps in current research. We extensively reviewed important historical literature related to Forrest and utilized online databases of herbarium collections. We employed Python to process data information, visualized the results of his collections, and analyzed his seven expeditions in China, including the species collected, date of collection, regional distribution of the collected plants, and factors related to the habitats, seasons, as well as preferences of the collected species. The study aimed to thoroughly review Forrest's botanical collections in China, explore his contributions to global plant dissemination, assess his impact on modern garden development, as well as provide a theoretical basis and data reference for related research.

2. Data and Methods

2.1. Data Sources

The sources of specimen data for this study are primarily divided into two parts: (1) online databases of collections held by various countries, as detailed in Table 1; (2) literature sources, as detailed in Table 2. The data collection cut-off date was 30 August 2022. A total of 38,603 plant specimen records were collected in this study, with each specimen record containing the collection number, species name, date of collection, place of collection, and some other information from the original collection record.

Table 1. The online sources of collected specimen records.

No.	Country	Herbarium Name	Website	Herbarium Code	Number
1	UK	Royal Botanic Garden Edinburgh	https://data.rbge.org.uk/search/herbarium/ (accessed on 30 August 2022)	E	9566
2	China	Biological Collections of the Chinese Academy of Sciences	http://nbc.ioz.ac.cn/View/Home/Specimen.aspx (accessed on 30 August 2022)	PE	7751
3	USA	Smithsonian National Museum of Natural History	https://collections.nmnh.si.edu/search/botany/ (accessed on 30 August 2022)	US	4208
4	China	Herbarium of Sun Yat-sen University	/	SYS	2240
5	China	South China Botanical Garden Herbarium	http://herbarium.scbg.cas.cn/ (accessed on 30 August 2022)	IBSC	1967
6	UK	The Natural History Museum	https://data.nhm.ac.uk/ (accessed on 30 August 2022)	BM	1857
7	UK	Royal Botanic Gardens, Kew	https://apps.kew.org/herbcat/navigator.do (accessed on 30 August 2022)	K	1564
8	China	Herbarium, Kunming Institute of Botany, Chinese Academy of Sciences	http://groups.kib.cas.cn/kun/ (accessed on 30 August 2022)	KUN	1268
9	France	Muséum National d'Histoire Naturelle	https://www.mnhn.fr/fr/collection-des-plantes-vasculaires (accessed on 30 August 2022)	P	1069

Table 1. *Cont.*

No.	Country	Herbarium Name	Website	Herbarium Code	Number
10	USA	Herbarium of the Arnold Arboretum, Harvard University Herbaria	https://kiki.huh.harvard.edu/databases/specimen_index.html (accessed on 30 August 2022)	A	1014
11	China	Herbarium, School of Life Sciences, Xiamen University	/	AU	284
12	Sweden	Swedish Museum of Natural History	https://herbarium.nrm.se/ (accessed on 30 August 2022)	S	233
13	Nederland	Naturalis Biodiversity Centre, formerly Leiden University	https://bioportal.naturalis.nl/nl/result (accessed on 30 August 2022)	L	165
14	USA	Missouri Botanical Garden Herbarium	https://tropicos.org/specimen/Search (accessed on 30 August 2022)	MO	65
15	China	The Herbarium of Nanjing University	/	N	52
16	USA	William and Lynda Steere Herbarium of the New York Botanical Garden	https://sweetgum.nybg.org/science/vh/ (accessed on 30 August 2022)	NY	45
17	Germany	Botanischer Garten und Botanisches Museum Berlin	https://www.bgbm.org/biodivinf/projects/digitalisierung/default.htm (accessed on 30 August 2022)	B	40
18	China	Herbarium of the Jiangsu Province and Chinese Academy of Sciences, Institute of Botany	/	NAS	31
19	Sweden	Museum of Evolution	https://databas.evolutionsmuseet.uu.se/botanik/home.php (accessed on 30 August 2022)	UPS	31
20	USA	The Botanical Collection at the California Academy of Sciences	https://www.calacademy.org/scientists/botany-collections (accessed on 30 August 2022)	CAS	19
21	Australia	Royal Botanic Gardens Victoria	https://www.rbg.vic.gov.au/science/herbarium/accessing-the-collection/ (accessed on 30 August 2022)	MEL	13
22	China	Lushan Herbarium, Jiangxi Province, Chinese Academy of Sciences	http://lbg.lsbg.cn:88/ (accessed on 30 August 2022)	LBG	8
23	China	Herbarium, College of Life Sciences, Sichuan University	/	SZ	6
24	Norway	Bergen Botanical Garden	https://www.uib.no/en/naturalhistory/148995/herbarium-bg (accessed on 30 August 2022)	BG	5
25	China	Herbarium, Yunnan University	/	YUKU	4
26	China	Herbarium of Northwest Institute of Plateau Biology, Chinese Academy of Sciences	/	HNWP	2
27	China	Herbarium of the Department of Biology, Fudan University	/	FUS	2
28	China	Fujian Normal University	/	FNU	2
29	China	Herbarium, Department of Biology, Peking University	/	PEY	1

Table 1. *Cont.*

No.	Country	Herbarium Name	Website	Herbarium Code	Number
30	China	Herbal Medicine Specimen Museum, School of Pharmacy, Peking University	/	PEM	1
31	China	Herbarium of Guangxi Institute of Botany, Chinese Academy of Sciences	/	IBK	1

Note: Some herbariums did not have official websites, and the related specimen records from these herbariums were accessed through GBIF (https://www.gbif.org/species/search, accessed on 30 August 2022) and iDigBio (https://www.idigbio.org/, accessed on 30 August 2022).

Table 2. The literature sources of collected specimen records.

No.	Literature
1	Plantae Chinenses Forrestianae: Catalogue of all the plants collected by George Forrest during his fourth exploration of Yunnan and eastern Tibet in the years 1917–1919.
2	Plantae Chinenses Forrestianae: Numerical catalogue of all the plants collected by George Forrest during his first exploration of Yunnan and eastern Tibet in the years 1904, 1905, 1906 (Nos. 1–1120).
3	Plantae Chinenses Forrestianae: Numerical catalogue of all the plants collected by George Forrest during his first exploration of Yunnan and eastern Tibet in the years 1904, 1905, 1906 (Nos. 1121–2757).
4	Plantae Chinenses Forrestianae: Numerical catalogue of all the plants collected by George Forrest during his first exploration of Yunnan and eastern Tibet in the years 1904, 1905, 1906 (Nos. 2758–4481).
5	Plantae Chinenses Forrestianae: Numerical catalogue of all the plants collected by George Forrest during his first exploration of Yunnan and eastern Tibet in the years 1904, 1905, 1906 (Nos. 4482–5099).
6	Plantae Chinenses Forrestianae: Catalogue of all the plants collected by George Forrest during his fourth exploration of Yunnan and eastern Tibet in the years 1917–1919: 001–148.
7	Plantae Chinenses Forrestianae: Catalogue of all the plants collected by George Forrest during his fourth exploration of Yunnan and eastern Tibet in the years 1917–1919: 147–406.
8	Plantae Chinenses Forrestianae: Catalogue of the plants (excluding *Rhododendron*) collected by George Forrest during his fifth exploration of Yunnan and eastern Tibet in the years 1921–1922.
9	Plantae Chinenses Forrestianae: Catalogue of the species arranged in alphabetical order.
10	Plantae Chinenses Forrestianae: Catalogue of the species arranged in natural orders.
11	Plantae Chinenses Forrestianae: Catalogue of the species arranged in natural orders (continued).

2.2. Data Processing

2.2.1. Preprocessing

To address inconsistencies in data sources, formats, and completeness, we used a combination of Python programming and manual processing for data preprocessing. The original specimen collection records contained non-standardized date entries such as "19050800", "15-Nov-05", "1906/2/9", and so on. To standardize date formats, we first reviewed the collection dates in the specimen data, converting various record formats into corresponding regular expressions for extracting the year, month, and day, and standardized the dates to the 'year/month/day' format. For date formats that the program could not automatically process, we manually standardized these dates. Similarly, the original altitude records were not standardized, with entries like "6000 to 7000 ft", "6000–7000 ft", "9–10,500 ft", and so on. For the automated processing of altitude data, we adopted a similar approach: first reviewing the specimen data for collection altitudes, converting various record formats into corresponding regular expressions for extracting altitude data, and converting the altitudes to meters in a standardized format. For altitude data that the program could not automatically extract and process, we manually handled the extraction

and processing of these altitudes. These unextractable altitude data often stemmed from spelling errors in the original records, such as '0' being written as the letter 'o', which significantly increased the difficulty of data preprocessing.

2.2.2. Scientific Name Verification

In order to verify the scientific names of the specimen data, we used the plant name verification function provided by iPlant (https://www.iplant.cn/pnc, accessed on 3 December 2023) along with the World Checklist of Selected Plant Families (https://wcsp.science.kew.org/, accessed on 3 December 2023) to determine the most up-to-date taxonomic scientific names of the specimens. The plant name verification function provided by iPlant includes three modes: iPlant Name Standardization, Catalogue of Life China (CoL-China) 2022 Annual Checklist, and Global Botanical Nomenclature Verification. To ensure the accuracy and completeness of the scientific name verification as much as possible, we used these three modes in order during the verification process and supplemented them with the World Checklist of Selected Plant Families.

2.2.3. Recoding Collection Numbers

Since different collections might have dissimilar identification results for the specimens with the same collection number, this study adhered to the following principles to finalize the identification results of specimens of the collection number:

a. If the collection number existed in both the online data and the original literature, the latest identification results (family, genus, species) of the online herbarium and other specimen information (time and location) in the original literature were retained;
b. If there were multiple specimens with the same collection number but different identification results, we followed the principle of majority rule, combining with the specimen information and expert judgment to prioritize the identification result that had the highest number of consistent identifications across different specimens, and assigned the same new collection number to these specimens. If it was not possible to determine the final result based on the majority rule, then we assigned different new collection numbers to these specimens in sequence.

2.2.4. Collection Date

Since the specimen data from herbaria was obtained through the recognition of Forrest's original handwritten information, errors inevitably occurred in this process. For some clearly erroneous or unrecognizable collection dates, we attempted to correct or complete them based on some reasonable rules. Specifically, if the collection date of a specimen was obviously outside the range of Forrest's collecting years, we identified it as an incorrect collection date. We then corrected it based on the collection dates of other specimens with the same collection number, following the principle of majority rule. If the majority of collection dates for specimens with the same collection number were the same, we used this collection date to correct the erroneous collection date, thus ensuring the accuracy of the data. For specimens whose collection dates could not be effectively recognized, we completed them following the same principles, thereby further enhancing the completeness of the data.

2.2.5. Collection Location

To analyze the routes and areas covered by the specimen collected by Forrest, we needed to extract the location descriptions from the original records of the specimens, which were written in the Wade–Giles system. Since the spelling of location names often incorporated dialects and were non-standard, this presents considerable challenges in verifying location names, necessitating the use of information from multiple sources. The primary sources for this study include *The Place Name of Chinese Plant Collection* [20] and internet searches. For specimens whose location names could not be extracted, we determined the specific locations of the specimens based on the latitude and longitude

information from the original records. Subsequently, we further investigated changes in the administrative divisions of China, comparing ancient maps from the literature [21] with current administrative maps to definitively determine the municipal affiliation of the collection locations. Once the location names were established, they were combined with the number of specimens collected from each location and a region heatmap of the collected specimen number (Figure 1) was created.

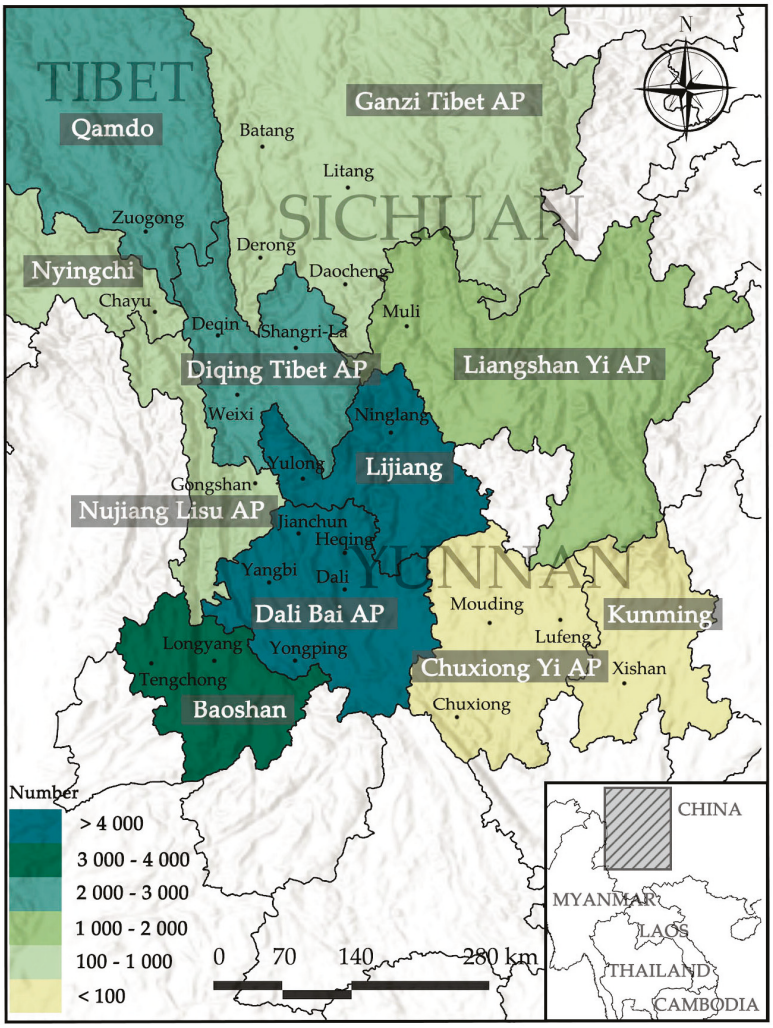


Figure 1. Distribution map of the collected specimen number. (AP: Autonomous Prefecture, the color on the distribution map represents the number of specimens collected by Forrest and his team, with darker color indicating a higher number of collected specimens.).

3. Results of Analysis of Forrest's Specimen Collection Activities

3.1. Taxonomic Composition

3.1.1. Family, Genus, and Species

According to the collected data, there are 38,492 identified plant specimens belonging to 233 families. In terms of the number of collected specimens (Table 3), the top 10 families are Ericaceae (7426 specimens), Rosaceae (2672 specimens), Asteraceae (2294 specimens), Primulaceae (2031 specimens), Orchidaceae (1640 specimens), Fabaceae (1288 specimens), Ranunculaceae (1200 specimens), Lamiaceae (799 specimens), Gentianaceae (682 specimens), and Papaveraceae (595 specimens). Looking at the number of species collected (Table 4), the top 10 families are Asteraceae (478 species), Rosaceae (335 species), Ericaceae (323 species), Fabaceae (230 species), Orchidaceae (229 species), Lamiaceae (205 species), Primulaceae (178 species), Ranunculaceae (173 species), Gentianaceae (116 species), and

Orobanchaceae (108 species). It is evident that, whether from the perspective of the number of specimens or the number of species collected, Forrest's collection obviously favored species with ornamental value, such as those from Ericaceae, Rosaceae, and Asteraceae.

Table 3. Top 10 families with the most collected specimens.

No.	Family	Number of Specimens	Percentage
1	Ericaceae	7426	19.29
2	Rosaceae	2672	6.94
3	Asteraceae	2294	5.96
4	Primulaceae	2031	5.28
5	Orchidaceae	1640	4.26
6	Fabaceae	1288	3.35
7	Ranunculaceae	1200	3.12
8	Lamiaceae	799	2.08
9	Gentianaceae	682	1.77
10	Papaveraceae	595	1.55

Table 4. Top 10 families with the most collected species.

No.	Family	Number of Species	Percentage
1	Asteraceae	478	8.81
2	Rosaceae	335	6.17
3	Ericaceae	323	5.95
4	Fabaceae	230	4.24
5	Orchidaceae	229	4.22
6	Lamiaceae	205	3.78
7	Primulaceae	178	3.28
8	Ranunculaceae	173	3.19
9	Gentianaceae	116	2.14
10	Orobanchaceae	108	1.99

According to the collected data, there are 38,440 identified plant specimens belonging to 1395 genera. In terms of the number of collected specimens (Table 5), the top 10 genera by collection number are *Rhododendron* (6640 specimens), *Primula* (1488 specimens), *Cotoneaster* (425 specimens), *Gentiana* (419 specimens), *Saxifraga* (373 specimens), *Euonymus* (363 specimens), *Meconopsis* (346 specimens), *Pedicularis* (345 specimens), Sorbus (339 specimens), and *Rubus* (338 specimens). In terms of the number of collected species (Table 6), the top 10 genera are *Rhododendron* (242 species), *Primula* (103 species), *Pedicularis* (85 species), *Gentiana* (70 species), *Saussurea* (67 species), *Saxifraga* (63 species), Rubus (51 species), *Cotoneaster* (51 species), *Corydalis* (41 species), and *Ligularia* (39 species). It is evident that Forrest had a particular interest in flowering plants such as those from the *Rhododendron*, *Primula*, and *Gentiana*, which can be extensively used in horticulture.

According to the collected data, there are 36,336 identified plant specimens belonging to 5426 species. In terms of the number of collected specimens (Table 7), the top 10 species by collection number are *Rhododendron rupicola* (204 specimens), *Rhododendron beesianum* (145 specimens), *Rhododendron fulvum* (135 specimens), *Rhododendron primuliflorum* (128 specimens), *Rhododendron roxieanum* (121 specimens), *Rhododendron anthosphaerum* (119 specimens), *Rhododendron wardii* (113 specimens), *Rhododendron haematodes subsp. chaetomallum* (99 specimens), *Rhododendron adenogynum* (98 specimens), and *Rhododendron racemosum* (97 specimens). It is evident that Forrest frequently collected the species he favored, particularly various species of *Rhododendron*.

Table 5. Top 10 genera with the most collected specimens.

No.	Genus	Number of Specimens	Percentage
1	*Rhododendron*	425	17.10
2	*Primula*	419	3.83
3	*Cotoneaster*	373	1.09
4	*Gentiana*	363	1.08
5	*Saxifraga*	346	0.96
6	*Euonymus*	345	0.93
7	*Meconopsis*	339	0.89
8	*Pedicularis*	338	0.89
9	*Sorbus*	425	0.87
10	*Rubus*	419	0.87

Table 6. Top 10 genera with the most collected species.

No.	Genus	Number of Specimens	Percentage
1	*Rhododendron*	242	4.46
2	*Primula*	103	1.90
3	*Pedicularis*	85	1.57
4	*Gentiana*	70	1.29
5	*Saussurea*	67	1.23
6	*Saxifraga*	63	1.16
7	*Rubus*	51	0.94
8	*Cotoneaster*	51	0.94
9	*Corydalis*	41	0.76
10	*Ligularia*	39	0.72

Table 7. Top 10 species with the most collected specimens.

No.	Species	Number of Specimens	Percentage
1	*Rhododendron rupicola*	204	3.76
2	*Rhododendron beesianum*	145	2.67
3	*Rhododendron fulvum*	135	2.49
4	*Rhododendron primuliflorum*	128	2.36
5	*Rhododendron roxieanum*	121	2.23
6	*Rhododendron anthosphaerum*	119	2.19
7	*Rhododendron wardii*	113	2.08
8	*Rhododendron haematodes* subsp. *chaetomallum*	99	1.82
9	*Rhododendron adenogynum*	98	1.81
10	*Rhododendron racemosum*	97	1.79

3.1.2. Species Composition of Main Genera

Among the specimens collected by Forrest, the main genera with higher numbers and greater influence on later generations are *Rhododendron*, *Primula*, *Gentiana*, and *Cotoneaster*. Forrest collected 242 species of *Rhododendron*, among which there is only 1 species with over 200 specimens, accounting for 0.42% of the *Rhododendron* species, and 6 species with 100–199 specimens, making up 2.47% (Table 8). He collected 103 species of *Primula*, with 4 species having 40 or more specimens, representing 3.88% of the *Primula* species, and 9 species with 30–39 specimens, accounting for 8.74% (Table 9). Seventy species of *Gentiana* were collected by him, with two species having over 20 specimens, comprising 2.85% of the *Gentiana* species, and nine species with 10–19 specimens, representing 12.86% (Table 10). In addition, Forrest collected 45 species of *Cotoneaster*, with 8 species having over 20 specimens,

making up 17.78% of the *Cotoneaster* species, 6 species with 10–19 specimens, representing 13.33%, and 31 species with 1–9 specimens, accounting for 68.89% (Table 11).

Table 8. Species composition of collected specimens of *Rhododendron*.

Number of Specimens	Number of Species	Percentage
≥200	1	0.42
100–199	6	2.47
50–99	30	12.40
1–49	205	84.71
Total	242	100.00

Table 9. Species composition of collected specimens of *Primula*.

Number of Specimens	Number of Species	Percentage
≥40	4	3.88
30–39	9	8.74
20–29	12	11.65
10–19	27	26.21
1–9	51	49.52
Total	103	100.00

Table 10. Species composition of collected specimens of *Gentiana*.

Number of Specimens	Number of Species	Percentage
≥20	2	2.85
10–19	9	12.86
1–9	59	84.29
Total	70	100.00

Table 11. Species composition of collected specimens of *Cotoneaster*.

Number of Specimens	Number of Species	Percentage
≥20	8	17.78
10–19	6	13.33
1–9	31	68.89
Total	45	100.00

3.2. Collection Expeditions

In this section, we will analyze the regions, time, and altitudes involved in the seven collecting expeditions of Forrest and his team by combining previous literature studies and corroborating with specimen information. It is important to note that Forrest rarely distinguished between plants he collected himself and those collected by his team. For example, the same plant species collected on the same day might be recorded as being collected in Tengchong (Teng Yueh) and another in Lijiang (Lichiang), likely because these specimens were collected by different people. Therefore, it is almost impossible to determine Forrest's exact collection routes; we can only attempt to reconstruct the areas he visited as accurately as possible. Dr. J. Macqueen Cowan of the Royal Botanic Garden Edinburgh reviewed nearly all specimens and marked on a map the areas Forrest collected from during each expedition. The results indicate that Forrest preferred to repeatedly collect in important areas to avoid missing crucial information. Our data collection shows the same conclusions. Furthermore, a significant portion of Forrest's sponsors had an interest in or requested the collection of *Rhododendrons*, making the collecting of *Rhododendrons* one of Forrest's primary tasks.

3.2.1. Collection Location

As can be seen from the distribution map (Figure 1), the areas where Forrest and his team collected plant specimens were mainly concentrated in the northwestern part of Yunnan Province, the southeastern part of the Tibet Autonomous Region, and the southern part of Sichuan Province. Among the specimen data collected for this study, specimens that could be pinpointed to a specific city based on original location records totaled 18,210, with the Dali Bai Autonomous Prefecture in Yunnan having 5012 specimens, which is the highest collected specimen data and Lijiang City having 4943 specimens. Other areas included Baoshan City with 3230 specimens, Diqing Tibetan Autonomous Prefecture with 2147 specimens, Nujiang Lisu Autonomous Prefecture with 253 specimens, Kunming City with 77 specimens, and Chuxiong Yi Autonomous Prefecture with 62 specimens. In Sichuan Province, Liangshan Yi Autonomous Prefecture had 1015 specimens. In the Tibet Autonomous Region, Nyingchi City had 635 specimens, and Qamdo City had 2626 specimens. In addition, the distribution map reveals that the number of specimens collected in the northwestern region is significantly higher than in other areas. The terrain of Yunnan slopes from high in the northwest to low in the southeast, descending gradually in a stair-step fashion from north to south. In the descriptions of specimen locations, Forrest often mentioned mountains, indicating that he frequently revisited higher-altitude areas in the northern region for specimen collection. This may also be related to the natural distribution of *Rhododendrons*, as Forrest noted that the variety of *Rhododendrons* increased towards the northwest. Thus, while fulfilling his sponsors' tasks of collecting *Rhododendron* species, this process also allowed him to gather a large number of alpine flowers, including species from the *Primula* and *Gentiana*.

Forrest's first collecting expedition spanned from May 1904 to April 1907, funded by Bees Ltd. (Cheshire, UK), the company of Arthur Kilpin Bulley. The specimens collected during this period were numbered 1–5498, and according to the data statistics, this study has collected 3957 specimen data within this timeframe. In May 1904, Forrest embarked on a cruise through the Suez Canal and Bombay, India, heading to Yangon, Myanmar. He arrived in Bhamo, Myanmar, in early July, traversed the high mountains and gorges between the Salween-N'Mai-hka (known as Nu River in China) and the Mekong River, and reached Tali-fu (including Dali, Eryuan, and Xianyun) by the end of August. In September, he traveled from Songgui (Sung Kwei) to Shangri-La (Chungtien), then crossed the Yangtze River, traversed the watershed between the Mekong and the Yangtze, and arrived at the alpine pasture of Fugong (Fu-kung). He then headed north to Cikai (Tsekou). In April 1905, he arrived in Cikai and collected for a week on the mountain 19 km northwest. In July, due to an uprising, he fled south along the west bank of the Mekong River to Weixi (Wei His), where he lost a lot of his findings along the way. In October, Forrest set out from Tengchong to collect in the upper reaches of the Nu River, crossed the watershed of the Nmai Kha-Shweli River, reached the Nujiang Lisu Autonomous Prefecture, then arrived at the watershed between the Nu River and the Mekong River, and continued westward through the Nu River valley for further collection, all the way to the source of the Longchuan River. It was difficult to find local guides to provide accurate routes and distances due to the war during this period. In March 1906, Forrest unfortunately fell ill, but his assistant continued to collect near Jade Dragon Snow Mountain, and after his recovery, he continued to collect in the Cangshan (Tsang-shan) and Jade Dragon Snow Mountain area. In 1907, Forrest returned to England, and during this journey, he met his lifelong assistant Zhao Chengzhang (Figure 2), who would help Forrest in leading the team for plant specimen collection. According to the specimen information, in addition to the locations mentioned above, Forrest or his assistants also visited Kunming City, Chuxiong Yi Autonomous Prefecture in Yunnan Province, Liangshan Yi Autonomous Prefecture, and Ganzi Tibetan Autonomous Prefecture in Sichuan Province, as well as Qamdo City in the Tibet Autonomous Region.



Figure 2. Forrest and his chief collector Zhao Chengzhang. Source: https://stories.rbge.org.uk/archives/14188 (accessed on 20 April 2024).

The second collecting expedition spanned from November 1910 to March 1911, also funded by Bees Ltd. (Cheshire, UK), the company of Arthur Kilpin Bulley. The plant specimens collected during this period were numbered from 5499 to 7401, and our study gathered data on 2677 specimens from this period. In 1910, Forrest departed from Liverpool, headed for Yangon, and reached Tengchong. He collected in the area around the watershed between the Ruili River (Shweli River) and the Nu River. In May of the same year, he encountered a memorable *Rhododendrons* bloom in Songgui and collected a large number of *Rhododendron* specimens. Additionally, the specimen information indicates that he or his assistants also reached Nyingchi City and Qamdo City in the Tibet Autonomous Region.

The third collection period was from February 1912 to March 1915. This expedition was funded by John Charles Williams, who provided Forrest with an annual salary of 500 pounds to collect plants in Yunnan for three years. The specimens collected during this period were numbered from 7402 to 13,598. Our study gathered data on 8248 specimens from this period. In February 1912, Forrest traveled from Bhamo towards Tengchong. At this time, China was undergoing a democratic revolution. In early May, Forrest and his assistants freely collected near the watershed between the Nu River and the Longchuan River, and by August 31, when an armed revolution broke out in China, they had already collected more than 1700 different plant species. In early September, he retreated to Myanmar from Tengchong to avoid the turmoil, but his assistants continued the collection. In early 1913, Forrest returned to Yunnan and conducted collections in the mountains near Dali and Lijiang. This time, he increased the number of assistants, who were dispersed throughout Yunnan to collect, significantly enhancing the efficiency of the collection. Four were at the Nu River–Longchuan River watershed, two near the Cangshan, two to four in the Zhongdian mountains 190 km northwest, and Forrest, with the remaining eight, went to the northwest of the Jade Dragon Snow Mountain. In early January 1914, Forrest returned to Tengchong to collect and sent assistants to collect upstream of the Mekong River and Baima Shan (Beima Shan), subsequently shipping back over 6000 plant specimens to England. In early January 1915, Forrest returned to England from Yangon. According to the specimen data, during this collection period, Forrest's team also reached places

including the Nujiang Lisu Autonomous Prefecture in Yunnan Province, the Liangshan Yi Autonomous Prefecture, and the Ganzi Tibetan Autonomous Prefecture in Sichuan Province, and Qamdo City and Nyingchi City in the Tibet Autonomous Region.

The fourth collection period was from January 1917 to March 1920, funded by 12 institutions or individuals. The specimens collected during this period were numbered from 13,599 to 19,333, and our study gathered data on 7569 specimens from this period. Forrest departed from Liverpool to Yunnan, establishing a collection base centered north of Cikai. He dispatched assistants to the surrounding areas, thoroughly collecting from two important regions: one was north of Chu-la at the Mekong–Salween watershed, and the other one was on the Baima Shan located at the Mekong–Yangtze watershed. This expedition collected a large number of *Rhododendrons*, and the collected materials were shipped back to England in August 1918. Unfortunately, an accident occurred during the journey, resulting in the loss of a substantial amount of materials. According to the specimen information, during this collection period, Forrest's team also reached the Dali Bai Autonomous Prefecture, Baoshan City, and Lijiang City in Yunnan Province; Liangshan Yi Autonomous Prefecture, and Ganzi Tibetan Autonomous Prefecture in Sichuan Province; and Qamdo City and Nyingchi City in the Tibet Autonomous Region.

The fifth collection period spanned from January 1921 to March 1923, funded by Williams and Reginald Cory in England. The specimens collected during this period were numbered from 19,334 to 23,258, and our study gathered data on 4841 specimens from this period. During his collecting process heading west, Forrest crossed the watershed between the Nu River and the Dulong River. During his collecting process heading north, Forrest followed the watershed between the Mekong and Nu Rivers, passing through Eryuan, Heqing (Hoching), Weixi, Shangri-La, Muli, Lijiang, and Yongbei (Yung-Pei). Forrest returned to England in March 1923, and during his time in England, his collection team continued their work, with many specimens collected in Jianchuan (Chien Chuan). According to the specimen information, Forrest's team during this collection period also reached Baoshan City in Yunnan Province, Ganzi Tibetan Autonomous Prefecture in Sichuan Province, and Nyingchi City and Qamdo City in the Tibet Autonomous Region.

The sixth collection period spanned from January 1924 to March 1926, with the initial funding for the expedition to China provided by Bulley and Williams. The specimens collected during this period were numbered from 24,000 to 27,833, and our study gathered data on 3780 specimens from this timeframe. Forrest traveled through the watersheds between the Nu River and the N'Mai Kha River, as well as between the Lancang River and the Nu River. In 1929, in Forrest's absence, his team collected several hundred specimens near the Lijiang Range, with collection numbers from 27,834 to 28,361. By late September 1929, Forrest's team had collected over 400 varieties of dried plant specimens. According to the specimen information, during this collection period, Forrest's team also reached the Dali Bai Autonomous Prefecture, Baoshan City, Lijiang City, Diqing Tibetan Autonomous Prefecture, and Nujiang Lisu Autonomous Prefecture in Yunnan Province, as well as Nyingchi City and Qamdo City in the Tibet Autonomous Region.

The last collection period was from November 1930 to January 1932, which also marked the most heavily funded of Forrest's seven expeditions in China, with support from 39 individuals or institutions. The specimens collected during this period were numbered from 28,362 to 31,015, and our study gathered data on 1634 specimens from this timeframe. The main objective of this collection was to find plants that had been missed in previous expeditions; thus, Forrest revisited the aforementioned areas. According to the specimen information, during this collection period, Forrest's team reached the Dali Bai Autonomous Prefecture, Baoshan City, Lijiang City, Diqing Tibetan Autonomous Prefecture in Yunnan Province; Liangshan Yi Autonomous Prefecture, Ganzi Tibetan Autonomous Prefecture in Sichuan Province; and Changdu City in the Tibet Autonomous Region. In 1931, Forrest discovered a giant Rhododendron in the forests of the Gaoligong Mountains in Tengchong, Yunnan (Datang Village, Jietou Township, north of Tengchong), which was 25 m tall, 87 cm in diameter, and approximately 280 years old. He instructed his assistants to cut it down and

secretly removed a disk from near the base as a trunk specimen (Figure 3). This specimen caused a sensation in the botanical community at the time. *Rhododendron protistum* var. *giganteum* is considered one of the species in Rhododendron with the largest tree form and flowers in the world, which also earned Forrest the title of "King of the Rhododendrons". On 5 January 1932, he passed away unexpectedly during a plant collection trip, and his body was buried in Tengchong.



Figure 3. Forrest's collectors were cutting up the massive *Rhododendron*. Source: https://stories.rbge.org.uk/archives/14186 (accessed on 20 April 2024).

3.2.2. Collection Time

As can be seen from Figure 4 and Table 12, the fourth collection had the highest number of plant specimens, and the third and fourth collections had the largest number of species. The collection of *Rhododendrons* was also the most abundant in the fourth collection. In fact, it was on the basis of this collection that Professor Balfour revised the taxonomy of *Rhododendron*. Additionally, the bar chart reveals that the number of specimens collected in summer and autumn is significantly higher than in other seasons. This may be due to the climate in the Yunnan region being more suitable for plant growth during the summer and autumn seasons, facilitating the efficient collection activities of the collectors, and the natural flowering period of *Rhododendron* being from April to June. Winter saw the fewest collections due to harsh climates in high-altitude areas. The line chart indicates a significant gap between the number of specimens and the Collection ID during the third collection. This may be due to the outbreak of war in China during that time, which led to a shift in the collection method to a decentralized approach by the team, coupled with a substantial increase in the number of assistants. This resulted in the chaos of collecting multiple duplicate specimens of the same species.

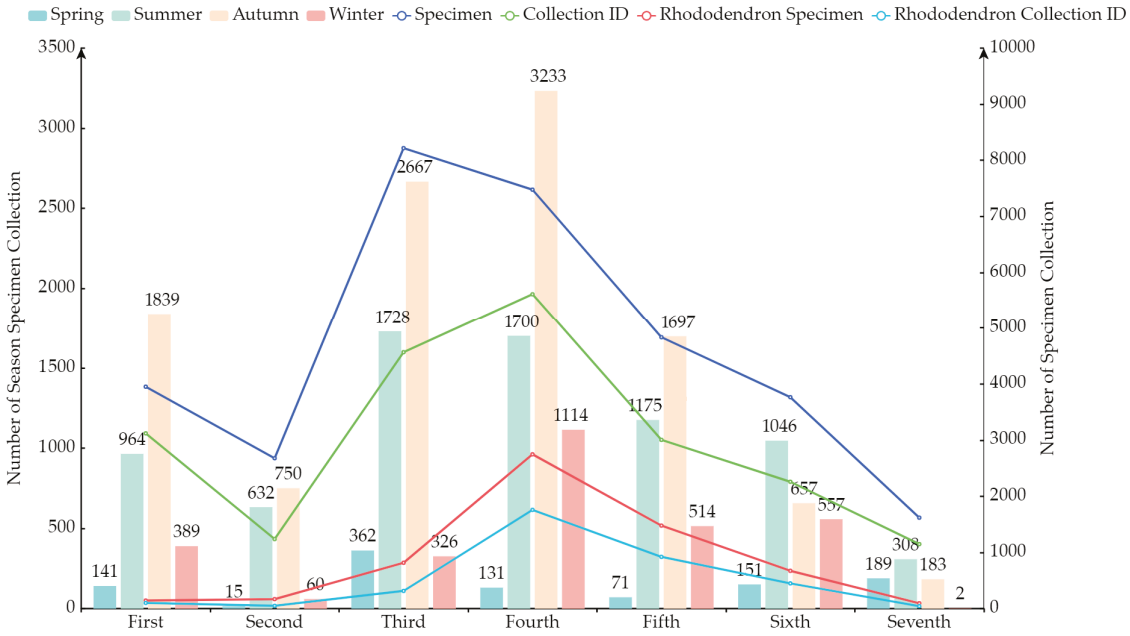


Figure 4. Number of specimens collected in seven collecting expeditions and their seasonal distribution. (Collection ID refers to the new collection number assigned to the plant specimens after recoding).

Table 12. Proportion of collected species during the seven expeditions.

Time	Number of Species	Percentage
First	1622	29.89%
Second	700	12.90%
Third	1991	36.69%
Fourth	1959	36.10%
Fifth	1127	20.77%
Sixth	918	16.19%
Seventh	399	7.35%
Others (Missing/Incorrect date)	3993	73.59%
Total	5426	100.00%

3.2.3. Collection Altitude

As shown in Figure 5, Forrest collected the highest number of specimens in high-altitude areas in summer. The line chart in Figure 6 indicates that the number of plant specimens collected begins to significantly increase between altitudes of 2000 and 3500 m, reaching a maximum of 3975 specimens in the altitude range of 3000–3500 m. According to the specimen data collected in this study, there are 15,114 specimens with verifiable altitude data. Among these, 135 species were collected from altitudes below 1500 m, with the top 10 species by number of specimens being *Ponerorchis monantha* (10 specimens), *Bulbophyllum amplifolium* (4 specimens), *Flemingia strobilifera* (4 specimens), *Synotis saluenensis* (3 specimens), *Lycium chinense* (3 specimens), *Ainsliaea fulvipes* (3 specimens), *Chamaegastrodia inverta* (3 specimens), *Camphora tenuipilis* (3 specimens), *Hiptage acuminata* (3 specimens), and *Cleisostoma racemiferum* (3 specimens). Species collected from altitudes of 1500 m and above total 3754, with the top 10 species by number of specimens being *Rhododendron rupicola* (76 specimens), *Rhododendron beesianum* (71 specimens), *Rhododendron primuliflorum* (63 specimens), *Rhododendron fulvum* (54 specimens), *Rhododendron anthosphaerum* (53 specimens), *Rhododendron phaeochrysum* var. *levistratum* (52 specimens), *Rhododendron heliolepis* (48 specimens), *Euonymus frigidus* (48 specimens), *Rhododendron roxieanum* (42 specimens), and *Rhododendron aganniphum* (42 specimens).

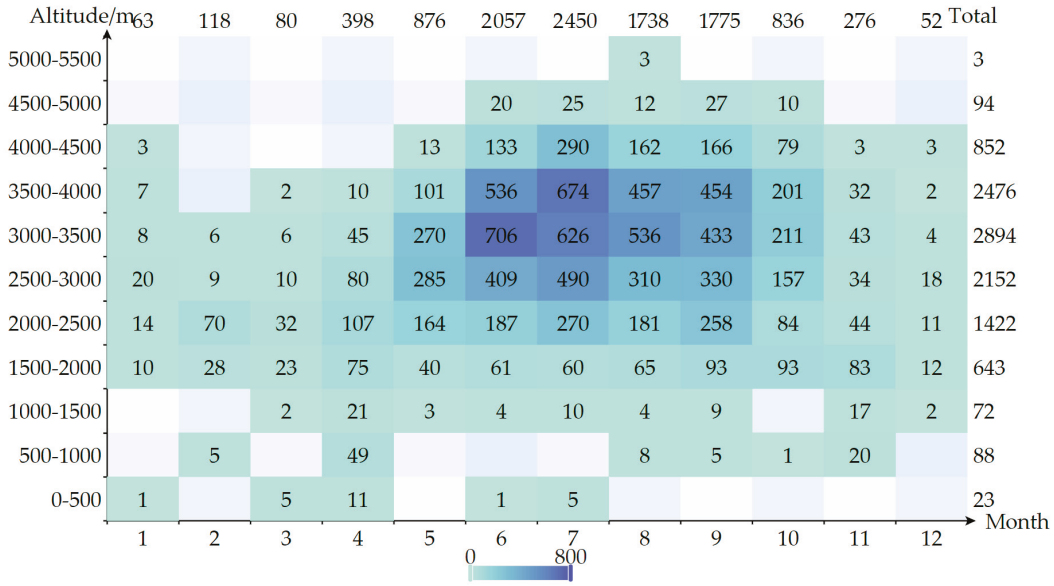


Figure 5. Altitude–Month Heatmap of specimen number.

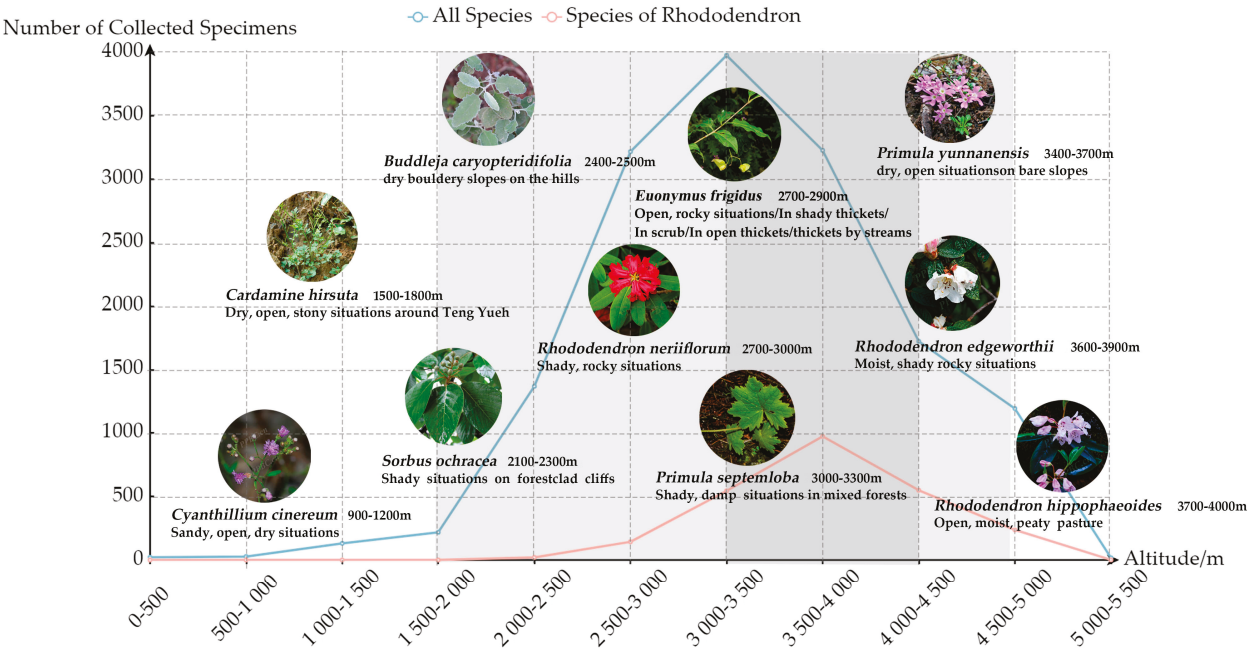


Figure 6. Plant altitude and habitat analysis.

The number of *Rhododendron* specimens collected from altitudes below 3000 m is 268, while those collected from altitudes of 3000 m and above total 2136. Forrest recorded that Above 1500 m, *Rhododendrons* occurred as isolated specimens or small groups growing in thickets and forests of mixed dicotyledonous shrubs and trees, gradually increasing in numbers up to 3500–4500 m, at which point they formed the dominant feature in the vegetation either as undergrowth in the forests of conifers or by themselves as dense thickets and forests. In a lecture that Forrest delivered to the members of the *Rhododendron* Society in 1920, he mentioned that except for *Rhododendron griersonianum* and *Rhododendron spinuliferum*, nearly all *Rhododendrons* in natural conditions were social plants, with isolated *Rhododendrons* being rare. In an environment where one species does not entirely dominate a situation, several or many have apparently adapted themselves to the environment for the necessary mutual protection. It was especially evident in some of the deeper side

valleys of such a range as the Cangshan, where *Rhododendron brachyanthum*, *Rhododendron neriiflorum*, *Rhododendron haematodes*, and others luxuriated in the shade. Additionally, the further north or northeast, and the higher altitude, the greater the number of species. As Forrest moved northwest, he found more and increasingly magnificent *Rhododendrons*, leading him to develop a theory since 1912 that was, the real home of the *Rhododendrons* was the high alpine region on the Tibetan frontier, which formed the basins and watersheds of the Salween, Mekong, and Yangtze. There, somewhere about 98–101° E and 25–31° N, the *Rhododendrons* reached their optimum. The data in this study show that the collected *Rhododendron* specimens were also concentrated between 3000 and 5000 m, indicating that *Rhododendron* specimens collected by Forrest in the high-altitude range were particularly rich. With a few exceptions like *Rhododendron racemosum*, *Rhododendron lepidotum*, and *Rhododendron decorum*, most *Rhododendrons* exhibited distinct locality in terms of latitude, longitude, and altitude. Among the species found in the Yangtze River basin, only a few were common in the Mekong or Salween River basins, and vice versa. Additionally, in Forrest's records, there are some descriptions of the collection environment (Figure 6) that provide valuable references for studying the living environment and habits of the species collected before.

Additionally, Forrest's fewer collections at lower altitudes may be related to Yunnan's unique terrain. The upstream valleys above 3500 m in Yunnan had relatively large undulations and were easily accessible once a sufficient altitude is reached, whereas the downstream valleys were rugged gorges. Forrest mentioned in his notes that collecting plants in upstream valleys might be quite straightforward, but traveling from one watershed to another could take several days.

4. Discussion

4.1. The Excellence of Forrest

As a plant collector, Forrest's achievements stand out in several aspects, and his work not only advanced botany but also had a profound impact on the fields of horticulture, ecology, and plant conservation. Statistical analysis from the collected specimens shows that there are 115 species named after George Forrest (Supplementary Materials). Even more remarkable is the fact that species collected by Forrest received the Award of Merit (AM) from the Royal Horticultural Society (RHS) 49 times, involving 726 specimens in this study. In addition, those species collected by Forrest have received the First Class Certificate (FCC) from RHS 12 times, involving 303 specimens. These impressive numbers not only demonstrate the widespread recognition of his collecting work but also serve as strong evidence of his outstanding contributions to the field of botany.

Compared to other collectors, Forrest's collection work was primarily concentrated in Yunnan and its surrounding areas. This geographically focused strategy reflects his in-depth study of plant diversity and efficient collection in specific regions [22–24]. The Yunnan region, with its unique geographical and climatic conditions, is rich in plant resources, especially species of *Rhododendron*. Forrest's focused collection here showcases his professional skills in identifying and collecting rare plants [25–27]. His collection activities not only enriched the botanical knowledge base but also raised awareness and conservation efforts for endemic plants in the region, providing a crucial basis for plant conservation work. By conducting in-depth collections in specific areas, Forrest was able to frequently revisit and monitor the growth conditions of plants, obtaining more accurate data and high-quality specimens, thereby also advancing local botanical research and laying the foundation for later ecological conservation and sustainable use.

Furthermore, Forrest not only excelled in the practice of plant collecting but also showed innovation and foresight in the methods of introduction. He pioneered the integration of commercial approaches into the field of plant collecting, a transformation that not only brought new funding sources for plant research but also set a new standard for the business model of plant collecting [28]. At that time, plant collectors typically relied on sponsorship from scientific associations or government departments, but Forrest was able

to attract support from individuals and private institutions, reflecting his influence in the botanical community and the appeal of his collecting work. His collecting activities were funded by more than 50 institutions or individuals, which was an unprecedented achievement at that time. It not only indicates that his collecting work was widely recognized but also suggests that his collecting strategies and outcomes held significant value for the botanical and horticultural communities [29,30]. Forrest's innovative spirit and fundraising capabilities are an important mark of his status as an excellent plant collector and provide a new mode of collecting work and funding sources for subsequent plant collectors.

4.2. Collecting Preferences and the Value of Journey Recording

From the data analyzed in this study, it can be seen that Forrest preferred to collect plant specimens during the mild spring and summer seasons and primarily focused on high-altitude areas ranging from 2500 to 5000 m. In his early collections, he chose a wide variety of plants but gradually began to pay more attention to trees and shrubs, especially the species of *Rhododendron*, *Primula*, and *Gentian*. He had a particular preference for flowering species with bright colors, and he used to collect multiple specimens of the same species, which were repeatedly collected at the same locations to carefully prevent the omission of important information. In addition, the assistants he dispatched were professionally trained, which also contributed to the completeness and professionalism of his collection work. Therefore, excluding herbaceous and mossy families with inconspicuous flowers or native plants from warmer regions below 1500 m, Forrest collected flowering plants from almost all the regions he visited. In addition, we find that Forrest's collecting seems to favor plant species with high ornamental properties. Such collecting preference was not only driven by Forrest's personal preferences but rather based on an awareness of the potentially great economic value of the newly discovered ornamental plant species in the horticultural industry. The discovery of new ornamental plant species can stimulate widespread interest and demand in the market, thus having a profound impact on the horticultural business sector. Forrest's collecting preference was also closely linked to his funding sources. Since his collection activities were primarily sponsored by garden owners and horticultural businesses, his efforts naturally tended to focus on ornamental plants that could bring direct economic returns to his sponsors. This strategy not only ensured ongoing support for his collecting work but also meant that his discoveries could meet the horticultural market's constant demand for novel and attractive plants.

Although he did not publish a botanical monograph, the valuable photographs and collection notes he left behind have provided significant assistance for various studies in the southwestern region of China [31,32]. Forrest's collecting activities not only recorded the species of plants but also their geographical distribution. These records are of great importance for understanding the distribution patterns and geographical changes of plants in the southwestern part of China. Additionally, in his plant specimen collection records, not only was there information about the altitudes where the specimens were collected, but there were also descriptions of the habitats where the plant specimens were collected. For example, in the original record of *Euonymus frigidus*, Forrest described it as "Open, rocky situations in side valleys on the eastern flank of the Lichiang Range" and "Side valleys on the mountains east of Yungning, thickets by streams". As for *Rhododendron hippophaeoides*, Forrest's original record states, "Open, boggy pasture on the western flank of the Lichiang Range" and "Open, moist, peaty pasture on the Haba Range". These detailed habitat records provide important reference material for later studies on the growth habits of plants.

Furthermore, at that time in Yunnan, due to limited conditions, missionaries did not have cameras to record what they found. As a result, Forrest became one of the early collectors who used cameras to record the natural scenery and biodiversity of Yunnan. His camera work not only captured the rich and diverse plant communities of the Yunnan region but also recorded the local wildlife, magnificent natural landscapes, and the daily life of the local residents (Figure 7). Forrest's camera work provided us with a precious

historical record, allowing us a glimpse into the Yunnan of that era, with its unique culture and natural environment, and also offering valuable reference for subsequent collectors, scientists, and historians.



(**a**) (**b**)

Figure 7. Photos taken by George Forrest: (**a**) *Primula pinnatifida* photo taken by George Forrest in 1910. Source: https://stories.rbge.org.uk/archives/14301, accessed on 24 April 2024. (**b**) A mule crossing the Cikai ropes. Source: https://stories.rbge.org.uk/archives/14301, accessed on 24 April 2024.

4.3. Impact on World Horticulture and Plant Propagation

Forrest's collecting work had a significant impact on the development of world horticulture. Through his observations and studies of the natural habitats of *Rhododendrons*, Forrest proposed new insights into their growth substrates [21]. He discovered that in Yunnan, many *Rhododendron* species roots were embedded in the crevices of limestone cliffs and boulders or in the limestone gravel at the base of these formations. For the taller tree species, although humus provided support, their roots were similarly situated, or at least covered, or in contact with limestone. This discovery was groundbreaking for the prevailing horticultural practices at that time as it challenged the traditional botanical understanding of *Rhododendrons*' growing environments. Forrest's findings were not only significant for the theoretical development of horticulture but also had a direct impact on practical *Rhododendron* cultivation methods. By bringing limestone samples back to England, he demonstrated the natural growth substrate of *Rhododendrons* to the horticultural community, thus promoting the use of calcareous soil in *Rhododendron* cultivation practices. This change was fundamental in improving the cultivation success and healthy growth of *Rhododendrons* in England and other regions.

Forrest's collection work not only enriched the botanical knowledge base but also fostered innovation and development in horticultural techniques. His practices and discoveries provided valuable experience and guidance for subsequent gardening enthusiasts and professionals, making the cultivation methods for *Rhododendrons* more scientific and effective. Thus, Forrest's work left an indelible mark not only in the field of botany but also in horticultural practice. Moreover, Forrest's collection efforts significantly influenced world horticulture and had profound impacts on plant dissemination. Western plant hunters like Forrest, who introduced Chinese plants, greatly enriched the botanical diversity of England. Previously, the total number of plant species in England was only about 1500. These hunters brought back countless rare Chinese plants, and these large-scale new discoveries influenced the direction of development for English botanical gardens and horticulture, bringing substantial economic benefits and causing a revolutionary impact on gardens in England and across the West [33]. The discovery and introduction of these rare plants changed the distribution of plants worldwide, advancing global biology and making a

tremendous contribution to plant dissemination in China and globally. His efforts not only enriched the plant resources of Western countries but also advanced botanical research and horticultural practice, allowing many rare and beautiful plants to be appreciated and studied worldwide [34]. His work not only deepened Western scholars' understanding of the plant diversity in Southwest China but also greatly enriched the botanical resources of Western countries through the numerous seeds, roots, and live plants he brought back to England [35].

4.4. Contribution to Rhododendron Introduction and Research

Forrest's collection work greatly enriched the *Rhododendron* resources not only in England but also globally. For example, he discovered famous species such as *Rhododendron griersonianum*, *Rhododendron racemosum*, *Rhododendron haematodes*, *Rhododendron floccigerum*, *Rhododendron hippophaeoides*, and so on.

The discovery and introduction of these new *Rhododendron* species profoundly impacted the horticultural world in England and worldwide. The moist and mild environment of England provided the ideal conditions for the cultivation and growth of *Rhododendrons*, making them rapidly popular among gardening enthusiasts and landscape designers. For instance, the species *Rhododendron griersonianum* he introduced in 1917, as a direct parent of 159 garden hybrids, had 34 descendants that received RHS horticultural awards. Moreover, due to the large volume of seeds collected by Forrest and the numerous hybrid offspring with excellent ornamental effects, thousands of seedlings were cultivated, forcing cultivators to expand their original garden areas and even move into woodland areas, thereby influencing policies and giving rise to modern woodland gardens. Thus, it is no exaggeration to say that Forrest played at least an indirect but significant role in the evolution of modern gardens. Statistical analysis of plant specimen data reveals that Forrest collected 6640 *Rhododendron* specimens, including 242 species, not only in large numbers but also covering a comprehensive range of species. Among the *Rhododendron* specimens he collected in China, over 400 were described as new species by researchers, and more than 150 of these are still accepted by many researchers today [18]. The *Rhododendron* specimens collected by Forrest are mainly preserved in the Royal Botanic Garden Edinburgh, making it the research center with the largest collection of *Rhododendron* specimens and helping English researchers take a leading position in the taxonomic study of *Rhododendron* [36]. Many types of specimens provide important materials and evidence for research in *Rhododendron* taxonomy and phytogeography in England.

4.5. The Negative Impact of Forrest's Collection Activities

Forrest's collecting activities can be seen as the forced export of Chinese species, and the negative impacts on the development of Chinese biology and the destruction of natural resources are evident.

In the late 19th and early 20th centuries, China had not yet established a modern biodiversity conservation system. At that time, society and the scientific community lacked awareness of the importance of species protection, and there were no corresponding laws and protection measures. This led to the unrestricted collection of a large number of plant specimens, and many seeds and specimens of rare and unique species were taken overseas. A large number of type specimens and original literature were scattered in major Western research institutions, making it very difficult for Chinese researchers to study and identify species [37]. Additionally, due to Forrest's limited knowledge of Chinese location names, lack of detailed records of plant collecting activities, and the employment of a large number of non-professional local staff, it becomes more difficult to study Forrest's plant specimen collection in China.

During Forrest's expeditions, sometimes, in order to reach deeper locations to collect rare or valuable plants or to hasten their expeditions, some natural resources were damaged. As Forrest and his assistants made their way through the thorn-filled valleys, they split miles of Rhododendrons because the bushes were so dense that it was difficult for them to

go on the expeditions, which caused some damage to the primitive plant resources and the natural environment [21]. Another example is that after he found the world's tallest and largest known *Rhododendron protistum* var. *giganteum* in the Gaoligong Mountains of Tengchong, Yunnan, he cut it down and brought it back to England, which was destructive and plunderous. Cutting down the giant Rhododendron without due consideration of the local community and cultural values was morally and ethically controversial. Such a behavior is disrespectful of natural resources and disregardful of the protection of ancient trees and rare plant resources.

Although Forrest's collection activities might have contributed to science, they set a bad precedent in terms of ecological protection and sustainable development. Such actions could damage China's image in the international community, which is seen as lacking awareness of local biodiversity protection. This also reminds us that when conducting scientific research and resource utilization, we must adopt a responsible attitude and ensure that activities conform to the principles of ecological protection and sustainable development.

4.6. Specimens Digitization and Information Sharing

Digitization and information sharing of plant specimens is a key direction in contemporary botanical research. It not only ensures the long-term preservation of valuable plant specimen data but also significantly enhances the usability and accessibility of the specimen data [38–40]. However, when processing the collected specimen data from Forrest, we faced a series of challenges, particularly in data standardization. Although original records contain information about the date, altitude, and location of collected specimens, they are not always standardized, which greatly increases the difficulty of data processing. For instance, the data format of recording specimens at different times and places may vary, and even specimens collected at the same period may differ due to the personal habits of the recorders. The altitudes may be recorded in various units, and the location information might lack precise geographic coordinates or use different place names. These issues not only pose obstacles to data integration and analysis but also affect the accuracy and reliability of the data. Therefore, the digitization process requires cleaning and standardizing these non-standard data, which could include unifying altitude units and date formats, updating place names, supplementing missing geographic coordinates, and so on. Moreover, establishing a standardized recording and data entry process is crucial for future plant specimen collecting work, which not only helps improve data quality but also provides more accurate and consistent specimen data for future researchers, offering valuable experience and lessons for future botanical research and data management.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/plants13101367/s1; Supplementary File S1: The list of species named after Forrest.

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Traditional Knowledge Evolution over Half of a Century: Local Herbal Resources and Their Changes in the Upper Susa Valley of Northwest Italy

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Abstract: Susa Valley, located in the Italian Western Alps, has served as a meeting point for cultural, spiritual, and commercial exchange for a long period of history. The valley's role as one of the main connecting routes between south and southwestern Europe resulted in its acquisition of a rich traditional ecological knowledge. However, like other Italian mountainous valleys, this valley has suffered from abandonment and depopulation in the past 50 years. Our study aims to investigate the current ethnobotanical medicinal knowledge in the valley and to compare our findings with a study conducted over 50 years ago in the same area. In 2018, we conducted 30 in-depth semi-structured interviews on medicinal plants and food-medicines used in the Susa Valley. We documented 36 species, of which 21 species were used for medical purposes and 15 species were used as food-medicine. The comparison with the previous study on medicinal herbs conducted in 1970 in the valley demonstrated a significant decrease in both the knowledge and use of medicinal plants, which could be attributed to socioeconomic, cultural, and possibly environmental changes that occurred in the past half-century. Our study highlights several promising species for future use as nutraceuticals, food, and medicinal products, such as *Taraxacum officinale*, *Urtica dioica*, and *Artemisia genipi*.

Keywords: Alps; ethnobotany; food-medicine; infusion; liqueur; rural development; secondary products; tea

1. Introduction

Traditional ecological knowledge (TEK) is vital for local communities and their well-being. TEK has been a focal point of research within the ethnobiological field, and recent developments have witnessed a shift towards a diachronic approach that emphasizes the historical evolution of these corpora of knowledge [1–7]. The TEK of mountain communities has received more attention in the past decades because of the crucial role of mountains in providing multiple services (i.e., water, pastures/dairy products, timber and non-timber forest products, and leisure) to both highland and lower-land dwellers and urban visitors [8]. Despite their essential contributions, mountain areas are particularly vulnerable to social and environmental phenomena such as depopulation and climate change [9,10]. Therefore, mountain areas have become a focus of important socio-ecological research and public debate [11–13]. In recent years, only a few ethnobotanical studies in the Western Alps

have focused on the interactions between plant resources and human societies [2–5,14,15]. These studies have partially discussed how traditional knowledge of plants evolves across cultures over time and space. Understanding the interactions between nature and culture and their transmission mechanisms across generations is essential for the development of strategies to maintain biocultural diversity in the Western Alps [1]. Over the last few decades, the current state of traditional plant knowledge has been undergoing a transition; this refers to the fact that there is continuous erosion and loss. Aswani et al. [16] suggest that the depletion of TEK can be attributable to geopolitical changes such as globalization, modernization, and market integration. Moreover, the modern cultural industries, including advertising and widespread media content and mass communication, have had a massive impact on traditional and folk cultures.

A few studies have addressed TEK related to food and medicinal plants in the Western Italian Alps [1,2,4,5]. In this context, Fontefrancesco and Pieroni [4] investigated the transformation of local botanical knowledge in the upper Sangone Valley of Piedmont. They compared historical and contemporary datasets, revealing qualitative shifts in plant use. Some medicinal plants from natural environments disappeared from use in local practices. At the same time, those from anthropogenic settings were introduced, likely influenced by urban residents who arrived in the late 1970s as original inhabitants left for urban areas. This study highlights the importance of considering the adaptive capacity of TEK systems and how societal and environmental changes impact traditional knowledge in mountain communities. Similarly, Fontefrancesco et al. [5] addressed rural depopulation in the upper Borbera Valley of the Piedmontese Apennines. By comparing historical and contemporary ethnobotanical data, they determined that the use of wild medicinal plants from natural environments had diminished. At the same time, species from anthropogenic areas, or those promoted by the nearby city of Genoa, were introduced or revitalized. These changes were closely tied to shifts in landscape ecology and the local agro-silvo-pastoral system. This research highlights the challenge of preserving TEK when local actors' expertise is limited to their villages and underscores the need for measures supporting mountain communities in a changing socio-economic landscape.

Focusing on the historical and ethnobotanical literature related to the Western Italian Alps, an interesting study was identified, which was conducted in 1970 and published in the journal *Allionia: Bollettino dell'Istituto ed Orto Botanico dell'Università di Torino* [17]. The study, which is based on the data collected during fieldwork carried out in 30 villages in the Susa Valley (high, middle, and low), was aimed at gathering information directly from the local people about the uses of medicinal herbs and their perceived properties. The work indicated the exact locations where the information was collected for each individual description of a plant and, when available, the scientific and folk names of the plants were recorded. We, therefore, used this study to carry out a diachronic analysis to investigate the current ethnobotanical medicinal knowledge in the Susa Valley and assess the evolution of this knowledge over half of a century, using as a proxy a comparison between the medicinal plants gathered and used by the local community in the 1970s and those gathered and used in 2018.

Our study aims to document the current ethnobotanical knowledge (specifically focusing on both medicinal and food-medicine plant uses) of the Susa Valley, in the NW Italian Alps. We also aim to compare the recorded data with that recorded in 1970. The study attempts to highlight and interpret possible differences in ecological, socioeconomic, and cultural changes/transformations of TEK.

2. Materials and Methods

2.1. Study Area

The study was conducted in the upper Susa Valley (*Val di Susa*) in the Piedmont region of NW Italy (Figure 1). This Alpine valley serves as a major corridor between Italy and France which has allowed an exchange of goods and cultures since antiquity, and consequently, trade with southwestern Europe. The Susa Valley has been a meeting point

for many cultures over the centuries, resulting in an area rich in culture, trade, and tourism. Several languages (Piedmontese, Occitan, French, and Italian) have been co-existing in the valley for a long period of history. The valley has also been a historical transit route for Christians, Muslims, and Jews on their way to the "Holy Land". Until 2009, the Susa Valley was divided into "*Alta Valle*" and "*Bassa Valle*". The higher valley, "*Alta Valle*", was part of France until 1713. The lower valley, "*Bassa Valle*", was under the influence of the Savoy family [18]. In 2009 the communities of the lower and higher valleys were united. There are more than 90,000 inhabitants in the valley.

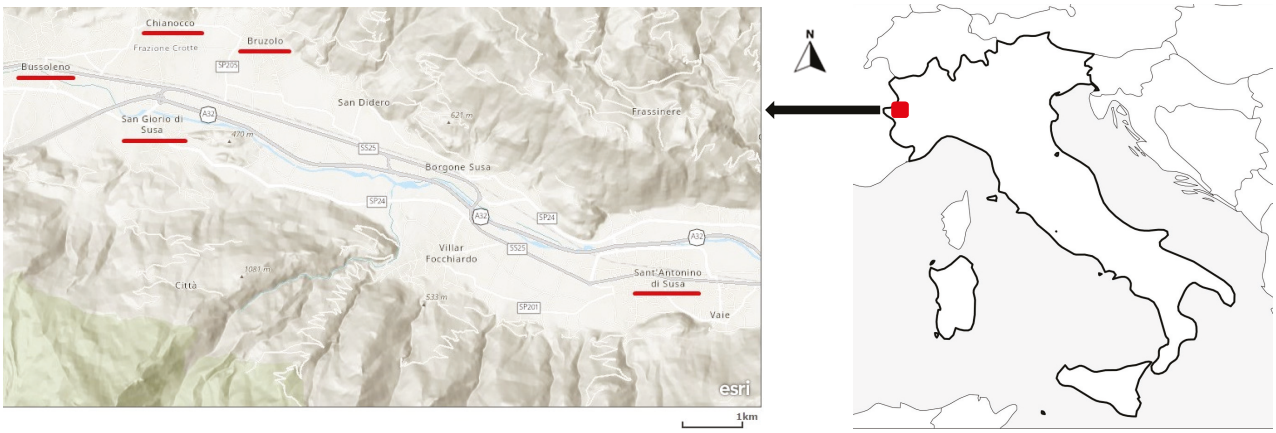


Figure 1. Map of the study area within the map of Italy. Red underlining of villages refers to the locations of the study participants.

Economically, local people have traditionally lived self-sufficiently. Until the 19th century, the economy of the valley was based on agriculture, especially pasturing and related activities like cheese making, milling, and blacksmithing. Aside from those activities, chestnut cultivation was one of the main agricultural activities in the area, producing sweet chestnuts for consumption and environmental value for the landscape. Wood handcrafting was another important economic activity, one which is still practiced in the higher valley. Typical products included, and still are, wine (in the lower valley), cheese, cured meats, chestnuts, potatoes, and fruits [19]. Following the growth of industries in the 19th and 20th centuries, the economic basis of the mountain community of the Susa Valley and many other Alpine valleys has changed existentially with major migrations to the lowlands. This turnover, from a society sustaining itself with its own agricultural products to a modern society based on industry, had great effects on lifestyle, local customs, traditions, culture and the environment. In the 19th century, the textile industry began growing in the valley, and in the 20th century, heavy industry became an important sector. In addition, skiing became increasingly popular in Italy, and winter sports tourism in the Upper Susa Valley became an important economic sector; the Upper Valley even hosted some competitions of the Olympic Winter Games in 2006. This significant socioeconomic, cultural, and landscape change was unwelcome for many local people, as many of them resisted, and still resist, the construction of a high-speed railway that would connect the Italian city of Turin with the French Lyon through the valley [20].

2.2. Fieldwork, Data Collection, and Data Analysis

The fieldwork was conducted in 2018, mainly in five villages in the Susa Valley (Figure 1). The villages are geographically distributed at elevations between 700 and 1100 m above sea level (Figure 2). The participants were chosen using a combination of random and snowball technique methods in order to attain the advantages of both a general representation of the local communities as well as a targeted search for the knowledgeable respondents [21]. We approached local people in the villages' streets and local markets (*mercato della terra*) and asked them about the use of medicinal plants in the area. Afterwards, we asked those randomly chosen informants to recommend other potential respondents

who may be knowledgeable about medicinal plants. Semi-structured in-depth interviews were conducted with 30 participants (18 men, and 12 women). The ages of our study participants ranged between 24 and 90; however, the majority of them were elderly people, older than 60 years old. Interviewees were first asked to report socioeconomic data related to their residency village, age, and occupation. Afterwards, respondents were asked to list all medicinal plants they used, the vernacular names of the plants, the parts used, the modes of preparation and consumption, the purposes of use, and the additional uses of the plant. We also recorded our observations about the social, cultural, and economic aspects of the area, which were later employed in our qualitative analysis. Verbal consent was always obtained from the study participants, following the Code of Ethics of the Society of Ethnobiology [22]. The interviews were mainly conducted in the Italian language. Plant specimens had been collected, identified, and deposited in a recognized herbarium during previous ethnobotanical fieldwork conducted by some of the authors in the same portion of the Western Alps [4,5]. The botanical nomenclature followed *World Flora Online* [23]. As the main focus of the study is to assess the change in knowledge and use of herbal resources over half of a century, we did not examine the possible differences within our study sample. Instead, we compared our results with the results of a study conducted in 1970 in the same area [17]. However, in order to minimize the limitations related to differences in the applied methodologies between our study and the study from 1970 (e.g., differences in the reported species and the availability of specific species), we conducted a comparison based on the genera level rather than the species level. Additionally, the recorded plant reports were also qualitatively compared with the most comprehensive worldwide wild food-plant compendia [5,7,24].



Figure 2. Autumn landscape in the Upper Susa Valley (photo: N. Sulaiman).

3. Results and Discussion

3.1. Diversity of Medicinal Plants Used in Susa Valley

The present study documented 36 plant species, among which 21 species were used for medical purposes, while 15 species were used for food-medicine (Table 1). The reported species belong to 33 genera and 19 botanical families. The most represented families are Asteraceae (ten species), Lamiaceae, and Rosaceae (three species each). These highly

represented families include mainly herbs (Asteraceae and Lamiaceae), while the family Rosaceae includes mainly shrubs and trees. Aromatic herbs mainly distinguish the family Lamiaceae, while Asteraceae is characterized by a bitter taste and is well-known for including plants with medical and nutritional properties [25] (and references therein). The most-reported species were *Artemisia genipi*, *Hypericum perforatum*, *Taraxacum officinale*, *Arnica montana*, and *Urtica dioica*, which were reported by more than one-third of our study's respondents. The study of Lomagno and Lomagno Caramiello [17] reported 99 species (including three mushrooms which are not considered by our analysis). The 96 plant species belong to 76 genera (Table 1).

Table 1. Plant species used for medicinal purposes in the Susa Valley.

Scientific Name; Family Name	Reported in the Study in 1970 [17]	Reported in the Present Study	Local Name(s) *	Part Used *	Mode of Preparation; Medical Use *	If Species is Reported in the Present Study	
						Frequency of Citation	Medicine (M); Food-Medicine (FM)
Achillea erba-rotta All.; Asteraceae	Yes	No	-	The whole plant	Tea; Diuretic	-	-
Achillea millefolium L.; Asteraceae	No	Yes	Achillea	Flowers	Tea; Helps digestion	1	M
Achillea nana L.; Asteraceae	Yes	No	-	The whole plant	Tea; Diuretic	-	-
Aconitum anthora L.; Ranunculaceae	Yes	No	Anthòr	Roots	Cut roots; To calm the pain of intestinal colic	-	-
Aconitum napellus L.; Ranunculaceae	Yes	No	Erba d'el luv	Leaves and flowers	Tea; Against pain	-	-
Aconitum anthora L.; Ranunculaceae	Yes	No	Erba d'el luv	Leaves and flowers	Tea; Against pain	-	-
Agrimonia eupatoria L.; Rosaceae	Yes	No	-	The whole plant	Tea; Anti-diarrheal	-	-
Alcea rosea L.; Malvaceae	Yes	No	Malva rosa	Roots	Tea; Against kidney stones	-	-
Alkekengi officinarum Moench; Solanaceae	Yes	No	-	Fruits	Tea; Diuretic	-	-
Allium ursinum L.; Amaryllidaceae	No	Yes	Aglio selvatico; Aglio orsino; L'ajursino	Leaves' juice	Raw in salad, Soup; Against arthritis	5	FM
Allium sativum L.; Amaryllidaceae	Yes	No	Aj	Bulbs	Crushed bulb with honey is used as a vermifuge; Tea against hypotension	-	-
Althaea officinalis L.; Malvaceae	Yes	No	Malva rosa	Roots	Tea; Against kidney stones	-	-
Angelica sylvestris L.; Apiaceae	Yes	No	Angelica	Roots	Infusion in liqueur; Digestion	-	-
Arctium lappa L.; Asteraceae	Yes	Yes	Bardana	Roots	Tea; Clean the blood and liver	2	M
Arctostaphylos uva-ursi (L.) Spreng.; Ericaceae	Yes	Yes	Uva ursina	Fruits	Raw; Good for urinary tracts	4	FM
Arnica montana L.; Asteraceae	Yes	Yes	Arnica; Fior di tabacco	Flowers	Infusion in oil; Against shocks and trauma, oil is also used for massage against pain and rheuma.	11	M
Artemisia absinthium L.; Asteraceae	Yes	Yes	Assenzio; Ford	Roots	Grinded into liqueur (infused with white wine); Anti-parasite, helps digestion, (anti-medical purpose evokes hallucinations)	4	M
Artemisia genipi Stechm.; Asteraceae	Yes	Yes	Genepì	Stem, Roots, and Flowers	Infusion in alcohol; Good for digestive system	13	M
Artemisia glacialis L.; Asteraceae	Yes	No	Genipí fumela	The whole plant	Tea; Digestion	-	-

Table 1. *Cont.*

Scientific Name; Family Name	Reported in the Study in 1970 [17]	Reported in the Present Study	Local Name(s) *	Part Used *	Mode of Preparation; Medical Use *	If Species is Reported in the Present Study	
						Frequency of Citation	Medicine (M); Food-Medicine (FM)
Artemisia umbelliformis subsp. umbelliformis; Asteraceae	Yes	No	Genipí fumela	The whole plant	Tea; Digestion	-	-
Brassica rapa L.; Brassicaceae	Yes	No	Rava	Root	Sugar is left in the root for two days and then given for children suffering from whooping cough	-	-
Calendula officinalis L.; Asteraceae	No	Yes	Calendula	Flowers	Infusion in alcohol; Disinfectant properties	2	M
Capsella bursa-pastoris Medik.; Brassicaceae	Yes	No	-	The whole plant	Tea; Anti-hemorrhagic (especially for nasal hemorrhages).	-	-
Carlina acaulis L.; Asteraceae	Yes	No	Cardon d' montagna	The whole plant	Tea; Used in pulmonary affections	-	-
Carum carvi L.; Apiaceae	No	Yes	Kumin	Seeds	Liquor; For digestion	1	FM
Chelidonium majus L.; Papaveraceae	Yes	Yes	Celidonia	Leaves juice	Leaves' juice helps against warts.	1	M
Cichorium intybus L.; Asteraceae	Yes	Yes	Cicoria selvatica; Girasole; Cuitserce; Cicoria delle montagne	Leaves	Boiled, raw in salad; Disinfectant of urinary system	6	FM
Crataegus monogyna Jacq.; Rosaceae	No	Yes	Biancospino	Flowers	Tea; Against heart diseases	2	M
Cyclamen purpurascens Mill.; Primulaceae	Yes	No	Ciclamin	Roots	-	-	-
Cynodon dactylon (L.) Pers.; Poaceae	Yes	No	Cramon	The whole plant	Tea; Diuretic	-	-
Daphne cneorum L.; Thymelaeaceae	Yes	No	-	The whole plant	Crushed plant with oil is used as rubefacient and excitatory	-	-
Daphne mezereum L.; Thymelaeaceae	Yes	No	-	The whole plant	Crushed plant with oil is used as rubefacient and excitatory	-	-
Datura stramonium L.; Solanaceae	Yes	No	-	Leaves	Smoke of leaves against asthma attacks	-	-
Digitalis grandiflora Mill.; Plantaginaceae	Yes	No	-	Flowers	Tea; Diuretic	-	-
Digitalis lutea L.; Plantaginaceae	Yes	No	-	Flowers	Tea; Diuretic	-	-
Dryopteris filix-mas (L.) Schott; Dryopteridaceae	Yes	No	-	Rhizome	Chewing; Anti-bacterial	-	-
Equisetum arvense L.; Equisetaceae	Yes	Yes	Equiseto; Erba cavallina	Aerial part	Tea; Diuretic	1	M
Equisetum telmateia Ehrh.; Equisetaceae	Yes	No	Coa d' caval	The whole plant	Tea; Diuretic	-	-
Foeniculum vulgare Mill.; Apiaceae	No	Yes	Finocchio selvatico	Stem, flowers, leaves	Stomachache (especially for children)	3	FM
Fragaria vesca L.; Rosaceae	Yes	No	Frôla	Stems	Tea; Febrifuge	-	-
Gentiana acaulis L.; Gentianaceae	Yes	Yes	Genzianella	Roots, flowers	Bitter liqueur; For digestion	4	M
Gentiana lutea L.; Gentianaceae	Yes	Yes	Genziana	Roots	Infused in alcohol or in oil; For digestion and treatment of ulcers	7	M
Hedera helix f. helix; Araliaceae	Yes	No	Edera	Leaves	To clean wounds; Tea against hair loss	-	-
Hepatica nobilis Schreb.; Ranunculaceae	Yes	No	-	Leaves	Cleaning wounds	-	-

Table 1. *Cont.*

Scientific Name; Family Name	Reported in the Study in 1970 [17]	Reported in the Present Study	Local Name(s) *	Part Used *	Mode of Preparation; Medical Use *	If Species is Reported in the Present Study	
						Frequency of Citation	Medicine (M); Food-Medicine (FM)
Hypericum perforatum L.; Hypericaceae	Yes	Yes	Iperico; trucarań	Leaves, flowers	Tea, infused in alcohol or oil; Against skin burns, anti-inflammatory, for sunburnt skin, for skin stress, oil used for massages; As a cosmetic oil; Calming the nervous system	12	M
Hyssopus officinalis L.; Lamiaceae	Yes	No	Issôp	Flowers	Tea; Against cough	-	-
Ilex aquifolium L.; Aquifoliaceae	Yes	No	-	Flowers and fruits	Tea; Febrifuge	-	-
Larix decidua Mill.; Pinaceae	Yes	No	Pin	Resin	Resin mixed with oil is used as antirheumatic	-	-
Lavandula officinalis Chaix.; Lamiaceae	Yes	Yes	Lavanda	Whole plant	Tea for digestion; Essential oil against mosquitos' bites	1	M
Malva pusilla Sm.; Malvaceae	Yes	No	Malva	Flowers and leaves	Calming, anti-neuralgic, and cough suppressant	-	-
Malva sylvestris L.; Malvaceae	Yes	Yes	Malva	Flowers	Tea; Anti-inflammatory; Vaginal cleanse during pregnancy; Blood purifier; Refreshing drink	5	M
Matricaria chamomilla L.; Asteraceae	Yes	Yes	Camomilla di montagna	Flowers	Tea; Against headache	1	M
Mentha spicata L. and possibly other *Mentha* spp.; Lamiaceae	Yes	Yes	Menta selvatica	Leaves	Tea; For digestion	3	FM
Nasturtium officinale R.Br.; Brassicaceae	No	Yes	Crescione	Aerial part	Salads; Good for blood	4	FM
Nepeta nepetella L.; Lamiaceae	Yes	No	-	The whole plant	Tea; Digestion	-	-
Olea europaea L.; Oleaceae	Yes	No	Uliva	Leaves	Tea; Hypotensive	-	-
Papaver rhoeas L.; Papaveraceae	Yes	No	Papaver	Leaves and petals	Tea; Calming and diaphoretic	-	-
Parietaria officinalis L.; Urticaceae	Yes	No	-	The whole plant	Tea; To promote peripheral circulation	-	-
Petroselinum crispum (Mill.) Fuss; Apiaceae	Yes	No	Pransemo	Roots	For veterinary uses	-	-
Peucedanum oreoselinum Moench; Apiaceae	Yes	No	-	Roots	Tea; Expectorant	-	-
Plantago major L.; Plantaginaceae	Yes	Yes	Plantago major	Leaves	Crushed leaves; Wounds healing	1	M
Picea abies (L.) H.Karst.; Pinaceae	Yes	No	Sapin	Resin	Resin mixed with oil is used as antirheumatic	-	-
Pinguicula alpina L.; Lentibulariaceae	Yes	No	-	Leaves	Crushed leaves with lard are used to treat bruises and sprains	-	-
Pinguicula vulgaris L.; Lentibulariaceae	Yes	No	-	Leaves	Crushed leaves with lard are used to treat bruises and sprains	-	-
Pinus uncinata Ramond ex DC.; Pinaceae	Yes	No	Pin	Resin	Resin mixed with oil is used as antirheumatic	-	-
Pinus sylvestris L.; Pinaceae	Yes	Yes	Pino selvatico; Pinje; Le coce	Young sprouts	Extract syrup by preserving it under sugar for 2 months; Cough treatment	2	M
Prunus avium (L.) L.; *Rosaceae*	Yes	No	Ceresé	Petioles	Tea; Diuretic	-	-
Prunus domestica L.; Rosaceae	Yes	No	Bergna	Seeds	Crushed seeds with honey are used as a vermifuge	-	-
Prunus padus L.; Rosaceae	Yes	No	-	Bark	Tea; Diaphoretic and febrifuge	-	-

Table 1. *Cont.*

Scientific Name; Family Name	Reported in the Study in 1970 [17]	Reported in the Present Study	Local Name(s) *	Part Used *	Mode of Preparation; Medical Use *	If Species is Reported in the Present Study	
						Frequency of Citation	Medicine (M); Food-Medicine (FM)
Prunus persica (L.) Batsch; Rosaceae	Yes	No	Perssi	Petals	Tea; Laxative	-	-
Pulmonaria officinalis L.; Boraginaceae	Yes	No	-	Leaves	Tea; Calming	-	-
Quercus robur L.; Fagaceae	Yes	No	Rol	Acorn, bark	Tea (decoction)	-	-
Rheum rhabarbarum L.; Polygonaceae NW	No	Yes	Rabarbaro	Roots	Infused in white wine; For digestion	2	FM
Rhododendron ferrugineum L.; Ericaceae	Yes	No	-	Flowers	Tea; Kidney stones	-	-
Rosa canina L.; Rosaceae	Yes	Yes	Rosa canina; Gratta cü	Fruits	Marmalade, raw, tea, or infusion in liquor; Rich in vitamin C, to calm the stress; Infused in liquor, is good during sickness	3	FM
Rubus idaeus L.; Rosaceae	Yes	No	Ampola	Fruits	Infusion with fruits of *v. myrtillus* in wine	-	-
Rubus ulmifolius Schott; Rosaceae	No	Yes	More; Rove; Pun di rovi	Young leaves	Tea; For throat pain	6	FM
Rumex alpinus L.; Polygonaceae	Yes	No	Rebarbar d' montagna	Leaves and flowers	Tea; Digestion	-	-
Ruscus aculeatus L.; Asparagaceae	Yes	No	Agrovert	Fruits	Tea; Febrifuge	-	-
Sambucus nigra L.; Viburnaceae	Yes	No	Sanbur	Flowers and fruits	Infusion in wine and used as cleansing drink; Flowers fried in oil and mixed with wax and fat to treat arthritis and rheumatism	-	-
Sambucus racemosa L.; Viburnaceae	Yes	No	Sanbur	Flowers and fruits	Infusion in wine and used as cleansing drink; Flowers fried in oil and mixed with wax and fat to treat arthritis and rheumatism	-	-
Salix caprea L.; Salicaceae	Yes	No	Sales	Leaves, bark, young branches	-	-	-
Salvia sp.; Lamiaceae	Yes	No	Salvia	Leaves	Tea; Digestion	-	-
Sempervivum sp.; Crassulaceae	Yes	No	-	Leaves	-	-	-
Siler montanum Crantz; Apiaceae	Yes	No	Apia	The whole plant	The whole plant crushed with lard is used to treat sprains	-	-
Solanum nigrum L.; Solanaceae	Yes	No	Erba morela	Leaves	Tea; For rheumatic pain	-	-
Syzygium aromaticum (L.) Merr. and L.M.Perry NW; Myrtaceae	No	Yes	Garofano	Flower buds	Tea, placing it between the teeth; Against pain in teeth and throat	1	M
Tanacetum vulgare L.; Asteraceae	Yes	No	T'nea	Leaves	Tea; Hypotensive	-	-
Taraxacum officinale F.H.Wigg.; Asteraceae	Yes	Yes	Tarassaco; Girasole; Ciguriaz	Stem, leaves, flowers	Salad, cooked; Blood purifier	12	FM
Teucrium chamaedrys L.; Lamiaceae	Yes	No	-	Leaves	Tea; Blood purifier	-	-
Thymus serpyllum L.; Lamiaceae	Yes	Yes	Timo selvatico; Timo serpillo; Timo delle montagne	Leaves, flowers	Food flavoring; Good for cough, fever, and respiratory diseases	7	FM
Tilia cordata Mill.; Malvaceae	Yes	No	Tilia	Flowers	Tea; Diaphoretic and cough-relieving	-	-

Table 1. *Cont.*

Scientific Name; Family Name	Reported in the Study in 1970 [17]	Reported in the Present Study	Local Name(s) *	Part Used *	Mode of Preparation; Medical Use *	If Species is Reported in the Present Study	
						Frequency of Citation	Medicine (M); Food-Medicine (FM)
Tussilago farfara L.; Asteraceae	Yes	Yes	Tussilagine	Leaves	Tea; Against cough	1	FM
Tragopogon pratensis L.; Asteraceae	Yes	No	Barbaboch	Leaves	Tea; Purifier	-	-
Urtica dioica L.; Urticaceae	Yes	Yes	Ortica	Leaves	As food; Iron deficiency, rich in vitamins E and C	11	FM
Vaccinium myrtillus L.; Ericaceae	Yes	Yes	Mirtilli	Fruits	Fresh; Good for eyes	1	FM
Valeriana locusta L.; Caprifoliaceae	Yes	No	Sarset	Leaves	Decoction to be used warm for eye baths in conjunctivitis	-	-
Valeriana officinalis L.; Caprifoliaceae	No	Yes	Valeriana	Rhizome	Tea; Against anxiety	1	M
Veratrum album L.; Melanthiaceae	Yes	No	-	Roots	For veterinary uses	-	-
Verbascum thapsus L.; Scrophulariaceae	Yes	No	-	Leaves	Tea for cough; Fresh leaves are used to soothe pain of arthritis topically	-	-
Veronica chamaedrys L.; Plantaginaceae	Yes	No	-	Flowering pods	Tea for cough	-	-
Veronica officinalis L.; Plantaginaceae	Yes	No	-	Flowering pods	Tea for cough	-	-
Veronica allionii Vill.; Plantaginaceae	Yes	No	Te d' montagna	Leaves	Tea; Invigorating	-	-
Vinca minor L.; Apocynaceae	Yes	No	-	Leaves	Tea; For gingivitis	-	-
Viola calcarata L.; Violaceae	Yes	No	Viola	Flowers	Tea; Anti-toxic	-	-
Viola cenisia L.; Violaceae	No	Yes	Viola di montagna; Viola del moncenisio	Flowers	Tea; Against cough	4	M
Viola tricolor L.; Violaceae	Yes	Yes	Viola del pensiero	Young aerial part	Tea; Against cold	3	M
Viscum album L.; Santalaceae	Yes	No	Ghi	Leaves	Tea; Hypotensive	-	-
Zea mays L.; Poaceae	Yes	No	Melia	-	Tea; Prostatitis	-	-

NW: Not wild; *: Data of the present study is prioritized when the taxon is reported in both studies.

We documented in our fieldwork 14 types of plant parts to be used for medical purposes (Figure 3). Flowers were the most reported plant part, with 13 citations by the study's respondents, followed by leaves (nine reports) and roots (six reports). On the other hand, the study of Lomagno and Lomagno Caramiello [17] documented that "the whole plant" was mostly used among the reported species. We also observed a higher diversity of parts used in 1970 compared to the current uses, as some plant parts reported by Lomagno and Lomagno Caramiello [17] (e.g., resin, petals, bark) are not reported in our present study.

The majority of our reported species are used solely for medical purposes (58%). However, we found that a significant number of the reported species (42%) are used as food-medicine. Some of the most-reported species were consumed as food while their medicinal benefits were targeted. *Urtica dioica* (11 reports), for instance, is frequently used to defeat the deficiency of iron, and for its richness in vitamins E and C. Similarly, *Taraxacum officinale* (12 reports) is consumed as salads or cooked for its benefits to blood and the circulatory system.

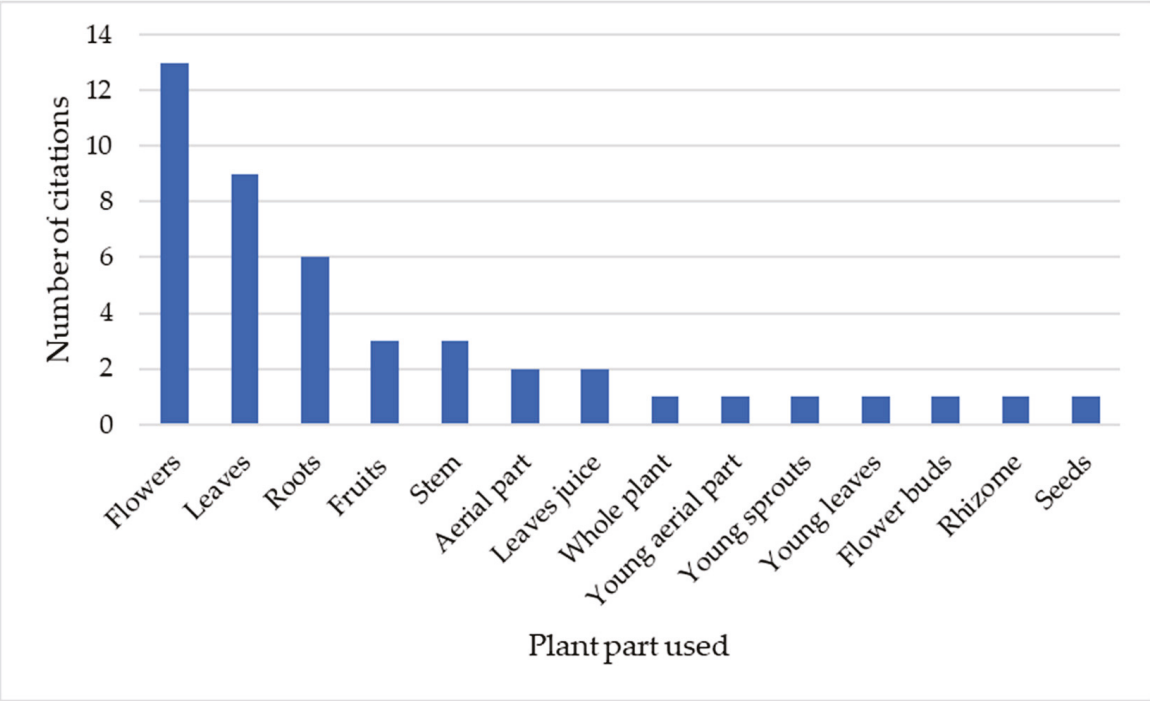


Figure 3. Plant parts used in the reported medicinal plants in the present study in Susa Valley.

Using food plants as medicine and medicinal plants as food has often been reported in the Mediterranean; for instance, Pieroni [24] highlighted that 60% of the medical plants in the upper Garfagnana in Italy also play a role as a food medicine.

Infusion was the main preparation method reported by our respondents; 50% of the reported medicinal plants were prepared as such. The infusion was mostly performed in water (tea), while infusion in liquor, wine, or oil was used with some plants. Similarly, Lomagno and Lomagno Caramiello [17] highlight that tea is the main preparation mode for the vast majority of the species reported in their study. Another main mode of preparation in our present study was consumption as food (cooked, in salads, or eaten raw).

3.2. Main Ailment Categories Treated by Medicinal Plants in the Susa Valley

Our present study recorded 41 medical-use reports, corresponding to 41 diseases/health complaints or disturbances treated with medicinal plants in the study area. These diseases were categorized into ten ailment categories based on the classifications of Cook [26]. Specifically, we characterized digestive, respiratory, circulatory, genitourinary, nutritional, musculoskeletal, and skin disorders, as well as disorders of the nervous system, inflammation, and pain (Table 2). The most-reported ailment categories (digestive, respiratory, circulatory, and blood systems) represented more than half of the total number of reports. On the other hand, we see a higher diversity of reports highlighted by Lomagno and Lomagno Caramiello [17], in which five ailment categories had been treated by at least ten plant species for each. Respiratory and digestive system disorders were the most cited category treated by local people half a century ago, which is roughly similar to our current findings in the present study. However, we observe two categories, genitourinary system disorders and musculoskeletal system disorders, that are highly reported in Lomagno and Lomagno Caramiello [17], while they are marginally highlighted by our current study. This could be attributed to the complicated nature of the infections associated with these two categories, which could be better treated by the current health system that has significantly developed over the past half-century.

Table 2. Aliment categories based on the respondents' reports.

Ailment Category	The Present Study		Study Published in 1970 [17]
	Number of Reported Species	Most-Reported Species for the Relevant Category	Number of Reported Species
Digestive system disorders	10	*Artemisia genipi*	15
Respiratory system disorders	7	*Thymus serpyllum*	18
Circulatory and blood system disorders	5	*Taraxacum officinale*	11
Genitourinary system disorders	4	*Cichorium intybus*	15
Nervous system disorders	4	*Hypericum perforatum*	7
Inflammation	3	*Hypericum perforatum*	6
Pain	3	*Arnica montana*	7
Nutritional disorders	2	*Urtica dioica*	2
Musculoskeletal system disorders	2	*Arnica montana*	10
Skin/subcutaneous cellular tissue disorders	1	*Hypericum perforatum*	5

Several herbal species are employed to treat digestive system disorders; the most cited among them is *Artemisia genipi*. In the Susa Valley and other Alpine valleys, *A. genipi* is used in liqueur preparations [27] made by macerating the plant's aerial parts (flowers, leaves, and stems) in alcohol for approximately 20–30 days. Next, sugary syrup is added to the alcoholic macerate. The resulting drink, referred to as "génépi" or "génépy", is used as a tonic and eupeptic beverage, having a bitter taste and unique flavor. Its peculiar sensory properties have been associated with the volatile constituents of the plant and attributed to the sesquiterpene lactone fraction, which conveys stimulating and mood-elevating properties [28]. Over 100 essential oils have been identified in *A. genipi* and other related species (such as *A. umbelliformis* Lam.), mainly produced in leaves and flowers. These are credited with spasmolytic, antiseptic, and sedative properties, and the most abundant of them are used to identify different chemotypes within a species or a group of species [28]. In *A. genipi*, four different chemotypes with distinct olfactory properties have been identified: (a) thujone, the most abundant monoterpene associated with the neurotoxic effect of absinthium; (b) borneol, which gives to the liqueur a woody, camphoraceous note with insect-repellent properties; (c) cineol, which promote a spicy note of cinnamon; and (d) α-,β-Pinenes, which confer a pine resin note [29,30].

The oil infused with the flower-heads of *Arnica montana* is used externally to treat various symptoms related to pain, inflammation, and musculoskeletal system disorders. The plant belongs to a relatively large group of the Asteraceae family, and is rich in sesquiterpene lactones such as helenalin, which have pharmacological and toxicological effects [31]. Other natural products typically found in the flower-head are flavonoids such as quercetin and kaempferol, coumarins, and an essential oil [31,32]. A preparation with *A. montana* showed anti-inflammatory effects in vivo for arthritis [33]. In particular, helenalin seems to interact with many cysteine residues in a number of target proteins, modifying their activity, such as with NFkB and NFAT, two transcription factors orchestrating the inflammation pathways. In addition, its cytotoxic effects have been well documented in several studies, and work analyzing helenalin anticancer potential is still ongoing [34].

Thymus serpillum is another plant highly reported in our survey for the treatment of respiratory disease. The oil found in several thyme-related species is carminative, antiseptic, antitussive, expectorant, and spasmolytic. In herbal medicine, it is employed in respiratory disorders such as coughs, bronchitis, and sinusitis, among others [35]. The active principals thymol (a volatile oil) and carvacrol are responsible for the expectorant activity, whereas the flavonoids such as apigenin and luteolin are expected to contribute to

the anti-inflammatory and antimicrobial effects of the plant extract [36,37]. The plant extract has also shown in vivo antispasmodic effects [38], further validating its use in respiratory disorders. Interestingly, the essential oil is currently being investigated as a potential food preservative [39].

The boiled leaves, or the decoction, of *Urtica dioca* are used in cases of nutritional deficiency (iron deficiency), and as a source of micronutrients (Vitamin C). The constituents of *U. dioca* are well documented, although it is still unclear which are the components responsible for the pharmacological activities. The root has several lignans, including pinoresinol, secoisolariciresinol, and neo-olivil, which may play a dominant role in inhibiting the interaction between sex hormone binding globulin and 5α-testosterone, a pathway that plays an important role in the development of benign prostate hyperplasia (BPH). The research around *U. dioica* has been focused on BPH symptom relief, and the use for this purpose has been supported by small-scale clinical trials. *U. dioica* extracts are also evaluated as anti-inflammatory agents in arthritis and rheumatism [40,41].

Taraxacum officinale leaves are used as a food with medicinal properties. The leaves are eaten raw in salad or cooked like spinach (sauteed in olive oil with garlic), and the flower buds are foraged and preserved in brine and used like capers. The plant is thought to be useful in blood disorders and is a systemically refreshing herb. Analysis of the nutrient content has shown a balanced combination of trace elements, making the plant an interesting source of oligo-elements (calcium, potassium), micronutrients (one of the highest sources in nature of β-carotene), and an array of phytochemicals with potentially beneficial effects [42]. It contains several sesquiterpene lactones with anti-inflammatory and anticancer properties, phenylpropanoids with anti-inflammatory effects, and terpenoid polysaccharides with immune regulation, platelet anti-aggregation activity, and hepatoprotection [43–46]. It is also an important source of inulin, which has immunostimulatory functions [42]. A growing body of evidence points out that *T. officinale* components such as chlorogenic acid, chicory acid, and taraxasterol have strong hypoglycemic effects, either alone or in combination with other herbs [47–49].

Therefore, the phytochemical and pharmacological analyses of plants used medicinally in the Susa Valley has largely provided evidence for their traditional uses and could be a promising economic resource for rural communities.

3.3. Changes in the Knowledge and Use of Medicinal Plants over a Half-Century in the Susa Valley

Compared to the previous study conducted in the region in 1970, the current survey study highlights significant changes in folk-medicine knowledge and associated uses. While our study reports 36 plant species, corresponding to 33 genera, Lomagno and Lomagno Caramiello [17] reported 96 plant species, corresponding to 76 genera. We found that both studies overlap in 26 plant genera which refer to plant genera that are still used in the region (Figure 4). These overlapping genera include the five most cited plant species in our present study (*Artemisia genipi*, *Hypericum perforatum*, *Taraxacum officinale*, *Arnica montana*, and *Urtica dioica*), which were also highlighted for its importance by Lomagno and Lomagno Caramiello [17]. This reflects the cultural importance of these genera in the local ethnobotanical heritage, as a half-century of critical changes could not impact the use and knowledge of these plants.

On the other hand, the use of a few plant genera (seven genera) newly arises in the new survey; this could be attributed to the newcomers to the region who brought with them the use of a few species (e.g., *C. Carvi*, *S. aromaticum*), or due to the recent availability of these species in supermarkets that have spread into the region in the past few decades. This phenomenon was reported in a previous study in Val Borbera (in the same region, Piedmont) on the possible sociodemographic drivers behind the differences in plants, parts used, and modes of preparation in the region. Fontefrancesco et al. [5] observed that the aerial parts of ramson (*A. ursinum*) were never gathered or used in the past in the study area, but city visitors from Genoa introduced a few years ago the custom of collecting and using this plant as a substitute for garlic (and basil leaves) in one of the most iconic Ligurian

culinary preparations: pesto. The introduction "from the city" of the use of *A. ursinum*, which grows widely in beech woodlands in spring in the upper Borbera Valley, testifies to a phenomenon that is well known in southern Europe, where this plant was introduced a few decades ago as a panacea, and also possibly thanks to the popularity it achieved when the books by Austrian herbalist Maria Treben (1907–1991), especially *Health Through God's Pharmacy*, which strongly advocated its use, were translated and became best-sellers in many countries. Similarly, we observed a similar dynamic for some species (e.g., *A. ursinum* and *Lepidium sativum*) that were not documented in the study conducted by Lomagno and Lomagno Caramiello [17]. We can assume that their collection and consumption have probably started in recent decades, following the socioeconomic and demographic changes that have occurred in the Susa Valley.

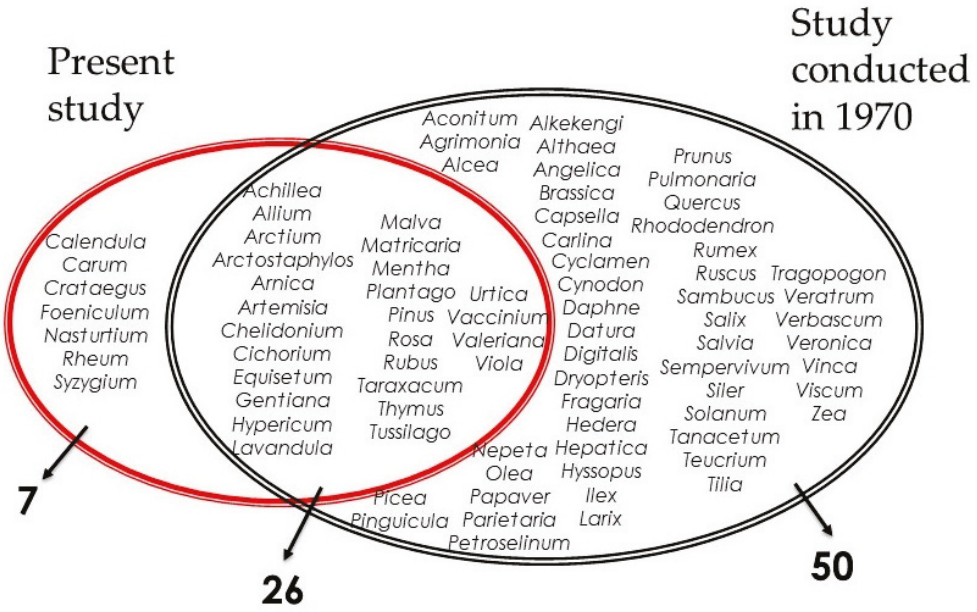


Figure 4. Genera overlapping within our present study and a previous study conducted in the region in 1970.

Figure 4 also illustrates the crucial decrease in the number of medicinal plants used in the region, where the use and knowledge of 50 genera, which correspond to 73 plant species, have been abandoned. This large number of plant species reported solely in 1970 could be attributed to, in addition to the erosion of traditional knowledge, the differences between the sampled participants in the two studies. While we interviewed normal local people, Lomagno and Lomagno Caramiello [17] mainly interviewed herbalists; this can be observed by the inclusion of some described species that are typically used in scholarly medicine, such as *Aconitum* spp., *Veratrum* spp., and *Dryopteris* spp., given that some of them have a level of toxicity and need to be used carefully. The decrease in traditional knowledge during a half-century's frame may be a reflection of the vast socioeconomic, cultural, urban, and environmental changes that have occurred in the region. Knowledge about herbs and plants of the valley once was necessary, as people in the valley were self-sufficient. People foraged plants and used them for cooking and as medicine to cure themselves. With the industrial growth in the Piedmont Plain and Turin area, which has attracted new human resources for labor from the mountain valleys, the decrease in agricultural activity, and, most notably, the decrease or even loss of dependence on this knowledge of local plants to sustain local populations, the number of practices linked to local plants and the number of people making use of them have shrunk. Food and medicinal products have been institutionalized, and non-prescribed drugs have been advertised on a massive scale. This is in addition to the spread of supermarkets and pharmacies that provide all necessities, independent of ethnobotanical knowledge. As already observed in other studies conducted

in northern Italy [5,7], the deeper integration of mountain communities within the national economy and the expansion of the health service from the end of the 1970s, along with a better access to modern drugs, could explain the erosion of TEK linked to the use of medicinal plants in the study area.

We observed during our field visits to the valley that local people are mainly dependent at present on the touristic seasons (usually during summer, and during ski period in winter), while during other periods of the year, few people permanently inhabit the villages. The development of mass tourism (leisure and sports tourism) in the Susa Valley, which also occurred in other Alpine valleys in Italy [50,51], engendered a profound transformation in the socioeconomic milieu, precipitating a transition from agrarian pursuits to engagement in the burgeoning tourist industry. This transition has been marked by a progressive detachment of the population from the local environment and, in particular, by the following human ecological changes: (1) major human migration from the upper valley to the lowlands over the past decades; (2) abandoning pastoralism (and all its derived animal products) and forest-based activities (e.g., chestnut and hazelnut collection) which were economic bases in the region; (3) the onward march of urban development, as exemplified by the expansion of touristic settlements like Bardonecchia and Sestriere, which started four decades ago. These transformations during the past few decades have significantly impacted the nexuses between local communities and their traditional activities and ultimately between the locals and their immediate landscape, and led to an erosion in the traditional ecological knowledge. Moreover, these dynamics have possibly impacted the ecological habitat of many medicinal plants, as humans' interest in maintaining the former ecosystem, including the useful plants, has significantly decreased. For instance, the study of Lomagno and Lomagno Caramiello [17] reported four species of the genus *Prunus* which have not been reported in our study, which may be a result of the current neglect of the forest. On the other hand, the absence of some pastoralism-related species (e.g., *M. pusilla*) could also be a result of the abandonment of pastoralism-related ecosystems.

3.4. Economically Promising Plant Species and Their Applications in the Food and Beverage Industry, Rural Development, Gastronomic Tourism, and More

Our study results highlight several plant species that may have high economic value for their primary or secondary products. Thirteen respondents (43%) in our study reported using *Artemisia genepi* for its digestive properties. All informants agreed on the method of preparation (infusion in alcohol). Such preparation has a historical link to other *Artemisia* spp.-based preparations of the scholarly Mediterranean such as the Roman "*vinum absinthiatum*", which can be considered the early precursor of what is known nowadays as vermouth [27]; however, as a previous study that we conducted in the upper Varaita Valley suggested [1], *genepì* was in the past mainly infused in hot milk by locals in the upper Piedmontese valleys and used as a kind of "aspirin", and, only later, possibly with the intensification of the trade with the lowlands, became an "alcoholic" beverage (first in wine, later in spirits) [1]. Furthermore, the growing popularity of wild *Artemisia* spp.-based alcoholic preparations and especially of those that are absinth-based, which are now legal in Europe if they comply with the regulatory limits for thujones (35 mg/L) [52], further testifies to the interest of consumers in this type of beverages. The ecological availability, however, of *A. genepi* and of its related species named with the same local phytonym (*A. umbelliformis* Lam., *Artemisia lagopus* subsp. *triniana* (Besser) Korobkov) in the Alps is minimal, and they are strongly regulated by regional laws in Italy [53]. The recent domestication of *A. umbelliformis* Lam. throughout the Alps has paved the way for the ever-growing popularity of *genepì*-based products such as teas, chocolates, candies, jams, alcoholic beverages (e.g., beer infused with *A. umbelliformis* flowers), and condiments. This trend has increased the number of studies aiming to isolate compounds useful as markers to fight adulteration [27]. Altogether, Alpine wild *Artemisia* spp. are highly recommended for consideration as to their further agronomic, economic, and gastronomic potentialities. Considering that the lower Susa Valley, and especially the Piedmontese hills, are well-known for their wine pro-

duction, combining locally cultivated *A. umbelliformis* and locally produced wine may have a promising economic value in the immensely growing light-alcoholic appetizing-beverage industry, i.e., the iconic Piedmontese vermouth industry. For the same purposes, and also for new possible "tonic waters", *A. absinthium* and *Achillea* spp. could possibly also be tested and evaluated in different combinations, as well as with spices, *Citrus* spp. peels, and, especially, local wild aromatic plants that have a long history of use at the study's site, such as *Carum carvi* fruits, *Thymus serpyllum* leaves, and aerial parts of *Tanacetum parthenium.* This latter taxon, in particular, is locally known as *arquebuse*; it is often even semi-domesticated in the local home gardens, and represents the main ingredient of a forgotten, fascinating alcoholic digestive beverage with the same name, which could be revitalized.

Other promising species in this context are the ubiquitous *T. officinale* (12 reports) and *Urtica dioica*; both plants are used as pillars of local wild gastronomy and as nutraceuticals, as well as for their medicinal interest. The leaves of *Taraxacum*, consumed raw or cooked, are perceived to be a blood purifier. *U. dioica* is widely appreciated in teas and local cuisine, cooked as spinach for its mild flavor and health benefits. The traditional use of these edible greens could be further exploited in local specialty food products and in the local restaurant/hospitality industry. Considering their agronomical and nutritional values, they could be considered for future domestication programs in the region. *Hypericum perforatum* is another species that our study participants cited frequently; the plant is prepared as tea or infused into alcohol or olive oil for external uses. Having a wide range of medicinal uses, it holds economic potential for its potential uses in herbal teas and traditional remedies. In dermatological preparation, as in many Mediterranean communities, it is used against skin burns, sunburnt skin, and skin stress, as well as for its anti-inflammatory properties. Therefore, diverse *Hypericum*-centered preparations (food supplements, herbal teas, and cosmetic products) may be promising and have an attractive economic value. Eleven respondents highlighted the species of *A. montana* for its benefits against shocks and trauma, while the oil is also used for massage against pain and rheumatism. As both *H. perforatum* and *A. montana* are prepared by infusing it into oil, this may suggest the further artisanal, small-scale use of new herbal oil plant extracts. Additionally, the small-scale production of new possible herbal teas for the gastronomic market and based on local wild plants could be the object of further feasibility explorations; this could be worthwhile for herbal teas based upon *Viola*, *Arctosphylus*, *Malva*, *Crataegus*, and *Carum* spp. aerial parts/fruits.

The two emerging trends that drive the use of herbs in the European food industry [54] are linked to certain considerations:

- Their functionality has been highlighted, as there is an increasing demand for functional food and beverages promoting gut, brain and holistic health. In our study this could open up innovative and novel uses of aromatic wild spp. (i.e., *Carum, Achillea*, and *Thymus* spp.). Moreover, in line with the increasing demand for prebiotic- and probiotic-rich foods and beverages [55], the identified species could be used in the development of lacto-fermented products based on wild plant resources (i.e., wild vegetables and seasoning spp.–based *kimchis* and *kombuchas*). Some of the above-mentioned species could also be used for the production of healthy condiments to substitute for salt and sugar. Our study possibly suggests the development of seasoning salts for the local market and the touristic one, in which the aromatic dried local wild-plant component, mixed with salt, could be used to decrease overall domestic salt intake.
- Their roles in shaping ethnic foods and beverages and in creating new sustainable opportunities for the local economy have been highlighted [56]. In the context of increasing food-tourism and the growing demand for local specialty foods and cuisine [57–60], wild plants and herbs may have potential in terms of distinguishing the local foodscape and its associated cuisine. This offers local actors the opportunity to support the continuation of food traditions and heritage through ad hoc projects in the restaurant industry and gastronomic-tourism sector, including ecotourism, with

local-food-based and avant-garde restaurants focusing on the revitalization of Alpine gastronomy. Additionally, artisanal entrepreneurial ventures based on traditional wild food-plants and herbs (e.g., vegetable and fruit preserves, and condiments) and educational and community-based projects aimed at promoting the sustainable use and consumption of these resources could be also envisioned. In our study area, this opportunity could be further fostered by designing and conducting specific food-scouting projects aimed at the documentation and revitalization of local plant-based heritage foods and cuisines in neighboring areas, both within the Provencal and Franco-Provencal speaking communities.

Some sustainability issues should be considered in the future development of projects aimed at the revitalization and promotion of wild plants and herbs in our study area. It is critical to mention that some of these promising economic species have been listed on the "Red List" as being of "Least Concern", such as *T. serpyllum* [61]. In addition, some other highly used species (e.g., *A. genepi*) have been highlighted by local people as threatened, even though they have not been listed on the Red List. Therefore, serious environmental consideration should be taken when planning to use these species on a wide economic scale, including the possibility of ad hoc local regulations to avoid over-exploitation of these natural resources.

4. Conclusions

Our study documented 36 species used as medicine and food-medicine in the Susa Valley of NW Italy. The study has conducted a comparison between our documented species and 96 plant species reported by a previous study conducted in the area in 1970. The comparison showed a critical decrease in the knowledge and use of medicinal plants in the region. This change was attributed to socioeconomic, urban, touristic, cultural, health system, and, possibly, environmental changes that have occurred in the region in the past half-century. However, further reasons for the documented change include differences between the methodologies applied in our study and those of the study conducted in 1970 [17]. The present study suggests several species for future applied-botany studies and projects using local plant resources in the study's region. These economically promising species could play a crucial role in the well-being and development of the communities in NW Italy, as they could be a basis for future innovative and sustainable foods, nutraceuticals, and medicinal products. Thus, this study has expanded the scientific knowledge beneficial for increases in the competitiveness of the food system of NW Italy in terms of quality and the added value of food products.

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Article

The Resilience and Change in the Biocultural Heritage of Wild Greens Foraging Among the Arbëreshë Communities in Argolis and Corinthia Areas, Peloponnese, Greece

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Abstract

The transformation of Local Ecological Knowledge (LEK) among minority populations undergoing cultural and linguistic assimilation over time is poorly understood. Arbëreshë communities in Greece, who have preserved Albanian-derived traditions for centuries, offer a unique opportunity to examine how folk plant knowledge adapts over time. This study examines the linguistic labels and culinary uses of wild greens among Arbëreshë (or Arvanites), an ethno-linguistic minority traditionally speaking Arbërisht or Arvanitika, the Tosk dialect of Albanian, who have resided in the Argolis and Corinthia regions of the Peloponnese for several centuries. In 2025, fieldwork was conducted in four rural Arbëreshë villages in the Argolis and Corinthia regions of Greece, combining semi-structured interviews with 24 elderly participants, participant observation, and the collection and identification of botanical specimens. The contemporary dataset was compared with historical ethnobotanical records from the 1970s to assess temporal changes in the use of wild vegetables and folk plant nomenclature. Our results reveal that current Arbëreshë ethnobotanical heritage has undergone profound Hellenisation, with 62% of folk plant names of Greek origin, 14% Albanian, and 24% hybrid, reflecting strong linguistic and cultural assimilation over the past half-century. The traditional boiled green mix (*lakra* in Arbëreshë, *chorta* in Greek) remains central to the local cuisine, which is rooted in foraged plants, although its culinary applications have diversified. In total, 37 taxa of wild vegetables across 37 genera and 14 families were documented in 2025, compared with 21 taxa across 21 genera in the filtered 1970 dataset. Core families, such as Asteraceae and Brassicaceae, remained dominant, while new families, like Malvaceae and Portulacaceae, appeared, possibly indicating both ecological and culinary changes. These findings raise questions about whether the Arbëreshë wild vegetable heritage was strongly influenced by the surrounding Greek majority or primarily acquired after migration, potentially facilitated by intermarriages and shared Orthodox Christian affiliation. Overall, our study highlights a largely Hellenised Arbëreshë biocultural heritage and underscores the urgent need for national and regional stakeholders to recognise and celebrate the remaining minority's linguistic and ethnobotanical diversity. The transformation of local ethnobotanical knowledge over the past fifty years appears influenced by ecological availability, socio-cultural dynamics, and changing taste preferences.

Keywords: ethnobotany; wild greens; Arbëreshë; Arvanites; Greece; local ecological knowledge

1. Introduction

The Albanian Arbëreshë, also known in Greece and occasionally in the literature as Arvanites, are an ethno-linguistic minority of Albanian origin who settled in mainland and insular Greece between the 14th and 16th centuries [1,2]. The relocation of Arbëreshë to Greece is linked to the depopulation of these regions due to continuous conflicts and internal wars, as well as to the imperial decree that required military forces to be stationed on Greek territory in the 14th century [1]. Their historical presence is reflected in local toponymy, customs, and oral traditions [2–4]. Over time, however, most Arbëreshë communities in mainland Greece have undergone a process of progressive Hellenization, particularly since the formation of the modern Greek state in the 19th century [5]. This process, shaped by national integration policies and sociolinguistic dynamics, has led to a significant decline in the use of the Arvanitika dialect and the assimilation of cultural practices into the dominant Greek framework [2,6,7]. This process intensified during the 19th and 20th centuries, marked by cultural assimilation, the marginalisation of minority identities, and the near disappearance of Arvanitika, the Tosk dialect of the Albanian language [8,9].

In contrast to their counterparts in Southern Italy, where the Arbëreshë (the Albanian diaspora in Southern Italy, which includes many who migrated from Albania via Greece in the 15th century) have had their identity more actively preserved and institutionally supported [8,10], the Arbëreshë in mainland Greece followed a different path. The combined forces of national integration policies, marginalisation and stigmatisation of linguistic differences, and rural-to-urban migration have dramatically reduced both the use of Arvanitika and the intergenerational transmission of cultural knowledge [6,11–13]. Immigration, particularly during the post-war decades, further accelerated this transformation: as younger generations left rural areas in search of work or education in cities, local dialects, subsistence practices, and place-based knowledge systems weakened [14,15].

Simultaneously, land use changes, including the abandonment of traditional agricultural terraces, the decline of small-scale herding and subsistence farming, and the expansion of monocultures and tourism-related development, transformed the ecological and social landscape of many villages [16–18]. As a result, the daily interaction with plants and natural environments that sustained ethnobotanical knowledge was disrupted. These environmental changes, combined with shifting economic and social structures, contributed to the erosion of orally transmitted ecological knowledge, especially among younger generations who were no longer tied to ancestral livelihoods or seasonal rhythms [15].

Nevertheless, in a few isolated mountain communities in the Argolis region of Central Greece, notably Limnes, Arachneo, Aggelokastro, and Sofiko, elderly speakers continue to retain fragments of the Arbëreshë language and aspects of traditional ecological knowledge [7]. These villages, geographically removed from urban centres and located in rugged terrain, have maintained a certain degree of cultural autonomy, making them valuable sites for investigating residual ethnobotanical heritage.

Ethnobotanical knowledge, also known as local ecological knowledge (LEK), is typically transmitted orally and is strongly tied to both the landscape and cultural identity [18,19]. Several studies have highlighted the nexus between diaspora communities and their adapted (and travelled) local ecological knowledge [20,21]. A growing body of research highlights the link between linguistic and ecological diversity [19] and the fact that language loss is often accompanied by the erosion of environmental memory [22]. Yet some scholars

have shown that foraging knowledge and plant uses can persist even when the original linguistic categories collapse, surviving in embodied practices and everyday use. In contrast, folk plant names may be retained, translated, or lost [21,23,24]. As such, the study of folk plant nomenclature provides a powerful lens through which to examine the relationship between language attrition, cultural resilience, and biocultural memory. In this context, ethnobotanical terminology among Arbëreshë speakers in Argolis offers a compelling case study. By examining the preservation, replacement, or loss of plant names of Albanian origin, it becomes possible to trace broader processes of cultural change and continuity, particularly in relation to migration, land abandonment, and social transformation.

This study aimed to: (1) document wild greens currently known by the Albanian-speaking communities in Argolis and Corinthia, Peloponnese, Greece; (2) assess changes in the diversity of wild greens used, by comparing the documented contemporary ethnobotanical data with a historical dataset from the 1970s; (3) evaluate the resilience and transformation of folk plant nomenclature, focusing on the retention, replacement, or hybridization of Albanian-origin names; and (4) examine how socio-cultural and ecological changes, including language shift and altered land use practices, may have influenced the continuity and adaptation of local ecological knowledge in these communities.

2. Materials and Methods

2.1. Study Area and Data Collection

The study was conducted in the Argolis region of the northeastern Peloponnese, Central Greece. Fieldwork focused on four villages: Limnes, Arachneo, Aggelokastro, and Sofiko, known for their historical Albanian populations (Figure 1). These villages are located in hilly and semi-mountainous terrain, ranging from 250 to 800 m above sea level. A Mediterranean climate with mixed land uses, including small-scale farming (i.e., olive groves), and areas of secondary vegetation, characterises them. Due to their relative geographic isolation from urban and coastal centres, these communities have preserved residual elements of Albanian cultural and linguistic heritage, particularly among the elderly.

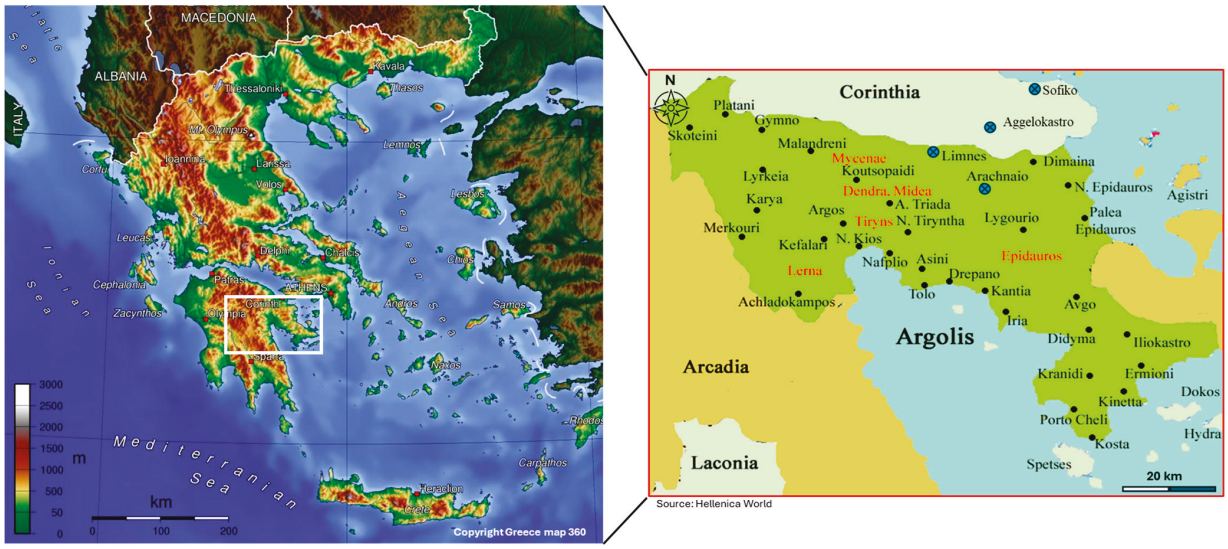


Figure 1. Study area map within the map of Greece. Locations of the villages where the study was conducted (blue circles and crosses refer to the studied villages of Limnes, Arachneo, Aggelokastro, and Sofiko) in the Argolis and Corinthia regions of Greece. Copyright Information: GreeceMap360: © 2025 Newebcreations. All rights reserved. Greece Map 360. Available online: https://greecemap360.com/ (accessed on 8 October 2025). Hellenica World: © Foundation of the Hellenic World. All rights reserved. Available online: https://www.hellenicaworld.com/ (accessed on 8 October 2025).

Over the past decades, however, the region has experienced significant demographic and land use changes, including population decline due to rural outmigration, abandonment of traditional agriculture, and ecological succession in previously cultivated or grazed areas. These transformations have influenced both the availability of wild plant resources and the transmission of local environmental knowledge. Between March and May 2025, ethnobotanical data were collected through semi-structured interviews with 24 elderly participants (16 men and eight women, aged 64–83) who identified themselves as native or heritage Albanian speakers. Such knowledgeable individuals, especially those familiar with local botanical plants, were increasingly rare to find in these villages. Interviews were conducted in Greek and, where possible, in Arvanitika dialect fragments, depending on speaker fluency. Participants were asked to list and describe the wild vegetables traditionally used for food and foraged in the surrounding landscape. For each plant mentioned, the following data were recorded local folk name(s) (with special attention to names of Albanian origin), used parts (e.g., leaves, shoots, bulbs), culinary preparation (e.g., boiling, salad, seasoning), and quotation frequency (classified as R = rarely, C = commonly, VC = very commonly). The Code of Ethics of the International Society of Ethnobiology was adhered to during this research, and every interviewee was informed about the aims of this study in advance [24]. Voucher specimens were collected and identified using the standard reference of the Greek Flora [25], verified using the online annotated checklist of the Greek flora (https://portal.cybertaxonomy.org/flora-greece/intro, accessed on 8 September 2025) and deposited at the Herbarium of the Bio-Cultural Diversity Lab of the Department of Environmental Sciences, Informatics, and Statistics, Ca' Foscari University of Venice, Italy. Botanical nomenclature was aligned with the World Flora Online database [26]. Recorded folk names were transcribed in the Latin alphabet, following standard rules of Albanian and (Latinised) Greek orthographies.

Folk plant names of likely Albanian etymology were highlighted and later cross-checked with a comparative Albanian-language botanical lexicon [27], and regional studies to determine their origins. Special attention was given to whether these names coexisted with Greek alternatives, had been entirely replaced, or were still actively used.

2.2. Historical Reference Dataset (1970)

For comparative purposes, a dataset from the US anthropologist Mary Clark Forbes, who conducted extensive field studies in 1970 in Eastern Argolis, was used as a historical reference for the foraged flora of Argolis. Although the original research was rooted in deep ethnography and ethnobotanical in its essence, it did not record folk plant names, and, nevertheless, still provides a valuable list of wild or semi-wild plant taxa used for food in the same region at that time.

The 1970 list includes 38 plant taxa, primarily recorded at the genus level, along with brief notes on edible parts. While it is not certain that Forbes' participants were of Albanian origin, the data were collected from eastern Argolis localities, thus offering a relevant baseline for temporal comparison of plant uses at the genus level.

To ensure the validity of diachronic comparison, we critically assessed the comparability of our 2025 dataset with the 1970 dataset by Clark Forbes. While both studies were conducted in the Argolis region in the spring season and documented wild edible plants, there are some limitations. First, although Forbes conducted her study in the eastern Argolis area, and thus geographically, there is no perfect overlap with our field sites. Second, sample sizes are not comparable as Forbes did not report participant numbers, whereas our 2025 study involved 24 informants.

Given these caveats, comparability was reasonable at the taxonomic level of plant genera, as the 1970 study did not collect botanical vouchers, and neither Forbes recorded vernacular plant names. We therefore limited the comparative analysis to the presence, absence, and innovation of wild green plant genera, while linguistic analysis was restricted to the 2025 dataset. By explicitly acknowledging these limitations, we sought to strike a robust balance between the attempt at a diachronic comparison and methodological reproducibility.

2.3. Data Analysis

Data were processed and analysed using R version 4.4.2 and SAS 9.4. The analysis focused on three primary objectives: describing the structure of the 2025 dataset, comparing it temporally with historical data from 1970, and assessing the degree of linguistic resilience in the preservation of folk plant nomenclature.

First, descriptive statistics were used to quantify the total number of plant taxa recorded in 2025 and to calculate the number and percentage of taxa bearing folk names of Albanian origin. The distribution of folk names was examined across botanical families and culinary preparation methods (e.g., boiled greens, salads, and seasonings). Citation frequencies were classified as rare, R, if wild green was quoted by less than 10% of the informants; common, C, if mentioned by more than 10% and less than 40% of the informants; very common, VC, if quoted by more than 40% of the informants.

Second, a diachronic comparison of the taxonomic lists from 1970 and 2025 was conducted to evaluate changes in species composition and ethnobotanical practices over time. Since the 1970 dataset did not report vernacular plant names, our analysis of continuity focuses on the persistence of taxa rather than the names themselves. Thus, categories of continuity, loss, and innovation are applied strictly to the taxonomic level. Linguistic variation could only be assessed within the 2025 dataset, where multiple folk names were recorded for specific genera. Genera common to both datasets were identified, and changes were categorised into three types: (1) continuity, where a plant continued to be used; (2) loss, where the genus was not mentioned in the 2025 data; and (3) innovation, where new taxa appeared in the 2025 data but were absent from the 1970 record. This allowed us to assess not only linguistic shifts but also broader cultural and ecological transformations in plant use practices.

Third, a linguistic resilience assessment was carried out to evaluate the extent of retention of Albanian folk names. The proportion of Albanian-origin names was calculated as a percentage of the total number of folk plant names recorded in 2025. Patterns of linguistic replacement were explored by identifying cases where Greek names had supplanted Albanian terms. Additionally, we examined whether specific wild greens were more likely to retain Albanian names or undergo lexical replacement, highlighting the uneven impact of language shift across plant-use categories. Finally, a series of multivariate analyses was considered to explore the deeper structure in the dataset. Correspondence Analysis (CA) was proposed to group plants based on naming origin and usage frequency. In addition, contingency tables and Chi-square tests were suggested to assess associations between the frequency of wild plant quotations and the retention of Albanian terminology. These analytical tools provide insight into the interaction between cultural resilience and linguistic attrition, particularly within an ageing minority population undergoing rapid sociolinguistic change.

3. Results

3.1. Botanical Diversity Change and Culinary Traditions Among the Greek Albanians

The wild greens dataset from 1970 included 21 species belonging to 21 genera across 10 families, whereas the 2025 dataset comprised 37 species from 37 genera distributed among 14 families.

Seventeen genera were consistently present in both 1970 and 2025, including *Allium*, *Amaranthus*, *Centaurea*, *Chondrilla*, *Cichorium*, *Origanum*, *Taraxacum*, and others, demonstrating continuity in core edible wild plant resources over time. Meanwhile, four genera recorded in 1970, such as *Solanum* (Solanaceae), *Capparis* (Caparaceae), *Discorea* (Dioscoreaceae), and *Hypochaeris* (Asteraceae), were absent in 2025. In contrast, twenty genera appeared exclusively in 2025, including *Asparagus* (Asparagaceae), *Beta* (Amaranthaceae), *Pelargonium* (Geraniaceae), *Raphanus* (Brassicaceae), and others (Figure 2), reflecting an expansion in both taxonomic diversity and ecological breadth of edible wild plants (Figure 2).

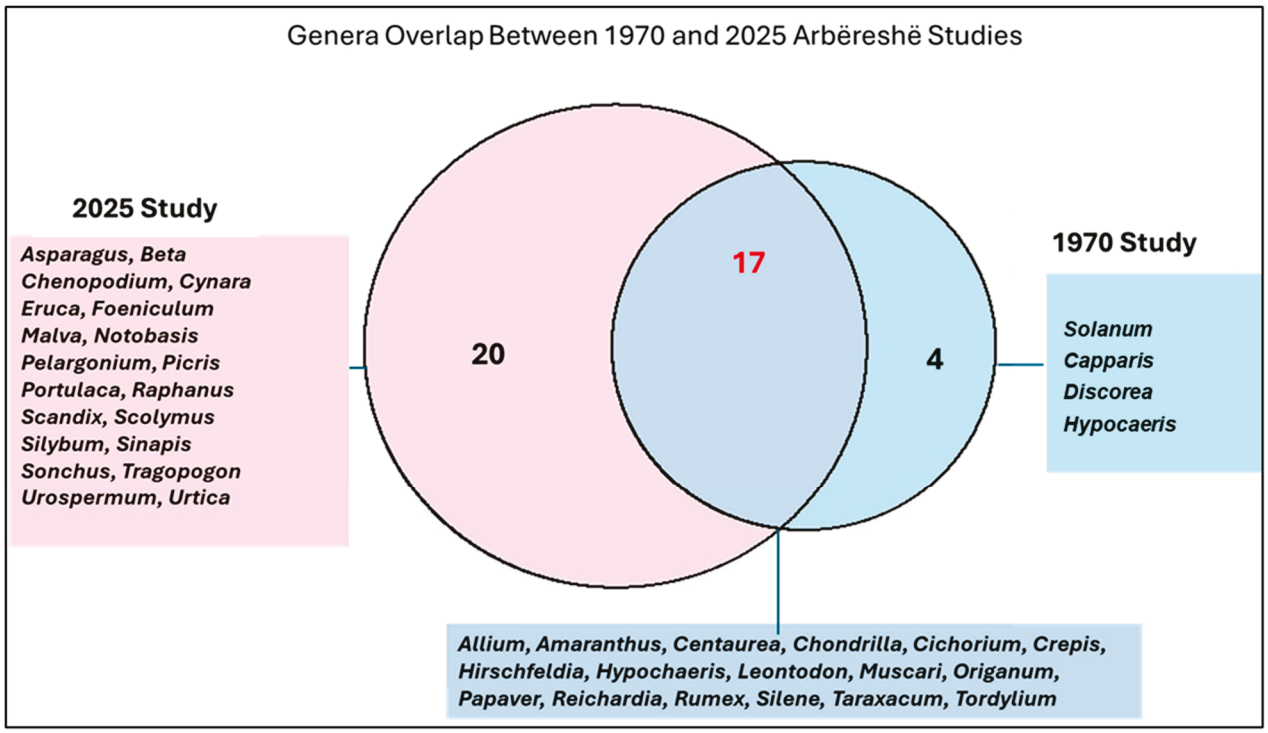


Figure 2. Overlap of the gathered and consumed wild greens genera between the current study and the field study conducted in Eastern Argolis in the 1970s.

At the family level, the diversity of Asteraceae increased from nine to 14 genera, Brassicaceae from two to four, and Apiaceae from one to three, while Lamiaceae declined markedly from four genera to just one genus. Additionally, Fabaceae and Solanaceae, which were present in 1970, were absent from the 2025 dataset. These shifts highlight notable changes in family-level diversity over the 55-year interval (see Table 1).

The comparison of plant parts used in the two periods reveals both continuity and change in foraging practices and dietary preferences. In both studies, young aerial parts dominated the records, with genera such as *Amaranthus*, *Cichorium*, *Hirschfeldia*, *Reichardia*, *Rumex*, *Silene*, *Sonchus*, *Taraxacum*, and *Tordylium* consistently valued for their palatability, seasonal availability, and ease of preparation. The use of flowering structures increased slightly in 2025, with taxa such as *Origanum* (flowering tops) and *Cynara* (flower receptacles) appearing, replacing the 1970 record of *Matricaria* (flower heads). This change may indicate a refined appreciation for floral textures or an improved understanding of ethnobotanical documentation. Specific categories persisted, albeit with shifts in genera; for example, shoots of *Chondrilla*, *Rumex*, and *Tamus* were recorded in 1970, whereas *Asparagus*, *Silene*, and *Tragopogon* featured prominently in 2025.

Table 1. Wild vegetables documented in the Albanian villages of the study area in Greece. The plant names in bold indicate taxa for which the recorded local names are of Greek origin; names in italics and bold indicate hybrid (Albanian and Greek) names; names rendered in plain fonts are of Albanian origin.

Botanical Taxon or Taxa	Botanical Family	Voucher Specimen Number, Starts with UVVETBOT	Local Plant Name(s)	Used Parts	Culinary Prepraration(s)	Quotation Frequency
Allium ampeloprasum L.	Amaryllidaceae	GRARB31	Hudhra e egër, Skordo	Whole plants	Seasoning	R
Amaranthus blitum L. and possibly other *Amaranthus* spp.	Amaranthaceae	GRARB27	Nena, Vlita	Tender aerial parts	Boiled	VC
Asparagus aphyllus L.	Asparagaceae	GRARB15	Sfaraghia, Sparaghia, Srokalià, Sporaghie, Spuraghie	Shoots	Cooked	VC
Beta vulgaris L.	Amaranthaceae	GRARB34	Spanakë e egër	Aerial parts	Lakra	C
Centaurea raphanina Sibth. & Sm.	Asteraceae	GRARB21	Aginarkai, Agriaginara, *Iannides e egër*	Young whorls	Lakra	VC
Chenopodium album L.	Amaranthaceae	GRARB20	Llabotë	Young aerial parts	Boiled	R
Cichorium intybus L.	Asteraceae		Radiki, *Radiki e kuqe*	Young aerial parts	Lakra	C
Chondrilla juncea L.	Asteraceae	GRARB34	Radiki	Young aerial parts	Lakra	R
Crepis bursifolia L.	Asteraceae	GRARB09	Prikrada, Radiki	Young aerial parts	Lakra	VC
Crepis capillaris (L.) Wallr.	Asteraceae		*Radiki e kuqe*	Young whorls	Lakra	VC
Cynara cardunculus L.	Asteraceae		Bukë e ljepuri, Iannides	Flower receptacles	Snack	C
Eruca vesicaria (L.) Cav.	Brassicaceae	GRARB14	Ruqë, Rukò	Young aerial parts	Salads	C
Foeniculum vulgare Mill.	Apiaceae	GRARB11	Anitho, Marathee, Maratho, Sidra	Aerial parts	Seasoning, Lakra	VC
Hirschfeldia incana (L.) Lagr.-Foss.	Brassicaceae	GRARB04	Ghinarides, Vruva	Young aerial parts	Lakra	VC
Leontodon spp.	Asteraceae		Glykoradiki	Young aerial parts	Lakra	C
Malva sylvestris L.	Malvaceae	GRARB28	Mallagë, Moaga, Molaga, Molocha	Leaves	Lakra	R
Leopoldia comosa (L.) Parl.	Asparagaceae		Vorvi, Vrovi, Vulvià, Vulvulli	Bulbs	Cooked, pickled	C
Notobasis syriaca (L.) Cass.	Asteraceae		*Glim e egër*	Stems	Snack	R
Origanum vulgare L.	Lamiaceae		Iasmo, Riganee	Flowering tops	Seasoning	C
Papaver rhoeas L.	Papaveraceae		Paparuna, Lule e kuqe	Young whorls	Lakra	R
Pelargonium graveolens L'Hér.	Geraniaceae		Arbarodisa	Leaves	Seasoning for jams and sweet preserves	C
Helminthotheca echioides (L.) Holub	Asteraceae		Radiki	Young aerial parts	Lakra	C
Pleurotus spp. (Fungi)	Pleurotaceae		Kepurdhë	Fruiting body	Cooked	C
Portulaca oleracea L.	Portulacaceae		Adrakla, Andrakla	Aerial parts	Salads	C
Raphanus spp.	Brassicaceae		Rapanidee	Aerial parts	Lakra	R

Table 1. *Cont.*

Botanical Taxon or Taxa	Botanical Family	Voucher Specimen Number, Starts with UVVETBOT	Local Plant Name(s)	Used Parts	Culinary Prepraration(s)	Quotation Frequency
Reichardia picroides (L.) Roth	Asteraceae	GRARB05	Bukë ljepuri, Ghieres, Kochinida, Lagomomachi	Aerial parts	Salads, Lakra	VC
Rumex spp.	Polygonaceae		Lahana	Leaves	Lakra, dolmades	C
Scandix pecten-veneris L.	Apiaceae	GRARB29	Marillida, Miridis	Aerial parts	Lakra	C
Scolymus hispanicus L.	Asteraceae		Glim	Stems	Cooked	R
Silene vulgaris (Moench) Garcke	Caryophyllaceae		Bathëz	Young shoots	Lakra	C
Silybum marianum (L.) Gaertn.	Asteraceae	GRARB08	*Glim e gomari*	Stems	Snack	R
Sinapis alba L.	Brassicaceae	GRARB12	Chichibetra, Ghinarides, Piperica, Vruva, Vruvi	Young aerial parts	Lakra	VC
Sonchus oleraceus L.	Asteraceae	GRARB07	Rreshellë, Rreshillë, Rushellë	Young aerial parts	Lakra	VC
Taraxacum campylodes G.E.Haglund	Asteraceae	GRARB33	Radiki, Taraxako	Young whorls	Lakra	VC
Tordylium apulum L.	Apiaceae	GRARB13	Kalkafidha, Kafkalithra, Marallida, Skarkalithra	Aerial parts	Lakra	VC
Tragopogon porrifolius L.	Asteraceae	GRARB25	Bukë cjapi, Bukë qapi, *Brokolë e egër*	Young shoots	Salads, Lakra	C
Urospermum spp.	Asteraceae		Radiki	Young whorls	Lakra	R
Urtica urens L.	Urticaceae	GRARB19	Hith, Hithra	Leaves	Lakra	R

Lakra—Boiled green mixes.

The culinary uses documented in the 2025 study (Table 1) highlight the enduring centrality of boiled green mixes, locally known as *lakra,* which account for the majority of preparations (20 out of all recorded uses). This traditional method commonly involves taxa such as *Beta*, *Centaurea*, *Chenopodium*, *Cichorium*, *Chondrilla*, *Crepis*, *Hirschfeldia*, *Leontodon*, *Malva*, *Papaver*, *Picris*, *Raphanus*, *Reichardia*, *Scandix*, *Silene*, *Sinapis*, *Sonchus*, *Taraxacum*, *Tordylium*, *Tragopogon*, *Urospermum*, and *Urtica*, often combined to create nutritious and flavourful boiled green mixes. Other commonly reported uses, including simple snacks made from *Cynara*, *Notobasis*, and *Silybum*, as well as cooked dishes with *Asparagus*, *Muscari*, and *Scolymus*, and fresh salads featuring *Eruca*, *Portulaca*, *Reichardia*, and *Tragopogon,* emphasise the versatility of wild plants in everyday diets. The inclusion of seasonings derived from *Allium*, *Foeniculum*, *Origanum*, and *Pelargonium*, the latter also used in jams and sweet preserves, as well as more elaborate preparations such as dolmades (stuffed leaves) made with *Rumex*, reflects the role of wild taxa not only as sources of nourishment but also as essential flavour enhancers. Occasional mentions of pickling, particularly of *Muscari* bulbs, point to preservation practices that further extend their utility, while also mellowing the otherwise strong or bitter flavour of the bulbs. Collectively, these data reveal a rich, adaptable, and enduring culinary tradition rooted in the flexible use of a diverse array of wild plant species.

3.2. Ethnolinguistic Origins and Citation Frequency

In our field data (2025 study), out of the 37 wild plant taxa recorded, five (13.5%) were associated with folk names of pure Albanian origin, including *Beta vulgaris, Chenopodium album*, *Silene vulgaris*, *Sonchus oleraceus*, and *Urtica urens* (Table 2). The majority, 23 taxa (62.16%), were linked to Greek-origin names, underlining the strong historical and linguistic influence of Greek on the local folk botanical vocabulary. Locals also reported seven folk names, which were hybrid Albanian-Greek, representing 24.32% of all phytonyms recorded across the study area. The plants used by this group belong to the genera *Amaranthus*, *Allium, Cynara*, *Eruca, Malva*, *Papaver, Reichardia*, and *Tragopogon*.

Table 2. Distribution of Wild Plant Folk Names by Linguistic Origin (2025 Study).

Linguistic Origin	Number of Taxa	Percentage (%)	Genera
Albanian only	5	13.5%	*Beta*, *Chenopodium*, *Silene*, *Sonchus*, *Urtica*
Greek only	23	62.16%	*Arbutus*, *Capparis*, *Chondrilla*, *Foeniculum*, *Hirschfeldia*, *Leontodon*, *Muscari*, *Notobasis*, *Origanum*, *Pelargonium*, *Picris*, *Portulaca*, *Pyrus*, *Quercus*, *Raphanus*, *Rumex*, *Scandix*, *Scolymus*, *Silybum*, *Sinapis*, *Satureja*, *Taraxacum*, *Tordylium*
Hybrid (Albanian and Greek)	9	24.32%	*Amaranthus*, *Allium, Centaurea*, *Crepis, Cynara*, *Eruca*, *Malva, Papaver*, *Reichardia, Tragopogon*

In the 2025 dataset, wild plant taxa were grouped by frequency of quotation into three categories (Table 3). Commonly quoted taxa (C) represented 37.8% of all genera (14 out of 37), including culturally significant species such as *Origanum*, *Rumex*, and *Pleurotus*, which are well embedded in local foodways and valued for their versatility. Widespread reported taxa (VC) accounted for 32.4% (12 genera), such as *Crepis* (with two quotations), *Taraxacum*, and *Sonchus*, reflecting frequent though less dominant usage. Rarely quoted taxa (R) comprised 29.7% (11 genera), including *Papaver*, *Urtica*, and *Silybum*. These plants may still hold ethnobotanical value, but their lower citation frequency suggests specialised, declining, or more locally restricted use.

Table 3. Quotation Frequency and Distribution of Wild Plant Genera in the 2025 Study.

Quotation Frequency	Number of Genera	Percentage (%)	Genera (List)
Common (C)	14	37.8%	*Beta*, *Cichorium*, *Cynara*, *Eruca*, *Leontodon*, *Muscari*, *Origanum*, *Pelargonium*, *Picris*, *Pleurotus*, *Portulaca*, *Rumex*, *Scandix*, *Silene*, *Tragopogon*
Very Common (VC)	12	32.4%	*Amaranthus*, *Asparagus*, *Centaurea*, *Crepis* (2), *Foeniculum*, *Hirschfeldia, Reichardia*, *Sinapis*, *Sonchus, Taraxacum, Tordylium*
Rare (R)	11	29.7%	*Allium*, *Chenopodium*, *Chondrilla*, *Malva*, *Notobasis*, *Papaver*, *Raphanus*, *Scolymus*, *Silybum*, *Urospermum*, *Urtica*

A cross-analysis of linguistic origin and citation frequency reveals distinct cultural and ethnobotanical patterns, as shown in Table 4. The majority of taxa (23 out of 37) are associated with Greek-origin folk names, underscoring the long-standing influence of the Greek language and plant knowledge in the region. These names dominate both the Very Common (VC) and Rare (R) categories, suggesting a heritage of transmission that persists even when usage has waned. Exclusively Albanian-origin names are fewer (five out of 37),

mainly appearing in the Common (C) and Rare (R) groups, indicating a localised retention of plant knowledge, particularly for widely available taxa such as *Beta*, *Pleurotus*, and *Urtica*. Hybrid Greek–Albanian names occur in nine genera, clustered in the three frequently cited categories with three genera for each one (Table 4). This clearly demonstrates a partial transformation of the traditional plant nomenclature over the past five decades.

Table 4. Linguistic origin and citation frequency of the documented plant genera.

Linguistic Origin	Very Common (VC)	Common (C)	Rare (R)	Total Genera
Albanian only	*Sonchus*	*Beta*, *Silene*	*Chenopodium*, *Urtica*	5
Greek only	*Asparagus*, *Foeniculum* *Hirschfeldia*, *Sinapis*, *Taraxacum*, *Tordylium*	*Cichorium*, *Leontodon*, *Muscari*, *Origanum*, *Pelargonium*, *Picris*, *Portulaca*, *Rumex*, *Scandix*,	*Chondrilla*, *Notobasis*, *Raphanus*, *Scolymus*, *Silybum*, *Urospermum*	25
Hybrid (Albanian and Greek)	*Amaranthus*, *Centaurea*, *Crepis*, *Reichardia*,	*Cynara*, *Eruca*, *Tragopogon*	*Allium*, *Malva*, *Papaver*,	10
Total	12	14	11	37

The Correspondence Analysis (CA) presented in Figure 3 reveals distinct associations between the linguistic origin of plant names, their frequency of use, and the specific plant parts utilised. Plant names of Albanian origin are predominantly associated with the "Rare" and, to a lesser extent, the "Common" frequency categories, indicating that these taxa are cited or utilised less frequently within the studied communities. In contrast, Greek-origin names cluster with the "Very Common" category, suggesting broader familiarity and more widespread use.

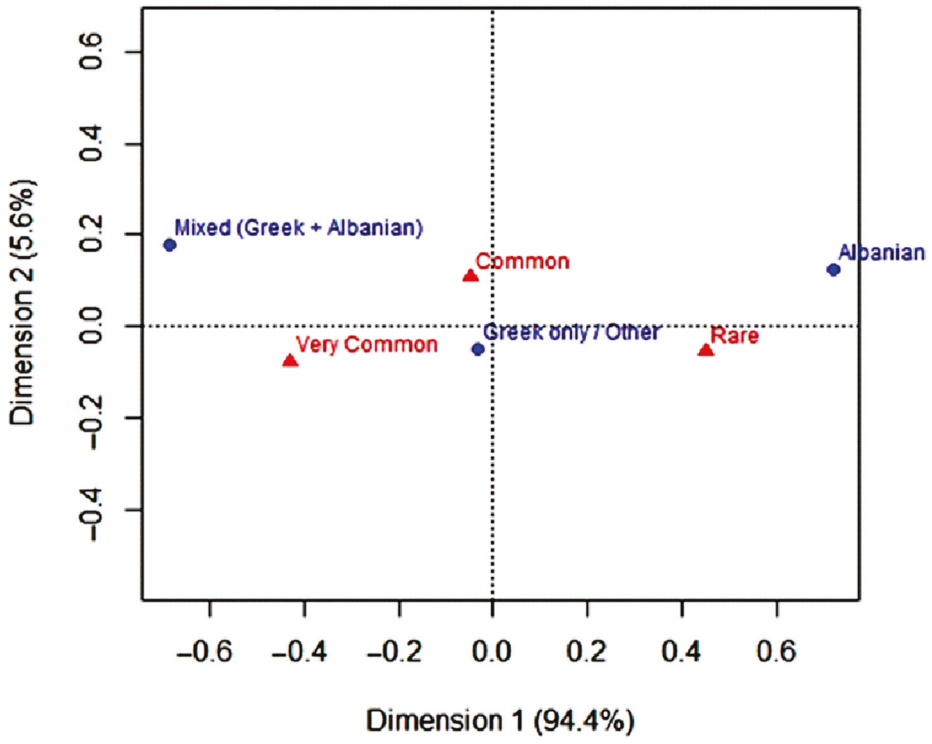


Figure 3. Correspondence analysis of wild green phytonyms' linguistic origin and quotation frequency, showing clusters corresponding to the Core Resilient Heritage (high use + Albanian names) and Marginalised/Borrowed Knowledge (low use + Greek names).

Notably, a subset of taxa, including *Beta*, *Urtica*, and *Pleurotus*, combines relatively high citation frequency with the retention of Albanian-origin names, possibly representing a "core resilient heritage" of the Arbëreshë ethnobotanical knowledge. Conversely, taxa such as *Chondrilla*, *Notobasis*, and *Raphanus*, cited rarely and associated with Greek names, form a possibly "marginalised or newly borrowed knowledge" group. These patterns highlight that cultural resilience is unevenly distributed across the wild plant repertoire, with some species preserving linguistic and cultural continuity while others reflect assimilation and innovation.

4. Discussion

The comparative analysis of botanical families and plant use between the 1970 and 2025 datasets reveals significant shifts in species composition and ethnobotanical practices, reflecting broader ecological, socio-cultural, and linguistic transformations. These findings support the hypothesis that traditional ecological knowledge (TEK) and plant use are dynamic, shaped by environmental change, cultural contact, and socio-economic factors [27–29].

4.1. Botanical Diversity Change

The herbaceous wild vegetable dataset from 1970 included 21 species belonging to 21 genera across 10 families, whereas the 2025 dataset comprised 37 species from 37 genera distributed among 14 families. Seventeen genera were consistently present in both 1970 and 2025, including *Allium*, *Amaranthus*, *Centaurea*, *Cichorium*, *Origanum*, and *Taraxacum*, demonstrating continuity in core edible wild plant resources over time [30]. Meanwhile, four genera recorded in 1970 were absent in 2025. In contrast, twenty genera appeared exclusively in 2025, including *Asparagus* (Asparagaceae), *Beta* (Amaranthaceae), *Pelargonium* (Geraniaceae), and *Raphanus* (Brassicaceae), reflecting an expansion in both taxonomic diversity and ecological breadth of edible wild plants [31].

At the family level, the diversity of Asteraceae increased from eight to twelve genera, Brassicaceae from two to four, and Apiaceae from one to three, while Lamiaceae declined markedly from four to just one genus. Additionally, Fabaceae and Solanaceae, which were present in 1970, were absent from the 2025 dataset. Similar shifts in ethnobotanical records elsewhere have been linked to a combination of ecological changes, shifts in agricultural practices, and evolving cultural food preferences [32,33]. These transformations may also reflect broader socio-economic dynamics, including the decline of subsistence foraging, increased market integration, and generational changes in the transmission of plant knowledge [15].

The documented changes suggest that Arbëreshë communities, while maintaining specific emblematic bitter taxa, have also integrated new (again, predominantly bitter) edible wild species into their contemporary foodscapes, possibly due to increased ecological availability, the adaptation of traditional recipes, or the revitalisation of foraging knowledge through gastronomic and heritage movements. However, the loss of some taxa recorded in 1970, most notably the bitter *Solanum* and *Disocorea* spp. that are often markers of ancient cuisines and poverty, raises questions about the persistence of associated cultural practices and taste preferences, the resilience of local plant knowledge, and the potential erosion of biocultural diversity, also in the face of environmental and cultural (social) change [32].

4.2. Continuity and Transformation of Wild Greens-Centred Culinary Practices

The persistent predominance of young aerial parts in both the 1970 and 2025 datasets aligns with ethnobotanical theory, which emphasises the preference for palatable, tender, and easily harvestable plant parts in traditional diets [34,35]. Such continuity supports the

idea of a profound cultural attachment to specific plant parts and preparation methods that have persisted despite environmental and socio-economic changes.

The increase in the use of flowering structures in 2025 may signal both ethnobotanical diversification and refined culinary appreciation, consistent with studies showing that changing tastes, innovation in recipes, and evolving plant knowledge can expand the range of plant parts exploited [36].

The predominance of boiled (bitter) green mixes is also reflected in the culinary preparation name, which is *lakra*, roughly meaning "wild greens" in Albanian and corresponding to the Greek term *chorta,* the South Italian term *foglia*, and the Cypriot Maronite Arabic *shkhekh*. In 2025, the relevance of these clusters of wild vegetables demonstrates remarkable cultural resilience in foraging and dietary practices, reinforcing ethnographic observations that certain culinary traditions serve as anchors of community identity across generations [37,38]. The continued use of wild plants as flavour enhancers and seasonings, as well as in preserved forms (e.g., jams, dolmades, pickling), further reflects a dynamic and adaptive food system that blends continuity with innovation [39,40]. This culinary adaptability supports the broader notion that traditional foodways are not static relics but living practices that evolve in response to ecological availability, cultural interaction, and changing socio-economic contexts [41,42].

4.3. Cultural Resilience and Linguistic Dynamics in Albanian Wild Greens Knowledge

Our findings raise a central question in cultural resilience studies: to what extent can resilience be claimed when embodied practices such as gathering and cooking wild greens remain active? Yet, the linguistic markers that once anchored these practices to a minority identity are lost mainly. In the case of the Arbëreshë, resilience appears to lie more in the persistence of embodied ecological knowledge than in the retention of linguistic heritage. This tension underscores the need for more comprehensive, multidimensional frameworks of resilience that encompass both external continuities and internal transformations of cultural knowledge. Our data reveal a rich and diverse use of wild greens within the Albanian community, with numerous species documented both in 1970 and 2025. This enduring ethnobotanical knowledge highlights a remarkable heritage of wild plant use, which may indicate a strong cultural resilience. However, it also raises the fundamental question of whether this tradition represents a direct continuity of the original Albanian customs brought by the community during its migration centuries ago, or whether it has been significantly influenced or even replaced by the ethnobotanical knowledge of neighbouring Greek populations. Given the strong presence of Greek-origin plant names in our dataset and the complex history of cultural contact and bilingualism in the region, it is plausible that the current repertoire results from both persistence and integration processes. Such syncretism is common in minority communities where identity, language, and traditional knowledge dynamically interact [11,43]. Understanding this balance is crucial for interpreting the cultural significance of wild greens in Arbëreshë life and their role in maintaining ethnic identity.

The significant reduction in Albanian-origin folk names, alongside the predominance of Greek-derived terminology, suggests a substantial linguistic shift likely driven by language attrition and sociopolitical pressures favouring dominant languages [11]. This shift prompts the question of whether Greek equivalents simply substituted original Albanian plant names or whether the community adopted new plant uses and names from Greek ethnobotanical traditions. Our data, showing numerous genera with mixed Greek-Albanian names and an increase in taxa only recorded in the 2025 dataset, support both processes. The replacement of names aligns with well-documented patterns of minority language

erosion, where specialised vocabularies, such as plant names, are among the first to be lost or replaced [12,19]. Simultaneously, the appearance of new taxa in the recent data hints at cultural borrowing or adaptation, reflecting ongoing intercultural exchange [39]. This dual process has important implications, as it highlights the dynamic nature of traditional knowledge systems, which are not static relics but evolve in response to changing linguistic and ecological contexts [41,44].

Another possible explanation for the predominance of Greek-origin names is that the Arbëreshë may have historically drawn upon a relatively restricted repertoire of wild greens when they first settled in the area, rather than possessing a broader Albanian ethnobotanical vocabulary that was later replaced. If this were the case, the subsequent adoption of additional taxa and their corresponding Greek names could reflect an expansion of plant knowledge through long-term cultural interaction, rather than a simple linguistic substitution. This perspective highlights the challenge of distinguishing between processes of adaptation, borrowing, and continuity in minority ethnobotanical systems. It highlights the need to consider both historical depth and intercultural dynamics when interpreting the present corpus of knowledge about wild greens.

A crucial area of inquiry concerns the plants that have retained their Albanian names and uses over the decades. Two aspects are essential: (a) whether these species continue to be used similarly to their documented applications in 1970, and (b) how frequently they are cited in contemporary ethnobotanical interviews. Our preliminary analysis indicates that species such as *Sonchus*, *Beta*, and *Silene* not only preserve their Albanian names but are also commonly used in traditional recipes, signalling a sustained cultural role. Additionally, other genera with Albanian-origin names, such as *Chenopodium* and *Urtica*, although less frequently cited, still appear in interviews and hold localised importance within specific subcommunities or ecological niches. The frequency of citations serves as a proxy for cultural relevance, as documented in ethnobotanical research [44]. The active use of plants often indicates ongoing knowledge transmission and practical application. In contrast, rarely cited taxa may reflect fragmented or fading knowledge limited to older generations or particular contexts.

These taxa can be interpreted as ecological "cultural keystone species" plants that hold critical significance in shaping and maintaining cultural identity, practices, and environmental knowledge [45,46]. Such species often contribute disproportionately to community resilience and the transmission of heritage knowledge, acting as symbolic and practical anchors in times of sociolinguistic change. Their persistent use and recognition underscore their embeddedness in everyday life, culinary traditions, and cultural narratives. Identifying and prioritising these species for conservation and cultural revitalisation efforts could strengthen both biodiversity and cultural heritage in the Albanian context. Furthermore, a nuanced understanding of citation patterns across genera enables targeted strategies to support those plants and associated knowledge that are at the most significant risk of loss.

In interpreting these shifts in botanical diversity and plant use, it is essential to consider the broader historical and socioeconomic context of Arbëreshë communities. In the 1970s, many villages experienced demographic changes due to rural outmigration, shifts from subsistence agriculture to market-oriented production, and increased exposure to neighbouring Greek populations, all of which influenced foraging practices and knowledge transmission [47,48]. Historical records suggest that the Arbëreshë migration and settlement in the area occurred centuries earlier, with initial communities likely maintaining a repertoire of wild greens adapted to local ecological conditions [49,50]. Over time, interactions with Greek populations, evolving culinary preferences, and socio-economic pressures may have led to both the integration of new taxa and the replacement of Albanian-origin

plant names [51,52]. These factors highlight that the current diversity of wild greens represents not only a continuation of traditional knowledge but also a product of adaptation and intercultural exchange, reflecting the dynamic interplay between ecology, culture, and livelihood practices over the last decades [53,54].

In this sense, what we refer to as "Albanian wild greens knowledge" in the studied villages should not be understood as a purely preserved and unchanged system, but rather as a layered repertoire shaped by both continuity and intercultural integration. The persistence of specific taxa with Albanian-origin names (e.g., *Sonchus*, *Beta*, *Silene*) demonstrates elements of resilience and cultural memory. In contrast, the predominance of Greek-origin plant names and the appearance of newly incorporated genera indicate processes of borrowing and replacement. Thus, the present ethnobotanical corpus is best viewed as a hybrid knowledge system, reflecting the dynamic interplay between inherited Arbëreshë practices and long-term interactions with neighbouring Greek traditions. In this light, the concepts of resilience, replacement, and integration are not contradictory but complementary in capturing the ongoing transformations of biocultural knowledge in these communities.

4.4. Implications for Biocultural Conservation

The intertwined dynamics of language loss and erosion of ethnobotanical knowledge underscore the urgent need for integrated biocultural conservation strategies. Language revitalisation and the preservation of traditional ecological knowledge (TEK) are mutually reinforcing processes, as linguistic diversity often embodies unique cultural perceptions of biodiversity and ecological relationships [19]. Without active efforts to maintain the Arbëreshë language, vital plant knowledge encoded in folk names, narratives, and usage practices risks disappearing, diminishing both cultural identity and environmental stewardship.

Effective conservation initiatives require a hands-on approach that bridges linguistic and ecological domains. Community-driven programmes such as bilingual education, intergenerational knowledge transmission projects, and the systematic documentation of oral histories have demonstrated success in maintaining both language and TEK [12]. For instance, in the Pacific Northwest, Indigenous language revival programmes have been paired with ethnobotanical projects that actively teach traditional uses of plants, thereby strengthening the link between linguistic and ecological knowledge [55].

Collaborative ethnobotanical research can also empower minority communities to further document, share, and revitalise their plant knowledge, and may increase the awareness among majority stakeholders of the value and richness of minority communities' complex heritage. Examples include participatory ethnobotanical field schools, heritage-based workshops, and community-led training sessions that engage both local members and visitors, fostering awareness, pride, and continuity of traditional practices [56]. In the Mediterranean and Balkan contexts, minority groups need to further act as custodians and revitalizers of traditional ecological knowledge, integrating it with education and intercultural exchange programmes.

Such proactive, hands-on initiatives not only protect endangered linguistic and ecological knowledge but also reinforce community identity, promote environmental stewardship, and contribute to cultural resilience [57,58]. By recognising local language and ethnobotanical knowledge as complementary vessels of cultural heritage, integrated efforts can simultaneously safeguard biodiversity and the socio-cultural fabric of Arbëreshë communities, aligning with broader global frameworks that advocate for biocultural diversity as essential to sustainable development [19].

5. Conclusions

This study highlights a rich yet increasingly fragile repertoire of wild edible plants within the Albanian villages of the study area in central Greece, documenting 41 genera used across multiple decades. The findings underscore both the resilience and transformation of traditional ecological knowledge in the face of profound socio-cultural changes. While many species and uses documented in 1970 persist, there is evident erosion, particularly among less commonly used taxa and specialised culinary applications. Simultaneously, our data reveal an expansion of the wild plant repertoire, marked by the introduction of new species and preparations, often reflecting cultural integration and influence from neighbouring Greek communities.

The linguistic analysis reveals a marked shift in folk plant nomenclature: Based on the 2025 data, many folk plant names of Greek or mixed origin are evident, while terms of Albanian origin are less prominent. Although this distribution may reflect long-term processes of linguistic borrowing and cultural assimilation, it cannot be directly compared with the 1970 dataset, which did not record local names. It is also possible that not only names but specific uses, such as the preparation of particular wild greens, were culturally borrowed from Greek "traditions". This lexical or cultural replacement may signal a deeper erosion among Albanians in Greece of the intimate connections between language, plant knowledge, and cultural identity.

These intertwined dynamics of language shift, changing land use patterns, and socioeconomic integration into Greek society have reshaped the biocultural landscape of the Albanians. To safeguard this unique heritage, efforts must extend beyond botanical inventory toward fostering active transmission of ethnobotanical knowledge in family and community settings, coupled with initiatives to revitalise the very threatened linguistic and cultural practices. Such integrative approaches will be crucial for sustaining the rich legacy of ecological wisdom and cultural identity of Albanians in Greece for future generations.

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Informed Consent Statement: The study adhered to the International Society of Ethnobiology Code of Ethics: https://www.ethnobiology.net/wp-content/uploads/ISE-COE_Eng_rev_24Nov08.pdf, accessed on 17 February 2025. Before conducting interviews, verbal informed consent was obtained from all participants. Participants were fully informed about the purpose of the research, methods, and their rights, including the right to withdraw from the study at any time.

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Medicinal Plant Use in North Karelia, Finland, in the 2010s

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Abstract: Finnish North Karelia is a region with a rich cultural history of ethnomedicinal plant use, shaped by centuries of interactions among various ethnic groups. This study identified both similarities and divergences between local Finns, Karelians war refugees, and individuals of mixed origin compared to historical records. Based on 67 semi-structured interviews, we documented the use of 43 medicinal plant taxa from 25 families, of which 31 remain in use. Notably, the number of medicinal plants continuously used in North Karelia is considerably lower than in other parts of Europe, with less than 25% of historically utilised species still in practice, which reflects the fragile state of this knowledge. Factors such as forced relocation, the loss of traditional lands, and the need to adapt to new environments might have contributed to this decline. Another influencing factor is official healthcare attitudes, which have prompted Finnish residents to shift from traditional herbal remedies to modern medical practices. Understanding the circulation of ethnomedicinal knowledge and its transformation over time is essential for identifying pathways to revitalise these practices within the framework of modern healthcare systems and cultural revitalisation efforts.

Keywords: North Karelia; ethnomedicine; borderland; plant-based remedies; herbals; written sources; herbalists; cultural transmission; healthcare systems; historical ethnobotany

1. Introduction

The use of plants is guided by various historical, socio-political, cultural, linguistic, and religious factors. When multiple cultures intersect, minority groups often adopt components of dominant cultures in their use of plants (e.g., [1,2]), integrating these components into their practices but often also keeping the specific cultural markers that help them to stand out and sustain their identity. This integration or the maintenance of one's own tradition extends to various aspects of knowledge, including indigenous and local plant knowledge. Indeed, various studies demonstrate that the exchange of local plant knowledge frequently manifests different degrees of cultural adaptations in favouring the practices of dominant groups [3–5].

Similarly, the homogenisation of local plant knowledge, particularly in the medicinal domain, has been guided by herbalists through medical instruction for centuries [6,7].

These processes intensified during the Enlightenment, especially in the 20th century with globalisation and the development of such centralised national health systems that contained medicinal plants in routine circulation [8,9].

Consequently, being embedded into new environments and cultures, the richness of indigenous and local plant knowledge undergoes profound transformations. This change affects not only the abundance of local plant knowledge of minority groups but also the mechanisms through which this knowledge is passed on to successive generations [10].

Diversity, by definition, inherently resists homogenisation. Regions rich in linguistic diversity often coincide with areas of high biodiversity, as evidenced by the cooccurrence of linguistic and biological diversity in many parts of the world [11]. However, the effect of culturally diverse and/or multilingual backgrounds on indigenous and local ecological knowledge corpora has yet to be studied. It could be supposed that those with diverse inputs can choose between different sources of knowledge and therefore possess a broader spectrum compared to those who have grown up in one dominant culture (although all cultures and languages are, to a certain extent, the result of the mixtures of different cultures and languages).

Prehistoric cultivation and gathering practices in Finland have been widely examined to understand the historical relationship between plants and humans [12]. During the medieval period, monastic communities became centres of horticultural expertise, cultivating medicinal herbs for both therapeutic and spiritual purposes. The first nuns and monks of the Naantali Cloister (Southwest Finland), sent from Vadstena Abbey in Sweden, likely introduced medicinal garden plants and gardening skills to the region [13].

The ethnobotanical practices of Finland have been documented in numerous ethnographic and historical accounts [14–16]. Limited but valuable details on the use of plants in the Northern Karelian part of Finland were documented by Manninen [17]. A significant focus has been on Sámi communities in northern Fennoscandia, where studies have documented the integration of indigenous plant knowledge with modern scientific understanding [18,19]. Despite their rich ecological knowledge and deep connection to the Arctic environment, the Sámi face significant vulnerabilities that threaten their traditional way of life in modern settings [20,21].

While the ethnobotanical knowledge of specific groups like the Sámi and historical practices in Finland have been studied, there is limited research on the interplay between multiethnic and multilingual influences and the transmission of medicinal plant knowledge. Furthermore, little is known about how individuals exposed to multiple cultural contexts navigate and retain ethnomedicinal practices, especially in regions like Finnish Karelia, where diverse cultural contexts intersect. This gap leaves questions about the influence of cultural diversity on the preservation, adaptation, and application of plant knowledge in contemporary and historical contexts.

In this article, we chose Finnish North Karelia, a multicultural region in Northern Europe, to develop the idea that exposure to and engagement with two or more cultures since childhood may affect the knowledge of medicinal plants. This is what should happen in the absence of solid control over local medicinal knowledge. Unlike regions with strong national homogenisation policies, the Finnish state did not actively promote the medicinal use of plants between the 1950s and 1980s, thereby limiting centralisation's effects [9]. Some historical resources [22] allow for a comparison of recent practices with historical plant uses. Additionally, Finnish historical ethnomedicine has been significantly influenced by written sources, owing to the high literacy rate of the population as early as the beginning of the 20th century [23–25]. Therefore, we:

- documented the ethnomedicinal use of plants among Karelians (and their descendants, including those of Karelians war refugees and mixed origin) and local Finns residing in or originating from Finnish North Karelia.
- identified similarities and divergences between the studied groups in their medicinal plants and uses.
- recognised similarities and divergences between the current ethnomedicinal practices and those reported in historical literature.

In the discussion, we contextualise our findings by comparing them with studies from neighbouring regions influenced by state-regulated, centralised medicinal plant systems. We hypothesise that North Karelia will exhibit a smaller repertoire of plants used but a broader diversity of applications, as well as more diverse ethnomedicinal knowledge among individuals raised by parents from distinct cultural backgrounds.

2. Results

We documented the current and past medicinal uses of 43 plant taxa (five of them identified at the genus level) belonging to 25 plant families (Table 1).

Table 1. Plants used in North Karelia, Finland, currently and in the past.

Scientific Name (Family), Herbarium №, W(ild) or (C)ultivated	Local Name (s)	Plant Part	Etic Disease Category	Past DUR	Current DUR
Allium cepa L. (Amaryllidaceae), C, *	sipuli (Fin)	Bulb	Ear	1	
			Gen	1	1
			Resp	2	
Allium sativum L. (Amaryllidaceae), C	valkosipuli (Fin)	Bulb	Ear	2	
			Gen		1
			Resp	1	
Aloe arborescens Mill. (Asphodelaceae), C	aloe (vera) (Fin)	Leaves	Skin		2
Achillea millefolium L. (Asteraceae), KARDR15, KARDR22, KAR06, W, *	siankärsämö (Fin)	Flowers	Dige		1
		Leaves	Skin *	1	
Matricaria chamomilla L. (Asteraceae), C, *	kamomilla (Fin)	Aerial parts	Skin		1
		Leaves	Psych	1	
Pseudopodospermum hispanicum (L.) Zaika, Sukhor. & N.Kilian (Asteraceae), C	mustajuuri (Fin)	Roots	Gen	1	
Taraxacum officinale F.H.Wigg. s.l. (Asteraceae), KAR16, KARDR25, W, *	voikukka (Fin)	Roots	Dige	1	
			Gen	1	
		Sap	Skin *	2	
Betula sp. (Betulaceae), KARDR28c, KARDR10, KAR12, W, *	rauduskoivu (Fin), koivu (Fin)	Leaves	Endocr		1
			Skin *	1	
			Uro	1	
		Sap	Gen	1	3
		Charcoal	Dige	2	
			Gen	1	

Table 1. *Cont.*

Scientific Name (Family), Herbarium №, W(ild) or (C)ultivated	Local Name (s)	Plant Part	Etic Disease Category	Past DUR	Current DUR
Betula sp. (Betulaceae), KARDR28c, KARDR10, KAR12, W, *		Twigs	Blood		1
			Musc	3	
		Birchbark	Skin	1	
Armoracia rusticana G.Gaertn., B.Mey. & Scherb. (Brassicaceae), C	piparjuuri (Fin)	Roots	Resp	1	
Brassica oleracea L. (Brassicaceae), C, *	kaali (Fin), keräkaali (Fin)	Leaves	Dige		1
			Endocr	1	1
			Musc	1	
			Skin	2	1
Humulus lupulus L. (Cannabaceae), C	humala (Fin)	Cones	Psych		1
Valeriana officinalis L. (Caprifoliaceae), KARDR16, C/W	valeria (Fin)	Flowers	Psych		1
Rhodiola rosea L. (Crassulaceae), C	ruusujuuri (Fin)	Roots	Gen		1
Juniperus communis L. (Cupressaceae), W, *	kataja (Fin)	Fruits	Gen	1	
			Uro	3	
		Twigs	Gen		1
Hippophae rhamnoides L. (Elaeagnaceae), C	tyrni (Fin)	Fruits	Dige		1
			Gen		1
Calluna vulgaris (L.) Hull (Ericaceae), KARDR07, KAR36, W	kanerva (Fin)	Flowers	Psych		2
			Uro	1	
Rhododendron tomentosum Harmaja (Ericaceae), KARDR26, W	suopursu (Fin)	Aerial parts	Endocr		1
			Gen	1	
			Musc	1	
Vaccinium myrtillus L. (Ericaceae), KAR03, W, *	mustikka (Fin), muščoi (Kar), mustoi (Kar), must'oi (Kar)	Fruits	Dige *	17	2
			Eye	1	1
			Gen	5	2
			Musc	1	
			Resp	5	
		Leaves	Gen	1	1
Vaccinium oxycoccos L. (Ericaceae), W, *	karpalo (Fin), garbalo (Kar), karbalo (Kar)	Fruits	Gen	1	
			Men		1
			Resp	4	1
			Uro	7	4
Vaccinium vitis-idaea L. (Ericaceae), KAR04, KAR37, KARDR16, W, *	puolukka (Fin), buola (Kar), puoloi (Kar)	Fruits	Dige	1	
			Gen	3	1
			Resp *	3	
			Uro		2
Trifolium pratense L. (Fabaceae), KARDR11, KARDR08, KAR32, W	puna-apila (Fin)	Aerial parts	Wom		1

Table 1. *Cont.*

Scientific Name (Family), Herbarium №, W(ild) or (C)ultivated	Local Name (s)	Plant Part	Etic Disease Category	Past DUR	Current DUR
Trifolium sp. (Fabaceae), W, *	apila (Fin)	Flowers	Musc	1	
Ribes nigrum L. (Grossulariaceae), KAR11, C, *	mustaherukka (Fin), mustaviinimarja (Fin), karpalo (Fin)	Fruits	Dige	1	
			Gen	9	5
			Resp	21	7
		Leaves	Gen	2	
Ribes rubrum L. (Grossulariaceae), C	punaherukka (Fin),	Fruits	Resp	1	1
Ribes spicatum E.Robson (Grossulariaceae), W	punaherukka (Fin)	Fruits	Resp	2	
Mentha × *piperita* L. (Lamiaceae), C, *	piparminttu (Fin)	Aerial parts	Resp	1	
Linum usitatissimum L. (Linaceae), C	pellava (Fin)	Seeds	Dige	1	
Picea abies (L.) H.Karst. (Pinaceae), KAR06a, W, *	kuusi (Fin)	Resin	* Skin	9	6
		Twigs (young)	Gen	2	
			Musc	1	
		Shoots and young twigs	Resp	1	4
Pinus sylvestris L. (Pinaceae), KARDR24, W, *	mänty (Fin), petäjä (Kar)	Resin	Blood	1	
			Dige	2	
			Gen	1	
			Resp	1	
			Skin *	10	
		Roots	Resp	1	3
		Tar	Endocr		1
			Gen		3
			Resp		1
			Skin	9	4
		Charcoal	Skin	1	
Plantago major L. (Plantaginaceae), KAR01, W, *	piharatamo (Fin), ratamo (Fin)	Leaves	Musc	1	
			Skin *	30	1
Avena sativa L. (Poaceae), C	kaura (Fin)	Seeds	Dige	1	
Dryopteris sp. (Polypodiaceae), W	alvejuuri (Fin)	Roots	Dige	1	
Alchemilla vulgaris L. (Rosaceae); KARDR29, W, *	poimu (Fin)	Leaves	Dige *		1
Filipendula ulmaria (L.) Maxim. (Rosaceae), KARDR09, KARDR12, KARDR28d, KAR13, W, *	mesiangervo (Fin)	Flowers/ Leaves	Gen		2
			Resp		1
Rosa sp. (Rosaceae), KAR17, W, *	ruusu (Fin)	Fruits	Gen *	3	1
Rubus arcticus L. (Rosaceae), KARDR14, KARDR23, KAR23, W	mesimarja (Fin) orhoi (Kar)	Fruits, sometimes leaves	Resp	2	
Rubus chamaemorus L. (Rosaceae), W, *	lakka (Fin)	Fruits	Resp *	3	

Table 1. *Cont.*

Scientific Name (Family), Herbarium №, W(ild) or (C)ultivated	Local Name (s)	Plant Part	Etic Disease Category	Past DUR	Current DUR
Rubus idaeus L. (Rosaceae), KARDR28b, KARDR06, KAR18, W, *	vadelma (Fin), vattu (Fin), vagoi (Kar)	Fruits	Resp *	4	
			Wom		1
		Leaves	Dige	1	
			Gen	1	2
			Resp	2	
Sorbus aucuparia L. (Rosaceae), KAR19, W, *	pihlaja (Fin)	Fruits and leaves	Gen		2
Bergenia sp. (Saxifragaceae), C	vuorenkilpi (Fin)	Aerial parts	Blood		1
Nicotiana rustica L. (Solanaceae), C, *	tupakka (Fin)	Leaves	Dige	2	
			Ear	11	
Daphne mezereum L. (Thymelaeaceae), W, *	näsiä (Fin), lehtonäsiä, riianmarja (Fin)	Fruits	Dige *	1	
			Gen *	2	1
			Musc	2	1
			Skin		1
Urtica dioica L. (Urticaceae), KARDR13, KAR02, W, *	nokkonen (Fin), čiiloiheinä (Kar), vihulainen (Kar)	Aerial parts	Gen		3
			Resp		1
			Skin *		1

*—Plant/use recorded in historical written sources. Fin—Finnish, Kar—Karelian. Blood—Blood, Blood-Forming Organs, and Immune Mechanism; Dige—Digestive; Ear—Ear; Endocr—Endocrine/Metabolic and Nutritional; Eye—Eye; Gen—General and Unspecified; Men—Male Genital; Musc—Musculoskeletal; Psych—Psychological; Resp—Respiratory; Skin—Skin; Uro—Urological; Wom—Female Genital diseases; DUR—Detailed Use Report.

Only 18 medicinal plant taxa were mentioned by three or more people, while the total number of use reports (DUR) was 322. The most frequently named families were Ericaceae (70 DUR), Pinaceae (60 DUR), Grossulariaceae (49 DUR), Plantaginaceae (32 DUR), and Rosaceae (25 DUR). The most popular taxa were *Ribes nigrum* (45 DUR), *Pinus sylvestris* (3,R), *Vaccinium myrtillus* (36 DUR), *Plantago major* (32 UR), *Picea abies* (23 DUR), *Vaccinium oxycoccos* (18 DUR), *Betula* (15 DUR), *Nicotiana rustica* (13 DUR), and *Vaccinium vitis-idaea* (10 DUR). The most widespread uses were for treating skin conditions (81 DUR), the respiratory system (74 DUR), general or unspecified diseases (69 DUR), and digestive tract problems (36 DUR). The use of specific taxa for the general disease category overlapped for at least three people in 21 taxon–use combinations. The general Informant Consensus Factor (ICF) was 0.85, with the ICF for the disease categories being relatively low, highest for ear diseases (0.83), skin (0.82), urological diseases (0.73), and respiratory diseases (0.72), while general and unidentified diseases and digestive diseases had values of 0.67 and 0.52, respectively.

Nine interviewees (three from each ethnic group) did not report using any medicinal plants. Hence, the number of interviewees (n) in Table 2 is smaller than the overall total. The birth year influenced only the mixed Karelian-Finnish (Mix) group, being highest for those born around the 1960s (55–70 years old), although the mean age did have a significant influence ($p = 0.027$) and the Mix group in general had a higher mean of used plants ($p = 0.026$). Additionally, women were more knowledgeable of medicinal plants and their uses ($p < 0.001$) than men.

Table 2. Comparison of plants mentioned per person and the sum of the Detailed Use Reports (DURs) per person across different groups of interviewees. With bold are highlighted more knowledgeable groups. **—$p < 0.05$, ***—$p < 0.001$.

		Plants	DUR	
Ethnic group	Fin	3.27	4.24	$n = 31$
**	Kar	3.36	4.71	$n = 14$
	Mix	**5.28**	**9.31**	$n = 13$
Gender	Male	3.05	4.38	$n = 21$
***	**Female**	**4.22**	**6.19**	$n = 37$
Age	Over 70	3.31	4.44	$n = 32$
**	**55–70**	**4.95**	**7.84**	$n = 19$
	Up to 55	2.88	4.29	$n = 7$
	All	3.79	5.53	$n = 58$

Only 12 taxa have been used continuously (Figure 1a,c), while most currently used plants have been recently adopted. Based on the number of plant taxa, past uses are more numerous than the recently adopted ones, and at the level of use records, past uses dominate (70%) (Figure 1b).

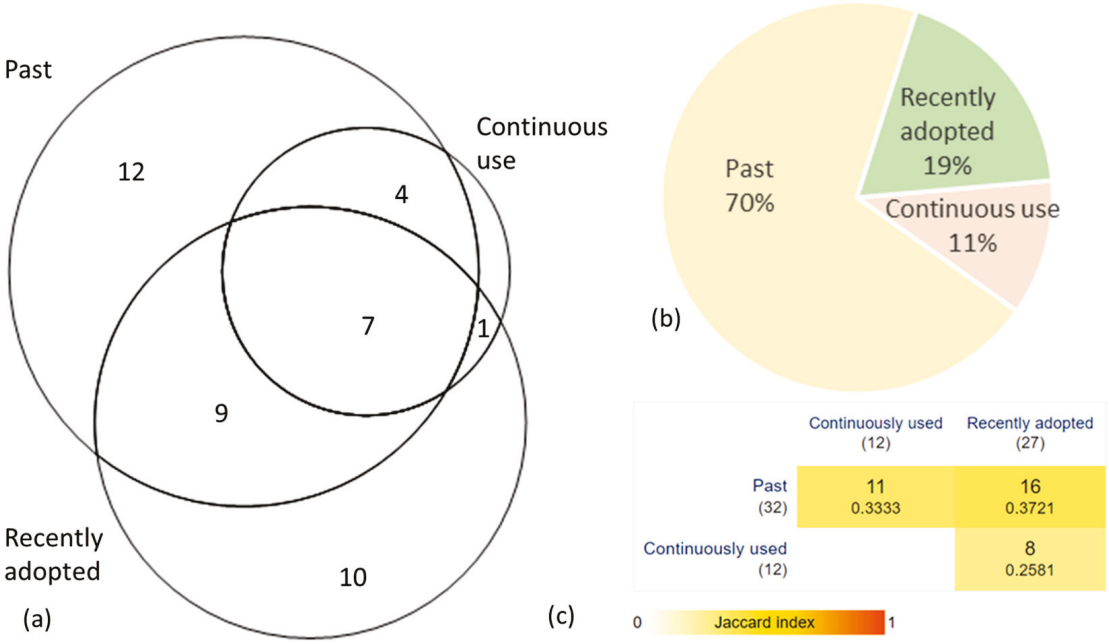


Figure 1. Knowledge circulation in time. (**a**) Number of taxa with different plant use periods. (**b**) Proportion of DURs in different use periods. (**c**) The Jaccard Index signals little overlap between the species used in different periods.

While the majority of disease categories show continuity in knowledge circulation, three disease categories are present in only one of the periods. The "ear" disease category has remained in the past, while the use for men's and women's diseases is currently adopted. Notably, the emic category "healthy" (meaning a plant generally good for health) was mentioned 19 times, sharing second and third place in frequency with "flu", following "wounds", the most mentioned category.

A total of 98 DUR (30%) were reported for personal use and based on personal knowledge, while 208 DUR (65%) were reported as being used within the family based on

family tradition. The remaining 16 DUR (5%) belonged to the prescriptions by a village traditional healer from Lieksa, Anni Pölönen (1889–1960), also known as *Viekin mummo* [Viekki's Grandma]. Either the plant itself or a medicine made of it by Pölönen was prescribed. For example, *Daphne mezereum* was used against toothache and rickets. The healer followed in the footsteps of her father and grandfather, both of whom were healers.

Four plants used by at least 50% of the interviewees were shared amongst all three groups (Figure 2a). Although the mixed group was the smallest, it had a proportionally highest shared of knowledge (Figure 2b).

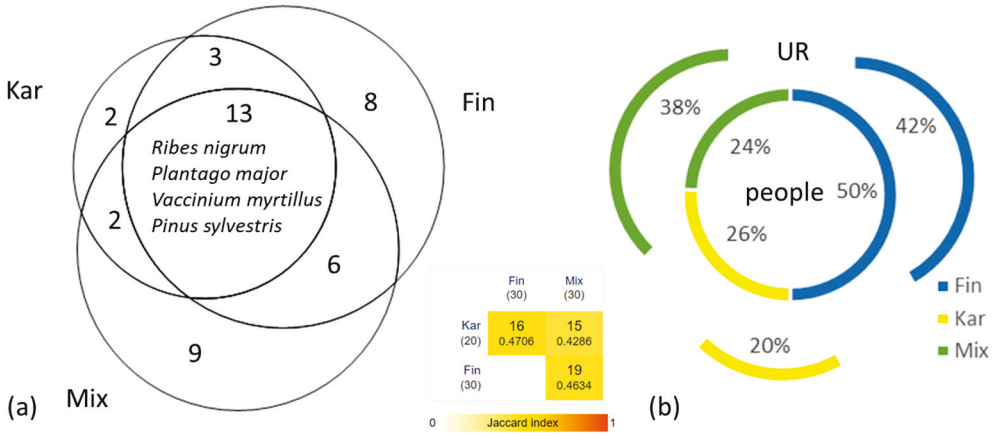


Figure 2. Overlap in the ethnomedicinal knowledge of plants: (**a**) Cross-cultural comparison of all used plants. The four listed species were reported by at least 50% of the interviewees. (**b**) Correspondence between the percentage of people in the group and the percentage of the knowledge of the use of the plants they shared. The Jaccard Index indicates a relatively high diversity between the studied groups.

The plant names listed by the interviewees were primarily in Finnish. Among the medicinal plants mentioned, only a few (forest) berries (*Rubus*, *Vaccinium*, and *Ribes*); one tree (*Pinus sylvestris*); and one weed (*Urtica dioica*) were named in Karelian (Table 1).

While the plants used only in the past were reported homogeneously (Figure 3b), the currently used plants are rather group-specific (except for Karelians, who used only one plant (*Matricaria chamomilla*) exclusively) (Figure 3a). Additionally, one to three people mainly reported specific uses.

Figure 4 demonstrates that the current ethnomedicinal knowledge of ethnic Finns (FIN) is similar to that of ethnic Karelians (KAR). In contrast, the uses named by the group with mixed ethnic backgrounds (MIX) draw from both and are more similar to historical ethnomedicine (HIST). Of the 31 currently used taxa, 23 have also been used historically (out of 104 taxa, according to Kolosova et al. [22]). While the Karelians did not introduce any new taxa, the MIX group, despite being smaller, experimented with five new taxa. Notably, all 12 taxa reported as being used continuously have also been recorded in historical sources. The dendrogram of the species highlights species linked to specific groups and/or historical use. For example, *Hippophea rhamnoides*, *Ribes rubrum*, and *Rhodiola rosea* are absent from historical sources and only used by a few Finns. At the same time, *Juniperus communis*, *Achillea millefolium*, *Alchemilla vulgaris*, and *Rosa* were used by the MIX group only, although they were also present in historical sources. On a large scale, we can differentiate the cluster of plants mentioned in historical sources from those absent (divided only between the FIN and MIX groups).

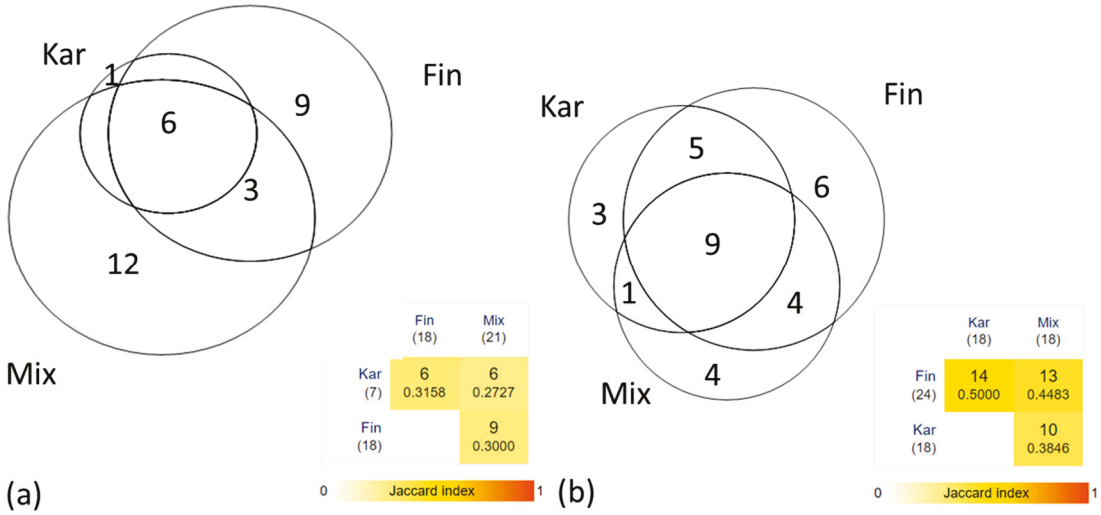


Figure 3. Comparison between the numbers of the used plants (**a**) currently and (**b**) in the past between different groups of respondents (Kar, Fin, and Mix). The past use is more homogenous compared to the current use of plants. The Jaccard Index indicates highly diverse current use, while the past remembered use is more homogenous.

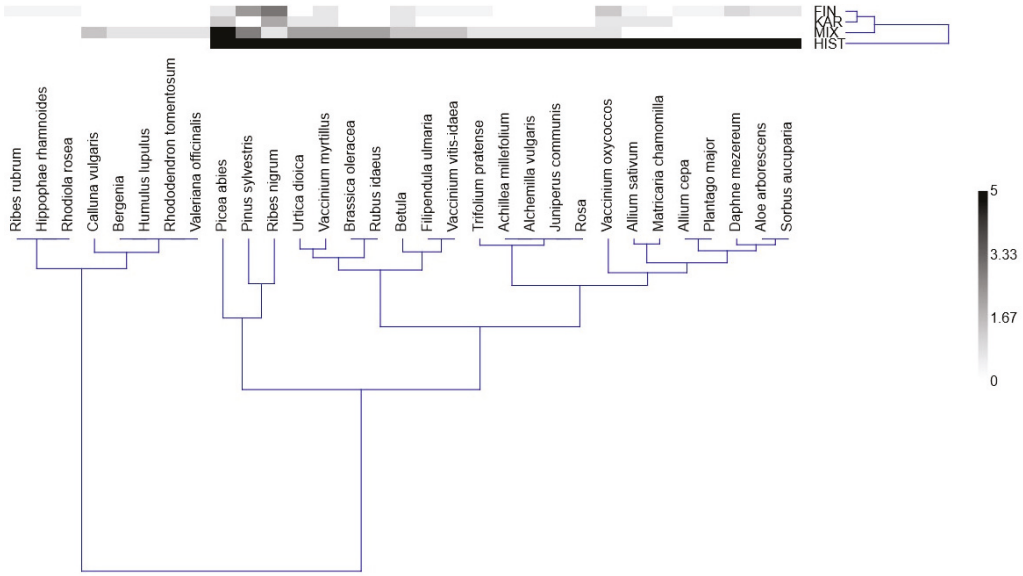


Figure 4. Comparison of the currently used medicinal plants in all groups with the historical (HIST) uses that overlapped with any of the current uses. A major part of the currently used taxa was also used according to historical sources. See Section 4.5 on how the values were calculated.

3. Discussion

The number of documented medicinal plants in the current study (43 taxa mentioned by the 67 interviewees, of which 31 currently used) is much smaller than that in other European studies with similar samples sizes and is comparable only with the results obtained on the small island of Kihnu (Estonia), where only 23 persons were interviewed. In that study, the respective numbers were 33 (medicinal taxa mentioned) and 29 (currently used) [9]. In neighbouring Estonia, the use of 86 taxa was recorded in a sample of the same size, with 69 still in use in Seto and Võromaa [8]. Meanwhile, in the cross-border Seto region in the Russian Federation, 62 people reported the current medicinal use of 112 plant taxa [26], while in Latgale, Latvia, the use of 116 plant taxa (108 of these currently used) was recorded in 73 interviews [2].

The cross-ethnic Jaccard Index calculated in our study (around 0.45 for all uses and around 0.3 for current uses) is much smaller compared to 0.6 between Seto and Russians in Russia [26] and 0.55 between Seto and Võro in Estonia [8]. This suggests a higher ethnomedical diversity in the current study.

We observed that a high proportion of the medicinal plants currently in use in Finnish Karelia were also used in historical Karelian folk medicine [22]. This suggests that much of the local knowledge about medicinal plants in Finnish Karelia has deep historical roots, and it has been at least partially preserved despite modernisation. However, all the current uses are highly fragmented (with little consensus), with only a minimal number of plants being used by more than one person or in more than one way. A significant portion (63%) of all presentday uses has been recently acquired. This may indicate that the overlap between historical and current uses is due to the incorporation of newly acquired uses through books, mass media, and other sources. In general, the low number of uses does not support a viable ethnomedical system.

Ethnic Karelians have preserved their ethnomedicinal practices without incorporating those of the Finns, as evidenced by the absence of new taxa in their current usage repertoire compared to historical data. This contrasts with the high degree of integration observed in other communities, such as Buryat in Siberia, who have adopted elements of Russian herbal medicine alongside their traditional Tibeto-Mongolian healing practices [27]. Rather than being static or isolated, Tibetan medicine in Buryatia was shaped by external forces, including global medical trends and state healthcare systems. This integration reflects a broad process of knowledge exchange and adaptation, where local traditions blend with external therapeutic approaches to create a unique, hybrid medical ecology [28].

It could be suggested that the limited current use of medicinal plants among Karelians may be influenced by factors like forced relocation, loss of traditional lands, and the need to adapt to new, albeit similar, environments—phenomena evident in many displaced communities, for instance, the Yaghnobi in Tajikistan [29] or Sámi [30–32]. The data from ethnic Karelians may also reflect the fact that a significant portion of the interviewees from families with exclusively Karelian roots belong to the older generation. The oldest interviewees moved to Finnish Karelia as adults and had already established their plant use habits before the relocation. It was relatively easy to maintain their original traditions due to the similarity of the natural environment and because they moved short distances from their original homes.

Another possible reason for Karelian migrants and their descendants in Finland not adopting other ethnobotanical medicinal traditions is the significant post-war rise in the accessibility and quality of national healthcare in Finland. People of Karelian and Finnish origin reported that, previously, especially in small settlements, official healthcare was often unavailable, and people had to resort to traditional medicine. In the 1930s–1940s, traditional healthcare was predominantly used in Finnish Karelia. By the 1940s–1950s, traditional and official medicine were being used side by side. Starting in the 1960s, official healthcare became widely accessible, and traditional medicine began to be oppressed as non-scientific. The case of the local healer Anni Pölönen (1889–1960) illustrates this development. According to her grandson, whom we interviewed, and the works of her great-granddaughter [33,34], local doctors had initially been supportive of Anni's work. However, after World War II (WWII), the legislation changed, and in 1956, Anni was tried for quackery and fined [33]. Her son was unable to continue her work, and after Finland entered the EU in 1995, herbal medicinal products became heavily regulated, with the sale of ingredients for self-made medicines prohibited [35].

For these reasons, the Karelian migrants who may have lost some of their original medicinal practices due to relocation in the 1940s did not have any a particular practical

need to adopt local medicinal ethnobotanical practices. The similar nature of their new habitat, combined with the rise in official healthcare and a lack of support for traditional medicine by the receiving society, meant that there was little stimulus to integrate new practices. The prioritisation of modern state-sponsored healthcare systems over indigenous and local medicinal practices prevented their integration into broader healthcare frameworks. A similar process has been observed among the Sámi and Greenlandic Inuit [36–39].

Since the 1990s, however, the situation in Finland has partially changed. For example, cultural revitalisation programs in the Sevettijärvi-Näätämö community, a Skolt Sámi group in Northern Finland, have focused primarily on preserving and revitalising local food practices, while efforts to revive traditional healing methods remain limited [39]. Among our interviewees from North Karelia, people continue to rely on official healthcare rather than on traditional practices. However, there has been a recent shift toward recognising the value of "organic" and "homemade" products, which are promoted in Finland under the label *luomu* (short for *luonnonmukainen*, "conforming with nature", meaning "organic"). This trend has influenced the attitudes towards traditional herbal medicine and its acceptance within official healthcare. Some interviewees mentioned that doctors nowadays occasionally recommend herbs or even use them themselves, and medicinal herbs are sold in the local natural product (*luontaistuotteet*) shops, such as in Nurmes. Overall, there is a growing trend to promote a holistic attitude toward health which also includes the use of medicinal herbs [40]. Those who want to learn the medicinal plant use themselves may avail of numerous books including those by the pioneer Toivo Rautavaara and, later, herbalists like Sinikka Piippo and Virpi Raipala-Cormier. Rautavaara (1905–1987), who was born in Karelia, introduced many of the modern types of natural products in Finland already in his first ground-breaking and highly popular herbal publication in 1942 [41], with more than a dozen reprints over several decades.

However, the presence of such publications, the organic product shops and a large number of plant-based medicines in the pharmaceutical system, has not yet resulted in widespread public recommendations of plants by medical professionals in Finland. While intense popularisation of herbal ethnomedicinal knowledge may have contributed to the current uptake of new and old plants, Finnish folk medicine remains highly literacy-based [23]. However, this trend has not entirely neutralised the negative attitudes that had previously prevailed in official healthcare. Despite recent introductions of new uses within the healthy lifestyle movement, the knowledge of medicinal plants remains highly eroded and fragile [42], with less than 25% of historically used plants still in practice.

In Finland, medicinal plants remain largely categorised under alternative medicine, and their use has significantly declined over the past decade, despite extensive promotion [43]. Finland boasts a highly accessible and robust healthcare system. However, according to the Finnish Institute of Health and Welfare [44], plants are only mentioned in the context of healthy food habits or as narcotic substances. Alternative medicine is often associated with the so-called "faith healing", and plants are occasionally mentioned as part of this domain [45].

Under these circumstances, the practice of collecting plants for minor health issues and general well-being remains an important skill. It could help strengthen the connection between people and nature (e.g., [1]). Furthermore, the continuity of the practice encourages people to spend more time in nature, observe the rhythms, and acquire the "dark" (unacknowledged by public and unknown to science) part of the local knowledge [46]. Therefore, we suggest that more effort should be directed towards recognising the value of local plants in published herbals, aiming to reintroduce plant uses with historical local roots, provided their safety is confirmed.

4. Data and Methods

4.1. Study Region

Karelia has been a border area since the Middle Ages. The region of the ancient Finno-Ugric Korela groups was officially divided into eastern and western parts after the Peace Treaty of Nöteborg between Sweden and the Novgorod Republic in 1323 [47]. Over time, the divided region experienced cultural, linguistic, economic, social, and religious influences from the West (Sweden, Catholicism, and, later, Lutheranism from the 1500s) and the East (Novgorod, Principality of Moscow, and, later, Russia, with its Orthodox Church) [48]. The Karelian borderlands on both sides of the contemporary Finnish–Russian border have a history of shifting boundaries, largely due to wars [49]. These frequent changes have imbued the region with significant political and cultural complexity, fostering the mixing of languages and cultures. They have also created regional differences with the Karelian Isthmus, Ladoga Karelia, Olonets Karelia, and White Sea Karelia, all now in Russia, and North and South Karelia of Finland.

From 1809 until the end of WWII, much of Karelia was part of the Grand Duchy of Finland, which was an autonomous part of the Russian Empire until 1917. Following Finland's independence, Eastern, or "Russian", Karelia remained part of the Soviet Union, and in 1923, it was formally designated as the Karelian Autonomous Soviet Socialist Republic [50]. By the mid-1920s, the region was expanded to include areas with a larger Russian population, which led to a decrease in the proportion of Karelians. Industrialisation also contributed to an influx of settlers. Additionally, during the late 1930s, the establishment of concentration camps covered nearly one-third of the territory [51].

At the end of the nearly three-month Winter War (1939–1940), following the Soviet invasion of Finland, the USSR was forced to sign the Moskva Peace Treaty in 1940. However, as part of the agreement, a significant portion of Finnish Karelia was ceded to the Soviet Union, and approximately 420,000 refugees fled to Finland [52]. During the Continuation War (1941–1944), Finnish forces briefly regained the territory but were eventually forced to withdraw, and the local population was evacuated to other regions of Finland, including Finland's North Karelia. The Soviet Union then relocated people from Russia, Belarus, Ukraine, and other regions to settle the area [53,54]. Only North and South Karelia remained within Finland's borders.

The dissolution of the Soviet Union in 1991 resulted in a more open border, Finland's accession to the European Union (EU), and reforms in regional governance that had a significant impact on local mobility. These changes led to increased economic and cultural ties between Finnish and Russian Karelia in the 1990s [53,55]. However, during the 2000s, especially in the past decade, contacts between the two regions have once again decreased due to the political situation in Russia.

Karelian is an endangered Uralic language, belonging to the Northern Finno-Ugric languages, together with Finnish [56]. In Finland, Karelians are bilingual, with approximately 11,000 fluent Karelian speakers and 30,000 with some knowledge, while others speaking only Finnish. In comparison, in Russian Karelia, where there are an estimated 9000 Karelian speakers (14,000 with some knowledge), all speakers also know Russian [57]. By the 1990s, anthropological fieldwork carried out by Estonians in Russian Karelia revealed that Karelian had largely disappeared as the primary language of communication in the region, being replaced by Russian. Today, the Karelian language has become strongly Russified [58].

4.2. Field Study and Data Collection

The province of North Karelia located in Eastern Finland, with its capital in Joensuu, covers approximately 23,000 km^2, and is home to around 162,000 people (as of 2021) [59].

As Finland's easternmost region, North Karelia shares a border of approximately 300 km with Russia. The climate is characterised by four distinct seasons, with cool continental summers and harsh, snowy, sub-Arctic winters. Precipitation occurs on about 30% of the days throughout the year, and the average annual temperature is around 5 °C. The region's landscape is dominated by state-owned boreal forests, covering two-thirds of the area. These forests mainly consist of Norway spruce, Scots pine, and broad-leaved trees such as birch. Timber production is one of the region's key industries, alongside forest and nature recreation and tourism [60].

Fieldwork for the study was conducted from May to September 2018. The research primarily focused on the province of North Karelia, covering municipalities such as Joensuu, Lieksa, Nurmes, Valtimo, Ylä-Valtimo, Puukari, Rasimäki, Varpasenkylä, Viensuu, Viinijärvi, and Sotkuma, with additional interviews conducted in Helsinki, the capital of Finland (Figure 5). A total of 67 individuals were interviewed, including 34 of Karelian Finnish origin (FIN), 17 relocated Karelians and their descendants (KAR), and 16 individuals from mixed families (one parent Finnish, the other Karelian) (MIX).

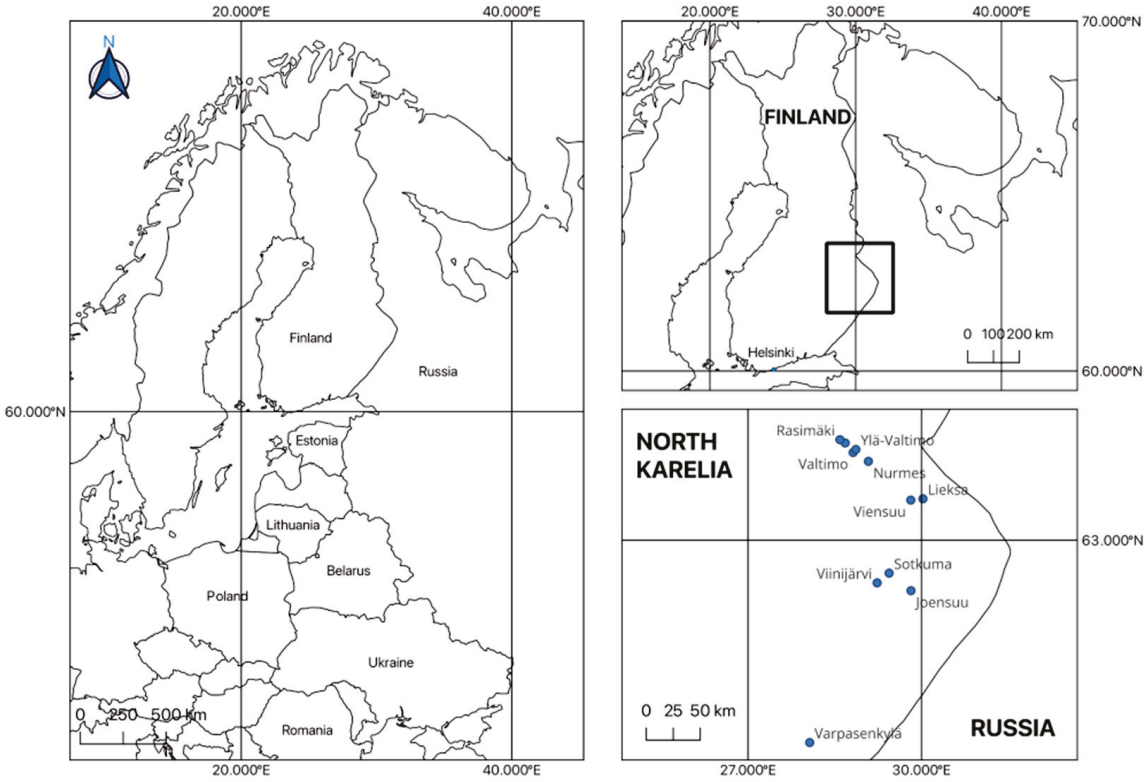


Figure 5. A map of the study area (black square). Designed in QGIS 3.22.

The oldest interviewee was born in 1925, while the youngest was born in 1994, with an average age of 70. Of the 67 interviewees, 41 were women, and 26 were men. Nineteen study participants had higher education, twenty-nine had secondary education, seventeen had primary education, and two had no formal education. Most of the interviewees lived in rural areas, with only ten participants residing in larger urban centres such as Helsinki or Joensuu, and most were retired. Participants were identified and recruited through social networks, using snowball sampling, as random sampling was challenging due to the local cultural context. The sample size was deemed sufficient, with saturation reached after approximately ten interviews per group; after which, few new data points were introduced by additional interviewees.

The research protocol was approved by the Ethics Committee of Ca' Foscari University of Venice. Prior to each interview, we provided a detailed description of the study and obtained informed consent from the participants, in accordance with the Code of Ethics of the International Society of Ethnobiology [61]. Upon obtaining consent, the interview began with questions about the use of wild food plants (see [1]), followed by inquiries related to ethnomedicine, including the use of medicinal plants. The initial "free listing" was typically brief. Participants were then asked about plant remedies for various diseases, beginning with ailments related to the head (e.g., headaches, colds, ear, and eye conditions, and sore throat), followed by internal organ diseases (e.g., stomach, heart, lung, and kidney issues), systemic disorders (e.g., joint diseases, diabetes, allergies, cancer, and immune system disorders), skin-related conditions (e.g., cuts, wounds, furuncles, and rashes), culture-bound diseases (e.g., the evil eye and nightmares), and other illnesses not yet mentioned. If any remedies from the free listing were not initially identified, participants were prompted to recall them. Interviewees were also asked to specify the first and last times they used each plant as accurately as possible. The ethnomedicine section concluded with questions on ethnoveterinary medicine, as detailed by Mattalia et al. [62]. The medicinal use of fungi in the region was addressed by Prakofjewa et al. [63]. For the purposes of this study, we considered plants and plant-based substances used for self-medication. The plants discussed were wild, cultivated, or purchased, and all parts and ingredients were identified to at least the genus level. We also inquired about specific methods of plant preparation.

The average duration of the interviews was two hours, and in some cases, the interviewees participated in small groups of two to three people. Following the interview, whenever possible, participants took a walk through their garden, around their homes, and the surrounding forest, during which additional plants or their uses were sometimes mentioned. Interviewees were encouraged to show all the plants they discussed whenever feasible. We also collected samples of dried plants available at the interviewees' homes. These voucher specimens are stored in the herbarium of the Ca' Foscari University of Venice (UVV), bearing numbers KAR02–KAR012 for herbarium specimens and KARDR01–KARDR24 for dried plant samples.

Some plants that were no longer used or were unavailable were identified by local names and descriptions provided by interviewees. Specific taxa, such as *Rosa*, *Betula*, *Trifolium*, and *Bergenia*, were identified solely at the genus level, as interviewees did not distinguish between species or the use of the plant was too distant in memory to confirm the species (e.g., *Dryopteris*). Botanical taxa nomenclature followed the Plants of the World Online [64].

Most of the interviews were recorded with the interviewee's written consent and transcribed in Finnish (and Karelian for plant names). In one case, the recording was refused, and in another, the recording did not succeed, and we only took notes. Later, the information was tabulated in Microsoft Excel in English. The file was structured as Detailed Use Reports (DURs) of plant-based remedies, where each row contained the interviewee code, the scientific name of the plant, its local name, the part used, when it was used, the mode of preparation, its medicinal use, an original citation from the interview, and any specific comments, respectively.

4.3. Data Analysis

Descriptive statistics were performed in Microsoft Excel and Past 4.16c, where a *t*-test was performed to compare the influence of gender, age group, and belonging to a specific ethnic group on the number of plants used [65]. Venn diagrams were created using the tools by the Bioinformatics and Evolutionary Genomics laboratory at the University of Ghent [66] and Multiple List Comparator [67]. Proportional diagrams were created using

the PAST Toolkit Venn diagram plotter software program [68]. Simple diagrams were plotted in Microsoft Excel, while RawGraph [69] was used for more complex diagrams.

The Jaccard Similarity Index (JI) was calculated as follows: (C/(A + B − C)), where C is the number of uses common to A and B, A is the number of uses in sample A, and B is the number of uses of sample B, following the methodology of González-Tejero et al. [70].

The Informant Consensus Factor (ICF) was calculated following Trotter and Logan [71] for etic disease categories, as follows: number of DUR minus the number of species used divided by the number of DUR minus one.

Following the temporal knowledge circulation framework [72], plant usage was categorised into three main groups to capture changes over time. These categories were based on the periods during which the plants were used:

- **Past uses** (no longer in active use)
- **Current uses:**
    - *Continuously used*—practices that have remained consistent over time (used more or less continuously from childhood to the present).
    - *Recently acquired uses*—practices adopted within recent years (approximately since 2000, with a focus on the last five years).

4.4. Disease Categorisation

Emic (local) disease names were translated into the etic (scientific) disease categories (Table 3) according to the International Classification of Primary Care, 2nd edition (ICPC-2, Updated March 2003) [73].

Table 3. Correspondence between emic disease names with etic disease categories and their frequency of mentioning.

Application	DUR
(Blood) diseases	3
decreasing blood pressure	1
good for blood circulation	1
varicose veins	1
(Dige)stive tract diseases	36
Cancer	2
Diarrhoea	10
Heartburn	1
intestinal problems	2
intestinal worms	1
liver problems	1
stomach problems	13
Stomach ache	1
Toothache	5
(Ear) diseases	14
ear infections	1
Earache	13

Table 3. *Cont.*

Application	DUR
(Endocr)inological diseases	5
Gout	1
Metabolism	1
Struma	1
Swelling	2
(Eye) diseases	2
good for sight	1
helps for night vision	1
(Gen)eral diseases	69
Antioxidant	1
body cleansing	2
body detoxication	1
Cancer	1
children's diseases	1
Cold	1
Fever	14
Hangover	2
Headache	1
Healthy	19
Inflammations	4
Medicine	4
Panacea	6
preventing cancer	1
Prophylactics	1
Rickets	2
Tuberculosis	1
vitamin C	5
whooping cough	1
(Men) diseases	1
prostate problems	1
(Musc)ulo skeletal diseases	12
back problems	2
for pains and tired feet	1
joint rheumatism	1
joints and ache	1
muscle strains	1
Muscles	1
Rheumatism	2

Table 3. *Cont.*

Application	DUR
rheumatoid arthritis	1
sore back	1
sore limbs	1
(Psych)ological diseases	5
calming down	1
calming down/sleep	1
for sleeping	3
Stress	1
(Resp)iratory diseases	74
Angina	1
Bronchitis	1
Cold	33
Cough	10
Flu	19
nasal catarrh	1
nose constipation	1
sore throat	7
when losing voice	1
(Skin) diseases	81
Abscesses	2
Allergy	3
bite of wasp	1
Bites	1
Bruises	2
Burns	3
Eczemas	1
Itching	1
nettle sting	1
Pimples	2
Rash	2
Scratch	1
Skin	2
skin (all body)	1
skin problems	4
to brighten the skin	1
Warts	5
Wounds	48

Table 3. *Cont.*

Application	DUR
(Uro)logical diseases	18
Cancer	1
cancer (for women)	1
diuretic/fluid balance	1
kidney problems	1
urinary infection	8
urinary problems	2
urinary problems in men	1
urinary tract infection	3
(Wom)en diseases	2
women diseases	1
women problems	1

4.5. Comparison with Historical Sources

To compare current uses with historical records [22], hierarchical clustering was performed by applying a two-way Ward's algorithm in Past 4.16c [65].

The colour gradient scale was calculated by dividing the number of DUR for each plant by the number of interviewees in each group, then multiplying the result by ten. The threshold for all historical uses was set at five, slightly above the highest gradient of uses to be differentiated in the illustration. Kolosova et al. [22] refers to historical use, the most recent one being from the 1950–1960s. It also covers only the Russian part of Karelia.

5. Conclusions

In Finnish North Karelia, we documented a limited repertoire of medicinal plants, most of which have remained in the past. While some differences in plant usage were observed between local Finns and Karelian migrants for the past, the remaining scattered knowledge does not provide sufficient grounds to draw definitive conclusions about broader trends or trajectories in local medicinal knowledge.

The most significant finding relates to the role of the state and its regulations in either supporting or oppressing the use of plants. The lack of state support for traditional plant use in post-war Finland, coupled with improvements in the quality and accessibility of official medicine, contributed to the marginalisation of plant-based ethnomedicine. Over time, the formal classification of plant uses as "alternative medicine" further diminished the practice. This has led to the erosion of the historical plant-based ethnomedicinal system and local knowledge.

Moving forward, greater efforts should be made to acknowledge and support the safe traditional uses of local plants while also promoting healthy wild food foraging. Such initiatives could help foster sustainable human–nature interactions in a bioculturally responsible manner. The current trend in Finland towards a more holistic approach to healthcare offers some hope in this regard, although resistance from official medical practitioners remains considerable.

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Informed Consent Statement: Written consent was obtained from all participants prior to the interviews.

Data Availability Statement: Data are available upon request to the corresponding authors.

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Abbreviations

W—wild; C—cultivated; ICF—Informant Consensus Factor; UR—Use Report; JI—Jaccard Index; KAR—Karelians; FIN—Fins; MIX—mixed; DUR—Detailed Use Report; ICPC-2—International Classification of Primary Care; EU—European Union; WWII—World War II; USSR—The Union of Soviet Socialist Republics.

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