

Review

Ecology, Cultivation, and Utilization of the Dittany of Crete (*Origanum dictamnus* L.) from Ancient Times to the Present: A Short Review

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Abstract: Medicinal and aromatic plants are a consistent component of the biodiversity heritage in numerous countries worldwide. *Origanum dictamnus* L. (Lamiaceae family), also known as Dittany, an endemic plant of the Greek island of Crete, has been widely used as traditional medicine since antiquity, all over Europe. The aim of the present review is to provide a thorough and detailed account of Dittany in antiquity, the plant’s physical characteristics and ecology, and its cultivation methods, as well as its chemical components, biological properties, and pharmacological studies. The information is presented and analyzed in a critical manner. A total of 86 research studies were systematically reviewed based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. The findings indicate that Dittany is one of the most important medicinal and aromatic plants, with many uses not only in pharmacology but also in gastronomy. While a large body of literature exists regarding the application of essential oils, the number of publications concerning the plant’s cultivation is rather small. Therefore, the main focus of this review is on the cultivation methods and the significance of cultivating and employing Dittany in Greece and the wider Mediterranean region in the future. Further research on this plant species is warranted since it has significant medicinal, economic, and environmental value.

Keywords: *Origanum dictamnus*; antiquity; morphology; cultivation; essential oil; Crete



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1. Introduction

The Mediterranean Basin is recognized as a “global biodiversity hotspot” and is the largest of the world’s five Mediterranean-type climatic zones [1,2]. Greece’s geographical location, diverse landscapes, and various edapho-climatic environments, along with their interactions with biotic factors, have made it a region of significant importance in terms of biodiversity and plant endemism. This has particularly favored the adaptation of aromatic and medicinal plant species, such as *Origanum* sp., *Sideritis* sp., *Salvia* sp., *Crocus* sp., and *Hypericum* sp. These plants offer therapeutic, economic, and environmental benefits [3,4].

O. dictamnus L. (Lamiaceae) (Figure 1) is an aromatic, Greek endemic, perennial species with multiple therapeutic uses [5]. Certain Aegean islands and mountains in southern

Greece are home to four closely related species of it, but the actual *O. dictamnus* L. is primarily found in the island of Crete in southern Greece. Given its origin, it is commonly known as “Cretan Dittany”, “Dittany of Crete”, and in its simplified version as “Dittany”. The plant belongs to the *Lamiaceae* family with 236 genera and over 7000 species, a family of plants valued for their aromatic, medicinal ingredients. Dittany grows wild as a rock-dweller on sharp, rocky mountainsides, cracks, and gorges from 500 to 1800 m above sea level, making its identification and harvest difficult [6]. According to the IUCN classification and under the protection of Greek Presidential Decree 67/81, this Dittany’s taxon conservation status has been recognized as Near Threatened [7].



Figure 1. *Origanum dictamnus* L. (Photo taken by Dr. I. Manolikaki).

Since ancient times, Dittany’s fluffy, heart-shaped leaves and purple flowering tops have been used for wound healing, to treat a variety of illnesses such as arthritis and ligament pains, and to soothe pain during childbirth. It has also been mentioned in a number of ethnobotanical sources that Dittany was used to treat various ailments and gynecological issues [8]. All these medicinal traits led to the formal registration of Dittany’s remedy in the EMA list of Traditional Herbal Medicines with the authorization of Dinnany’s monograph [9,10].

Dittany’s extracts have been shown to exhibit a number of biological benefits, including antibacterial action (against bacteria, protozoans, and fungi), as well as antioxidant and anti-aging properties [11–15]. But, despite its high potential (94.4%) in the medicinal and cosmetics sector, as well as its extremely high feasibility for sustainable exploitation (91.67%), as estimated by Krigas et al. [16], in a study exploring the potential of 399 neglected local endemic plants of the Mediterranean region, *O. dictamnus* stands out as the most propitious exemplar of an underutilized endemic plant [16], with scarce studies that refer to its ecology, cultivation, and utilization.

This study provides a concise overview of all the existing literature on Dittany, encompassing topics such as mythology, ecology, cultivation, ethnobotany, and phytochemistry. We have also made efforts to assess unique applications of the plant that, to our knowledge, have not been documented in any scientific research. This is done to offer an innovative perspective on the ethnopharmacological significance of the plant in Greece and other regions.

2. Literature Review

This review was conducted by analyzing the Google Scholar and Scopus databases. The keywords that were used were “Dittany” OR “mythology of Dittany” OR “ecology of Dittany” OR “cultivation of Dittany” OR “climate-soil of Dittany” OR “diversity of

essential oils of Dittany" OR "Dittany plants' utilization". These keywords yielded a total of 359 publications. After eliminating PowerPoint presentations and posters, the total number of available papers decreased to 96. The aforementioned procedure involved the elimination of literature based on the title and abstract, resulting in a reduction of the total number to 86. Subsequently, errors were eliminated, yielding a total of 89. Ultimately, after assessing the association with the key aspects of our evaluation, we selected a final count of 69 papers. The methodology employed in this study adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) criteria for conducting reviews, as depicted in Figure 2 [17]. It is also noted that the majority of the reviewed papers were published in scientific journals either as journal papers (62) and as book chapters (5). There were also papers included in conference proceedings (1) and a website (1).

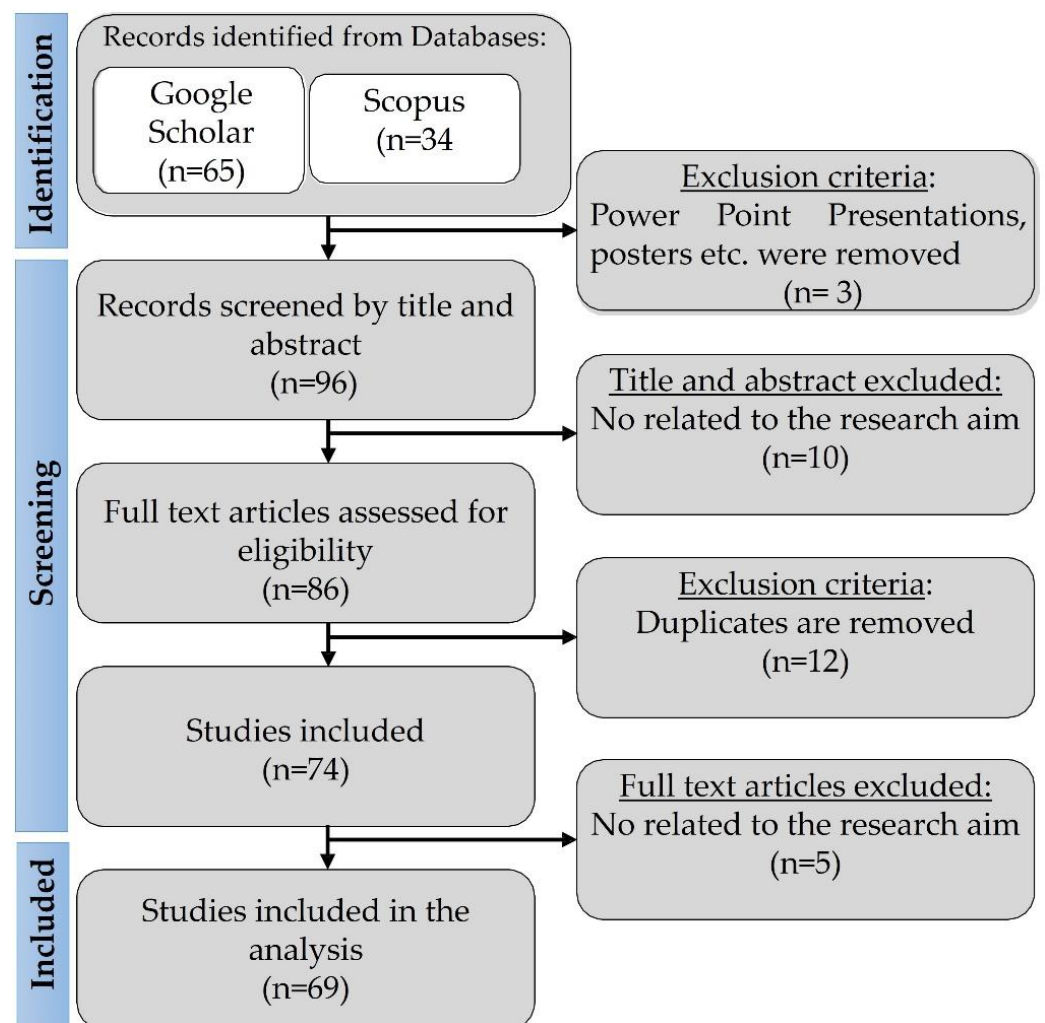


Figure 2. PRISMA flowchart (created by Dr. A. Solomou).

The review of the ancient texts was conducted by analyzing the Thesaurus Linguae Graecae [18]. A total of 287 mentions were found using the terms "δικταμνίτης" OR "δικταμνοειδής" OR "δικτάμνοισι" OR "δίκταμνον" OR "δίκταμνος" OR "δικτάμνου" OR "δικτάμνω" OR "δίκταμνον" OR "δίκταμος" OR "δικτάμου" OR "δικτάμω" as keywords. (Note: The mentions of the words were counted. Note that there were numerous instances of later works citing the text of the previous ones.) In addition to the review of the ancient literary sources, modern scholarship studies were also used for the Dittany in Antiquity overview: 11 book chapters, 8 monographs, 8 journal papers, 2 unpublished theses, and 4 websites.

Figure 3 depicts the distribution of the review studies per time period, confirming that scientific interest in Cretan Dittany has particularly increased in recent years. It is also noted that the majority of the reviewed papers were published in scientific articles (66.99%). There were also papers included in books (22.33%), other categories (e.g., websites) (9.70%), and conference proceedings (0.98%).

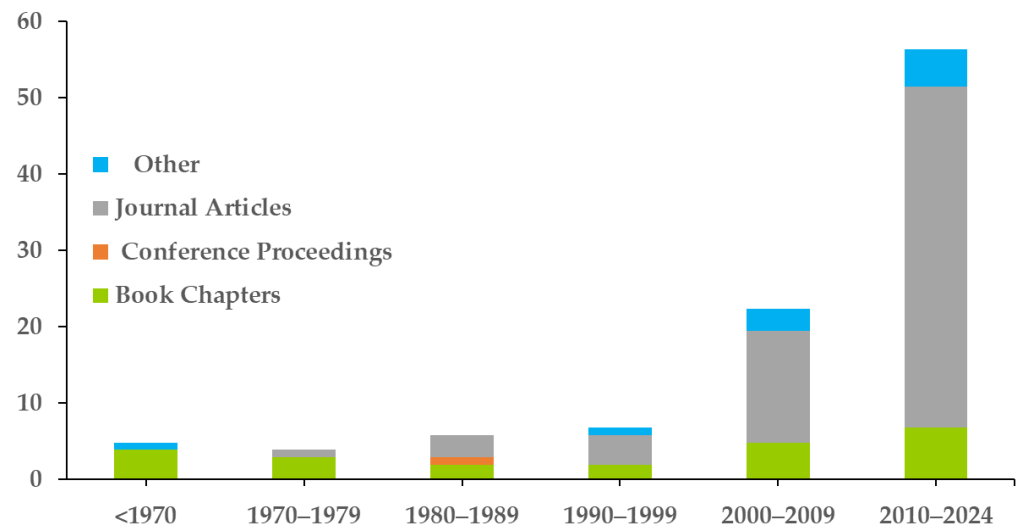


Figure 3. Distribution (%) of the reviewed papers per time period and publication type.

The research studies cover four perspectives. These were as follows: (i) Dittany in Antiquity; (ii) crop ecology and cultivation; (iii) Dittany as an essential oil and (iv) Dittany plants' utilization.

3. Dittany in Antiquity

Dittany has attracted the interest of ancient writers, and modern scholars have extensively studied its historical and cultural significance in antiquity [19]. This section of the paper begins by examining the etymology of Dittany and by questioning the religious implications associated with it. Subsequently, we provide a chronological overview of its uses in antiquity. Finally, we address the absence of Dittany archaeobotanical remains in archaeological contexts.

3.1. Etymology

Two alternate etymologies exist for Dittany (ancient Greek *δίκταμνον*, *diktamnon*): one associated with a mountain in east Crete, Dikte, and the other with a goddess venerated in West Crete, Diktyнна [19] (pp. 135–136). Mount Dikte served as an important cult center since the end of the third millennium BCE until the seventh century BCE and holds significant importance in ancient myth, being one of the proposed birthplaces of Zeus [20] (pp. 1–75). The connection between Mount Dikte and Dittany is attested in antiquity, namely, in a commentary on Aratus [21] (p. 83).

Diktyнна [22–24], primarily worshiped in western Crete, also appears in modern literature as the namesake of Dittany. This is also the most famous etymology for Dittany. However, the ancient authors connect Diktyнна with nets (*δίκτην*, *dikty* being the Greek word for net) and not Dittany, as already implied by Aristophanes at the end of the fifth century BCE [25] and described in detail by Diodorus [26] (p. 108). According to the latter's account, a maiden named Britomartis, in her bid to evade King Minos' romantic advances, leaped into the sea and was rescued by fishermen's nets, hence acquiring the name Diktyнна. Nevertheless, possibly because the later etymology has been already disputed in antiquity, notably by Strabo [27] (p. 411) appearing to be a purely etiological myth [28] (meaning a narrative crafted solely to provide an etymology for a name whose origin was obscure). Modern scholarship tends to equally accept the etymology linking

Dittany to Diktynna. In its support, modern scholars have interpreted her role as protector of childbirth [19] (pp. 135–136), for which Dittany was also beneficial. Nonetheless, there is insufficient evidence to support the above. Firstly, literary sources do not associate Dittany with Diktynna. There is a reference found in the ancient commentary on Euripides, wherein the commentator mentions wreaths made for Artemis in Crete, either of Dittany, schninos, or lotus [29] (pp. 15–16). Sporn notes that the commentator might have meant Diktynna instead of Artemis [22] (p. 232), but this remains a single late-date source reference where the Diktynna is not explicitly stated (the same is true from a passage of an ancient scholiast of Aratus, also noting, by quoting Euphoriion, that Dittany was said to crown Eileithyia [21] (p. 83), not Diktyna). Secondly, Diktynna, often syncretized with Artemis, was primarily regarded as the protector of hunters and fishermen [30], with her rituals also including rites of passage of women, possibly at various life stages, including the support of pregnant women but not limited to it. Similarly, assistance in childbirth was just one aspect among the numerous properties associated with Dittany. Regarding iconography, although examples are scarce, Diktynna is never depicted with Dittany. For example, on a first-century BCE tetradachmon from Kydonia, an olive wreath and not a Dittany one, frames the scene [23] (p. 393). Furthermore, the excavations in the Diktynnaion on the Rodopou peninsula, the main sanctuary of the Cretan goddess, have brought to light architectural sculpture, featuring wreaths, not of Dittany, but of pinecones [22] (p. 232). From the aforementioned points, it becomes evident that despite the appealing notion of a connection between Dittany and Diktynna, there is insufficient data to substantiate it. Even if such a connection was established (since the lack of evidence does not necessarily prove absence), both Dittany and Diktynna ultimately derive their names from Mount Dikte [31] (pp. 52–53).

As for the ending of the word *-amno*, meaning bush, it has gained traction in modern scholarship as the second compound of the word [19] (p. 135). While not entirely incorrect, it is worth noting that *-amno(s)* is a suffix, albeit relatively uncommon, particularly employed in words denoting bushes (including *thamnos*) such as *ramnos* and *iamnos*; *herbs*, like *sfendamnon* and *kritamnon*; and *branches*, such as *radamnon* and *horodamnon* [32] (pp. 789, 815, 1255, 1740).

3.2. Dittany through Ancient Greek Authors

Fifty-two writers in seventy works mention Dittany from the 5th century BCE to the 15th century CE. Most of the texts are medical or pharmacological books. From the above, thirty-eight sources were used for the following analysis. The earliest secure source for Dittany is Hippocrates, who mentions Dittany in three of his works, dated to the end of the fifth/beginning of the fourth century BCE. Dittany as a Cretan endemic plant is undisputed; Hippocrates characterized it as Cretan [33], and it is repeated multiple times throughout the Antiquity [29,34–47].

All eleven of Hippocrates' mentions are in his works dealing with women. In his book *Nature of Women*, he gives a recipe, according to which you have to mix an obol of Dittany in water and give it to a woman to expel the placenta [33]. It is interesting that he notes the quantity of Dittany needed. In the same book, he includes Dittany in a list of aromatic substances to use for the uterus. This time he does not mention proportions, but other specs. This is to boil it in water or wine or just put it in wine, individually or in combination with the other substances on his list [33]. In his *Diseases of Women*, he proposes Dittany's use, again in water, this time in the amount of a bean, to treat the pain of a woman who has not expelled the afterbirth immediately after birth [33]. He also suggests Dittany as an agent to hasten childbirth, whether administered in water or as part of a medicinal compound [33]. However, it is worth noting that this use was later contested by Soranus in the late first or early second century CE [48]. Last, Hippocrates mentions Dittany as medicine during the abortion of a dead fetus [33]. Its use as a medicine for abortion is also later found in the texts of Plutarch [38] and Soranus [48].

The next reference in chronological order is found in Aristotle's works from the fourth century BCE. In two of his books, Aristotle mentions a story about Dittany [34,49]. According to the tale, in Crete, it is believed that wild goats consume Dittany when wounded by arrows, causing the arrows to be expelled from their bodies. Aristotle is cautious in his account, noting that this is just what people say (even one of the two mentions is in a book themed by marvelous things heard, i.e., fables). Despite his disclaimer, this mention of Dittany became significantly influential in antiquity and was frequently reiterated [21,35–38,42,43,45,50,51].

Theophrastus, writing at the end of the fourth and beginning of the third century BCE, provides the earliest detailed description of Dittany. He observes that its appearance resembles pennyroyal but with slimmer twigs. In addition to its established applications in gynecological matters, he specifies that the leaves of the plant are utilized, noting that it is ingested directly into the mouth. Theophrastus is also the first to introduce the concept of pseudodictamon, a plant similar to Dittany but lacking comparable efficacy, and that grows in various locations [35] (p. 43).

A fragment of Euphorion, from the third century BCE preserved by a commentator on Aratus, alludes to one of the two confirmed religious associations of Dittany. It suggests that Dittany was utilized to fashion wreaths used to crown the statue of Eileithyia, the goddess of childbirth [21] (p. 83). The second reference is found in the Scholia in Euripidem, where the crown is made for Artemis, as previously mentioned [29] (pp. 15–16).

The remaining references to Dittany, which we analyze further, date from the first century CE onwards. One of the most comprehensive descriptions of Dittany and its properties comes from Dioscorides Pedanius' monumental work, *On Medical Material* [37] (pp. 41–43). In his third book, on roots, he describes Dittany as sharp and smooth, similar to pulegium, but with larger and downy leaves, with a wooly adherence, and without flower or seed. He also adds much information in the ways it can be used: he adds that it can also be inhaled as smoke to expel dead embryos, its juice can be rubbed with cleansing results, it helps spleen pain (also noted by Archigenes [52]), it induces warmth upon ingestion, it aids in childbirth, and it serves as an antidote to snake bites (administered either as a drink or a topical lotion in wine). Additionally, its scent is believed to repel poisonous creatures (Aelius Promotus, second century CE, also advises putting Dittany in a mattress to keep animals away [40]) and is reputed to heal wounds caused by iron. Dioscorides also recommends harvesting Dittany in the summer and fall.

In his fifth book, dedicated to wines, Dioscorides presents a detailed recipe featuring Dittany as the primary ingredient: diktamnites wine. He provides precise proportions and preparation time for this medicinal concoction, which is efficacious for stomachaches, aiding in the expulsion of bodily wastes and menstrual flow. In the book *Euporista*, attributed to Dioscorides, although he does not seem to be the author, ref. [53] it is said that Dittany is also used to cure swellings [37] (p. 203).

In the second book of *Cyranides*, which encompasses natural sciences, medicine, and magic, we encounter the sole reference to Dittany, associated with magical remedies. It is suggested to be consumed following a potion containing earthworms as its primary ingredient, purportedly to alleviate dysuria [54] (pp. 129–131). However, its diuretic properties are also noted to have been recognized as early as the 5th century BCE by Euryphonas cited by Soranus [48] and reiterated by the physician Rufus in the late first or early second century CE [55].

Galen, second century CE, one of the most prominent and influential ancient physicians, references Dittany approximately fifty times in his works, offering a comprehensive description of its attributes. In addition to the previously discussed uses, his efficacy is in treating muscle pain, ostealgia, headaches, and eye pain [39], suggesting the utilization of Dittany as a cost-effective substitute for expensive medicinal ingredients [39]. Also, Oribasius, in the fourth century CE used it as an ingredient for eye drops [44].

The interest in Dittany persisted through Late Antiquity and into the Middle Ages. In the third century CE, Alexander of Aphrodisias mentions Dittany as beneficial for the heart [56]. Aetius, writing in the sixth century CE, informs us of the plant's use as a diaphoretic [57]. In the ninth century CE, the *Hippiatrica* (attributed to an unknown author) noted its ability to alleviate cough [58]. In the *Geoponica*, compiled in the 10th century CE, there is a curious mention: rubbing the bellies of goats with Dittany purportedly increases milk production, blending elements of myth and folklore medicine [59]. Finally, in the 13th century CE, Nicolaus Myrepsus, whose work *Dynameron* encompasses nearly every aforementioned use and capacity of Dittany, describes a cream recipe containing Dittany that proves effective for alleviating itchiness [47] (pp. 39, 48, 99, 100, 142, 144, 184, 187, 194, 246, 357, 359, 371, 372, 419, 422, 436, 437, 449, 458, 486, 628, 631, 635, 747, 940, 962, 1023, 1035).

Lastly, it is worth mentioning the Roman author Virgil mentioned in Dittany: according to the myth, Venus used braces Dittany to stop her son Aeneas from bleeding [60,61]. This scene has been identified in a first-century CE wall painting in a house in Pompeii [19] (pp. 133–134).

In addition to Dittany's medical uses, we shall note there is actual evidence of its transportation, already in the Roman period, as scholars have speculated [19] (pp. 140–141). Evidence is provided by a papyrus written and found in Egypt [62]. This papyrus, inscribed in the Greek language, functioned as a pharmacist's inventory, detailing medicinal ingredients and their respective prices, including Dittany, dating back to the third to seventh century CE.

Throughout ancient Greek literature, Dittany emerges as a plant of multifaceted significance, predominantly in the medical domain. The diverse ways in which it can address numerous different illnesses extended its influence into folklore and mythology and contributed to its reputation, albeit somewhat exaggerated, as a panacea.

3.3. Dittany in Archaeological Contexts—An Old Misunderstanding

Modern scholarship on Dittany mentions that archaeobotanical remains of the plant have been unearthed in excavations at Knossos and Zakros on Crete and, furthermore, in mainland Greece, at Mycenae and Pylos [63–65]. Ever since, this information has been further disseminated in university theses [66,67] and on various (non-academic) informational websites [68–71]. Below, we demonstrate that Dittany has never been found in any archaeological context.

Residue analysis, which has begun to be systematically used in archaeological excavations only in the last decades, is a prerequisite to find seeds of Dittany. Furthermore, the mesh used for sieving may have been too large to recover since the use of fine mesh sieve (0.3–0.5 mm) is recent and not often used. Moreover, Dittany, as herbs in general, was used for its soft parts rather than for seeds, which were rarely in contact with fire for their processing or consumption, so it is even more difficult for them to be charred, and therefore less likely to be preserved. It is therefore not surprising that none of the recent archaeobotanical studies targeting Crete mention any Dittany findings [72–76].

Kouremenos [19] (p. 139) was the first to cast doubt, tracing this misunderstanding back, citing Diapoulis' book on Greek flora, published in 1949 [77] (p. 114), as at the time, the means and methodologies for identifying such remains were not sufficiently developed. Indeed, the origins of this misunderstanding can be traced back to Diapoulis, but not in the 1949 book, where there is only a description of the plant and information on its names and places of growth. It was not until a paper published in 1980 that Knossos, Zakros, Mycenae, and Pylos appeared as find spots of Dittany [63] (p. 131): "The excavations in the palace of Knossos, of Zakro, of the royal quarters of Mycenae and of the Mycenaean palace of Pylos, revealed that even from prehistoric times there were laboratories for manufacturing perfumes and cosmetics. Seeds that have been found there belong to the following plants...". First on Diapoulis list is "Δίκταμνος *Amaracus Dictamnus*".

Regarding Knossos, two plausible reasons could have led Diapoulis to identify it as a find spot of Dittany. The first is that Sir Arthur Evans, who excavated it, mentions collecting some fresh Dittany (travelers were fond of Dittany during the 19th century) just outside of

the cave of Stravomyti, on the road leading to Knossos. However, there is no doubt that the Dittany he collected was not ancient [78] (pp. 68–70). Alternatively, Diapoulis might have misunderstood the potential identification of Dittany representation in a fresco at Knossos [78] (pp. 103, 111). This is the only possible representation of Dittany, regarding Bronze Age Crete, although it could also be ivy [79] (p. 52) or acacia [80] (p. 103) [81] (p. 22).

As for the other three sites, the source of the misleading information can be traced to the Zakros publication, in 1971, about a decade before Diapoulis' paper. Platon, who excavated Zakros, speculated—or more correctly, Pomerance who first proposed this hypothesis, as noted by Platon in the Greek version of the publication [82] (p. 197)—about the potential existence of a perfume workshop based solely on pottery, a group of braziers, and incense burners found in one of the storerooms of the palace, underlining the speculative nature of this hypothesis [83] (pp. 212–213): “A suggestion that these utensils were used independently for extracting essences from aromatic herbs led to the hypothesis of a workshop here for the production of perfume from local plants. This would not be unlikely, for both in the Mycenaean palace at Pylos and in the annexes of the palace at Mycenaean there was evidence for such a royal industry. Written tablets from these two sites and from elsewhere refer to the availability and the processing of such aromatic substances as mint, coriander, fennel, celery, cumin, cress, laurel and myrtle”.

Interestingly, Platon did not mention Dittany specifically. Moreover, he clearly discussed the possible processing of aromatic substances based on evidence from Linear B tablets from Mycenae and Pylos. It is noteworthy that some years later these two sites are those pinpointed by Diapoulis as find spots of Dittany, along with Zakros and Knossos. Furthermore, the catalogue of seeds mentioned by Diapoulis aligns with the words on the Linear B tablets [84] (pp. 345–346), as these were provided by Platon: coriander, fennel, celery, and cumin, to which Dittany, absinth, and sage have been added.

Taking into account all of the above, it becomes clear that despite the wide use of Dittany throughout antiquity, material evidence from the archaeological record is entirely lacking. This absence can easily be explained by Dittany's nature and by the fact that archaeobotany with its analytical methods is only a very recent discipline involved in the scientific study of the bygone past.

4. Crop Ecology and Cultivation

Cretan Dittany (*O. dictamnus* L.) is a species of *Lamiaceae* genera and belongs to the *Origanum* genus. It is a unique chamaephyte local endemic plant to the island of Crete [6], declared as threatened [85]. It grows wild on fissures of calcareous cliffs and gorge beds shaded or semi-shaded up to 1900 m above sea level [8].

It is a green-white perennial plant, and its height reaches up to 0.35 m. Its leaves of up to 15 pairs per stem dimensioned 13–25 × 12–25 mm are nearly rounded and laterally hairy with distinct veins on the lower side. Its spicules are in groups of 3–10, dense, ovate, or oblong, arranged in opposite reticulate pairs in lax panicles. *O. dictamnus* has bracts eight pairs per spike, dimensioned 7–10 mm, being distinct, purple, and longer than the calyx. Two flowers are arranged per verticillaster, subsessile. The calyces 3/5.5 mm long have one lip, with throats sparsely pilose or not, and the rest glabrous. The upper lip of the calyx is sub-entire, the lower shallowly toothed. The corolla has two lips 11 mm long, pink, more or less saccate, outside sparsely pilosellous. The upper lip is divided into lobes 2.0.3 mm long; the lower lip is divided into subequal lobes 1.5 mm long. The staminal filament of Cretan Dittany reaches up to 12 and 14 mm long. The roots are extended up to 1 cm in diameter [64]. Cretan Dittany flowers in summer, while due to its dimorphism, a variability in shoots and leaves characteristics has been reported in winter and summer [86]. Dittany is found across Crete, with higher concentrations in the western region (Figure 4).



Figure 4. Distribution of Dittany across Crete (created by Dr I. Manolikaki).

There are uncertain reports of its presence in southwestern Asiatic Turkey [87,88]. Dittany closely resembles the plant *O. calcaratum* Juss (also known as *O. tournefortii* Aiton or *A. tournefortii* Benth) but can be distinguished by its woolly and slender leaves, less dense flower clusters, and typically round spikes [87]. Previously, botanists categorized *Amaracus* (Gleditsch) Benth as a distinct genus from *Origanum* and *Majorana* [77]. However, modern research suggests that Dittany should be classified within the genus *Origanum*, specifically in the section *Amaracus* (Gleditsch) Benth of the *Lamiaceae* family [87,89].

Recent research conducted by Ietswaart [87] has identified eight sections within the genus *Origanum*, which can be categorized into three informal categories. *O. dictamnus* is included in the third category, characterized by plants with calyces that are unequally lobed and possess big membrane bracts [90]. The section *Amaracus* (Gleditsch) Benth comprises ancient species of the genus *Origanum*, the majority of which originated during the Pliocene period [87,91]. The identified hybrids of Dittany include *Origanum hybridum* Miller (*O. dictamnus* × *O. sipyleum*), *O. amanum* × *O. dictamnus*, and *O. calcaratum* × *O. dictamnus* [87,92].

The cultivation of Dittany on Crete was noticed for the first time in 1920. The farmers started to cultivate *Dictamnus* in pots for local use using wild-growing plants [93]. Afterward, an attempt was made so that Dittany could be cultivated in small fields. During the second war, cultivation was limited. Right after the end of the war, cultivation started again in an area of about 200 ha in the Herakleion area and the farmers managed to produce 500 tonnes per year. In 1956, the first Dittany cooperative was created by the farmers, and cultivation reached its peak between 1980 and 1990. In the decade from 1991 until 2000, the farmers managed to export about 85% of their products to Italy, France, Germany, and Japan [64]. Nowadays, *O. dictamnus* is cultivated only by a few farmers in the mountains of Crete. The data concerning the cultivation and harvest of *Dictamnus* are sparse, and most of the information is based on the experience of Crete's farmers [94]. It is believed that Dittany's cultivation in areas away from the island of Crete is unsuccessful [93], but nowadays, researchers have made some efforts to cultivate Dittany. Sarropoulou et al. [85] investigated with excellent results an efficient in vitro propagation system of Dittany. The study of Bosabalidis et al. [86] shows the ways of an integrated mechanism of adaptation of the plant to cold stress. *O. dictamnus* cultivation under different fertilization scheme applications (chemical and organic fertilizers) was conducted by Biliadis et al. [95]. Moreover, Martini et al. [96] assessed the development of Dittany under different urban locations, and the safety for human consumption was investigated. The salt stress in combination with drought in Dittany cultivation was studied by Stefanakis et al. [97], and the data showed that *O. dictamnus* plants have a strong tolerance to elevated salinity levels.

5. Dittany Essential Oil

Many studies have demonstrated that the essential oil of Dittany has a particularly high diversity [98–101]. This diversity refers to the quantity of the essential oil produced by the plant, as well as its quantitative and qualitative composition. The content and composition of essential oils can vary: (a) among different populations of a species (geographic diversity),

(b) among individuals within a population (intrapopulation diversity), and (c) within the same individual across different periods (seasonal diversity) [101].

The causes of the observed diversity are not fully known, although it has been extensively shown that the production of essential oils by these plants is influenced by both genetic factors and factors of their macro- and micro-environment [100]. More specifically, some of the factors that influence the amount of essential oil in aromatic plants include (a) plant physiology (growth stage, plant part, sampling season, mechanical injuries), (b) environmental conditions (climate, pollution, territorial factors), (c) geographical location, and (d) genetic factors [102].

The most important elements of *Dittany* essential oil are carvacrol, thymol, γ -terpinene, and p-cymene [12,103]. Previous studies indicated that the major component of its essential oil is carvacrol, which is responsible for the antimicrobial activity of *Dittany* [104]. According to [104], the concentrations of carvacrol, γ -terpinene, and p-cymene were 62.44, 11.41, and 13.49%, respectively.

Multiple studies have investigated the therapeutic potential of *Dittany*'s essential oil [105–107]. The studies' results, combined with consumers' preference for natural ingredients incorporated in the pharmaceutical and beauty industry, have increased the interest in cultivating *Dittany* to extract its essential oils.

Similar to most aromatic herbs, *Dittany*'s essential oil is obtained using steam distillation from a blend of the wild herb's leaves and bracts [108]. As described by Duijker et al. [109] and according to the protocol that applied in most of the studies, plant material is air-dried in the dark at room temperature (25 °C) for ten days. One milliliter of volatile oils is steam-distilled, then diluted with two milliliters of ether, filtered through anhydrous sodium sulphate to eliminate any traces of water, and stored at 4 °C until analysis. Following a 2 μ L injection, analysis is carried out using gas chromatography—mass spectroscopy with a MDN-5 column and a quadrupole mass spectrometer, which serves as the detector. Helium is the carrier gas, flowing at a rate of 0.9 mL/min. A split mode approach is used to measure the sample (1:35), and an electron ionization device with an ionization energy of 70 eV is employed for GS-MS detection [107,109].

Analysis of the extract showed that the most important elements of *Dittany*'s essential oils are carvacrol, γ -terpinene, p-cymene, and thymol [12,103]. According to Sivropoulou et al. [104], the concentrations of γ -terpinene and p-cymene were 11.41 and 13.49%, respectively, whereas Acimovic et al. [110] reported that they found a 70.8% concentration of carvacrol in *Dittany*'s essential oils, making it the dominant component. Carvacrol and p-cymene were found in higher percentages in the bracts and in the leaves, respectively [111].

The high concentration of carvacrol is expected in *Dittany*'s essential oils, as many essential oil extracts from the Lamiaceae family contain it as their primary constituent [100,112,113]. Carvacrol is known for having antioxidant qualities that are comparable to those of ascorbic acid and vitamin E [107,114], and it displays a remarkable antimicrobial, antibacterial, and anti-inflammatory effect [115–117]. A wide range of Gram-positive and -negative bacteria are susceptible to carvacrol's antibacterial action [107,118]. This effect is attributed to a reduction in the synthesis of inflammatory mediators, such as prostaglandins, enzymes, nitric oxide (NOS), reactive oxygen species (ROS), and cytokines [119]. p-Cymene is a hydroxyl group that displays antinociceptive activity [120] and an antimicrobial effect [121]. On the contrary, the antimicrobial effect of γ -terpinene is debatable, with positive [122] and negative [104] reports against strains of Gram-positive or Gram-negative bacteria. Finally, thymol is an isomer of carvacrol and a naturally occurring phenol monoterpene derivative of cymene, mainly found in thyme [123]. Examples from studies of major components of studied essential oils of *Dittany* are presented in Table 1.

Table 1. Major components of studied essential oils of Dittany.

Area	Analysis and Components	Plant Part Used for the Extraction	Source of Plant (Cultivated/Wild)	Use	Mode of Preparation	Reference
Greece	carvacrol (52.2%) g-terpinene (8.4%) p-cymene (6.1%) linalool (1.4%) caryophyllene (1.3%)	dried leaves and flowers	wild	antimicrobial, antioxidant, and antiproliferative activity	hydrodistillation, using 40 g of dry material and 500 mL of water	Mitropoulou et al. [124]
Greece	carvacrol (69.89%) p-cymene (12.92%) g-terpinene (7.12%) a-terpinene (1.49%) b-caryophyllene (1.38%) b-myrcene (1.11%)	dried aerial parts	wild	postharvest disease use	hydrodistillation by using a Clevenger apparatus for 2.5 h	Tzortzakis [125]
Greece	carvacrol (51.7%) g-terpinene (9.2.1%) p-cymene (10.1%) a-terpinene (2.39%)	dried aerial parts	cultivated	antimicrobial activity	hydro-distillation for 4 h, in 2 L of water, using a Clevenger-type apparatus	Liolios et al. [126]
Greece	carvacrol (42.9%) g-terpinene (14.1%) p-cymene (8.78%) a-terpinene (2.82%)	dried aerial parts	wild	antimicrobial activity	hydro-distillation for 4 h, in 2 L of water, using a Clevenger-type apparatus	Liolios et al. [126]
Greece	carvacrol (14.7%) p-cymene (32.7%) g-terpinene (12.4%) linalool (7.8%)	dried aerial parts	wild	antibacterial, antioxidant, and antiproliferative activities	hydrodistillation by using a Clevenger apparatus	Marrelli et al. [127]

6. Dittany Plants' Utilization

Dittany is a traditional medicinal plant widely used in Crete. The herb of Dittany is used for the cure of almost every illness and the maintenance of good health [128], possessing antimicrobial, antiviral, antioxidant, anti-spasmodic, cytotoxic, and anti-ulcer pharmacological properties [5,128]. Extensive analysis of the cultivated medicinal herbal drug *Origanum dictamnus* L. and antimicrobial activity of its constituents has been conducted [129,130]. Studies of Gortzi et al. [131] and Liolios et al. [126] demonstrated the antioxidant and antimicrobial activity ability of *O. dictamnus* in the preservation of food. The beneficial effects of Dittany essential oil in pathogenic bacteria were investigated by Mitropoulou et al. [124] and Alexopoulos et al. [132].

It is well known that the above-ground parts of the plant are being used against influenza and viruses, as well as for stomach and gastrointestinal disorders [96]. Furthermore, the Dittany plants have healing and calming characteristics, and they can act positively against respiratory diseases [6,133]. In Greek and Roman antiquity, Dittany has been mentioned to be used as an antidote after the bite of poisonous snakes [134] and for several other beneficial uses (see Section 3.2).

Its dried flowering parts are used for the preparation of an infusion or a decoction [6]. Nowadays, the above-ground part of the herb is used as an antispasmodic to lower fever, alleviate headaches, and treat minor skin conditions. Additionally, Dittany's infusion (called "vrastari" locally in Crete, from the verb *vrazo* = to boil) is recommended for stomach disorders as well as sore throat, the common cold, and digestive issues [64,135]. The antiproliferative effects of Dittany's essential oil against tumor cells were investigated by Marrelli et al. [127], and their data showed *O. dictamnus* could prevent cancer.

Moreover, Dittany is used as a spicy ingredient for gastronomic purposes all over the world [103]. Dittany's culinary application is limited; however, it has been reported that liqueurs, vermouth, salads, and sauces have occasionally included flower heads, stems, leaves, and extracts [6,103]. The primary taste of Crete's Dittany is robust and sharp, with a distinctive bitterness, and it offers a balance among oregano (due to carvacrol) or thyme (due to thymol) [65]. The strong flavor of Dittany has limited its culinary use according to

Chishti et al. [103], but when it is used in certain amounts, a unique cooking experience can be offered in cooking.

7. Conclusions

Over the past decade, aromatic and medicinal plants have experienced a significant surge in appeal both in European and global markets. Dittany, in particular, is widely used in the local cultures and it serves as a bridge between antiquated and contemporary traditions.

The herb's ability to heal wounds has been consistently used throughout history, from ancient civilizations to the present day, despite the lack of experimental research or supporting evidence. The same purpose still drives the continued use of this traditional practice. The herb's pharmacological qualities include antibacterial, antioxidant, antiviral, anti-spasmodic, cytotoxic, and anti-ulcer effects, making it ideal to treat nearly all illnesses and to promote overall good health.

Greece produces exceptional quality of Dittany plants, and their production has an enormous effect on Greek agriculture. It can grow at both low and high altitudes and can withstand a variety of climatic conditions, providing high value even on deteriorated sloping soils in the nation's semi-arid zone. As such, it is recommended for semi-fertile lands and for cultivation throughout the entire Mediterranean basin since it has adapted to the region's climate.

Expanding the production of Dittany could yield major advantages for both the environment and the local economy presenting new opportunities for people. In degraded lands of Greece's semi-arid zone, it can aid in biodiversity conservation and lessen soil erosion, land degradation, and desertification. It could also be promoted as a novel ingredient in the culinary section, enhance the gastronomy of certain places, and increase the farmers' income since it is a low-input plant that requires less energy to grow.

At this point, the proper management and maintenance of this plant may provide new options for local development and act as a new functional food, cosmetic, antidote, or nutraceutical in the future. To support both *ex situ* conservation and future sustainable exploitation strategies, it is critical to highlight the urgent need to develop the domestication procedure for range-restricted species of medicinal and cosmetic interest. This will enable the wider use of locally endemic plants with significant potential and closely related medicinal and aromatic plants from regions that likely have similar medicinal potential. Local communities and stakeholders prioritize conserving threatened phytogenetic resources, both in their natural habitats (*in situ*) and through preservation outside their natural habitats (*ex situ*). This approach will facilitate the sustainable utilization of these resources.

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