



Ethnobotanical Applications and Their Correspondence with Phylogeny in Apiaceae-Apioideae

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Abstract

The Apiaceae family includes some of the most known medicinal, food and spice species in the world some of which have been used by humans since antiquity. Local people in different regions use many species of the family but the information regarding their uses is scattered. Traditionally used species are good candidates for bioprospecting. Combining traditional uses with phylogenetic data helps in selecting species for bioprospecting. In the present study, an ethnobotanical literature review was conducted to outline a comprehensive overview of the ethnobotanical importance of the family in Iran. To highlight the most ethnobotanically used groups in the family, ethnobotanical data were overlapped with generic phylogeny tree of the subfamily Apioideae. In total, 72 species (17.27%) from 42 genera (33.87%) were found to have ethnobotanical uses. Main uses of the family members were medicinal purposes (67.30%) followed by culinary (25%) and ethnoveterinary (11.11%) uses. Two categories of potential species groups for further bioprospecting investigations have been identified based on the phylogenetic analysis. Based on the findings of the present study, phylogenetic analysis can help in identifying potential groups for bioprospecting studies. More rigorous phylogenetic analysis that combines chemotaxonomy data, ethnomedicinal data and phylogenetic data are necessary to pinpoint exact lineages for specific medicinal properties.

Keywords: Apiaceae, ethnobotany, *Ferula* L., Iran, medicinal uses, phylogeny

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Introduction

The Apiaceae family (Umbelliferae) is one of the largest plant families in the world including more than 455 genera and 3600-3780 species [1-3]. Members of the family are widely distributed almost all over the world from temperate to subtropical and tropical regions. The family includes some important aromatic and medicinal plants and culinary herbs and spices such as fennel root (*Foeniculum vulgare* Mill.), female ginseng (*Angelica sinensis* (Oliv.) Diels),

asafetida (*Ferula assa-foetida* L.), cumin (*Cuminum cyminum* L.), anise (*Pimpinella anisum* L.), coriander (*Coriandrum sativum* L.), parsley (*Petroselinum crispum* (Mill.) Fuss), and carrot (*Daucus carota* L.), some of them have been used by humans since ancient times [4]. Many species are used in traditional and folk medicine throughout the world [5] and many have therapeutic values because of rich bioactive compounds such as terpenoids, coumarins,

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sesquiterpenes, flavonols, essential oil components as β -phellandrene and α -terpineol and fatty acids like petroselinic acid [6-9].

Iran is a major diversity center of Apiaceae among Asian countries [10-11]. The family is represented by 124 genera and 417 species, distributed in different parts of the country, while 114 species are endemic [12-13]. Some large genera like *Ferula* L. (34 spp.) and *Dorema* D. Don. (7 spp.) are distributed mainly in Irano-Turnian region. They include several important economic and medicinal species like asafoetida (*F. assa-foetida* L.), galbanum (*F. gummosa* Bioss.), sagapenum (*F. persica* Willd.), and ammoniacum (*Dorema ammoniacum* D. Don) that are distributed mainly in central and southern parts of Iran [14-16]. Gum ammoniac, gum galbanum and gum asafoteida are among the important Apiaceae exudates products exported from Iran [17]. There are many other species that are used in different parts of Iran. However, accounts on their ethnobotanical uses are scattered in local reports or other publications and there is a need for an inclusive review that gives an overview on the ethnobotanical importance of the family in the region.

It has been shown that when traditional plant uses of a group of taxa are mapped over phylogenetic lineages of that group, evolutionary patterns of distribution of useful plants in some lineages are revealed [18-19]. This suggests that phylogenies can be used as tools for identifying potential useful plant lineages and to target investigations to groups with the highest potential of bioactive compounds [20]. Combining an ethnobotanical approach together with phylogenetic analyses seems to be a promising methodology for finding lineages with desired chemical or medicinal properties [18-19].

The present review has aimed to compile and collate a database of ethnobotanical uses of Iranian Apiaceae and has presented a comprehensive account of different ethnobotanical use of the family. Further, ethnobotanical uses have been mapped over the generic phylogenetic tree of the family to understand and interpret the patterns of use distribution over phylogenetic lineages and investigate these patterns for making predictions on potential species and genera for further pharmacological studies. This review has tried to highlight the ethnobotanical importance of

Apiaceae family in Iran and to facilitate and guide future bioprospecting research on the members of this family.

Methods

An extensive literature review with a focus on ethnobotany and traditional uses of Apiaceae in Iran was conducted. Publications in Persian and English languages were assessed. Literature without taxonomic data or with doubtful identifications or without proper voucher specimen documentation was excluded from the analysis. All information regarding different uses of Apiaceae species, scientific and vernacular names, their uses, used parts, modes of preparation and administration and geographical locations were extracted and tabulated in an excel spreadsheet. Each specific use reported in the literature for a given species was considered as one use report for that species (Species-use reports). Ethnobotanical uses were categorized into three main groups: medicinal uses, culinary uses including vegetables and spices and ethnoveterinary uses. Furthermore, medicinal uses were organized into 20 use categories [21-22]. Inferential statistical analysis were conducted using excel software. Information about the ethnobotanical uses of Apiaceae species was compiled from 56 sources, including published articles and two books. Botanical nomenclatures were verified using Flora Iranica [23], Flora of Iran [15] and The Plant List [24]. All literature sources have been given in table 1. For phylogenetic analysis, medicinal and culinary uses of species were overlapped on a generic level phylogenetic tree [3]. Percentage of useful species for each genus was calculated and highlighted on the tree.

Results and Discussion

Diversity of useful species

Ethnobotanical uses were grouped into three main categories including medicinal, culinary (including vegetables and spices) and veterinary uses. A total of 72 species (17.27% of total species of the family) from 42 (33.87%) genera were found to be used at least in one of the main categories. Main uses of the family members were medicinal purposes (67.31%) followed by culinary (25%) and ethnoveterinary (11.11%) uses. Table 1 gives details of the species and their uses along with the corresponding

references. The genera of *Ferula* (14 spp.), *Eryngium* and *Prangos* (4 spp.) and *Carum*, and *Heracleum* (3 spp.) included the highest number of useful species. *Ferula* is the largest genus of Apiaceae in Iran and also one of the most economically exploited genera [12].

Plant part used

Depending on the use category, different plant parts of the Apiaceae were used most. Considering all types of uses together, the most frequently used parts were seeds (26%) followed by leaves (19%) aerial parts (11%) and roots (10%) (figure 1). Both seeds and leaves were most favored parts in many reports likely because they contain high concentration of bioactive compounds [25] and they are easily available. It is also thought that the leaves contain more easily extractable phytochemicals, crude drugs and many other mixtures that may be regarded as valuable in phytotherapy [26]. However, in medicinal and culinary applications, the seeds were the most frequently used plant part (25% and 50%, respectively) and gum and aerial parts were the most frequently used parts (25%) in the ethnoveterinary category.

Modes of preparation and administration

Decoction was the most common way of preparation of medicines (36.11%), followed by infusion (21%) and grinding plant parts (15.28%) (figure 2). Water was frequently used as the solvent if required.

Medicinal uses

Medicinal use reports have been categorized into 20 health system disorders [21-22]. A total of 752 use records have been documented. Members of Apiaceae were mainly used for digestive system disorders (34.6%, 52 spp), genitourinary system disorders (12.7%, 28 spp), infections/infestations (12.4%, 36 spp) and respiratory system disorders (8.8%, 25 spp) but they also had wide applications for muscular-skeletal and nutritional disorders. Sensory system disorders, metabolic and poison remedies were the least common. The unspecified medical disorders category had the lowest number of records (0.1%) (figure 3). Most mentioned medicinal properties were carminative (94 citations), diuretic (44), gastritis treatment (35) and vermifuge (29).

In terms of ethnomedicinal uses, *Ferula assa-foetida* L. is a very valuable species in traditional medicine and showed the maximum number of use reports (61 use reports), followed by *Foeniculum vulgare* (60 use-reports), *Anethum graveolens* L. (56 use reports) and *Coriandrum sativum* (49 use reports). The wider utilization of these species might relate to the presence of effective bioactive constituents. Also, the mentioned species were the most popular plants reported for a majority of the medicinal and non-medicinal uses.

Although, Apiaceae species are mainly used for digestive system afflictions but they have applications for genitourinary health problems, infections/infestations, and respiratory conditions.

According to the reviewed references, 52 species were recorded as being used for digestive system disorders. *Foeniculum vulgare*, *Bunium persicum* (Boiss.) B. Fedtsch., *Anethum graveolens*, *Heracleum persicum* Desf. ex Fisch., C.A.Mey. & Avé-Lall., *Ferula assa-foetida*, *Coriandrum sativum* and *Cuminum cyminum* were used to treat a wide variety of digestive disorders such as gastritis and showed to have carminative and digestive effects. A total of 29 species have been documented as being used for genitourinary system disorders (figure 3). *Foeniculum vulgare*, *Anethum graveolens*, and *Petroselinum crispum* were mostly used as diuretic and to stimulate menstruation in young women, and were used for reducing and relieving menstrual pain.

The infections/infestations were the third frequent category of ailments for the studied family. Thirty-nine species were used for treating infectious diseases; the most common was *Ferula assa-foetida*. Twenty-seven species have been reported for the treatment of respiratory system ailments including asthma and cough, bronchitis and as expectorant. The effect of *Ferula assa-foetida* against flu may support the similar reports from traditional manuscripts [60].

Culinary uses

According to the European Spice Association, culinary herbs are the edible plants that are traditionally added to foodstuff for their natural flavorings, aroma, visual appearance and preservative purposes [80]. In our analysis, we included plants used as vegetables, spices, and flavorings under culinary use category.

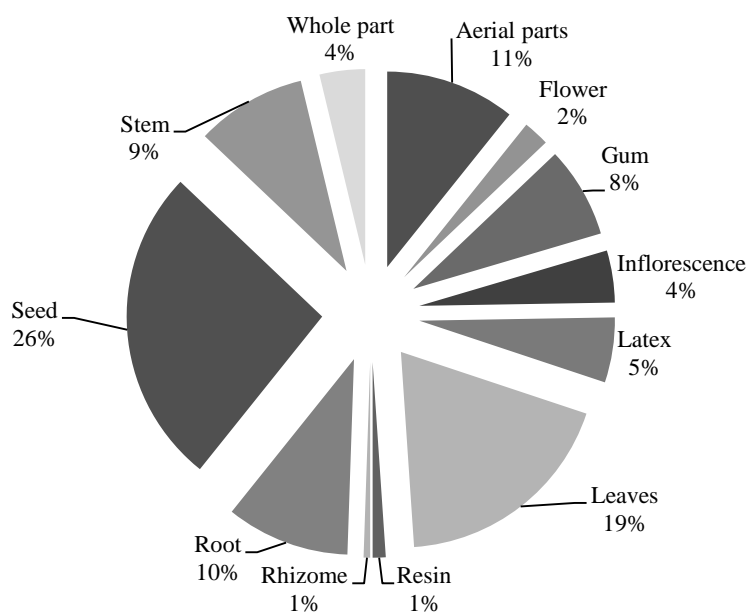


Figure 1. Proportion of different plant parts used for the ethnobotanical purpose in the Apiaceae family

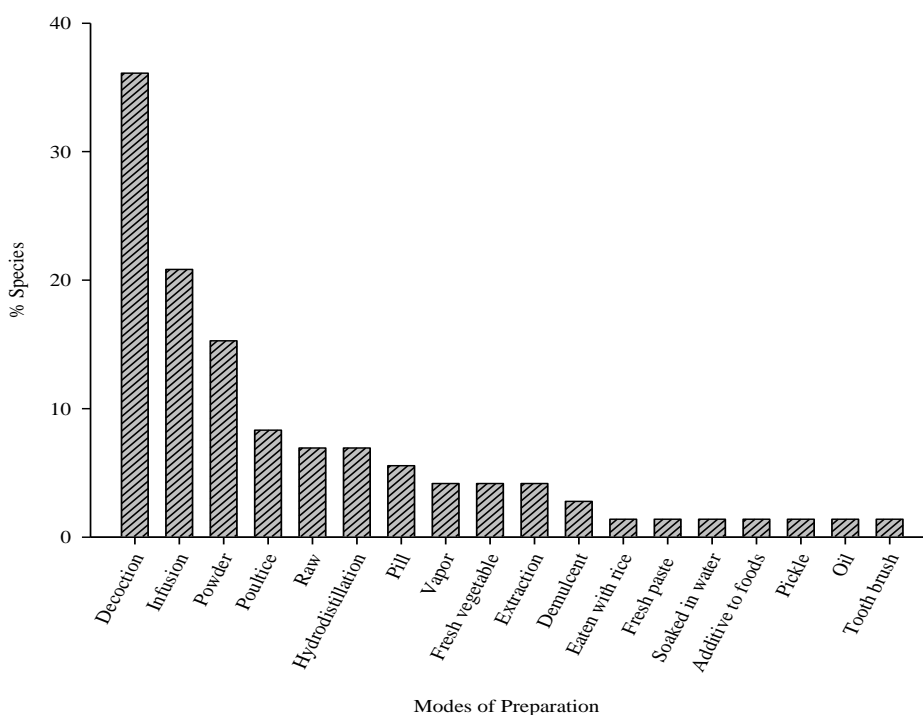


Figure 2. Mode of utilization of the Apiaceae plants

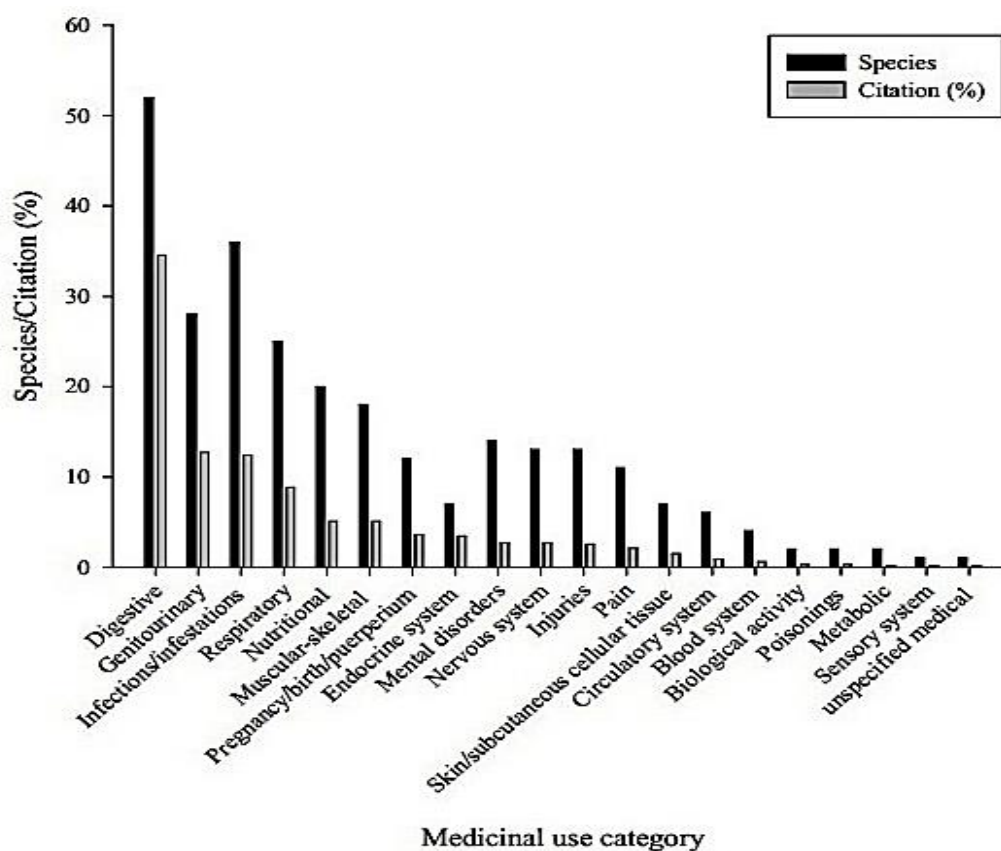


Figure 3. Percentage of species and citations in each medicinal use category

Apiaceae family included many species that have been used as flavoring agents, condiments and spices in food products since the ancient times due to their pleasant aroma and also as preservatives. Among 72 plants reported in this review, 23 species were mentioned to have culinary applications. From the reported species, 44% were used as flavourings, 22% as fresh vegetables, 17% as condiments and 11% as spices (figure 4). *Bunium persicum*, *Coriandrum sativum* and *Heracleum persicum* were the most frequently used culinary plants of Apiaceae in Iran.

Ethnoveterinary uses

In a broad sense, 'ethnoveterinary medicine' is the science that specifically deals with treating ailments of livestock and other domestic animals with herbal medicine, which plays a key role as the major source of medicine being used to cure animals in rural area [81-82]. A large number of

rural people use local herbal medicines for the treatment of their domestic animals and the role of ethnoveterinary medicine in livestock development is beyond dispute [81]. In spite of the importance of ethnoveterinary applications of medicinal plants for rural communities, few studies have been conducted on ethnoveterinary uses of plants in Iran. Only nine species of Apiaceae were documented for application in primary health care of ruminants and treatments of different ailments in animals. *Cuminum cyminum*, *Dorema ammoniacum*, and *Oliveria decumbens* Vent. were reported as the prevailing species, which were used for ethnoveterinary purposes. The routine maladies of livestock were diarrhea, infections/infestations, nutritional disorders, digestive disorders, and pustules that were treated with these medicinal plants (figure 5). The usages of two species of *Dorema* for infectious wounds have been also documented.

Moazzami Farida S.H. et al.

Table 1. List of medicinal plants of Apiaceae and details of their uses

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|---|--|----------------|--|---|------------------------------|
| <i>Ammi majus</i> L. | Alaf-e osghofi, amy, khalal dandan | Ap, Se | As carminative, to ease digestion, as diuretic; for dyspepsia, gastritis, kidney stones, psoriasis and skin allergies, as tooth stick and general tonic | Decoction, powder/Oral | [5,12,27-29] |
| <i>Anethum graveolens</i> L. | Mitkham, shabat, shevet, shevid, toragh | Ap, F, Le, Se | To relieve abdominal pain, back pain, low back pain and joint pain. For bladder inflammation, and nephritis (kidney inflammation), as diuretic. For amenorrhea (missed period), menstrual cramps, dysmenorrheal problems and impotence. It can cause abortion. As appetizer, to ease digestion, against bloating, nausea, gastritis, gastric reflex in children, hypercholesterolemia, hyperlipidemia; to reduce blood sugar, hypertension, to increase lactation in nursing mothers; anti- seizure and sedative, helps dyspnea, hiccup and common cold; culinary uses | Decoction, infusion, powder, raw / Oral | [28,30-46] |
| <i>Apium graveolens</i> L. | Karafs | Le, Se | To relieve asthma, headache and low back pain; aAs carminative, diuretic, sedative and general tonic. For rheumatic diseases, to stimulate menstruation (amenorrhea) and urinary tract infection; culinary uses | Decoction, vapor/Oral, inhalation | [12,30-34,38,47] |
| <i>Apium nodiflorum</i> (L.) Lag. | NA | Le | For chronic skin disorders and as diuretic | NA | [5] |
| <i>Bunium cylindricum</i> (Boiss. & Hohen.) Drude | Zireh-e siyah | Se | As carminative | NA | [34] |
| <i>Bunium persicum</i> (Boiss.) B.Fedtsch | Gharah zireh, zireh, zireh-e- Irani (Kermani), zireh-e kuhi, zireh-e siyah | Ap, Le, Se, St | As appetizer, carminative, astringent, decongestant, diuretic, spasmolytic, sedative. For children earache, cough; to ease digestion, as stomach tonic, to help indigestion and vomiting, gastritis; to increase lactation in nursing mothers and against infection; helps weight loss; culinary uses | Hydrodistillation, decoction, powder/Oral | [12,29,33-34,37-39,41-42,48] |
| <i>Bupleureum falcatum</i> L. | NA | Le, Se | To relieve fever, joint pains and for wound healing | Decoction, poultice/Oral, topical | [49] |
| <i>Bunium bulbocastanum</i> L. | Zireh-e siyah-e- kermani | Se | As carminative; culinary uses | NA | [32] |
| <i>Carum carvi</i> L. | Hoshtarak, zireh, zireh-e siyah, zireh-e siyah-e europaei | Le, Se | To relieve asthma, hyperlipidemia, impotence and parasite infections; to increase lactation in nursing mothers; as carminative, diuretic and to ease digestion. Culinary uses. | Decoction, infusion/Oral | [12,31,40,50,51] |

Ethnobotanical applications and their correspondence with phylogeny in Apiaceae-Apioideae

Table 1. Continued

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|--|---|-----------------------|--|---|--------------------------------------|
| <i>Carum copticum</i> (L.) C. B. Clarke | Ezbootk, zeniyān | Se | As blood thinner, carminative for children, vermifuge; against cholera, fever, cough, dysmenorrheal, gastritis and hyperlipidemia | Decoction, powder/Oral | [32,51] |
| <i>Chaerophyllum macropodium</i> Boiss. | Chelghaba, garkava | St | Culinary uses | Eaten with rice | [52] |
| <i>Chaerophyllum</i> sp. | Ghur dumana | Se | As carminative | NA | [32] |
| <i>Conium maculatum</i> L. | Bikh-e shokaran | R, Se | Against cholera and skin allergies; for hair removal and as sedative | NA | [32,34] |
| <i>Coriandrum sativum</i> L. | Gardilu, geshnij, geshniz | Ap, Le, Se, St | Against seizure, diabetes, acne; to relieve dental pain, headache, general pain, sore throat and as sedative; used as aphrodisiac, appetizer, carminative, stomach tonic, vermifuge and diuretic; to increase lactation in nursing mothers, against hyperlipidemia, gastritis, gastrointestinal infections, gout and jaundice; culinary uses | Decoction, extraction, infusion, powder, raw vegetable/Oral | [27,30-36,39, 41,43,44,46, 48,53-54] |
| <i>Cuminum cyminum</i> L. | Zireh-e sabz | Le, Se | To relieve abdominal pain, body pains, colic pain, post-delivery pains, menstrual pain, gastric reflex, gastritis, asthma and dyspnea; used as carminative, stomach tonic, spasmolytic, diuretic, blood tonic, for diarrhea, for healing fractures, to increase lactation in nursing mothers, for bloating and inflammatory bowel disease, against parasite infection and to stimulate menstruation (amenorrhea) in young women; it helps weight loss; culinary uses. Ethnoveterinary use: as aphrodisiac for camel and carminative for cattle and sheep | Decoction, infusion, poultice, powder/Oral, topical | [31-32,34,37-38, 40,42,55-56] |
| <i>Daucus carota</i> L. | Gezar, havij | R, Se | As appetizer, laxative, diuretic, stimulant, for constipation; to improve eyesight, to stimulate menstruation (amenorrhea) and for anemia; culinary uses | NA | [32-34,42-43,58] |
| <i>Dorema ammoniacum</i> D. Don. | Ashtarak, kandal, koma, oshgh, oshtorak, vasha | Gu, La, R, Re | Against acne, bronchitis, asthma, infection and intestinal parasites. To relieve bladder inflammation, colic pain, sciatic pain, cough, gastritis and seizure. As expectorant, laxative, stimulant, to ease digestion, to heal wounds and pustules and to stimulate menstruation (amenorrhea). It can cause abortion. ethnoveterinary uses: healing infectious wounds and pustules in animals | Pill/Oral | [32-34,39,49, 56,59-61] |
| <i>Dorema aucheri</i> Boiss. | Ashtarak, balhar, bilhar, kal, kandal-e kuhi, koma, zou, zu | Ap, Gu, La, Le, R, St | Against asthma, bronchitis and as expectorant; to cure burnings and constipation; culinary uses. Ethnoveterinary uses: for gastritis, parasite infection and wound healing. | Fresh paste/Oral, topical | [12,39,49,52,54,56] |

Table 1. Continued

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|---|--|-----------------------|---|---|-------------------------------------|
| <i>Ducrosia anethifolia</i> (DC.) Boiss. | Baghiz, cheshm-e baghiz, maial, moshgak, rashgak | Ap, In, Wp | To relieve low back pain, delivery pain and irregular menstruation; as carminative and against gastritis and infection | Decoction, raw/Oral | [36,38-39,48,62] |
| <i>Ducrosia assadii</i> Alava | Baghiz, maial, moshgak bakraii | Se | As carminative and vermifuge and against gastritis | Decoction, soaked in water/Oral | [28,49] |
| <i>Echinophora platyloba</i> DC. | Keravi, khosharizeh | Ap, Le, Wp | For common cold, cough, fungal infection and kidney stones; culinary uses | Decoction, extraction, infusion/Oral | [46,53,62-65] |
| <i>Eryngium billardierei</i> Heldr. ex Boiss. | Chichagh, zul | Ap, Le, R, St | As carminative, expectorant, sedative and spasmolytic; against constipation, fungal infection, pertussis and rheumatic diseases | Decoction/Oral | [38,48,52,65] |
| <i>Eryngium bungei</i> Boiss. | Shochagh | Ap | As sedative | NA | [48] |
| <i>Eryngium caeruleum</i> M.B. | Chuchagh, zalang | Le | Culinary uses | NA | [12] |
| <i>Eryngium campestre</i> L. | Zallash | F, St | As appetizer and carminative; against kidney stones. | Decoction, fresh vegetable/Orally | [66] |
| <i>Eryngium caucasicum</i> Trautv. | Sisak teli, zulnak | Le | Culinary uses | Oral | [67] |
| <i>Falcaria vulgaris</i> Bernh. | Ghaz yaghi, paghaze | Ap, Le, Se, St | As carminative and hemostatic; against cough, fever, gastritis, hypertension, stomach problems, vitiligo, and for wound healing; culinary uses | Decoction, powder, fresh vegetable/Oral, topical | [12,34,38,45, 46,53-54,61,68,69] |
| <i>Ferula alliacea</i> Boiss. | Barijeh | Gu | As carminative and to ease digestion; against seizure, intestinal infection and parasites and to cure scorpion stings | NA | [5,12] |
| <i>Ferula angulata</i> (Schltdl.) Boiss. | Chavir, chenour | Gu, Le | As carminative and against infection; culinary uses | NA | [38,52,70] |
| <i>Ferula assa-foetida</i> L. | Anghuzeh, anghuzeh-e hangoo, gane-bu, heltit, peterk | Gu, La, Le, R, Re, St | Used as aphrodisiac, diaphoretic, sedative, spasmolytic, expectorant, laxative, and carminative; against intestinal parasites, seizure, ascites, asthma, bronchitis, cholera, common cold, cough, constipation, and diabetes; to ease digestion to relieve pain, tremor, dyspepsia, earache, fever, gastritis, gastric ulcer, hemorrhoid, hiccup, hypertension; as insect repellent, liver tonic, to cure tooth cavity and wounds. It can cause abortion. | Extracted in vinegar or oil, powder/Oral, topical | [12,33,38-39,42, 51-52,59-60,71-73] |
| <i>Ferula behboudiana</i> (Rech.f. & Esfand.) Chamberlain | Anio, kame | F, In, Le | Against infection; ethnoveterinary uses: appetizer for cattle | Decoction/Oral | [70] |
| <i>Ferula foetida</i> (Bunge) Regel | Anghuzeh | Gu, R | To relieve colic pain, earache and infection; as insect repellent, to remove parasite infection, to stimulate menstruation (amenorrhoea), and for wound healing | Powder/Oral | [29,34] |
| <i>Ferula galbaniflua</i> Boiss. & Buhse. | Barijeh | Gu | For gastritis and wound healing | Poultice/Topical | [32] |
| <i>Ferula galbanum</i> L. | Anghuzeh | La | To relieve asthma, hiccup, parasite infection, gastritis, and as carminative | Infusion, pill/Oral | [30] |

Ethnobotanical applications and their correspondence with phylogeny in Apiaceae-Apioideae

Table 1. Continued

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|---|---|--------------------------|---|---|----------------------------------|
| <i>Ferula gummosa</i> Boiss. | Angiyun, barijeh, ghasni | Gu, R, Se, St | As appetizer, stomach tonic and vermifuge; to cure common cold, dust allergy, dyspepsia, stomach problems, liver cists, wounds and to stimulate menstruation (in amenorrhea) | NA | [33-34,52-53] |
| <i>Ferula haussknechtii</i> Wolff ex Rech.f. | Komeh, komieh | In, Le | For infections | NA | [70] |
| <i>Ferula hezarlalehzarica</i> Y. Ajani | Kahoo vahshi | Rh, St | As carminative and for gastritis | Hydrodistillation/Oral | [49] |
| <i>Ferula latisecta</i> Rech.f. & Aell. | Sasekoma | Ap, Le | To ease digestion and for gastritis in children, also as vermifuge | NA | [53,74] |
| <i>Ferula oopoda</i> (Boiss. & Buhse.) Boiss. | Ejek-ghamaghi, kal, kal ja-shour, koma-e ghalafdar | Gu, La, Se | To relieve asthma, cough, dental pain, headache (migraine), tooth infection and as diuretic, expectorant, spasmolytic | Demulcent, pill, vapor/Oral, topical, inhalation | [30,38-39,48,75] |
| <i>Ferula ovina</i> Boiss. | Koma | F, Re, Se, St | To relieve constipation and infection | Decoction/Oral | [58,62,65,72] |
| <i>Ferula persica</i> Willd. | Anghuzeh, sakbinaj | Gu, La | For bites, low back pain, rheumatic diseases, cough and as laxative and spasmolytic | Poultice/Topical | [32,48,59] |
| <i>Ferula</i> sp. | Anghuzeh | La | To relieve asthma and hiccup and as carminative. | Infusion/Orally | [50] |
| <i>Ferula szowitziana</i> DC. | Anghuzeh-e shirin, ghamagh-mumi, sagapen | Gu, La, R | To relieve asthma, cough, rheumatic diseases, skin wounds and as stomach tonic | Demulcent, pill, vapor/Oral, external, inhalation | [5,30,42] |
| <i>Ferulago angulata</i> (Schlecht.) Boiss. | Chenour, garchik | Ap, La | For wound healing; culinary uses | Poultice, powder/Oral | [49,54] |
| <i>Foeniculum vulgare</i> Mill. | Badian, badian-e sabz, badio, badioun, raajuneh, raz, razianeh, zaljooneh | Ap, F, La, Le, R, Se, St | To relieve abdominal pain, back pain, joint pain, low back pain, colic pain, dental pain, menstrual pain, post delivery pains, cough, asthma, bronchitis, diarrhea, gastritis and reflex; as appetizer, carminative, sedative, diuretic, digestive; to remove gallstones and urinary tract stones, to cure gout, hemorrhoid, bloating, kidney infections and parasitic infection; to increase lactation in nursing mothers and to stimulate menstruation (in amenorrhea). | Decoction, hydrodistillation, infusion, powder/Oral | [27,30-37,39-43, 46,51-52,55,61] |
| <i>Froriepia subpinnata</i> (Ledeb.) Baill. | Chuchugh, zalang | Se | Culinary uses | NA | [12] |
| <i>Haussknechtia elymaitica</i> Boiss. | Kelos-e kuhi | Ap | To relieve diabetes and hypertension | decoction, fresh vegetable/Oral | [44,52,76] |
| <i>Heracleum gorganicum</i> Rech. f. | Jengel-e ghamaghi | Se | To ease digestion; culinary uses | Additive to foods | [30] |
| <i>Heracleum lasiopetalum</i> Boiss. | Golpar, kerson | Se | Against infection; culinary uses | NA | [62] |
| <i>Heracleum persicum</i> Desf. | Kolek, koolak, koolakpar, golpar, golspar | F, Le, R, Se | As appetizer, carminative, stomach tonic, vermifuge diuretic and sedative; to relieve dyspepsia, gastritis in children, headache (migraine), hiccup, flu, infection and skin diseases; also used to ease digestion and as mouthwash; culinary uses | Decoction, infusion, pickle/Oral, food flavoring | [5,12,32-34,40,67, 75,77-79] |
| <i>Hydrocotyl vulgaris</i> L. | Ab boshghabi-e mamuli | Wp | For cleansing blood and healing wounds and as diuretic and laxative | NA | [64] |

Moazzami Farida S.H. et al.

Table 1. Continued

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|---|--|-------------------|--|---|------------------------|
| <i>Kelussia odoratissima</i> Mozaff. | Bakhtyari karafs, keluss | Le, Wp | To relieve cough, rheumatic diseases, diabetes and dyspepsia; culinary uses | NA | [12,44,61-62] |
| <i>Lagoecia cuminoides</i> L. | Alaf-e kaaji, zireh-e vahshi | Ap | For diarrhea and gall stones | Infusion, raw/Oral | [29,36,52] |
| <i>Laser trilobum</i> (L.) Borkh. | NA | Le, Se | As carminative; ethnovetinary use | NA | [5] |
| <i>Levisticum officinale</i> W. D. J. Koch. | Karafs-e kuhi | Le, R, Se | To relieve asthma, diabetes and gastritis; as carminative, diaphoretic, diuretic, sedative, stimulant and heart tonic; to ease digestion, to induce sweating, to stimulate menstruation (amenorrhea) and to cure nervous disorders; culinary uses | Infusion/Oral, eaten as vegetable | [5,34,39,44,49] |
| <i>Oliveria decumbens</i> Vent. | Den, denak, la'le biaban, nuneh khoda | AP, In, Le, Se | To relieve thirst in children, dyspepsia, gastritis, gastrointestinal disorders and infection and as carminative; ethnovetinary use: to cure diarrhea in sheep and goats | Decoction/Oral, eaten as vegetable | [27-28,52,60,63] |
| <i>Opopanax hispidus</i> (Friv.) Griseb. | Alaf shir | In, Le, St | Against infection. | NA | [70] |
| <i>Petroselinum crispum</i> (Mill.) Fuss | Jafari, tokhm-e kalam (Parsley=Eng. Name) | Ap, Le, R, Se, Wp | As aphrodisiac, appetizer, carminative, expectorant, diuretic, spasmolytic and general tonic; to relieve low back pain, joint pain, menstrual pain, fever, diabetes, bladder disorders, dysuria, fatigue, gout, kidney problems and kidney stone; to increase lactation in nursing mothers and to stimulate menstruation (amenorrhea); culinary uses | Infusion, oil/Oral, topical | [31-34,38,41-42,44,59] |
| <i>Peucedanum officinale</i> L. | Bokhur ol ekrad | Not available | To relieve cough, kidney stones, meningitis, respiratory ulcers and as diuretic | NA | [60] |
| <i>Pimpinella anisum</i> L. | Anison (badian roomi), anisun, raz, vaveh shing | Le, Se | To relieve colic pain, bloating, common cold, cough headache (migraine), menstrual pain, gastritis, gastric reflex, nausea and infection; as diuretic, carminative, vermifuge and to increase lactation in nursing mothers; culinary uses | Decoction, hydrodistillation, infusion / Orally | [32-34,40,51,70] |
| <i>Prangos acaulis</i> (DC.) Bornm | Jashir-e kutooleh | Gu, St | As appetizer and against parasite infection; culinary uses | NA | [64] |
| <i>Prangos cheilanthifolia</i> Boiss. | Sakbinaj | Ap | As carminative | NA | [48] |
| <i>Prangos ferulacea</i> (L.) Lindl. | Bale har, ginu, javsheer, jhashir, jooshir, marzah | Ap, F, Le, Se, Sh | As carminative, diuretic, laxative and sedative; to relieve pain, dyspepsia, parasite infection and vomiting; it can cause abortion; ethnovetinary use: to remove lice and ticks in animals | Decoction/Orally | [43,60,62-63,70] |
| <i>Prangos uloptera</i> Dc. | Jashir-e sakhreh roui, kharkool | F, Le | As carminative, against infection and tonic | NA | [62,72] |
| <i>Psammogeton canescens</i> (DC.) Vatke | Shen jar | F, Le | Against infection; culinary uses | NA | [72] |

Ethnobotanical applications and their correspondence with phylogeny in Apiaceae-Apioideae

Table 1. Continued

| Scientific name | Local name | Parts used | Uses | Preparation / Administration | References |
|--|---|---------------|--|--|------------------|
| <i>Pyncocycla aucherana</i> Decne. Ex Boiss. | Sak dandan | Le, R | To relieve muscle pain, bad breath, to cure snake scorpion and insect bites and to remove urinary tract stones | Decoction, poultice, tooth brush/Oral | [29,51] |
| <i>Sanicula europaea</i> L. | Marhami | Not available | As stomach tonic and for wound healing | NA | [79] |
| <i>Scandix pecten-veneris</i> L. | Suzanak | Ap | For blood coagulation, body pains and palpitation | Decoction/Oral | [53] |
| <i>Scandix stellata</i> Banks & Soland | Badian-e kuhi | Wp | As stomach tonic | NA | [48] |
| <i>Smyrniium cordifolium</i> Boiss. | Andol, avandol, gonour, ovandol | Ap, R, Se | To relieve hypertension, parasite infection, prostate problems, urinary tract diseases and gynaeco-urinary disease; ethnoveterinary use: urinary retention in horse and mule | Decoction, infusion/Oral | [45,52,60] |
| <i>Thapsia garganica</i> L. | Safsia | Not available | To reduce appetite, as carminative and nerves tonic | NA | [60] |
| <i>Trachydium lehmanni</i> Benth. | Shaghaghi | R | To improve memory | NA | [32] |
| <i>Trachyspermum ammi</i> (L.) Sprague | Ajghu, keserk, zenian, zenyan (khordaneh) | F, R, Se | To relieve colic pain, common cold, gastric reflex, gastritis and nausea; as carminative and vermifuge and to increase lactation in nursing mothers; culinary uses | Hydrodistillation, decoction, raw/Oral | [33-35,37,42,55] |
| <i>Turgenia latifolia</i> Hoffm. | Dareh jouyi | Ap | For urinary tract problems | Infusion/Oral | [52] |
| <i>Zosima orientalis</i> Hoffm. | Karafs-e kuhi | Se | For digestive and nerve system disorders | NA | [34] |

Se: seed, Le: leaf, R: root, Ap: aerial part, St: stem, Gu: gum, La: latex, Wp: whole part, In: inflorescence, F: flower, Re: resin and Rh: rhizome. NA: not available

Generally, freshly collected plants or plant parts were used for treatment. Most commonly used plant parts were gum, aerial parts, seeds, and stems. Some of the commonly used ethnoveterinary medicines were the decoction of the leaves and flowers of *Ferula behboudiana* as appetizer while aerial parts of *Oliveria decumbens*, *Prangos ferulacea* (L.) Lindl. and *Smyrniium cordifolium* Boiss. were used for treatment of diarrhea, lice, and ticks in sheep and goats and urinary retention in horse and mule, respectively.

Phylogenetic pattern of ethnobotanical uses

Medicinal and culinary uses were overlapped on a genus level phylogenetic tree in Apiaceae-Apioideae [3]. Clusters of genera with medicinal uses have been shown in figure 6. This figure has shown potential groups of plants having medicinal properties based on the phylogenetic relation with known medicinal species. The rationale behind is that if a clade contained a number of medicinal species or genera, then it is very likely that other species or genera in that

clade might have similar medicinal properties as their relatives. As a result, it points out the species or genera with potential bioactivity for future research on drug discovery and bioprospecting. Some clustering of medicinal species could be seen on the tree in figure 6. Based on this figure, the potential medicinal plants for future bioprospecting could be grouped into two categories. The first category was species without any use record in genera that already contained useful species. For example, the genus *Eryngium* included 12 species in total, from which three already used medicinally and 2 culinary. The other seven members of this genus that do not have any use reports might have similar properties and bioactive compounds as their relative species in the genus. The species of the first category included plants in genera *Eryngium*, *Buplerum*, *Anthriscus*, *Scandix*, *Daucus*, *Dorema*, *Ferula*, *Heracleum*, *Zosima*, *Ducrosia*, *Peucedanum*, *Bunium*, *Pimpinella*, *Psammogeton*, *Opopanax*, *Pyncocycla*, *Echinophora*, *Bifora*, *Carum*, *Falcaria*, and *Prangos* (figure 6). The second category included

species in the genera where their sister groups in the same clade contained medicinal species. For example in the tribe *Ferulinae*, both *Ferula* and *Dorema* contained medicinal species.

Therefore there was a big chance that species of *Leutea* possessed similar properties and bioactive compounds (figure 6). The second category includes *Hohenackeria*, *Lecokia*, *Chaerophyllum*, *Leutea*, *Athamanta*, *Laserpitium*, *Orlaya*, *Polylophium*, *Malabalia*, *Pistinaca*, *Semenovia*,

Tetrataenium, *Tordylium*, *Trigonosciadium*, *Kalakia*, *Cymbocarpum*, *Elaeostica*, *Galagania*, *Hyalolaena*, *Muretia*, *Aphanopleura*, *Damavendia*, *Opsicarpium*, *Zeravschania*, *Smyrniopsis*, *Anisosciadium*, *Dicyclophora*, *Chamaesciadium*, *Fuernrohria*, *Gongylosciadium*, *Grammosciadium*, *Rhabdosciadium*, *Alococarpum*, *Azilia*, *Bilacunaria*, *Diplotaenia* and *Eriocycla*.

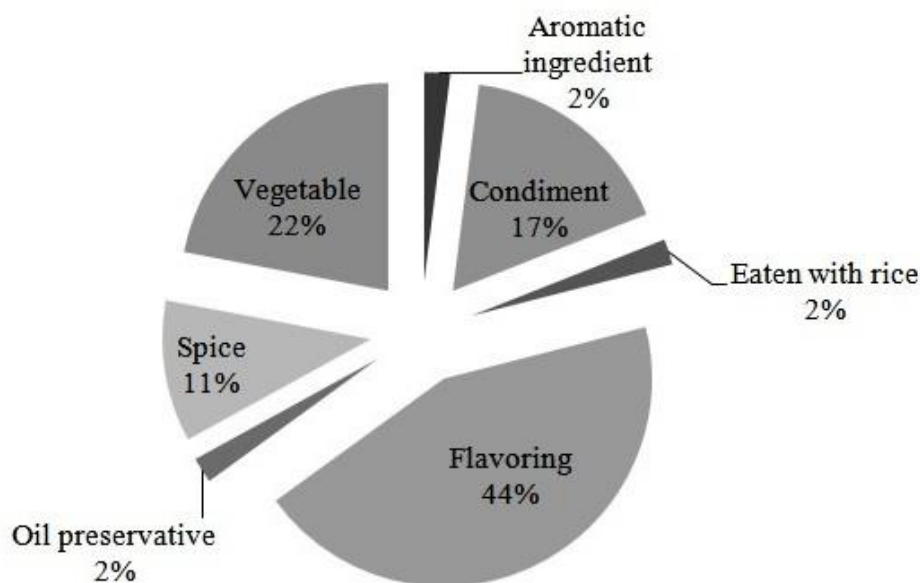


Figure 4. Proportion of different applications for culinary purpose in the Apiaceae family

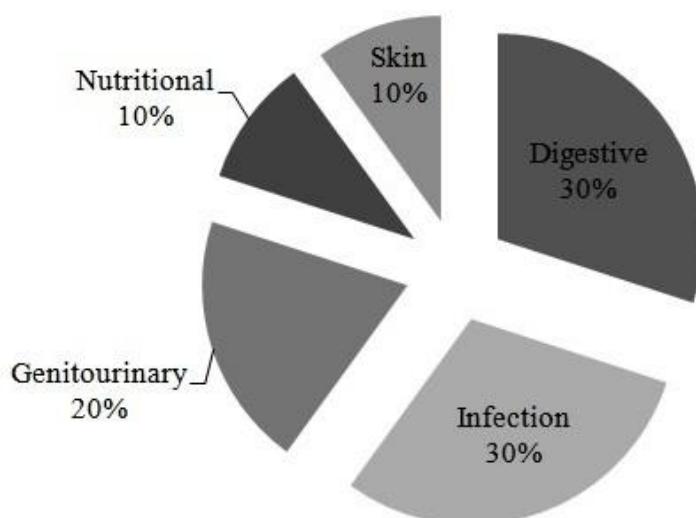


Figure 5. Percentage of ethnoveterinary use category

Ethnobotanical applications and their correspondence with phylogeny in Apiaceae-Apioideae

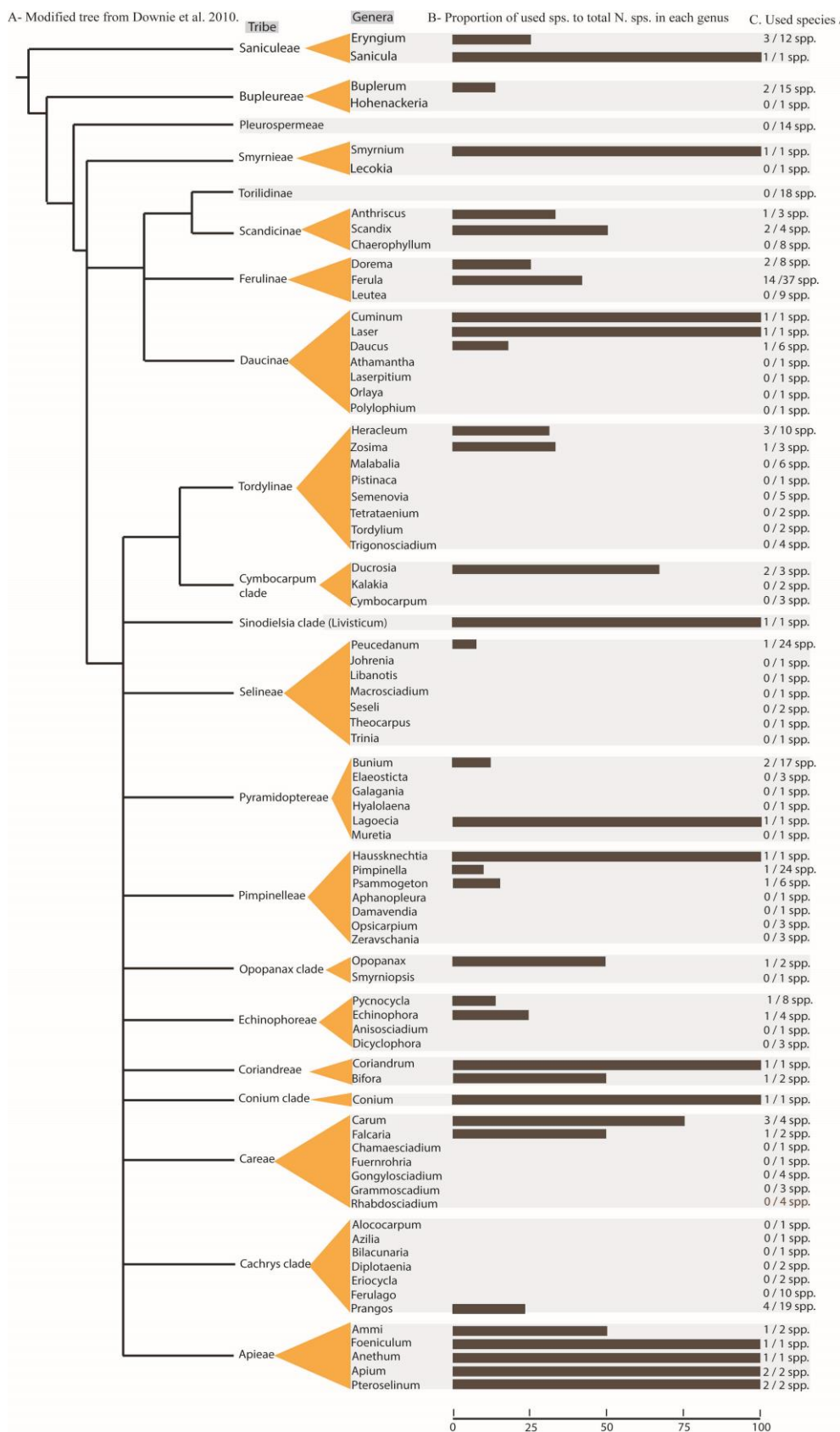


Figure 6. Distribution of medicinal species and their ration to the total number of species in each genus along the generic phylogenetic tree

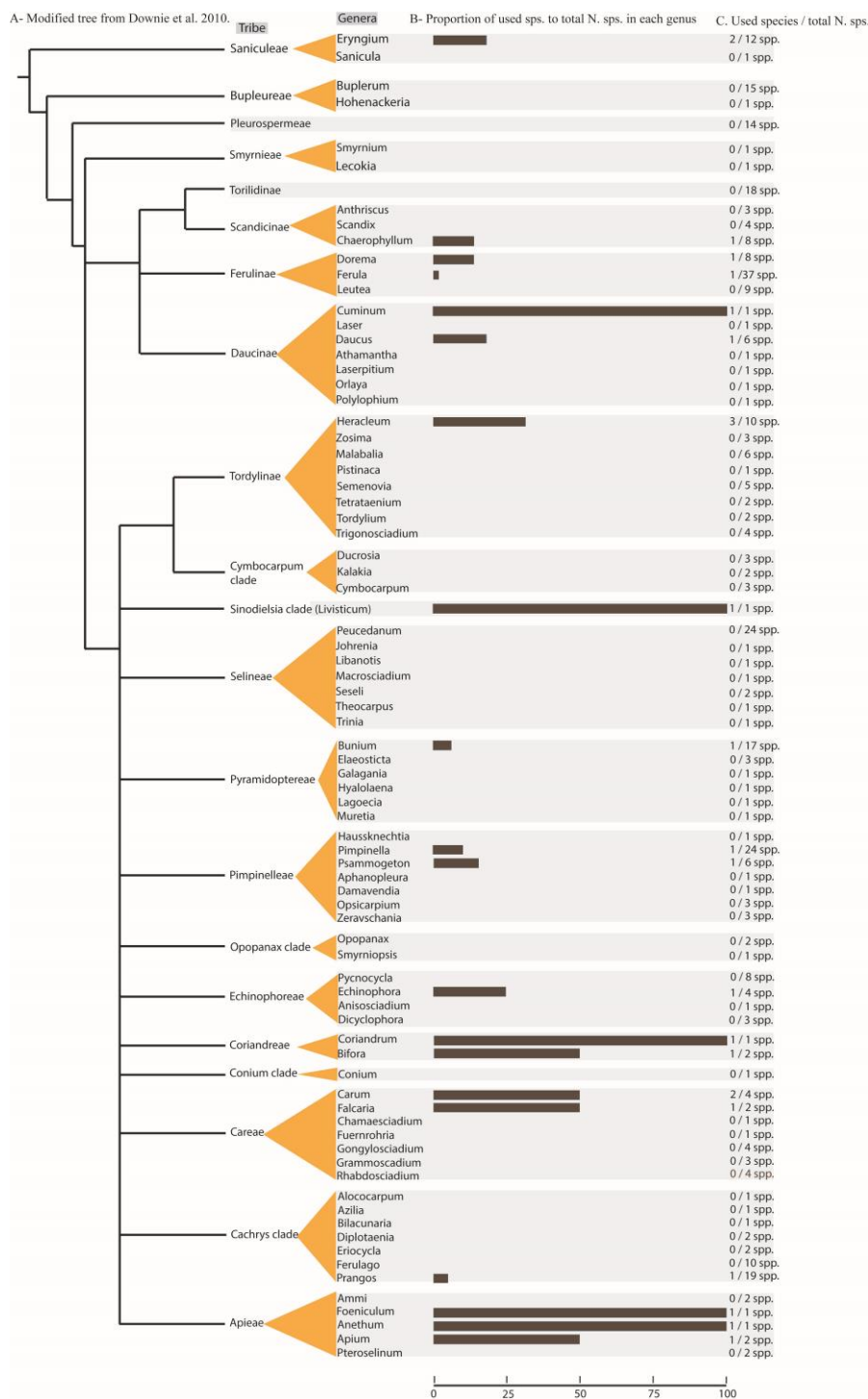


Figure 7. Distribution of culinary species and their ration to the total number of species in each genus along the generic phylogenetic tree

In some clades, the phylogenetic signal was very weak (*Selineae*, *Cachrys* clade, *Torilidinae*, *Pleuropermeae*) and only few members had medicinal uses but in some other clades such as *Apleae*, this signal seemed strong with many members being medicinally used. Other studies

have shown that there is a phylogenetic clustering pattern of plants with medicinal properties across different plant groups [18, 83-84].

Distribution of edible and culinary species along the phylogenetic tree seemed different from medicinal species (figure 7). Although the family

includes some of the oldest known edible species, they were distributed within few certain groups including *Apieae*, *Careae*, *Coriandreae*, *Sinodielsia* clade and *Daucinae*.

Conclusion

The current study gives an overview on the available ethnobotanical information of Apiaceae and detailed information on their uses. It shows that medicinal and culinary properties are not randomly distributed across the species in Apiaceae and they tend to be present in some phylogenetic pattern. It highlights the potential species groups of the family for further bioprospecting investigations; however, more rigorous phylogenetic analysis combining chemotaxonomy is necessary to pinpoint the exact lineages for specific medicinal application and properties.

Author contributions

Abdolbaset Ghorbani designed the study. Seyed Hamed Moazzami Farida and Abdolbaset Ghorbani conducted literature review. Seyed Hamed Moazzami Farida, Mohammad Sadr, and Abdolbaset Ghorbani conducted data analysis. Yousef Ajani and Valiollah Mozaffarian did the taxonomic review and nomenclature checks. Abdolbaset Ghorbani, Seyed Hamed Moazzami Farida, and Yousef Ajani drafted the manuscript.

Declaration of interest

The authors declare that there is no conflict of interest. The authors alone are responsible for the content of the paper.

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Abbreviations

None