

A SURVEY OF MEDICINAL PLANTS OF WADI AL-KOUF IN AL-JABAL AL-AKHDAR, LIBYA

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Al-Jabal Al-Akhdar (the Green Mountain) of Cyrenaica, Libya is known to have the highest plant species diversity in the country, particularly in the depressions and the valleys of the mountain. Wadi Al-Kouf is the largest valley in the mountain, with a rich flora of aromatic and medicinal plants. The present investigation was conducted to record and list the medicinal plant species growing in the valley during the flowering season of 2019. Results revealed that Wadi Al-Kouf hosts 107 medicinal plant species belonging to 49 families and 93 genera. Dicotyledons were the most represented group of angiospermae with 38 families, 79 genera and 89 species, whereas Monocotyledons were represented by only 8 families, 10 genera and 13 species. Asteraceae, Lamiaceae, Fabaceae and Solanaceae were the families with the highest number of species; 11, 9, 6 and 6 species, respectively. The most dominant life forms found in the valley were Therophytes (25.2%), Phanerophytes (25.2%) and Chamaephytes (24.3%), followed by Hemicryptophytes (15.9%) and Geophytes (9.3%). Nine endemic species were detected and recorded.

Keywords: Cyrenaica, endemic flora, ethnobotany, Libyan vegetation, medicinal plants, Mediterranean flora

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Al-Jabal Al-Akhdar (Zelena planina) u pokrajini Cirena u Libiji poznata je po najvećoj biljnoj raznolikosti u zemlji, osobito u udolinama i nizinama te planine. Wadi Al-Kouf je najveća udolina u planini, s bogatom florom koja se sastoji od aromatičnog i ljekovitog bilja. Cilj našeg istraživanja tijekom vegetacijske sezone 2019. bilo je zabilježiti i popisati ljekovito bilje koje raste u toj dolini. Rezultati su pokazali da u dolini Wadi Al-Kouf raste 107 vrsta ljekovitog bilja, iz 49 porodica, odnosno 93 roda. Najzastupljenije kritosjemenjače su dvosupnice, s 38 porodica, 79 rodova i 89 vrsta, dok su jednosupnice zastupljene sa samo 8 porodica, 10 rodova i 13 vrsta. Porodice s najviše zabilježenih vrsta bile su Asteraceae, Lamiaceae, Fabaceae i Solanaceae; redom 11, 9, 6 i 6 vrsta. Najdominantniji životni oblici u dolini bili su terofiti (25,2%), fanerofiti (25,2%) i hamefiti (24,3%), zatim hemikriptofiti (15,9%) i geofiti (9,3%). Zabilježeno je devet endemičnih vrsta.

Ključne riječi: Cirena, endemska flora, etnobotanika, vegetacija Libije, ljekovite biljke, mediteranska flora

INTRODUCTION

Medicinal plants are the foundation of herbal medicine, aromatherapy, homoeopathy and ayurvedic medicine. Herbal medicine is defined as the use of plant material or plant extract to cure illness, relieve pain or boost overall health (WHITE & FOSTER, 2000). To manufacture some conventional pharmaceuticals, certain chemical constitu-

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ents have to be extracted from medicinal plants. It is estimated that 35% of all prescription drugs are derived from plants. Cultures and civilizations all over the world have used herbal medicine for thousands of years. The earliest records of herbal medicine were found in China dating back to 2000 B.C. containing around 365 herbal formulas (LEWIS & ELVIN-LEWIS, 2003). The use of medicinal plants started to decline in the late 19th century when scientists managed to manufacture synthetic versions of the active ingredients of the medicinal herbs. However, with the growing dissatisfaction with the harmful side effects of modern synthetic medicines, attention to medicinal plants has been renewed and the benefits of using natural plant remedies have been rediscovered (EL-GADI, 1989).

Libyan culture, like every other culture in the world, relies to a certain extent on local medicinal plants to treat several kinds of illness. The inhabitants of the Green Mountain (Al-Jabal Al-Akhdar) of Cyrenaica, Libya have used the medicinal plants grown in the region for thousands of years and have, therefore, provided a rich heritage of folk herbal medicine which have survived through generations (EL-GADI & EL-MUGHRABI, 1999). The vegetation of Cyrenaica has long been investigated and a detailed description of the flora of Al-Jabal Al-Akhdar has been produced and published over the last three centuries (LEMAIRE, 1703; DELLA-CELLA, 1819; PACHO, 1827; BEECHEY & BEECHEY, 1828; PAMPANINI, 1931; SIMPSON & SANDWITH, 1941; BOULOS, 1972; BRULLO & FURNARI, 1979; EL-SHERIF & SINGH, 1996; EL-MOKASABI, 2014; ALAIB *et al.*, 2016; SAAED *et al.*, 2019). Due to their rich vegetation, the floristic composition of the valleys (Wadis) of Al-Jabal Al-Akhdar have lately been devoted special attention; for instance; Wadi Murqus (EL-SHERIF *et al.*, 1991); Wadi Al-Ashrha (ASKER, 1998); Wadi Zaza (EL-BARASI *et al.*, 2003); Wadi Al-Kouf (EL-MOKASABI, 2014); Wadi Belkaf (ALAIB *et al.*, 2016); Wadi Al-Agar (ALAIB *et al.*, 2017). However, little is known about the medicinal plants grown in the largest valley of Al-Jabal Al-Akhdar; Wadi Al-Kouf, as no thorough investigation has been carried out. The aim of this study, then, was to record and list the medicinal plant species growing in Wadi Al-Kouf and detect the endemic medicinal species characterizing the valley.

MATERIALS AND METHODS

The study area

Wadi Al-Kouf is a valley located in the Cyrenaica district, Eastern Libya, approximately 180 km north-east of Benghazi, Libya (Fig. 1). It covers the northern slopes and plateau of Al-Jabal Al-Akhdar. The valley extends from the north (the Mediterranean coastline where sand dunes and seasonal wetlands can be found) and gradually ascends to the south to reach an elevation of more than 800 m asl, with rocky low cliff formation characterizing the sides of the valley (BEN AMER & SHAKMAN, 2013). The study area lies between latitudes 32.5°N and 32.8°N and longitudes 21.4°E and 22.00°E, covering an area of 938 km².

Climate

A typical Mediterranean climate is predominant in the study area with an average annual rainfall exceeding 630 mm/yr. Al-Jabal Al-Akhdar is considered the wettest region of Libya receiving an average of (375 – 600 mm) of annual precipitation, which increasing with elevation and reaching an average of 1200 mm/yr (KAWASMA, 1979).

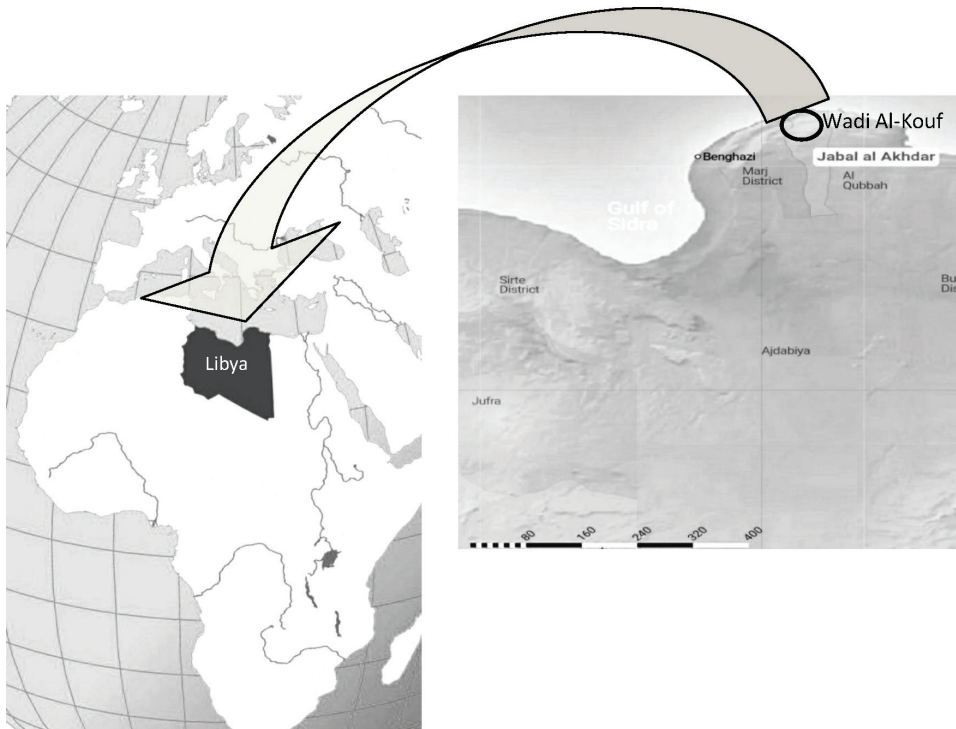


Fig. 1. Geographic position of Wadi Al-Kouf (Map adapted from Google Maps, <http://maps.google.com>).

Most of the rainfall occurs during the period from October to April, reaching the maximum in December and January (Fig. 2). The lowest average monthly temperature ranges between 4 C° in January and 16 C° in August, while the highest average monthly temperature ranges between 11.8 C° in January and 26.7 C° in August (Fig. 3). The relative humidity in the valley ranges between 49%–55% in the summer and 65%–75% in the winter. Soil varies at different locations and altitudes; red ferrisialitic carbonate saline clay and red ferrisialitic clay dominate the coastal plains. Rendzinas are found in the lower and middle terraces, with clay-clay loamy-loamy texture, rich in calcium carbonate. Lithic haploxeralfs were the most dominant, followed by Calcic haploxeralfs, Lithic calcixerolls and Typic calcixerolls (SELKHOZPROM EXPORT, 1980).

Specimen Collection and Identification

Medicinal plant samples were listed and collected during several field trips during the flowering season (March-April) in 2019. Specimens of the collected plant species were stored at the herbarium of the botany department, Faculty of Sciences, University of Benghazi, Libya. They were identified with the aid of the Libyan Flora Encyclopedia (Flora of Libya) (ALI & JAFRI, 1977; JAFRI & EL-GADI, 1986). Plant life forms were also classified into five life forms according to Raunkiaer's system (RAUNKIAER, 1934); Phanerophytes (Ph), Chamaephytes (Ch), Cryptophytes (C), Hemicryptophytes (H) and Therophytes (Th). Endemic plant species were also detected, recorded and identified. Photographs of all the recorded plant species were taken for documentation.

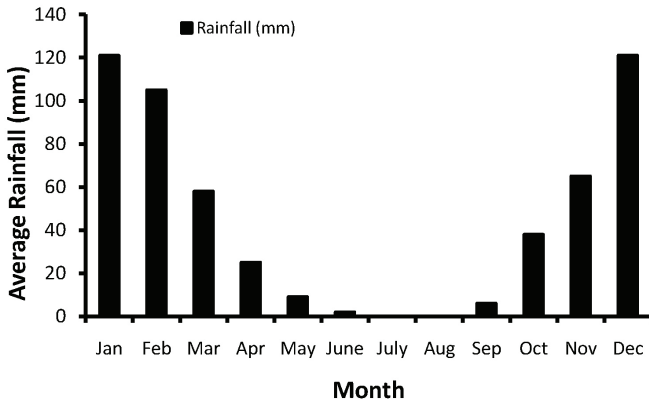


Fig. 2. Average monthly rainfall (mm) in Al-Jabal Al-Akhdar, Libya (Data obtained from www.en.climate-data.org).

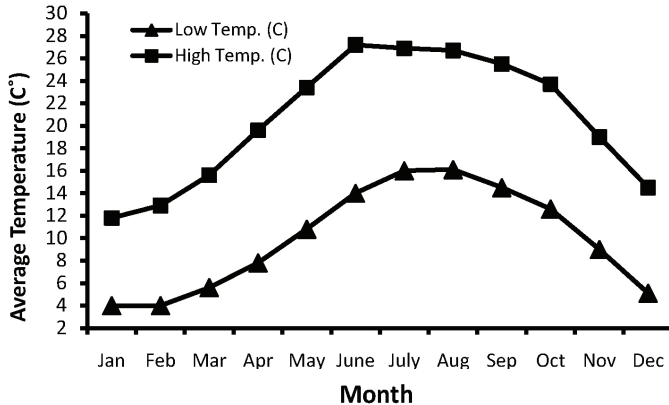


Fig. 3. Average minimum and maximum monthly temperature (C°) in Al-Jabal Al-Akhdar, Libya (Data obtained from www.en.climate-data.org).

RESULTS AND DISCUSSION

Findings of the present study showed the predominance of the Mediterranean flora as the valley was mainly composed of dense scrubland vegetation comprising shrubs and small trees that characterize the Mediterranean biome. Tab. 1 lists the medicinal plant species found in the valley, according to their families, their life-form, their active ingredients and medicinal uses. The results indicated the presence of a total of 107 medicinal plant species belonging to 49 families and 93 genera. Angiosperms composed the most dominant botanical group with 46 families, 89 genera and 102 species, whereas Gymnosperms were represented by only 3 families, 4 genera, and 5 species (Tab. 2). Dicotyledons were the most presented group of the angiosperms with 38 families, 79 genera and 89 species, whereas Monocotyledons comprised a far less diverse group of medicinal plants in the valley with only 8 families, 10 genera and 13 species.

Asteraceae attained the highest number of genera recorded in the study area with 10 genera and 11 species, followed by Lamiaceae with 9 genera and 9 species,

Fabaceae was represented by 5 genera and 6 species, whereas Solanaceae had the lowest number of genera, 5, and only 6 species (Tab. 1). Similar results have been reported in previous studies investigating the vegetation of Al-Jabal Al-Akhdar's valleys; Asteraceae was the most dominant family in Wadi Al-Ager, with 46 species (ALAIB *et al.*, 2017). It was also the largest family in the Sedy Boras region, represented by 130 species (ALZERBI & ALAIB, 2016) as well as in the Al-mansora region of Al-Jabal Al-Akhdar (ABUSAIEF & DAKHIL, 2013). Along with Poaceae, Asteraceae was found to dominate the valley of Wadi Belkaf with 18 species (ALAIB *et al.*, 2016). Generally, Asteraceae was recorded as the family with the highest number of endemic genera in Al-Jabal Al-Akhdar (EL-DARIER & MOGASPI, 2009). Overall, Asteraceae has been documented as the most dominant family in Libya representing 237 species (KEITH, 1965; FENG *et al.*, 2013).

Our results revealed that the most represented life-forms of the medicinal plants in the valley were Therophytes (Th) (25.2%), Phanerophytes (Ph) (25.2%), Chamaephytes (Ch) (24.3%), followed by Hemicryptophytes (H) (15.9%) and Geophytes (G) (9.3) (Tab. 1; Fig. 4). This biological spectrum is very similar to that of many areas located on the Mediterranean basin. As annuals complete their life-cycle in one single season, Therophytes, the most dominant life-form, are well adapted to the summer droughts and high temperatures that characterize the Mediterranean climate and account for approximately 50% of the floristic composition present in the biome (ARCHIBOLD, 1995). Similarly, EL-MOKASABI (2014) indicated that Therophytes were dominant (49%) in Wadi Al-Kouf. The same has been reported for the majority of the valleys investigated in Al-Jabal Al-Akhdar; Therophytes accounted for the highest percentage of contribution to the life form spectrum of medicinal plants across four valleys examined in Al-Jabal Al-Akhdar; Wadi Zaza, Wadi Al Ager, Wadi Jar jar Uma and Wadi Ras Al-Hilal, followed by Phanerophytes and Chamaephytes (MUKASSABI *et al.*, 2017). In the present study, like Therophytes, Phanerophytes were represented by an equivalent number of species with a percentage of 25.2 %; they were mostly dominated by ever-green sclerophyllous shrubs exhibiting the characteristic morphological features to withstand the dry summer conditions and prevent radiation damage. In similar findings, Phanerophytes were the most dominant representing 50% of the species found in Wadi Belkaf (ALAIB *et al.*, 2016). As they were represented by a percentage of 24.3, Chamaephytes were also considered dominant in this study. Most Chamaephytes of the Wadi Al-Kouf were low growing shrubs having buds and short

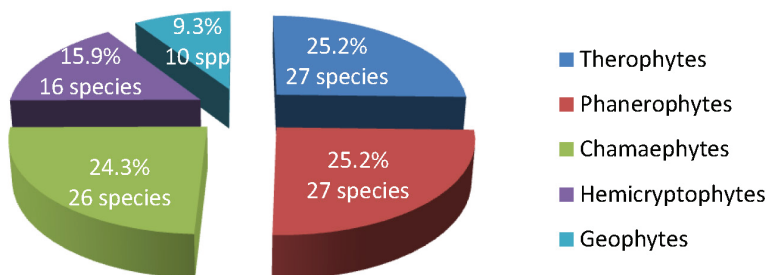


Fig. 4. Life-form spectrum of medicinal plants in Wadi Al-Kouf, Al-Jabal Al-Akhdar (categorized according to Raunkiaer's system; RAUNKIAER, 1934).

Tab. 1. List of medicinal plant species recorded in Wadi Al-Kouf, Al-Jabal Al-Akhdar in spring, 2019, arranged in alphabetical order of families, their life-form, their active ingredients and medicinal uses. Abbreviations used for plant life-forms are: (Ch) Chamaephyte, (G) Geophyte, (H) Hemipterophyte, Ph (Phanerophyte), Th (Therophyte).

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Adoxaceae	<i>Viburnum tinus</i> L.	Ph	Viburnin, tannins	Constipation, depression
Alliaceae	<i>Allium longatum</i> Pamp.	G	Alliin, alliin, ajoenes, quercetin	Antioxidant, anticarcinogenic, antibacterial, antifungal effects
	<i>Allium roseum</i> L.	G	Alliin, alliin, saponins	Respiratory infection, hypertension. Antioxidant, anticarcinogenic, antihyperlipidemic effects
Amaranthaceae	<i>Chenopodium murale</i> L.	Th	Cyanogenic glycosides, saponins, tannins	Fever
Amaryllidaceae	<i>Pancratium maritimum</i> L.	G	Flavonoids, alkaloids, tannins	Anticarcinogenic, antifungal effects
Anacardiaceae	<i>Pistacia lentiscus</i> L.	Ph	Oleic and linoleic acids, mastic resin	Ulcer, diarrhea. Antioxidant, anticarcinogenic, antimicrobial effects
	<i>Rhus tripartita</i> (Ucria) Grande	Ph	Flavonoids, proanthocyanidins	Stomach disorders, appetite stimulant. Antioxidant, antimicrobial effects
Apiaceae	<i>Anmmi majus</i> L.	Th	Flavonoids, coumarins	Ulcer. Antioxidant, antiviral effects
	<i>Conium maculatum</i> L.	H	Alkaloids, conine, flavone glycosides, essential oils	Dizziness, swollen glands, neurological disorders
	<i>Eryngium campestre</i> L.	H	Saponins, tannins, essential oils	Coughs, urinary infections
	<i>Thapsia garganica</i> L.	H	Essential oils, resins	Rheumatism
Apocynaceae	<i>Carallium europaea</i> (Guss.) N.E.Br.	Ch	Flavonoids, saponins, quercetin, myricetin	Diabetes. Anti-inflammatory, antioxidant effects
	<i>Nerium oleander</i> L.	Ph	Cardiac glycosides, flavone-glycosides	Cardiac conditions, angina, intestinal problems, eczema
	<i>Periploca angustifolia</i> Labill.	Ph	Flavonoids, quercetin, coumarin	Ulcer, diarrhea, diabetes. Anti-inflammatory effect
Araceae	<i>Arum cyrenicum</i> Hurby.	G	Essential oils	Diarrhea, diabetes. Anti-oxidant effect
Asparagaceae	<i>Asparagus aphyllus</i> L.	G	Rutin, diosgenin, saponins	Antioxidant, anti-inflammatory, antibacterial effects
	<i>Asparagus stipularis</i> Forssk.	Ph	Saponin, asparagalin	Liver disorder, stomachache, rheumatism

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Asteraceae	<i>Achillea santolina</i> L.	H	Alkaloids, flavonoids, sesquiterpene lactones, saponins, resin, tannins, essential oil	Diabetes, ulcer. Antioxidant, anti-inflammatory effects
	<i>Calendula suffruticosa</i> Vahl.	Ch	Flavonoids, triterpenoids, essential oils	Antiseptic, antimicrobial, anti-inflammatory effects
	<i>Carduus pycnocephalus</i> L. ssp <i>pycnocephalus</i> auct. non L.	Th	Lignans, flavonoids	Stomachache, cold, rheumatism. Anti-inflammatory effects
	<i>Cichorium endivia</i> L.	H	Choline, tannins, bitters, coumarins, triterpenoids	Stomach disorder, appetite stimulant
	<i>Cichorium spinosum</i> L.	Th	Phenolic acids, coumarins, flavonoids, triterpenoids, steroids	Diabetes. Anti-inflammatory, antioxidant, anticarcinogenic effects
	<i>Cynara cyrenatica</i> Maire & Weiller	Th	Carotenes, vit. A, iron, tannins	Anaemia, diabetes
	<i>Helichrysum stoechas</i> (L.) Moench	Ch	Essential oils	Kidney disorders, urinary tract infection. Anti-inflammatory effects
	<i>Matricaria aurea</i> (Loefl.) Sch. Bip.	Th	Flavonoids, coumarins, essential oils	Eczema, skin disorders, stomach disorders, urinary tract infections. Anti-inflammatory effects
	<i>Onopordum cyrenaicum</i> Maire & Weiller	Th	Unknown	Hepatitis. Antimicrobial effects
	<i>Phagnalon rupestre</i> (L.) DC.	Ch	Flavonoids, hydroquinones	Urinary tract infections, headache, asthma. Anti-allergic effects
	<i>Sonchus oleraceus</i> L.	Th	Vit. C, riboflavins, sterols, saponins	Liver disorders, diuretic
Boraginaceae	<i>Borago officinalis</i> L.	Th	Tannins, saponins, flavonoids, mucilage	Fever, dry cough, menstrual problems, eczema
Brassicaceae	<i>Lobularia litbyca</i> (Viv.) Meisner	Th	Glucosiniferin, glucoiberin, glucoerucin	Eczema. Antimicrobial effects
	<i>Matthiola fruticulosa</i> (L.) Maire.	Ch	Unknown	Diuretic, stimulant, expectorant, stomach disorders
Caesalpinaceae	<i>Cerantonía siliqua</i> L.	Ph	Tannins, pectin, mucilage, organic acids	Stomach disorders, diarrhoea, diuretic
Capparaceae	<i>Capparis spinosa</i> var. <i>kruegeriana</i> (Pamp.) Jafri	Ch	Pectic acid, capric acid, sugar	Stomach disorders

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Caprifoliaceae	<i>Lonicera etrusca</i> Santi.	Ph	Organic acids, flavonoids.	Upper respiratory infections, digestive disorders, skin infections, cold, flu
Caryophyllaceae	<i>Parnoychia arabica</i> (L.) DC.	Th	Essential oils	Antioxidant effects
Cistaceae	<i>Cistus incanus</i> L.	Ch	Galic acid, rutin, quercetin, kaempferol	Anti-inflammatory, antibacterial, antiallergic effects
	<i>Cistus parviflorus</i> Lam.	Ch	Terpenoids, flavonoids, alkaloids	Urinary tract infection, intestinal irritation, digestive problems, cold
	<i>Cistus salicifolius</i> L.	Ch	Flavonoids, alkaloids, terpenoids, resins	Eczema, skin diseases, rheumatism, cold. Antimicrobial, anti-inflammatory effects
Convolvulaceae	<i>Convolvulus arvensis</i> L.	H	Glycosides, tannins, flavonoids, saponins	Laxative, rheumatism
	<i>Cuscuta planiflora</i> Ten.	Th	Flavonoids, saponins, alkaloids, phenolics	Urinary tract infection, muscle pain, hepatic disorder, depression
Cucurbitaceae	<i>Echallium elaterium</i> (L.) A. Rich.	Ch	Cucurbitacins	Rheumatism, kidney complaints, sinusitis, headache. Anti-oxidant, anti-inflammatory effects. Hepatoprotective effect
Cupressaceae	<i>Cupressus sempervirens</i> L. var. <i>horizontalis</i> (Mill) Gord.	Ph	Tannins, essential oil	Coughs, asthma, varicose, haemorrhoids
Ephedraceae	<i>Juniperus phoenicea</i> L.	Ph	Tannins, essential oils, resins	Diarrhea, flatulence, bronchitis, rheumatism
	<i>Ephedra alata</i> Decne.	Ch	Ephedrine	Asthma, bronchitis, lung infections, kidney disorders
Ericaceae	<i>Ephedra altissima</i> Desf.	Ph	Ephedrine, pseudo-ephedrine	Asthma, bronchitis
	<i>Arbutus pavarii</i> Pamp.	Ph	Flavonoids, tannins, glycosides, triterpenes	Laxative, constipation, urinary tract infection
	<i>Erica multiflora</i> L.	Ph	Monoterpenes, flavonoids, coumarins, triterpenoids	Diuretic. Antiseptic, anti-inflammatory effects
Euphorbiaceae	<i>Euphorbia dendroides</i> L.	Ph	Phenolics, Flavonoids	Skin diseases. Antioxidant effects
	<i>Euphorbia peplus</i> L.	Th	Diterpene (ingenol mebutate)	Skin infections. Antipyretic effects
	<i>Ricinus communis</i> L.	Ph	Tannins, saponins, riboflavins, ricin, ricinoleic acid	Headache, constipation

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Fabaceae	<i>Calicotome spinosa</i> (L.) Link.	Ph	Flavonoids, polyphenols, saponins	Antioxidant, antimicrobial, antitumoral effects
	<i>Calicotome villosa</i> (Poiret.) Link.	Ph	Phenylethanoid, flavone glucoside	Anti-oxidant, antibacterial effects
	<i>Lotus tetragonolobus</i> L.	Th	Vit. C	Cough, diarrhea, diuretic. Anti-oxidant, anti-inflammatory effects
	<i>Melilotus sulcatus</i> Desf.	Th	Coumarin	Rheumatism, cardiac complications
Fagaceae	<i>Retama raetam</i> (Forssk) Webb & Berth	Ph	Spartine, ritamine	Allergic conditions, acne
	<i>Spartium junceum</i> L.	Ph	Triterpenic saponins	Diuretic, sedative. Antileishmanial activity
Geraniaceae	<i>Quercus coccifera</i> L.	Ph	Tannins	Coughs, diarrhea, hemorrhages
	<i>Gernium molle</i> L.	Th	Flavone, ellagitannins	Antioxidant, anticarcinogenic effects
Iridaceae	<i>Geranium robertianum</i> L.	Th	Tannins, bitters, essential oils	Toothache, gum infections
	<i>Moraea sisyrinchium</i> L.	G	Flavonoids, essential oils	Antioxidant, anticarcinogenic, antifungal, anti-inflammatory effects
Lamiaceae	<i>Ajuga reptans</i> (L.) Schreber	H	Ecdysterone, tannins	Stomach disorders, diarrhea, diabetes
	<i>Lavandula multifida</i> L.	Ch	Triterpenic acids, phenolic monoterpene, glucosides	Rheumatism, insomnia, migraine, acne, eczema
	<i>Marrubium vulgare</i> L.	H	Marrubiin, tannins, essential oils	Coughs, diabetes
	<i>Phlomis floccosa</i> (D.) Don.	Ch	Marrubiin, phenolics	Expectorant, bronchitis, diuretic, tonic
	<i>Rosmarinus officinalis</i> L.	Ch	Tannins, flavonoids, bitters, essential oil	Rheumatism, gout, throat infection. Antibacterial and antifungal effects
	<i>Salvia officinalis</i> L.	Ch	Tannins, flavonoids, terpenes, essential oil	Bloating, diarrhea, diabetes, diuretic, throat infection. Anti-inflammatory effects
	<i>Satureja thymbra</i> L.	H	Thymol, carvacrol, γ -terpinene, essential oils	Diarrhea. Antiseptic, antioxidant, antimicrobial effects
	<i>Teucrium polium</i> L.	Ch	Glycosides, essential oils	Hypertension, diabetes, kidney disorders
	<i>Thymus capitatus</i> (L.) Hoffmanns & Link	Ch	Thymol, carvacrol, resin, tannins	Throat infection, cough, stomach disorders, intestinal irritation
	Lauraceae	<i>Laurus nobilis</i> L.	Ph	Essential oils, bitters

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Liliaceae	<i>Asphodelus aestivus</i> Brot. <i>Asphodelus microcarpus</i> Salzm. & Viv.	H G	Flavonoids, phenolic acids, triterpenoids. Anthraquinones, terpenoids	Skin disorders, abscess. Antifungal, antioxidant, anti-parasitic effects Diarrhea. Antioxidant, antiprotozoal, antimicrobial effects
Malvaceae	<i>Urginea antumnalis</i> (L.) El-Gadi <i>Malva aegyptia</i> L.	G Th	Sallarín-A, sallarin-B, scillaroside, scillarubroside Anthocyanins, flavonoids, organic acids, essential oils	Cardiac conditions, cough, lung complaints, skin infection Cough, throat infection, laxative effects
Myrtaceae	<i>Malva sylvestris</i> L.	Th	Tannins, anthocyanins, mucilage	Cough, throat infection, intestinal irritation
Oleaceae	<i>Myrtus communis</i> L. <i>Olea europaea</i> L. subsp. <i>cuspidata</i> (Wall. ex G. Don) cif <i>Phillyrea angustifolia</i> L.	Ph Ph Ch	Cineol, myrtenol, terpenes, tannins, bitters Alkaloids, oleic acid, bitters, tannins, carotenes Unknown	Cough, bronchitis, tuberculosis, lung complaints Hypertension, constipation, gum infection, ear problems Hypertension, diuretic
Oxalidaceae	<i>Oxalis pes-caprae</i> L.	G	Oxalic acid, vit. C	Constipation
Papaveraceae	<i>Glaucium flavum</i> Crantz. <i>Fumaria judaica</i> Boiss. <i>Papaver rhoeas</i> L.	H Th Th	Alkaloid (Glaucine), protopine Alkaloids, flavonoids, saponins, terpenoids alkaloids	Coughs, ulcer. Antioxidant effects Diuretic, hypertension, rheumatism, skin rashes, anti-oxidant effects Sedative
Pinaceae	<i>Pinus halepensis</i> Mill	Ph	Terpenoids, flavonoids, phenolic acids, steroids	Diarrhea, hypertension, rheumatism. Antiseptic, antifungal, antiparasitic, anti-inflammatory effects
Plantaginaceae	<i>Globularia alybium</i> L.	Ch	Flavonoids	Skin diseases, abscesses, rheumatism. Anti-inflammatory, antibacterial effects
Plumbaginaceae	<i>Plantago cyrenaica</i> E.D. Durand. & Barratte. <i>Plantago major</i> L.	H H	Flavonoids, terpenoids, lipids, polysaccharides Tannins, aucubin, mucilage, vit. C	Digestive and respiratory disorders, skin disorders Ear infection, toothache
Poaceae	<i>Limonium pruinosum</i> (L.) O. Ktze. <i>Cynodon dactylon</i> (L.) Pers. <i>Dactylis glomerata</i> L.	Th H H	Essential oils, antioxidants Saponins, vit. C Unknown	Rheumatism, diuretic. Antioxidant, anti-inflammatory effects Urinary infections Anticarcinogenic effects

Family	Botanical name	Life-form	Active ingredients	Diseases treated and therapeutic effects
Polygonaceae	<i>Polygonum equisetiforme</i> Sibth & Sm.	H	Saponins, glycosides	Rheumatism, Diabetes
	<i>Polygonum maritimum</i> L.	H	Avicularin, gallic acid, polygonic acid, saponins	Kidney disorders, diarrhea, bleeding
Primulaceae	<i>Cyclamen rohlfsianum</i> Asch.	G	Phenolics, saponins, triterpenoids	Anti-inflammatory effects
Rhamnaceae	<i>Rhamnus lycioides</i> L.	Ph	Quercetin, flavonoids, anthraquinones, saccharides	Laxative (in small doses), rheumatism. Antioxidant effects
	<i>Ziziphus lotus</i> (L.) Lam.	Ch	Flavons, emodin	Stomach disorders, constipation
Rosaceae	<i>Sarcopoterium spinosum</i> (L.) Spacht.	Ch	Essential oils, elemol	Diabetes, kidney disorders
Scrophulariaceae	<i>Scrophularia canina</i> L.	Ch	Unknown	Fertility problems
Smilacaceae	<i>Smilax aspera</i> L.	G	Flavonoids, phenylpropanoids	Rheumatism, diabetes, diuretic. Antioxidant effects
Solanaceae	<i>Datura innoxia</i> Mill.	Th	Hyoscyne, hyoscyamine, atropine, meteloidine	Bleeding
	<i>Lycium europaeum</i> L.	Ch	Flavonoids, Vit. A, C, E	Antioxidant, anticancer agent. antihyperglycemic, antihyperlipidemic effects
	<i>Nicotiana glauca</i> R. C. Graham.	Ph	Rutin, anabasine	Bleeding
	<i>Solanum nigrum</i> L.	Th	Solasomine, solanine, solanidine, solamargine	Liver complaints, skin infection, constipation
	<i>Solanum sodomaeum</i> L.	Th	Essential oil, fatty acid (linoleic acid), alkaloids, tetrahydronaphthalene	Sore throat, skin rash and cancer, toothache, fertility
	<i>Withania somnifera</i> (L.) Dunal.	Ch	Unknown	Diuretic
Thymelaeaceae	<i>Thymelaea hirsuta</i> (L.) Endl.	Ph	Unknown	Gum infection, eye disease. Antimicrobial, antioxidant effects
Urticaceae	<i>Urtica pilulifera</i> L.	Th	Flavonoids, phenolic compounds, terpenes, sugars	Antidandruff, astringent, diuretic, depurative, blood purifier
Zygophyllaceae	<i>Egonia cretica</i> L.	Ch	Flavonoids, saponins, alkaloids, glycosides	Anticarcinogenic effects
	<i>Zygophyllum album</i> L.	Ch	Essential oils	Diabetes, rheumatism, asthma

Tab. 2. Number of families, genera and species for each botanical group, Angiospermae and Gymnospermae, recorded in Wadi Al-Kouf, Al-Jabal Al-Akhdar in spring, 2019.

Botanical group	Family	Genus	Species
Angiospermae	46	89	102
Gymnospermae	3	4	5
Total	49	93	107

apices close to the ground to be able to survive the unfavorable conditions. Perennials were abundant in the area as their total species number was 74 with a percentage reaching 74.7% of the total medicinal plants listed. Annuals were represented by 24 species (25.2%), whereas only 8 species were classified as biennials, representing 8.1% of the total plant species found in this study.

The findings of this study clearly indicated that Wadi Al-Kouf had a higher number of medicinal plant species than the adjacent valleys investigated in Al-Jabal Al-Akhdar such as Wadi Zaza, Wadi Al Ager, Wadi Jar jar Uma and Wadi Ras Al-Hilal, in which the total number of medicinal plant species recorded was 49, 36, 41 and 29, respectively (MUKASSABI *et al.*, 2017), whereas fewer medicinal plant species, only 17 of them, were found and listed in Wadi Belkaf (ALAIB *et al.*, 2016), 13 of which were recorded in the present study; *Asparagus aphyllus* L., *Ceratonia siliqua* L., *Cistus parviflorus* Lam., *Cistus salvifolius* L., *Cyclamen rohlfsianum* Asch., *Helichrysum stoechas* (L.) Moench, *Juniperus phoenicea* L., *Marrubium vulgare* L., *Plantago cyrenaica* E.D. Durand. & Barratte., *Quercus coccifera* L., *Rosmarinus officinalis* L., *Teucrium polium* L., *Thymus capitatus* (L.) Hoffmanns & Link. As Wadi Al-Kouf covers an area of approximately 938 km², it is considered the largest and the widest valley in Al-Jabal Al-Akhdar. It is, therefore, possible that it was the large size that increased the capacity of the valley to host rich and diverse flora. Certain abiotic factors such as temperature, moisture, and soil physical and chemical properties may have positively affected plant growth in the valley and contributed to the observed species richness and the highly diverse flora of medicinal plants characterizing Wadi Al-Kouf. However, such effects are still insufficiently comprehended and need to be thoroughly examined. It should be noted that several human activities pose serious threats to the vegetation of Al-Jabal Al-Akhdar, such as timber exploitation, land reclamation, urbanization, excessive grazing, hunting and touristic activities (EL-BARASI & SAAED, 2013). However, due to the steep slopes and hills surrounding the valley, many areas of Wadi Al-Kouf are naturally protected from grazing and other human activities as they are out of reach and hard of access. This naturally protective environment may have acted to improve growth conditions for a significant number of plant species, enabling them to survive, reproduce and maintain a complete life cycle in undisturbed environment, consequently, providing a highly diverse cover of flora in the valley. It is worth mentioning that, in the populated area of the valley, numerous medicinal plant species are extensively collected for their medicinal uses and economic values (EL-BARASI & SAAED, 2013). Information concerning the therapeutic effects and diseases treated by the medicinal plants were obtained from local people and owners of herb shops with the aid of references describing the usage of medicinal plants in Libya (EL-GADI, 1989; EL-GADI & BISHINA, 1992; EL-GADI & EL-MUGHRABI, 1999) (Tab. 1). Data revealed that the most frequently used medicinal plants were *Ceratonia siliqua* L., *Cynara cyrenaica* Maire & Weiller, *Helichrysum stoechas* (L.) Moench, *Matricaria aurea* (Loefl.) Sch. Bip.,

Tab. 3. List of the endemic medicinal plant species recorded in Wadi Al-Kouf, Al-Jabal Al-Akhdar in spring, 2019, arranged in alphabetical order of families.

	Species	Family
1	<i>Allium longanum</i> Pamp.	Alliaceae
2	<i>Arum cyrenaicum</i> Hurby.	Araceae
3	<i>Cynara cyrenaica</i> Maire. & Weiller.	Asteraceae
4	<i>Onopordum cyrenaicum</i> Maire. & Weiller.	Asteraceae
5	<i>Capparis spinosa</i> Linn. var. <i>krugeriana</i> (Pamp.) Gafri.	Capparaceae
6	<i>Cupressus sempervirens</i> L. var. <i>horizontalis</i> (Mill) Gord.	Cupressaceae
7	<i>Arbutus pavarii</i> Pamp.	Ericaceae
8	<i>Plantago cyrenaica</i> E.D. Durand. & Barratte.	Plantaginaceae
9	<i>Cyclamen rohlfsianum</i> Asch.	Primulaceae

Olea europaea L., *Rosmarinus officinalis* L., *Salvia officinalis* L., *Thymus capitatus* (L.) Hoffmanns & Link., *Ziziphus lotus* (L.) Lam. Available medicinal plants were commonly used for the treatment of digestive disorders (27.7%), respiratory system problems (16%), rheumatism (15%), skin infection (13.5%), diabetes (11.7%), cancer (8.5%), cold and flu (7.5%). There is an increasing concern that irresponsible resource exploitation may lead to vegetation deterioration threatening the existence of the medicinal plants in the valley.

In total, there are 134 endemic plant species in Libya (BEENTJE *et al.*, 1994). Due to its distinctive physiographic and climatic barriers, Al-Jabal Al-Akhdar represents an exceptional refuge for numerous endemic plant species (AL-SODANY *et al.*, 2003), as it is known to host most of the endemic species of the country (BOULOS, 1997), approximately 60% of Libya's endemic species (RADFORD *et al.*, 2011). In all, in Al-Jabal Al-Akhdar 59 endemic plant species have been recorded (QAISER & EL-GADI, 1984), 29 of them in Wadi Al-Kouf (EL-MOKASABI, 2014). Nine of the 107 medicinal plants listed in the present study were classified as endemic species (Tab. 3). Five of the 9 reported endemic medicinal plants; *Allium longanum* Pamp., *Arbutus pavarii* Pamp., *Arum cyrenaicum* Hurby, *Cyclamen rohlfsianum* Asch., *Onopordum cyrenaicum* Marie & Weiller were also found in the neighboring Wadi Al-Ager and listed as endemic species along with an additional 13 species (ALAIIB *et al.* 2017). Similarly, the five endemic species recorded in Wadi Belkaf (ALAIIB *et al.*, 2016) were also found and listed in this study; *Allium longanum* Pamp., *Arbutus pavarii* Pamp., *Arum cyrenaicum* Hurby., *Cyclamen rohlfsianum* Asch., *Plantago cyrenaica* E.D. Durand. & Barratte.

Two of the endemic medicinal plants listed in the present study, *Arbutus pavarii* Pamp. and *Cupressus sempervirens* L. var. *horizontalis* (Mill) Gord., were classified by the Libyan conservation program as endangered species (EL-BARASI & SAAED, 2013; MOSALLAM *et al.*, 2017). Based on its current observation status, *Arbutus pavarii* (Fig. 5) has also been placed in the Red List by the International Union for Conservation of Nature (IUCN, 2021) as vulnerable and threatened with global extinction (IUCN, 1998), whereas *Cupressus sempervirens* L. was categorized as (Least Concern) (FARJON, 2013). Several regulations and laws regarding management of natural resource and conservation of natural vegetation have been passed and issued by the Libyan authorities in the past four decades; however, they have not been properly implemented. For instance; Al-Kouf National Park was one of the early conservation projects in Libya (BEN AMER & SHAKMAN, 2013). This natural reserve was established in



Fig. 5. *Arbutus pavarii* Pamp. Al-Jabal Al-Akhdar, Libya. Photograph by M. Al-Traboulsi, 2020.

1979 to conserve biodiversity and provide protection for natural flora and fauna living in a protected area of approximately 9000 ha of the valley. Unfortunately, most of the conservation attempts have had a little effect on preserving the site and failed to monitor human activities, the main cause of vegetation disturbance, within the boundaries of the valley.

Based on the findings of the present study, it can be concluded that Wadi Al-Kouf has a higher medicinal plant species richness than neighbouring valleys in Al-Jabal Al-Akhdar. However, given the fact that two of the endemic medicinal plants have been designated endangered species, there is a growing concern that they may become extinct in the near future as they are not yet protected. Therefore, immediate measures should be taken to activate the conservation programs designed to preserve the unique species diversity of Wadi Al-Kouf and provide protection for medicinal, rare and endemic species. The conservation efforts should also involve the local community living in the valley. Human activities should be regulated, not only by legal regulations, but also by increasing the inhabitants' awareness of the value of the endemic medicinal plants and the destructive impact of biodiversity loss on the region. Frequent documentation of the natural vegetation, particularly, medicinal and endemic plants, is strongly recommended.

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