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

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-
ents have to be extracted from medicinal plants. It is estimated that 35% of all pre-
scription 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 dissatisfac-
tion with the harmful side effects of modern synthetic medicines, attention to medi-
cinal 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 herit-
age 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 pub-
lished 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; Alaub et
al., 2016; Saed 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
(Alaub et al., 2016); Wadi Al-Agar (Alaub 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, approxi-
mately 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 Mediterra-
nean 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 & Shorman, 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).
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 Cº in January and 16 Cº in August, while the highest average monthly temperature ranges between 11.8 Cº in January and 26.7 Cº 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), Cryptrophytes (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.
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 & Dakhl, 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 & Megaspi, 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).](image-url)
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 lifeform, their active ingredients and medicinal uses. Abbreviations used for plant life-forms are: (Ch) Chamaephyte, (G) Geophyte, (H) Hemicryptophyte, Ph (Phanerophyte), Th (Therophyte).

| Family               | Botanical name               | Life-form | Active ingredients                                      | Diseases treated and therapeutic effects                                      |
|----------------------|------------------------------|-----------|--------------------------------------------------------|--------------------------------------------------------------------------------|
| Adoxaceae            | Viburnum tinus L.            | Ph        | Viburnin, tannins                                      | Constipation, depression                                                       |
| Alliaceae            | Allium longanum Pamp.        | G         | Alliin, allicin, ajoenes, quercetin                     | Antioxidant, anticarcinogenic, antibacterial, antifungal effects                |
|                      | Allium roseum L.             | G         | Alliin, allicin, saponins                               | Respiratory infection, hypertension. Antioxidant, anticarcinogenic, antihyperlipidemic effects |
| Amaranthaceae        | Chenopodium murale L.        | Th        | Cyanogenic glycosides, saponins, tannins                | Fever                                                                         |
| Amaryllidaceae       | Pancratium maritimum L.      | G         | Flavonoids, alkaloids, tannins                         | Anticarcinogenic, antifungal effects                                           |
| Anacardiaceae        | Pistacia lentiscus L.        | Ph        | Oleic and linoleic acids, mastic resin                 | Ulcer, diarrhea. Antioxidant, anticarcinogenic, antimicrobial effects           |
|                      | Rhus tripartita (Ucria) Grande | Ph       | Flavonoids, proanthocyanidins                         | Stomach disorders, appetite stimulant. Antioxidant, antimicrobial effects      |
| Apiaceae             | Ammi majus L.                | Th        | Flavonoids, courmarins                                 | Ulcer. Antioxidant, antiviral effects                                           |
|                      | Conium maculatum L.          | H         | Alkaloids, onoine, flavone glycosides, essential oils  | Dizziness, swollen glands, neurological disorders                               |
|                      | Eryngium campestre L.        | H         | Saponins, tannins, essential oils                      | Coughs, urinary infections                                                     |
|                      | Thapsia garganica L.         | H         | Essential oils, resins                                 | Rheumatism                                                                     |
| Apocynaceae          | Caralluma europaea (Guss.) N.E.Br. | Ch      | Flavonoids, saponins, quercetin, myricetin             | Diabetes. Anti-inflammatory, antioxidant effects                               |
|                      | Nerium oleander L.           | Ph        | Cardiac glycosides, flavone-glycosides                 | Cardiac conditions, angina, intestinal problems, eczema                         |
|                      | Periploca angustifolia Labill. | Ph       | Flavonoids, quercetin, coumarin                        | Ulcer, diarrhea, diabetes. Anti-inflammatory effect                             |
| Araceae              | Arum cyrenacum Hurby.        | G         | Essential oils                                         | Diarrhea, diabetes. Anti-oxidant effect                                        |
| Asparagaceae         | Asparagus aphyllus L.         | G         | Rutin, diosgenin, saponins                             | Antioxidant, anti-inflammatory, antibacterial effects                          |
|                      | Asparagus stipularis Forssk. | Ph        | Saponin, asparagalin                                  | Liver disorder, stomachache, rheumatism                                       |
| Family              | Botanical name                          | Life-form | Active ingredients                                                                 | Diseases treated and therapeutic effects                                                                 |
|---------------------|----------------------------------------|-----------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Asteraceae          | *Achillea santolina* L.                | H         | Alkaloids, falvonoids, sesquiterpene lactones, saponins, resin, tannins, essential oil | Diabetes, ulcer. Antioxidant, anti-inflammatory effects                                                  |
|                     | *Calendula suffruticosa* Vahl.         | Ch        | Flavonoids, triterpenoids, essential oils                                         | Antiseptic, antimicrobial, anti-inflammatory effects                                                    |
|                     | *Carduus pycnocephalus* L. ssp pycnocephalus auct. non L. | Th        | Lignans, flavonoids                                                              | Stomachache, cold, rheumatism. Anti-inflammatory effects                                               |
|                     | *Cichorium endivia* L.                 | H         | Choline, tannins, bitters, coumarins, triterpenoids                              | Stomach disorder, appetite stimulant                                                                    |
|                     | *Cichorium spinosum* L.                | Th        | Phenolic acids, coumarins, flavonoids, triterpenoids, steroids                   | Diabetes. Anti-inflammatory, antioxidant, anticarcinogenic effects                                        |
|                     | *Cynara cyrenaica* Maire & Weiller    | Th        | Carotenes, vit. A., iron, tannins                                              | Anaemia, diabetes                                                                                       |
|                     | *Helichrysum stoechas* (L.) Moench     | Ch        | Essential oils                                                                   | Kidney disorders, urinary tract infection. Anti-inflammatory effects                                      |
|                     | *Matricaria aurea* (Loefl.) Sch. Bip.  | Th        | Flavonoids, coumarins, essential oils                                           | Eczema, skin disorders, stomach disorders, urinary tract infections. Anti-inflammatory effects          |
|                     | *Onopordum cyrasticum* Maire & Weiller | Th        | Unknown                                                                          | Hepatitis. Antimicrobial effects                                                                      |
|                     | *Phagnalon rupestre* (L.) DC.          | Ch        | Flavonoids, hydroquinones                                                       | Urinary tract infections, headache, asthma. Anti-allergic effects                                         |
|                     | *Sonchus deraceus* L.                  | Th        | Vit. C, riboflavins, sterols, saponins                                           | Liver disorders, diuretic                                                                               |
| Boraginaceae        | *Borago officinalis* L.                | Th        | Tannins, saponins, flavonoids, mucilage                                          | Fever, dry cough, menstrual problems, eczema                                                            |
| Brassicaceae        | *Lobularia libya* (Viv.) Meisner       | Th        | Gucoiberverin, glucoiberin, glucoerucin                                          | Eczema. Antimicrobial effects                                                                            |
|                     | *Matthiola fruticulosa* (L.) Maire.    | Ch        | Unknown                                                                          | Diuretic, stimulant, expectorant, stomach disorders                                                  |
| Caesalpiniaceae     | *Ceratonia siliqua* L.                 | Ph        | Tannins, pectin, mucilage, organic acids                                       | Stomach disorders, diarrhea, diuretic                                                                    |
| Capparaceae         | *Capparis spinosa* var. *kruegeriana* (Pamp.) Jafri | Ch        | Pectic acid, capric acid, sugar                                                 | Stomach disorders                                                                                        |
| Family           | Botanical name                        | Life-form | Active ingredients                           | Diseases treated and therapeutic effects                                              |
|------------------|---------------------------------------|-----------|----------------------------------------------|---------------------------------------------------------------------------------------|
| Caprifoliaceae   | *Lonicera etrusca* Santi.              | Ph        | Organic acids, flavonoids.                   | Upper respiratory infections, digestive disorders, skin infections, cold, flu          |
| Caryophyllaceae  | *Parnoychia arabica* (L.) DC.          | Th        | Essential oils                               | Antioxidant effects                                                                   |
| Cistaceae        | *Cistus incanus* L.                    | Ch        | Gallic acid, rutin, quercetin, kaempferol    | Anti-inflammatory, antibacterial, antiallergic effects                                 |
|                  | *Cistus parviflorus* Lam.              | Ch        | Terpenoids, flavonoids, alkaloids            | Urinary tract infection, intestinal irritation, digestive problems, cold              |
|                  | *Cistus salviifolius* L.               | Ch        | Flavonoids, alkaloids, terpenoids, resins    | Eczema, skin diseases, rheumatism, cold. Antimicrobial, anti-inflammatory effects      |
| Convolvulaceae   | *Convovulus arvensis* L.               | H         | Glycosides, tannins, flavonoids, saponins    | Laxative, rheumatism                                                                  |
|                  | *Cuscuta planiflora* Ten.              | Th        | Flavonoids, saponins, alkaloids, phenolics    | Urinary tract infection, muscle pain, hepatic disorder, depression                    |
| Cucurbitaceae    | *Ecballium elaterium* (L.) A. Rich.    | Ch        | Cucurbitacins                                | Rheumatism, kidney complaints, sinusitis, headache. Anti-oxidant, anti-inflammatory effects |
| Cupressaceae     | *Cupressus sempervirens* var. *horizontalis* (Mill) Gord. *Juniperus phoenicea* L. | Ph        | Tannins, essential oil                       | Coughs, asthma, varicose, haemorrhoids                                               |
|                  |                                       | Ph        | Tannins, essential oils, resins              | Diarrhea, flatulence, bronchitis, rheumatism                                          |
| Ephedraceae      | *Ephedra alata* Decne.                 | Ch        | Ephedrine                                    | Asthma, bronchitis, lung infections, kidney disorders                                 |
|                  | *Ephedra altissima* Desf.              | Ph        | Ephedrine, pseudo-ephedrine                 | Asthma, bronchitis                                                                     |
| Ericaceae        | *Arbutus pavonii* Pamp.                | Ph        | Flavonoids, tannins, glycosides, triterpenes | Laxative, constipation, urinary tract infection                                       |
|                  | *Erica multiflora* L.                  | Ph        | Monoterpenes, flavonoids, coumarins, triterpenoids | Diuretic. Antiseptic, anti-inflammatory effects                                      |
| Euphorbiaceae    | *Euphorbia dendroides* L.              | Ph        | Phenolics, Flavonoids                        | Skin diseases. Antioxidant effects                                                   |
|                  | *Euphorbia peplus* L.                  | Th        | Diterpene (ingenol mebutate)                | Skin infections. Antipyretic effects                                                  |
|                  | *Ricinus communis* L.                  | Ph        | Tannins, saponins, riboflavins, ricin, ricinoic acid | Headache, constipation                                                               |
| Family     | Botanical name                  | Life-form | Active ingredients                                          | Diseases treated and therapeutic effects                                      |
|------------|---------------------------------|-----------|-------------------------------------------------------------|-------------------------------------------------------------------------------|
| Fabaceae   | Calicotome spinosa (L.) Link.    | Ph        | Flavonoids, polyphenols, saponins                           | Antioxidant, antimicrobial, antitumoral effects                                 |
|            | Calicotome villosa (Poiret.)    | Ph        | Phenylethanoid, flavone glucoside                           | Anti-oxidant, antibacterial effects                                           |
|            | Link.                           |           |                                                             |                                                                                |
|            | Lotus tetragonolobus L.         | Th        | Vit. C                                                      | Cough, diarrhea, diuretic. Anti-oxidant, anti-inflammatory effects             |
|            | Melilotus sulcatus Desf.        | Th        | Coumarin                                                    | Rheumatism, cardiac complications                                             |
|            | Retama raetam (Forssk)          | Ph        | Spartine, ritamine                                          | Allergic conditions, acne                                                      |
|            | Webb & Berth                    |           |                                                             |                                                                                |
|            | Spartium junceum L.             | Ph        | Triterpenic saponins                                        | Diuretic, sedative, Antiileishmanial activity                                 |
|            |                                 |           |                                                             |                                                                                |
|            | Quercus coccifera L.            | Ph        | Tannins                                                    | Coughs, diarrhea, hemorrhages                                                  |
|           | Geraniaceae                     |           |                                                             |                                                                                |
|            | Geranium molle L.               | Th        | Flavone, ellagitannins                                      | Antioxidant, anticarcinogenic effects                                          |
|            | Geranium robertianum L.         | Th        | Tannins, bitters, essential oils                            | Toothache, gum infections                                                     |
|           | Iridaceae                       |           |                                                             |                                                                                |
|            | Moraea sisyrinchium L.          | G         | Flavonoids, essential oils                                 | Antioxidant, anticarcinogenic, antifungal, anti-inflammatory effects            |
|           | Lamiaceae                       |           |                                                             |                                                                                |
|            | Ajuga iva (L.) Schreber          | H         | Ecdysterone, tannins                                       | Stomach disorders, diarrhea, diabetes                                          |
|            | Lavandula multifida L.          | Ch        | Triterpenic acids, phenolic monoterpene, glucosides        | Rheumatism, insomnia, migraine, acne, eczema                                   |
|            | Marrubium vulgare L.            | H         | Marrubiin, tannins, essential oils                         | Coughs, diabetes                                                             |
|            | Phlomis floccosa (D.) Don.       | Ch        | Marrubiin, phenolics                                       | Expectorant, bronchitis, diuretic, tonic                                      |
|            | Rosmarinus officinalis L.       | Ch        | Tannins, flavonoids, bitter, essential oil                 | Rheumatism, gout, throat infection. Antibacterial and antifungal effects      |
|            | Salvia officinalis L.           | Ch        | Tannins, flavonoids, terpenes, essential oil               | Bloating, diarrhea, diabetes, diuretic, throat infection. Anti-inflammatory     |
|            | Satureja thymbra L.             | H         | Thymol, carvacrol, y-terpinene, essential oil              | Diarrhea. Antiseptic, antioxidant, antimicrobial effects                      |
|            | Teucrium polium L.              | Ch        | Glycosides, essential oils                                | Hypertension, diabetes, kidney disorders                                       |
|            | Thymus capitatus (L.) Hoffmanns & Link | Ch | Thymol, carvacrol, resin, tannins | Throat infection, cough, stomach disorders, intestinal irritation              |
|           | Lauraceae                       |           |                                                             |                                                                                |
|            | Laurus nobilis L.               | Ph        | Essential oils, bitters                                   | Sores, sprains, muscle pain                                                   |
| Family       | Botanical name                        | Life-form | Active ingredients                                                                 | Diseases treated and therapeutic effects                                                                 |
|-------------|---------------------------------------|-----------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Liliaceae   | *Asphodelus aestivus* Brot.            | H         | Flavonoids, phenolic acids, triterpenoids.                                         | Skin disorders, abscess. Antifungal, antioxidant, anti-parasitic effects                                      |
|             | *Asphodelus microcarpus* Salzm. & Viv. | G         | Anthraquinones, terpenoids                                                        | Diarrhea. Antioxidant, antiprotozoal, antimicrobial effects                                               |
|             | *Urginea autumnalis* (L.) El-Gadi      | G         | Sallarín-A, sallarín-B, scillaroside, scillarubroside                             | Cardiac conditions, cough, lung complaints, skin infection                                                |
| Malvaceae   | *Malva aegyptia* L.                    | Th        | Anthocyanins, flavonoids, organic acids, essential oils                            | Cough, throat infection, laxative effects                                                                 |
|             | *Malva sylvestris* L.                  | Th        | Tannins, anthocyanins, mucilage                                                    | Cough, throat infection, intestinal irritation                                                            |
| Myrtaceae   | *Myrtus communis* L.                   | Ph        | Cineol, myrtenol, terpenes, tannins, bitters                                      | Cough, bronchitis, tuberculosis, lung complaints                                                          |
| Oleaceae    | *Olea europaea* L. subsp. *cuspidea* (Wall. ex G. Don) cif | Ph | Alkaloids, oleic acid, bitters, tannins, carotenes                                | Hypertension, constipation, gum infection, ear problems                                                  |
|             | *Phillyrea angustifolia* L.            | Ch        | Unknown                                                                            | Hypertension, diuretic                                                                                   |
| Oxalidaceae | *Oxalis pes-caprae* L.                 | G         | Oxalic acid, vit. C                                                                | Constipation                                                                                             |
| Papaveraceae| *Glaucoma flavum* Crantz.              | H         | Alkaloid (Glaucine), protopine                                                     | Coughs, ulcer. Antioxidant effects                                                                       |
|             | *Fumaria judaica* Boiss.               | Th        | Alkaloids, flavonoids, saponins, terpenoids                                       | Diuretic, hypertension, rheumatism, skin rashes. anti-oxidant effects                                      |
|             | *Papaver rhoas* L.                    | Th        | Alkaloids                                                                          | Sedative                                                                                                 |
| Pinaceae    | *Pinus halepensis* Mill                | Ph        | Terpenoids, flavonoids, phenolic acids, steroids                                  | Diarrhea, hypertension, rheumatism. Antiseptic, antifungal, antiparasitic, anti-inflammatory effects      |
| Plantaginaceae | *Globularia alybum* L.               | Ch        | Flavonoids                                                                         | Skin diseases, abscesses, rheumatism. Anti-inflammatory, antibacterial effects                           |
|             | *Plantago cretica* E.D. Durand. & Barratte. | H      | Flavonoids, terpenoids, lipids, polysaccharides                                   | Digestive and respiratory disorders, skin disorders                                                      |
|             | *Plantago major* L.                   | H         | Tannins, aucubin, mucilage, vit. C                                                 | Ear infection, toothache                                                                                  |
| Plumbaginaceae | *Linonion prünosum* (L.) O. Ktze.     | Th        | Essential oils, antioxidants                                                       | Rheumatism, diuretic. Antioxidant, anti-inflammatory effects                                            |
| Poaceae     | *Cynodon dactylon* (L.) Pers.          | H         | Saponins, vit. C                                                                  | Urinary infections                                                                                        |
|             | *Dactylis glomerata* L.               | H         | Unknown                                                                            | Anticarcinogenic effects                                                                                  |
| Family          | Botanical name                                                                 | Active ingredients                                      | Diseases treated and therapeutic effects               |
|----------------|--------------------------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------|
| Polygonaceae   | *Polygonum cuspidatum* Sibth. & Sm.                                              | Saponins, glycosides                                     | Rheumatism, Diabetes                                  |
|                | *Polygonum maritimum* L.                                                        | Phenolics, saponins, triterpenoids                       | Anti-inflammatory effects                              |
| Primulaceae    | *Cyclamen hederifolium* L.                                                      | Phloroglucinol, flavonoids                               | Kidney disorders, diarrhea, bleeding                  |
|                | *Rhamnus catharticus* L.                                                        | Quercetin, flavonoids, anthraquinones, saponins          | Laxative (in small doses), rheumatism, Antiinflammatory effects |
| Rhamnaceae     | *Ziziphus lotus* (L.) Lam.                                                       | Flavonoids, emodin                                       | Stomach disorders, constipation                        |
|                | *Ziziphus spinosa* (L.) var.                                               | *Sarcopoterium spinosum* (L.)                           | Diabetes, kidney disorders                             |
| Rosaceae       | *Safflower* L.                                                                  | Essential oils, elemol                                   | Fertility problems                                    |
| Scrophulariaceae| *Scrophularia canina* L.                                                        | *Saponaria officinalis* (L.)                            | Rheumatism, diabetes, diuretic, anticancer agent       |
|                | *Smilax aspera* L.                                                              | *Smilax aspera* L.                                       | Antioxidant effects                                   |
| Solanaceae     | *Datura innoxia* Mill.                                                          | Hyoscine, hyoscyamine, atropine, meteloidine            | Diabetes, kidney disorders, Anticancer agent          |
|                | *Nicotiana glauca* R. C. Graham. *Solanum nigrum* L.                            | Rutin, arabinose                                         | Antioxidant effects                                   |
|                | *Solanum sodomeum* L.                                                           | Solasonine, solanine, solandine, solamargin            | Sore throat, skin rash and cancer, toothache, fertility |
|                | *Withania somnifera* (L.) Dunal.                                                | Essential oil, fatty acids (fusiferic acid), alkaloids, tetralydronaphthalene | Diabetes, anthelmintic, antidiabetic, blood purifier |
| Urticaceae     | *Urtica pilulifera* L.                                                          | *Rumex crispus* L.                                       | Antioxidant, anti-inflammatory effects                 |
|                | *Fagonia cretica* L.                                                            | Essential oils                                           | antioxidants effects                                   |
|                | *Zygophyllum abscutum* L.                                                       | *Zygophyllum ammoniacum* (L.)                           | Diabetes, rheumatism                                   |
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 parvisflorus Lam., Cistus salviifolius L., Cyclamen rohlsianum 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.,

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

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.
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 orders (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 rohlfssianum 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 (Alaib et al., 2017). Similarly, the five endemic species recorded in Wadi Belkaf (Alaib et al., 2016) were also found and listed in this study; Allium longanum Pamp., Arbutus pavarii Pamp., Arum cyrenaicum Hurby., Cyclamen rohlfssianum 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 & Saed, 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

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

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**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 orders (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.

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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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