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Original article

New records and addition to the flora of Saudi Arabia, mainly from Faifa Governorate, Jazan Region

Abdul Wali. Al-Khulaidi ^{a,b}, Eisa Ali Al Faify ^c, Mohammed Musa Alfaifi ^d, Ali A. Al-Namazi ^{e,*}

^a Faculty of Science and Arts, Albaha University, Baljurashi, Saudi Arabia

^b Agricultural Research & Extension Authority, Yemen

^c Academic Institute in Faifa, Saudi Arabia

^d Agricultural Development Fund, Faifa, Saudi Arabia

^e King Abdulaziz City for Science and Technology (KACST), P.O. Box 6086, Riyadh 11442, Saudi Arabia



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ABSTRACT

Based on vegetation surveys made in the southern region of Saudi Arabia between 2020 and 2021, five new plant taxa including four species and one subspecies, belonging to four families that had not previously been recorded in Saudi Arabia's flora were discovered. Within the Arabian Peninsula, all newly recorded species (i.e., *Alysicarpus vaginalis* (L.) DC. (Fabaceae), *Commiphora schimperi* (O.Berg) Engl. (Burseraceae), *Maerua angolensis* DC. subsp. *angolensis* (Capparaceae), *Peperomia leptostachya* Hook. & Arn. (Piperaceae), and *Vigna vexillata* (L.) A.Rich. (Fabaceae) were recorded in Yemen while *A. vaginalis* was also recorded in Oman. Brief descriptions and comments on the phytogeography of each taxon are given. The distribution of plants in Faifa Mountains and surrounding areas was mapped using geographic information systems (GIS) and ground surveys.

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1. Introduction

The vegetation cover in Saudi Arabia has received many surveys and studies. A number of books on the flora and vegetation of Saudi Arabia have been published (e.g., Migahid, 1996; Collenette, 1999; Chaudhary, 1999, 2000, 2001; Qashash, 2007; Mandaville, 2013; Al-Surour, 2018). The southwestern region of Saudi Arabia has the majority of the floristic diversity in Saudi Arabia (Fadl et al., 2021; Al-Namazi et al., 2022). Jazan is considered as one of the rich regions in plant diversity (Abbas et al., 2020). Therefore, several studies have occurred on its vegetation cover (e.g. Al-Turki, 2004; AlFarhan et al., 2005; El-Shabasy, 2016; Al-Gifri et al., 2019; Shalabi and Masrahi, 2019; Abbas et al., 2020).

The high plant diversity of Jazan region might be due to the variation in altitudes from sea level to 3100 m, in addition to the variation in climate conditions resulting from the altitudinal vari-

ations (Abbas et al., 2020). Moreover, most likely because environmental deviations caused by latitudinal and altitudinal gradients may have a significant influence on the spatial distributions of plant community diversity, where herbaceous plants grow well in low latitude regions (Jump et al., 2009). In general, there has been little research on latitudinal range retractions. The latitudinal gradient creates variation in the ecological conditions, which leads to variation in the plant community composition among the different altitudes. Thus, the mountainous areas have high plant diversity (Al-Namazi et al., 2021). Similarly, the mountainous region of Faifa in Jazan is one of the richest areas of plant diversity since about 537 species were recorded in this region (AlFarhan et al., 2005).

The study of natural plant species and the discovery of new plants enrich a country's plant life and aid in their protection, as well as enrich its economy if these plants are economically significant. Understanding the distribution of plant species across environmental and geographic gradients has long been a goal of ecology and plant management. However, the mechanisms governing this phenomenon are unknown, particularly along latitude gradients. (Zhang et al., 2019).

Several studies, however, have discovered that changes in plant functional behaviors along with a latitudinal gradient pattern, as well as community diversity along geographical gradients, as well as the effects of latitude and altitude on plant community diversity,

* Corresponding author.

E-mail address: alnamazi@kacst.edu.sa (A.A. Al-Namazi).

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are essential topics in biodiversity research. (Xu et al., 2017). The geographic distribution of plants is significantly influenced by physiography, climate, and edaphic conditions. (Jump et al., 2009; Xu et al., 2017).

In addition to the known high species richness of Faifa, this study aims to highlight the new records and novel taxa additions to the flora of Saudi Arabia. In this article, we are aiming to identify and describe these species and their habitats.

2. Materials and methods

2.1. The study area

The surveyed areas are located in southwestern Saudi Arabia's Asir region and are part of Jazan Province (Fig. 1). The region is regarded as Saudi Arabia's least known, and it remains largely unexplored. In fact, until the last decade of the twentieth century, botanists rarely visited the Faifa and surrounding areas, which can be considered a Hot Spot and an important plant area (IPA) in the Arabian Peninsula.

2.2. Fieldwork

Several field trips for plant collections have been done during the period from 2020 to 2021. Fig. 2 shows the spatial distribution map of the vascular plants. This study used geographic information systems (GIS) and ground surveys to map the distribution of the plants in the Faifa and surrounding areas. The most recent floras' books and research were used to identify the collected specimens. All the specimens were kept and deposited in the herbarium of the Faculty of Science, of the University of Albaha, and in the herbarium of King Abdulaziz City for Science and Technology (MUZ). Several photographs of plant parts (e.g., the whole plant, stems, leaves, flowers, and fruits) were taken, in addition, to free-hand drawings.

3. Results

For the first time, the study recorded five new taxa (4 species, and 1 subspecies) belonging to four families (i.e., *Alysicarpus vagi-*

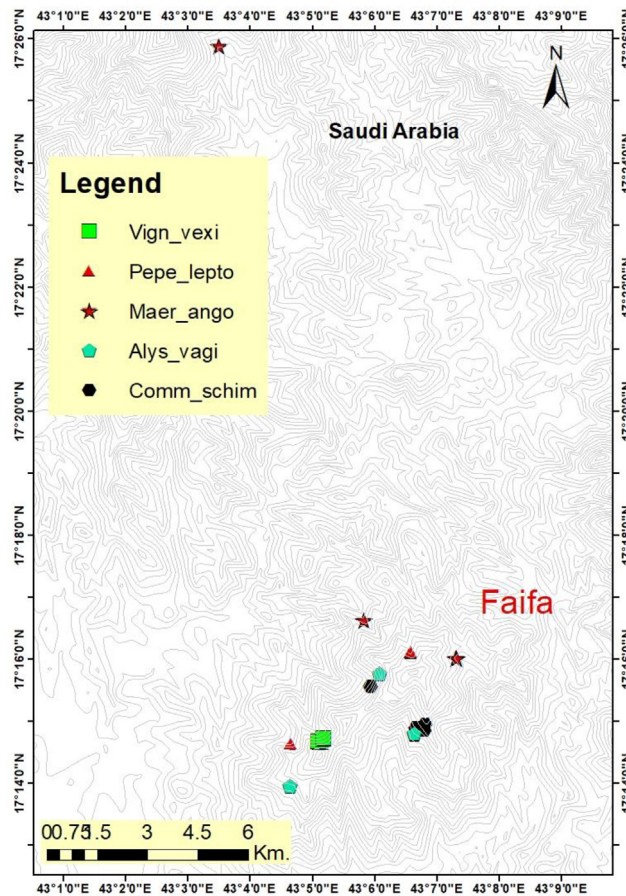


Fig. 2. Distribution pattern of the five newly recorded taxa in Faifa province, Saudi Arabia (*Alys_vagi*: *Alysicarpus vaginalis*; *Comm_schim*: *Commiphora schimperi*; *Maer_ango*: *Maerua angolensis* DC. subsp. *angolensis*; *Pepe_lepto*: *Peperomia leptostachya*; *Vign_vexi*: *Vigna vexillata*).

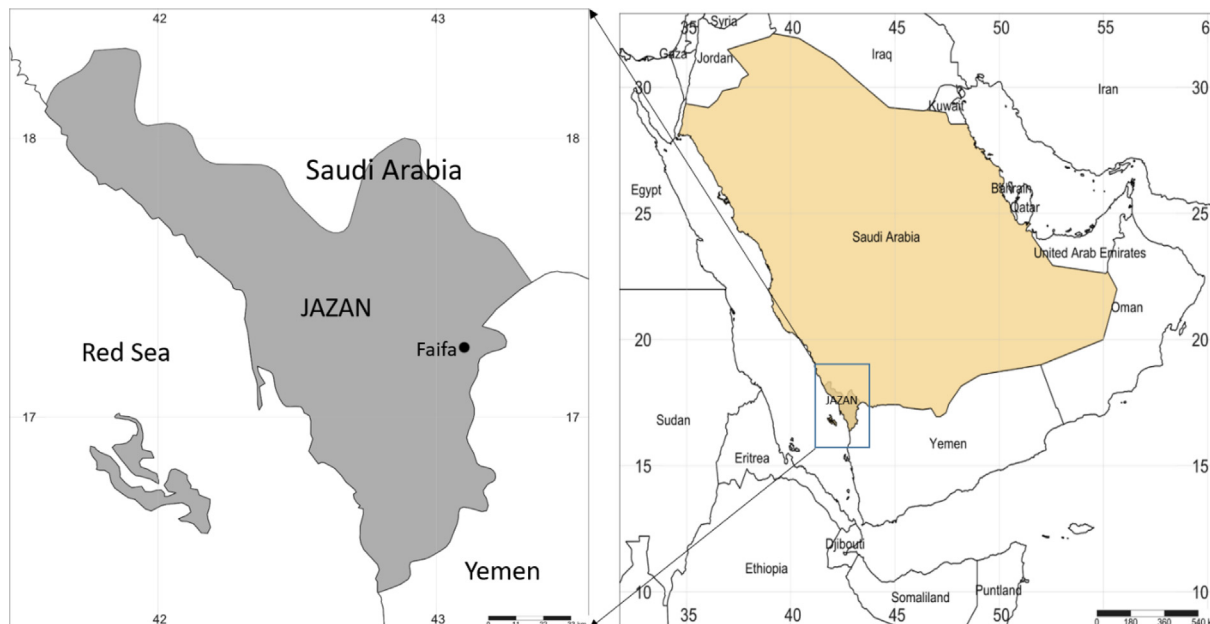


Fig. 1. The location of the investigated area.

nalis (L.) DC. (Fabaceae), *Commiphora schimperi* (O.Berg) Engl. (Burseraceae), *Maerua angolensis* DC. subsp. *angolensis* (Capparaceae), *Peperomia leptostachya* Hook. & Arn. (Piperaceae), and *Vigna vexillata* (L.) A.Rich. (Fabaceae). Although all of the five taxa had not previously been recorded in Saudi Arabia's flora, they were recorded from Yemen, with the exception of recording *A. vaginalis* in Oman. The following are brief descriptions and maps of each taxon. Table 1. describes the environmental and phytogeographical data of each plant species.

3.1. *Alysicarpus vaginalis* (L.) DC., (Fabaceae)

Published in Prodrum Systematis Naturalis Regni Vegetabilis 2: 353. 1825. (Fig. 3).

Ascending to prostrate annual or perennial herb. Leaves simple, ovate, oblong, to lanceolate, entire, alternate, petiolate, with little hairs, up to 2.5 cm. Flower in racemes up to 14 axillary flowers, blue, pink, purple, reddish-pink or rarely orange-yellow, 5–8 mm. Pod slightly hairy, cylindrical, not constricted between seeds up to 2 cm.

Alysicarpus is a genus of about 30 species, confined to the tropical and subtropical of the Old World (Pedley, 2001) with maximum diversity in India (leeratiwong et al., 2017). Only four species of *Alysicarpus* were recorded from the Arabian Peninsula. *Alysicarpus vaginalis* species has been recorded from the Arabian Peninsula only from Yemen and Oman (Wood, 1997; Al-Khulaidi, 2013; Ghazanfar, 2007) and appears to be recently introduced into Saudi Arabia. The plant is considered a weed plant threatening crops around the world (Holm et al., 1979).

Alysicarpus vaginalis is recognized from the other two species recorded from Saudi Arabia (*Alysicarpus rugosus* and *Alysicarpus glumaceus*) by its valvate calyx lobes, the color variation of the corolla, and pods not constricted between seeds. In the study area, we recorded a few individuals of this species growing on the roadside and rocky slopes (Table 1).

Specimen examined: Faifa, Jazan Region, 17.2465N, 43.1107E, 1275m alt., roadside, 10 Nov. 2020, M. Alfaifi & E. Al Faify MUZ-20210; Faifa, 17.2628N 43.1013E, 1373m alt., rocky slope, Al-Namaz, M. Alfaifi & E. Al Faify 21 Oct. 2021 MUZ 20229 (KACST).

Table 1
The plant species with their environmental data.

Lat.	Long.	Plant name	no.	Altitude	World Distribution	habitat
17.2465	43.1107	<i>Alysicarpus vaginalis</i> (L.) DC.	2	1275	Yemen, Oman, Africa, Tropical & Subtropical Asia to N. Australia.	roadside
17.2468	43.1106	<i>Alysicarpus vaginalis</i> (L.) DC.	1	1273		roadside
17.2628	43.1013	<i>Alysicarpus vaginalis</i> (L.) DC.	1	1373		rocky slope
17.2325	43.0773	<i>Alysicarpus vaginalis</i> (L.) DC.	1	1130		roadside
17.248	43.1111	<i>Commiphora schimperi</i> (O.Berg) Engl.	2	1300	Yemen, East to SE Africa (From Sudan to South Africa	roadside
17.2594	43.0989	<i>Commiphora schimperi</i> (O.Berg) Engl.	3	1350		rocky slope
17.2482	43.1112	<i>Commiphora schimperi</i> (O.Berg) Engl.	2	1305		roadside
17.2473	43.1111	<i>Commiphora schimperi</i> (O.Berg) Engl.	1	1292		roadside
17.2491	43.1135	<i>Commiphora schimperi</i> (O.Berg) Engl.	3	1400		terraces
17.2475	43.1134	<i>Commiphora schimperi</i> (O.Berg) Engl.	1	1357		slope
17.4314	43.0582	<i>Maerua angolensis</i> DC. subsp. <i>angolensis</i>	3	1360	Yemen, Tropical Africa & S. Africa,	rocky slope
17.2669	43.1218	<i>Maerua angolensis</i> DC. subsp. <i>angolensis</i>	2	1315		rocky slope
17.2772	43.0972	<i>Maerua angolensis</i> DC. subsp. <i>angolensis</i>	1	935		rocky slope
17.2669	43.122	<i>Maerua angolensis</i> DC. subsp. <i>angolensis</i>	2	1308		roadside
17.2684	43.1095	<i>Peperomia leptostachya</i> Hook. & Arn.	3	1497	Tropical & Subtropical America	wall terraces
17.2441	43.0773	<i>Peperomia leptostachya</i> Hook. & Arn.	3	1050		wall terraces
17.2686	43.1095	<i>Peperomia leptostachya</i> Hook. & Arn.	5	1480		wall terraces
17.2445	43.0853	<i>Vigna vexillata</i> (L.) A.Rich.	1	1306	Yemen, Tropics & Subtropics of America, Africa, Asia and Australia	roadside
17.2444	43.0855	<i>Vigna vexillata</i> (L.) A.Rich.	5	1310		roadside
17.2447	43.085	<i>Vigna vexillata</i> (L.) A.Rich.	3	1300		roadside
17.2455	43.0862	<i>Vigna vexillata</i> (L.) A.Rich.	4	1235		roadside
17.2455	43.0861	<i>Vigna vexillata</i> (L.) A.Rich.	3	1254		roadside

3.2. *Commiphora schimperi* Engl. (Burseraceae)

Published in: Monogr. Phan. 4: 13. (1883). (Fig. 4).

A small tree up to 6 m tall. Branches spine-tipped. Leaves 3-foliolate, dentate, obovate, the terminal leaflet up to 3 cm. lateral leaflets 18 mm to 20 mm. Flowers red to yellow, in dense clusters, fruits beaked, ovoid drupe, 16 mm. long (Fig. 4).

The genus *Commiphora* contains about 185 species in the world (Daly et al., 2011), and 15 species of *Commiphora* were recorded from the Arabian Peninsula. *Commiphora schimperi* was recorded only from Yemen, (Wood, 1997; Miller and Morris, 2004). For the first time in Saudi Arabia, we recorded this species. It is occur in scattered and varied habitats in Faifa such as roadside, rocky slopes, and terraces (Table 1 & Fig. 6). *Commiphora schimperi* is similar to *C. kua*, but the lateral leaflets are fully developed, dentate, and the terminal leaflet is larger (see Table 2).

Specimen examined: Faifa, Jazan Region, 17.2594N, 43.0989E, 1350m alt., rocky slope, 19 Dec. 2020, M. Alfaifi & E. Al Faify MUZ-20204 (KACST); Faifa, 17.2491N, 43.1135E, 1400m alt., terraces, Al-Namaz, M. Alfaifi & E. Al Faify 18 Jan. 2021 MUZ 20223 (KACST).

3.3. *Maerua angolensis* DC. subsp. *angolensis* (Capparaceae)

Published in: Prod. 1: 254. (1824). (Fig. 5).

Shrub up to 2 m tall, with a rounded crown and smooth grey bark flaking to reveal yellowish-orange patches. Leaves, simple, ovate to oblong, up to 4 cm, petiolate, alternate, and broadly elliptic to ovate with rounded or notched apex. Inflorescence of short, terminal, corymbose racemes. Fruit up to 22 cm, long, narrowly cylindrical, torulose (Miller and Cope, 1996; and see Fig. 7).

Within the Arabian Peninsula, three species and two subspecies, and two varieties of the genus *Maerua* are recorded from Yemen, one subspecies is endemic to Socotra Island (Miller and Morris, 2004; Collenette, 1999; Miller and Cope, 1996). In the study area, we recorded the subspecies of *Maerua angolensis* DC. subsp. *angolensis* occurs in four locations with altitudes varying from 935 to 1360 m above sea level (a. s. l.); see (Table 1).



Fig. 3. *Alysicarpus vaginalis* floral and vegetative parts. A: Life form, B: branches with simple alternate leaves, C: The inflorescences. D: The flower. E: The fruits.

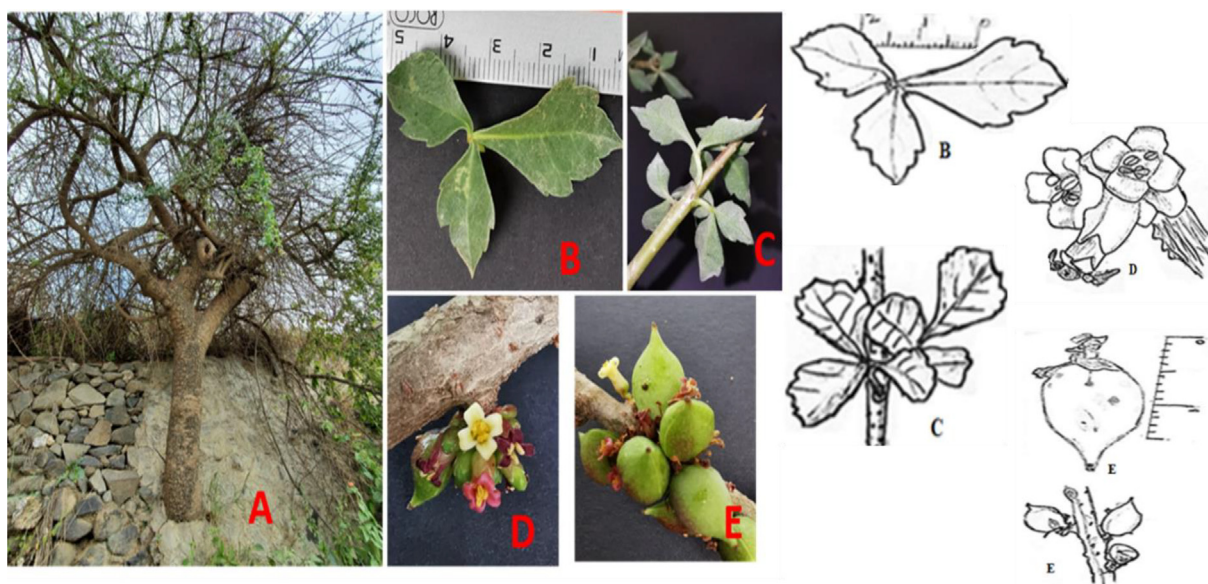


Fig. 4. *Commiphora schimperi* floral and vegetative parts. A: life form. B: 3-foliolate leaves. C: branch with the leaves. D: The clusters of the flowers. E: The fruits.

Maerua angolensis DC. subsp. *angolensis* can be distinguished from other species of *Maerua* in Saudi Arabia by the size of its leaves and fruits which are elongated bean-like pods, up to 16 cm, constricted between the seeds (Wood, 1997; Edwards et al., 2000; Thulin, 2008; see also Table 3 and Fig. 5).

Specimen examined: Faifa, Jazan Region, 17.4314N, 43.0582E, 1360m alt., rocky slope, Al-Namazi, M. Alfaifi & E. Al Faify 21 May. 2021 MUZ 20225 (KACST).

3.4. *Peperomia leptostachya* Hook. & Arn. (Piperaceae)

Published in: Bot. Beechey Voy. 96. (1832). (Fig. 6).

Annual and perennial succulent herb up to 30 cm tall, prostrate to creeping. Stems brownish to red. Leaves dark green, in whorls of three and opposite, margin entire hairy, elliptic to obovate, up to 3 cm. long, 2 cm. wide, with palmately 3 to 5 nerves, petiole up to 9 mm long. Flowers are small, borne in slender spikes or panicles, greenish-white (Fig. 6). In the Arabian Peninsula, the plant

is only recorded in Yemen (Wood, 1997). We recorded this species in Faifa, growing in the walls of terraces at altitudes between 1050 and 1500 m a. s. l. (Table 1).

Specimen examined: Faifa, Jazan Region, 17.2686N, 43.1095E, 1480m alt., wall terraces, 15 Jan. 2021, M. Alfaifi & E. Al Faify MUZ-20216 (KACST).

3.5. *Vigna vexillata* (L.) A.Rich. (Fabaceae)

Published in: R.de la Sagra, Hist. Fis. Cuba, Bot. 10: 191 (1845). (Fig. 7).

Perennial climbing herb. Stem covered by brownish hair. The stipules are linear. Leaves three foliolate, leaflets entire to undulating, ovate to lanceolate, 6 to 8 cm. long, apex acute. The inflorescence is axillary, flower pink, purple, 2–3 cm long, solitary on long peduncles 2–4-flowered at the peak. Fruits are sessile, linear, straight, covered with brown hairs, 6–10 cm. long (Fig. 7).

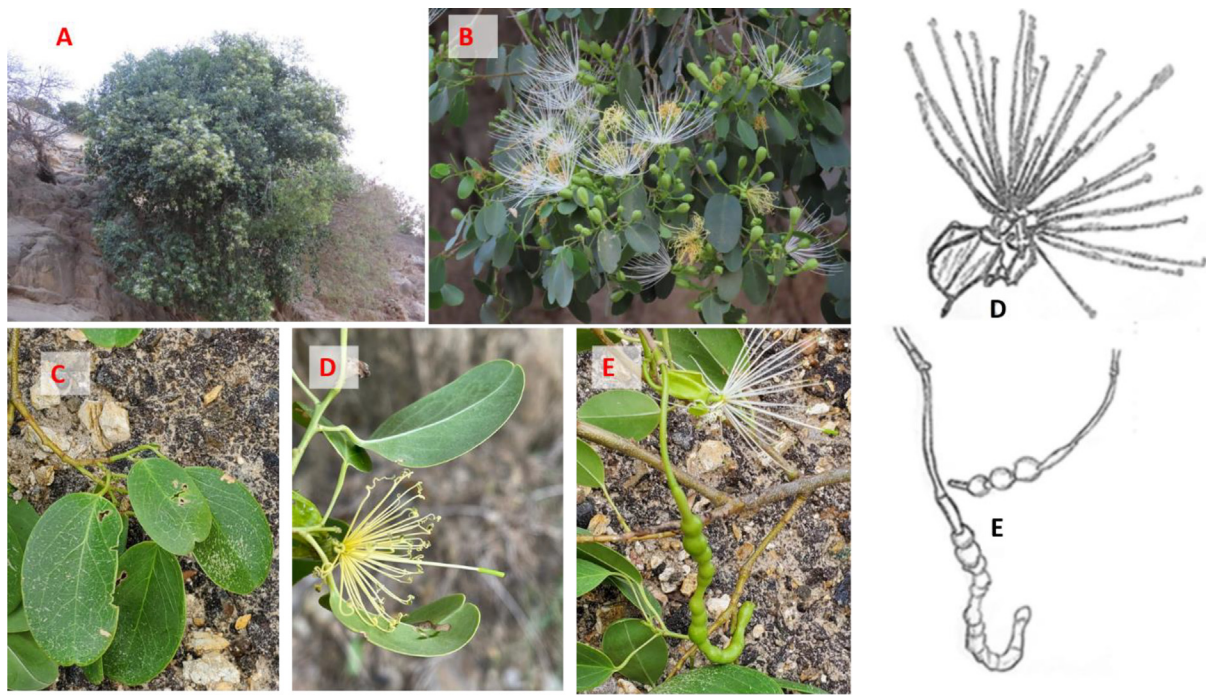


Fig. 5. *Maerua angolensis* DC. subsp. *angolensis* floral and vegetative parts. A: Life form, B: branches with the flowers, C: Leaves, D: flowers, E: Fruits.

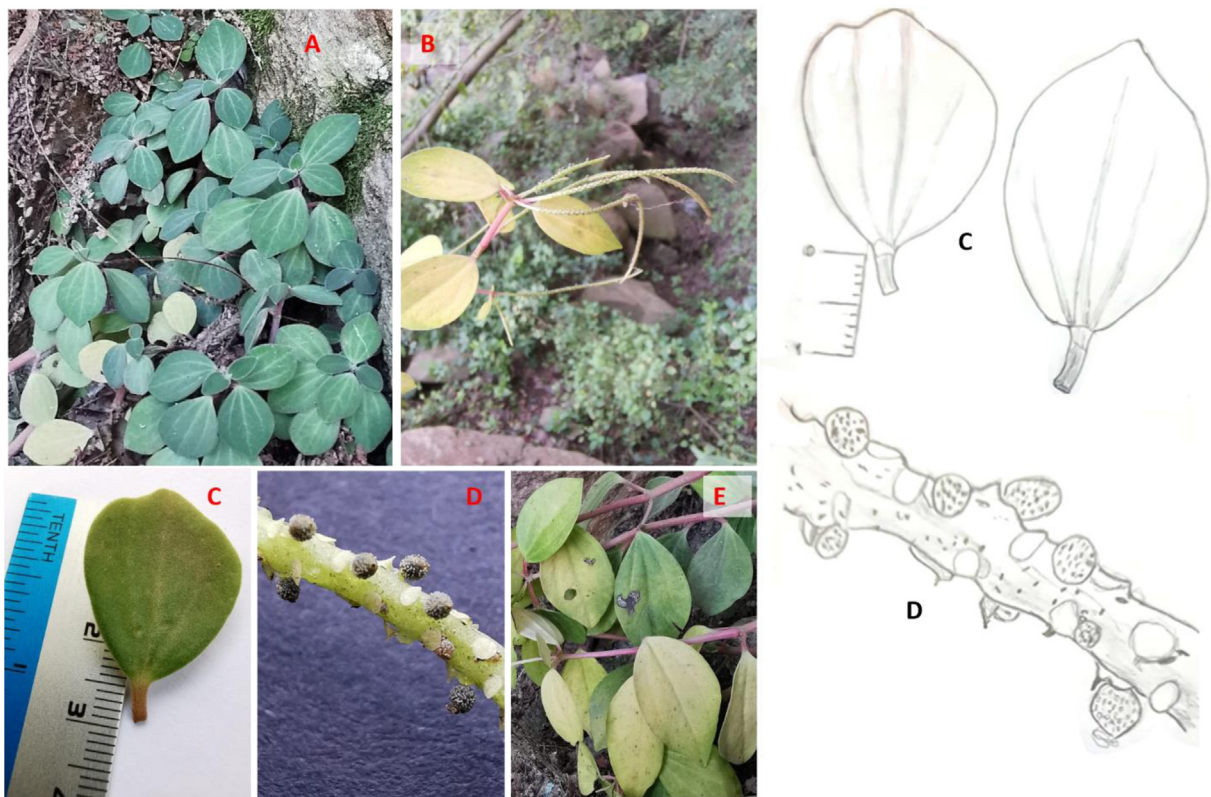


Fig. 6. *Peperomia leptostachya* floral and vegetative parts. A: Plant habit, B: the inflorescence, C: leaves, D: part of the fruiting rachis, E: a brownish to red stem, showing the whorls and opposite leaves.

There are three species and two subspecies of *Vigna* recorded from Saudi Arabia (Collenette, 1999). In Arabian Peninsula, *Vigna vexillata* is only recorded from Yemen (Wood, 1997; Al-Khulaidi, 2013). *Vigna vexillata* has been divided into different varieties

according to the morphology of the terminal leaflets (Pienaar and Kok, 1991; Maxted et al., 2004), in which var. *vexillata* with broadly or narrowly ovate to elliptic terminal leaflets. We found this plant in five locations in Faifa region, growing on the roadside (see

Table 2

Summarizes the variations between the six species of the genus *Commiphora* found in Saudi Arabia (Wood, 1997).

Species	Leaves	Fruits	Branches
<i>Commiphora gileadensis</i> (L.) C.Chr	3 to 5-foliolate, entire, Lateral leaflets less than 3 cm	4-valved, apiculate	spineless
<i>Commiphora kataf</i> (Forssk.) Engl.,	1–3-foliolate, dentate with long petiole, lateral leaflets more than 1 cm long	Flattened to rounded	spineless
<i>Commiphora kua</i> (R.Br. ex Royle) Vollesen (= <i>C. erythraea</i> (Ehrenb.) Engl)	1–3-foliolate, terminal leaflets, dentate, up to 5 cm. lateral leaflets less than 3 mm dentate, sometimes absent	Apiculate, Not beaked	Spine-tipped
<i>Commiphora myrrha</i> (Nees) Engl	1–3-foliolate, lateral leaflets less than 3 mm, entire	Apiculate, beaked	Spine-tipped
<i>Commiphora quadricincta</i> Schweinf.	simple leaves, about 2.5 cm, entire	Apiculate, the stone with 4 winged beaked	Spine-tipped
<i>Commiphora schimperi</i> (Berg.) Engl.,	1–3-foliolate, terminal leaflets, dentate, up to 3 cm, lateral leaflets, dentate, always present		Spine-tipped

Table 1. *Vigna vexillata* can be distinguished from other species of *Vigna* in Saudi Arabia by linear, straight pods, covered with brown hairs (Hedberg and Edwards, 1989; see Table 4).

Specimen examined: Faifa, Jazan Region, 17.2444N, 43.0855E, 1310m alt., roadside, 21 Dec. 2020, M. Alfaifi & E. Al Faify MUZ-20205 (KACST).

4. Discussion

This study adds four new species, and one subspecies belonging to four families to the flora of Saudi Arabia. These plants are found in the Faifa Governorate and surrounding areas within, Jazan Province. The majority of these plants are concentrated on mountain slopes facing north and northwest, particularly west of Faifa.

Despite the fact that the vegetation and the flora in these areas have been surveyed by AlFarhan et al., 2005; Al-Turki, 2004; El-Shabasy, 2016; Al-Gifri et al., 2019; Shalabi and Masrahi,

Table 3

Summarizes the variations between the taxonomic characteristics of the different species of *Maerua* in Saudi Arabia (Wood, 1997; Edwards et al, 2000; Thulin, 2008).

Plant name	petioles	leaves	fruits
<i>Maerua angolensis</i>	more than 1 cm long	Simple, up to 7 cm	elongated bean-like pod, up to 16 cm, constricted between the seeds
<i>Maerua crassifolia</i>	less than 1 cm long	Simple, clustered on branches, less than 2 cm	Strongly torulose, less than 7 cm., constricted between the seeds
<i>Maerua triphylla</i> var. <i>calophylla</i>	more than 1 cm long	Simple or 3-foliolate	globose to cylindrical, not constricted between seed
<i>Maerua oblongifolia</i>	less than 2 cm long	Simple, up to 5 cm.	Cylindrical, beaded, aggregate, slightly constricted between seed

2019; Abbas et al., 2020, the new discovery plants in our study were not included in these studies. Studies and herbarium searches also revealed that these plants had never been reported or collected in any Saudi Arabian herbarium (Collenette, 1999; Chaudhary, 1999, 2000, 2001).

Almost all plants reported in this study can only be seen in the low latitudes of the Faifa Mountains (Table 1). These plants are not found in almost similar environments at high latitudes between 19° to 22° latitude such as Albaha region and its surrounding areas (Al-Aklabi et al., 2016; Al-Khulaidi et al., 2016; Al-Zandi et al., 2018). This phenomenon has also been seen in some plants, such as *Senegalia mellifera* (Benth.) Seigler & Ebinger, *Euryops arabicus* Steud. Ex Jaub. & Spach and the recently discovered species of *Celtis toka* (Forssk.) Hepper & Wood (Alfaifi et al., 2021) and *Aspilia kotschyi* (Sch. Bip. Ex Hochst.) Oliv (Al-Khulaidi et al., 2021a,b), which are limited to the low latitudes of the SW Arabian Peninsula (Wood, 1997; Al-Khulaidi, 2013).

Several of these plant species have previously been documented in neighboring Yemen and Oman, as well as in East and West Africa and South America (Hutchinson and Dalziel, 1958; Wood, 1997; Holm et al., 1979; Koopman, 2011; Darbyshire et al., 2015; Germishuizen and Meyer, 2003).

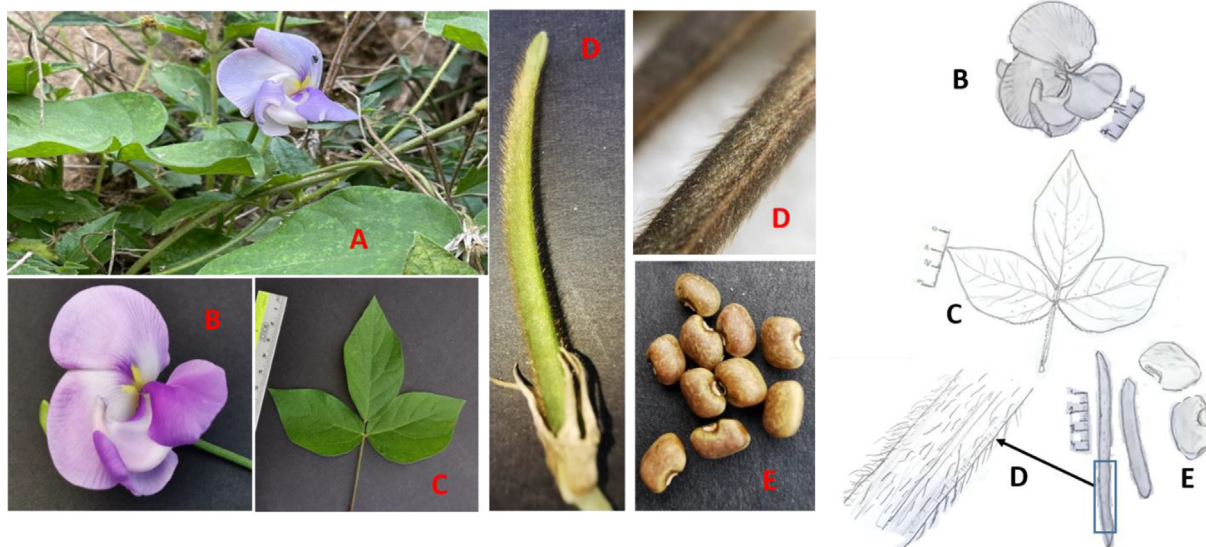


Fig. 7. *Vigna vexillata* floral and vegetative parts. **A:** close-up with long peduncles and the twining stems. **B:** flower showing the yellowish nectar on the standard petal, the twisted keel beak, and the spur. **C:** typical 3- leaflets with rounded bases. **D:** a whole fruit, close-up fruit with brown hairs. **E:** the seeds.

Table 4

summarizes the variations between the taxonomic characteristics of the different species of *Vigna* in Saudi Arabia (Hedberg and Edwards, 1989).

plant name	keel	stipules	pod
<i>Vigna aconitifolia</i>	With marked pocket	peltate, small, linear-lanceolate	Cylindrical hairy, up to 3 cm
<i>Vigna ambacensis</i>	Without marked pocket, with short beak	Bilobed at the base	Linear, pubescent up to 6 cm
<i>Vigna membranacea</i>	Without marked pocket, with short beak	Bilobed and unequally prolonged at the base	Linear-cylindrical up to 10 cm
<i>Vigna macrorhyncha</i>	Without marked pocket, without marked pocket, with long beak	Small not extended below the base	Up-curved at the apex, glabrous, up to 11 cm
<i>Vigna vexillata</i>	With marked pocket	Linear. Prolonged and subcordate at the base	linear, straight, covered with brown hairs, up to 10 cm.

This paper also supplements the research contributions by (Fayed and Alzahrani, 2007; Al-Sodany, 2016; Thomas et al., 2014; Basahi and Masrahi, 2019; Alfaifi et al., 2021; (Al-Khulaidi et al., 2021b; Al-Khulaidi et al., 2021a) of new records for Saudi Arabia, primarily from Faifa.

With the understanding that careful surveys may reveal more wild plants in this region, which is known for its high biodiversity. Its proximity to Yemen may aid in the presence of new species.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Abbas, A.M., Al-Kahtani, M.A., Alfaifi, M.Y., Elbehairi, S.I., Badry, M.O., 2020. Floristic Diversity and Phytogeography of JABAL Fayfa: A Subtropical Dry Zone, South-West Saudi Arabia. *Diversity* 12, 345.
- Al-Gifri, A.N., Kasem, W.T., Shehata, R.S., Eldemerdash, M.M., 2019. The African Paleontological Influence on the Biogeography of the Flora of Jazan, KSA. *Asian J. Soil Sci. Plant Nutr.* 4 (1), 1–10.
- Al-Khulaidi, A., 2013. Flora of Yemen. The Sustainable Natural Resource, Management Project (SNRMP II), EPA and UNDP, Republic of Yemen; <http://ye.chm-cbd.net/implementation/documents/1-flora-final-by-dr.-abdul-wali-al-khulaidi-2013-part-1-introduction.pdf>.
- Al-Khulaidi, A., Al-Sagheer, N., Darfaoui, M., Al-Ameri, S.M., 2016. Trees of Albaha region and surrounding areas. FAO and Ministry of Environment Water and Agriculture, Riyadh, Saudi Arabia. (In Arabic version) <https://www.fao.org/3/i6725a/i6725a.pdf>.
- Al-Khulaidi, A., Al-Sagheer, N., Filimban, F.Z., 2021a. *Erigeron canadensis* L. (Asteraceae): A New Record to the Flora of the Arabian Peninsula. *J. North Basic Appl. Sci.* (2021/1442 H) 6(1), 30–46.
- Al-Khulaidi, A., Filimban, F., Alfaifi, M., Al-Namazi, A., 2021b. A New Record of Generic Vascular Plant for the Flora of Saudi Arabia: *Aspilia kotschyi* (Asteraceae). *Saudi J. Biol. Sci.* 28 (3), 1962–1965.
- Al-Namazi, A.A., Al-Khulaidi, A.W.A., Algarni, S., Al-Sagheer, N.A., 2021. Natural plant species inventory of hotspot areas in Arabian Peninsula: Southwest Al-Baha region, Saudi Arabia. *Saudi J. Biol. Sci.* 28 (6), 3309–3324.
- Al-Namazi, A.A., Algarni, S.M., Wan, J.S., Al Mosallam, M.S., Alotaibi, F., 2022. Floristic composition of Jandaf Mountain as biodiversity hotspot area in southwestern Saudi Arabia. *Saudi J. Biol. Sci.* 29 (5), 3654–3660.
- Al-Sodany, Y., 2016. A New Record to the Flora of Saudi Arabia: *Ipomoea carnea* Jacq. *Convolvulaceae*. *World J. Res. Rev.* 3 (4), 25–30.
- Al-Surour, A., 2018. *Illustrated Atlas of Wild Plants*, 2 volumes. Authors Books. p. 827. (in Arabic). <https://www.jarir.com/arabic-books-519505.html>.
- Al-Turki, T.A., 2004. A prelude to the study of the flora of Jabal Fayfa in Saudi Arabia. *Kuwait J. Sci. Eng.* 31 (2), 77–145.

- Al-Zandi, A., Al-Khulaidi, A., Al-Sagheer, N.A., 2018. Preliminary Analysing of plant Diversity of high altitude area of Albaha region, Saudi Arabia. *Int. J. Adv. Res.* 6 (2), 412–426.
- Al-Aklabi, Abdullah, Al-Khulaidi, Abdul Wali, Hussain, Akram, Al-Sagheer, Nageeb, 2016. Main vegetation types and plant species diversity along an altitudinal gradient of Al Baha region, Saudi Arabia. *Saudi Journal of Biological Sciences* 23 (6), 687–697.
- Alfaifi, M.M., Al-Khulaidi, A., Al Aklabi, A., Al-Gifri, N., Al-Al Faify, E.A., 2021. New record of vascular plant for the flora of Saudi Arabia: *Celtis toka* (Forssk.) Hepper and Wood, Cannabaceae. *Int. J. Curr. Res. Biosci. Plant Biol.* 8 (7), 1–6.
- Alfarhan, A.H., Al-Turki, T.A., Basahy, A.Y., 2005. Flora of Jazan Region. King Abdulaziz City for Science and Technology, Riyadh, p. 545
- Basahi, M.A., Masrahi, Y.S., 2019. *Blepharis saudensis* (Acanthaceae), a new species from Saudi Arabia. *Saudi J. Biol. Sci.* 26 (7), 1509–1512.
- Chaudhary, S.A., 1999. Flora of the Kingdom of Saudi Arabia, vol. I. Ministry of Agriculture and Water, Riyadh, Saudi Arabia.
- Chaudhary, S.A., 2000. Flora of the Kingdom of Saudi Arabia, vol. II, parts 1–3. Ministry of Agriculture and Water, Riyadh.
- Chaudhary, S.A., 2001. Flora of the Kingdom of Saudi Arabia, vol. III. Ministry of Agriculture and Water, Riyadh.
- Collenette, S., 1999. Wildflowers of Saudi Arabia. Riyadh, Saudi Arabia: National Commission for Wildlife Conservation and Development (NCWCD); <https://www.worldcat.org/title/wildflowers-of-saudi-arabia/oclc/42968766>.
- Darbyshire, I., Kordofani, M., Farag, I., Candiga, R., Pickering, H. (Eds.), 2015. The Plants of Sudan and South Sudan: 1–400. Kew Publishing, Royal Botanic Gardens, Kew.
- Daly, D.C., Harley, M.M., Martínez-habibe, M.C., Weeks, A., 2011. Burseraceae. The families and genera of vascular plants. 10, 76–104.
- Edwards, S., Tadesse, M., Demissew, S., Hedberg, I. (Eds.), 2000. Flora of Ethiopia and Eritrea. Volume 2, part 1. Addis Ababa, Ethiopia. Uppsala, Sweden.
- El-Shabasy, A., 2016. Survey on medicinal plants in the flora of Jizan Region, Saudi Arabia. *Int. J. Botany Stud.* 2 (1), 38–59.
- Fadl, Mohamed, Al-Yasi, Hatim, Alsharif, Emad, et al., 2021. Impact of elevation and slope aspect on floristic composition in wadi Elkor, Sarawat Mountain, Saudi Arabia. *Scientific Reports*.
- Fayed, A.A., Alzahrani, D.A., 2007. Three new spiny Euphorbia (Euphorbiaceae) species from western Saudi Arabia. *Edinburgh J. Botany* 64 (02), 117–129.
- Germishuizen, G., Meyer, N.L., (eds.), 2003. Plants of Southern Africa an annotated checklist Strelitzia 14: 1–1231. National Botanical Institute, Pretoria.
- Ghazanfar, S.A., 2007. Flora of Sultanate of Oman. Volume 2. Crassulaceae – Apiaceae Scripta Botanica Belgica 36, 1–220.
- Hedberg, I., Edwards, S. (Eds.), 1989. Flora of Ethiopia, volume 3. Addis Ababa, Ethiopia. Uppsala, Sweden.
- Holm, L.G., Pancho, J.V., Herbeniger, J.P., Plucknett, D.L., 1979. *A Geographical Atlas of World Weeds*. John Wiley & Sons, New York, USA.
- Hutchinson, J., Dalziel, J.M., 1958. Flora of West Tropical Africa. In: Keay, R.W.J. (Ed.), 2nd Edition, Vol. 1. Part 2, Published on Behalf of the Governments of Nigeria, Ghana, Sierra Leone & The Gambia by Crown Agents for Overseas Governments and Administrations, Millbank, London.
- Jump, A.S., Matyas, C., Penuelas, J., 2009. The altitude-for-latitude disparity in the range retractions of woody species. *Trends Ecol. Evol.* 24 (12), 694–701.
- Koopman, J., 2011. *Carex Europaea*. The Genus *Carex* L. (Cyperaceae) in Europe 1: 1–726. Margraf publishers, Weikersheim, Germany.
- Leeratiwong, C., Sattaphorn, J., Chantaranonthai, P., 2017. The genus *Alysicarpus* Neck. Ex Desv. (Leguminosae) in Thailand. *Thai Forest Bull., BOT.* 45 (2), 125–133.
- Maxted, N., Mabuza-Diamini, P., Moss, H., Padulosi, S., Jarvis, A., Guarino, L., 2004. An Ecogeographic Study African Vigna; International Plant Genetic Resources Institute (IPGRI): Rome, Italy, 2004. ISBN 978-92-9043-637-9.
- Mandaville, James, 2013. *Flora Of Eastern Saudi Arabia*. Taylor and Francis.
- Migahid, A.M., 1996. *Flora of Saudi Arabia* (3 Vols). University Libraries, King Saud University.
- Miller, A.G., Morris, M., 2004. Ethnobotany of the Socotra Archipelago. Royal Botanic Garden Edinburgh: Edinburgh; 1st edition. 776 pages.
- Miller, A.G., Cope, T.A., 1996. *Flora of the Arabian Peninsula and Socotra*, 1st edition, vol. 1. Edinburgh University Press, 586 pages.
- Pedley, L., 2001. *Alysicarpus* (Leguminosae: Desmodieae) in Australia: a taxonomic revision. *Austrbailey* 6 (1), 107–116.
- Pienaar, B.J., Kok, P.D.F., 1991. The *Vigna vexillata* complex (Fabaceae) in southern Africa. *S.-Afr. Tydskr. Plantk.* 57 (5), 236–245.
- Qashash, A.S., 2007. *The Book of Plants in the Sarat and Hijaz Mountains*, 2 volumes. Sarawat. (in Arabic).
- Shalabi, L.F., Masrahi, Y.S., 2019. Floristic composition, life forms and phytogeography of Al-Hashr Mountain, Jazan region, SW Saudi Arabia. *Egypt. J. Exp. Biol.* 15 (1), 73–85.
- Thomas, J., Sivadasan, M., Al-Ansari, A.M., Alfarhan, A., El-Sheikh, M., Basahi, M., Alatar, A.A., 2014. New generic and species records for the flora of Saudi Arabia. *Saudi J. Biol. Sci.* 21 (5), 457–464.
- Thulin, M., 2008. *Flora Somalia*, vol. 1, Royal Botanic Gardens, Kew. 501 pages.
- Wood, J.R.I., 1997. *A Handbook of the Yemen Flora*. Royal Botanic Gardens, Kew. UK. pp 434.
- Xu, M., Ma, L.I., Jia, Y., Liu, M., Hewitt, J., 2017. Integrating the effects of latitude and altitude on the spatial differentiation of plant community diversity in a mountainous ecosystem in China. *PLoS ONE* 12 (3), e0174231. <https://doi.org/10.1371/journal.pone.0174231>.
- Zhang, X., Hea, X., Gao, J., Lei, W., 2019. Attitudinal and climate effects on key plant traits in Chinese forest ecosystems. *Global Ecol. Conserv.* 17.