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Preliminary Study on the Floristic Features of the Unique Microhabitat of Al-Wahbah Crater at Taif Region, Saudi Arabia

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AL-WAHBAH Crater is the largest of five basaltic tuff rings and a unique habitat in Saudi Arabia that is considered the largest among its kind in the Middle East. The present study is the pioneer that describes the floristic composition and economic services provided by the recorded plant species in Al-Wahbah Crater northeast Taif Province, Saudi Arabia. The plant species were recorded through different sites along three main habitats (bed, terrace and slope). Thirty-two species (7 annuals and 25 perennials) belonging to 28 genera and 20 families were recorded in the different habitats of Al-Wahbah Crater. Fabaceae and Zygophyllaceae had the highest contribution, followed by Brassicaceae and Areaceae. The highest number of species was recorded on the slope of the crater, while the lowest was in the bed. *Hyphaene thebaica* was the dominant in the crater terrace, while *Tetraena alba* var. *alba* was the dominant in the crater bed, and the slope was dominated with *Phoenix dactylifera, Cenchrus ciliaris* and *Fagonia indica*. Chamaephytes were dominated over the other life forms. In addition, bioregional elements were dominated over monoregional and pluriregional taxa with the dominance of Sudano-Zmbezian elements. About 75.0% of the recorded species were medicinal, while 40.6% were either grazing or used as fuel and 18.8% were edible. Owing to the information resulted produced by the present study, which represents the base for further ecological studies, there is an urgent need for monitoring and conserving Al-Wahbah Crater and the corresponding microhabitats in Saudi Arabia.

Keywords: Chorology, Crater, Economic services, Harrat Kishb, Floristic diversity.

Introduction

Ecologists have long been interested in plant community structure, since ecosystems and biomes are described according to the dominant plant communities (Makkay et al., 2008). The plant community plays an important role in maintaining biodiversity and conserving the environment (Kandi et al., 2011). The main concern of most community studies has been to identify species composition and their distribution along the environment gradients (Fried et al., 2008). Species composition and diversity are fundamental characteristics of ecosystems respecting the development of restoration ecology and understanding the principles of biodiversity (Galal & Fahmy, 2012). In addition, vegetation diversity should be considered in the course of vegetation restoration (Burke, 2001). Therefore, if diversity dynamics is linked to vegetation restoration, some crucial constraints to revegetation in extreme habitats may be discovered (Yang et al., 2006).

During the past century, nature conservation suffered from the effects of land use changes, particularly when dealing with the traditional semi-natural landscape (Rosén & Bakker, 2005). The biodiversity of floras is usually measured in terms of species number and species abundance (Ayyad et al., 2000). In addition, floristic studies are important in describing plant species composition and their socioeconomic significance, since they provide shelter, food, medicine and everything for human being (Shehata & Galal, 2015). During the past century, the plant diversity suffered from the effects of land use changes, that leads to habitat fragmentation and degrade biodiversity. Rare species that are associated with specific and restricted habitats as they often lack the ability to survive in these extreme habitats (Al-Ansari & El-Keblawy, 2003). Habitat disturbance is an important issue for spatial and temporal variability in plant communities (Hammouda et al., 2003). It is widely recognized as a keystone element in community dynamics (Pickett & White, 1985). Disturbances

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can maintain plant diversity by maintaining species richness and increase spatial heterogeneity (Wittaker & Levin, 1977).

Several major volcanic fields (termed harrats) occur throughout the western part of the Kingdom of Saudi Arabia (Fig. 1) (Abdel Wahab et al., 2014). Harrat Kishb is approximately 6000 km^2 and is the youngest of these volcanic fields, the earliest lavas being erupted approximately 1.5 million years ago (Camp et al., 1992). Al-Wahbah Crater (41° 08' 299" E, 22° 54' 040" N) is located in the western part of the Harrat Kishb about 250km northeast Taif city, and it is the largest of five basaltic tuff rings (Abdel Wahab et al., 2017). It is a unique habitat in Saudi Arabia and is considered the largest among its kind in the Middle East (Grainger, 1996). The crater is elliptical in shape, measuring between 1.7 and 2.3 km, with a depth approximates 250 m (Grainger, 1996). The crater is filled with material that has eroded from the crater walls and wind-blown dust. The central part of the crater floor surface is covered by a large patch of gypsum polygons that overlie gypsum-bearing mud deposits (Abdel Wahab et al., 2014, 2017).

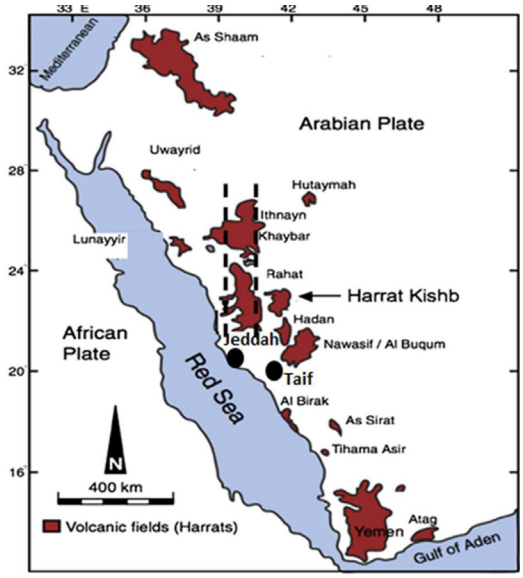

Fig. 1. Location map showing the main Cenozoic volcanic fields including Harrat Kishb and Al-Wahbah Crater (modified from Moufti et al., 2012).

Plant diversity in Al-Wahbah Crater can provide ecological, socioeconomic, scientific, educational, cultural, recreational and aesthetic values, which may give these plant species significances for their conservation. Till now, no elaborate research on the floristic diversity in Al-Wahbah Crater was carried out. Therefore, the present study is the pioneer for describing the floristic composition and economic services provided by the recorded plant species in Al-Wahbah Crater northeast Taif Province, Saudi Arabia. Such study is a keystone for further studies, which may help in conserving such unique microhabitat.

Material and Methods

Plant collection

The plant life of Al-Wahbah Crater was surveyed during winter and summer seasons 2019. Plant species were recorded and collected from different sites representing the apparent variation in the vegetation physiognomy in three main habitats (bed, terrace and slope) of Al-Wahbah Crater (Plates 1 and 2). The cover abundance of the recorded species was recorded according to the scale of Braun-Blanquet. The identification and nomenclature of the recorded species were according to Migahid (1996), Chaudhary (2001), Collentette (1999) and Boulos (2009). The Voucher specimens were deposited in Taif University Herbarium.

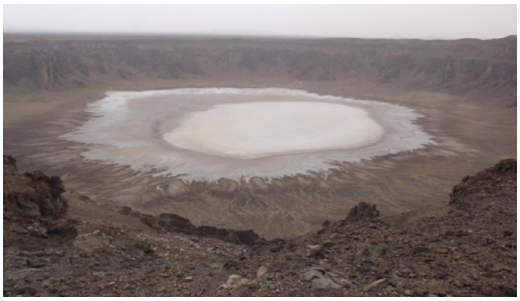

Plate 1. A photograph showing Al-Wahbah Crater in Harrat Kishb, by Hatim Al-Yasi (2019).

Plate 2. Associated vegetation inside Al-Wahbah Crater, by Hatim Al-Yasi (2019).

Vegetation measurements

Life forms of the recorded species in Al-Wahbah Crater were identified following the Raunkiaer scheme (Raunkiaer, 1937) as follows: Ph: phanerophytes, Ch: chamaephytes, He: hemicryptophytes, Ge: geophytes and Th:

therophytes. The actual and relative numbers of species belonging to each life form (biological spectrum) were calculated. The global geographical distribution (Chorology) of the recorded species in Al-Wahbah Crater were gathered from Täckholm (1974), Zohary (1966, 1973), Feinbrun–Dothan (1978, 1986), Wickens (1977) and Boulos (2009). The abundance categories of these species (c: common, r: rare) in the different phytogeographical regions of Saudi Arabia were also indicated. The global distribution (i.e. floristic regions) are coded as follows: In: Indian, IT: Irano-Turanean, ME: Mediterranean, SA: Saharo-Arabian, TR: Tropical, SU: Sudano-Zambezian.

The potential and actual economic services of wild plants recorded in Al-Wahbah Crater were assessed on three bases; field observations, information collected from local inhabitants, and literature review (Täckholm, 1974; Feinbrun–Dothan, 1978, 1986; Boulos, 1983, 1989; Mossa et al., 1987; Mandaville, 1990; Al-Yasi et al., 2019). The economic uses are classified into 5 major categories: grazing, fuel, medicinal uses, human food, and other uses (e.g. ornamental uses, sand binder, soap manufacture and oil and dye extraction…etc.).

Results

Floristic features

Thirty-two species belonging to 28 genera and 20 families were recorded in the different habitats of Al-Wahbah Crater (Table 1). About 75% of the recorded species were perennial, while 25% were annuals. Fabaceae and Zygophyllaceae had the highest contribution (four species), followed by the Brassicaceae and Boraginaceae (three species); and Areaceae and Asteraceae (two species) (Fig. 2). Moreover, 14 families were represented by one species (e.g. Amaranthaceae, Caryophyllaceae and Urticaceae). According to the geographical distribution in Saudi Arabia, nine species representing 28.1% of the recorded species were rare plants, while 23 species (71.9%) were common (Table 1).

Habitat characterization

Three main habitats were recognized in Al-Wahbah Crater: bed of the crater; terrace representing the buffer zone around the crater; and the slope of the crater.

Table 1: Fourteen species representing 43.8% of the total species were recorded in the terrace of the crater, while 17 species (53.1%) were recorded on the slope and 5 species (15.6%) were in the crater bed. It is worth noting that the recorded species (*Sevada schimperi, Moringa peregrina, Salvadora persica, Tetraena simplex* and *Tetraena alba var. alba*) in the crater bed were restricted to this habitat, while 10 species (e.g., *Hyphaene thebaica, Pulicaria jaubertii* and *Monsonia nivea*) were exclusively recorded in the terraces of the crater. Moreover, 13 species were only recorded on the slope of the crater of them were *Farsetia stylosa, Tephrosia purpurea* and *Moricandia sinaica.* According to Braun-Blanquet cover scale, *Hyphaene thebaica* is the dominant in the crater terrace, while *Tetraena alba* var. *alba* represented the dominant in the crater bed, and the slope was dominated with *Phoenix dactylifera, Cenchrus ciliaris* and *Fagonia indica*.

Life form spectrum

The life form spectra of the recorded species in Al-Wahbah Crater indicated the predominance of chamaephytes (31% of the total species), followed by phanerphytes (28%), therophytes (25%), and Geophytes (13%) (Fig. 3). Meanwhile, hemicryptophytes were represented exclusively by one species (*Polycarpaea robbairea*).

Floristic categories

The global phytogeographical distribution of the recorded species in Al-Wahbah Crater indicated the predominance of bioregional elements (53% of the recorded species) over monoregional (31%) and pluriregional (16%) taxa (Fig. 4a). Moreover, Sudano-Zmbezian elements had the highest contribution (87.5%) to the total recorded species, followed by Saharo-Arabian, Medierranean, Irano-Turanian, Indian and Tropical with relative numbers of 62.5, 28.1, 25.0, 18.8 and 3.1, respectively (Fig. 4b).

Economic services

The economic services offered by the recorded species in Al-Wahbah Crater (Fig. 5) indicated that 24 species representing 75.0% of total recorded species were medicinal (e.g., *Hyphaene thebaica, Moringa peregrina* and *Salvadora persica*), while 13 species (40.6%) were grazing (e.g., *Blepharis ciliaris*, *Arnebia hispidissima* and *Acacia asak*) and other 13 species were used as fuel (e.g., *Pulicaria jaubertii, Heliotropium digynum* and *Acacia ehrenbergiana*). In addition, 6 species (18.8%) were edible by man (*Phoenix dactylifera, Schouwia purpurea* and *Maerua crassifolia*).

TABLE 1. Floristic features of the different habitats of Al-Wahbah Crater northeast Taif City.

Species	Life form	Habit	Chrotype	A	Economic service					Habitat		
					M	G	E	F	O	Terrace	Bed	Slope
Acanthaceae												
Blepharis ciliaris (L.) B.L. Burtt.	Ch	Perennial	SA+SZ+IT	c	+	+	-	-	-	2		2
Amaranthaceae												
Aerva javanica (Burm.f.) Juss.ex schult	Ch	Perennial	SA+SZ+TR	c	+	+	-	+	-			
Arecaceae												
Hyphaene thebaica(L.) Mart.	Ph	Perennial	SZ,ME	c	+	-	+	+	+	5		
Phoenix dactylifera L.	Ph	Perennial	SZ+IN	c	+	-	+	+	+			3
Asclepiadaceae												
Pentatropis nivalis (J.F. Gmel.)	Th	Perennial	SA+IT+SZ+IN	a	+	+	-	-	-	1		
Asteraceae												
Rhanterium epappoSZm Oliv.	Th	Annual	IT	c	-	+	-	-	-	2		
Pulicaria jaubertii E.Gamal-Eldin	Ch	Perennial	SZ	c	+	-	-	+	+	2		
Boraginaceae												
Anchusa milleri Willd.	Th	Annual	ME+IT+SA	c						2		
*Arnebia hispidissima*a (Lehm.) A.DC.	Th	Annual	SA+SZ	c	+	+	-	-	+	1		
Heliotropium digynum(Forssk.) Asch.ex. C. Chr.	Th	Annual	SA+SZ	c	+	-	-	+	-	2		
Brassicaceae												
Schouwia purpurea (Forssk.) Schweinf.	Ge	Perennial	SZ	r	-	-	+	-	+			1
Farsetia ramosissima R. BR.	Ch	Perennial	SA+SZ	r	-	+	-	-	-			
Moricandia sinaica (Boiss.) Boiss.	Ge	Perennial	SZ+ME+IN	r	+	-	-	-	-			1
Capparaceae												
Maurea crassifolia Forssk.	Ph	Perennial	ME+IT+SA+SZ	r	+	+	+	+	+			1
Caryophyllaceae												
Polycarpaea robbairea (Kuntze) Greauter & Burdet	He	Perennial	SZ+ME	c	-	+	-	-	-	2		
Chenopodiaceae												
Sevada schimperi Moq.	Ch	Perennial	SZ+ME	r	-	-	-	-	-		4	
Euophorbiaceae												

TABLE 1. Cont.

Species	Life form	Habit	Chrotype	A	Economic service					Habitat		
					M	G	E	F	O	Terrace	Bed	Slope
Euphorbia granulata Forssk.	Th	Annual	SA +SZ	c	+	-	-	-	-	2		
Fabaceae												
Acacia ehrenbergiana	Ph	Perennial	SZ+SA	c	+	+	-	+	+			2
Acacia tortilis	Ph	Perennial	SZ	c	+	+	-	+	+			2
Acacia asak	Ph	Perennial	SZ	c	+	+	-	+	-			2
Tephrosia purpurea (L.) Pers.	Ch	Perennial	SA+SZ	r	-	+	-	-	-			2
Geraniaceae												
Monsonia nivea (Decne.) Decne. ex Webb.	Ge	Perennial	SA+SZ+ME	r	+	-	-	-	-	1		
Malvaceae												
Abutilon pannosum (Forst.f.) Schlecht.	Ch	Perennial	SA+IT+SZ+IN	c	+	+	-	+	-	1		2
Moringaceae												
Moringa peregrine (Forssk.) Fiori	Ph	Perennial	SZ+SA+IN	c	+	-	+	+	+		2	
Nyctaginaceae												
Commicarpus sinicus Meikle	Ph	Perennial	SA+SZ	r	+	+	-	-	-			1
Poaceae												
Cenchrus ciliaris L.	Ge	Perennial	SZ+IN	c	+	-	-	+	+			3
Salvadoraceae												
Salvadora persica L.	Ph	Perennial	SZ+SA+ME	c	+	-	+	+	+		3	
Urticaceae												
Forsskaolea tenacissima L.	Ch	Perennial	SA +SZ	c	-	-	-	-	-	2		2
Zygophyllaceae												
Fagonia tristis Sickenb.	Ch	Perennial	SA+IT	c	+	-	-	-	-			2
Fagonia indica Burm.f.	Ch	Perennial	SA+IT	c	+	-	-	-	-			3
Tetraena simplex	Th	Annual	SA+SZ	C	+	-	-	-	-		2	
Tetraena alba var. alba (L.f.) Beier & Thulin	Th	Annual	SZ+ME	c	+	-	-	-	-		5	
Total species					24	13	6	13	11	14	5	17

- Ch, chamaephytes; He, hemicryptophytes; Ge, geophytes; Ph, phanerophytes; Th, therophytes; SA, Saharo-Arabian; SZ, Sudano-Zambezian; IT, Irano-Turanian; ME, Mediterranean; IN, Indian; TR, Tropical; M, medical; G, grazing; E, edible; F, fuel and O, other uses.
- Cover abundance of the recorded species was according to the scale (1-5) of Braun-Blanquet.

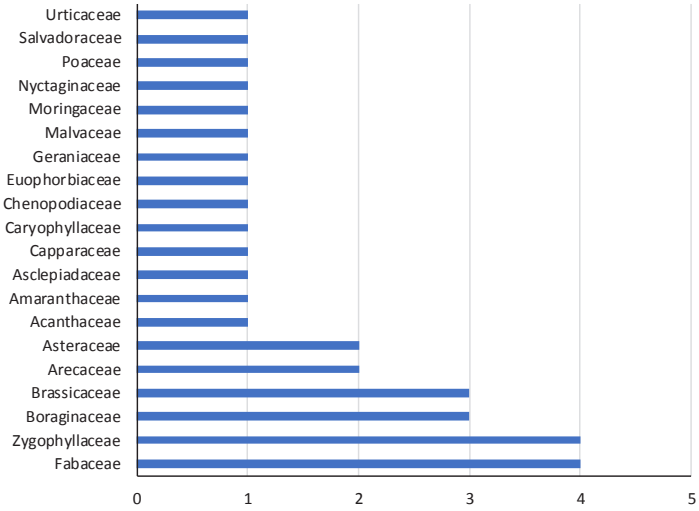

Fig. 2. Number of species in the different families recorded in Al-Wahbah Crater.

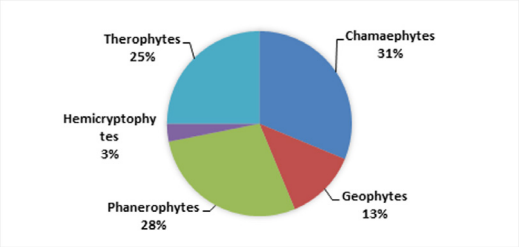

Fig. 3. Life form spectra of the recorded species in Al-Wahbah crater.

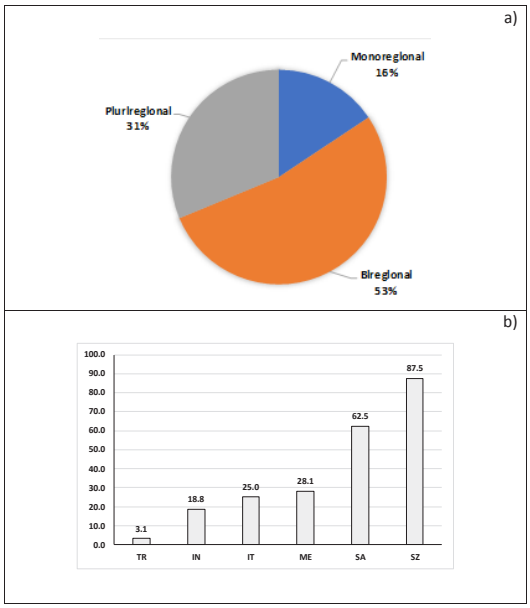

Fig. 4. a) Global phytogeographical distribution; b) Relative number of each phytogegraphical element of the recorded species in Al-Wahbah Crater [SA: Saharo-Arabian; SZ, Sudano-Zambezian; IT: Irano-Turanian; ME: Mediterranean; IN: Indian; TR: Tropical.].

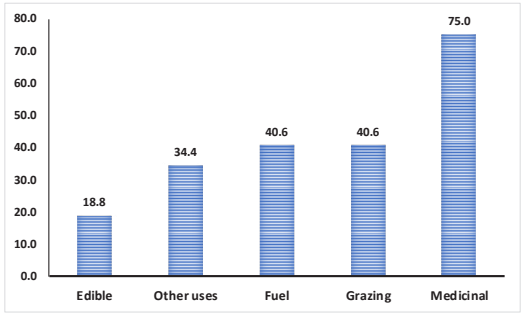

Fig. 5. Economic importance (%) of the recorded plants in Al-Wahbah Crater.

Discussion

Al-Wahbah is the most spectacular of several volcanic explosion craters, found on the lava fields, western Saudi Arabia, which is rimmed with a tuff ring of debris from the explosion (Grainger, 1996). Therefore, the number of recorded species is relatively low recording 32 species belonging to 28 genera and 20 families. However, this number indicated the high species diversity at Al-Wahbah Crater depending on the high number of genera in proportion to species (1.1 species/ genus), which is lower than 1.9 that recorded by Al-Yasi et al. (2019) on Sarrawat Mountains, but a very close figure to 1.3 recorded by Alsherif & Fadl (2016) on Al-Shafa highland at Taif region. According to Al-Sodany et al. (2013, 2014) and Al-Yasi et al. (2019), the area that has a certain number of species, each one belongs to a specific genus, is relatively more diverse than an area with the same number of species belonging to a few number of genera. Consequently, the floristic diversity at Al-Wahbah Crater is the richest among the flora of

several regions in Saudi Arabia (Al-Nafie, 2008; Alsherif & Fadl, 2016; Al-Yasi et al., 2019).

On the contrary of the study of Al-Nafie (2008) on the flora of Saudi Arabia and Alsherif & Fadl (2016) and Al-Yasi et al. (2019) on the flora of Taif region, Fabaceae was dominated over that Asteraceae and Poaceae. This contradiction may be attributed to the extreme conditions of the unique microhabitat of Al-Wahbah Crater. The number of species in the bed of the crater is lower than that recorded on the slope and terrace of the crater. According to Grainger (1996), the center of the crater bed is an ephemeral Salt Lake, which is fed by rare rainfall and is characterized with high salinity and overlaid with chocolate-brown gypsiferous mud, however the crater cliffs are masked by alluvial fans and hence the higher number of plant species. In addition, a localized rainstorm in 1994 had caused mudflows to form at the foot of the crater walls, and wet patches on the Salt Lake indicated that there had been standing water (Abdel Wahab et al., 2017).

The present study recorded 9 species representing 28.1% of the recorded species were rare plants. Although the number of species in Al-Wahbah Crater represents 5.6 % of that recorded by Al-Yasi et al. (2019) on the highlands of Taif region, 15 species were exclusively recorded in the present study and not recorded in other Taif regions. Of these species *Fagonia tristis, Monsonia nivea, Moricandia sinaica, Schouwia purpurea* and *Tetraena simplex*. In addition, the area is dominated with an economic plant species (*Hyphaene thebaica*), where the area is designated as Al-Doom area depending on this species (local inhabitance). This result may be attributed to the extreme conditions, the different climate and the elevation of Al-Wahbah Crater. Therefore, there is an urgent need for conserving such unique habitat with its plant diversity.

The life form spectrum of plants may help in assessing type of vegetation in relation to its environmental (Galal et al., 2012). Chamaephytes were the predominant over the other life forms in Al-Wahbah Crater, which is in a harmony with Taif region (El-Ghanim et al., 2010; Al-Sodany et al., 2016; Al-Yasi et al., 2019) Bisha and Asir region (Heneidy & Bidak, 2001) and southwestern Saudi Arabia (El-Demerdash et al., 1994). Al-Yasi et al. (2019) attributed the dominance of chamaephytes to the hot dry climate, topographic variations and biotic influences, while Zahran (1982) attributed it to the ability of these plants to resist drought, salinity, sand accumulation and grazing. Moreover, the bioregional taxa were dominated over mono- and pluri-regional elements, which may be attributed to the presence interzonal habitats including anthropogenic or hydro-, halo- and psammophilous sites (Galal & Fahmy, 2012). Furthermore, the Sudano-Zambezian and Saharo-Arabian elements were the most dominant chorotypes in accordance with Al-Yasi et al. (2019), who stated that the boundaries of these two regions in Saudi Arabia are very difficult to delimit and ill-defined. According to Zohary (1973), deserts could support Sudano-Zambezian taxa as a result of their hot climate.

Twenty-eight species (87.5% of the total recorded species) have at least one aspect of the potential or actual economic services. Local inhabitants can use 24 species (75.0%) in traditional medicinal, while domestic and wild animals can graze and browse 13 species (40.6%). In addition, other 13 species were used as fuel and the remaining 6 species (18.8%) were eaten by man. According to Al-Yasi et al. (2019), many substances that we use in our daily lives (for example: food, fuel, medicine, etc.) are of plant products. In addition, Heneidy & Bidak (2004) reported that numerous medicinal and industrial products are plant products; most of them are the food base of human culture. Owing to the information resulted produced by the present study, which represents the base for further ecological studies, there is an urgent need for monitoring and conserving Al-Wahbah Crater and the corresponding microhabitats in Saudi Arabia.

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دراسة مبدئية على الصفات الفريدة للتنوع الفلوري في فوهة الوعبة بمنطقة الطائف في المملكة العربية السعودية

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تعتبر فوهة الوعبة أكبر فوهة من الفوهات البازلتية الخمس في المملكة العربية السعودية وهي موطن فريد يعد الأكبر من نوعه في الشرق الأوسط. وهذه الدراسة هي دراسة فريدة من نوعها لأنها تصف التكوين النباتي البري والخدمات الأقتصادية التي تقدمها الأنواع النباتية المسجلة في فوهة الوعبة شمال شرق محافظة الطائف بالمملكة العربية السعودية.

تم تسجيل الأنواع النباتية في هذه الدراسة من خلال مواقع مختلفة على طول ثلاثة موائل رئيسية (منتصف الفوهة واعلى الفوهة ومنحدر الفوهة). وتم تسجيل اثنين وثلاثين نوعًا (7 حوليات و 25 معمرة) تنتمي إلى 28 جنسًا و 20 فصيلة في موائل مختلفة من فوهة الوعبة ، وكان لكل من فصيلتي Fabaceae وZygophyllaceae أعلى تسجيل ، تليها Brassicaceae و Areaceae. تم تسجيل أكبر عدد من الأنواع على منحدر الفوهة ، بينما كان أقلها في العمق (منتصف الفوهة).

كانت نباتات *Hyphaene thebaica* هي السائدة في اعلى الفوهة ، بينما نبات *Tetraena alba* var. *alba* كانت هي السائدة في منتصف فوهة البركان ، وكان المنحدر يسيطر عليه نبات *Phoenix dactylifera*, *Cenchrus ciliaris* and *Fagonia indica*. وتسيدت النباتات الفوق سطحية Chamaephytes على أشكال الحياة الأخرى بالإضافة إلى ذلك سيطرت العناصر البيولوجية الإقليمية على الأصناف أحادية المنطقة والمتعددة المناطق مع هيمنة الاقليم السوداني الزامبيزي (SZ). تمثل النباتات طبية حوالي 75٪ من الأنواع المسجلة في منطقة الدراسة ، بينما 40,6٪ كانت إما نباتات رعوية أو استخدم كوقود و 18,8% كانت نباتات صالحة للأكل. بسبب المعلومات الناتجة عن هذه الدراسة والتي تمثل الأساس لمزيد من الدراسات البيئية ، هناك حاجة ملحة لرصد وحفظ فوهة الوعبة والموائل الصغيرة المميزة (Microhabitats) المشابهة لها في المملكة العربية السعودية.