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PLANT DISTRIBUTION IN JAMADAN MOUNTAIN, SAUDI ARABIA

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Abstract

Granite outcrops occurring as low mountains or oulder-strewn hills are found on the crystalline plates of all continents across a wide range of biomes and climates. The study area was divided into three different habitats: rocky slopes, shallow soil, and surrounding habitats that were surveyed for five consecutive years and related the surveys to the total rain. A total of 81 plant species belonging to 64 genera and 27 families were identified. The Fabaceae, Poaceae, and Amaranthaceae plant families made up 35.8% of the total number of species recorded in the study area. The dendrogram obtained through Ward classification of the recorded fifteen floristic assemblages confirms the high impact of slight precipitation on the floristic composition. Fourteen species of plants were restricted to the granite outcrop, most of which have medicinal importance and are not found in other habitats, which shows that granite outcrops offer comparable kinds of microenvironments. Sudano-Zambesian elements by 31.5% dominate the recorded chorological elements. Due to the existence of numerous microhabitats, the study has shown that Mount Jamadan contains a wide variety of plant species that are distinct from the surrounding habitats. In addition, the study proved that small amounts of rainfall have a strong impact on floristic composition, life forms, and chorotype in the granite outcrops in arid land.

Key words: Arid land, Precipitation; Granite outcrop; Chorotype, Life form.

Introduction

Granite outcrops are classified as habitat islands and are sometimes referred to collectively as inselbergs (Ornduff, 1987). These landforms are relics, frequently of great antiquity, which have retained relief when the surroundings have been eroded to expose bedrock (Campbell, 1997, Bremer & Sander, 2000). Granite outcrops appear as dome-shaped hills or low mountains, disklike pavements, and block or boulder-strewn hills on the crystalline shields of all continents in a range of climates and biomes (Porembski & Barthlott, 2000; Twidale & Vidal Roman, 2005; Migon, 2006). It was reported that environmental conditions on granite outcrops are often challenging for plant life (Szarzynski, 2000), and they can alter dramatically over short distances (Schut *et al*., 2014), resulting in heterogeneity that fosters plant diversity. In granite outcrops, numerous depressions of distinct size and depth occur on peaks and gradual inclines where soil has accumulated. In addition, because ecosystems on or near granite outcrops have both water-gaining and water-shedding locations, they can expand the ranges of mesic species at arid border and arid species at mesic border (Hopper *et al*., 1997; McGann, 2002). As a result, the flora on and around outcrops contribute significantly to regional species richness and serve as crucial conservation focus places. Granite outcrop, for example, make up less than 1% of the surface area in the south-west Australian floristic region but host over 17% of the vascular native flora (Hopper *et al*., 1997).

Saudi Arabia is classed as a desert zone (Kottek *et al*., 2006), its topography is divided into several physiographic zones, which include slopes, valleys, and mountains with very sharp peaks or flat peaks, rocky and sandy deserts, salt flats (Sabkhahs), and lava fields (Harrats). The majority of the Saudi's climate, except for Asir Province, is categorized as "dry climate" in Koppen's classification and as an "arid province" by Thornthwaite (Al-Nafie 2008). Numerous earlier studies (Abulfatih, 1992; ElKady *et al*., 1995; Shaltout & Mady, 1996, Shaltout *et al*., 1997) revealed that the topography of the region and the climatic conditions are the key determinants impacting the degree of speciation. There are many rocky outcrops in the Kingdom of Saudi Arabia, and it is very clear to specialists that their vegetation differs from that of the surrounding area. Due to rising concerns such as mining, grazing, urbanization, water harvesting, and weed invasion, determining patterns of plant diversity on granite inselbergs, as well as their environmental, biogeographical, and spatial correlates, is an essential matter for conservation biogeography worldwide (Porembski *et al*., 2016). Although many studies have been done on granite outcrops in many countries (Eskew, 1938; Rundel, 1975; Ornduff, 1987; Porembski & Barthlott, 2000; Szarzynski, 2000; McGann, 2002; Migon, 2006; Porembski *et al*., 2016), this topic has not yet been studied in Saudi Arabia. The current study had dual aims: (1) Determine the floristic composition of Jamadan mountain and (2) to test the effect of precipitation on the floristic composition, life form, and chorology distribution in the studied area.

Materials and Method

Study area: The Jamadan Mountain lies in Khulais governorate, Saudi Arabia, about a hundred kilometers north of Makkah, at 22° 7' 39.21" N and 39° 17' 39.29" E (Fig. 1a, b), with a maximum elevation of 251 meters. Jabal Jamdan differs by its large area (4 km^2) relatively from the granite rocks in the region, which range in area from 0.26 to 0.9 Km^2. Most Jamdan Mountain's rocks are bare granite, with little to no soil cover and scant vegetation that is mostly confined to narrow fractures or depressions where pockets of fine silt have built up. It is considered a granite outcrop (rocky island), as it is surrounded by a huge amount of sandy land. The soil pockets in Jamdan rocks are rich in silt and clay particles, which may act as a haven for plants that struggle to adapt to the desert. In our earlier publications, we provided a thorough description of the study area's flora (Alsherif *et al*., 2013). The study area is devoid of human activity, as there is no agriculture, industry, or grazing in the area. The average temperature, precipitation, and humidity of the study area for five years are presented in (Table 1). The maximum average temperature ranged from 22.3ºC in January to 34.2ºC in August, and the rainfall was scarce and infrequent. The lowest (46%) and highest (66%) mean monthly relative humidity were recorded in May and September, respectively. Rainfall in the study area is rare and little not more than 100 mm and the total rainfall for some years does not exceed 42 mm (Table 1). Even though every month in the study area was dry, more precipitation fell in 2018 and 2022 than in 2019, 2020, and 2021. As a result, the two years in the current study were referred to as "the wet years," and the remaining years as "the dry years."

Sample collection and vegetation study: Due to the lack of rainfall in the study area and to follow up on the effect of rainfall on flora, the study continued for five consecutive years, from 2018 to 2022. Every year, the area was visited during the rainy season (from October to March). The studied granite outcrop was divided into two habitat types: (a) shallow-soil habitats and (b) rocky slope habitats; in addition, a third habitat was selected: (c) the surrounding area. The last habitat was included for comparison to granite outcrop habitats (Hopper *et al*., 1997). To explore as much topographic diversity as possible within the three habitat types, nine plots at each habitat were selected (Table 2). The size of the plots differed between the three habitats: were 1 × 1 m for habitat (a) and 5 × 5 m for habitats (b) and (c). The different plot sizes were chosen based on the sizes of the species that were most common in each habitat. The plant specimens were recognized and named according to Collentette (1999) and Chaudhary (2001). The life forms of the collected species were determined by the location of the regenerative buds and the portions lost during the unfavorable season (Raunkiaer, 1934). The biogeographic affinities of the species were determined according to Zohary (1973).

Statistical analysis

We assessed floristic similarities among different floristic assemblages during the five years by performing a hierarchical classification analysis based on presence/absence data with Wards' (minimum variance) method and Euclidean distances as a dissimilarity measure (Ward, 2012). Statistica statistical software version 8 (StatSoft, Inc., Tulsa, OK, USA) was used to conduct the analysis.

Table 1. Averages of monthly temperature, rainfall (mm)and humidity (%) of the studied area. Data obtained from Department of Hydrology, Ministry of Agriculture and Water, Riyadh.

	Aver. Temp.					Precipitation (mm)					Relative humidity (%)				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
January	23.8	25	22.3	25.7	24.6	0	30	0	23.6	0	47	61	46	55	46
February	25.9	24.9	23.6	25	24.6	0.001	0	1	7	1.2	54	52	53	52	55
March	27.5	24.9	25.3	27.5	26.8	3	0	6.2	0	0	56	50	55	53	56
April	28.8	28	27.8	27.6	25.9	0	0	0	4	0	52	50	53	57	53
May	32.5	32.5	31.2	30	29.7	1.8	1	0	0	3.6	45	46	49	55	49
June	32.9	34.1	32.3	30.9	30	0	1.5	0	0	0	52	47	52	55	53
July	33.9	34	33.6	32	31.5	0	0	2	0	0	51	48	49	56	51
August	33.9	34	34.2	32.1	32.1	0	0	0	0	0	54	54	52	62	55
September	33	32.3	33.9	31.1	30.8	0	0	0	0	0	64	64	58	66	62
October	31.1	31.5	32.4	29.6	28.9	8.8	2.8	3.8	3	19.2	59	59	49	65	60
November	27.6	29	28.8	27.1	28.9	70.8	0	19	2	59	54	55	57	63	61
December	25.7	25.6	26.6	24.7	24.3	2	0.001	8	15	95	58	52	53	61	59

Table 2. The GPS coordinates of the surveyed plots.

Sites	Shallow-soil habitats	Rocky slope habitats	Surrounding area
1	22° 7'49.95"N 39°18'5.05"E	22° 7'48.07"N 39°17'59.37"E	22° 8'0.49"N 39°16'39.85"E
2	22° 7'43.02"N 39°17'54.50"E	22° 7'45.02"N 39°17'58.94"E	22° 6'47.71"N 39°16'23.20"E
3	22° 7'53.84"N 39°18'8.30"E	22° 7'38.15"N 39°17'53.51"E	22° 8'17.54"N 39°18'1.36"E
4	22° 8'12.79"N 39°17'41.27"E	22° 7'40.56"N 39°17'49.16"E	22° 6'32.81"N 39°16'37.55"E
5	22° 7'25.22"N 39°16'57.20"E	22° 7'36.96"N 39°17'44.60"E	22° 6'37.91"N 39°16'40.71"E
6	22° 7'17.49"N 39°17'2.39"E	22° 7'26.81"N 39°17'36.27"E	22° 6'6.97"N 39°18'11.35"E
7	22° 7'46.12"N 39°17'16.54"E	22° 7'33.90"N 39°16'57.22"E	22° 8'22.60"N 39°18'20.60"E
8	22° 8'12.60"N 39°17'12.33"E	22° 8'7.55"N 39°17'6.18"E	22° 5'46.07"N 39°16'46.90"E
9	22° 7'25.15"N 39°17'29.99"E	22° 7'2.83"N 39°17'1.81"E	22° 8'45.42"N 39°17'35.51"E

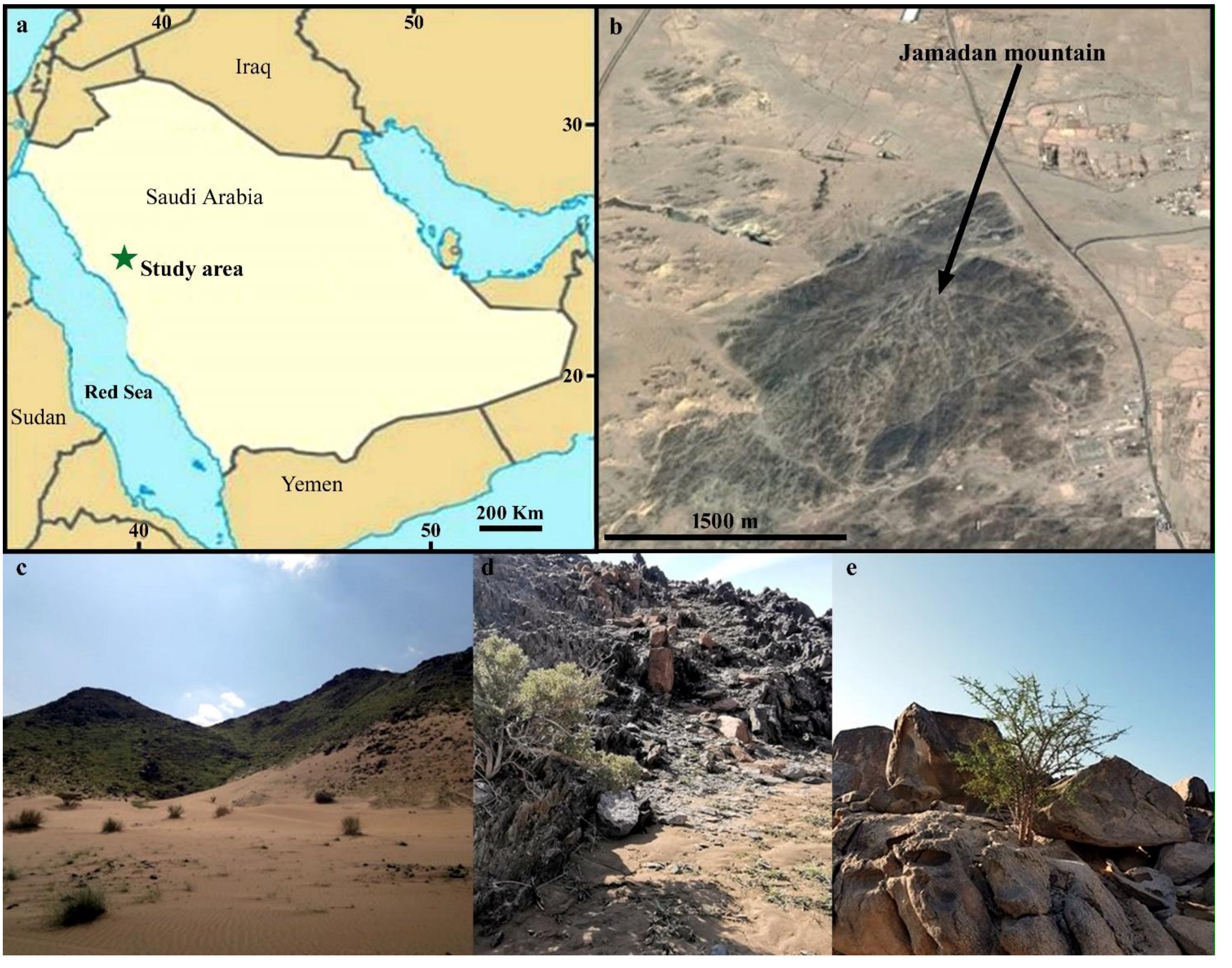

Fig. 1. Location map of the study area (a), aerial view of the study area (b), Lateral view of the study area (c), rocky slope and shallow soil habitats (d) and *C. gileadensis* tree, important medical species, (e).

Results

Vegetation of the different habitats

Vegetation of the rocky habitat: On the rocky habitat, there are several little shrubby trees that are entirely devoid of leaves. When it rains, there is a great flush of plant growth; many previously dry plants become recognized, while others that were before hidden emerge. Small trees that are scattered across the stony slopes, which were previously nearly undetectable in their dry, leafless state, now stand out and become green. The most prevalent tree is *Senegalia hamulosa*, and *Maerua oblongifolia* is also frequently present. *Commiphora gileadensis*, a tiny tree with highly scented leaves, is also frequently present, as is *Euphorbia cuneata*. But the annual and perennial herb vegetation have undergone the most obvious modifications. Green tinges appear, especially *Stipa capensis*, which grows up between the rocks and is widely distributed.

Vegetation of deep soil habitat: *Farsetia longisiliqua*, *Colocynthis vulgaris*, *Cenchrus ciliaris*, and *Pergularia tomentosa* are some typical plants of this habitat. In the deep soil habitat, the evergreen shrub *Cadaba glandulosa* can be seen rarely in flower throughout the year and is particularly common in some of the drainage lines. The distinctive plants of this habitat, *Abutilon pannosum* and *A. fruticosum*, can be found with green leaves and even bloom well into the dry season. The muddy gullies are obstructed by *Panicum turgidum* tussocks. Rarely does the *Panicum* entirely dry up.

Vegetation of the crop surrounding habitat: However, there is a heavily interrupted fringe made up of *Calotropis procera*, *Leptadenia pyrotechnica*, as well as the typical *Acacia* species. On enormous sand mounds, *Pennisetum setaceum*, *Rhazya stricta*, *Aerva javanica*, and other herbs thrive on beds of finer silt. The *Cleome pallida*-*Panicum turgidum* association grows on the plain where floodwater produces a deep, dusty alluvium, albeit it is much less well-developed and confined than on the coastal plain. Alluvial channels are surrounded by *Tamarix nilotica*, which may have been planted, and they also contain *Haloxylon salicornicum*, a plant that is uncommon in the tropics and absent from the coastal plain. Except for the salt shrubs *Haloxylon* and *Salsola*, which indicate that the rainfall is not sufficient for the establishment of the *Acacia tortilis* association, the desert is exceedingly arid beyond the flood's boundary.

Floristic composition and their distribution: A total of 81 plant species belonging to 64 genera and 27 families were identified (Appendix-1). The main plant families present in the study area were Fabaceae (11 species), followed by Poaceae and Amaranthaceae (9 species for each), representing 32.9% of the total number of species recorded in the study, while eleven families were represented by only one species. It is noted that the number of plant species found in the three habitats varied with the different years of study (Fig. 2). The highest numbers of species were recorded in the wet years of 2018 and 2022, indicating that species richness is directly proportional to the amount of precipitation throughout the year. Although the difference between wet and dry years is not significant and the study area is very dry in all years of the study, the number of plant species found in the shallow soil habitat was greater than that recorded in the surrounding habitat during the wet years 2018 and 2022 and vice versa. Rocky habitats exhibit 14 species of plants, most of which have medicinal importance and are not found in other habitats. The most important are *Commiphora gileadensis*, *Lavandula coronopifolia*, *Euphorbia cuneata*, and *Lycium shawii*. Regarding the variation in species numbers during the study period, shallow soil habitat showed the highest numbers in the two wet years, 2018 and 2022 (Fig. 2). In contrast, the same habitat exhibited the lowest species numbers during the dry three years, while rocky and surrounding habitats showed constant numbers in the lower rainy years.

N-fixing species exhibited the highest species number in rocky-slope habitat during the wet years. *Acacia tortilis* and *Indigofera spinosa* were the more frequent species in all floristic assemblages. Six N-fixing species were recorded in surrounding habitats, while only one species, *Acacia hamulosa*, were recorded in shallow soil habitat (Fig. 3). All floristic assemblages generally contained twelve succulent species, with the surrounding habitat having the most species (10), the shallow soil habitat having the second-highest number of species (6), and the rocky, sloping habitat having the fewest species (3). The previously distributed ranking of succulent plants was recorded in all habitats; in addition, species numbers in all habitats increased with increasing precipitation (Fig. 3).

Classification of the obtained floristic assemblages: The fifteen assemblages obtained during the study period in the three different habitats were divided into two main groups (Fig. 4). The first group includes only four assemblages representing shallow soil habitat and surrounding habitats in the wet years 2018 and 2022. The second group included the other 11 assemblages, which were represented in the three dry years. Interestingly, the first group was subdivided into two subgroups separating deep soil crack habitats from the surrounding habitats, while the second group was subdivided into two subgroups separating rocky habitat assemblages from the other two habitats (Fig. 4). The previous classification of the flora assemblages showed the importance of rain, although its little amount, because the first grouping was based on wet habitat and the subgrouping was based on the habitat type.

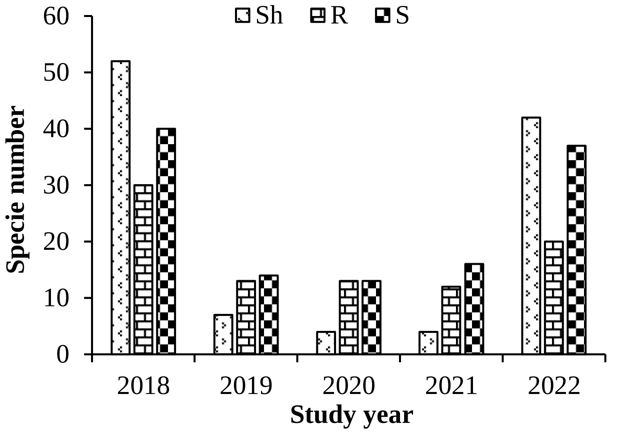

Fig. 2. Species numbers recorded in the different habitats during the study period. Sh: shallow soil habitat, R: rocky habitat and S: surrounding habitat.

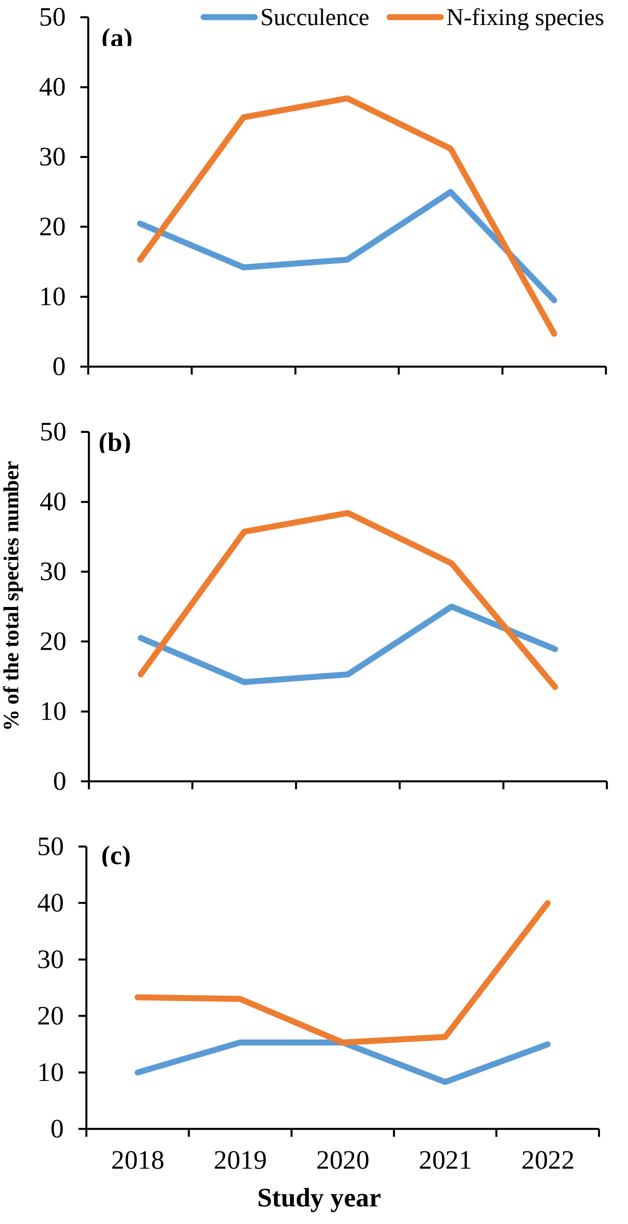

Fig. 3. Percentages of nitrogen-fixing and succulent species in the different habitats during the study period. (a) Surrounding habitat (b) Shallow soil habitat (c) Rocky habitat.

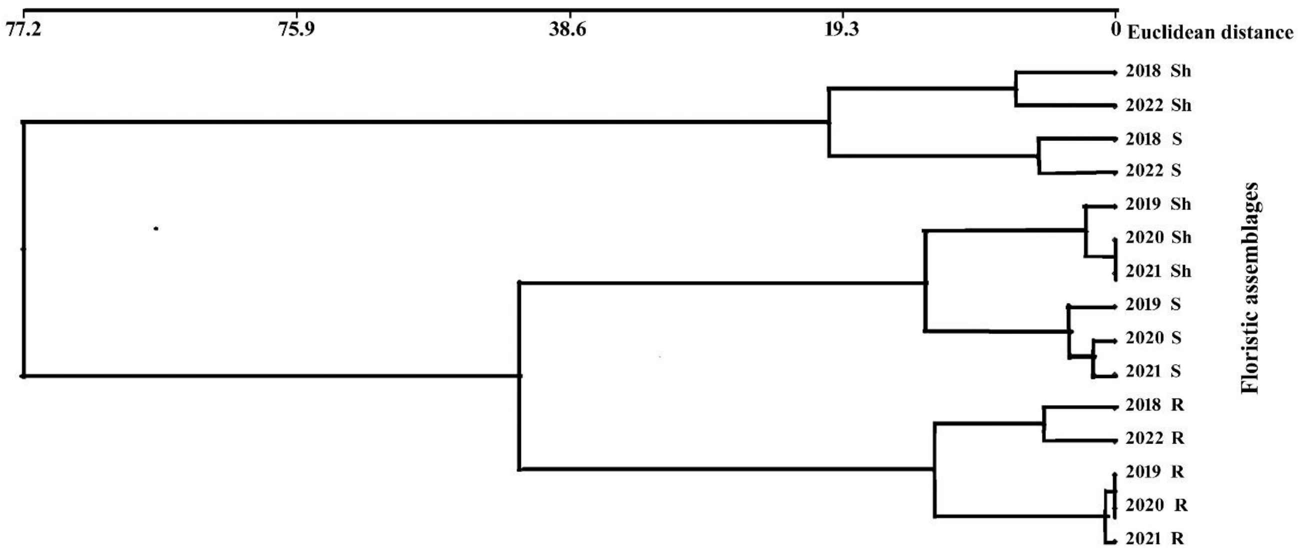

Fig. 4. Hierarchical classification of the different habitats based on their floristic composition (incidence data), obtained using Ward's method and Euclidean distances as measures of Linkage Distance. Sh: shallow soil habitat, R: rocky habitat and S: surrounding habitat.

Table 3. The proportion of the main chorological elements in the different habitats during the studied period.

	2018			**2019**			**2020**			**2021**			**2022**		
	39	**56**	**30**	**14**	**6**	**13**	**13**	**4**	**13**	**16**	**4**	**12**	**37**	**42**	**20**
	M	**D**	**R**	**M**	**D**	**R**	**M**	**D**	**R**	**M**	**D**	**R**	**M**	**D**	**R**
SA	0.33	0.25	0.13	0.14	0.17	0.15	0.15	0.25	0.15	0.19	0.25	0.17	0.30	0.33	0.15
SZ	0.33	0.27	0.33	0.50	0.67	0.31	0.46	0.50	0.31	0.38	0.00	0.25	0.38	0.33	0.30
SA +SZ	0.10	0.09	0.30	0.14	0.17	0.31	0.15	0.00	0.31	0.13	0.50	0.33	0.19	0.07	0.25
TR	0.08	0.11	0.13	0.07	0.00	0.08	0.08	0.00	0.08	0.00	0.00	0.08	0.08	0.14	0.15
IT	0.08	0.00	0.03	0.21	0.17	0.08	0.08	0.25	0.08	0.13	0.25	0.08	0.05	0.02	0.05
Cosm	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.00

SA: Saharo-Arabian; SZ: Sudano- Zambezian; SA + SZ: Saharo-Arabian/ Sudano- Zambezian; TR: Tropical; IT: Irano-Turanian

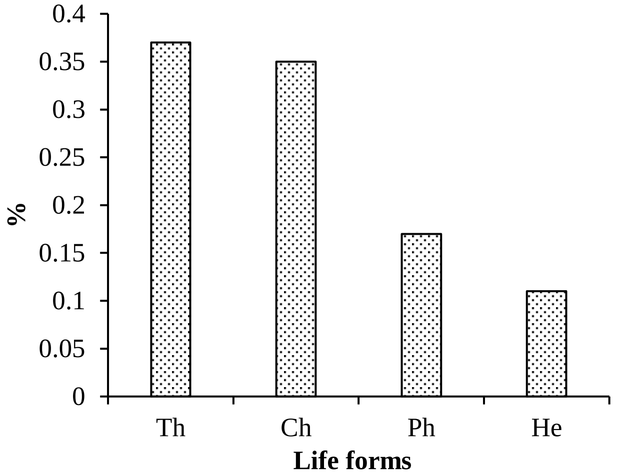

Fig. 5. Total life form of the study area. Th: therophytes, Ch: Chamaephytes, Ph: phanerophytes and He: Hemicryptophytes.

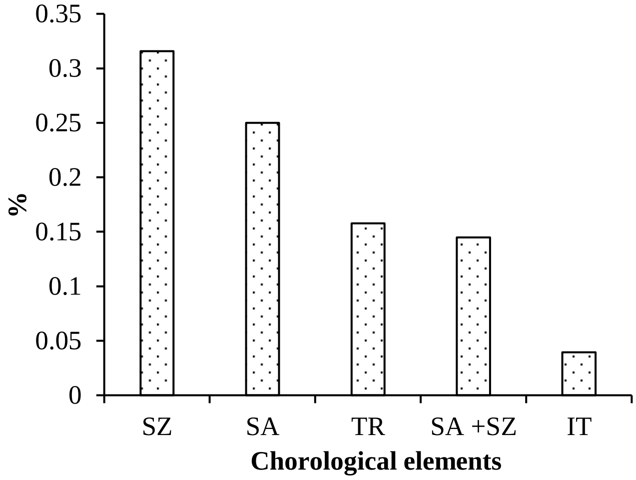

Fig. 7. Main chorological elements percentages in the studied area. SA: Saharo-Arabian; SZ: Sudano- Zambezian; SA + SZ: Saharo-Arabian/ Sudano- Zambezian; TR: Tropical; IT: Irano-Turanian.

Life forms: Four life forms were recorded in the study area: therophytes, chamerophytes, phanerophytes, and hemicryptophytes. Generally, the therophytes dominated the others by 37 %, while chamerophytes exhibited 35% of the recorded life forms (Fig. 5). Unexpectedly, compared to their record in the previous study (Al-Sharif *et al*., 2013; Al-Sharif & Al-Maghrabi, 2022) in the region, phanerophytes recorded 17%, while hemicryptophytes recorded the lowest ratio with 11%. (Fig. 6) shows the distribution of the different life forms in all assemblages through the study period. Chaemophyts life form dominated the surrounding habitat followed by therophytes; in addition, therophytes competed with chaemophytes in the two rainy years and equaled them in the dry three years. Rocky sloping habitat was dominated by Phanerophytes in all periods of study except the first year, while hemicryptophytes show the lowest proportions in the most floristic assemblages.

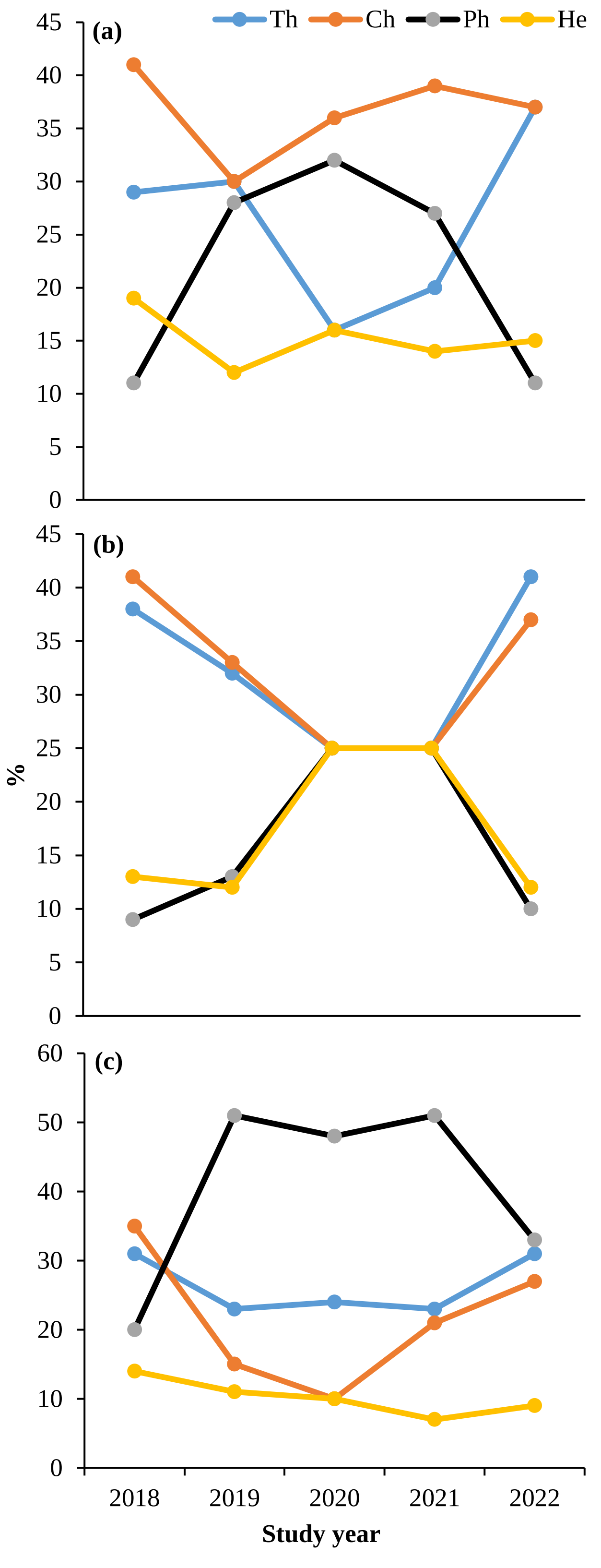

Fig. 6. Life form percentage in the different habitats during the study period, (a) Surrounding habitat (b) Shallow soil habitat (c) Rocky habitat. Th: therophytes, Ch: Chamaephytes, Ph: phanerophytes and He: Hemicryptophytes.

Chorological affinities: Figure (7) displays the findings of the detailed chorological investigation of the sampled flora. The monoregional species dominate the studied area by 76.3%, where Sudano-Zambesian elements alone represented 31.5% of the total recorded species, followed by the Saharo-Arab elements (by 25%). Approximately 19% of the sampled species were biregional, with their distributions extending across the Saharo-Sindian, Sudano-Zambesian, and Mediterranean regions. Cosmopolitan, American, and paleotropical elements were represented by only one species for each. The total amount of precipitation affected not only the number of chorological elements but also their proportion in different habitats during the period of study (Table 3) shows that the proportion of the Saharo-Arabian elements increased in the surrounding habitat and decreased in rocky slopy habitat with increasing precipitation. In addition, the biregional elements, Sudano-Zambezian / Saharo-Arabian showed the same trend as the monoregional elements, Sudano-Zambezian. In contrast, the proportion of both Sudano-Zambezian and Irano-Turanian elements decreased with increasing precipitation.

Discussion

The current study showed that only three families (11%) make up the 32.9% of plant species in the studied area. This is a characteristic of desert flora and is thought to be a sign that just a small number of the numerous species that are members of these ancient plant families have adapted to and survived in this harsh climate, while other species that were unable to do so have gone extinct. This result is in line with the results of previous studies that confirmed that the Poaceae and Fabaceae are the largest families in the Flora of Saudi Arabia (Collentte, 1999; Alsherif *et al*., 2013). Amaranthaceae recorded high species number because seven species previously belonged to Chenopodiaceae and now it now added to Amaranthaceae. In contrast to the results of previous studies of the area surrounding the current study area, the number of plant species belonging to the family Fabaceae in this study is higher than the number of plant species belonging to the family Poaceae, which could be attributed to the fact that Fabaceae has a wider variety of root functional strategies than Poaceae and exhibits a wide range of root trait plasticity in response to water availability levels (Fort *et al*., 2015). Previous studies (Fort *et al*., 2012; 2014) showed that Fabaceae family possess many significant trade-offs between various resource management and soil exploration tactics that lead to this variety. The larger species number for Fabaceae and Poaceae could be due to their broad ecological tolerance range and effective seed dispersal capacity. Small topographical depressions have formed soil on these rocks, and plants have grown there in a known pattern of primary succession (Smith, 1941; Shure & Ragsdale, 1977). According to Shurr & Ragsdale (1977), soil is initially relatively shallow, nutrient-poor, and has a low capacity to hold water. Unique plant communities, including several endemic or nearly endemic species, can be found in outcrop soils (Baskin & Baskin, 1988). It was documented that plant biodiversity tends to rise as depressions become more mature soil and as soil fertility rises (Suhre & Ragsdale, 1977), which explains the presence of more plant species in the shallow soil habitat than in the rocky habitat. Conversely, in dry years, the number of plant species found in the cracks of rocks is greater than the number of plant species found in shallow soil because the first habitat contains larger quantities of water (Suhre & Ragsdale, 1977), is protected from direct sunlight, or because water vapor condenses on the rocks and falls into the cracks. One notable feature of Saudi Arabia's flora is that the majority of plant species are members of a small number of plant families (Al-Nafie, 2008). Eleven families (40.7%) out of the 27 families in the current study were represented by one species. The fact that only a small number of the largest plant family's species are able to adapt and survive is a common characteristic of desert flora and is thought to be an indicator of plant adaptation to a xeric environment (Al-Nafie, 2008).

The herbaceous N-fixers *Astragalus vogelii* and *Indigofera spinosa*, which were present in 66% of the floristic assemblages, demonstrate how fast-growing N-fixers can complete their life cycles with little competition and plenty of resources. Previously it was reported that plant species having features linked to high water usage efficiency will have an advantage over their rivals, such as N-fixing legumes (Reich *et al*., 2014). The presence of succulent plants in reasonable proportions in different environments may be due to besides being able to store water internally, succulents have a higher water use efficiency than other plant functional types (Mort *et al*., 2007). In addition, it was documented that succulent does not provide a competitive advantage over other functional features with excessive precipitation, for instance in the constantly wet laurel forest, because storing water is uneconomical if there is an abundance of it (Teeri *et al*., 1978).

The little change in the amount of rainfall caused a significant change in the proportion of life forms in the different habitats. According to Cooper (1961), there are links between the distribution and significance of life-forms and minor variations in local climate, just as there are relationships between life-forms and the planet's major climatic zones. These microenvironments are similar in that they include increased local relief, barren to semi-barren surfaces, and low moisture retaining capacity of the shallow soil over granite (Suhre & Ragsdale, 1977).

Wild plants may be genetically related to domesticated crops since they frequently have common ancestors with such crops known as CWR. CWR is "a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop," according to Maxted *et al*., (2006). In order to meet the worldwide problems of climate change, breeders need to conserve and use crop wild cousins, since they offer rich genetic resources for the development of innovative crop varieties with increased crop yield, quality, etc. Put another way, CWRs are the precious genes that are hidden away in the world of plants. Many of the plant species found in Jamdan mountain are medicinal plants, such as or crop rootstocks, such as: *Cymbopogon schoenanthus, Commiphora gileadensis, Rumex vesicarius L, Aizoon canariense,* and *Calotropis procera*. On the other hand, many plant species recorded in the present studies are wild crop relatives such as *Corchorus depressus, Indigofera spinosa, Tephorosia apollineae* and *Cenchrus ciliaris*.

Therophytes dominate the life-form spectrum in the current study, which supports the theory put forth by Dechenes (1969) that arid climate, excessive grazing, and trampling, all of which are inclined to increase the proportion of therophytes via the introduction and spread of weedy therophyte grasses and forbs. Barbero *et al*., (1990) also claim that human activities are to blame for the therophytes' high prevalence. Unsurprisingly, therophytes (annuals and biennials) make up 37% of the species in the studied area. They typically blossom and develop opulent growth in surrounding and shallow soil habitats. The biggest number of species was found in Sudano-Zambesian followed by Saharo-Arabian elements because plant species there typically adapt to aridity and extremely high temperatures in such hard environments. Saudi Arabia is a part of the Nubo-Sindian Province, which is a part of the Sudanian Region (Zohary, 1973), or the Nubo-Sindian local center of endemism, which belongs to the Saharo-Sindian regional zone. In dry areas, chamaephytes are known to predominate (Körner, 2003), due to these traits, chamaephytes can finish their life cycle even during the brief growing seasons that occur after rainfall (Vogiatzakis *et al*., 2003, Pellissier *et al*., 2010). This backs up Danin & Orshan's (1990) observation that chamaephytes can endure dryness and harsh light better. Additionally, the prevalence of chamaephytes, which herds avoid, is a result of overgrazing worldwide. Chamephytes, which make up 31 species (or 49%) of plants, are also widely represented due to the variety of ways they may adapt to drought. As a result, the amount of leaf surface decreases, and a strong root system develops. The process of aridification would suit chamaephytes nicely (Orshan *et al*., 1984; Floret *et al*., 1990).

The obtained dendrogram from Ward classification showed that the little change in precipitation led to a big change in floristic composition. This is clear from the fact that the division was based on the difference in the amount of rainfall at first and then based on the type of habitat. It was reported that in arid regions, the correlation between vegetation and precipitation is higher than in wet regions (Fang *et al*., 2005; Piao *et al*., 2006). Fang *et al*., (2005) who reported that with increasing precipitation frequency, the vegetation cover response to precipitation became less important. In addition, Piao *et al*., (2006) reported that high moisture conditions cause the vegetative response to precipitation to become less responsive. Furthermore, in arid and semi-arid ecosystems, Weiss *et al*., (2004) and, subsequently, He (2014) discovered significant connections between patterns of vegetation and climate variability. Similar results have been recorded in several arid regions all over the world. For instance, in the semi-arid and arid areas of the African Sahel, Fensholt *et al*., (2013) found that the vegetation was very sensitive to the amount of precipitation. These findings support Sohoulande *et al*.'s (2014) report that there was a significant correlation between total precipitation amounts and incident frequencies in the southwest of the United States. In addition, the same results recently obtained by Jia *et al*., (2024) in China.

Conclusion and Recommendation

The present results may be useful for future planning of water resources and ecosystem management in arid and semi-arid regions. The Jamdan Mountain is home to a wide variety of economically valuable plants, including wild crop relatives and medicinal plants. The increasing drought and lack of rain are putting these plants in danger of going extinct. Consequently, the study advises being mindful of Jamdan Mountain's wild flora, particularly in light of the effects of climate change.

Appendix 1. Frequencies of the plant species recorded in the studied area with their families, life forms and chorotypes.

Families	Species	Life form	Chorotype
Acanthaceae	*Blepharis attenuate* Napper	Th	SZ
	Ecbolium gymnostachyum (Nees) Milne-Redh	Th	SZ
	Justicia adhatoda L.	Ph	TR
	Odontanthera radians (Forssk.) D.V. Field	Ch	TR
	Peristrophe aculeata (C.B. Clarke) Brummitt	Th	SA +D
Aizoaceae	*Aizoon canariense* L.	Th	SZ
	Zaleya pentandra (L.) C. Jeffrey	Th	SZ
	Trianthema sedifolia Visiani	Ch	Am
	Gisekia phranaceoides L.	Th	TR
Amaranthaceae	*Aerva javanica* (Burm. f.) Juss. ex Schul.	Th	SZ
	Amaranthus sp.		
	Anabasis setifera Moq.	Ch	SA
	Atriplex sp.	Ph	SA
	Haloxylon scoparium Pomel	Ch	IT
	Salsola imbericata Forssk.	Th	IT
	Suaeda monica Frossk.ex J.F. Gmel.	Ch	SU
	Sueda vermiculata Forssk. ex J.F. Gmel.	Ch	SA
	Salsola spinescens Moq.	Ch	Cosm
Asclepiedaceae	*Calotropis procera* (Aiton) W.T.Aiton	Ph	SZ
	Leptadenia pyrotechnica (Forssk.) Decne.	Ph	SA+SZ
	Pergularia tomentosa L.	Ch	SA+SZ
Asteraceae	*Pulicaria schimperi* DC.	TH	TR
	Sida rhambifolia L.	Th	TR
Boraginaceae	*Heliotropium bacciferum* Forssk.	Ch	SA+SZ
Brassicaceae	*Farsetia longisiliqua* Decne	Ch	SZ
	Morettia canescens Boiss.	Ch	Me
Burseraceae	*Commiphora gileadensis* (L.) C.Chr.	Ph	SA+SZ
Capparaceae	*Cadaba longifolia* Dc.	Ch	SZ
	Cadaba farinosa Frossk.	Ch	SZ
	Cadaba glandulosa Frossk.	Ph	TR
	Capparis decidua (Forssk.) Edgew.	Ph	SA +SU
	Diptergium glaucum Decne.	Th	SZ
	Maerua oblongifolia (Forssk.) A. Rich.	He	SZ
Cleomaceae	*Cleome brachycarpa* DC.	Ch	SA
	Cleome droserfolia (Forssk.) Delile	Ch	SZ
	Cleome scaposa DC.	Th	TR
	Convolvulus sp.	Th	SA
Convolvulaceae	*Convolvulus deserti* Hochst. & Steud.	Ch	SA
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Th	SA
Euphorbiacea	*Chrozophora brocchiana* Vis.	Ch	SU
	Euphorbia cuneata Vahl	Ph	SU
	Euphorbia arabica T. Anderson	Th	SZ
Fabaceae	*Acacia ehrenbergiana* (Forssk.) Hayne	PH	SZ
	Acacia hamulosa Benth.	PH	SZ
	Acacia tortilis (Forssk.) Hayne	Ph	SZ
	Astragalus vogelii (Webb) Bornm.	Th	SA
	Crotalaria microphylla Vahl	Th	SA+SU
	Indigofera spinosa Frossk	Th	SZ
	Prosopis Juliflora (Sw.) DC.	Ph	SA
	Rhynchosia minima (L.) DC	Ch	SU
	Senna italica Mill.	Ch	SZ
	Tephorosia apollineae (Delile) DC.	Ch	SZ
	Tephrosia nubica (Boiss.) Baker	Th	SA

Appendix 1. (Cont'd.).

Families	Species	Life form	Chorotype
Lamiaceae	*Lavandula coronopifolia* Poir.	Ch	SA+ SZ
Malvaceae	*Abutilon pannosum* (G. Forst.) Schltdl.	Ch	TR
	Sida rhambifolia L.	Th	TR
Menispermaceae	*Cocculus pendulus* (J.R. & G. Forst.) Diels	Ch	Pal
Poaceae	*Bromus* sp.	He	ME+IT
	Cenchrus ciliaris L.	He	SA+SZ
	Cymbopogon schoenanthus (L.) Spreng.	Th	SA
	Lasiurus hirsutus (Forssk.)	He	SZ
	Panicum turgidum Forssk.	He	SA
	Pennisetum divisum (J.F. Gmel.) Henrard	He	SA
	Sorghum halepense	Th	TR
	Stipa capensis Thunb.	He	IT
	Stipagrostis plumosa (L.) Mun. ex T. And.	He	IT+SA
Polygonaceae	*Polygala erioptera DC*	Th	SA
	Rumex vesicarius L.	Th	SA
Molluginaceae	*Limeum indicum* Stocks ex T. Anderson	Th	SA
Resedaceae	*Ochradenus baccatus* Del.	He	SA
Plantaginaceae	*Schweinfurthia pterosperma* A. Braun	Th	SA
Solanaceae	*Lycium shawii* Roem. & Schult.	Ph	SA+SZ
Tiliaceae	*Corchorus depressus* (L.) Stocks	Ch	ME+SA
	Grewia tenax (Forssk.) Fiori	Ph	SA+SZ
	Forsskaolea tenacissima L	Ch	SA+SU
Zygophyllaceae	*Fagonia indica* Burm. f.	Ch	SA
	Fagonia mollis Delile.	Ch	SA
	Tribulus macropterus Boiss.	TH	SZ
	Tribulus terrestris L.	Th	ME+SZ
	Zygophyllum simplex L.	Ch	SA
Cistaceae	*Helianthemum lippii* L.	Th	SA

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