Life-forms and Chorotypes of Succulent plants of Al-Dale'a Governorate, Yemen

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Abstract

The present study was carried out during the years 2015- 2019, deals with the floristic composition of the flora, life forms and phytogeographical affinities of Succulent plants of Adhale Governorate, Yemen., The succulent flora of the study area consisted of 104 succulent taxa belonging to 52 genera and 29 families. Life form of study area, was dominated Chamaephytes with the maximum number of species they were represented by 46species (44.23%), followed by Phanerophytes represented by 29 species (27.88%), Geophytes represented by 13species (12.5%), Hemicryptophytes represented by 9 species (8.65%) Therophytes represented by 6 species (5.7%) and 1 parasite (0.96%). From the chronological point of view, the largest proportion of the succulent flora belongs to Monoregional constituting 77.8% (81) of species is native to the Sudano-Zambenzian phytochoria. The second dominant phytochoria was Bi-Regional constitute (11.46 %) "Sudano-Zambenzian + Saharo-Sindian (11 sp. 10.5%) and Sudano-Zambenzian + Mediterranian (1 sp., 0.96%), while Plueriregional comprises (11sp.; 10.57%) "The Tri-Regional element "Sud-Zam +Sah-Sin+ Med, 3 sp. Cosm. 5 sp.; Trop. 2 sp.; Pan. 1 sp. Results also revealed that 41 taxa (39.4%) are endemic, (among them are 21 taxa (20.19%) which were endemic to Yemen alone, while the remaining (19.23%) are near endemic.

Keywords: Succulent, life-forms, phytogeographical affinities, Endemic, Adhale, Yemen.

1.Introduction:

The Republic of Yemen is located in the southwestern corner of the Arabian Peninsula. It extends between latitudes 12°40` to 19°00` N. and longitudes 42°30` to 53°05` E. It is bordered by the Kingdom of Saudi Arabia from the north, the Arabian Sea and the Gulf of Aden from the south, the Sultanate of Oman from the east, and the Red Sea from the west. The flora of Yemen is characterized by its high diversity and density, particularly, in the South and West regions. Furthermore, the related flora of this region has affinities with the floras of the Tropical African, Sudanese region, the Saharo-Arabian region, the Mediterranean countries and the Irano-Turanian region (13، 60 ، 2). The flora of Yemen is extremely rich and diverse. Species diversity is a result of considerable climatic changes in former periods, which enabled different species to survive in the different ecological habitats. Previous studies reported approximately 2838 plant species belonging to 1068 genera within 179 families (18 ، 61 ، 59 ، 42 ، 43 ، 15 ، 47، 6 ، 7 ، 8 ، 9).The area of the present study is located in the South west part of the Yemeni western high lands. It lays between longitudinal range "44º: 28:00 to 45^0:9:30 East and latitudinal range between(13^0: 31:30 to 14^0: 12-30North".It is bordered by Ibb and Al-Beyeda from the north. Ibb and Taiz from the west. Lahj and Al-Beyeda from the east, Lahej from the south. The center of the governorate lays 245 km South of Sana'a, the capital of Yemen. The study area consist of nine Districts: AL-Ddale'a, Qataba, Damt, Al- Huseen, Al-Husha, Al-Shuaib, Guban, Jihaf and Al-Azareq **(Fig. 1).**

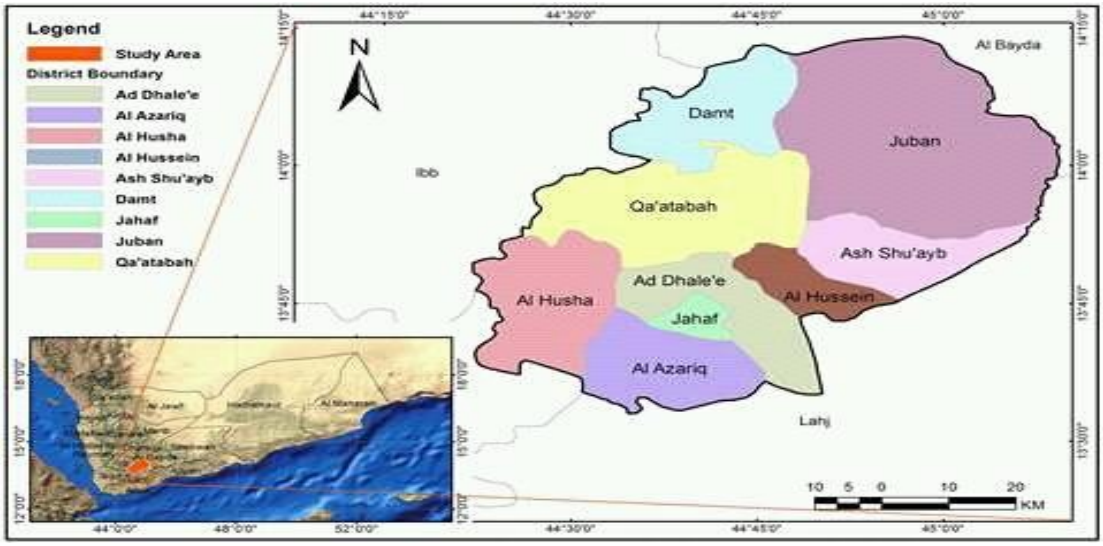

Figure 1. Location of the study area and its Districts

The present study aims at carrying out a comprehensive survey of the natural succulent flora of the study area, as well as analyzing the floristic composition. Furthermore, an annotated checklist is given in a step towards a thorough understanding of the succulent flora of Yemen.

2.Materials & Methods

The field studies were carried out through several trips during the different seasons in the period 2015-2019, in order to study the succulent flora of the Al-Dale'a governorate. The specimens collected include flowers and fruits, in addition to the leaves and stems (plants of small or moderate size, herbs and small shrubs), which were dug up carefully and the complete plant collected,included the underground succulent parts (roots, rhizomes, tuber and bulbs). The plant specimens were pressed during the field trip and transported to be preserved and mounted on a herbarium sheet. Another taxa were cultivated in our Botanical Garden at home as: Euphorbia, Aloe, Kalanchoe, Dorstenia. Plectranthus, Huernia, Monolluma, Orbea , Cissus etc., while flowers of stapeliads were treated with interest by keeping them in dark plastic bottles containing preserver solution which composed of formalin, glycerin and distilled water (3:1.5 : 30 ml) respectively.

The collected plant specimens were undergone to identification to species, subspecies, and variety level with the help of available literature. (45 ، 46 ، 2 ، 22 ، 23 ، 24، 27، 18 ، 61، 4 ، 28، 31 ، 32 ، 19 ، 20 ،54، 52 ،50 ، 26).

Plants species were classified on the basis of life forms as defined by Raunkiaer (51) and Hassib (38), determined the phytoclimate of the area. The chorology of the recorded taxa was retrieved from the literature (44 ، 60 ، 61 ، 5 ، 42 ، 43 ، 16 ، 17 ، 1 ، 48 ، 56 ، 58 ، 33 ، 49 ، 37 ، 3). The plant taxa, found in the study area, are listed in Appendix 1. This comprehensive list provides the scientific name, life form and chorotype of each plant taxon. Moreover, voucher specimens for each taxon reported were kept in the Herbarium of Biology, Faculty of Education, Aden University.

3.Results&Discussion:

Analysis of Succulent flora:

According to Kent and Coker (41), the main purpose of studying the vegetation is to know the dynamic and to develop strategies to protect species (34)**.**

Succulent life forms of Al-Dale'a are a prominent feature and unique that reflects the shaping climatic, biotic, soil and topographical features of the study areas. The present results revealed that the study area comprised of 104 succulent taxa belonging to 52 genera and 29 families (Appendix 1).The enclosed appendix includes a checklist of all species collected in Al-Dale'a Governorate, which displays the related information on their life forms and chorological types. From the recorded 29 families in the present investigation there are 10 families 13 genera and 21 species of monocots, while dicots comprised 19 families, 39 genera and 83 species. At the level of species, Monocots are represented by 21 (17.2%) and Dicots by 83 (82.6%)**.**From the present results, the largest succulent families of the monocots were Aloeacea (8 sp. , 1 g.). while dicots were: Apocynaceae "the largest and most diverse family with 33 sp. , 14 g. constituting 31.7% (33\104) of the total recorded species are including 2 subsp and 3 variety follow it Euphorbiaceae (8 sp. , 1 g.), Crassulaceae (6 sp. , 3g), Asteraceae (5 sp. , 3g) and Lamiaceae (5 sp. , 1g). Regarding the number of taxa belonging to these families, our results is agreement with (15:30:35).These six families constituted about 57.6% 60\104 of the whole succulent species of the study area**.**

The analysis of the present data has showed that, there are six genera that have the most number of species, represented about 57.6% 60\104 of the whole succulent genera of study area, Apocynaceae has been the largest number of genera which constitute 26.9% (14\52) and species which constitute 31.6% (33\104) of the total genera and species of succulents study area**,** followed by Aloeaceae representing by 1 genus and 8 species**,** Crassulaceae represented by 3 genera and 6 species, then Asteraceae. represented by 3 genera and 5 species and Lamiaceae represented by 1 genera and 5species.It was noted that the generic index was 2(52\104), that means that the study area has high diversity. These results agree with (10 ، 30).

Chorological affinities

Phyto-geography, which is known to botanists, phytogeography or plant geography, as Good (36). Its aims to record and then, if possible to explain, the distribution of plants over the world's surface (16). Early plant geographers and phytogeographers in the last century and the first half of this century have delimited the globe into natural chorological units or phytochoria according to different bases. These natural chorological units or phytochoria were delineated by some authors, such as Schouw (53), on a purely floristic classification, namely in accordance with the distribution, presence and absence of certain families, genera and species that are endemic to a particular region. Phytogeographical elements include Structure of succulent species of the study area with respect to origin "Chorophyte".The chorological studies showed that Monoregional species constitute a remarkable portion of the studied succulent flora, 77.8% (81) of species were native to the Sudano-Zambenzian phytochoria. The second dominant phytochoria was Bi-Regionalconstitute (11.46 %) "Sudano-Zambenzian + Saharo-Sindian(11 sp. 10.5%) and Sudano-Zambenzian +Mediterranian(1 sp. ., 0.96%). While Plueriregional comprise (11sp. ; 10.57 %) "TheTri-Regional element "Sud-Zam +Sah-Sin+ Med, 3 sp. Cosm. 5 sp. ; Trop. 2 sp. ; Pan. 1 sp." **(Table 1; Fig. 1).**The dominant Sudano-Zambenzian region confirm that the study area "as a part of Yemen" belong to the African Horn region, our results agree with (3 ، 5 ، 44 ، 37).The results proved that the Sudanian-Zambezian regions are home to the most of the succulent species. Zohary (62) and Takhtajan (57) indicated that south and south-western Arabian Peninsula is one of the richest areas of the Sudanian (Sudano-Zambezian) territories, However, this area is the richest part of the Arabian Peninsula in terms of endemic species (16).

Life forms spectrum:

According to Raunkiaer, (51) that the climate of a region is characterized by life form and the propose of life form classification system based on the manner in which plants protect their perennating buds during unfavorable seasons. Life-form is the sum of all the adaptations undergone by a plant to the climate in which it resides (41). Raunkiaer (51) proposed the term "Biological Spectrum" to express both the life-form distribution in a flora and the phytoclimate under which the prevailing life-forms evolved. Literature dealing with the life form demonstrated that a very little work has been made in Yemen. Accordingly, life form of the study area exhibit that the most frequent life form class was Chamaephytes with the maximum number of species they are represented by 46 species (44.23%), followed by Phanerophytes represented by 29 species (27.88%), Geophytes 13 species (12.5%), Hemicryptophytes 9 species (8.65%) and Therophytes are represented by 6 species (5.76 %) 1 parasite (0.96%) **(Table 2; Fig. 2).**The dominance of the Chamaephytes life form may be attributed to the hot dry climate, topographic variation and biotic influence, while Phanerophytes provide good evidence that their abundance is, in fact, an expression of monsoon climate. These results agree with (12 ، 10). Same results from neighboring countries, such as Taif, Hail and Najd regions in Saudi Arabia (48 ،33) reported that the dominant life form of those regions are Therophytes and Chamaephytes. Abd-El-Ghani and Abdel-Khalik (1), from the south east Egypt, reported that the dominant life forms of that region are Chamaephytes, Therophytes and Phanerophytes.. That mean the study area has been under heavy biotic and abiotic pressure.

Endemism is a key component of biodiversity that, particularly, interests biologists and plant taxonomists (14). it's also an important concept in conservation biology and is considered one of the criteria used to set priorities for species conservation efforts. A taxon (e.g. a species) is considered endemic to a particular area if it occurs only in that area (29). One of the most distinct features of the flora of Yemen is the high percentage of the endemic plants among its components (13 ، 61 ، 15).The endemic and near endemic succulent plants in the study area represented by 39.4% (41\104) of the total collected area and constitute 27.3 % (41\150) of endemics in succulent flora of Yemen as a whole. The percentage explain the richness in species and endemics that interpret the high importance of the study area floristically.

Table 1. The chorological analysis of the collected succulent species

Succulent floristic categories	**No. of species**	Percentage %
Mono-Regional		
SU-ZA	81	**77.8**
Bi-Regional		
SU-ZA + SA-SI	11	**10.5**
Sud-Zam + ME	1	**0.96**
Pluri-Regional		
SU-ZA , SAH-SIN, MED	3	**2.88**
COSM	5	**4.80**
TR.	2	**1.92**
PAN.	1	**0.96**
Total	104	**100 %**
Endemic		
Endemic Yemen*	21	**20.19**
Endemic Arabia**	20	**19.2%**

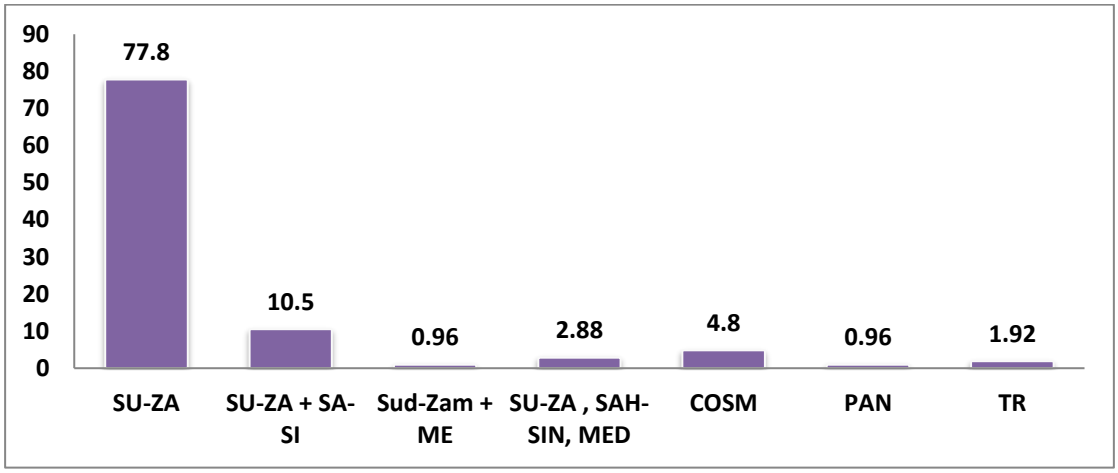

Fig. 1. Chorological type of the recorded succulent species in the study area

Table 2. life form spectra of the recorded succulent species in the study area according to Raunkiaer 1937 classification

Raunkiaer life form	**No. of species**	%of collected species
Chamaephytes	46	**44.23**
Phanerophytes	29	**27.88**
Geophytes	13	**12.5**
Hemicryptophytes	9	**8.65**
Therophytes	6	**5.76**
Parasite	1	**0.96**
Total	104	**100 %**

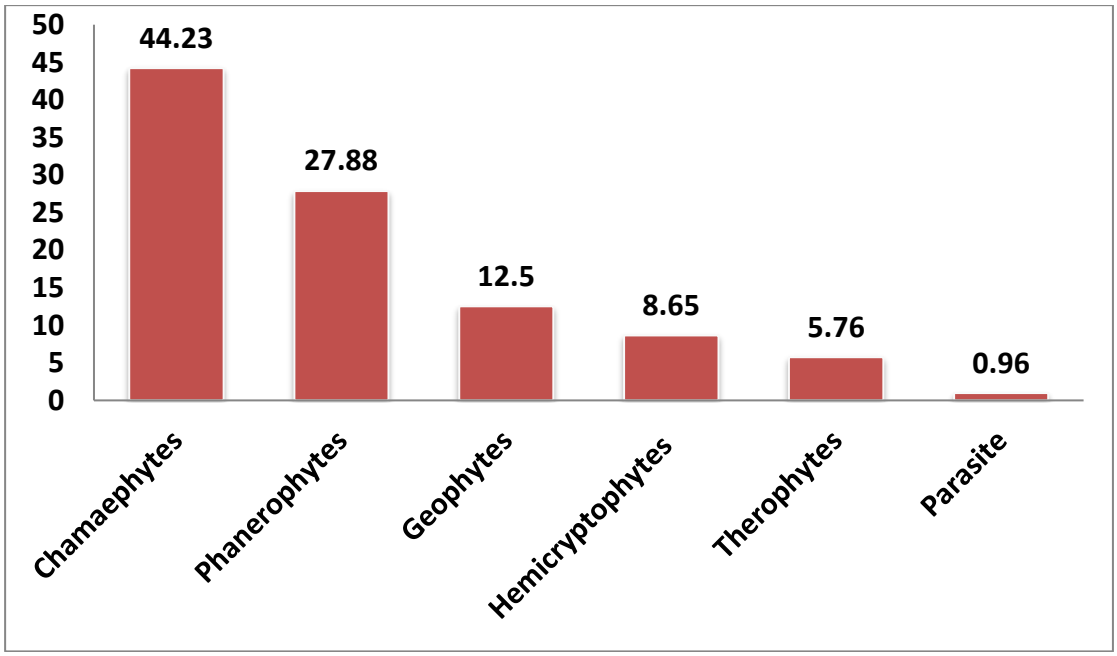

Figure 2. Percentage contribution of different life form class in the study area

5.Conclusion

1. The succulent flora of Al-Dale'a consists of 104 succulent taxa belonging to 52 genera and 29 families.
2. In the present study, higher percentages of Chamaephytes have been recorded in the study area.
3. The succulent flora of Adhleis the closest to the Sudano-Zambezian element.
4. About 41 succulent species recorded in the studied area are either endemic or near endemic to Yemen.

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

Family	Sp. No.	Species name	Life form	Chorotype
Dicots				
Aizoaceae	1	*Aizoon canariensis*L.	Th	Su-ZaMed,Sah-Sin,
	2	*Trianthema crystallinum* (Forssk.)Vahl.	He	Su-Za
	3	*Trianthema portulacastrum* L.	He	Su-Za
	4	*Trianthema triquetrum*Rottlerex Willd.	He	Su-Za,Sah–Sin
Amaranthaceae	5	*Kali tragus(*l.)Scop.	Ch	Cosm
Apocynaceae = Asclepiadaceae	6	*Adenium obesum (*Forssk.)Roem. & Schult.	Ph	Su-Za,Sah-Sin
	7	*Boreallumaplicatiloba* (Lavranos) Plowes.	Ch	Su-ZaSah-Sin,Med,
	8	*Caralluma subulata (*Forssk.) Decne.	Ch	Su-Za,Sah-Sin,
	9	*Ceropegia arabica* H.Huber. *var. arabica.*	Ge	END**
	10	*Ceropegia aristolochioides*Decne *subsp. deflersiana* Bruyns	Ch	END**
	11	*Ceropegia botrys* K. Schumann	Ge	Su-Za
	12	*Ceropegia bulbosa*Roxb.*(syn. C. vignaldiana*A. Rich.*).*	Ge	Su-Za,Sah-Sin,
	13	*Ceropegia rupicola* Defl. *var. rupicola.*	Ch	END*
	14	*Ceropegia somalensis* Chiov.	Ch	Su-Za
	15	*Ceropegia nov. sp.*	Ge	END*
	16	*Ceropegia variegata. var. variegata var. Adelaidae*Bally	Ch	END**
	17	*Crenulluma awdeliana* (Defl.) Plowes	Ch	END**
	18	*Cynanchum gerrardii* (Harv.)Liede	Ch	Su-Za
	19	*Cynanchum viminale L. subsp. stipitaceum* (Forssk.) Meve & Liede	Ch	Su-Za
	20	*Desmidorchis penicillata* (Deflers) Plowes	Ch	Su-Za
	21	*Echidnopsis scutellata* (Defl.) Berger. *ssp. Scutellata*	Ch	END*
	22	*Echidnopsis squamulata (*Decne.)Bally	Ch	END*
	23	*Echidnopsis yemenensis* Plowes	Ch	END*
	24	*Huernia marnieriana*Lav.	Ch	END*
	25	*Huernia rosea* Newton & Lavranos.	Ch	END*
	26	*Huernia nov. sp.* 116	Ch	END*
	27	*Huernia nov. sp.* 220	Ch	END*
	28	*Monolluma cicatricose* (Defl.)Plowes	Ch	END**
	29	*Monolluma quadrangula (*Forssk.)Plowes	Ch	END**
	30	*Orbea chrysostephana* (Deflers) Plowes	Th	END*

	31	*Orbea deflersiana*	Th	END**
	32	*Orbea eremastrum*(O.Schwartz) Plowes	Th	END**
	33	*Orbea wissmannii* (0.Schwartz) Bruyns	Th	END**
	34	*Rhytidocaulon macrolobum* ssp. *Macrolobum*	Ch	Su-Za
	35	*Sarcostemma sp.*	Ph	Su-Za
	36	*Sulcolluma foulcheri-delboscii* (Lavranos) Plowes	Ch	END*
	37	*Sulcolluma hexagona* (Lav.) *var. septentrionalis*	Ch	END*
	38	*Sulcolluma* nov. sp. 281	Ch	END*
Aristolochiaceae	39	*Aristolochia bracteolate* Lam.	He	Su-ZaSah-Sin,
Asteraceae	40	*Kleinia odora* (Forssk.) A.Berger	Ph	Su-Za
	41	*Kleinia pendula (*Forssk.) Seh.Bip.S.	Ch	Su-Za
	42	*Kleinia semperviva* (Forssk.) D.C.	He	Su-Za
	43	*Senecio hadiensis* Forssk.	Ph	Su-Za
Bombaceae	44	*Adansonia digitata* L.	Ph	Su-Za
Burseraceae	45	*Commiphora gileadensis (*L.) Christ.	Ph	Su-Za
	46	*Commiphora habessinica* (O.Berg.)	Ph	Su-Za
	47	*Commiphora myrrha* (Nees) Engl.	Ph	Su-Za
	48	*Commiphora schimperi* (Berg.) Engl.	Ph	Su-Za
Cactaceae	49	*Opuntia dillenii (*Ker-Gawl.)Haw.	Ph	Cosm
	50	*Opuntia ficus-indica* (L.)Mill.	Ph	Cosm
Capparidaceae	51	*Capparis cartilaginea* Decne.	Ch	Su-Za,Sah-Sin
	52	*Capparis spinosa* L. var. spinosa.	Ch	Su-Za,Sah-Sin,
Crassulaceae	53	*Cotyledon barbeyi* Baker	Ch	Su-Za
	54	*Crassula alba* Forssk	Ch	Su-Za
	55	*Crassula schimperi* Fisch. & Mey.	Ch	Su-Za ,Sah-Sin
	56	*Kalanchoe deficiens* (Forssk.) *var.glabra* Raatts.	Ch	END*
	57	*Kalanchoe glaucescens* Britten.	Ch	Su-Za
	58	*Kalanchoe lanceolata* (Forssk.)Pers.	Ch	Su-Za
	59	*Kalanchoe yemensis* (Deflers) Schweinf.	Ch	END*
Euphorbiaceae	60	*Euphorbia ammak* Forssk.	Ph	END**
	61	*Euphorbia balsamiphera* Ait.	Ph	Su-Za
	62	*Euphorbia cactus* Ehrenb. *var. tortirama* Rauh &Lavr	Ph	END*
	63	*Euphorbia fractiflexa* carter & Wood	Ph	END**
	64	*Euphorbia inarticulata* Schweinf.	Ch	END**
	65	*Euphorbia parciramulosa* Schweinf.	Ph	END**
	66	*Euphorbia sp. aff. fruticosa* Forssk	Ch	END*
Hydnoraceae	67	*Hydnora johannis* Becc.	P	Su-Za
Lamiaceae	68	*Plectranthus sp.*	Ch	Su-Za
	69	*Plectranthus barbatus*Andr.	Ch	Su-Za
	70	*Plectranthus hyemalis* J.R.I. Wood.	Ch	END*
	71	*Plectranthus montanus* Benth.	Ph	Su-Za
	72	*Plectranthus tenuiflorus* (Vatke)Agnew	Ch	Su-Za
Moraceae	73	*Dorstenia barnimiana* Schweinf.	Ge	Su-Za
	74	*Dorstenia foetida (*Forssk.) Schweinf.& Engl.	Ch	Su-Za
Passifloraceae	75	*Adenia venenata* Forssk	Ph	Su-Za
Polygonaceae	76	*Rumex nervosus* Vahl.	Ph	Su-Za,ME
Portulacaceae	77	*Portulaca oleracea* L.	He	Cosm
	78	*Portulaca quadrifida*L.	He	PAN
	79	*Talinumportulacifolium*(Forssk.) Aschers ex Schweinf	Ph	Su-Za,Sah-Sin,
Scrophulariaceae	80	*Bacopa monnieria*(L.)Wettst.	Th	Trop.

Vitaceae	81	*Cissus quadrangularis* L	Ch	Su-Za,Sah-Sin,
	82	*Cissus rotundifolia* (Forssk.) Vahl.	Ch	Su-Za
	83	*Cyphostemma digitatum* (Forssk.) Desc	He	Su-Za
Monocots				
Agavaceae	84	*Agave sisalana* Perrine.	He	Cosm
Aloaceae	85	*Aloe inermis* Forssk.	Ph	Su-Za
	86	*Aloe lanata* McCoy &Lavr.	Ph	END*
	87	*Aloe lavranosii*Reynoids.	Ph	END*
	88	*Aloe rubroviolacea* Schweinf.	Ph	END**
	89	*Aloe sabaea* Schweinf.	Ph	END**
	90	*Aloe tomentosa* Defl.	Ph	END*
	91	*Aloe vacillans* Forssk.	Ph	END**
	92	*Aloe yemenica*Wood.	Ph	END**
Amarylldaceae	93	*Crinum album* (Forssk.) Herb.	Ge	END**
	94	*Scadoxus multiflorus* (Martyn) Raf.,	Ge	Trop
Araceae	95	*Arisaema flavum* (Forrsk.) Schott.	Ge	Su-Za
Asparagaceae	96	Albuca abyssinica Jacq.	Ge	Su-Za
Commelinaceae	97	*Cyanotis nyctitropa* Deflers.	He	END**
Dracaenaceae	98	*Dracaena serrulata* Baker.	Ph	Su-Za
	99	*Sansevieria ehrenbergii* Schweinf. ex Bak.	Ge	Su-Za
	100	*Sansevieria forskaliana*(Schult.)f.) Hepper & Wood	Ge	Su-Za
Hyacinthaceae	101	*Dipcadi viride (*L.)Moench.	Ge	Su-Za,Sah-Sin, Med
	102	*Ledebouria aff. revoluta* (L.f.) Jessop	Ge	Su-Za, Sah-Sin
Orchidaceae	103	*Eulophia petersii* (Reichb.f.) Reichb.f.	Ge	Su-Za
Velloziaceae	104	*Xerophyta arabica* (Baker)N.Menezes	He	END**

Abbreviation: Su-Za = Sudano-Zambezian. **M =** Mediterranean. **Sah-Sin =**Saharo-Sindian **, Cosm=** Cosmopolitanism. **PAN**= Pantropical, **TROP**. =Tropical. **Ph=** Phanerophytes; **Ch=**Chamaephytes; **Ge=**Geophytes ; **He=** Hemicryptophytes, **Th=** Therophytes. **P =** Parasite . END* = Endemic Yemen , END** = Endemic Yemen, Oman , Saudi Arabia.

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شكل الحياة والارتباط الجغرافي للنباتات العصارية في محافظة الضالع ، اليمن

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الملخص

نُفذَت الدراسة الحالية في المدة من 2015 – 2019م، حيث أبرزت التركيب الفلوري وأشكال الحياة والانتماء الجغرافي للنباتات العصارية في محافظة الضالع. تكونت الفلورا العصارية من 104 نوع عصاري تنتمي إلى 52 جنساً و29 عائلة، دراسة أشكال الحياة لمنطقة الدراسة كانت السيادة للكاميفيتس 46 نوعاً (44,23٪) يليها نباتات الفانير وفيتس مثلت ب 29 نوع (27,88٪)، ثم الجيوفيتس 13 نوع (12,5٪)، فالهيموكريبتوفيتس مثلت ب 9 أنواع (8,65٪)، الثيروفيتس مثلت ب 6 انواع (5,7٪)، النباتات المتطفلة أقل الأنواع حضوراً مثلت بنوع واحد فقط (0,96٪).

الانتماء الجغرافي للنباتات العصارية شكلت الأنواع أحادية الانتماء النسبة الأكبر81 نوع (77,8٪)، جميعها تنتمي إلى الإقليم السوداني-الزيمبابوي، يليها الأنواع ثنائية الانتماء الجغرافي مثلت ب 12 نوعاً (11,46٪) توزعت بين إقليمين هما السوداني-الزيمبابوي + الصحراوي – السندي11 نوعاً (10,5٪) والسوداني-الزيمبابوي+ المتوسطي مثل ب نوع واحد (0,96٪)، باقي الأنواع كانت عديدة الانتماء الجغرافي مثلت ب 11نوعاً (10,57٪) توزعت كالتالي (3 انواع ثلاثية الأقاليم السوداني - الزيمبابوي + الصحراوي – السندي + المتوسطي، و5 عالمية ونوعين مداريين، ونوع شمولي).

أما حالة التوطن قد أبرزت النتائج أن نسبة التوطن كانت (39,4٪) 41 نوعاً منها 21 نوعاً (20,19٪) متوطن اليمن و20 نوعاً (19,23٪) متوطن اليمن، السعودية، عمان.

الكلمات المفتاحية : نباتات عصارية، شكل الحياة، ارتباط جغرافي، توطن، الضالع، اليمن.