Influence of the African paleotropical floristic categories on the flora of high-altitude mountains in Yemen: case study of Jabal An-Nabi Shuáyb, Sana'a (capital of Yemen)

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Abstract. About 205 plant species (eight Ferns, 167 Dicots & 30 Monocots) from a total of 288 species, recorded in 2013 from Jabal An-Nabi Shuáyb (the highest point in Yemen and Arabia), show a distribution relationship with three African paleotropical floristic regions and 10 African paleotropical floristic elements. The distribution relationship among the African paleotropical floristic elements was subjected to numerical analysis: the African paleotropical floristic region with the highest number of species is Sudano-Zambezian with 184 (63.9 %) species; while the African paleotropical floristic element with the highest number of species is the Afro-Montane Archipelago-Like Regional Centre of Endemism, with 175 (60.8 %) species.

Key words: african, floristic elements, numerical analysis, paleotropical, Yemen

Introduction

White (1965) proposed a chorological sketch map of the Northern and Central Africa, in which he distinguished between six or eventually seven regions, although in 1983 he replaced the earlier traditional hierarchy (Floral Empires or Kingdoms, Regions, Provinces, Domains, Sectors, Districts, etc.) by a new system attempting to establish phytochoria based on the richness of their endemic flora at the species level. Thus, African mainland was divided into 18 phytochoria, comprising nine regional centers of endemism separated by six regional transition zones and three regional mosaics.

White's system was extended by Léonard (1988-1989) so as to cover Southwest Asia and was based on the distribution of 509 species collected from the deserts of Iran. In 1991, White and Léonard adopted a map of the African phytochoria and those extending to SW Asia, with slight modification of some phytochoria.

Zohary (1973) had placed Yemen within two phytogeographical categories: Eritero-Arabian Province, which is part of the Sudanian region and Saharo-Arabian region, while Léonard (1988-1989) and White & Léonard (1991) had shown that Yemen is a meeting point of three phytogeographical categories: Somalia-Masai Regional Centre of endemism, Afro-Montane Archipelago-Like Regional Centre of Endemism and Arabian Region Subzone. Furthermore, Al-Khulaidi (2013) mentioned that the flora of Yemen is a mixture of the Tropical African Sudanian Plant Region and the Saharo-Arabian Plant Region. There, the Sudanian element dominates in the western mountains and parts of the highland plains

of Yemen, whereas the Saharo-Arabian element dominates in the coastal plains, eastern mountains and eastern and northern desert plains. He also pointed out that a high percentage of Yemen plants belong to the tropical African plants of the Sudanian Region. On the other hand, Ibrahim (2013) recorded 288 plant species from Jabal An-Nabi Shuáyb (the highest mountain in Yemen and Arabia, located 30 km westwards of Sana'a, the capital of Yemen, with coordinates 043°56' – 044°00' E & 15°13' – 15°9' N) and also mentioned that the Tropical African Sudanian Plant Region is strongly presented in the flora not only of the Saharo-Arabian Plant Region.

Material and methods

The paleotropical kingdom in Africa can be divided according to Zohary (1973), Takhtajan (1986) and a recent map presented by White and Léonard (1991) into three main floristic regions and ten phytogeographical elements: Saharo-Sindian Region, including Sahara Regional Subzone (SS1); Sudano-Zambezian Region (Sudanian Region), including Sudanian Regional Centre of Endemism (S), Sahel Regional Transition Zone (Sa), Somalia-Masai Regional Centre of Endemism (SM), Afro-Montane Archipelago-Like Regional Centre of Endemism (Af), Zambezi Regional Centre of Endemism (Z) & Zanzibar-Inhambane Regional Mosaic (ZI); Guinean Region divided further into Guineo-Congolian Centre of Endemism (GC) Guinea-Congolian / Sudania Regional Transition Zone (GCS), and finally, Guinea-Congolian / Zambezia Regional Transition Zone (GCZ).

In this work, the phytogeographical distribution relationship of 205 plant species (Table 1) from a total of 288 species, recorded by Ibrahim (2013) from Jabal An-Nabi Shuáyb, were examined among the African paleotropical floristic regions and elements by using the following literature: Broun & al. (1929), Schwartz (1939), Andrews (1950,1952 & 1956), Wickens (1976), Gallego & al. (1980), Johns (1991), Friis & Gibert (1993), Gilbert (1993), Jeffrey& Thulin (1993), Jonsell (1993), Thulin (1993a-m & 1995a-c), Thulin & Moggi (1993a,b), Townsend (1993), Cope (1995, 2005 & 2007), Lye (1995), Boulos (1996, 1999, 2000a-k, 2002a,b & 2005a,b), Chamberlain (1996a,b), Miller (1996a-e), Wood (1997) Abedin & al. (1999), Chaudhary (1999a-f, 2000a-c & 2001a,b), El-Hadidy & Boulos (2000), Abedin & al. (2001), Alfarhan & Thomas (2001), Chaudhary & Abdul Rub (2001), Chaudhary & Hedge (2001), Boulos & Hind (2002), Boulos & Snogerup (2002), Hepper (2002), Snogerup & Boulos (2002), Burrows & Willis (2005), Kukkonen & Simpson (2005), Snogerup & Snogerup (2005), Ibrahim & al. (2009) and Al-Khulaidi (2013).

On the other hand, the distribution relationship of the plant species with 10 African paleotropical floristic elements are shown as a dendrogram, by using the Group Average Method as a sorting strategy, also known as UPGMA (Unweighted Pair-Group Average Linkage) method (Primer-E, 2001). As a result of cluster analysis, the dendrogram represents a hierarchical classification at numerically defined levels, conveniently represented on the ordinate by similarity coefficient scale multiplied by 100 to give percentage values.

Results and discussion

In the period 2009-2011, 288 plant species were collected and identified from Jabal An-Nabi Shu'ayb (Ibrahim, 2013), including 205 species (eight Ferns, 197 Angiosperms: 167 Dicotyledons and 30 Monocotyledons) showing a distribution relationship with the African paleotropical floristic categories. Three paleotropical floristic regions can be identified as follows: Sudano-Zambezian Region presented by 184 (63.9 %) species; Afro-Montane Archipelago-Like Regional Centre of Endemism (Af) represented by 175 (60.8 %) species; where Somalia-Masai Regional Centre of Endemism (SM), Sahel Regional Transition Zone (Sa), Sudanian Regional Centre of Endemism (S), Sudanian Regional Centre of Endemism (Z), and Zanzibar-Inhambane Regional Mosaic (ZI) are represented by 149 (51.7 %), 117 (40.6 %), 114 (39.6 %), 102 (35.4 %) & 90 species (31.3 %), respectively, followed by 114 (39.6 %) species in the Sahara Regional Subzone (SS1), although about 64 (22.2 %) species show a relationship between the Guinean Region and the flora of Jabal An-Nabi Shu'ayb (Tables 1-2 & Fig. 1) (Guineo-Congolian Centre of Endemism (GC) is represented by 63(21.9 %) species, whereas Guinea-Congolian / Sudania Regional Transition Zone (GCS) & Guinea-Congolian / Zambezia Regional Transition Zone (GCZ) are represented by 59 (20.5 %) & 55 (19.1 %) plant species, respectively).

According to the chorological analysis, about 87 (30.2 %) of all recorded species in the flora of Jabal An-Nabi Shuáyb are monoregional, of which 66 (22.9 %) species are native to the Sudano-Zambezian Region,

followed by the Saharo-Arabian Region with 21 (7.3%) species. Although biregional categories are represented by 79 (27. 4%) species of all recorded species in the flora of Jabal An-Nabi Shuáyb, of these the categories of the Saharo-Arabian Region and Sudano-Zambezi Region are represented by 54 (18.8%) species, while the categories of the Sudano-Zambezi Region and Guinean Region are represented by 25 (8.7%) species.

On the other hand, the triregional categories are represented by 39 (13.5%) species (Table 2).

The dendogran resulting from the UPGMA method divides the 10 African paleotropical floristic elements on the basis of their species composition into two main groups at a relative similarity level of 51.9%.

Group I includes the Saharo-Sindian Region element (Saharan Regional Subzone), Group II includes the Sudano-Zambezian Region elements (Sudanian Regional Centre of Endemism, Sahel Regional Transition Zone, Somalia-Masai Regional Centre of Endemism, Afro-Montane Archipelago-Like Regional Centre of Endemism, Zambezi Regional Centre of Endemism & Zanzibar-Inhambane Regional Mosaic) and the Guinean Region elements (Guineo-Congolian Centre of Endemism, Guinea-Congolian / Sudania Regional Transition Zone, and finally, Guinea-Congolian / Zambezia Regional Transition Zone). Furthermore, Group II is divided into two subgroups at a relative similarity level of 63.8%.

Subgroup A (Sudano-Zambezian Region Elements) includes two main clusters at a relative similarity level of 77%. Cluster 1 includes two elements (Somalia-Masai Regional Centre of Endemism and Afro-Montane Archipelago-Like Regional Centre of Endemism) at a relative similarity level of 87.7%. Cluster 2 includes two sub-clusters at a relative similarity level of 85.6%: Sub-cluster A includes the Sudanian Regional Centre of Endemism and Sahel Regional Transition Zone at a relative similarity level of 96.1%; Cluster B includes the Zambezian Regional Centre of Endemism & Zanzibar-Inhambane Regional Mosaic at a relative similarity level of 93.7%.

Furthermore, Subgroup B (Guinean Region Elements) includes two main clusters at a relative similarity level of 93.1%: Cluster 1 includes two elements (Guineo-Congolian Centre of Endemism, Guinea-Congolian / Sudania Regional Transition Zone) at a relative similarity level of 96.7 %, while Cluster 2 includes one element (Guinea-Congolian / Zambezia Regional Transition Zone) (Fig. 2)

Conclusion

According to the earlier phytogegraphical analysis, 184 (63.9%) species from the flora of Jabal An-Nabi Shu'ayb show more distribution relationships with the Sudano-Zambezian Region than the other two African paleotropical floristic regions, although about 175 (60.8%) plant species show more distribution relationships with the Afro-Montane Archipelago-Like Regional Centre of Endemism than the other nine African paleotropical floristic elements. This corresponds to the findings of White and Leonard (1991), which placed the southwestern mountains of the Arabian Peninsula (including Jabal An-Nabi Shu'ayb) within the Afro-Montane Archipelago-Like Regional Centre of Endemism.

The relative similarly level of the Saharo-Sindian Region (Saharan Regional Subzone) and the other African paleotropical floristic regions (Sudano-Zambezian Region Elements and Guinean Region) is low – 51.9%, followed by the relative similarly level of the Guinea-Congolian Regional Centre of Endemism and Guineo-Congolian/Sudania Regional Transition Zone at a relative similarity level of 96.7%, the relative similarly level of the Sudanian Regional Centre of Endemism and Sahel Regional Transition Zone of 96.1%.

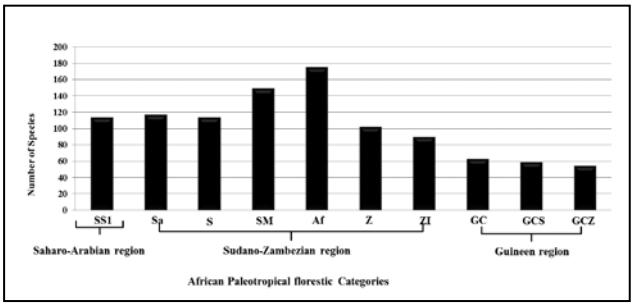

Fig. 1. Distribution of species among the 10 African paleotropical elements. For abbreviations see Table 1.

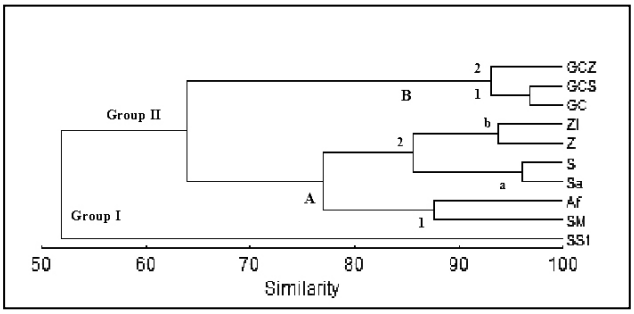

Fig. 2. Cluster analysis of the 10 African paleotropical floristic elements based on the similarity of their species composition by the UPGMA method. For abbreviations see Table 1.

Table 1. Distribution of species among the 10 African paleotropical elements.

	Plant species	Phytogeographical elements									
		SS1	Sa	S	SM	Af	Z	ZI	GC	GCS	GCZ
Ferns	*Adiantum capillus-veneris* L.	+	+	+	+	+	+	+	+	+	+
	Asplenium aethiopicum (Burm. f.) Bech.	–	+	+	+	+	+	+	–	–	–
	Ceterach officinarum Willd.	–	+	+	+	+	+	+	–	–	–
	Cheilanthes coriacea Decne.	+	+	+	+	+	–	–	–	–	–
	Equisetum ramosissimum Desf.	+	+	+	+	+	+	+	+	+	+
	Hypodematium crenatum (Forssk.) Kuhn	–	+	+	+	+	+	+	–	–	–
	Ophioglossum polyphyllum A. Braun ex Schub.	+	–	–	+	+	–	–	–	–	–
	Pteris dentata Forssk.	–	+	+	+	+	+	+	+	+	+
Dicotyledon	*Acanthus arboreus* Forssk.	–	+	+	+	+	+	+	+	+	+
	Acacia origena Asfaw	–	–	–	+	+	+	+	–	–	–
	Achyranthes aspera L.	+	+	+	+	+	+	+	+	+	+
	Aerva javanica (Burm.f.) Juss. ex Schult.	+	+	+	+	+	+	+	+	+	–
	Agrocharis melanantha Hochst.	–	–	–	–	+	–	–	+	+	–
	Alkanna orientalis (L.) Boiss.	+	–	–	–	–	–	–	–	–	–
	Amaranthus hybridus L.	+	+	+	+	+	+	+	+	+	+
	Anagallis arvensis L.	+	–	–	+	+	–	–	–	–	–
	Anagallis foemina Mill.	+	–	–	–	–	–	–	–	–	–
	Anarrhinum forsskaolii (J. F. Gmel.) Cufod.	–	+	+	+	+	+	+	–	–	–
	Anchusa arvensis (L.) M. Bieb.	–	+	+	+	+	–	–	–	–	–
	Andrachne aspera Spreng.	+	+	+	+	+	+	+	+	+	+
	Apium nodiflorum (L.) Lag.	+	–	–	–	+	–	–	–	–	–
	Arabis alpina L.	–	–	–	–	+	–	–	–	–	–
	Argyrolobium rupestre (E. Mey.) Walp.	–	–	–	+	+	–	–	–	–	–
	Artemisia abyssinica Sch. Bip. ex A. Rich.	–	–	–	–	+	–	–	–	–	–
	Astragalus atropilosulus (Hochst.) Bunge	–	–	–	–	–	+	–	–	–	–
	Astragalus vogelii (Webb) Bornm.	+	+	+	+	+	+	+	+	+	+
	Berberis holstii Engl.	–	+	+	+	+	+	+	–	–	–
	Bidens bipinnata L.	+	–	–	–	–	–	–	–	–	–
	Buddleja polystachya Fresen.	–	–	–	+	+	–	–	+	–	–
	Calendula arvensis M. Bieb.	+	–	–	–	–	–	–	–	–	–
	Campanula edulis Forssk.	–	–	–	–	+	–	–	–	–	–
	Capsella bursa-pastoris (L.) Medik.	+	+	+	+	+	–	–	–	–	–
	Caylusea hexagyna (Forssk.) M. L. Green	+	+	+	+	+	+	+	–	–	–
	Chenopodium album L.	+	–	–	+	–	–	–	–	–	–
	Chenopodium murale L.	+	+	+	+	+	+	+	+	+	+
	Chenopodium schraderianum Schult.	–	+	+	+	+	+	+	+	+	+
	Cineraria abyssinica Sch.Bip. ex A. Rich.	–	–	–	–	+	–	–	–	–	–
	Cirsium vulgare (Savi) Ten.	–	–	–	–	+	–	–	–	–	–
	Clematis simensis Fresen.	–	+	+	+	+	+	+	+	+	+
	Commicarpus pedunculosus (A.Rich.) Cufod.	–	+	+	+	+	–	–	–	–	–
	Convolvulus arvensis L.	+	–	–	+	+	–	–	–	–	–
	Convolvulus sagittatus Thunb.	–	+	+	+	+	+	+	+	+	+
	Conyza bonariensis (L.) Cronquist	+	–	–	–	–	–	–	–	–	–
	Conyza hochstetteri Sch. Bip. ex A. Rich.	–	–	–	–	+	+	–	–	–	–
	Conyza incana (Vahl) Willd.	–	–	–	–	+	–	–	–	–	–
	Conyza stricta Willd.	+	+	+	+	+	+	+	+	+	+
	Crassula alata (Viv.) A. Berger	–	+	+	+	+	+	+	+	+	–
	Crepis rueppellii Sch. Bip.	–	–	–	–	+	–	–	–	–	–
	Cuscuta planiflora Ten.	+	–	–	–	+	+	–	–	–	+
	Datura stramonium L.	+	+	+	–	–	–	–	–	–	–

Table 1. Continuation.

	Plant species	Phytogeographical elements									
		SS1	Sa	S	SM	Af	Z	ZI	GC	GCS	GCZ
Dicotyledon	*Debregeasia saeneb* (Forssk.) Hepper & J.R.I.Wood	–	–	–	–	+	–	–	–	–	–
	Dichrocephala chrysanthemifolia (Blume) DC.	+	+	+	+	+	+	+	+	+	–
	Diplotaxis erucoides (L.) DC.	+	+	–	+	+	+	+	–	–	–
	Echinops spinosissimus Turra	–	–	–	–	+	–	–	–	–	–
	Epilobium hirsutum L.	+	–	–	–	–	–	–	–	–	–
	Erodium cicutarium (L.) L'Hér.	+	–	–	–	+	–	–	–	–	–
	Erodium malacoides (L.) L'Hér.	+	–	–	+	–	–	–	–	–	–
	Erucastrum arabicum Fisch. & C. A. Mey.	+	+	+	+	+	+	+	+	+	+
	Euphorbia helioscopia L.	+	–	–	–	–	–	–	–	–	–
	Euphorbia inaequilatera Sond.	+	+	+	+	+	+	+	–	–	–
	Euphorbia peplus L.	+	–	–	–	–	–	–	–	–	–
	Euphorbia schimperiana Scheele	–	+	+	+	+	+	+	+	+	+
	Euryops arabicus Steud. ex Jaub. & Spach	–	–	–	+	+	–	–	–	–	–
	Fagonia bruguieri DC.	+	+	+	+	+	+	+	–	–	–
	Fagonia indica Burm. f.	+	+	+	+	+	–	–	–	–	–
	Farsetia longisiliqua Decne.	+	+	+	+	+	–	–	–	–	–
	Felicia abyssinica Sch. Bip. ex A. Rich.	–	–	–	+	+	+	–	–	–	–
	Felicia dentata (A. Rich.) Dandy	+	+	+	–	+	–	–	–	–	–
	Ficus carica L.	+	+	+	+	+	+	+	+	+	+
	Ficus palmata Forssk.	+	+	+	+	+	–	–	–	–	–
	Forsskaolea tenacissima L.	+	+	+	+	+	+	+	–	–	–
	Fumaria abyssinica Hammar	–	+	+	+	+	+	+	–	–	–
	Fumaria parviflora Lam.	+	–	–	–	+	–	–	–	–	–
	Galinsoga parviflora Cav.	+	–	–	+	–	–	–	–	–	–
	Galium aparinoides Forssk.	–	–	+	–	+	–	–	+	+	–
	Geranium arabicum Forssk.	+	+	+	+	+	+	+	+	+	+
	Geranium biuncinatum Kokwaro	+	+	+	+	+	–	–	–	–	–
	Geranium mascatense Boiss.	–	+	+	+	+	+	+	–	–	–
	Gomphocarpus sinaicus Boiss.	+	–	–	–	–	–	–	–	–	–
	Gymnosporia senegalensis (Lam.) Loes.	+	+	+	+	+	+	+	+	+	+
	Helichrysum foetidum (L.) Cass.	–	–	–	+	+	–	–	–	–	–
	Helichrysum forskahlii (J. F. Gmel.) Hilliard & B.L. Burtt	–	+	+	+	+	+	+	+	+	+
	Helichrysum glumaceum DC.	+	+	+	+	+	+	+	+	+	+
	Helichrysum pumilum Hook.f.	–	–	–	+	–	–	–	–	–	–
	Heliotropium longiflorum (A.DC.) Jaub. & Spach	–	+	+	+	+	+	+	–	–	–
	Hypericum revolutum Vahl	–	+	+	+	+	+	+	+	+	+
	Hypoestes forskaolii (Vahl) R. Br.	–	+	+	+	+	+	+	+	+	+
	Indigofera arabica Jaub. & Spach	+	+	+	+	+	+	+	+	+	+
	Jasminum grandiflorum L.	+	+	+	+	+	–	–	+	–	–
	Kleinia odora (Forssk.) DC.	–	–	–	+	+	–	–	–	–	–
	Kleinia semperviva DC.	–	–	–	+	+	–	–	–	–	–
	Lactuca inermis Forssk.	–	+	+	+	+	+	+	+	+	+
	Launaea fragilis (Asso) Pau	+	–	–	–	–	–	–	–	–	–
	Launaea nudicaulis (L.) Hook.f.	+	–	–	+	–	–	–	–	–	–
	Lavandula dentata L.	–	–	–	–	+	–	–	–	–	–
	Lepidium armoracia Fisch. & C.A. Mey.	–	–	–	–	+	+	–	–	–	–
	Leucas glabrata (Vahl) Sm.	+	+	+	+	+	+	+	+	+	+
	Linum usitatissimum L.	+	–	–	–	–	–	–	–	–	–
	Lotononis platycarpa (Viv.) Pic. Serm.	+	+	+	+	+	+	+	–	–	–
	Lotus arabicus L.	+	+	+	+	+	+	+	+	+	+
	Lotus corniculatus L.	–	–	–	–	+	–	–	–	–	–

Table 1. Continuation.

	Plant species	Phytogeographical elements									
		SS1	Sa	S	SM	Af	Z	ZI	GC	GCS	GCZ
Dicotyledon	*Lythrum hyssopifolia* L.	+	+	+	+	+	+	+	+	+	+
	Macowania ericifolia (Forssk.)B. L. Burtt & Grau.	–	–	–	–	+	–	–	–	–	–
	Malva parviflora L.	+	+	+	+	+	+	+	+	+	+
	Malva verticillata L.	–	–	–	+	+	–	–	–	–	–
	Marrubium vulgare L.	+	+	+	+	+	+	+	+	+	+
	Medicago lupulina L.	+	+	+	+	+	+	+	–	–	–
	Medicago polymorpha L.	+	–	–	+	+	–	–	–	–	–
	Mentha longifolia (L.) Huds.	+	–	–	+	+	–	–	–	–	–
	Micromeria imbricata (Forssk.) C. Chr.	+	+	+	+	+	+	+	+	+	+
	Minuartia filifolia (Forssk.)Schweinf. ex Mattf.	–	+	+	+	+	+	+	–	–	–
	Misopates orontium (L.) Raf.	–	+	–	+	+	–	–	–	–	–
	Nicotiana glauca Graham	+	–	–	–	–	–	–	–	–	–
	Orobanche cernua Loefl.	+	+	–	+	+	–	–	–	–	–
	Orobanche ramosa L.	+	–	–	–	–	–	–	–	–	–
	Osteospermum vaillantii (Decne.) Norl	+	+	+	+	+	+	–	+	–	–
	Otostegia fruticosa (Forssk.) Schweinf. ex Penzig	+	+	+	+	+	+	+	–	–	–
	Oxalis corniculata L.	+	–	–	+	–	+	–	–	–	–
	Phagnalon stenolepis Chiov.	–	+	+	–	+	–	–	–	–	–
	Plantago albicans L.	+	–	–	+	+	–	–	–	–	–
	Plantago lanceolata L.	+	+	+	+	+	+	+	+	+	+
	Plantago major L.	+	–	–	–	–	–	–	–	–	–
	Pollichia campestris Aiton	–	+	+	+	+	+	+	+	+	+
	Polygala abyssinica R. Br. ex Fresen.	–	+	+	+	+	+	+	–	–	–
	Polygala steudneri Chodat	–	–	–	+	+	–	–	–	–	–
	Polygonum aviculare L.	+	+	+	+	+	+	+	+	+	+
	Potentilla dentata Forssk.	–	–	–	+	+	–	–	–	–	–
	Primula verticillata Forssk.	–	–	–	+	+	–	–	–	–	–
	Psiadia punctulata (DC.) Vatke	–	–	–	+	+	+	–	–	–	–
	Pulicaria inuloides (Poir.) DC.	+	+	+	–	+	–	–	–	–	–
	Pulicaria jaubertii E. Gamal-Eldin	+	–	–	+	+	–	–	–	–	–
	Pulicaria petiolaris Jaub. & Spach	+	+	+	+	+	–	–	–	–	–
	Pulicaria undulata (L.) C.A. Mey.	+	+	+	+	+	+	+	+	+	+
	Ranunculus multifidus Forssk.	–	+	+	+	+	+	+	+	+	+
	Reichardia tingitana (L.) Roth	+	+	+	+	+	+	+	–	–	–
	Rhus retinorrhaea Steud. ex A. Rich.	–	+	+	+	+	–	–	–	–	–
	Ricinus communis L.	+	+	+	+	+	+	+	+	+	+
	Rosa abyssinica R. Br. ex Lindl.	–	+	+	+	+	–	–	–	–	–
	Rumex nervosus Vahl	–	+	+	+	+	+	+	–	–	–
	Rumex steudelii Hochst. ex A. Rich.	–	+	+	+	+	+	+	+	+	+
	Rumex vesicarius L.	+	+	–	+	+	–	–	–	–	–
	Ruta chalepensis L.	+	+	+	+	+	+	+	+	+	+
	Salsola kali L.	+	–	–	–	–	–	–	–	–	–
	Salvia aegyptiaca L.	+	+	+	–	+	–	–	–	–	–
	Salvia merjamie Forssk.	–	–	+	+	+	+	–	–	–	–
	Salvia schimperi Benth.	–	–	–	–	+	–	–	–	–	–
	Scabiosa columbaria L.	–	+	+	+	+	+	+	+	+	+
	Scutellaria arabica Jaub. & Spach	–	+	+	–	+	–	–	–	–	–
	Senecio lyratus Forssk.	–	–	–	–	+	–	–	–	–	–
	Senecio schimperi Sch. Bip. ex A. Rich.	–	+	+	+	+	+	+	+	+	+
	Senecio vulgaris L.	+	+	+	+	+	+	+	+	+	+

Table 1. Continuation.

	Plant species	Phytogeographical elements									
		SS1	Sa	S	SM	Af	Z	ZI	GC	GCS	GCZ
Dicotyledon	*Silene burchellii* Otth ex DC.	+	–	+	+	+	–	–	–	–	–
	Silene macrosolen Steud. ex A. Rich.	–	+	+	+	+	+	+	–	–	–
	Sisymbrium irio L.	+	–	–	+	+	–	–	–	–	–
	Solanum incanum L.	+	+	+	+	+	+	+	+	+	+
	Solanum villosum Mill.	+	+	+	+	+	+	+	+	+	+
	Sonchus oleraceus L.	+	+	+	+	+	+	+	–	–	–
	Tagetes minuta L.	+	–	–	–	–	–	–	–	–	–
	Thesium radicans Hochst. ex A. Rich.	–	+	+	+	+	+	+	–	–	–
	Tribulus terrestris L.	+	–	–	+	–	–	–	–	–	–
	Trifolium fragiferum L.	–	–	–	–	+	–	–	–	–	–
	Trifolium semipilosum Fresen.	–	–	–	+	+	–	–	–	–	–
	Tylophoropsis heterophylla (A. Rich.) N.E. Br.	–	–	–	–	+	–	–	–	–	–
	Urospermum picroides (L.) Scop. ex F.W.Schmidt	+	–	–	–	–	–	–	–	–	–
	Urtica urens L.	+	+	+	+	+	+	+	+	+	+
	Vaccaria hispanica (Mill.) Rauschert	+	–	–	–	–	–	–	–	–	–
	Verbena officinalis L.	+	+	+	+	+	+	+	–	–	–
	Vermifrux abyssinica (A. Rich.) J.B. Gillett	–	+	+	+	+	–	–	–	–	–
	Vernonia leopoldi (Sch. Bip. ex Walp.) Vatke	–	–	–	–	+	–	–	–	–	–
	Veronica anagallis-aquatica L.	+	–	–	–	–	–	–	–	–	–
	Veronica polita Fr.	+	–	–	–	–	–	–	–	–	–
	Withania somnifera (L.) Dunal	+	+	+	+	+	+	+	+	+	+
	Xanthium spinosum L.	+	–	–	–	–	–	–	–	–	–
	Zehneria scabra (L. f.) Sond.	–	+	+	+	+	+	+	+	+	+
	Ziziphus spina-christi (L.) Willd.	+	+	+	+	+	+	–	–	–	–
Monocotyledon	*Albuca abyssinica* Jacq.	–	+	+	+	+	+	+	+	+	–
	Androcymbium schimperianum (Hochst.) K.Perss	–	–	–	+	+	–	–	–	–	+
	Andropogon distachyos L.	–	+	+	+	+	+	+	+	+	–
	Arundo donax L.	+	–	–	+	+	–	–	–	–	+
	Asparagus africanus Lam.	+	+	+	+	+	+	+	+	–	–
	Asphodelus fistulosus L.	+	–	–	+	+	–	–	–	–	–
	Avena fatua L.	+	–	–	–	+	–	–	–	–	–
	Brachypodium retusum (Pers.) P. Beauv.	–	–	–	–	+	–	–	–	–	–
	Bromus leptoclados Nees	–	–	–	+	+	–	–	–	–	–
	Bromus pectinatus Thunb.	+	+	+	+	+	+	+	–	–	–
	Carex distans L.	+	+	+	+	+	+	+	–	–	–
	Cenchrus ciliaris L.	+	+	+	+	+	+	+	–	–	–
	Cyperus niveus Retz.	–	+	+	+	+	+	+	+	+	+
	Digitaria abyssinica (Hochst. ex A. Rich.) Stapf	–	+	+	+	+	+	+	+	+	+
	Eleusine floccifolia (Forssk.) Spreng.	+	–	–	+	+	–	–	–	–	–
	Eragrostis braunii Schweinf.	–	+	+	+	+	+	+	–	–	–
	Eragrostis papposa (Roem. & Schult.) Steud.	–	+	–	+	+	+	–	–	–	–
	Hyparrhenia hirta (L.) Stapf	–	+	–	+	+	–	–	–	–	–
	Juncus fontanesii J. Gay ex Laharpe	+	+	+	+	+	+	+	+	+	+
	Juncus punctorius L. f.	+	+	+	+	+	–	–	–	–	–
	Lamarckia aurea (L.) Moench	+	–	–	–	+	–	–	–	–	–
	Oryzopsis holciformis (M.Bieb.) Hack.	–	–	–	+	+	–	–	–	–	–
	Pennisetum setaceum (Forssk.) Chiov.	+	+	+	+	+	+	–	–	–	–
	Pennisetum thunbergii Kunth	–	+	+	+	+	+	+	–	–	–
	Pennisetum villosum R. Br. ex Fresen.	–	–	–	+	+	–	–	–	–	–

Table 1. Continuation.

	Plant species	Phytogeographical elements									
		SS1	Sa	S	SM	Af	Z	ZI	GC	GCS	GCZ
Monocotyledon	*Polypogon viridis* (Gouan) Breistr.	+	+	+	+	+	+	+	–	–	–
	Pycreus sanguinolentus (Vahl) Nees	–	+	+	+	+	+	+	+	+	+
	Snowdenia polystachya (Fresen.) Pilg.	–	+	+	+	+	+	+	–	–	–
	Themeda triandra Forssk.	+	+	+	+	+	+	+	+	+	+
	Tragus racemosus (L.) All.	+	+	+	+	+	+	+	+	+	+

Legend: **SS1**: Saharan regional sub zone, **Sa**: Sahel regional transition zone, **S**: Sudanian regional central of endemism, **SM**: Somalia-Masai regional centre of endemism, **Af**: Afromontane archipelago-like regional centre of endemism, **Z**: Zambezian regional central of endemism, **ZI**: Zanzibar-Inhambane regional mosaic, **GC**: Guineo-Congolian regional centre of endemism, **GCS**: Guinea-Congolian/ Soudania regional transition zone & **GCZ**: Guinea-Congolian/ Zambezia regional transition zone.

Table 2. Mono, bi & tri-regional species.

Phytogeographical regions / phytogeographical categories	No. of species	Percentage (%) of the total No. of species recorded from J. An-Nabi Shu'ayb flora
Monoregional:		
Saharo-Arabian region	**21**	
SS1		
Total	**21**	**7.3%**
Sudano-Zambezian region:		
SM.	**1**	
Af.	**18**	
Z.	**1**	
SM+ Af.	**14**	
Af + Z.	**2**	
Sa + S + Af.	**2**	
Sa+ SM+ Af.	**2**	
SM + Af + Z.	**2**	
Sa + S + SM + Af.	**5**	
S+ SM+ Af+ Z.	**1**	
SM + Af + Z + ZI	**1**	
Sa + SM + Af + Z	**1**	
Sa + S + SM + Af + Z + ZI	**16**	
Total	**66**	**22.9%**
Total number of monoregional species	**87**	**30.2%**
Biregional:		
Saharo-Arabian region + Sudano-Zambezian region		
SS1+ SM.	**5**	
SS1+ Af.	**5**	
SS1+ Sa+ S.	**1**	
SS1+ SM + Af.	**11**	
SS1+ SM+ Z.	**1**	
SS1 + Sa + S +Af.	**3**	
SS1+ S+ SM+ Af.	**1**	
SS1 + Sa + SM + Af.	**2**	
SS1 + Sa + S + SM + Af.	**8**	
SS1 + Sa + S + SM + Af + Z.	**2**	
SS1 + Sa + SM + Af + Z + ZI.	**1**	
SS1 + Sa + S + SM + Af + Z + ZI	**14**	
Total	**54**	**18.8%**
Sudano-Zambezian region + Guinean region:		
SM + Af + GC.	**1**	
Af + GC + GCS.	**1**	
S + Af + GC + GCS.	**1**	
Sa + S + SM + Af + Z + ZI + GC + GCS.	**1**	
Sa + S + SM + Af + Z + ZI + GC + GCS + GCZ	**21**	
Total	**25**	**8.7%**
Total number of biregional species	**79**	**27.4%**
Tri-regional:		
Saharo-Arabian region + Sudano-Zambezian Region + Guinean Region		
SS1 + Af + Z + GCZ	**1**	
SS1 + Sa + S + SM + Af + GC	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ GC.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GC.	**1**	
SS1 + Sa + S + SM + Af + Z + ZI + GC + GCS.	**2**	
SS1 + Sa + S + SM + Af + Z + ZI +GC + GCS + GCZ.	**33**	
Total	**39**	**13.5%**
Total number of triregional species	**39**	**13.5%**
The total number of species shows distribution relationships with the African phytogeographical regions	**205**	
Sudano-Zambezian region + Guinean region:		
SM + Af + GC.	**1**	
Af + GC + GCS.	**1**	
S + Af + GC + GCS.	**1**	
Sa + S + SM + Af + Z + ZI + GC + GCS.	**1**	
Sa + S + SM + Af + Z + ZI + GC + GCS + GCZ	**21**	
Total	**25**	**8.7%**
Total number of biregional species	**79**	**27.4%**

Table 2. Continuation.

Phytogeographical regions / phytogeographical categories	No. of species	Percentage (%) of the total No. of species recorded from J. An-Nabi Shu'ayb flora
Tri-regional:		
Saharo-Arabian region + Sudano-Zambezian Region + Guinean Region		
SS1 + Af + Z + GCZ	**1**	
SS1 + Sa + S + SM + Af + GC	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ GC.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GC.	**1**	
SS1 + Sa + S + SM + Af + Z + ZI + GC + GCS.	**2**	
SS1 + Sa + S + SM + Af + Z + ZI +GC + GCS + GCZ.	**33**	
Total	**39**	**13.5%**
Total number of triregional species	**39**	**13.5%**
The total number of species shows distribution relationships with the African phytogeographical regions	**205**	

Legend: For abbreviations see Table 1.

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