The African Paleotropical floristic categories links to the Flora of highland plains in Yemen

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Abstract

About 222 plant species (two Ferns, one Gymnosperm, 219 Angiosperms: 169 Dicotyledons and 50 Monocotyledons) from the total 249 species were recorded from the Highland plains in Yemen, showing 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 207 (83.1 %) species; while the African paleotropical floristic element, with the highest number of species, is the Afro-Montane Archipelago-Like Regional Centre of Endemism, with 184 (73.9 %) species.

Key words: African floristic elements, paleotropical, highland plains, Yemen, numerical analysis.

Introduction

Based on the physiography of Yemen; eight main vegetation land scope units have been identified: Coastal plains, Low altitude mountains, Medium altitude mountains, High altitude mountains, Highland plains, Eastern and northern east mountains, Eastern desert and Soqotra Archipelago(2); seven of them (Coastal plains, Low altitude mountains, Medium altitude mountains, High altitude mountains, Highland plains, Eastern and northern east mountains, Eastern desert) are represented in the western part of Yemen (2&34); while the large part of the eastern side of Yemen is represented by the Eastern desert (2). However, Highland plains of Yemen consist of a series of intermountain plains (45) most of them located in the Eastern and Northern east mountains(34). Moreover, Highland plains are divided into two elements according to elevation; High altitude plains located over 1800m asl and low altitude plains located lower than 1800m asl (2).

In this respect White (44) illustrated seven ecological regions in north and center Africa; while Zohary (49) classified Africa as a part of the Paleotropic kingdom except its northern part (Mediterranean region) that was classified as a part of the Holarctic Kingdom. In addition, he placed Yemen within the Eriterio-Arabian province which is a meeting point between the Sudanese region and Saharo- Arabian region.

Furthermore, White (45) renewed the classical phytogeographical definitions such as Kingdom, Regions, Provinces, Sections, Districts, etc. by establishing a new system based on the richness of endemic flora in such a region, thus he classified Africa into 18 Phytogeographical regions, including nine regional centres of endemism parted by six regional transitional zones and three regional mosacics. Following White's system(44), a chorological map covering southwest of Asia and a part of Africa has been obtained by Leonard (29&30).

Based on the previous studies, a phytogeographical map of Africa and southwest of Asia was modified by White & Leonard (45) where they classified the African Paleotropical Kingdom into 10 phytogeographical elements; namely: Sahara Regional Subzone (SS1); 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); Guineo-Congolian Centre of Endemism (GC) Guinea-Congolian / Sudania Regional Transition Zone (GCS), and finally, Guinea-Congolian / Zambezia Regional Transition Zone (GCZ). Furthermore, they suggested that Yemen is a meeting point of two regional centres of endemism (Somalia-Masai Regional Centre of Endemism

(SM) and Afro -Montane Archipelago-Like Regional Centre of Endemism) and one regional subzone (Arabian Region subzone).

Recently, Al Khulaidi [2] revealed that the flora of Yemen is a combination of Tropical African Sudanese plant region (west mountains and part of highland plains of Yemen) and Saharo- Arabian plant region (coastal plains, eastern mountains, eastern and northern east desert plains). He also mentioned that the Tropical African Sudanian plant region is highly presented in the flora of Yemen. On the other hand, about 249 plant species (three Ferns, one Gymnosperm, 56 Monocotyledoneae and 189 Dicotyledoneae) were recorded from the Highland plains in Yemen [1; 2; 3; 4 &47].

The present study seeks to investigate the links between the African paleotropical floristic elements and the flora of highlands in Yemen.

Material and methods

The Phytogeographical relationship between the African paleotropical floristic elements and the flora of highland in Yemen was investigated by studying the distribution of 222 plant species (Table 1) from the total 249 plant species recorded by Al Khulaidi [2], Al Khulaidi & Kessler [4], Wood [48], Al Khulaidi & Dubaie [3] and Al Hubaishi & Muller-Hohenstein,[1] among the African paleotropical floristic elements, by utilizing the following floristic literatures: Richard [35 ,34]; Masters [31]; Baker [9]; Hooker [24]; Hiern [23]; Broun *et al*.[17]; Schwartz[37]; Andrews [6, 7&8]; Zohary [49]; Wickens [47]; Takhtajan [40];Johns [28]; White and Leonard [46]; Jefferey & Thulin [27]; Thulin [43,42];Battandier[10, 11]Boulos [12, 13, 14,15, 16]; Cope [19&20]; Tamado & Milberg [41]; Hepper [22]; Snogerup & Boulos [38]; Ali & Boulos [5]; Burrows & Willis [18];Scholte, et.al[36] Snogerup & Snogerup [39]; Frits *et al*.[21]; Hutchinson *et al*. [25] and Ibrahim *et al*.[26].

Moreover, the distribution of 222 plant species, among the African paleotropical floristic elements, was subjected to numerical analysis (UPGMA method) to investigate the links between the 10 African paleotropical floristic elements.

Results

About 222 Plant species (two Ferns, one Gymnosperm, 219 Angiosperms: 169 Dicotyledons and 50 Monocotyledons), from the total of 249 species, were recorded from the Highland plains in Yemen showing a distribution relationship with three African paleotropical floristic regions; Sudano-Zambezian Region represented by 207 (83.1 %) species; Afro-Montane Archipelago-Like Regional Centre of Endemism (Af) represented by 184 (73.9 %) species; whereas Somalia-Masai Regional Centre of Endemism (SM), Sahel Regional Transition Zone (Sa), Sudanese Regional Centre of Endemism (S), Zambezi Regional Centre of Endemism (Z), and Zanzibar-Inhumane Regional Mosaic (ZI) are denoted by 175 (70.3 %), 155 (62.3 %),145 (58.2 %), 116 (46.6 %) &

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
Fern	***Adiantum capillus-veneris L.***	+	+	+	+	+	+	+	+	+	+
	***Equisetum ramosissimum* Desf.**	+	+	+	+	+	+	+	+	+	+
Gym	***Juniperus procera* Hochst. ex Endl.**	-	+	+	+	+	+	-	-	-	-
Dicotyledon	***Acacia etbaica* Schweinf**	+	+	+	+	+	+	+	+	+	+
	***Acacia gerrardii* Benth.**	-	+	+	+	+	+	+	+	+	+
	***Acacia origena* Asfaw**	-	-	-	+	+	+	+	-	-	-
	***Acanthus arboreus* Forssk.**	-	+	+	+	+	+	+	+	+	+
	***Achyranthes aspera* L.**	+	+	+	+	+	+	+	+	+	+
	***Aerva javanica* (Burm.f.) Juss. ex Schult.**	+	+	+	+	+	+	+	+	+	+

***Alkanna orientalis* (L.) Boiss.**	+	-	-	-	-	-	-	-	-	-
***Althaea ludwigii* L.**	+	+	-	-	-	+	-	+	-	+
***Amaranthus hybridus* L.**	+	+	+	+	+	+	+	+	+	+
***Anagallis arvensis* L.**	+	+	+	+	+	-	-	-	-	-
***Anarrhinum forsskaolii* (J.F.Gmel.) Cufod.**	-	+	+	+	+	+	+	-	-	-
***Anastatica hierochuntica* L.**	+	+	-	-	-	-	-	-	-	-
***Anchusa arvensis* (L.) M. Bieb.**	-	+	+	+	+	-	-	-	-	-
***Andrachne aspera* Spreng.**	+	+	+	+	+	+	+	+	+	+
***Apium nodiflorum* (L.) Lag.**	+	-	-	-	+	-	-	-	-	-
***Argemone mexicana* L.**	+	+	+	+	-	-	+	+	+	-
***Argyrolobium arabicum* (Decne.) Jaub. & Spach**	+	+	+	-	+	-	-	-	-	-
***Artemisia abyssinica* Sch. Bip. ex A. Rich.**	-	-	-	-	+	-	-	-	-	-
***Astragalus sieberi* DC.**	+	-	-	-	-	-	-	-	-	-
***Astragalus tribuloides* Delile**	+	-	-	-	-	-	-	-	-	-
***Astragalus vogelii* (Webb) Bornm.**	+	+	+	+	+	+	+	+	+	+
***Atriplex leucoclada* Boiss.**	+	-	-	-	-	-	-	-	-	-
***Berula erecta* (Huds.) Coville**	+	+	+	-	+	-	-	+	+	-
***Blepharis ciliaris* (L.) B. L. Burtt**	-	-	-	+	-	-	-	-	-	-
***Boerhavia boissieri* Heimerl**	+	-	-	-	-	-	-	-	-	-
***Boerhavia diffusa* L.**	+	+	+	+	+	+	+	+	+	+
***Boerhavia helenae* Roem. & Schult**	+	+	+	+	+	+	+	+	+	+
***Boerhavia pedunculosa* A.Rich.**	-	+	+	+	+	+	+	+	-	-
***Boerhavia sinuata* (Meikle) Greuter & Burdet**	+	-	-	+	+	-	-	-	-	-
***Calendula arvensis* (Vaill.) L.**	+	+	-	-	-	-	-	-	-	-
***Calotropis procera* (Aiton) Dryand.**	+	+	+	+	+	+	+	+	+	+
***Capparis cartilaginea* Decne.**	+	+	+	+	+	+	+	-	-	-
***Caylusea hexagyna* (Forssk.) M.L.Green**	+	+	+	+	+	+	+	-	-	-
***Centella asiatica* (L.) Urb.**	-	+	+	+	+	+	+	+	+	+
***Chenopodium murale* L.**	+	+	+	+	+	+	+	+	+	+
***Chenopodium procerum* Hochst. ex Moq.**	-	-	-	-	+	-	-	-	-	-
***Chenopodium schraderianum* Schult.**	-	+	+	+	+	+	+	+	+	+
***Chrozophora oblongifolia* (Delile) A.Juss. ex Spreng**	+	+	+	+	+	-	-	-	-	-
***Cirsium vulgare* (Savi) Ten.**	-	-	-	-	+	-	-	-	-	-
***Cissus rotundifolia* Vahl**	-	-	-	+	-	+	+	-	+	-
***Citrullus colocynthis (*L.) Schrad.**	+	+	+	+	+	+	+	+	+	+
***Cleome amblyocarpa* Barratte & Murb.**	+	+	+	+	+	-	-	-	-	-
***Cleome brachycarpa* (Forssk.) Vahl ex DC.**	+	+	+	+	+	-	-	-	+	-
***Cometes abyssinica* R.Br. ex Wall.**	+	+	+	+	+	-	-	-	-	-
***Convolvulus arvensis* L.**	+	+	+	+	+	-	-	-	-	-
***Conyza incana* (Vahl) Willd.**	-	-	-	+	+	-	-	-	-	-

***Conyza pyrrhopappa* Sch.Bip. ex A.Rich.**	-	-	+	+	+	+	-	+	+	+
Crepis rueppellii Sch.Bip.	-	+	-	-	+	-	-	-	-	-
***Crotalaria emarginella* Vatke**	-	-	+	+	+	-	+	-	-	-
***Cucumis prophetarum* L.**	+	+	+	+	+	+	+	-	+	+
***Datura stramonium* L.**	+	+	+	+	+	+	+	+	+	+
***Desmidorchis penicillata* (Deflers) Plowes**	-	+	-	-	+	-	-	-	-	-
***Diplotaxis erucoides* (L.) DC.**	+	+	-	+	+	+	+	-	-	-
***Echinops spinosissimus* Turra**	+	+	+	+	+	-	-	-	+	-
***Echium rauwolfii* Delile**	+	+	+	-	-	-	-	-	-	-
***Erigeron bonariensis* L.**	+	+	+	+	-	+	-	-	+	-
***Erigeron trilobus* (Decne.) Boiss.**	+	+	+	+	+	+	+	+	+	+
***Erodium cicutarium* (L.) L'Hér.**	+	-	-	-	+	-	-	-	-	-
***Erodium malacoides* (L.) L'Hér.**	+	+	-	+	+	-	-	-	-	-
***Erucastrum arabicum* Fisch. & C.A.Mey.**	+	+	+	+	+	+	+	+	+	+
***Euphorbia cactus* Ehrenb. ex Boiss.**	-	-	-	+	-	-	-	-	-	-
***Euphorbia granulata* Forssk.**	+	+	+	+	+	+	+	-	+	+
***Euphorbia helioscopia* L.**	+	-	-	-	-	-	-	-	-	-
***Euphorbia inaequilatera* Sond.**	+	+	+	+	+	+	+	+	+	+
***Euphorbia peplus* L.**	+	+	-	-	+	-	-	-	-	-
***Euphorbia schimperi* C. Presl**	-	+	-	-	-	-	-	-	-	-
***Euphorbia schimperiana* Scheele**	-	+	+	+	+	+	+	+	+	+
***Euryops arabicus* Steud. ex Jaub. & Spach**	-	-	-	+	+	-	-	-	-	-
***Fagonia bruguieri* DC.**	+	+	+	+	+	+	+	-	+	-
***Fagonia indica* Burm.f.**	+	+	+	+	+	+	+	-	-	-
***Fagonia paulayana* J.Wagner & Vierh.**	+	+	+	+	+	+	+	-	-	-
***Falkia oblonga* Bernh.**	-	-	-	-	+	-	-	-	-	-
***Farsetia longisiliqua* Decne.**	+	+	+	+	+	-	-	-	-	-
***Felicia abyssinica* Sch. Bip. ex A. Rich.**	-	-	-	+	+	+	-	-	-	-
***Felicia dentata* (A. Rich.) Dandy**	+	+	+	+	+	-	-	-	-	-
Ficus palmata* Forssk. ssp. *palmate	+	+	+	+	+	-	-	-	-	-
***Flaveria trinervia* (Spreng.) C. Mohr**	-	-	-	-	+	-	-	-	-	-
***Forsskaolea tenacissima* L.**	+	+	+	+	+	+	+	-	-	-
***Galium tricornutum* Dandy**	+	-	-	-	-	-	-	-	-	-
***Geranium biuncinatum* Kokwaro**	+	+	+	+	+	-	-	-	-	-
***Gnidia somalensis* (Franch.) Gilg**	-	-	-	+	+	-	-	-	-	-
***Gomphocarpus fruticosus* (L.) W. T. Aiton**	+	+	+	+	+	+	+	+	+	+
***Helichrysum schimperi* (Sch. Bip. ex A. Rich.) Moeser**	-	+	-	+	+	+	+	+	-	+
***Helichrysum somalense* Baker f.**	-	-	-	+	-	-	-	-	-	-
***Heliotropium crispum* Desf.**	+	+	+	-	-	-	-	+	+	-
***Heliotropium europaeum* L.**	+	-	+	-	-	-	-	-	-	-
***Heliotropium longiflorum* (A.DC.) Jaub. & Spach**	-	+	+	+	+	+	+	-	-	-

Dicotyledon	***Heliotropium steudneri* Vatke**	-	+	-	+	+	-	+	-	-	-
	***Hibiscus trionum* L.**	+	+	+	+	+	+	+	+	+	+
	***Hypoestes forsskaolii* (Vahl) R. Br.**	-	+	+	+	+	+	+	+	+	+
	***Indigofera arabica* Jaub. & Spach**	+	+	+	+	+	+	+	+	+	+
	***Indigofera spinosa* Forssk.**	+	+	+	+	+	+	+	-	-	-
	***Kickxia elatine* (L.) Dumort.**	+	-	-	-	-	-	-	-	-	-
	***Kleinia odora* (Forssk.) DC.**	-	-	-	+	+	-	-	-	-	-
	***Kleinia semperviva* DC.**	-	-	-	+	+	-	-	-	-	-
	***Laggera decurrens* (Vahl) Hepper & J. R. I. Wood**	+	+	+	-	-	-	-	-	+	-
	***Laphangium luteoalbum* (L.) Tzvelev**	-	-	+	-	+	-	-	+	+	-
	***Launaea capitata* (Spreng.) Dandy**	+	+	+	+	-	-	-	-	-	-
	***Launaea nudicaulis* (L.) Hook. f.**	+	+	+	+	-	-	-	-	+	-
	***Lavandula coronopifolia* Poir.**	+	+	+	+	+	-	-	-	-	-
	***Lepidium draba* L.**	+	+	+	-	+	+	-	+	+	+
	***Leucas inflata* Benth.**	+	+	+	+	+	-	-	-	-	-
	***Lotononis platycarpos* (Viv.) Pic. Serm.**	+	+	+	+	+	+	+	-	-	-
	***Lotus corniculatus* L.**	+	+	-	-	+	-	-	-	-	-
	***Lotus quinatus* (Forssk.) J. B. Gillett**	-	-	-	+	+	-	-	-	-	-
	***Lycium shawii* Roem. & Schult.**	+	+	+	+	+	-	-	+	-	-
	***Lythrum hyssopifolia* L.**	+	+	+	+	+	+	+	+	+	+
	***Malva parviflora* L.**	+	+	+	+	+	+	+	+	+	+
	***Malva verticillata* L.**	-	+	+	+	+	-	-	-	-	-
	***Medicago lupulina* L.**	+	+	+	+	+	+	+	-	-	-
	***Mentha longifolia* (L.) L.**	+	-	-	+	+	+	+	-	+	-
	***Micromeria imbricata* (Forssk.) C. Chr.**	+	+	+	+	+	+	+	+	+	+
	***Myriophyllum spicatum* L.**	+	+	-	-	+	-	-	-	-	-
	***Notoceras bicorne* (Aiton) Amo**	+	+	-	-	-	-	-	-	-	-
	***Otostegia fruticosa* (Forssk.) Schweinf. ex Penzig**	+	+	+	+	+	+	+	-	-	-
	***Oxalis corniculata* L.**	+	+	+	+	+	+	+	+	+	+
	***Peganum harmala* L.**	+	-	-	-	-	-	-	-	-	-
	***Persicaria amphibia* (L.) Delarbre**	-	-	-	-	+	-	-	-	-	-
	***Phyla nodiflora* (L.) Greene**	+	+	+	+	+	+	+	+	+	+
	***Plantago lanceolata* L.**	+	+	+	+	+	+	+	+	+	+
	***Plantago major* L.**	+	-	-	+	+	+	-	-	-	-
	***Plantago ovata* Forssk.**	+	-	-	-	-	-	-	-	-	-
	***Polycarpaea repens* (Forssk.) Asch. & Schweinf.**	+	+	+	+	+	-	-	-	-	-
	***Polycarpaea robbairea* (Kuntze) Greuter & Burdet**	+	+	-	+	+	-	-	-	-	-
	***Polygala erioptera* DC.**	+	+	+	+	+	+	-	+	+	+
	***Polygonum aviculare* L.**	+	+	+	+	+	+	+	+	+	+
	***Portulaca quadrifida* L.**	+	+	+	+	+	+	+	+	+	+
	***Potentilla reptans* L.**	+	-	-	+	+	-	-	-	-	-
	***Psiadia punctulata* (DC.) Vatke**	-	-	-	+	+	+	-	-	-	-

Dicotyledon	***Pulicaria inuloides* (Poir.) DC.**	+	+	+	+	+	-	-	-	-	-
	***Pulicaria jaubertii* E. Gamal-Eldin**	+	-	-	+	+	-	-	-	-	-
	***Pulicaria undulata* (L.) C. A. Mey.**	+	+	+	+	+	+	+	+	+	+
	***Ranunculus multifidus* Forssk.**	-	-	+	+	+	+	+	+	+	+
	***Reichardia tingitana* (L.) Roth**	+	+	+	+	+	+	+	+	-	-
	***Rhynchosia minima* (L.) DC.**	+	+	+	+	+	+	+	+	+	+
	***Ricinus communis* L.**	+	+	+	+	+	+	+	+	+	+
	***Rosa abyssinica* R.Br. ex Lindl.**	-	+	+	+	+	-	-	-	-	-
	***Rumex dentatus* L.**	+	-	-	-	-	-	-	-	-	-
	***Rumex nervosus* Vahl**	-	+	+	+	+	+	+	-	-	-
	***Rumex steudelii* Hochst. ex A. Rich.**	-	+	+	+	+	+	+	+	+	+
	***Salix mucronata* Thunb.**	+	-	-	+	+	+	-	-	-	-
	***Salsola bottae* Boiss.**	-	-	-	+	-	-	-	-	-	-
	***Salvia aegyptiaca* L.**	+	+	+	+	+	-	-	-	-	-
	***Salvia schimperi* Benth.**	-	-	-	-	+	-	-	-	-	-
	***Sageretia thea* (Osbeck) M.C. Johnst.**	+	-	-	-	+	-	-	-	-	-
	***Senecio schimperi* Sch. Bip. ex A. Rich.**	-	+	+	+	+	+	+	+	+	+
	***Senna italica* Mill.**	+	+	+	+	+	+	+	+	+	+
	***Sisymbrium irio* L.**	+	+	-	+	+	-	-	-	-	-
	***Solanum glabratum* Dunal**	-	-	-	-	+	-	-	-	-	-
	***Solanum incanum* L.**	+	+	+	+	+	+	+	+	+	+
	***Solanum nigrum* L.**	+	+	+	+	+	+	+	+	+	+
	***Solanum villosum* Mill.**	+	+	+	+	+	+	+	+	+	+
	***Sonchus oleraceus* (L.) L.**	+	+	+	+	+	+	+	+	+	+
	***Spergularia marina* (L.) Besser**	+	-	-	-	-	-	-	-	-	-
	***Suaeda aegyptiaca* (Hasselq.) Zohary**	+	+	+	+	-	-	-	-	-	-
	***Tamarix senegalensis* DC.**	+	+	-	+	+	-	-	-	+	-
	***Telephium sphaerospermum* Boiss.**	+	-	-	+	+	-	-	-	-	-
	***Tragia pungens* (Forssk.) Müll. Arg.**	-	+	+	+	+	-	-	-	-	-
	***Trianthema crystallina* Vahl**	+	+	-	+	+	-	-	-	-	-
	***Tribulus terrestris* L.**	+	+	+	+	+	+	+	+	+	+
	***Trichodesma africanum* (L.) Sm.**	+	+	+	+	+	+	+	+	+	+
	***Trifolium fragiferum* L.**	+	+	-	+	+	-	-	-	-	-
	***Tripteris vaillantii* Decne.**	+	+	+	+	+	+	+	+	-	-
	***Verbena officinalis* L.**	+	+	+	+	+	+	+	-	+	-
	***Veronica polita* Fr.**	+	-	-	-	-	-	-	-	-	-
	***Volutaria abyssinica* (Sch.Bip. ex A.Rich.) C.Jeffrey ex Cufod.**	-	-	-	+	+	-	-	-	-	-
	***Withania somnifera* (L.) Dunal**	+	+	+	+	+	+	+	+	+	+
	***Xanthium spinosum* L.**	+	-	-	+	-	-	-	-	-	-
	***Ziziphus spina-christi* (L.) Desf.**	+	+	+	+	+	+	-	-	+	-
Monocotyledo	***Aeluropus lagopoides* (L.) Thwaites**	+	+	+	+	-	-	-	-	+	-
	***Andropogon greenwayi* Napper**	-	-	-	+	+	+	+	-	-	-
	***Aristida adscensionis* L.**	+	+	+	+	+	+	+	+	+	+
	***Aristida congesta* Roem. & Schult.**	-	-	-	-	+	-	-	-	-	-
	***Avena abyssinica* Hochst.**	-	-	-	+	+	+	+	-	-	-
	***Brachiaria eruciformis* (Sm.) Griseb.**	+	+	+	+	+	+	-	-	+	+

Monocotyledon	***Carex distans* L.**	+	+	+	+	+	+	+	-	-	-
	***Cenchrus ciliaris* L.**	+	+	+	+	+	+	+	+	+	+
	***Chrysopogon plumulosus* Hochst.**	-	+	+	+	+	+	+	+	+	-
	***Coelachyrum poiflorum* Chiov.**	-	-	-	+	+	-	-	-	-	-
	***Commelina albescens* Hassk.**	-	+	+	+	+	+	+	-	-	-
	***Crypsis schoenoides* (L.) Lam.**	+	+	+	+	+	+	-	+	+	+
	***Cynodon dactylon* (L.) Pers.**	+	+	+	+	+	+	-	+	+	+
	***Cyperus conglomeratus* Rottb.**	+	+	+	+	+	-	-	-	+	-
	***Cyperus laevigatus* L.**	+	+	+	+	+	+	+	+	+	+
	***Cyperus obtusiflorus* Vahl**	-	+	+	+	+	+	+	+	+	+
	***Cyperus rigidifolius* Steud.**	-	-	-	-	+	-	-	-	-	-
	***Dipcadi viride* (L.) Moench**	-	+	+	+	+	+	+	+	+	+
	***Eleocharis palustris* (L.) Roem. & Schult.**	+	-	-	-	-	-	-	-	-	-
	***Eleusine floccifolia* Spreng.**	+	-	-	+	+	-	+	-	-	-
	***Elionurus muticus* (Spreng.) Kuntze**	-	+	+	+	+	+	+	+	+	+
	***Enneapogon desvauxii* P. Beauv.**	+	+	+	+	+	+	+	-	+	-
	***Enneapogon schimperianus* (Hochst. ex A.Rich.) Renvoize**	-	-	+	+	+	+	+	-	-	-
	Eragrostis barrelieri Daveau	+	+	+	+	+	+	+	+	+	+
	***Eragrostis papposa* (Desf. ex Roem. & Schult.) Steud.**	+	+	+	+	+	+	+	+	+	-
	***Fingerhuthia africana* Lehm.**	-	-	-	-	-	+	-	-	-	-
	***Helictotrichon elongatum* (Hochst. ex A. Rich.) C .E. Hubb.**	+	-	+	+	+	+	-	-	-	-
	***Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.**	+	+	+	+	+	+	+	+	+	+
	***Hyparrhenia hirta* (L.) Stapf**	+	+	+	+	+	+	+	-	+	-
	***Isolepis setacea* (L.) R.Br**	+	+	+	+	+	-	-	-	+	-
	***Juncus bufonius* L.**	+	+	-	+	+	-	-	-	-	-
	***Juncus inflexus* L.**	+	-	-	-	-	-	-	-	-	-
	***Juncus punctorius* L. f.**	+	+	+	+	+	-	-	-	-	-
	***Leptochloa fusca* (L.) Kunth**	+	+	+	+	+	+	+	+	+	+
	***Microchloa kunthii* Desv.**	-	-	+	+	+	+	+	+	+	+
	***Oropetium minimum* (Hochst.) Pilg.**	-	+	+	+	+	-	-	-	-	-
	***Pennisetum setaceum* (Forssk.) Chiov.**	+	+	+	+	+	+	+	-	+	-
	***Pennisetum villosum* Fresen.**	+	-	+	+	+	-	-	-	+	-
	***Polypogon viridis* (Gouan) Breistr.**	+	+	+	+	+	+	+	-	-	-
	***Potamogeton pusillus* L.**	+	+	+	+	+	-	-	-	+	-
	***Pycreus elegantulus* (Steud.) C. B. Clarke**	-	+	+	+	+	+	-	+	+	+
	***Schoenoplectus corymbosus* (Roth ex Roem. & Schult.) J.Raynal**	+	+	+	+	+	+	+	+	+	+
	***Sporobolus ioclados* (Trin.) Nees**	+	+	+	+	+	+	+	+	+	+
	***Sporobolus tourneuxii* Coss.**	+	-	+	+	-	-	-	-	+	-
	***Stipagrostis ciliata* (Desf.) De Winter**	+	+	+	+	+	+	+	-	+	+
	***Stipagrostis hirtigluma* (Steud. ex Trin. & Rupr.) De Winter**	+	+	+	+	+	+	+	+	+	+
	***Stipagrostis obtusa* (Delile) Nees**	+	-	-	+	+	-	-	-	-	-

***Tetrapogon villosus* Desf.**	+	+	+	+	+	-	-	+	-	-
***Themeda triandra* Forssk.**	+	+	+	+	+	+	+	+	+	+
***Tragus racemosus* (L.) All.**	+	+	+	+	+	+	+	+	+	+

SS1: Saharan regional sub zone, **Sa**: Sahel regional transition zone, **S**: Sudanese 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.

103 species (41.4 %), respectively (Tables 1-2 & Fig. 1), followed by Sahara Regional Subzone (SS1) with 158 (63.5 %) species and Guinean Region with 106 (42.6%) species Guineo-Congolian Centre of Endemism (GC) is represented by82 species (32.9 %), whereas Guinea-Congolian / Sudanese Regional Transition Zone (GCS) & Guinea- Congolian / Zambezia Regional Transition Zone (GCZ) are represented by99 (39.8 %) & 75 (31.3 %) plant species, respectively).

According to the chorological analysis, about 59 (23. 7%) of all recorded species in the flora of Highland plains in Yemen are monoregional, of which 44species (17.7%) are native to the Sudano-Zambezian Region, followed by the Saharo-Arabian Region with 15 species (6%). Although biregional categories are represented by77 species (30.9%) of all recorded species in the flora of Highland plains. Of these, the categories of the Saharo-Arabian Region and Sudano-Zambezi Region are represented by 57 (22.9%) species, while the categories of the Sudano-Zambezi Region and Guinean Region are represented by20(8%) species. On the other hand, the triregional categories are represented by86 (34.5%) species (Table 2).

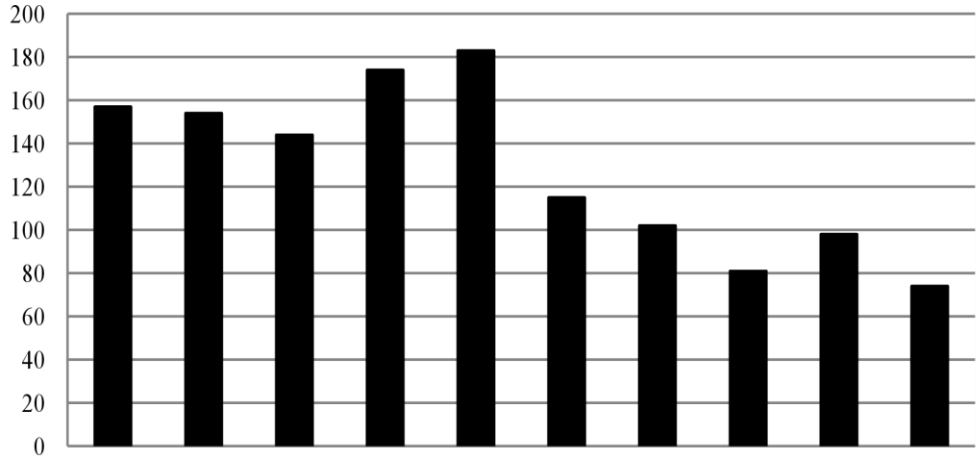

Fig. 1. Distribution of species among the 10 African paleotropical elements
Fabbreviations see Table1.

Table 2. Mono, bi & tri-regional species

Phytogeographical regions / phytogeographical categories	No. of Species	Percentage (%) of the total No. of Species recorded from Highland plains
Monoregional:		
Saharo-Arabian region		
SS1	**15**	
Total	**15**	**6%**
Sudano-Zambezian region:		
Sa	**1**	
SM.	**4**	
Af.	**10**	
Z	**1**	
Sa+Af	**2**	
SM+Af	**8**	
SM+Af+Z.	**2**	
Sa+ S+SM+ Af.	**5**	
Sa+ SM+Af, ZI.	**1**	
S+ SM+Af+ZI.	**1**	
SM+ Af+ Z+ ZI.	**3**	
Sa+S+SM+Af+Z.	**1**	
S+ SM+ Af+Z+ZI.	**1**	
Sa+ S+ SM+Af+Z+ZI.	**4**	
Total	**44**	**17.7%**
Total number of monoregional species	**59**	**23.7%**
Biregional:		
Saharo-Arabian region + Sudano-Zambezian region		
SS1+ Sa.	**3**	
SS1+ S.	**1**	
SS1+ SM.	**1**	
SS1+Af.	**3**	
SS1+ Sa+S.	**1**	
SS1+ Sa+ Af.	**3**	
SS1+ SM+ Af.	**5**	
SS1+ Sa+ S+ SM.	**2**	
SS1+ Sa+ S+ Af.	**1**	
SS1+ Sa+ SM+ Af.	**6**	
SS1+ SM+ Af+ Z.	**2**	
SS1+ SM+ Af+ ZI.	**1**	
SS1+ Sa+ S+ SM+ Af.	**15**	
SS1+ S+ SM+ Af+ Z.	**1**	
SS1+ Sa+ SM+ Af+ Z+ ZI.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI.	**11**	
Total	**57**	**22.9%**
Sudano-Zambezian region + Guinean region:		
S+ Af+ GC+ GCS.	**1**	
SM+ Z+ ZI+ GCS.	**1**	
Sa+ S+ SM+ Af+ Z+ ZI+ GC.	**1**	
Sa+ SM+ Af+ Z+ ZI+ GC+ GCZ.	**1**	
S+ SM+ Af+ Z+ GC+ GCS+ GCZ.	**1**	

Sa+ S+ SM+ Af+ Z+ ZI+ GC+ GCS.	**1**	
Sa+ S+ SM+ Af+ Z+ GC+ GCS+ GCZ.	**1**	
S+ SM+ Af+ Z+ ZI+ GC+ GCS+ GCZ.	**2**	
Sa+ S+ SM+ Af+ Z+ ZI+ GC+ GCS+ GCZ.	**11**	
Total	**20**	**8%**
Total number of biregional species	**77**	**30.9%**
Tri-regional: **Saharo-Arabian region + Sudano-Zambezian Region + Guinean Region**		
SS1+ Sa+ S+ GCS.	**1**	
SS1+ S+ SM+ GCS.	**1**	
SS1+ Sa+ S+ SM+ GCS.	**2**	
SS1+ Sa+ SM+ Af+ GCS.	**1**	
SS1+ Sa+ S+ GC+ GCS.	**1**	
SS1+ Sa+ Z+ GC+ GCZ.	**1**	
SS1+ S+ SM+ Af+ GCS.	**1**	
SS1+ Sa+ S+ SM+ Af+ GCS.	**5**	
SS1+ Sa+ S+ SM+ Af+ GC.	**2**	
SS1+ Sa+ S+ SM+ Z+ GCS.	**1**	
SS1+ Sa+ S+ Af+ GC+ GCS.	**1**	
SS1+ SM+ Af+ Z+ ZI+ GCS.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ GCS.	**1**	
SS1+ Sa+ S+ SM+ ZI+ GC+ GCS.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GC.	**2**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GCS.	**5**	
SS1+ Sa+ S+ SM+ Af+ Z+ GCS+ GCZ.	**1**	
SS1+ Sa+ S+ Af+ Z+ GC+ GCS+ GCZ.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GC+ GCS.	**1**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GCS+ GCZ.	**3**	
SS1+ Sa+ S+ SM+ Af+ Z+ GC+ GCS+ GCZ.	**3**	
SS1+ Sa+ S+ SM+ Af+ Z+ ZI+ GC+ GCS+ GCZ.	**50**	
Total	**86**	**34.5%**
Total number of tri-regional species	**86**	**34.5%**
The total number of species shows distribution relationships with the African phytogeographical regions	**222**	

*For abbreviations see Table 1.

The dendrogram resulting from the UPGMA method divides the 10 African paleotropical floristic elements on the basis of their species composition into two main groups (Group I & Group II) at a relative similarity level of 66.72 %.

Group I includes the Saharo-Sindian Region element (Saharan Regional Subzone) and 4 elements of the Sudano-Zambezian Region (Sahel Regional Transition Zone, Sudanese Regional.

Centre of Endemism, Somalia- Masai Regional Centre of Endemism & Afro-Montane Archipelago-Like Regional Centre of Endemism) which are located north and north east of the Equator; while Group II includes the two remaining elements of the Sudano-Zambezian Region (Zambezi Regional Centre of Endemism & Zanzibar-Inhambane Regional Mosaic) which are located south of the Equator and all the elements of the Guinean Region (Guineo-Congolian Centre of Endemism, Guinea-Congolian / Sudania Regional Transition Zone & Guinea-Congolian / Zambezia Regional Transition Zone). Furthermore, Group I & Group II are divided in two

subgroups; A&B at relative similarity level of 76.59% and C&D at relative similarity level of 76.61% respectively.

Subgroup A includes the Saharo-Sindian Region element (Saharan Regional Subzone); while Subgroup B includes two clusters (1&2) at relative similarity level of 83.63%, cluster1 includes Somalia- Masai Regional Centre of Endemism & Afro-Montane Archipelago-Like Regional Centre of Endemism at relative similarity level of 90.25%, while cluster 2 includes Sahel Regional Transition Zone, Sudanese Regional Centre of Endemism at relative similarity level of 90%. Moreover, subgroup C includes Zambezi Regional Centre of Endemism & Zanzibar-Inhambane Regional Mosaic at relative similarity level of 90.41%. On the other hand, subgroup D includes two clusters (3&4) at relative similarity level of 83.39%; cluster 3 includes the Guinea-Congolian / Sudania Regional Transition Zone; while cluster 4 includes Guineo-Congolian Centre of Endemism & Guinea-Congolian / Zambezia Regional Transition Zone at relative similarity level of 90.45% (Fig. 2).

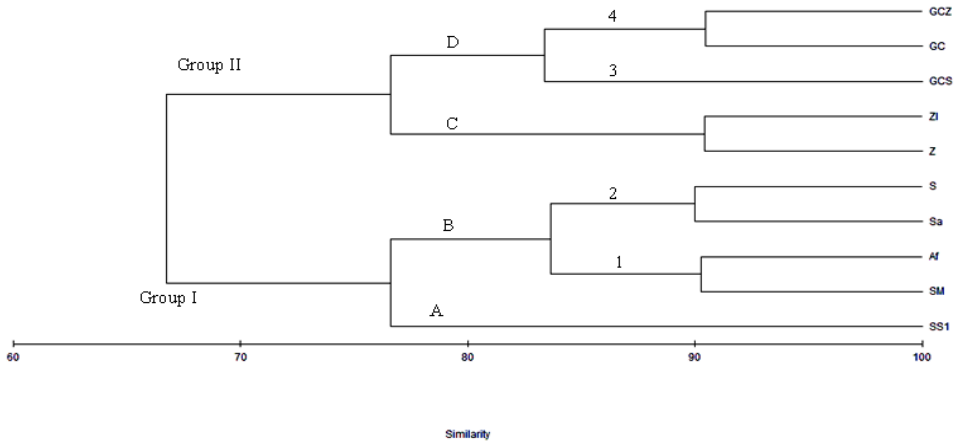

Fig. 2. Cluster analysis of the 10 African paleotropical floristic elements based on the similarity of their species composition by the UPGMA method

Discussion

According to the previous phytogegraphical analysis, 207 (83.1%) species from the flora of Yemen highland plains of show more distribution relationships with the Sudano-Zambezian Region then other two African paleotropical floristic regions although about 184 (73.9 %) plant species show more distribution relationships with Afro-Montane Archipelago-Like Regional Centre of Endemism more than the other nine African paleotropical floristic elements. Then, the flora of highland plains of Yemen is more like Afro-Montane Archipelago-Like Regional Centre of Endemism than Somalia- Masai Regional Centre of Endemism and Saharo-Sindian Region which boarded the mountains of Yemen (including of highland plains of Yemen) from the south and the east respectively. This corresponds to the findings of White and Leonard [(46)], which placed the southwestern mountains of the Arabian Peninsula (including mountains & highland plains of Yemen) within the Afro-Montane Archipelago- Like Regional Centre of Endemism.

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ارتباط أقاليم المملكة النباتية الاستوائية القديمة بفلورا سهول المرتفعات في اليمن

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الملخص

حوالي 222 نوعاً نباتياً (نوعان من السرخس، واحد من عاريات البذور، 219 كاسيات البذور: 169 من ذوات الفلقتين و 50 من ذوات الفلقة) من إجمالي 249 نوعاً سُجّلت من سهول المرتفعات في اليمن ، أظهروا علاقة التوزيع مع ثلاث مناطق نباتيه مداريه أفريقية من المملكة النباتية الاستوائية القديمة و 10 أقاليم نباتيه مدارية أفريقية من المملكة النباتية الاستوائية القديمة. وقد خضعت علاقة التوزيع بين ال 10 الاقاليم النباتية المدارية الأفريقية للتحليل العددي: و كان الإقليم السوداني – الزنبيزي يضم العدد الأكبر من الأنواع النباتية 207 (83.1٪) نوعاً نباتيا التي أظهر علاقه توزيعه مع سهول المرتفعات في اليمن، ومن ناحيه اخري وجد أنَّ إقليم الجبال الأفريقية يضم العدد الاكبر من الانواع النباتية (مقارنه بباقي الاقاليم) 184 (73.9٪) نوعا نباتي التي أظهر علاقه توزيعه مع سهول المرتفعات في اليمن.

الكلمات المفتاحية: فريقا، أقاليم نباتية، تحليل عددي، المملكة النباتية الاستوائية القديمة، سهول المرتفعات.