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Biological spectrum and phytogeographical patterns of endemic and near-endemic plants in Abyan Governorate, Yemen

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Abstract. *Obel MA, Aljeddani GS, Masdoos ZM, Hussein MA, Al-Khulaidi AWA, Al-Gifri AN, Nour IH. 2026. Biological spectrum and phytogeographical patterns of endemic and near-endemic plants in Abyan Governorate, Yemen. Biodiversitas 27 (3): d270329. https://doi.org/10.13057/biodiv/d270329*. Yemen faces serious biodiversity challenges; documenting endemic and near-endemic taxa supports its strategic conservation goals. This study reports and catalogs the endemic and near-endemic plant species in Abyan, emphasizing their life forms, life spans, growth forms, and phytogeography. Vegetation surveys were conducted for two successive spring seasons in 2023 and 2024. The field survey used a timed exploratory meander technique using non-plot sampling to maximize detection of taxa in inaccessible areas of the study site. Eight mountain peaks were selected to reflect the geographic extent of the study region. Fifty-seven endemic and near-endemic taxa, representing 21 plant families, were recorded, of which 23 are endemic and 34 are near-endemic. *Aloe serriyensis*, *Kleinia deflersii*, and *Stapelia* × *anemoniflora* are endemic to Jabal Al-Arays, located in the Khanfir District of Abyan. The floristic study revealed that Apocynaceae and Asteraceae were the most abundant families. Forty-one genera were recorded, with *Aloe* being the most species-rich genus. Perennial plants were more abundant than annuals in the study area, reflecting their greater tolerance to arid conditions. Subshrubs represented the dominant growth form, surpassing trees, shrubs, and herbs. Among the five identified life forms, chamaephytes were the most dominant. Phytogeographically, the Sudano-Zambezian chorotype accounts for more taxa than the Saharo-Arabian/Sudano-Zambezian, which is consistent with Yemen's geography and best represents hot desert habitats. Jabal Al-Arays comprises 57.9% of the total recorded taxa, including 13 near-threatened taxa and 1 critically endangered species. Thus, an urgent conservation plan should be implemented in Jabal Al-Arays through habitat protection and grazing control to safeguard endemic taxa under threat. Sustaining mountain biodiversity under increasing anthropogenic pressures and climatic change will require coordinated efforts among scientists, the governmental sector, and local communities, supported by predictive modeling to anticipate future biodiversity loss at high elevations in the coming decades.

Keywords: Abyan, chorotypes, endemism, life form spectrum, Saharo-Arabian

INTRODUCTION

The Arabian Peninsula comprises seven countries and is located in southwest Asia. It occupies a unique position between Africa and Asia, combining biogeographic features of both continents, with plant endemism estimated at 20% (White and Léonard 1991; Miller and Cope 1996). The Republic of Yemen is located on the southern edge of the Arabian Peninsula, between 12° and 19°N latitude. The country occupies an area of 527,970 km², surrounded to the north by Saudi Arabia, to the east by Oman, and to the south and west by approximately 2,200 km of coastline along the Gulf of Aden, the Arabian Sea, and the Red Sea. Yemen is divided into five principal topogeographic regions (Noaman 2018). Yemen has a tropical arid and semiarid climate along its coast and inland desert, as well as a subtropical and temperate climate in its highlands (World Bank Group 2023).

The flora of Yemen has been studied by many authors (Gabali and Al-Gifri 1990; Al-Gifri and Hussein 1993; Al-Gifri and Al-Subai 1994; Kilian et al. 2002; Al-Khulaidi and Miller 2010; Al-Khulaidi 2013). The country is facing multiple challenges, including climate change, urbanization, overgrazing, limited institutional capacity, widespread corruption, and persistent political instability (Al-Khulaidi and El-Naggar 2011; EPA 2017), which have been contributing to species loss. Floristic surveys are necessary to assess biodiversity losses, which have been hindered by ongoing insecurity, making it more challenging to gather accurate species distribution data. Yemen's strategic vision goals align with the urgent need to document native taxa and develop effective conservation measures (Ahmed 2003; Aljarmouzi et al. 2023). Al-Khulaidi (2013) documented

that 21.4% of the Yemeni flora consists of endemic and near-endemic taxa, most of which live in different topographic regions (Ministry of Water and Environment 2010). These plants are useful for maintaining ecological balance and providing high medicinal potential (Ghazanfar 2024; Mokbel et al. 2025). In 2011, the country announced six key biodiversity areas that host many endemic and near-endemic species, in addition to the Socotra Archipelago (EPA 2024), which is renowned for its unique biodiversity and designation as a UNESCO World Heritage Site (UNESCO 2026). These priority areas include the southern Hadhramaut plateau, the Fartak and Hawf Mountains in the Gulf of the Moon, the Al-Mahra eastern desert plains, the Taiz southwestern highlands, the western highlands (Jabal Malhan, Bura', and Hadiya in Raymah), and the southeastern highlands of Abyan, particularly Jabal Al-Arays (EPA 2024). Endemic and near-endemic taxa are unique to a specific geographical area (Myers et al. 2000). They persist in their current habitats through habitat selection and gradual adaptation to local environmental conditions (Walther et al. 2002). Endemism correlates with environmental gradients such as temperature, precipitation, and elevation, where mountains are known to have a higher rate of endemism (Kilian 1999). These species may be evolutionary novelties and ecologically unique from their non-endemic relatives (Sobral et al. 2016).

Several studies in Yemen's governorates surrounding Abyan have comprehensively identified endemic and near-endemic plant taxa. Twenty-one endemic and twenty near-endemic succulent species have been identified in Al Dali' governorate by Alhood et al. (2020), while Al-Super (2023) also studied the same region and identified twenty-three endemic and thirty-four near-endemic taxa. The Lahij governorate was studied by several authors, including Al-Hawshabi et al. (2017), Alasbahi and Al-Hawshabi (2020), and Atif et al. (2024). However, Saif et al. (2024) documented the highest numbers: eight endemic and twenty near-endemic species.

The overall flora of Abyan was studied by Hussein et al. (2007), who reported no endemic species in the governorate. Subsequent studies by Masdoos et al. (2023), Obel et al. (2024), and Obel et al. (2025) reported endemic and near-endemic taxa only in the Mudiyah and Al Wade'a districts of Abyan. Those works lack a systematic inventory and comprehensive biological and chorological analysis. Despite these contributions, endemic and near-endemic taxa remain insufficiently addressed in other districts of Abyan. Therefore, this study aims to fill that gap by recording and cataloging both endemic and near-endemic plant species in Abyan. The study provides data on their biological spectrum (Raunkiaer's life form classification), life span, growth form, and phytogeographical distribution. Moreover, this study provides baseline information to support national conservation initiatives in biodiversity-rich areas of Abyan, particularly Jabal Al-Arays in the Khanfir District.

MATERIALS AND METHODS

Study area

The Abyan governorate covers an area of approximately 28,187 km² and is located along Yemen's southern coastal plain (13°00'-14°20' N and 45°05'-47°12' E) (Figure 1) and borders Aden (Al-Hawshabi 2015). The governorate consists of 11 districts; it comprises coastal plains along the Gulf of Aden and inland mountainous regions (Yemen Local Governance 2025). This mountainous region encompasses the central highlands, a temperate zone located more than 2,000 m in elevation (Wenner and Burrowes 2023). Geographically, Abyan lies within two topogeographic regions: the Tihama coastal plain and the Sarawat mountains. The Tihama coastal plain extends for approximately 2,200 km along the Red Sea, Gulf of Aden, and Arabian Sea, with a width ranging from 30 to 60 km. The Sarawat mountains rise steeply along Yemen's western border and extend northward into Saudi Arabia (Noaman 2018).

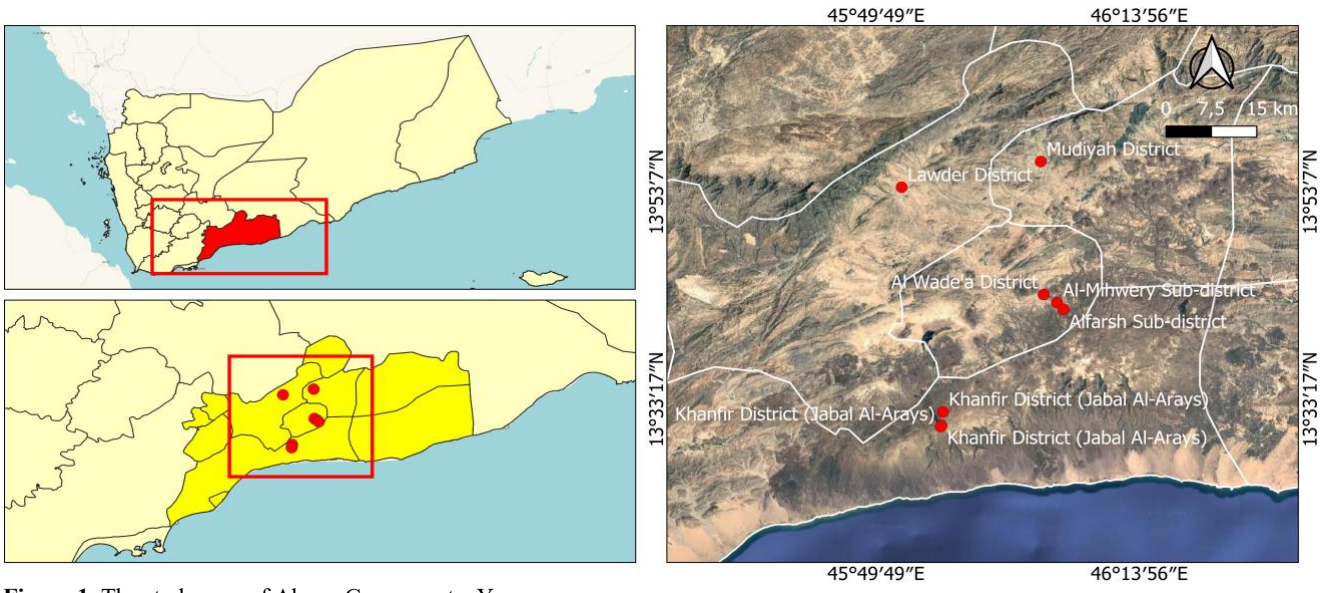

Figure 1. The study area of Abyan Governorate, Yemen

Table 1. Sampling sites, localities, coordinates, and elevations of the eight mountain peaks in Abyan, Yemen

Location	Coordinates		Elevation (m asl)
	Latitude	Longitude	
Lawder District	13.892771	45.869395	978
Mudiyah District	13.933682	46.081829	780
Al Wade'a District	13.721741	46.086452	1042
Al-Mihwery Sub-district	13.708773	46.106617	1050
Alfarsh Sub-district	13.698039	46.116659	1100
Khanfir District (Jabal Al-Arays)	13.534744	45.932419	1685
Khanfir District (Jabal Al-Arays)	13.513068	45.930173	1730
Khanfir District (Jabal Al-Arays)	13.511332	45.929186	1732

The soil of the study area was classified by Al-Mansiri (2002) into three main types. Firstly, the arid soils along the coast exhibit low organic matter and form salt crusts under elevated temperatures. Secondly, the young, undeveloped soils are recent alluvial deposits poor in key nutrients. Finally, the deep soils, which exhibit a silty-clay texture with lateral cracking, are well-suited for cultivation. Abyan has scrub vegetation of small bushes or is covered by open woodland, which has been commonly used in Yemeni folk medicine throughout history (Al-Fatimi 2019).

Based on data retrieved from the World Bank Group (2025) for Abyan, the seasonal cycle over the last 3 decades (1991-2020), the data show that the surface air temperature ranged from 16.5°C in January to 35.34°C in June, indicating that the coolest months were November to February, whereas the warmest months were April to October. The mean total annual precipitation at the national level during this period was 190.09 mm, while in Abyan it was 199.16 mm. The wettest months were May through September, and the driest were October through February.

Sampling design and data analysis

A comprehensive survey was carried out to record endemic and near-endemic plant species in Abyan. Eight mountain peak locations were chosen to represent the entire geographic scope of the study area, and vegetation surveys were conducted **(**Figure 1).

Sampling sites, localities, coordinates, and elevations of the eight mountain peaks in Abyan are illustrated in Table 1. Fieldwork was extended for two successive spring seasons in 2023 and 2024. The field survey used a timed exploratory meander technique, based on transect walks (non-plot sampling). This approach was applied to reduce bias and detect the highest possible number of taxa located in the inaccessible field locations, with a focus on documented species richness rather than abundance (Huebner 2007). The mountain peaks were selected to maximize microhabitat coverage, including rocky slopes, mountain wadis, semi-arid foothills, and sparsely vegetated highlands, with different elevations ranging from 780 to 1732 m asl. Certain sites were physically and geographically inaccessible, resulting in a bias toward more safely accessible microhabitats. However, the regional distribution of the selected peaks and the repeated surveys over two seasons alleviate this bias. The survey effort was standardized across sites, with two observers documenting each location, covering 3.5-7.2 km over 4-8 hours, depending on species richness and terrain ruggedness. GPS coordinates were obtained using a Garmin GPSMAP 64s (±5 m accuracy), with track logs recorded for each route.

One hundred seventy-one voucher specimens for the collected taxa were deposited in the herbarium of the Botany Department, Faculty of Education, University of Aden, Yemen, with codes UAB-1 to UAB-171. Identification of taxa was carried out using stereomicroscopy, according to the Flora of Yemen by Al-Khulaidi (2013). The classification of the latter author was followed in the present study, where endemic species are restricted to Yemen, while near-endemic taxa are restricted to neighboring countries like Saudi Arabia and Oman. The Plants of the World Online database (POWO 2024) and the Global Biodiversity Information Facility (GBIF 2025) were used to confirm the geographic distribution of the identified species. The former database (POWO 2024) was used to revise the nomenclature of the identified taxa and their accepted synonyms. The identified subspecies were recognized as separate taxa. Raunkiaer's (1934) classification system was used to identify life forms. Phytogeographical categories were determined using White and Léonard (1991). Extensive distribution data necessary for chorotype identification were obtained from Yemen Flora (Al-Khulaidi 2013) and comprehensive online databases (POWO 2024; GBIF 2025). Furthermore, the national threat status was assessed for the recorded taxa according to Al-Khulaidi and Miller (2010). The percentage contribution of each category was calculated relative to the total number of recorded taxa. Charts illustrating plant diversity were created and analyzed using MS Excel 365.

RESULTS AND DISCUSSION

Endemism in Abyan is represented by 57 endemic and near-endemic taxa, all angiosperms. All spectra presented refer to the recorded endemic and near-endemic taxa (Table 2, Figures 2-8). Out of 57 taxa, 23 were recognized as endemic and 34 as near-endemic (Figure 4). 41 genera were recorded, with *Aloe* being the most species-rich genus (6 species). These taxa belong to 21 plant families. There are 18 dicotyledonous families, while 3 monocotyledonous families were identified (Figure 5). The monocotyledonous families are Asparagaceae, Asphodelaceae, and Velloziaceae. Floristic analysis indicated that the most represented families were Apocynaceae (15 taxa), Asteraceae (9 taxa), and Asphodelaceae (7 taxa), accounting for approximately 26.3%, 15.8%, and 12.2% of the total recorded taxa, respectively (Figure 6).

Table 2. List of plant taxa recorded in Abyan, with their synonyms and voucher specimen number

Family name	Taxon name	Voucher specimen number	Endemic/ Near endemic	Life form	Life span	Growth form	Chorology	IUCN status
Acanthaceae	*Barleria farinosa* Deflers	UAB-1, UAB-2, UAB-3	E	Ch	Perennial	Subshrub	SZ	NE
	Barleria prionitis subsp. *appressa* (Forssk.) Brummitt & J.R.I.Wood (Syn. *Barleria appressa* (Forssk.) Deflers, *Justicia appressa* Forssk.)	UAB-4, UAB-5, UAB-6	NE	Ch	Perennial	Subshrub	SA+SZ	NE
	Justicia areysiana Deflers (Syn. *Bentia fruticulosa* Rolfe, *Justicia bentii* V.A.W.Graham)	UAB-7, UAB-8, UAB-9	NE	Ch	Perennial	Shrub	SZ	DD
Amaranthaceae	*Halothamnus bottae* Jaub. & Spach (Syn. *Caroxylon bottae* (Jaub. & Spach) Moq., *Salsola bottae* (Jaub. & Spach) Boiss.)	UAB-10, UAB-11, UAB-12	NE	Ch	Perennial	Shrub	SA+SZ	NE
Apiaceae	*Adenosciadium arabicum* (T.Anderson) H.Wolff (Syn. *Ammoides arabica* (T.Anderson) M.Hiroe, *Ptychotis arabica* T.Anderson)	UAB-13, UAB-14, UAB-15	NE	Th	Annual	Herb	SZ	NE
	Ducrosia areysiana (Deflers) Pimenov & Kljuykov (Syn. *Peucedanum areysianum* Deflers)	UAB-16, UAB-17, UAB-18	NE	Th	Annual	Herb	SZ	NE
Apocynaceae	*Ceropegia foliosa* Bruyns	UAB-19, UAB-20, UAB-21	E	Ge	Perennial	Shrub	SZ	NT
	Cynanchum areysianum (Bruyns) Meve & Liede (Syn. *Sarcostemma areysianum* Bruyns)	UAB-22, UAB-23, UAB-24	E	Ch	Perennial	Shrub	SZ	NE
	Cynanchum forskaolianum (Schult.) Meve & Liede (Syn. *Asclepias aphylla* Forssk., *Sarcostemma forskaolianum* Schult., *Asclepias contorta* Forssk.)	UAB-25, UAB-26, UAB-27	NE	Ch	Perennial	Shrub	SZ	NE
	Desmidorchis adenensis (Deflers) Meve & Liede (Syn. *Boucerosia adenensis* Deflers, *Caralluma adenensis* (Deflers) A.Berger, *Ceropegia adenensis* (Deflers) Bruyns, *Crenulluma adenensis* (Deflers) Plowes)	UAB-28, UAB-29, UAB-30	NE	Ch	Perennial	Subshrub	SZ	NT
	Desmidorchis awdeliana (Deflers) Meve & Liede (Syn. *Boucerosia awdeliana* Deflers, *Caralluma awdeliana* (Deflers) A.Berger, *Ceropegia awdeliana* (Deflers) Bruyns, *Crenulluma awdeliana* (Deflers) Plowes	UAB-31, UAB-32, UAB-33	NE	Ch	Perennial	Subshrub	SZ	NT
	Huernia lodarensis Lavranos (Syn. *Ceropegia lodarensis* (Lavranos) Bruyns)	UAB-34, UAB-35, UAB-36	NE	Ch	Perennial	Subshrub	SZ	NT
	Huernia marnieriana Lavranos (Syn. *Ceropegia marnieriana* (Lavranos) Bruyns)	UAB-37, UAB-38, UAB-39	E	Ch	Perennial	Subshrub	SZ	NT
	Monolluma cicatricosa (Deflers) Plowes (Syn. *Boucerosia cicatricosa* Deflers, *Caralluma cicatricosa* (Deflers) N.E.Br., *Ceropegia cicatricosa* (Deflers) Bruyns)	UAB-40, UAB-41, UAB-42	E	Ch	Perennial	Subshrub	SA+SZ	NT

	Monolluma hexagona (Lavranos) Meve & Liede (Syn. *Caralluma hexagona* Lavranos, *Ceropegia hexagona* (Lavranos) Bruyns, *Sulcolluma hexagona* (Lavranos) Plowes)	UAB-43, UAB-44, UAB-45	NE	Ch	Perennial	Subshrub	SA+SZ	NT
	Monolluma quadrangula (Forssk.) Plowes (Syn. *Boucerosia forskalii* Decne., *Boucerosia quadrangula* (Forssk.) Decne., *Caralluma forskalii Plowsen, Caralluma quadrangula* (Forssk.) N.E.Br., *Ceropegia quadrangula* (Forssk.) Bruyns, *Desmidorchis forskalii* Decne., *Desmidorchis quadrangula* (Forssk.) Kuntze, *Echidnopsis quadrangula* (Forssk.) Deflers, *Stapelia quadrangula* Forssk.)	UAB-46, UAB-47, UAB-48	NE	Ch	Perennial	Subshrub	SZ	NT
	Orbea araysiana (Lavranos & Bilaidi) Bruyns (Syn. *Angolluma araysiana* (Lavranos & Bilaidi) Plowes*, Ceropegia araysiana* (Lavranos & Bilaidi) Bruyns, *Pachycymbium araysianum* (Lavranos & Bilaidi) M.G.Gilbert, *Stultitia araysiana* Lavranos & Bilaidi.)	UAB-49, UAB-50, UAB-51	E	Ch	Perennial	Subshrub	SZ	NT
	Orbea chrysostephana (Deflers) Bruyns (Syn. *Angolluma chrysostephana* (Deflers) Plowes, *Caralluma chrysostephana* (Deflers) A.Berger, *Ceropegia chrysostephana* (Deflers) Bruyns, *Pachycymbium chrysostephanum* (Deflers) M.G.Gilbert, *Stapelia chrysostephana* Deflers.)	UAB-52, UAB-53, UAB-54	E	Ch	Perennial	Subshrub	SZ	NT
	Orbea deflersiana (Lavranos) Bruyns (Syn. *Angolluma deflersiana* (Lavranos) Plowes, *Caralluma deflersiana* Lavranos, *Ceropegia deflersiana* (Lavranos) Bruyns, *Pachycymbium deflersianum* (Lavranos) M.G.Gilbert.)	UAB-55, UAB-56, UAB-57	NE	Ch	Perennial	Subshrub	SZ	NT
	Rhytidocaulon macrolobum subsp. *macrolobum* (Syn. *Ceropegia macroloba* (Lavranos) Bruyns)	UAB-58, UAB-59, UAB-60	NE	Ch	Perennial	Subshrub	SZ	NT
	Stapelia × *anemoniflora* Deflers	UAB-61, UAB-62, UAB-63	E	Ch	Perennial	Subshrub	SZ	NE
Asparagaceae	*Dracaena serrulata* Baker (Syn. *Dracaena neoserrulata* Idrees & Z.Yong Zhang)	UAB-64, UAB-65, UAB-66	NE	Ph	Perennial	Tree	SZ	EN
Asphodelaceae	*Aloe ahmarensis* Favell, M.B.Mill. & Al-Gifri	UAB-67, UAB-68, UAB-69	E	Ch	Perennial	Subshrub	SZ	NE
	Aloe lanata T.A.McCoy & Lavranos	UAB-70, UAB-71, UAB-72	E	Ch	Perennial	Subshrub	SZ	NE
	Aloe lavranosii Reynolds	UAB-73, UAB-74, UAB-75	E	Ch	Perennial	Subshrub	SZ	NT
	Aloe rubroviolacea Schweinf.	UAB-76, UAB-77, UAB-78	NE	Ch	Perennial	Subshrub	SZ	NT
	Aloe serriyensis Lavranos	UAB-79, UAB-80, UAB-81	E	Ch	Perennial	Subshrub	SZ	NT
	Aloe vacillans Forssk.	UAB-82, UAB-83, UAB-84	NE	Ch	Perennial	Subshrub	SZ	NT

	Aloidendron sabaeum (Schweinf.) Boatwr. & J.C.Manning (Syn. *Aloe sabaea* Schweinf.)	UAB-85, UAB-86, UAB-87	NE	Ch	Perennial	Shrub	SZ	NT
Asteraceae	*Cynoglossum bottae* Deflers (Syn. *Paracynoglossum bottae* (Deflers) R.R.Mill & A.G.Mill.)	UAB-88, UAB-89, UAB-90	NE	Ch	Annual/Biennial	Herb	SZ	NE
	Iphiona senecionoides (Baker) Anderb. (Syn. *Grantia senecionoides* Baker, *Perralderiopsis senecionoides* (Baker) Rauschert.)	UAB-91, UAB-92, UAB-93	NE	Ch	Perennial	Shrub	SA+SZ	NE
	Kleinia deflersii (O.Schwartz) P.Halliday (Syn. *Senecio deflersii* O.Schwartz)	UAB-94, UAB-95, UAB-96	E	Ch	Perennial	Shrub	SZ	CR
	Launaea almahrahensis N.Kilian	UAB-97, UAB-98, UAB-99	NE	Ge	Perennial	Herb	SZ	NE
	Pluchea indica subsp. *yemenensis* King-Jones	UAB-100, UAB-101, UAB-102	E	Ch	Perennial	Shrub	SA+SZ	NE
	Pulicaria nivea O.Schwartz	UAB-103, UAB-104, UAB-105	E	Ch	Perennial	Herb	SZ	NE
	Pulicaria somalensis subsp. *schweinfurthii* E.Gamal-Eldin	UAB-106, UAB-107, UAB-108	NE	Ch	Perennial	Herb	SZ	NE
	Vernonia areysiana Deflers	UAB-109, UAB-110, UAB-111	NE	Ch	Perennial	Subshrub	SZ	NE
	Volutaria albicaulis (Deflers) Wagenitz (Syn. *Centaurea albicaulis* (Deflers) O.Schwartz, *Volutarella albicaulis* Deflers.)	UAB-112, UAB-113, UAB-114	NE	Ch	Perennial	Herb	SZ	NE
Boraginaceae	*Heliotropium azzanum* O.Schwartz	UAB-115, UAB-116, UAB-117	NE	Ch	Perennial	Herb	SZ	NE
Brassicaceae	*Farsetia linearis* Decne. ex Boiss.	UAB-118, UAB-119, UAB-120	NE	Ch	Perennial	Subshrub	SZ	NE
Euphorbiaceae	*Euphorbia ammak* Schweinf.	UAB-121, UAB-122, UAB-123	NE	Ph	Perennial	Tree	SA+SZ	VU
	Euphorbia greuteri N.Kilian, Kürschner & P.Hein	UAB-124, UAB-125, UAB-126	E	Ch	Perennial	Subshrub	SZ	NE
	Euphorbia inarticulata Schweinf.	UAB-127, UAB-128, UAB-129	NE	Ch	Perennial	Subshrub	SA+SZ	NT
Fabaceae	*Leucas alba* (Forssk.) Sebald (Syn. *Ballota forskahlii* Benth., *Elbunis alba* (Forssk.) Raf., *Phlomis alba* Forssk.)	UAB-130, UAB-131, UAB-132	NE	Ch	Perennial	Subshrub	SZ	NE

	Vachellia hunteri (Oliv.) Ragup., Seigler, Ebinger & Maslin (Syn. *Acacia hunteri* Oliv.)	UAB-133, UAB-134, UAB-135	E	Ph	Perennial	Tree	SZ	NE
	Zygocarpum yemenense (J.B.Gillett) Thulin & Lavin (Syn. *Ormocarpum yemenense* J.B.Gillett)	UAB-136, UAB-137, UAB-138	E	Ch	Perennial	Shrub	SZ	NE
Lamiaceae	*Lavandula citriodora* A.G.Mill.	UAB-139, UAB-140, UAB-141	NE	Ch	Perennial	Subshrub	SA+SZ	NE
	Salvia areysiana Deflers (Syn. *Pleudia areysiana* (Deflers) M.Will, N.Schmalz & Class.-Bockh.)	UAB-142, UAB-143, UAB-144	E	Ch	Perennial	Subshrub	SZ	NE
Malvaceae	*Gossypium areysianum* Deflers (Syn. *Gossypium anomalum* subsp. *areysianum* (Deflers) Roberty)	UAB-145, UAB-146, UAB-147	E	Ch	Perennial	Subshrub	SZ	NT
Nyctaginaceae	*Commicarpus adenensis* A.G.Mill.	UAB-148, UAB-149, UAB-150	E	Ch	Perennial	Subshrub	SZ	NE
Orobanchaceae	*Cistanche rosea* Baker	UAB-151, UAB-152, UAB-153	NE	Pa	Perennial	Herb	SZ	NE
Plantaginaceae	*Campylanthus pungens* O.Schwartz	UAB-154, UAB-155, UAB-156	NE	Ch	Perennial	Shrub	SZ	NE
Resedaceae	*Reseda sphenocleoides* Deflers	UAB-157, UAB-158, UAB-159	NE	Ch	Perennial	Subshrub	SZ	NE
Rubiaceae	*Pavetta longiflora* Vahl (Syn. *Ixora longiflora* (Vahl) Poir.)	UAB-160, UAB-161, UAB-162	NE	Ch	Perennial	Shrub	SZ	NE
Velloziaceae	*Xerophyta arabica* (Baker) N.L.Menezes (Syn. *Barbacenia arabica* (Baker) Schwartz, *Vellozia arabica* Baker.)	UAB-163, UAB-164, UAB-165	NE	Ch	Perennial	Shrub	SZ	NE
Verbenaceae	*Chascanum yemenense* Sebsebe	UAB-166, UAB-167, UAB-168	E	Ch	Perennial	Subshrub	SZ	NE
Zygophyllaceae	*Zygophyllum hadramauticum* (Beier & Thulin) Christenh. & Byng (Syn. *Fagonia hadramautica* Beier & Thulin)	UAB-169, UAB-170, UAB-171	E	Ch	Perennial	Subshrub	SZ	NE

Note: E: Endemic, NE: Near-endemic, life form: Chamaephytes (Ch), Geophytes (Ge), Parasites (Pa), Phanerophytes (Ph), Therophytes (Th), chorotypes: Saharo-Arabian (SA), Sudano-Zambezian (SZ), IUCN status at the national level: Critically Endangered (CR), Data Deficient (DD), Endangered (EN), Near Threatened (NT), Not Evaluated (NE)

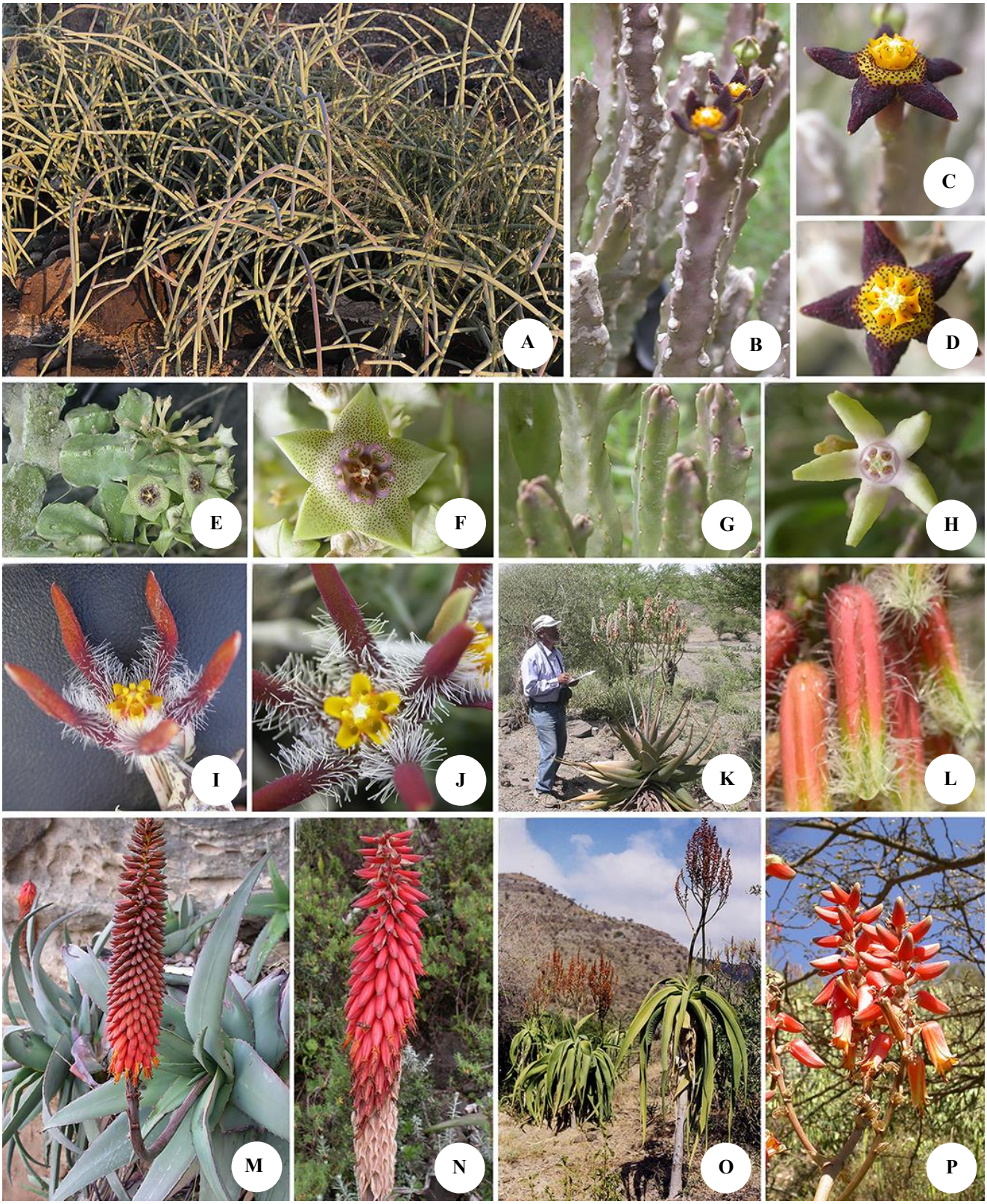

Figure 2. A-D. Apocynaceae: A. *Cynanchum forskaolianum*, B-D. *Monolluma cicatricosa*, E-F. *Monolluma hexagona*, G-H. *Monolluma quadrangula*, I-J. *Orbea chrysostephana*, K-P. Asphodelaceae: K-L. *Aloe lanata*, M-N. *Aloe rubroviolacea*, O-P. *Aloidendron sabaeum*

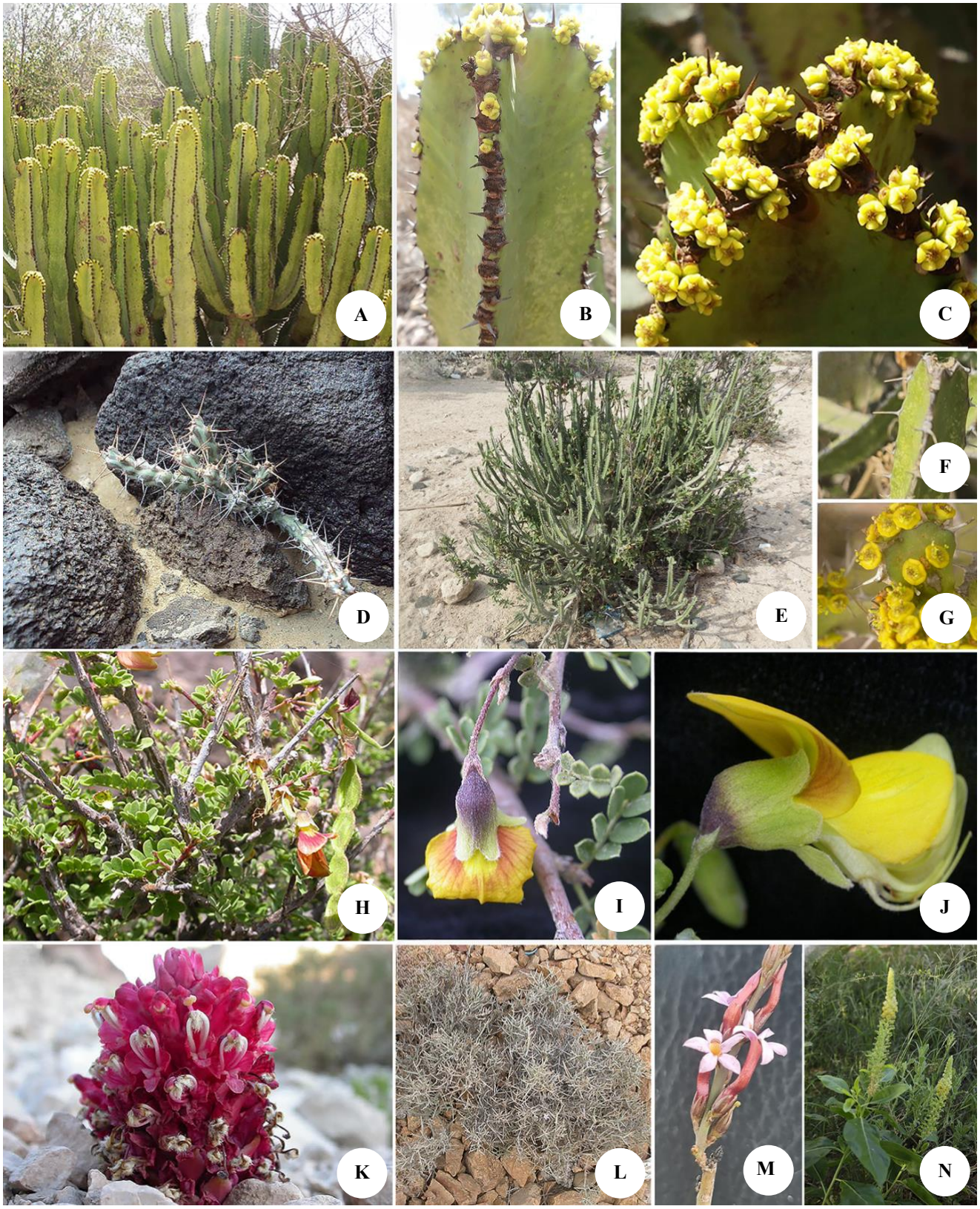

Figure 3. A-G. Euphorbiaceae: A-C. *Euphorbia ammak*, D. *Euphorbia greuteri*, E-G. *Euphorbia inarticulata*, H-J. Fabaceae: *Zygocarpum yemenense*, K. Orobanchaceae: *Cistanche rosea* Baker (Photograph by Miller AG, Royal Botanic Garden, Edinburgh, United Kingdom), L-M. Plantaginaceae: *Campylanthus pungens*, N. Resedaceae: *Reseda sphenocleoides*

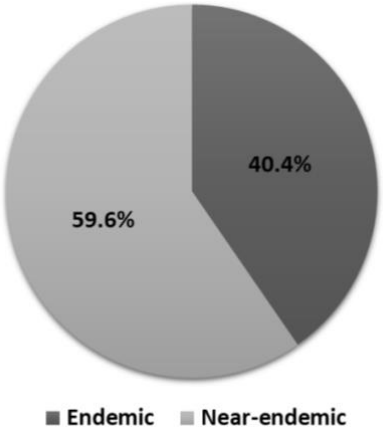

Figure 4. Endemic and near-endemic taxa in the study area

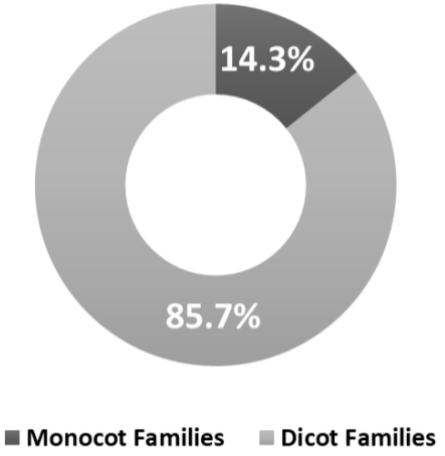

Figure 5. Doughnut chart of the proportional contribution of Monocotyledonous and Dicotyledonous families in Abyan

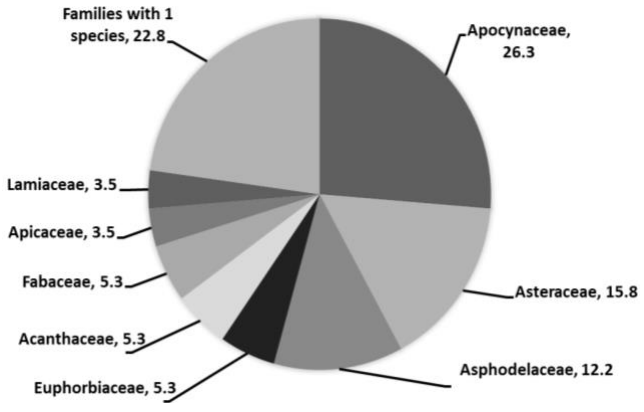

Figure 6. The proportional contribution of endemic and near-endemic plant families in Abyan

Based on Raunkiaer's life form classification, five life forms were identified; the Chamaephytes are the most abundant, with 49 taxa, followed by the Phanerophytes, with 3 taxa. Geophytes include *Ceropegia foliosa* and *Launaea almahrahensis*. Therophytes are represented by *Adenosciadium arabicum* and *Ducrosia areysiana*. Parasites are represented by a single species, *Cistanche rosea* Baker (Figure 7). Among the recorded taxa, perennial species are dominant, comprising 54 species. The only annual species recorded are *A. arabicum* and *D. areysiana*, and they belong to the Apiaceae. *Cynoglossum bottae* (Asteraceae) is classified as an annual/biennial species.

The recorded taxa were classified into five growth form categories. Subshrubs were the most common (32 taxa; 56.1%), followed by shrubs (13 taxa; 22.8%) and herbs (9 taxa; 15.8%). Trees were least represented (3 taxa; 5.3%), including *Dracaena serrulata* (Asparagaceae), *Euphorbia ammak* (Euphorbiaceae), and *Vachellia hunteri* (Fabaceae). *C. foliosa* was recorded as a climbing shrub (liana).

The identified chorotypes include Saharo-Arabian/ Sudano-Zambezian, represented by 9 taxa (*Barleria prionitis* subsp. *appressa*, *Halothamnus bottae*, *Monolluma cicatricosa*, *Monolluma hexagona*, *Iphiona senecionoides*, *Pluchea indica* subsp. *yemenensis*, *E. ammak*, *Euphorbia inarticulata*, and *Lavandula citriodora*, while the remaining taxa belong to the Sudano-Zambezian chorotype, comprising 48 taxa (Figure 8).

Discussion

Most endemic taxa occur in mountainous areas, which provide a diverse range of ecological niches and relative environmental stability during climatic fluctuations (Ghazanfar and McDaniel 2015). The current study reported that Abyan has 57 species that are either endemic (23 taxa) or near-endemic (34 taxa). The family-level pattern of endemism in Abyan indicates that Apocynaceae contains the highest number of endemic species, as endemism is particularly frequent in the Apocynaceae (Walker 2020), followed by Asteraceae. This may be partly explained by the highly efficient dispersal capability of both families, which plays a vital role in their adaptability and ecological success (Galal et al. 2021; Marzouk et al. 2021). Fruiting structures of both Asteraceae and Apocynaceae have specialized accessories, such as the pappus of the former and the membranous wings of the latter, which facilitate wind- and animal-mediated dispersal (Xu and Chang 2017; Cummins 2018; Bitencourt et al. 2021). In addition, the present study reported high levels of endemism in Euphorbiaceae, Acanthaceae, and Boraginaceae within their respective orders, a pattern that aligns with the most dominant families of endemic plants at the national level (EPA 2024). From a conservation perspective, several of these families include a high proportion of threatened members (30-50%), highlighting the need for targeted monitoring and protection (Bachman et al. 2024).

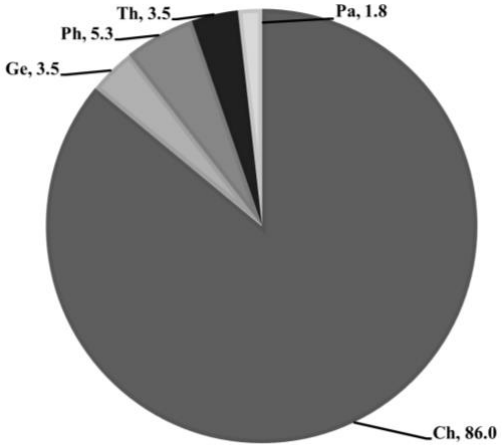

Figure 7. Life form spectrum of the recorded species in Abyan. Ch: Chamaephytes, Ge: Geophytes, Pa: Parasites, Ph: Phanerophytes, Th: Therophytes

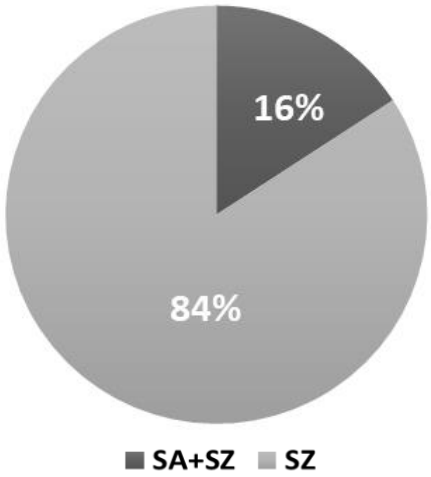

Figure 8. Proportion of Saharo-Arabian (SA) and Sudano-Zambezian (SZ) elements

According to the POWO (2024), *A. arabicum* (Apiaceae) and *Heliotropium azzanum* (Boraginaceae) are native species to Oman, while *Cynanchum forskaolianum* (Apocynaceae) is native only to Saudi Arabia. However, the three species were recorded in the study area; the former two species were recorded in Jabal Al-Arays, whereas the latter was documented in the Mudiya District. These findings do not represent new country records but corroborate their occurrence, corresponding with previous records available in GBIF (2025). According to GBIF (2025), *C. forskaolianum* is recorded only at 40 km SW of Taiz between Hajdah and Al Barh in Yemen (1975). *H. azzanum* is collected from Jabal Al-Arays (1992), Shabwa (1988), Aden (1898, 1987, 1988), Lahij (1987), and Hadramout (1898). *A. arabicum* is recorded at Jabal Al-Arays (1992), Hadhramout (1961, 2002), Al Mahrah (1992, 1998), and Aden (1837, 1847, 1861, 1933, 1958, 1961). However, the current survey provides updated locality-specific evidence for the three species.

Although *Gossypium areysianum*, *Orbea araysiana*, *Salvia areysiana*, and *Vernonia areysiana* have their specific epithets referring to Jabal Al-Arays, they were later discovered in the Hadhramaut and Shabwah governorates of Yemen (Al-Khulaidi 2013). However, *Aloe serriyensis* (recorded at site 8), *Kleinia deflersii* (recorded at site 6), and *Stapelia* × *anemoniflora* (recorded at site 7) are restricted to Jabal Al-Arays, located in the Khanfir district of Abyan. *A. serriyensis* was also recorded in the same location by Al-Wajih et al. (2022).

At the global level, the IUCN Red List evaluated *D. serrulata* (recorded at Lawder, Mudiyah, and Al Wade'a) as Endangered, while *E. ammak* (recorded at Lawder) is listed as Vulnerable (IUCN 2025). At the national level, Al-Khulaidi and Miller (2010) recorded 19 native plant species as being threatened in Yemen. Regarding the studied taxa, *K. deflersii* is reported as a critically endangered endemic species at Jabal Al-Arays. There are also 19 near-threatened taxa, 13 of them recorded at Jabal Al-Arays. These near-threatened taxa comprised 8 endemic (*C. foliosa*, *Huernia marnieriana*, *M. cicatricosa*, *O. araysiana*, *Orbea chrysostephana*, *Aloe lavranosii*, *A. serriyensis*, and *G. areysianum*), and 11 near-endemic species (*Desmidorchis adenensis*, *Desmidorchis awdeliana*, *Huernia lodarensis*, *M. hexagona*, *Monolluma quadrangula*, *Orbea deflersiana*, *Rhytidocaulon macrolobum* subsp. *macrolobum*, *Aloe rubroviolacea*, *Aloe vacillans*, *Aloidendron sabaeum*, and *E. inarticulata*. The National Biodiversity Strategy and Action Plan (NBSAP2) focuses on the protection and restoration of Yemen's endemic, near-endemic, and native endangered plant taxa, which are under threat owing to habitat degradation and climate change. The plan aims to safeguard 50% of vulnerable plant species (UNDP 2010; IUCN 2025).

Jabal Al-Arays inhabits 57.9% of the total recorded endemic and near-endemic taxa in Abyan, Yemen. Endemic taxa are weak competitors that exhibit limited seed dispersal, high habitat specialization, a narrow geographic range, and small population sizes. Consequently, their vulnerability to environmental changes contributes to increased extinction risk (Gaston 1994; Thuiller 2005). According to the Copernicus Climate Change Service (2017), one of the climatic challenges affecting Jabal Al-Arays is the decrease in annual total precipitation, accompanied by a progressive increase in the annual average temperature between 1940 and 2024. Relevant studies pointed out that mountaintop endemic species may be most at risk of the negative consequences of climate change under different climate scenarios. Predicting significant bioclimatic niche loss and associated population declines as the century progresses, highlighting the need for species-specific conservation strategies (Costion et al. 2015; Collette et al. 2026). Accordingly, targeted monitoring and conservation plans, including grazing control and habitat protection, should be prioritized to safeguard critically endangered and near-threatened taxa in Jabal Al-Arays, which represents a key biodiversity hotspot in Yemen. Over the past three decades, Abyan's mean total annual precipitation (199.16 mm) has been relatively higher compared to the other adjacent governorates (World

Bank Group 2025). According to Zhao et al. (2022), there is a positive correlation between precipitation and species richness. Previous comparative surveys across other governorates in Yemen show that Abyan contains a higher number of recorded endemic (23 species) and near-endemic (34 species) taxa. However, variations in sampling methodologies among studies should be considered. This is consistent with the findings of Al-Super (2023) for Al Dali' Governorate. In contrast, Alhood (2020), Atif et al. (2024), and Saif et al. (2024) reported lower numbers.

The diversity of life forms reflects environmental conditions, as their perennating organs are adapted to their surroundings (Raunkiaer 1934; Bazzaz 1996). Life forms also show how vegetation adapts to prevailing environmental conditions (Franks et al. 2013; Al-Aklabi et al. 2016) and serve as reliable indicators of the ecological factors currently influencing the region (Ehrlén and Morris 2015). The life form spectrum of endemic and near-endemic plants in Abyan revealed that chamaephytes are the most represented life form (86%), which is in agreement with previous studies' findings in Yemen, Alhood (2020), Atif et al. (2024), Saif et al. (2024), and Obel et al. (2024). Chamaephytes are ecological indicators of hot-dry climates and exhibit stress-tolerant strategies that reflect their resilience and adaptation to arid disturbed ecosystems, including rocky substrates, limited water availability, and nutrient-poor soils (Bradai et al. 2015; Mutillod et al. 2023). They also dominated over therophytes at higher altitudes (Lizarraga et al. 2025). Followed by phanerophytes, whose presence indicates their relative adaptation to the monsoon climate (Al-Aklabi et al. 2016; Alhood 2020). *C. rosea* was the sole parasitic species recorded in the study area. It parasitizes the roots of the *Calotropis procera* tree, which is frequently distributed in arid regions (Kong et al. 2018). The diversity of life forms and growth forms highlights the region's rich biodiversity, which is influenced by climatic factors and elevation gradients shaped by the local topography (Al-Khulaidi and Miller 2010). Approximately 95% of the recorded taxa were perennial species. This reflects the long-term adaptation to the local environmental conditions. Perennial plants are more resilient to climatic change than annuals, which may explain their prevalence over the recorded taxa in the study area (Vico and Brunsell 2018). Additionally, perennials and chamaephytes are often associated with Saharo-Arabian and Sudano-Zambezian phytogeographical regions (Bradai et al. 2015; Al-Hawshabi et al. 2025).

Phytogeographically, the recorded species were classified as either Sudano-Zambezian or Saharo-Arabian/Sudano-Zambezian. The Sudano-Zambezian flora exhibits species shared with the Saharo-Arabian regions, attributable to historical biogeographic linkages and habitat adjacency (Abd El-Ghani and Amer 2003). Mono-regional elements were more prevalent than bi-regional elements among the reported taxa. The predominance of Sudano-Zambezian components due to their drought tolerance likely reflects longstanding phytogeographic affinities with hot desert ecosystems reported in earlier floristic studies and aligns with Yemen's topography (Abd El-Ghani and Amer 2003; Abdel Khalik et al. 2013; Abo Hatab et al. 2024; Al-Hawshabi et al. 2025).

Future floristic surveys across Yemen should use multiple sampling approaches to assess species diversity and document endemism, especially at higher elevations. It is also necessary to perform species distribution models for endangered and threatened species that are under environmental stress. DNA barcoding should be used to assess genetic diversity and to monitor population structure and change, supporting early detection of declines and helping to prevent local extinctions (El-Banhawy et al. 2021).

In conclusion, this study addressed 57 endemic and near-endemic taxa (23 endemic and 34 near-endemic) recorded in Abyan, Yemen. Jabal Al-Arays in the Khnafir district is recognized as a biodiversity hotspot mountain, hosting 33 taxa, representing 57.9% of all recorded taxa. *A. serriyensis*, *K. deflersii* (a critically endangered species), and *Stapelia* × *anemoniflora* are endemic to Jabal Al-Arays, located in the Khanfir district of Abyan. At the national level, conservation priorities should focus on thirteen taxa (8 endemic and 5 near-endemic), which are listed as near-threatened at Jabal Al-Arays. The endemic near-threatened species include *C. foliosa*, *H. marnieriana*, *M. cicatricosa*, *O. araysiana*, *O. chrysostephana*, *A. lavranosii*, *A. serriyensis*, and *G. areysianum*. The near-endemic near-threatened species are *D. adenensis*, *D. awdeliana*, *M. hexagona*, *A. rubroviolacea*, and *A. sabaeum*. To support sustainable natural resource management in Yemen, this study provides an essential baseline for monitoring habitat loss and for identifying priority endemic threatened species. Identifying key botanical areas, such as Jabal Al-Arays, contributes to the protection and establishment of reserves through national conservation initiatives. Sustaining mountain biodiversity under increasing anthropogenic pressures and climatic change will require coordinated efforts among scientists, the governmental sector, the private sector, and local communities, supported by predictive modeling to anticipate future biodiversity loss at high elevations in the coming decades.

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