Chapter 4
The Inland Eastern Desert of Egypt

Abstract The inland part of the Eastern Desert of Egypt forms an ecosystem with characteristic habitats: (1) rocky surface, (2) erosion pavement, (3) gravel desert, (4) slopes, (5) cliffs, and (6) desert wadi, which represents a drainage system collecting water from extensive catchment area. The geographic position of the mountainous range along the Red Sea coast is very conspicuous. The flora and vegetation of the Gebel Elba mountainous group is much richer than that of the other coastal mountain, where the Palaearctic and Afrotropical regions meet. The species composition of the Gebel Elba National Park was greatly influenced by disturbances such as severe cutting of trees and shrubs either for domestic fuel or charcoal production and browsing. In terms of classification and ordination, the vegetation and environment in northern wadis and southern wadis in four transects representing three different types of desert running from the Nile Valley to the Red Sea coast were investigated. Based on the current status of flora of the Eastern Desert, a biogeographical analysis and phytogeographical divisions of the were re-assessed.

4.1 General

The monumental basic studies on the habitat and plant communities in the Egyptian Eastern Desert were achieved by Kassas M (1952), Kassas (1953a, b), Kassas (1955, 1956, 1960, 1966 and 1971). They proposed a schema for the classification of the different types of habitats and gave an outline of the main ecosystems in the Egyptian Desert. These ecosystems are, (1) Rocky surface, this type of habitat includes chasmophytic plants that can send their roots into rock crevices such as *Stachys aegyptiaca*, *Reaumuria hirtella*, *Helianthemum kahiricum*, and *Iphiona mucronata*. (2) Erosion pavement, the main channels and affluent of this type of habitat include annual and perennial plant species including *Diplotaxis acris*, *Pteranthus dichotomus*, *Zilla spinosa*, and *Zygophyllum coccineum*. (3) Gravel desert, which harbours a group of plants that are peculiar to this type of habitat among others, *Mesembryanthemum forsskalei*, *Aizoon canariense*, *Fagonia glutinosa*, and *Centaurea aegyptiaca*. (4)

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Slopes that are well represented on the plateau edges, wadi sides, and mountain and hill sides. Characteristic species of this type include *Diplotaxis harra*, *Gymnocarpus decandrus*, and *Reaumuria hirtella*. (5) Cliffs, as it is well represented in waterfalls in wadi beds and outer curves of meanders. *Capparis spinosa*, *Iphiona mucronata*, *Cocculus pendulus*, *Ficus palmata*, *Fagonia mollis*, and *Zygophyllum coccineum* are common species of this type of habitat. (6) Desert wadi, which represents a drainage system collecting water from extensive catchment area. It is richer in vegetation than other types of desert habitats. Shallow soil of wadi bed inhabited by *Zygophyllum coccineum*, *Anabasis setifera* communities, and *Zilla spinosa* is the most dominated community at the intermediate stage; *Pennisetum dichotomus* and *Panicum turgidum* communities are in sandy soil; and *Nitraria retusa*, *Atriplex halimus*, *Tamarix nilotica*, and *T. tetragyna* are among the climax vegetation. (7) Sand drifts and dunes, which include plants capable to act as obstacles and have the ability to accumulate wind born materials building mound and dunes around them such as *Zygophyllum album*, *Deverra tortuosa*, *Calligonum polygonoides*, and *Convolvulus lanatus*.

4.2 Surveyed Areas

4.2.1 The Coastal Mountains: Gebel Elba

The coastal mountain ranges of the Red Sea represent a conspicuous habitat type of special interest for their complex patterns of natural communities interrelating the floras and faunas of Egypt, Sudan, and Ethiopia. One of these ranges is the Gebel Elba mountains of south-eastern Egypt. This mountain range is considered a continuation of the granitic formation of the Red Sea highland complex between Egypt and Sudan, situated between 36° and 37° of the eastern longitudes and about 22° of the northern latitude. The flora and fauna of this area comprise hundreds of species of plants and animals; these include a number of endemics and a number of species that represent the northern outpost of the biota of the Ethiopian highlands.

The geographic position of this group of mountains combines the following: (a) the bend of the coastal line, (b) the proximity to a large water body (Red Sea), (c) altitudinal and seaward direction of slope, and (d) a coastal plain with few topographic features. The combination of these features allows for orographic condensation of cloud moisture, particularly on the seaward slopes, which forms an essential source of water for plants in this area. This provides for rich plant growth and creates "mountain oases" or "mist oases" (Troll 1935; Kassas 1955). The floristic richness of the Gebel Elba area is noticeable, compared to the rest of Egypt, and this is considered one of the main phytogeographical territories of the country (El Hadidi 2000a) as it borders the Saharo–Arabian and Sudanian floristic regions. The flora and vegetation of the Gebel Elba group is much richer than that of the other coastal mountain groups (Drar 1936; Hassib 1951), where the Palaearctic and Afrotropical regions meet. It comprises elements of the Sahelian regional transition zone (White and Léonard 1991) and represents the northern limit of this geoelement in Africa. Within its massive, the vegetation on the north and northeast flanks is much richer than that on the south and southwest (Kassas and Zahran 1971). Its ecological features, together with its particular geographic position, seem to have promoted plant diversity, singularity, and endemism in this area and favoured the persistence of an extensive woodland landscape dominated by thickets of *A. tortilis* (Forssk.) Hayne subsp. *tortilis*. It is not known elsewhere in the Eastern Desert of Egypt (Zahran and Willis 1992).

Geographical areas containing high species richness and a high level of endemism and/or harbouring a high number of rare or threatened species have been defined as biodiversity hotspots and have been considered to set priorities for conservation planning (Reid 1998). In spite of the interesting biogeographical and botanical features of the Gebel Elba mountain range, it has been overlooked in most global biodiversity assessments (Heywood and Watson 1995). Of the 142 woody perennial threatened plant species that are included in the Plant Red Data Book of Egypt (El Hadidi et al. 1992), 56 or 39.4% were known from the Gebel Elba district. Therefore, this area was protected in 1986 as the Gebel Elba National Park (Prime Ministerial Decrees 450/1986, 1185/1986, and 642/1995), covering 35,600 km^2, aiming to promote the sustainable management of natural resources and maintain its biodiversity. To fulfil this mandate, it is essential that each national park has adequate knowledge of its biodiversity (Hawksworth and Kalin-Arroyo 1995). Inventorying is, therefore, the fundamental starting point for any strategy of conservation, sustainable use, or management (Strok and Samways 1995). Biodiversity conservation in Egypt is supported by a network of important protected areas (21 representing 8% of the country's land surface, and a further 19 areas are proposed for protection), based on natural region classification of the land, having a mandate to preserve a representative sample of the ecosystem characteristic of each region.

The rugged topography and inaccessibility of the mountainous escarpment of the Gebel Elba district have resulted in a paucity of studies on its vegetation and no complete survey of the flora. Previous studies on the flora and vegetation of the Gebel Elba mountain range are fragmentary and rely on a qualitative description of the vegetation (Drar 1936; Fahmy 1936; Kassas and Zahran 1971). It is worth noting that a complete modern flora (or at least checklist giving a precise account of its extant plant taxa) is still lacking. A complete list of the plant taxa of this area is therefore essential.

The Gebel Elba mountainous group is one of the three coastal mountains in the south-east corner of Egypt that faces the Red Sea, extending between latitude 24° 50′ N and 22° N on the Sudano–Egyptian border (Fig. 4.1). This group is mainly of igneous basement nature, forming a complex of high summits such as Asotriba (2217 m), Shendib (1912 m), Shendodin (1526 m), Elba (1465 m), and Shellal (1409 m). A wide coastal desert plain separates the Gebel Elba mountain range from the Red Sea coast. Although not the highest of its group, Gebel Elba is nearest to the sea (20–25 km).

The igneous mountains extend southwards from latitude 28° N to beyond latitude 22° N (the Sudano–Egyptian frontier). Fahmy (1936) reported that Gebel Elba is a compact mass of light-coloured granite, covered with jagged peaks and numerous precipitous gorges. It is separated from the chain extending further south by the broad deeply wadis of Osir Hadal and Sarimtai. The peak of Gebel Elba (22° 10′ 33″ N and 36° 21′ 52″ E) represents the centre from which drainage systems (wadis) radiate in all directions. The principal of these wadis is Wadi Yahameib, which with

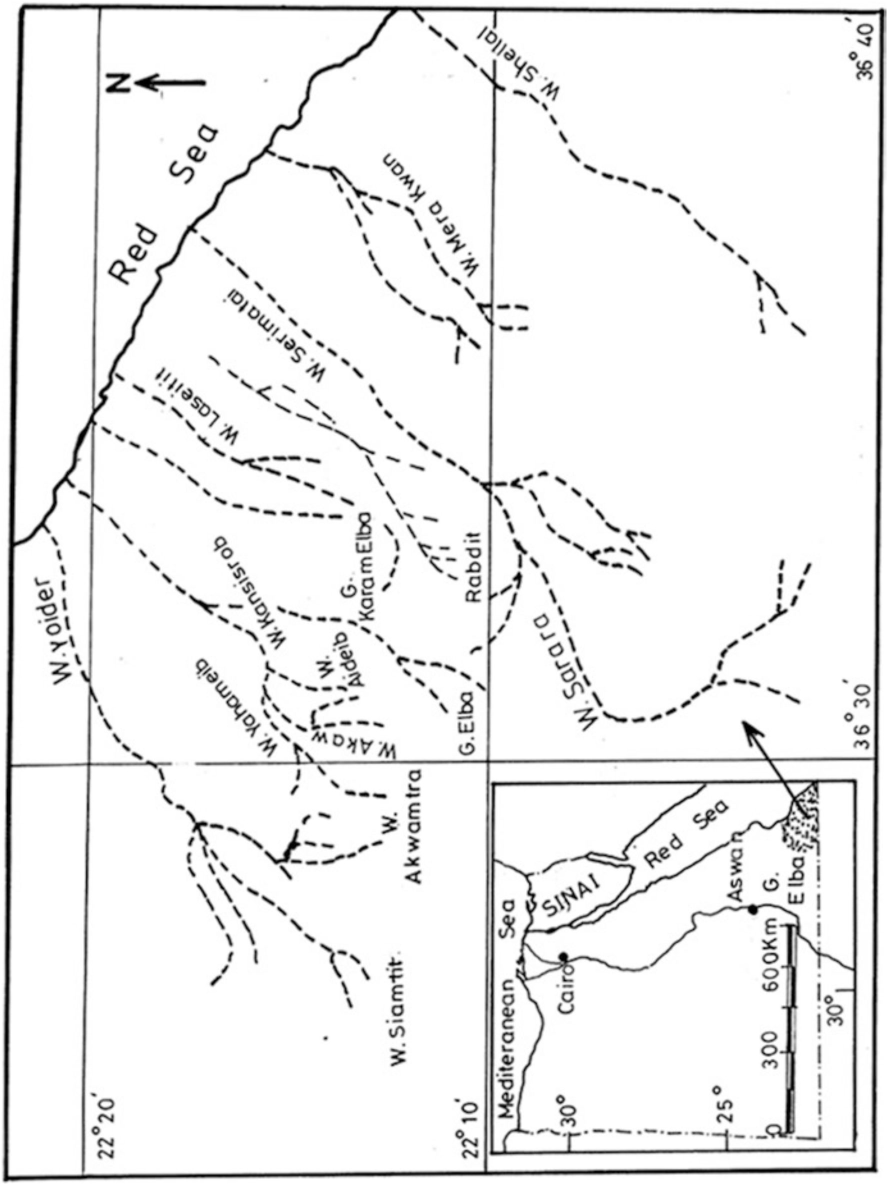

Fig. 4.1 Location map of Gebel Elba region, showing the dissecting wadis

its tributaries Wadi Akaw and Wadi Kansisrob drains the north faces of the mountains (Fig. 4.1). Except for the alluvial wadi fan at the foot of the mountain, which consists of gravel and sandy soil, the surface is of bare exposed rocks. Slopes are steep with sharp rocks. Most of the vegetation grows in soil pockets in the drainage cracks and runnels. Large boulders, small stones, and gravel are found in the steep runnels. Said (1962) described the rock formations in the study area as mainly igneous and metamorphic deposits of very ancient origin. The igneous rocks cover one-third of south-eastern Egypt, forming irregularly distributed tracts alternating with others occupied by metamorphic rocks. In general, gneisses, schists, breccias, and many other minerals comprise the metamorphic rocks in this district. On the other hand, the sedimentary deposits can be classified recently as gypsum and gypseous limestone and Nubian sandstone (Cretaceous).

Within the complex biological and physical framework that constitutes the biodiversity resources of the Gebel Elba National Park, rich ethnic inheritance has lived in, used, and modified the natural habitats in different ways through time. The Bishari tribe, the principal of three tribes, inhabits the immediate vicinity of Gebel Elba. They are sedentary to seminomadic, are related to the tribes in Sudan and Ethiopia, and speak their own language. The Ababda tribe, ranked second, is sedentary to seminomadic people found in the northern areas of the park and is considered Arab in origin. The Rashayda tribe is a nonindigenous tribe inhabiting the coastal plain. The human activities from ancient up to the present time must be considered factors which have contributed to the disturbance of the natural ecosystems, the banality of the flora, and the more or less uniformity of the vegetation in our area. The main socio-economic activities of the local community are livestock herding and charcoal production (especially from *Acacia* trees). The local community relies heavily on the natural flora for their way of life, particularly wood for fuel, building materials, fodder, tools, handicrafts, and other goods, some of which are sold or traded. Plants and animals are also used for medicinal purposes. Other activities include small-scale cultivation along the coastal plain and fisheries in the offshore waters. In the coastal communities, there are commercial enterprises, including trade between the Sudan and Egypt. These activities have produced environmental alterations and in some instances positively influenced the genetic maintenance of some ecosystems.

The climate of the study area seems to occupy an intermediate position between those of the regions of the tropical rains and those of the dry Egyptian rocky deserts with their occasional precipitation in winter months (Fahmy 1936). According to Ayyad and Ghabbour (1986), the study area lies in the arid climatic province characterized by spring rainfall ranges between 50 and 10 mm year^{-1}, mild winters (18–22 °C), and hot summers (28–33 °C). As for its geographical position and peculiar set of environmental conditions, Gebel Elba receives greater water revenue from orographic precipitation than the other northern blocks (Kassas and Zahran 1971). Unfortunately, recent climatic records for the Gebel Elba area are not available.

4.2.1.1 Floristic Richness and Taxonomic Diversity

As a result of the fieldwork, the vascular flora of the Gebel Elba Park contains a total of 179 taxa from 51 families and 124 genera (Table 4.1) . More than 50% of the recorded taxa belong to only ten species-rich families (Fig. 4.2). The largest families in terms of the number of genera were Compositae (14), Gramineae (10),

Table 4.1 Floristic richness of the Gebel Elba Park

Plant group	Families	Genera	Species	Infraspecific taxa
Ferns and allied groups	3	3	3	–
Gymnosperms	1	1	1	–
Angiosperms	47	120	175	23
Monocotyledons	7	16	22	3
Dicotyledons	40	104	153	20
Total of vascular flora	51	124	179	23

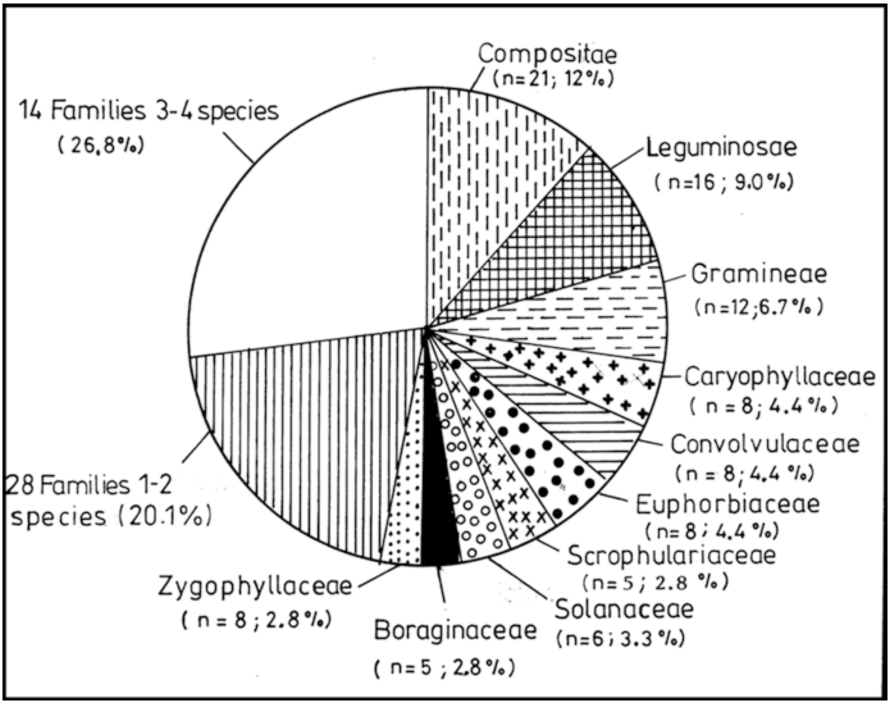

Fig. 4.2 Diagram of floristic composition with the ten families richest in species separately notated (*n* number of species)

Leguminosae (9), Caryophyllaceae (6), and Asclepiadaceae, Cruciferae, Scrophulariaceae, and Zygophyllaceae (4 for each). These families represent the most common in the Mediterranean North African flora (Quézel 1978). On the other hand, Gramineae, Leguminosae, Compositae, and Cruciferae constitute the main bulk of the alien plant species in Egypt and also in the agroecosystems of other adjacent countries such as Saudi Arabia and Kuwait (Abd El-Ghani and El-Sawaf 2004). A comparison of families in terms of the largest number of species recorded in this investigation and in similar studies in neighbouring countries (Table 4.2) revealed an agreement with such studies, e.g. Wickens (1976) in Jebel Marra of

Table 4.2 Comparison of the eight families containing the most species in studies conducted in Egypt and neighbouring countries, with their numbers and percentages (in parentheses)

Families	Estimated number of species in Egypt[a]	Egypt		Jebel Marra (Sudan)[c]	Asir Mountains (Saudi Arabia)[d]
		Present study	Eastern Desert (Egypt)[b]		
Compositae	230 (11.0)	21 (12)	57 (13.2)	76 (8.1)	21 (9.6)
Leguminosae	233 (11.1)	16 (9)	33 (7.6)	108 (11.6)	26 (11.9)
Gramineae	250 (11.9)	12 (6.7)	38 (8.8)	105 (11.3)	40 (18.3)
Caryophyllaceae	85 (4.0)	8 (4.4)	24 (5.5)	10 (1.1)	5 (2.3)
Convolvulaceae	48 (2.3)	8 (4.4)	7 (1.6)	18 (1.9)	3 (1.4)
Euphorbiaceae	55 (2.6)	8 (4.4)	5 (1.1)	21 (2.2	10 (4.6)
Solanaceae	33 (1.6)	6 (3.3)	7 (1.6)	10 (1.1)	8 (3.7)
Scrophulariaceae	62 (2.9)	5 (2.8)	11 (2.5)	23 (2.5)	7 (3.2)

Sources: [a]Boulos (1995, 1999–2002); [b]Hassan (1987); [c]Wickens (1976); [d]Boulos (1985) and Hosni and Hegazy (1996)

Sudan, Hassan (pers. comm.; 1987, Ecological and Floristic Studies on the Eastern Desert, Egypt), and Boulos (1985) and Hosni and Hegazi (1996) in the Asir Mountains of Saudi Arabia. Compositae (the largest family in our list) is not only the largest family in the flora of Egypt (Täckholm 1974; Boulos 2002) but also the largest and most widespread family of flowering plants in the world (Good 1974). This can be attributed to their wide ecological range of tolerance and to their high seed dispersal capability. The largest genera were *Euphorbia* L. (six), *Launaea* Cav. and *Solanum* L. (five for each), and *Acacia* and *Convolvulus* L. (four for each). The species composition of the Park was greatly influenced by disturbances such as severe cutting of trees and shrubs either for domestic fuel or charcoal production and browsing.

These factors affect particularly *Acacia tortilis* (Forssk.) Hayne subsp. *tortilis*, *Balanites aegyptiaca* (L.) Del., and *Maerua crassifolia* Forssk. regrowth while favouring an increase in density of species not browsed, such as *Calotropis procera* (Ait.) Ait., *Leptadenia pyrotechnica* (Forssk.) Decne, and *Senna italica* Mill. The latter were the most frequent species of the Park. On the tropical scale, Vetaas (1992) detected some similar taxa on an arid misty mountain plateau in Sudan and concluded that the species composition, at all spatial scales, was directly or indirectly related to variation in temperature and moisture. Frederiksen and Lwesson (1992), while dealing with the vegetation types and patterns in Senegal, described communities dominated by *Calotropis procera*, *Acacia tortilis*, and *Ziziphus* Mill. spp. in the Sahelian grassland.

The floristic richness of the Gebel Elba Park might be better understood by comparing it to other known taxonomic groups and/or regions located in Egypt. The Park contains approximately 9% of the 2094 vascular plant species found in Egypt (Boulos 1995). The floristic richness of the Park can be compared also to that of other floristically known regions in Egypt, which show different physiographic and geomorphologic features and vegetation communities (Fig. 4.3) . The ratios species/

genera and genera/families for the Gebel Elba Park and other floristically known regions in Egypt (Table 4.3) indicated higher taxonomic diversity (lower ratios) in the Park than in other regions. Pielou (1975) and Magurran (1988) pointed out that, in intuitive terms, hierarchical (taxonomic) diversity will be higher in an area in which the species are divided among many genera as opposed to one in which most species belong to the same genus and still higher as these genera are divided among

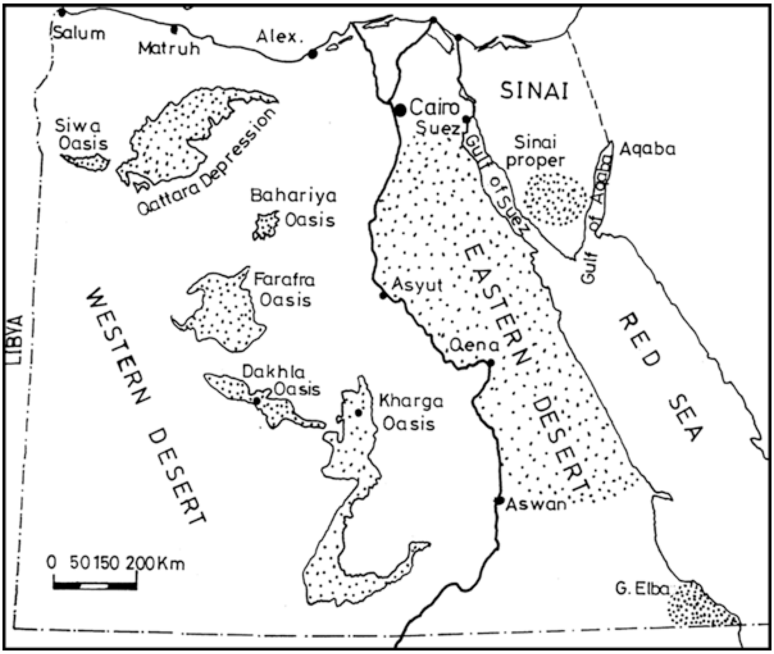

Fig. 4.3 Geographical distribution of the floristic richness of the Gebel Elba Park with other well-studied regions (*dotted areas*) in Egypt

Table 4.3 Comparative floristic richness and taxonomic diversity in some Egyptian regions and in the Gebel Elba Park

	Gebel Elba Park	Eastern Desert (the whole area)[a]	Sinai Peninsula (the whole area)[b]	Sinai proper (S El-Tih Desert)[b]	Western Desert[c]
Total number of species (S)	179	433	1217	716	328
Total number of genera (G)	124	266	566	422	212
Total number of families (F)	51	64	125	105	59
S/G	1.4	1.6	2.1	1.7	1.5
G/F	2.2	4.1	4.5	4.0	3.6

Sources: [a]Hassan (1987); [b]Ayyad et al. (2000); [c]Abd El-Ghani and El-Sawaf (2004)

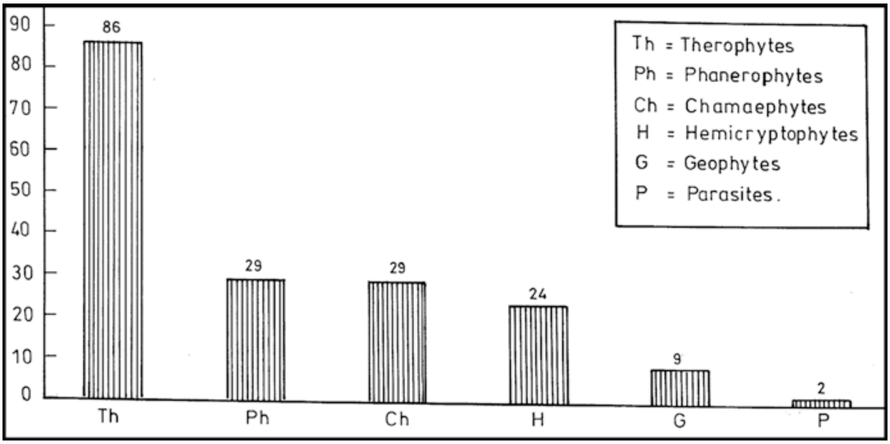

Fig. 4.4 Life-form spectrum of the vascular flora of Gebel Elba Park (figures are the number of species)

many families as opposed to few. The present study revealed that the Gebel Elba Park is more diverse than other well-studied regions in Egypt.

Life Forms

The life-form spectrum in the present study is characteristic of an arid desert region with the dominance of therophytes (48% of the recorded species; Fig. 4.4) , followed by phanerophytes and chamaephytes (16.2% for each) and hemicryptophytes (13.5%). The majority of annuals were winter species or cool-season species; some were hot-weather species (e.g. *Amaranthus graecizans* L. subsp. *graecizans*, *Portulaca oleracea* L., *Eragrostis ciliaris* (L.) R.Br., *Corchorus depressus* (L.) Stocks, and *Setaria viridis* (L.) Beauv.), and a few were nonseasonal species responding to rainfall at any time of the year (e.g. *Tribulus terrestris* L., *Chenopodium murale* L. and *Launaea capitata* (Spreng.) Dandy). The occurrence of the two parasitic plants *Cuscuta chinensis* Lam. and *C. pedicellata* Ledeb. (leafless or functionally so) denotes the importance of water conservation. As in most arid regions, the desert vine species were few, i.e. *Plicosepalus acaciae* (Zucc.) Wiens & Polhill, *P. curviflorus* (Benth. ex Oliv.) Tiegh., *Citrullus colocynthis* (L.) Schrad., *Coccinia grandis* (L.) Voigt, *Cocculus pendulus* (J.R. & G.Forst.) Diels, and *Cucumis prophetarum* Juss. subsp. *prophetarum*.

The dominance of shrubby plant species over the grasses was evident. The relative advantage of shrubs over grasses when water is limited, as in this area, can be explained by their extensive root systems, which are capable of utilizing water stored at different soil depths, whereas grasses utilize the transient water stored in the upper soil synchronic with precipitation pulses. Besides the spatial variations in the species composition of plant communities, the composition of life forms reflects the response of vegetation to variations in certain environmental factors. In this study, the dominance of therophytes, phanerophytes, and chamaephytes over other life forms seems to be a response to the hot dry climate, topographic variations, and human and animal interference.

Therophytes (annuals) are drought evaders in the sense that the whole plant is shed during the unfavourable conditions. Moreover, the high proportion of therophytes in this study is also attributed to human activities according to Barbero et al. (1990). It is also necessary to point out that the increase in both Leguminosae and therophytes in a local flora can be considered a relative index of disturbance for Mediterranean ecosystems. Regardless of the altitude or type of ecosystem, it was noted that the increase in grazing pressure throughout the southern Mediterranean ecosystems leads to the occupation of the understories by invasive therophytes and indicates hyperdegradation (forest therophytization) .

The remarkably high percentages of phanerophytes and chamaephytes (16.2% for both) must also be emphasized. The dominant perennials were the non-succulent trees and shrubs (or subshrubs) and the perennial herbs. Some of these perennials are drought-enduring plants in which the photosynthetically and transpiring organs were maintained at nearly constant proportion (Abdel-Razik et al. 1984). A comparison of the life-form spectra of the northern part of the Eastern Desert of Egypt (Abd El-Ghani 1998) and those in the Tihama coastal plains of Jazan region in southwestern Saudi Arabia (El-Demerdash et al. 1994) showed the same results.

Spatial Distribution Patterns of Species

None of the 93 perennial species occurred at all the 16 studied sites, whereas the annuals, i.e. *Amaranthus graecizans* subsp. *graecizans*, *Achyranthes aspera* L. var. *sicula* L., and *Sisymbrium erysimoides* Desf., showed the highest species occurrences (56% for the first, 50% for the other two species) in the flora. Ninety-two species or 51.4% of the total recorded species (179) demonstrated a certain degree of consistency, where they were exclusively recorded in or confined to a certain site or groups of sites. These species were distributed as follows: 12 in W. Aideib (e.g. *Plicosepalus acaciae*, *Indigofera spinosa*, *Coccinia grandis*, *Commicarpus boissieri*, and *Delonix elata*), 58 in W. Yahameib (e.g. *Acacia oerfota* var. *oerfota*, *A. asak*, *Balanites aegyptiaca*, *Cocculus pendulus*, *Ochradenus baccatus*, *Dracaena ombet*, *Dodonaea viscosa*, *Rhus tripartita*, *Euclea racemosa* subsp. *schimperi*, *Ophioglossum polyphyllum*, and *Aneilema tacazzeanum*), 9 in W. Darawina (e.g. *Ruellia patula*, *Peristrophe paniculata*, *Euphorbia granulata* var. *glabrata*, and *Blainvillea acmella*), 6 in W. Shellal (e.g. *Ficus palmata*, *Acacia mellifera*, *Ziziphus spina-christi*, and *Boerhavia elegans*), 2 in W. Topeet (*Launaea procumbens* and *Senecio flavus*), and 5 in W. Sarara (e.g. *Melanoloma pullatum* and *Leptothrium senegalense*) .

Sørensen's coefficients of floristic similarities between the six studied wadis were generally low, indicating smooth species composition changes among the wadis (Table 4.4). Significant positive similarity and the highest beta diversity were

Table 4.4 Sørensen's coefficients of floristic similarity (lower half) and the beta diversity (upper half) between the studied wadis in the Gebel Elba Park

Wadis	A	Y	D	Sh	T	S
A		0.60	0.3	0.1	0.2	0.05
Y	0.3*		0.3	0.2	0.2	0.07
D	0.1	0.07		0.2	0.07	0.03
Sh	−0.07	−0.07	0.04		0.1	0.1
T	0.1	0.15	−0.05	0.15		0.1
S	−0.06	−0.15**	−0.09	0.08	0.04	

A Wadi Aideib, *Y* W. Yahameib, *D* W. Darawina, *Sh* W. Shellal, *T* W. Topeet, and *S* W. Sarara
**P* significant at 0.01 level; ***P* significant at 0.05 level

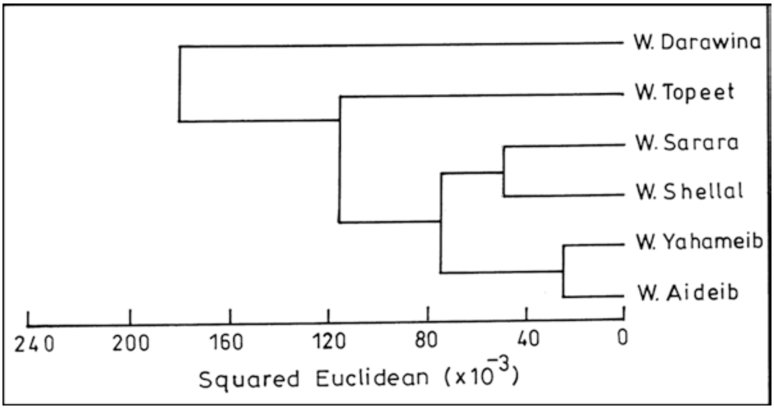

Fig. 4.5 Dendrogram of similarity among the wadis analysed

between W. Yahameib and W. Aideib, but a negative significant correlation was estimated between W. Sarara and W. Yahameib. Floristic composition in the six studied sites showed differences in species richness. The highest species richness value was recorded in W. Yahameib (123 species), whereas the lowest was recorded in W. Sarara (12 species). W. Yahameib, therefore, was the most diversified among the other studied wadis.

From the dendrogram in (Fig. 4.5), four main groups (I–IV) can be recognized. Wadi Darawina (group IV) was markedly dissimilar from the others. Two other large groups were closely associated; the first includes W. Yahameib and W. Aideib (group I) and the other includes W. Sarara and W. Shellal (group II). DCA supported this classification, which indicates a reasonable segregation among these groups along the ordination plane of axes 1 and 2 (Fig. 4.6). In the present study, DCA estimated the compositional gradient in the vegetation data along DCA axis 1 to be larger than 4.8 SD units for all subset analyses, indicating that a complete turnover in species composition took place (Hill 1979) .

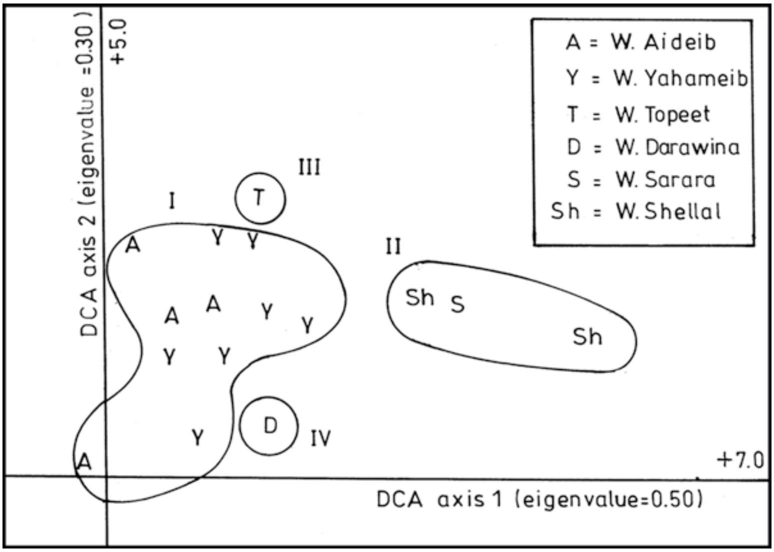

Fig. 4.6 Detrended Correspondence Analysis (DCA) ordination diagram of 16 sample plots and sites represents the four cluster groups (I–IV) resulted in Fig. 4.5

The four DCA axes explain 30.1% of the total variation in the species data. This low percentage of variance explained by the axes was attributed to the many zero values in the data set. DCA axis 1 may represent a geographical trend in the floristic data set, where W. Shellal and W. Sarara are located in the southern part of the region, while the other wadis are located in the northern part.

Species Richness Versus Altitudinal Gradient: A Case Study

This study showed variations in floristic composition and species richness along an altitudinal gradient in Wadi Yahameib (Fig. 4.7). These variations may be attributed to the climatic differences, substrate discontinuities, and mountainous escarpment along the altitudinal gradient. It may be noted that species richness on W. Yahameib was highest (ranged from 47 ± 7.3 to 53 ± 11.0 species) in the middle altitudes from 300 to 450 m. This zone on the mountain was probably more climatically equable for plant growth and diversity than either lower (90–250 m) or higher (460–680 m) altitudes. At lower altitudes (species richness ranged between 15 ± 6.4 and 28 ± 8.6), the temperature is higher and the climate more arid, and although higher altitudes (species richness ranged between 13 ± 5.5 and 24 ± 9.4) are less arid, the temperatures are much lower. Records of some ferns such as *Actiniopteris semiflabellata*, *Onychium divaricatum*, and *Ophioglossum polyphyllum* of less arid habitats were further evidence of this. It can also be noted that trees frequently occurred and constitute the main bulk of the plant cover and in certain instances may form forest-like growth at the middle and higher altitudes of the wadi. Trees and shrubs of *Olea europaea L.* subsp. *africana*, *Ficus salicifolia*, *Acacia tortilis* subsp. *tortilis*,

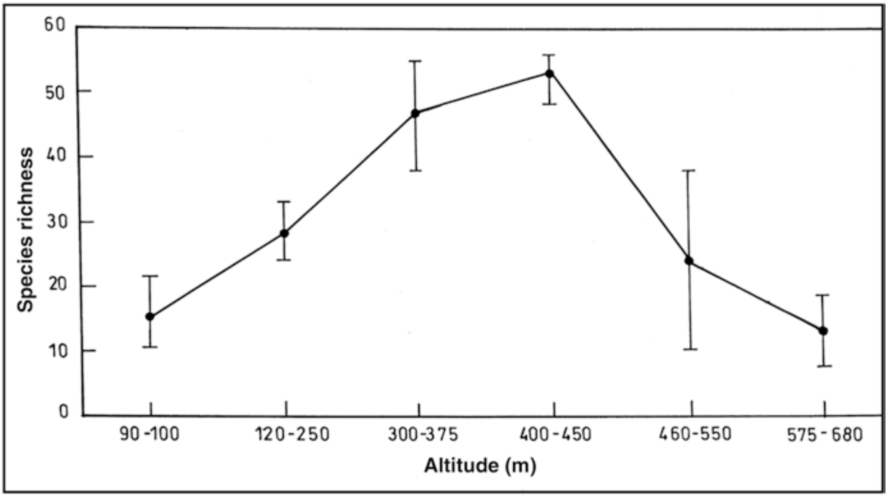

Fig. 4.7 Species richness along the altitudinal gradient of W. Yahameib

Dracaena ombet, *Euclea* spp., *Dodonaea viscosa*, *Delonix elata*, and *Rhus* spp. were recorded. *Dracaena ombet* was recorded in the middle and higher zones of the north and east slopes of Gebel Elba. In several localities there were limited groves of this tree; otherwise there were isolated individuals. Reference may be made to the studies on the growth of *D. ombet* within the Sudanese coastal mountains including the mist oasis of Erkwit (Kassas 1956, 1960). The occurrence of *Dracaena* in the Gebel Elba area represents its most northern limit within the Red Sea coastal mountains (Kassas and Zahran 1971). This pattern of altitudinal variation in species diversity can be contrasted with that of wet tropical mountains, where species richness decreases linearly with increasing altitude (Oshawa et al. 1985).

The altitudinal pattern of plant diversity in W. Yahameib, where the highest diversity occurs at middle altitudes on the mountain, may be more typical of arid mountains in desert regions. These results were consistent with other studies on diversity–altitude relationships from the arid region as in Asir Mountains of southwestern Saudi Arabia (Abulfatih 1984; Hegazy et al. 1998), in Jebel Tageru of the southern Libyan Desert (Neumann 1987), in Jabal Shams of Oman (Ghazanfar 1991), in the central Hijaz mountains of Saudi Arabia (Abd El-Ghani 1997), on the eastern and western sides of the Red Sea (Hegazy and Amer 2001), in Al-Jabal Al-Akhadar of Libya (Al-Sodany et al. 2003), and in the arid parts of Chile (Hoffmann and Hoffmann 1982) .

4.2.1.2 Phytogeographical Affinities

The phytogeographical analysis of the studied area must be regarded as provisional, due to the still poorly known overall distribution features of many taxa. With regard to the relation between biogeographic elements (geoelements) and life forms

Table 4.5 Distribution of the geoelements among life forms (%)

Life form	COSM		PAL		PAN		ME		IT		SA		SZ		Afr. mont. Afr. alp.	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*M*	%
Ph (29)	–	–	1	3.4	–	–	1	3.4	–	–	18	62.1	9	31.1	–	–
Ch (29)	1	3.4	1	3.4	1	3.4	1	3.4	–	–	20	69.1	5	17.3	–	–
H (24)	–	–	3	12.5	–	–	3	12.5	–	–	14	58.3	4	16.7	–	–
G (9)	1	11.1	1	11.1	1	11.1	–	–	–	–	4	44.4	2	22.3	–	–
Th (86)	4	4.7	11	12.8	5	5.8	20	23.2	1	1.2	28	32.6	15	17.4	2	2.3
P (2)	–	–	–	–	–	–	–	–	–	–	2	100.0	–	–	–	–
Total (179)	6	3.3	17	9.5	7	3.9	25	14.0	1	0.6	86	48.0	35	19.6	2	1.1

N number of species, *Ph* phanerophytes, *Ch* chamaephytes, *H* hemicryptophytes, *G* geophytes, *Th* therophytes, *P* parasites, *COSM* Cosmopolitan, *PAL* Palaeotropical, *PAN* Pantropical, *ME* Mediterranean, *IT* Irano–Turanian, *SA* Saharo–Arabian, *SZ* Sudano–Zambezian, *Afr. mont.* Afromontane, *Afr. alp.* Afroalpine

(Table 4.5), therophytes, the most abundant life form, were important in all categories. Trees and shrubs were also more or less fairly represented in almost all categories. Annuals contributed largely to the Saharo–Arabian element. In turn, the Saharo–Arabian element was well represented in the flora of the Gebel Elba Park and constituted 48% of the recorded taxa. In fact, chamaephytes, phanerophytes, and hemicryptophytes make a substantial contribution to the Saharo–Arabian and Sudano–Zambezian geoelements.

Phytogeographically, as the study area lies within the Saharo–Arabian belt of the Holarctic floristic realm, the analysis of the floristic data showed the prevalence of the Saharo–Arabian geoelement (Fig. 4.8) . The Sudano–Zambezian geoelement ranked second. According to Wickens (1976), the Sudano–Zambezian region is bounded to the north by the desert and semi-desert of the Saharo–Arabian region, while in the south it extends to the desert and semi-desert of the Karoo–Namib region. The extent of this geoelement in south-eastern Egypt and along the western coast of the Red Sea has not yet been satisfactorily determined.

It is worth mentioning that the monoregional (pure) Sudano–Zambezian geoelement was not represented further north in the Arabian Desert (Abd El-Ghani 1998), whereas it constituted 14% of the flora of the studied area. These geoelements are more typical of the southern Egyptian Desert (Bornkamm and Kehl 1990; Springuel et al. 1997; Abd El-Ghani et al. 2003). Thus, the tree and shrub layer is composed mainly of Saharo–Arabian geoelement with a Sudano–Zambezian focus of distribution. The Mediterranean geoelement was modestly represented in the tree and shrub layer. This may be attributed to the fact that plants of the Saharo–Arabian and Sudano–Zambezian geoelements are good indicators for harsh desert environmental

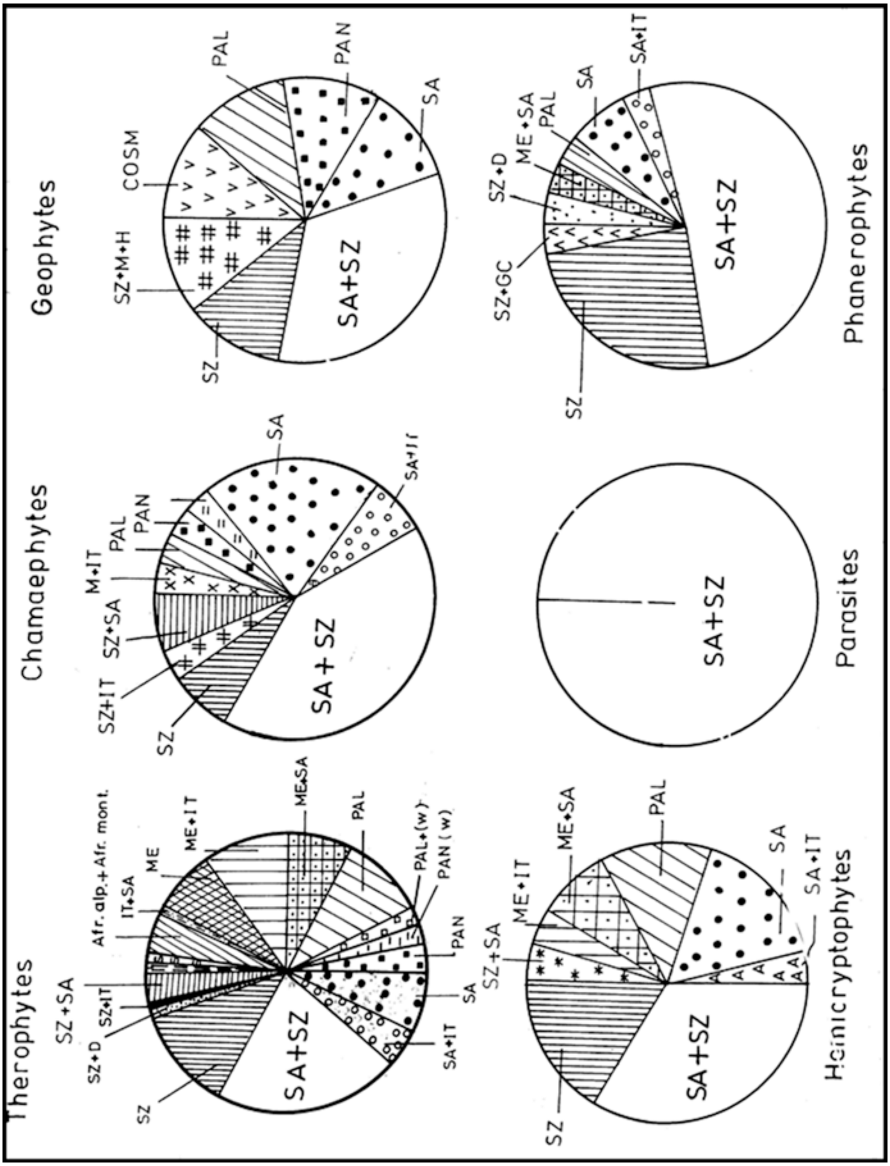

Fig. 4.8 Distribution of the chorotypes in the life-form categories. *D* Deccan, *H* Himalayan, *M* Madagascan, *GC* Guineo–Congo. For other chorotype abbreviations, see Table 4.5

conditions, while Mediterranean species stand for more mesic conditions. It can be, therefore, concluded that the flora of the Gebel Elba Park represents a continuation of the Sudanian tropical region with very similar climatic and topographic conditions. Further studies should attempt to define the environmental constraints on the species distribution recorded here.

4.2.2 The Northern Wadis

4.2.2.1 Wadis of Matuli and Qarn

The inland desert wadis, particularly those intersecting the Eastern Desert, differ greatly in their water resources. The wadis studied in the work hitherto presented lack of water resources and therefore belong to extremely dry habitats among similar wadis that drain this desert into the Nile Valley on rare occasions when rainfall occurs. Such rains usually happen in sudden torrents that overflow in wadi courses usually originating in mountainous areas in the middle of this desert and flowing eastwards or westwards to the Red Sea and Nile Valley, respectively. Torrential rains (in January 2010) that had suddenly swept the general area of Qena–Luxor where these wadis extend (Fig. 4.9) resulted in enriching the vegetation of some extremely dry wadis at this location. This leads to the prevalence of annuals and the flourishing of the scarce perennial vegetation (El-Sharkawi et al. 1982a, b).

Wadi EI-Matuli (25°55′–26°00′ N and 32°50′–33°00′ E) is a tributary of Wadi EI-Qarn, and the latter comprises the deltaic part (Fig. 4.9). Both wadis proliferate in an area extending about 45 km east of the Nile Valley in the vicinity of the town of "Qift" in Upper Egypt. In their extension, the two wadis are rather wide (2 km width in some parts), with a flat floor which is mostly exposed to solar radiation at daytime, and are without microhabitat shelters for shade plants. Meteorological data averages showed that the warmest summer month has maximum temperature of 40.9 °C and minimum temperature of 25.1 °C and the coldest winter month has maximum temperature of 23.3 °C and minimum temperature of 8 °C. Relative

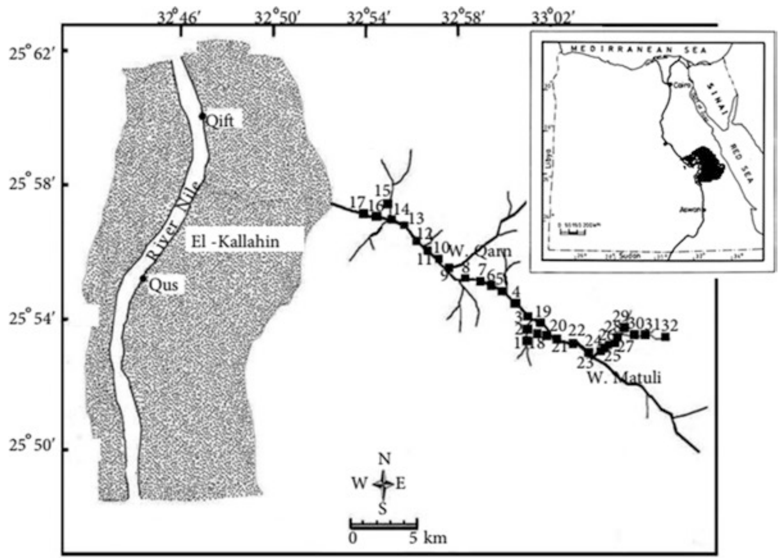

Fig. 4.9 Location map of the study area (*shaded area*)

humidity ranges from 45.9% in winter to 17.1% in summer. Rains occur only in May with 0.5 mm.

Floristic Composition

A total of 32 species (11 annuals and 21 perennials) belonging to 27 genera and 15 families were recorded (Table 4.6). The largest families were Zygophyllaceae (seven), Asteraceae and Boraginaceae (four for each), Papilionaceae (three), and Asclepiadaceae, Chenopodiaceae, and Tamaricaceae (two for each). They constituted about 75% of the recorded flora and represent most of the floristic structure in the Eastern Desert. Seven families were represented by only one species. The largest genus was *Fagonia* (four species) .

Table 4.6 Floristic composition, presence value, life forms, and chorology of the recorded species in the studied area of wadi El-Matuli and wadi El-Qarn in the Eastern Desert of Egypt

Species	Duration	Chorology	L.F	P%
Amaranthaceae				
Amaranthus graecizans L.	Per.	ME+IT	Ch	3.13
Asclepiadaceae				
Calotropis procera (Aiton) W.T.Aiton	Per.	SA+SZ	Ph	6.25
Leptadenia pyrotechnica (Forssk.) Decne.	Per.	SA+SZ	Ph	9.38
Asteraceae				
Cotula cinerea Delile	Ann.	SA	Th	40.63
Launaea cassiniana (Boiss.) Kuntze	Ann.	SA	Th	68.75
Pergularia tomentosa L.	Per.	SA+SZ	Ch	3.13
Pulicaria undulata (L.) C.A.Mey	Per.	SA	H	9.38
Boraginaceae				
Trichodesma africanum (L.) R.Br.	Ann.	SA+SZ	Ch	18.75
Morettia philaeana (Delile) DC.	Ann.	SA	H	12.5
Schouwia purpurea (Forssk.) Schweinf.	Ann.	SA	Th	93.75
Zilla spinosa (L.) Prantl.	Per.	SA	Ch	84.38
Brassicaceae				
Diplotaxis acris (Forssk.) Boiss	Ann.	SA	Th	9.38
Chenopodiaceae				
Haloxylon salicornicum (Moq.) Bunge ex Boiss.	Per.	SA+IT	Ch	21.88
Salsola imbricata Forssk. subsp. *imbricata*	Per.	SA	Ch	96.88
Cucurbitaceae				
Citrullus colocynthis (L.) Schrad.	Per.	ME+SA+IT	H	12.5
Malvaceae				
Malva parviflora L.	Ann.	ME+ES+IT	Th	15.63
Mimosaceae				
Acacia tortilis (Forssk.) Hayne subsp. raddiana (Savi) Brenan	Per.	SA	Ph	6.25

(continued)

Table 4.6 (continued)

Species	Duration	Chorology	L.F	P%
Papilionaceae				
Astragalus hamosus L.	Per.	ME+IT	Th	9.38
Crotalaria aegyptiaca Benth.	Per.	SZ	H	3.13
Lotus hebranicus Brand.	Ann.	SA	H	6.25
Poaceae				
Phragmites australis (Cav.) Trin. ex Steud.	Per.	PAL	G	6.25
Polygonaceae				
Rumex vesicarius L.	Ann.	ME+SA+IT	Th.	21.88
Rhamnaceae				
Ziziphus spina-christi (L.) Desf.	Per.	ME+SA+IT+SZ	Ph	12.5
Tamaricaceae				
Tamarix aphylla (L.) H.Karst.	Per.	SA+SZ+IT	Ph	15.63
T. nilotica (Ehreub.) Bunge	Per.	ME+SA+IT	Ph	53.13
Zygophyllaceae				
Fagonia Arabica L.	Per.	SA	Ch	34.38
F. bruguieri DC	Per.	SA+IT	H	3.13
F. indica Burm.	Per.	SA	Ch	3.13
F. thebaica Bioss	Per.	SA	Ch	3.13
Tribulus pentandrus Forssk	Ann.	SA+SZ	Th	12.5
Zygophyllum coccineum L.	Per.	SA	Ch	93.75
Z. simplex L.	Ann.	SA+SZ	Th	68.75

Four of the recorded species are ubiquitous (have a wide ecological range of distribution), viz. *Salsola imbricata* subsp. *imbricata*, *Schouwia purpurea*, *Zygophyllum coccineum*, and *Zilla spinosa* with highest presence values (96.88%, 93.75%, 93.75%, and 84.38%, respectively). On the other hand, *Launaea cassiniana*, *Zygophyllum simplex*, *Tamarix nilotica*, and *Cotula cinerea* showed the highest presence estimate among annuals (68.75%, 68.75%, 53.13% and 40.63%, respectively). Twenty-one species or about 65.63% of the total recorded species are perennials and demonstrated a certain degree of constancy. The presence of *Tamarix aphylla*, *T. nilotica*, and *Salsola imbricata* subsp. *imbricata* refers to salinization.

Biological Spectrum

According to the Raunkiaer system (1937), six life forms were recognized (Fig. 4.10), of which chamaephytes (31.25%) constitute the largest number of species (ten species) and therophytes (nine species) ranked second with 28.13%. Phanerophytes and hemicryptophytes (six species for each) represent about 37.5% of the total flora. Geophytes (3.13%) are represented by one species.

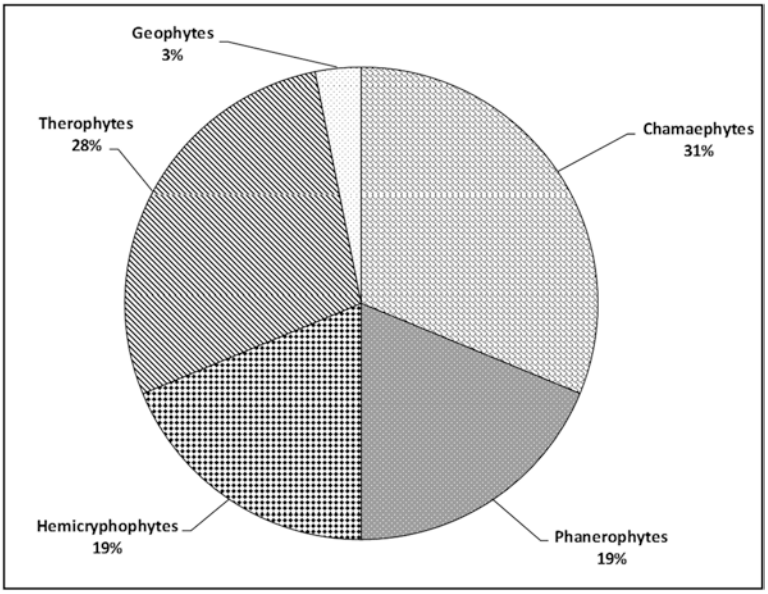

Fig. 4.10 Life-form spectrum of the recorded species in the study area

Chorological Analysis

Results of the total chorological analysis (Fig. 4.11) of the surveyed flora presented revealed that 16 species (50% of the total flora) are monoregional, of which 15 species (46.9%) are native to the Saharo–Arabian chorotype. Sudano–Zambezian ranked second with 3.1%. About 46.9% of the recorded species are biregional and pluriregional extending their distribution all over the Saharo–Arabian, Sudano–Zambezian, Irano–Turanian, and Mediterranean regions. Being part of Saharo–Arabian region, the Saharo–Arabian chorotype (bi- and pluriregional) constitutes 28.1% and 16.7%, respectively, of the recorded species. Thus, it forms the major component of the floristic composition of this study.

Multivariate Analysis

Classification of the presence–absence data set of 32 species recorded in 32 stands using the cluster analysis yielded four vegetation groups at level 3 of the hierarchy (Fig. 4.12; Table 4.7). These groups are named after the first and second dominant species as follows: (A) *Schouwia purpurea–Tamarix nilotica*, (B) *Zilla spinosa–Zygophyllum coccineum*, (C) *Rumex vesicarius–Salsola imbricata* subsp. *imbricata*, and (D) *Fagonia arabica–Launaea cassiniana*. Group C was the largest (7 stands) among other groups including 21 species, followed by group D (9 stands, 20 species). Some species showed certain degree of fidelity; e.g. *Amaranthus*

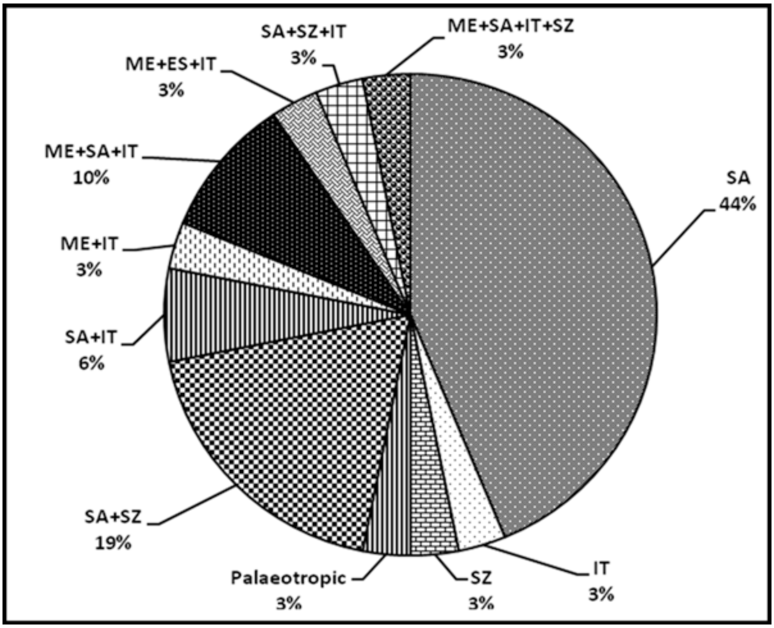

Fig. 4.11 Chorological analysis of the recorded species in the study area. For abbreviations, see (Table 4.6)

graecizans was confined to group A; *Fagonia thebaica*, *F. bruguieri*, and *Crotalaria aegyptiaca* to group B; *Rumex vesicarius* and *Malva parviflora* to group C; and *Astragalus hamosus*, *Lotus hebranicus*, *Pergularia tomentosa*, and *Fagonia indica* to group D . Eight species were recorded in all groups, among others *Cotula cinerea*, *Schouwia purpurea*, and *Zygophyllum simplex* as annuals and *Haloxylon salicornicum*, *Salsola imbricata* subsp. *imbricata*, and *Tamarix nilotica* as woody perennials. Detrended Correspondence Analysis (DCA) represented the distribution of the four vegetation groups along the first two axes (Fig. 4.13).

Soil–Vegetation Relationships

Soil characteristics of each of the four vegetation groups of the study are identified by cluster analysis and summarized in Table 4.8. Soil reaction (pH), total soluble salts (TSS), potassium, calcium, magnesium, and chlorides showed significant differences between the identified vegetation groups. The ordination diagram produced by CCA is shown in Fig. 4.14. The length and the direction of an arrow representing a given environmental variable provide an indication of the importance and direction of the gradient of environmental change for that variable, within the set of samples measured. The cumulative percentage variance of species–environment relations for the four axes amounts to 67.6% that suggests a strong association between vegetation and the measured parameters presented in the biplot (Jongman et al. 1987).

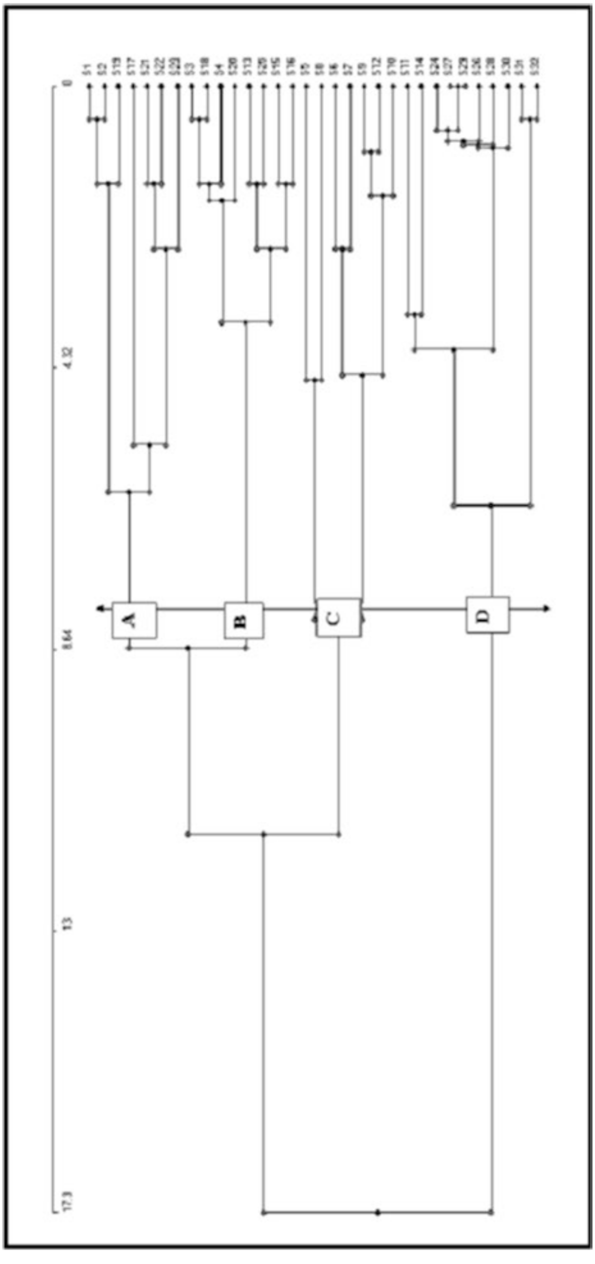

Fig. 4.12 Classification of the studied 32 stands using cluster analysis. A–D are the vegetation groups

Table 4.7 Synoptic table of the vegetation groups yielded from the classification

Species	A	B	C	D
Tamarix nilotica	100	50		
Schouwia purpurea	100	100	71.4	
Zygophyllum coccineum	85.7	100	85.7	100
Salsola imbricata subsp. *imbricata*	85.7	100	100	100
Launaea cassiniana	85.7		85.7	100
Haloxylon salicornicum	57.1			
Zilla spinosa		100	85.7	100
Zygophyllum simplex		75	57.1	88.8
Rumex vesicarius			100	
Malva parviflora			71.4	
Fagonia arabica				100
Cotula cinerea				88.8

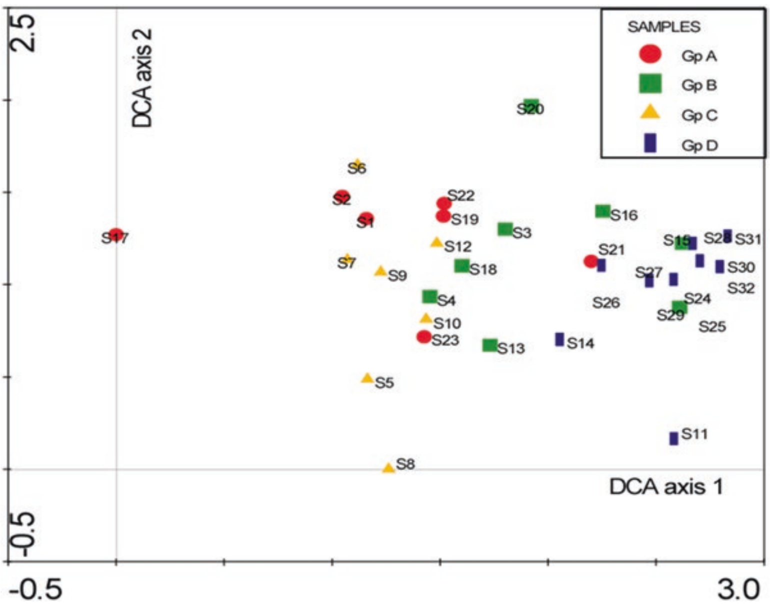

Fig. 4.13 DCA ordination diagram of the 32 stands on axes 1 and 2 as classified by cluster analysis; A–D are the four vegetation groups

Stands of group A and C were highly associated with chlorides. Whereas stands of group A were highly associated with water content, stands of group C and D showed the lowest levels. Gravel, clay, PO_4^{-3}, pH, and organic matter were highly associated with groups B and D. From the inter-set correlations (Table 4.9) resulted from the Canonical Correspondence Analysis (CCA), it demonstrated that CCA axis 1 was highly positively correlated with gravel and pH and negatively correlated

Table 4.8 Mean values, standard errors (±SE), ANOVA F-values of the soil variables in the 32 stands representing the four vegetation groups (A–D) obtained by cluster analysis

Soil variables		Vegetation groups A	B	C	D	F-ratio
pH		8.6 ± 0.3	8.2 ± 0.3	8.4 ± 0.3	8.8 ± 0.3	7.69*
TSS (mg /l)		2.7 ± 3.8	6.4 ± 4.6	78.2 ± 3.9	1.08 ± 7.2	6.2*
Gravel	(%)	2.3 ± 1.6	3.6 ± 5.4	0.39 ± 0.44	6.6 ± 6.4	2.75
Silt	(%)	18.4 ± 11.4	23.2 ± 9.5	21.2 ± 14.6	17.2 ± 12.7	0.43
Clay	(%)	7.5 ± 5.0	7.2 ± 2.9	6.0 ± 2.7	8.8 ± 7.5	0.41
OM	(%)	2.4 ± 1.2	3.2 ± 1.0	2.3 ± 1.5	2.8 ± 1.2	0.82
WC	(%)	0.4 ± 0.6	0.3 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	1.4
K^+	(mg/g soil)	0.1 ± 0.09	0.23 ± 0.07	0.05 ± 0.04	0.06 ± 0.05	13.3*
Ca^{+2}	(mg/g soil)	0.4 ± 0.3	0.7 ± 0.4	0.3 ± 0.09	0.3 ± 0.14	4.8*
Mg^{+2}	(mg/g soil)	0.2 ± 0.1	0.3 ± 0.1	0.1 ± 0.05	0.1 ± 0.05	7.9*
Cl^-	(mg/g soil)	1.0 ± 0.4	1.4 ± 0.4	1.2 ± 0.2	0.9 ± 0.3	3.6**
SO_4^{-2}	(mg/g soil)	4.2 ± 0.5	3.9 ± 1.5	3.5 ± 0.3	2.9 ± 1.2	2.17
PO_4^{-3}	(mg/g soil)	0.17 ± 0.06	0.20 ± 0.04	0.2 ± 0.08	0.2 ± 0.05	2.3

TSS total soluble salts, *OM* organic matter, *WC* water content
*P < 0.01; **P < 0.05

with SO_4^{-2} and chlorides. This axis can be identified as gravel–SO_4^{-2} gradient. The CCA axis 2 was highly positively correlated with K^+, Mg^{+2}, and total soluble salts and negatively with pH. This axis can be identified as K–pH gradient.A test for significance with an unrestricted Monte Carlo permutation test found the F-ratio for the eigenvalue of CCA axis 1 and the trace statistics to be significant (P < 0.05) indicating that the observed patterns did not arise by chance.

4.2.3 The Southern Wadis (Between 26°45′ and 24°01′ N and 32°45′ and 35°00′ E)

The surveyed area covered nearly the southern quarter of the Eastern Desert (about 54,500 km^2) between 26° 45′ and 24° 1′ N latitudes and 32° 45′ and 35° 00′ E longitudes (Fig. 4.15). It covered the area between Qena Governorate and Aswan

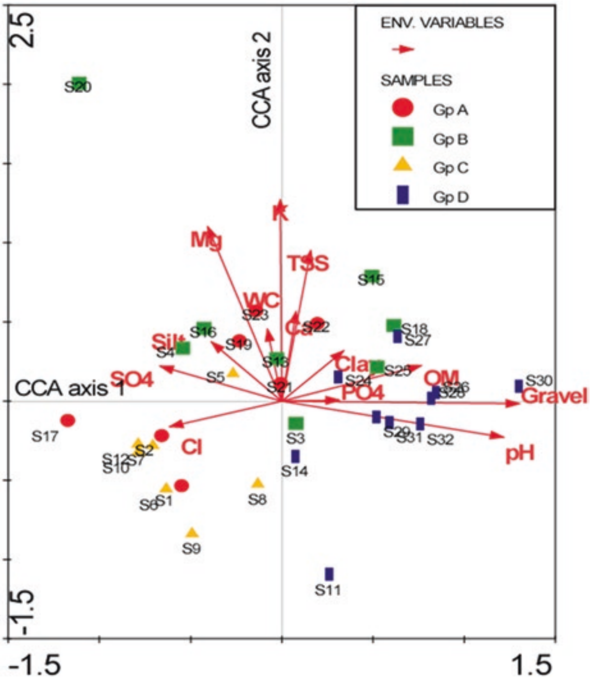

Fig. 4.14 CCA ordination biplot of the studies of 32 stands and soil variables, together with their vegetation groups

Table 4.9 Results of ordination for the first three axes of CCA. Inter-set correlations of the soil variables, together with eigenvalues and species–environment correlation coefficients

	CCA axis		
	1	2	3
Eigenvalues	0.273	0.225	0.153
Species–environment correlation coefficients	0.917	0.926	0.787
pH	0.45	−0.09	0.15
TSS	−0.05	0.38	−0.02
Gravel	0.48	−0.01	0.13
Silt	−0.014	0.15	−0.38
Clay	0.13	0.13	−0.15
Organic matter	0.28	0.09	−0.18
Water content	−0.03	0.18	−0.06
K^+	−0.003	0.51	−0.14
Ca^{+2}	0.03	0.23	−0.11
Mg^{+2}	−0.15	0.44	0.17
Cl^-	−0.23	−0.06	−0.26
SO_4^{-2}	−0.25	0.09	0.17
PO_4^{-3}	0.11	0.002	−0.43

For units and abbreviations, see Table 4.8

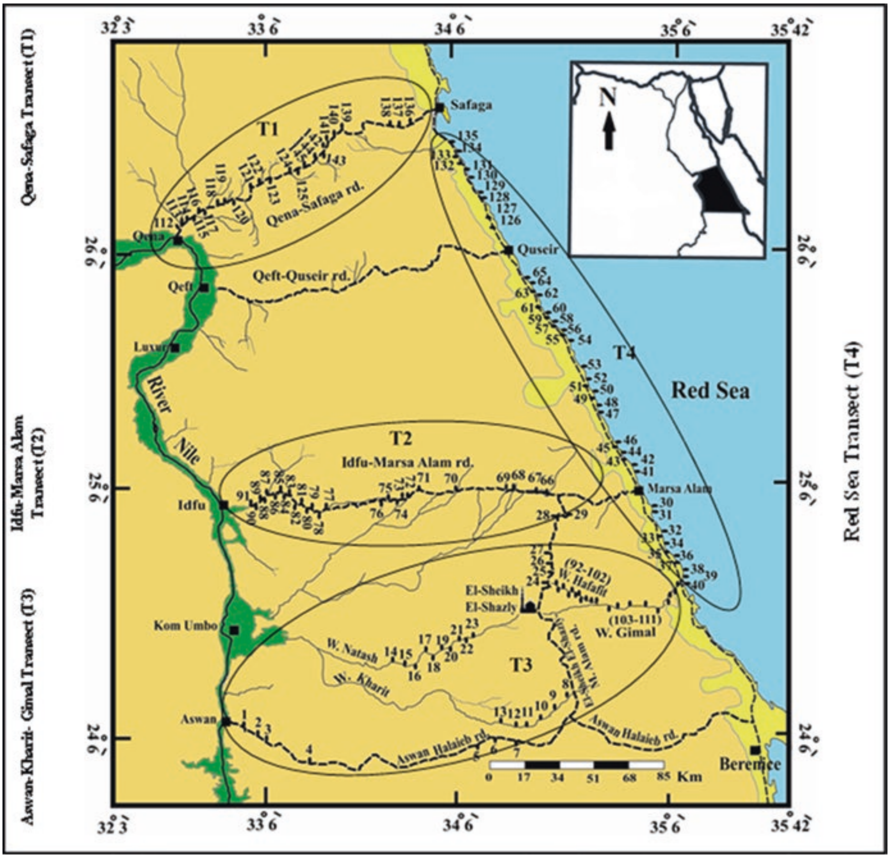

Fig. 4.15 Location map of the study area, showing the distribution of the studied stands along the four transects

Governorate on the Nile Valley and from Safaga to Berenice on the Red Sea coast. According to Zahran and Willis (2009), this area covered three desert types: (1) the limestone desert (Assiut–Qena Desert), (2) the sandstone desert (Edfu–Kom Ombo Desert), and (3) the Red Sea coastal plain. Detailed studies on the geology, geomorphology, topography, and lithology have been documented by Said (1962), Abu Al-Izz (1971), and Zahran and Willis (2009).

Vegetation sampling was performed in the surveyed area using four transects representing the three desert types. The sandstone desert included T1 which comprised of Aswan–Berenice road (300 km, 24° 05′–24° 00′ N, and 32° 55′–35° 24′ E), Wadi Kharit (250 km, 24° 26′ – 24° 12′ N, and 33° 11′–34° 40′ E), W. Natash (100 km, 24° 21′–24° 40′ N, and 33° 24′–34° 30′ E), and W. Gimal (65 km, 24° 34′–24° 40′ N, and 34°35′–35° 05′ E) and T2 which comprised of Edfu–Marsa Alam road (100 km, 25° 55′ N, 32° 55′–34° 55′ E). In the limestone desert, T3 included Qena–Safaga road (155 km, 26° 12′–26° 46′ N, and 32° 44′–33° 56′ E), and along the Red

Sea coastal plain, T4 extends for about 240 km between 24° 39′–26° 36′ N and 32° 05′–34° 00′ E. The degree of occurrence of each species was determined using the *Q*-value (Danin et al. 1985) as follows: *Q* = number of entries of a species × total number of species/13,348 (total number of entries). The *Q*-values and occurrences were categorized as follows: D = dominant, Q-value ≥0.2; VC = very common, Q-value 0.1–0.199; C = common, Q-value 0.05–0.099; O = occasional or rare species, Q-value 0.01–0.049; and S = sporad``ic or very rare, Q-value ≤0.01.

4.2.3.1 Floristic Composition

In total, 94 species (62 perennials and 32 annuals) constituted the floristic composition, representing 76 genera and 33 families (Table 4.10). About more than 50% of these species belonged to six families arranged in the following sequence, Asteraceae > Zygophyllaceae > Fabaceae > Poaceae > Chenopodiaceae > Brassicaceae. The largest family was Asteraceae (7 genera and 10 species), while 18 families were monospecific. The total number of recorded species was 46, 35, 52, and 46 for T1, T2, T3, and T4, respectively.

Table 4.10 Species composition of the four transects classified according to the different functional groups, together with their presence values (P%), chorology, Q-values, and occurrences

Species	P% for each transect				Chorotype	Q-value	Occ
	T1	T2	T3	T4			
Species present in all transects							
Shrubs							
Zilla spinosa (L.) Prantl.	81.8	96.4	73.9	15.2	SA	0.61	D
Zygophyllum coccineum L.	59.1	3.6	8.7	30.4	SA	0.23	D
Caroxylon imbricatum (Forssk.) Akhani & E. H. Roalson	45.5	67.9	2.2	2.2	SA	0.22	D
Lotus hebranicus Hochst. ex Brand	13.6	14.3	17.4	13	M	0.15	VC
Aerva javanica (Burm. F.) Juss ex Schult.	18.2	25	8.7	4.3	SA	0.12	VC
Leptadenia pyrotechnica (Forssk.) Decne.	18.2	7.1	6.5	2.2	SA+SZ	0.07	C
Annual herbs							
Astragalus vogelii (Webb.) Bornm.	9.1	21.4	13	6.5	SA	0.12	VC
Tetraena simplex (L.) Beier & Thulin	9.1	28.6	8.7	2.2	SA+SZ	0.11	VC
Polycarpaea repens (Forssk.) Asch. & Schweinf.	4.5	3.6	4.3	6.5	SA	0.05	C
Species present in three transects							
Trees							
Acacia tortilis (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan	0	46.4	65.2	17.4	SA	0.36	D

(continued)

Table 4.10 (continued)

Species	P% for each transect				Chorotype	Q-value	Occ
	T1	T2	T3	T4			
Tamarix aphylla (L.) H. Karst.	0	10.7	26.1	17.4	SA+IT	0.16	VC
T. nilotica (Ehreub.) Bunge	18.2	0	4.3	30.4	SA+IT	0.14	VC
Calotropis procera (Aiton) W. T. Aiton	4.5	7.1	6.5	0	SA+SZ	0.04	O
Shrubs							
Fagonia thebaica Boiss.	18.2	46.4	0	2.2	SA	0.13	VC
Pulicaria undulata (L.) C. A. Mey	0	39.3	10.9	2.2	SA	0.12	VC
Panicum turgidum Forssk.	0	3.6	15.2	8.7	M+SA	0.08	C
Ochradenus baccatus Delile	18.2	0	2.2	6.5	SA	0.06	C
Pergularia tomentosa L.	13.6	10.7	2.2	0	SA	0.05	C
Suaeda monoica Forssk. ex J. F. Gmel.	0	7.1	2.2	6.5	SA+SZ	0.04	O
Cleome droserifolia (Forssk.) Delile	4.5	0	4.3	6.5	SA+IT	0.04	O
Perennial herbs							
Citrullus colocynthis (L.) Schrad.	22.7	35.7	32.6	0	M+SA+IT	0.21	D
Phragmites australis (Cav.) Trin. ex Steud.	18.2	3.6	0	13	PAN	0.08	C
Monsonia heliotropioides (Cav.) Boiss.	0	3.6	10.9	2.2	SA	0.05	C
Annual herbs							
Morettia philaeana (Delile) DC.	31.8	60.7	39.1	0	SA	0.3	D
Schouwia purpurea (Forssk.) Schweinf.	9.1	35.7	8.7	0	SA	0.11	VC
Trichodesma africanum (L.) R. Br.	22.7	25	4.3	0	SA+SZ	0.1	VC
Cotula cinerea Delile	9.1	3.6	19.6	0	IT	0.09	C
Forsskaolea tenacissima L.	18.2	3.6	6.5	0	SA+SZ	0.06	C
Eremobium aegyptiacum (Spreng.) Asch. & Schweinf. ex Boiss.	4.5	10.7	2.2	0	SA	0.04	O
Species present in two transects							
Trees							
Phoenix dactylifera L.	22.7	0	0	2.2	SA+SZ	0.04	O
Shrubs							
Farsetia stylosa R. Br.	0	10.7	17.4	0	SA+SZ	0.08	C
Pulicaria incisa (Lam.) DC.	27.3	0	4.3	0	SA	0.06	C
Senna italica Mill	0	3.6	17.4	0	SA+SZ	0.06	C
Convolvulus hystrix Vahl	0	0	2.2	8.7	SA	0.04	O
Fagonia indica Burm. F.	0	0	6.5	2.2	SA	0.03	O
Heliotropium bacciferum Forssk.	0	7.1	0	2.2	SA	0.02	O
Perennial herbs							
Cynodon dactylon (L.) Pers.	13.6	0	0	4.3	COSM	0.04	O
Annual herbs							

(continued)

Table 4.10 (continued)

Species	P% for each transect				Chorotype	Q-value	Occ
	T1	T2	T3	T4			
Launaea nudicaulis (L.) Hook. F.	0	0	13	8.7	SA+IT	0.07	C
Asphodelus tenuifolius Cav.	0	7.1	15.2	0	M+SA+IT	0.06	C
Tribulus pentandrus Forssk.	0	14.3	10.9	0	SA+SZ	0.06	C
Malva parviflora L.	0	0	2.2	10.9	M+ES+IT	0.04	O
Cleome amblyocarpa Barratte &Murb.	0	3.6	10.9	0	SA+SZ	0.04	O
Arnebia hispidissima (Lehm.) DC.	4.5	0	0	4.3	SA	0.02	O
Euphorbia granulata Forssk.	0	3.6	4.3	0	M+SA+IT	0.02	O
Reseda pruinosa Delile	0	0	2.2	2.2	SA	0.01	O
Cistanche phelypaea (L.) Cout.	4.5	3.6	0	0	M+SA+IT	0.01	O
Tribulus megistopterus Kralik	4.5	0	2.2	0	SA+SZ	0.01	O
Species present in one transect							
Trees							
Balanites aegyptiaca (L.) Delile	0	0	28.3	0	SA+SZ	0.09	C
Ziziphus spina-christi (L.) Desf.	18.2	0	0	0	SA	0.03	O
Avicennia marina (Forssk.) Vierh.	0	0	0	8.7	SA	0.03	O
Ricinus communis L.	9.1	0	0	0	PAN	0.01	O
Acacia nilotica (L.) Delile	4.5	0	0	0	SU	0.007	S
Capparis decidua (Forssk.) Edgew.	0	0	2.2	0	SA+SZ	0.007	S
Hyphaene thebaica (L.) Mart.	0	0	0	2.2	SA+SZ	0.007	S
Moringa peregrina (Forssk.) Fiori	4.5	0	0	0	SZ+GC	0.007	S
Shrubs							
Zygophyllum album L.	0	0	0	26.1	M+SA+IT	0.08	C
Nitraria retusa (Forssk.) Asch.	0	0	0	26.1	SA	0.08	C
Limonium axillare (Forssk.) Kuntze	0	0	0	21.7	SA+SZ	0.06	C
Crotalaria aegyptiaca Benth.	0	0	0	10.9	SZ	0.04	O
Arthrocnemum macrostachyum (Moric.) K. Koch	0	0	0	13	M+SA+IT	0.04	O
Salvadora persica L.	0	0	8.7	0	SA+SZ	0.03	O
Cornulaca monacantha Delile	0	0	0	6.5	SA	0.02	O
Artemisia judaica L.	9.1	0	0	0	SA	0.01	O
Senna holosericea (Freseu) Greuter	0	0	4.3	0	SA	0.01	O
Fagonia mollis Delile	9.1	0	0	0	SA	0.01	O
Iphiona mucronata (Forssk.) Asch. & Schweinf	0	7.1	0	0	SA	0.01	O
Atriplex leucoclada Boiss.	4.5	0	0	0	SA+IT	0.007	S
Fagonia bruguieri DC.	4.5	0	0	0	SA+IT	0.007	S
Capparis spinosa L.	0	0	0	2.2	M+SA+SZ	0.007	S
Chrozophora oblongifolia (Delile) Spreng.	4.5	0	0	0	M+SA	0.007	S

(continued)

Table 4.10 (continued)

Species	P% for each transect				Chorotype	Q-value	Occ
	T1	T2	T3	T4			
Oxystelma esculentum (L.F.) R. Br.	0	0	2.2	0	SZ+GC	0.007	S
Caroxylon villosum (Schult.) Akhani & E. H. Roalson	4.5	0	0	0	M+SA+IT	0.007	S
Taverniera aegyptiaca Boiss.	0	0	0	2.2	SA	0.007	S
Perennial herbs							
Aeluropus littoralis (Gouan) Parl.	0	0	0	6.5	M+IT	0.02	O
Imperata cylindrica (L.) Raeusch	9.1	0	0	0	PAN	0.01	O
Juncus rigidus Desf.	0	0	0	2.2	M+SA+IT	0.007	S
Leptochloa fusca (L.) Kunth	0	0	0	2.2	PAL	0.007	S
Stipagrostis plumosa (L.) Munro ex T. Anderson	4.5	0	0	0	M+SA+IT	0.007	S
Dichanthium annulatum (Forssk.) Stapf	4.5	0	0	0	PAL	0.007	S
Cyperus rotundus L.	0	0	0	2.2	PAN	0.007	S
Typha domingensis (Pers.) Poir. ex Steud.	4.5	0	0	0	PAN	0.007	S
Annual herbs							
Astragalus eremophilus Boiss.	0	0	30.4	0	SA	0.1	C
Hippocrepis constricta Knuze	0	0	6.5	0	M+SA+IT	0.02	O
Lupinus digitatus Forssk.	0	0	6.5	0	M	0.02	O
Polycarpaea robbairea (Kuntze) Greuter & Burdet	0	0	6.5	0	SA	0.02	O
Launaea amal-aminae N. Kilian	0	0	4.3	0	SA	0.01	O
Echium horridum Batt.	4.5	0	0	0	SA	0.007	S
Chenopodium album L.	4.5	0	0	0	COSM	0.007	S
Ch. murale L.	0	0	0	2.2	COSM	0.007	S
Launaea capitata (Spreng.) Dandy	0	0	2.2	0	SA	0.007	S
Filago desertorum Pomel	4.5	0	0	0	SA+IT	0.007	S
Glinus lotoides L.	0	0	2.2	0	PAL	0.007	S
Oligomeris linifolia (Vahl.) ex Hornem J. F. Macbr.	0	0	0	2.2	SA+SZ	0.007	S
Sonchus oleraceus L.	0	0	0	2.2	COSM	0.007	S

T1 Qena–Safaga transect, *T2* Edfu–Marsa Alam transect, *T3* Aswan–Kharit–Gimal transect, *T4* Red Sea transect. *SA* Saharo–Arabian, *SZ* Sudano–Zambezian, *M* Mediterranean, *IT* Irano–Turanian, *ES* Euro–Siberian, *SU* Sudanian, *GC* Gueno–Cungo, *COSM* Cosmopolitan, *PAN* Pantropical, *PAL* Palaeotropical, *Occ* occurrence (*D* dominant, *VC* very common, *C* common, *O* occasional, *S* sporadic)

In terms of functional groups (Fig. 4.16), shrubs predominated (37 species, 39.4%) followed by annual herbs (32 species, 34%), trees (13 species, 13.8%), and perennial herbs (12 species, 12.8%). It can be noted that trees and perennial herbs were the least (2–7 species) represented among the four studied transect, while annual herbs and shrubs were the most (14–24 species). The distribution of func-

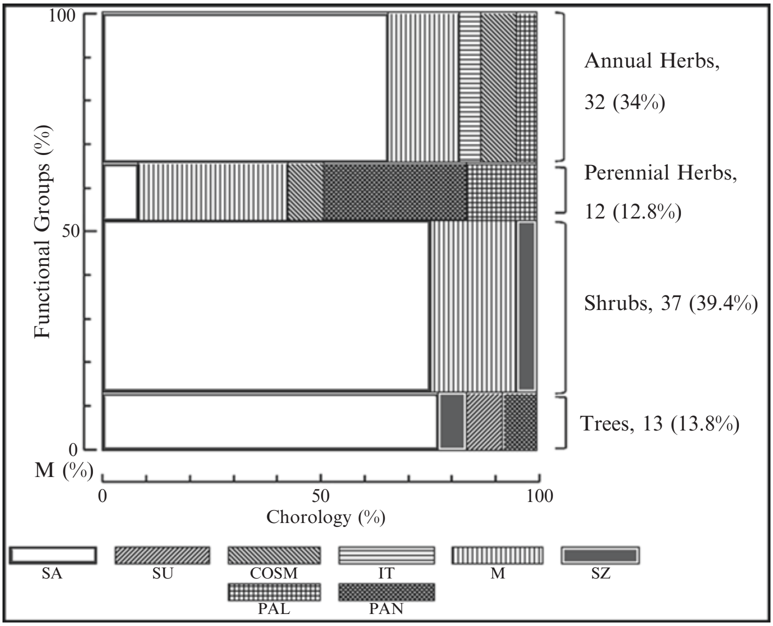

Fig. 4.16 Chorotype spectrum and functional group diagram of the study area. *M* species magnitude and average group abundance

tional groups within the studied transects showed significant difference (F-value = 3.11, *P* = 0.032) for the Red Sea transect (T4) among the others (F-value = 0.92, *P* = 0.44; F-value = 0.51, *P* = 0.68; and F-value = 0.65, *P* = 0.58 for T1, T2, and T3, respectively). Few grasses (Poaceae) were recorded within transects (5, 2, 1, and 5 species in T1, T2, T3, and T4, respectively), whereas shrubs dominated (17, 14, 20, and 23 species in T1, T2, T3, and T4, respectively).

Table 4.10 also showed the distribution of the different functional groups within the study area. The recorded 13 tress were, among others, *Acacia tortilis* subsp. *raddiana*, *Tamarix aphylla*, *Balanites aegyptiaca*, *Ziziphus spina-christi*, *Avicennia marina*, *Hyphaene thebaica*, and *Moringa peregrina*.

Shrubs were the largest (37 species) represented functional group. The widely distributed species included *Zygophyllum coccineum*, *Zilla spinosa*, *Caroxylon imbricatum*, *Aerva javanica*, and *Leptadenia pyrotechnica* that occurred in all transects. Whereas *Caroxylon villosum*, *Artemisia judaica*, *Atriplex leucoclada*, *Chrozophora oblongifolia*, *Fagonia mollis*, and *F. bruguieri* were represented only in the northern transect (T1), *Zygophyllum album*, *Nitraria retusa*, *Limonium axillare*, *Arthrocnemum macrostachyum*, *Cornulaca monacantha*, *Taverniera aegyptiaca*, and *Capparis spinosa* were confined to the Red Sea transect (T4), and another three shrubs showed consistency to the southern sector (Aswan–Kharit–Gimal transect; T3) .

Four perennial herbs (*Aeluropus littoralis*, *Juncus rigidus*, *Leptochloa fusca*, and *Cyperus rotundus*) showed consistency to the Red Sea transect (T4). For the northern transect (T1), *Imperata cylindrica*, *Stipagrostis plumosa*, *Dichanthium annulatum*, and *Typha domingensis* exhibited certain degree of consistency to this transect.

Three annual herbs (*Astragalus vogelii*, *Polycarpaea repens*, and *Tetraena simplex*) had wide range of distribution (occurred in all transects). The Aswan–Kharit–Gimal transect (T3) was characterized by *Astragalus eremophilus*, *Hippocrepis constricta*, *Lupinus digitatus*, *Launaea amal-aminae*, *L. capitata*, *Polycarpaea robbairea*, and *Glinus lotoides* which were not recorded elsewhere.

4.2.3.2 Species Abundance

The recorded species were categorized according to their Q-values as follows: (i) dominant species, of which *Zilla spinosa* had presence value of 61% and *Acacia tortilis* subsp. *raddiana* with $P = 36\%$. *Caroxylon imbricatum* and *Zygophyllum coccineum* (shrubs), *Morettia philaeana* (annual herb), and *Citrullus colocynthis* (perennial herb) had lower presence values; (ii) very common species, ten species (e.g. *Tamarix aphylla*, *Fagonia thebaica*, *Aerva javanica*, *Pulicaria undulata*, *Schouwia purpurea*); (iii) common species, 20 species included some salt-tolerant species such as *Nitraria retusa*, *Zygophyllum album*, and *Phragmites australis*; (iv) occasional species, constituted the main bulk of the flora (33 species, 35.1% of total species), with their Q-values ranged between 0.01 and 0.049; and (v) sporadic species, comprised of 25 species with Q-values = 0.007 which included four trees, seven shrubs, six perennial herbs, and eight annual herbs.

4.2.3.3 Chorological Affinities

The chorological spectrum of the recorded species was illustrated in Fig. 4.15. The Cosmopolitan, Palaeotropical, and Pantropical species constituted 12 species (12.8% of the total flora). Monoregional Saharo–Arabian chorotype was well represented (35 species) in the study area, while species of Sudano–Zambezian (*Crotalaria aegyptiaca*), Sudanian (*Acacia nilotica*), Mediterranean (*Lotus hebranicus* and *Lupinus digitatus*), and Irano–Turanian (*Cotula cinerea*) were very modestly represented.

A total of 30 species were biregional chorotypes representing 31.9% of the recorded species, distributed as follows: (1) 18 species belonging to Saharo–Arabian+Sudano–Zambezian (e.g. *Trichodesma africanum*, *Balanites aegyptiaca*, *Leptadenia pyrotechnica*, *Calotropis procera*, *Cleome amblyocarpa*, *Salvadora persica*, *Limonium axillare*, and *Hyphaene thebaica*), (2) 7 species belonging to the Saharo–Arabian+Irano–Turanian (e.g. *Tamarix aphylla*, *Launaea nudicaulis*, *Cleome droserifolia*, and *Fagonia bruguieri*), (3) 2 species belonging to Sudano–Zambezian+Guineo–Congo (*Moringa peregrina* and *Oxystelma esculentum*), (4) 1 species belonging to Mediterranean+Irano–Turanian (*Aeluropus littoralis*), and (5) 2 species belonginig to Mediterranean+Saharo–Arabian (*Panicum turgidum* and *Chrozophora oblongifolia*). In general, 18 species belonged to Saharo–Arabian+Sudano–Zambezian, while the Saharo–Arabian+Irano–Turanian species were represented by 7 species.

About 12.8% of the recorded species (12 species) were pluriregional with wide geographical range of distribution (e.g. *Citrullus colocynthis*, *Zygophyllum album*, *Arthrocnemum macrostachyum*, *Juncus rigidus*, and *Capparis spinosa*) .

4.2.3.4 Classification of the Vegetation

Application of classification using cluster analysis to the floristic presence–absence data matrix of the study area yielded seven vegetation groups (Fig. 4.17, Table 4.11). Each of the identified vegetation group will be named after the dominant species

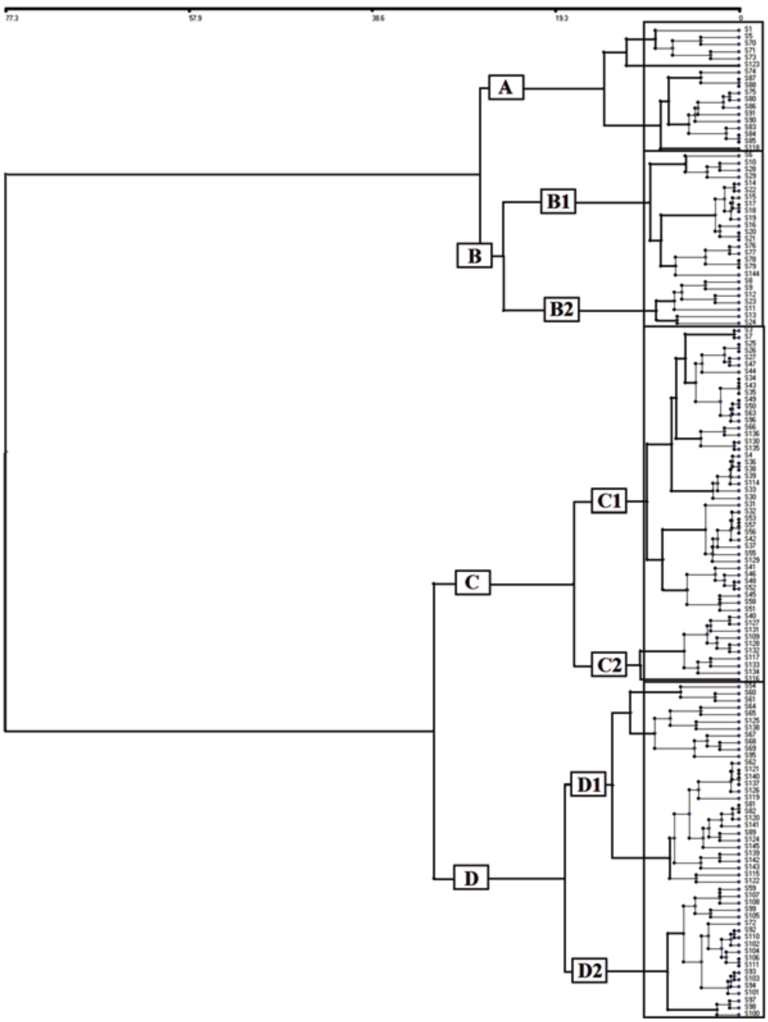

Fig. 4.17 Dendrogram showing cluster analysis of the studied 142 stands, with the 7 vegetation groups (*A*–*D2*) separated

Table 4.11 Species composition of the obtained seven vegetation groups, together with their presence values (P%)

Vegetation groups	A	B1	B2	C1	C2	D1	D2
Total number of stands	18	18	7	41	8	31	19
Total number of species	41	26	30	32	19	53	20
Species present in six groups							
Zilla spinosa	100	94.4	100		12.5	90.3	78.9
Acacia tortilis subsp. *raddiana*	38.9	77.8	71.4	19.5		16.1	63.2
Species present in five groups							
Tamarix aphylla	16.7			14.6	12.5	3.2	63.2
Zygophyllum coccineum	5.6			7.3	100	51.6	21.1
Aerva javanica	27.8		14.3	12.2		16.1	5.3
Pulicaria undulata	27.8	22.2		4.9		9.7	15.8
Lotus hebranicus	27.8	5.6	57.1	7.3		25.8	
Species present in six groups							
Citrullus colocynthis	44.4	83.3	57.1			9.7	
Morettia philaeana	94.4	83.3	85.7			12.9	
Pergularia tomentosa	5.6	5.6	14.3			12.9	
Tetraena simplex	50	11.1	14.3			9.7	
Tribulus pentandrus	27.8	11.1	14.3				5.3
Caroxylon imbricatum	83.3	22.2		2.4		35.5	
Astragalus vogelii	38.9		85.7			9.7	5.3
Forsskaolea tenacissima	11.1		28.6			9.7	5.3
Phragmites australis	11.1			7.3	37.5	9.7	
Tamarix nilotica	5.6			22	100	6.5	
Malva parviflora	5.6			2.4		9.7	5.3
Leptadenia pyrotechnica		5.6		4.9		12.9	15.8
Panicum turgidum			14.3	12.2		12.9	10.5
Species present in three groups							
Asphodelus tenuifolius	5.6	22.2	57.1				
Astragalus eremophilus	11.1	33.3	85.7				
Cotula cinerea	16.7	16.7	85.7				
Monsonia heliotropioides	11.1		57.1			3.2	
Pulicaria incisa	11.1		28.6			12.9	
Schouwia purpurea	61.1		42.9			6.5	
Trichodesma africanum	44.4		14.3			16.1	
Eremobium aegyptiacum	16.7		14.3				5.3
Farsetia stylosa	16.7		85.7				10.5
Arnebia hispidissima	5.6			2.4		3.2	
Fagonia indica	5.6			4.9		3.2	
Cynodon dactylon	5.6				25	6.5	
Fagonia thebaica	72.2				12.5	12.9	
Polycarpaea robbairea		5.6	14.3	2.4			
Convolvulus hystrix		5.6		2.4		9.7	

(continued)

Table 4.11 (continued)

Vegetation groups	A	B1	B2	C1	C2	D1	D2
Calotropis procera		11.1				3.2	15.8
Launaea nudicaulis			85.7	2.4		9.7	
Polycarpaea repens			28.6	2.4		12.9	
Nitraria retusa				17.1	50		5.3
Ochradenus baccatus					12.5	19.4	5.3
Species present in two groups							
Euphorbia granulata	11.1	5.6					
Suaeda monoica	16.7			7.3			
Cistanche phelypaea	5.6					3.2	
Ricinus communis	5.6					3.2	
Cleome amblyocarpa		11.1	57.1				
Hippocrepis constricta		5.6	28.6				
Lupinus digitatus		5.6	28.6				
Senna italica		44.4	14.3				
Artemisia judaica		5.6				3.2	
Fagonia mollis		5.6				3.2	
Limonium axillare				19.5	25		
Zygophyllum album				24.4	25		
Crotalaria aegyptiaca				7.3		6.5	
Heliotropium bacciferum				2.4		6.5	
Reseda pruinosa				2.4		3.2	
Balanites aegyptiaca				2.4			63.2
Cleome droserifolia					25	12.9	
Phoenix dactylifera					12.5	16.1	
Species present in one group							
Echium horridum	5.6						
Glinus lotoides	5.6						
Oxystelma esculentum	5.6						
Caroxylon villosum	5.6						
Stipagrostis plumosa	5.6						
Tribulus megistopterus	11.1						
Chenopodium album		5.6					
Filago desertorum		5.6					
Launaea capitata			14.3				
L. amal-aminae			28.6				
Aeluropus littoralis				7.3			
Arthrocnemum macrostachyum				14.6			
Avicennia marina				9.8			
Capparis spinosa				2.4			
Cornulaca monacantha				7.3			
Senna holosericea				4.9			
Chenopodium murale					12.5		

(continued)

Table 4.11 (continued)

Vegetation groups	A	B1	B2	C1	C2	D1	D2
Cyperus rotundus					12.5		
Hyphaene thebaica					12.5		
Juncus rigidus					12.5		
Leptochloa fusca					12.5		
Sonchus oleraceus					12.5		
Acacia nilotica						3.2	
Atriplex leucoclada						3.2	
Chrozophora oblongifolia						3.2	
Dichanthium annulatum						3.2	
Fagonia bruguieri						3.2	
Imperata cylindrica						6.5	
Iphiona mucronata						6.5	
Moringa peregrina						3.2	
Oligomeris linifolia						3.2	
Taverniera aegyptiaca						3.2	
Typha domingensis						3.2	
Ziziphus spina-christi						12.9	
Capparis decidua							5.3
Salvadora persica							21.1

(i.e. highest presence percentages). Notably, none of the recorded species occurred in all the identified groups. Apart from coarse sand, clay, and bicarbonates, the other 13 (out of total of 16) measured soil variables showed significant differences ($p < 0.05$, 0.01) between the vegetation groups (Table 4.12).

Group (A): *Zilla spinosa–Morettia philaeana* Group

The 18 stands of this group (41 species) were mostly located along Edfu–Marsa Alam transect (T2), with soil rich in its organic matter (OM) content and highest pH but had the lowest contents of fine sand, water content, Mg^{+2}, and Cl^{-}. Co-dominant species included *Caroxylon imbricatum*, *Fagonia thebaica*, *Schouwia purpurea*, and *Tetraena simplex*. Consistent species to this group were *Echium horridum*, *Glinus lotoides*, *Oxystelma esculentum*, *Caroxylon villosum*, *Stipagrostis plumosa*, and *Tribulus megistopterus*.

Group (B1): *Zilla spinosa–Citrullus colocynthis–Morettia philaeana* Group

The 18 stands of this group (26 species) were located along Wadi Natash, W. Kharit, and El-Sheikh El-Shazly-Marsa Alam road (T3). Soil contents of gravels, fine sand, OM, and pH were higher than the total means. The lowest contents were recorded in Na^{+2} and HCO_3^{-}.

Besides the dominants, *Acacia tortilis* subsp. and *Senna italica* were the co-dominants. Some species were confined to this group such as *Chenopodium album* and *Filago desertorum.*

Group (B2): *Zilla spinosa* Group

Table 4.12 Mean values, standard deviations (±SD), and ANOVA values of the soil variables in the vegetation groups (A–D2) of the study area

Soil factors	Total means	Vegetation groups							F-value
		A	B1	B2	C1	C2	D1	D2	
Gravel	11.27 ± 10.62	13.03 ± 10.4	12.03 ± 8.3	6.91 ± 3.6	9.56 ± 10.1	7.44 ± 14.1	16.22 ± 11.7	7.76 ± 9.9	2.223*
CS	20.97 ± 16.5	15.37 ± 10.6	21.67 ± 12	20.49 ± 9.3	25.44 ± 21.9	8.53 ± 7.6	24.06 ± 15	16.36 ± 14.6	2.145
FS	9.31 ± 6.19	5.59 ± 2.9	11.40 ± 7.9	12.83 ± 4.9	9.70 ± 6.4	7.58 ± 6.3	8.39 ± 5.4	10.99 ± 6.3	2.421**
Silk	35.52 ± 16.51	39.59 ± 13.7	34.16 ± 13	44.85 ± 9.0	33.44 ± 17.6	48.35 ± 14.8	26.38 ± 13	43.52 ± 19.2	4.36**
Clay	22.91 ± 18.13	26.43 ± 13.7	20.74 ± 20	14.93 ± 6.1	21.86 ± 19.3	28.10 ± 14.6	24.95 ± 23.7	21.37 ± 9.7	0.592
TSS	0.39 ± 1.07	0.10 ± 0.04	0.07 ± 0.02	0.07 ± 0.02	0.52 ± 0.7	2.81 ± 3.4	0.19 ± 0.3	0.12 ± 0.2	11.296**
WC	2.61 ± 4.40	1.20 ± 1.1	1.51 ± 1.2	1.27 ± 0.8	5.16 ± 6.1	5.33 ± 8.7	1.58 ± 2.1	0.53 ± 1.1	5.186**
OM	1.09 ± 0.1	1.13 ± 0.1	1.12 ± 0.04	1.01 ± 0.1	1.08 ± 0.1	1.12 ± 0.03	1.11 ± 0.1	1.03 ± 0.1	3.639**
pH	7.80 ± 0.5	8.02 ± 0.3	7.97 ± 0.7	7.67 ± 0.8	7.7 ± 0.4	7.20 ± 0.5	7.77 ± 0.4	7.86 ± 0.2	3.599**
EC	1.22 ± 3.3	0.32 ± 0.1	0.22 ± 0.05	0.21 ± 0.05	1.62 ± 2.3	8.78 ± 10.8	0.60 ± 1.00	0.39 ± 0.5	11.296**
Na^+	0.83 ± 2.3	0.11 ± 0.1	0.05 ± 0.02	0.05 ± 0.02	1.29 ± 1.7	5.68 ± 7.3	0.31 ± 0.7	0.25 ± 0.5	10.916**
K^+	0.08 ± 0.1	0.04 ± 0.01	0.03 ± 0.01	0.02 ± 0.00	0.11 ± 0.1	0.21 ± 0.3	0.05 ± 0.03	0.11 ± 0.2	3.606**
Ca^{+2}	0.63 ± 1.5	0.31 ± 0.3	0.16 ± 0.04	0.15 ± 0.05	0.83 ± 0.9	3.80 ± 5.0	0.38 ± 0.7	0.17 ± 0.1	9.575**
Mg^{+2}	0.26 ± 0.5	0.08 ± 0.03	0.10 ± 0.04	0.14 ± 0.05	0.43 ± 0.7	1.04 ± 1.4	0.16 ± 0.2	0.05 ± 0.03	5.53**
Cl^-	1.41 ± 6.0	0.09 ± 0.1	0.10 ± 0.03	0.10 ± 0.03	1.51 ± 4.1	15.0 ± 20	0.33 ± 0.8	0.15 ± 0.2	10.51**
HCO_3^-	0.18 ± 0.1	0.18 ± 0.05	0.16 ± 0.05	0.16 ± 0.1	0.18 ± 0.1	0.20 ± 0.1	0.17 ± 0.05	0.18 ± 0.04	0.64
SO_4^{-2}	5.47 ± 7.4	1.36 ± 1.2	1.44 ± 1.7	0.67 ± 1.0	10.27 ± 8.3	15.11 ± 10.1	4.29 ± 6.6	2.46 ± 2.7	12.009**

EC electrical conductivity ($mS.cm^{-1}$), soil fractions (%), *CS* coarse sand, *FS* fine sand, *OM* organic matter, Na+, K+, Ca^{+2}, Mg^{+2}, Cl^-, and HCO_3^- ($mg.g^{-1}$ d.wt. soil), SO_4^{-2} ($\mu g.g^{-1}$ d.wt. soil), OM (%)
$*p < 0.05$; $**p < 0.01$

This group (7 stands, 30 species) was characterized by the dominance of *Zilla spinosa* (*P* = 100%), distributed along Aswan–Kharit–Gimal transect (T3). Most of the examined soil variables (gravels, clay, EC, OM, Na^+, K^+, Ca^{+2}, HCO_3^-, and SO_4^{-2}) attained their lowest levels in the stands of this group. However, fine sand content was the highest among the others. Among the important co-dominant species, *Astragalus vogelii*, *Cotula cinerea*, and *Launaea nudicaulis* were included. Consistent species to this group were *Launaea capitata* and *L. cassiniana*.

Group (C1): *Zygophyllum album–Tamarix nilotica* Group

Most stands of this group (41 stands, 32 species) were located along the Red Sea coast transect (T4) between Marsa Alam and Quseir and occurred on saline soil with soluble anion and cation contents higher than the groups (A, B1, B2, D1, and D2). The dominant species of this group, together with the co-dominants *Nitraria retusa* and *Limonium axillare*, exhibited the saline nature of this group. Certain species showed consistency to this group such as *Aeluropus littoralis*, *Arthrocnemum macrostachyum*, and *Avicennia marina*.

Group (C2): *Zygophyllum coccineum–Tamarix nilotica* Group

This group (8 stands) was the least diversified (19 species) among others. The stands of this group were mainly located in T4 (Quseir–Safaga transect) along the Red Sea coast which occurred on saline soil with the highest silt, clay, electric conductivity, water content, and all the examined ions. However, it recorded the lowest pH and coarse sand content. The co-dominant species included *Phragmites australis*, *Nitraria retusa*, *Limonium axillare*, and *Zygophyllum album*. Four weed species (*Chenopodium murale*, *Cyperus rotundus*, *Leptochloa fusca*, and *Sonchus oleraceus*) were recorded among the six confined species to this group.

Group (D1): *Zilla spinosa–Zygophyllum coccineum* Group

This group of stands (31) was the most diversified (53 species) among other groups and collected from three different transects (T1, T2, and T4) found on soil rich in gravels and poor in silt content. The other soil factors had intermediate position among the other groups. The co-dominant species included *Caroxylon imbricatum*, *Lotus hebranicus*, and *Ochradenus baccatus*. Twelve species showed consistency to this group such as *Acacia nilotica*, *Moringa peregrina*, *Ziziphus spina-christi* (trees), *Atriplex leucoclada*, *Fagonia bruguieri* (shrubs), and *Dichanthium annulatum* and *Imperata cylindrica* (herbs) .

Group (D2): *Zilla spinosa–Acacia tortilis* subsp.*–Tamarix aphylla–Balanitesaegyptiaca* Group

This group (19 stands, 20 species) was characterized by the combination of the dominant species, mostly located in Wadi Gimal and its tributaries (T3) on a soil rich in fine sand, silt, pH, and K^+ and poor in Mg^{+2} and water contents. The co-dominants of this group had low presence values such as *Zygophyllum coccineum*, *Pulicaria undulata*, and *Calotropis procera*. Two species were confined to this group: *Capparis decidua* and *Salvadora persica*.

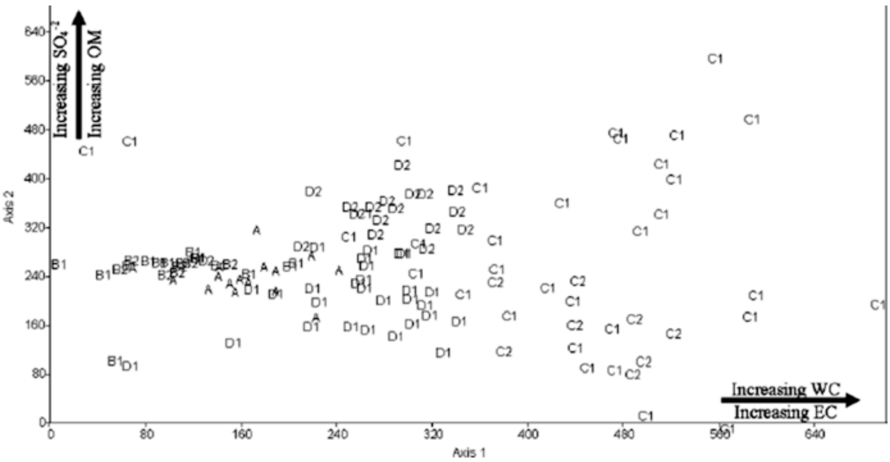

Fig. 4.18 The first two axes of the DCA ordination of 142 stands with the 7 vegetation groups (*A–D2*) separated by cluster analysis superimposed

4.2.3.5 Ordination of the Vegetation

Analysis of 142 stands along axes 1 and 2 (eigenvalues 0.707 and 0. 497, respectively) by DCA confirms the classification results, where the seven vegetation groups were also segregated (Fig. 4.18). Linear response models were dropped because gradients along the first two axes were longer than 4 SD units (Jongman et al. 1987). The length of gradient represented by axis 1 was >9 SD, indicating a complete turnover in species composition along this gradient. Therefore, DCA was the appropriate ordination method or indirect gradient analysis to be used.

The four DCA axes explained 5.3%, 3.7%, 2.8%, and 2.6% of the total variation in the species data, respectively. This low percentage of variance explained by the axes was attributed to the many zero values in the vegetation data set. It can be observed that the eigenvalue for the first DCA axis was high, indicating that it captured the greater proportion of the variation in species composition among stands. It is clear that group C1 occupied the positive end of the first DCA axis, while groups B1 and B2 occupied the negative end. This arrangement may explain a gradient of increasing soil salinity and moisture content, where stands of group C1 were located along the Red Sea coast transect, while B1 and B2 in the inland desert of Wadi Gimal–Aswan–Wadi Kharit transect. The first DCA axis (Table 4.13) was positively correlated with electrical conductivity ($r = 0.297$), sodium ($r = 0.342$), potassium ($r = 0.307$), calcium ($r = 0.296$), magnesium ($r = 0.318$), chlorides ($r = 0.217$), moisture contents ($r = 0.418$), and sulphates ($r = 0.612$) and negatively with pH ($r = -0.167$) and gravels ($r = -0.249$). The second axis was positively correlated with sulphates ($r = 0.172$) and organic matter ($r = 0.218$) .

Table 4.13 Simple linear correlation coefficient (r) between the soil variables and DCA axes

Soil variables	DCA axis 1	DCA axis 2
pH	−0.167*	−0.15
EC	0.297**	0.116
Na^+	0.342**	0.146
K^+	0.307**	0.026
Ca^{+2}	0.296**	0.119
Mg^{+2}	0.318**	−0.015
Cl^-	0.217**	0.098
HCO_3^-	0.119	0.072
SO_4^{-2}	0.612**	0.172*
MC	0.418**	−0.058
OM	−0.024	0.218**
Gravels	−0.249**	0.022
CS	0.034	−0.111
FS	−0.013	0.081
Silt	0.073	0.009
Clay	0.053	0.052

For soil factor abbreviations and units, see Table 4.12
*$p < 0.05$; **$p < 0.01$

4.2.3.6 Comparison Between Northern and Southern Parts of the Eastern Desert

Table (4.14) displayed the floristic composition between two geographically distant (253 km) parts (northern and southern) of the Eastern Desert. Whereas the southern part was represented by the four transects included in this study, the northern part (c. 28,800 km^2; 30° 05′ – 28° 21′ N and 31° 20′ – 33° 50′ E) included three transects, Cairo–Suez (T1N; 112 species), Korimat–Zafarana (T2N; 111 species), and Sheikh Fadl–Ras Gharib (T3 N; 54 species) mainly in the limestone part of this desert (Abdel-Aleem 2013). Altogether, 60 species were in common, 103 species confined to the northern part, and 34 to the southern part (Table 4.14).

Four trees, *Acacia tortilis* subsp. *raddiana*, *Tamarix aphylla*, *T. nilotica*, and *Calotropis procera*, exhibited a wide range of distribution where they were recorded in both parts. While nine tree species were confined to the southern part and do not penetrate northwards (e.g. *Avicennia marina*, *Hyphaene thebaica*, *Balanites aegyptiaca*, *Moringa peregrina*), the northern part was devoid of any characteristic tree species. Twenty-eight shrubby species were recorded in both areas and included among others *Zilla spinosa*, *Zygophyllum coccineum*, *Caroxylon imbricatum*, *Suaeda monoica*, *Zygophyllum album*, and *Pulicaria incisa*. Whereas 33 species were confined to the northern part, 9 species characterized the southern part. Perennial herbs were represented by 19 species, of which 6 were in common (e.g. *Phragmites australis*, *Citrullus colocynthis*, *Stipagrostis plumosa*), 7 species showed consistency to the northern part (e.g. *Lavandula stricta*, *Lasiurus scindicus*, *Aeluropus lagopoides*), and 6 species to the southern part (e.g. *Juncus rigidus*,

Table 4.14 Floristic diversity between the northern and southern parts of the Eastern Desert

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Trees							
Species present in both parts							
Acacia raddiana (Savi) Brenan	35	18.2	16.7	0	46.4	65.2	17.4
Tamarix aphylla (L.) H Karst.	0	0	16.7	0	10.7	26.1	17.4
Tamarix nilotica (Ehrenb.) Bunge	40	59.1	30	18.2	0	4.3	30.4
Calotropis procera (Aiton) W. T. Aiton	30	0	0	4.5	7.1	6.5	0
Species present in the southern part							
Phoenix dactylifera L.	0	0	0	22.7	0	0	2.2
Avicennia marina (Forssk.) Vierh.	0	0	0	0	0	0	8.7
Hyphaene thebaica (L.) Mart.	0	0	0	0	0	0	2.2
Balanites aegyptiaca (L.) Delile	0	0	0	0	0	28.3	0
Capparis decidua (Forssk.) Edgew.	0	0	0	0	0	2.2	0
Ziziphus spina-christi (L.) Willd.	0	0	0	18.2	0	0	0
Acacia nilotica (L.) Delile	0	0	0	4.5	0	0	0
Ricinus communis L.	0	0	0	9.1	0	0	0
Moringa peregrina (Forssk.) Fiori	0	0	0	4.5	0	0	0
Shrubs							
Species present in both parts							
Zilla spinosa (L.) Prantl.	95	81.8	83.3	81.8	96.4	73.9	15.2
Zygophyllum coccineum L.	85	63.6	83.3	59.1	3.6	8.7	30.4
Salsola imbricata Forssk.	0	22.7	40	45.5	67.9	2.2	2.2
Aerva javanica (Burm. F.) Juss. ex Schult.	10	0	10	18.2	25	8.7	4.3
Lotus hebranicus Brand	0	0	6.7	13.6	14.3	17.4	13
Leptadenia pyrotechnica (Forssk.) Decne.	0	0	10	18.2	7.1	6.5	2.2
Pulicaria undulata (L.) C. A. Mey	50	77.3	40	0	39.3	10.9	2.2
Panicum turgidum Forssk.	55	22.7	0	0	3.6	15.2	8.7
Suaeda monoica Forssk. ex J. F. Gmel.	0	13.6	0	0	7.1	2.2	6.5
Ochradenus baccatus Delile	55	59.1	56.7	18.2	0	2.2	6.5
Cleome droserifolia (Forssk.) Delile	0	0	3.3	4.5	0	4.3	6.5
Fagonia indica Burm.	20	22.7	10	0	0	6.5	2.2
Heliotropium bacciferum Forssk.	30	4.5	6.7	0	7.1	0	2.2
Zygophyllum album L.	0	9.1	0	0	0	0	26.1
Nitraria retusa (Forssk.) Asch.	0	4.5	0	0	0	0	26.1
Capparis spinosa L.	0	4.5	0	0	0	0	2.2
Taverniera aegyptiaca Boiss.	0	9.1	0	0	0	0	2.2
Crotalaria aegyptiaca Benth.	20	0	0	0	0	0	10.9
Cornulaca monacantha Delile	5	0	0	0	0	0	6.5
Pergularia tomentosa L.	25	40.9	6.7	13.6	10.7	2.2	0
Senna italica Mill.	15	0	0	0	3.6	17.4	0
Pulicaria incisa (Lam.) DC.	10	18.2	0	27.3	0	4.3	0
Fagonia arabica L.	10	4.5	0	0	0	2.2	0

(continued)

Table 4.14 (continued)

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Iphiona mucronata (Forssk.) Asch. & Schweinf.	20	31.8	0	0	7.1	0	0
Artemisia judaica L.	5	9.1	10	9.1	0	0	0
Fagonia mollis Delile	25	50	13.3	9.1	0	0	0
Fagonia bruguieri DC.	30	36.4	43.3	4.5	0	0	0
Atriplex leucoclada Boiss.	0	0	6.7	4.5	0	0	0
Chrozophora oblongifolia (Delile) Spreng.	10	0	0	4.5	0	0	0
Species present in the northern part							
Atriplex halimus L.	15	40.9	36.7	0	0	0	0
Anabasis setifera Moq.	40	31.8	33.3	0	0	0	0
Farsetia aegyptia Turra	60	50	13.3	0	0	0	0
Haloxylon salicornicum (Moq.) Bung ex Boiss.	65	59.1	56.7	0	0	0	0
Launaea spinosa (Forssk.) Sch. Bip.	10	18.2	3.3	0	0	0	0
Retama raetam (Forssk.) Webb & Berthel.	45	27.3	13.3	0	0	0	0
Hyoscyamus muticus L.	50	22.7	3.3	0	0	0	0
Astragalus trigonus DC.	0	9.1	3.3	0	0	0	0
Calligonum polygonoides L.	0	9.1	26.7	0	0	0	0
Deverra tortuosa (Desf.) DC.	35	0	3.3	0	0	0	0
Hyoscyamus boveanus(Dunal) Asch. & Schweinf.	0	0	3.3	0	0	0	0
Achillea fragrantissima (Forssk.) Sch. Bip.	5	13.6	0	0	0	0	0
Anabasis articulata (Forssk.) Moq.	40	9.1	0	0	0	0	0
Cynanchum acutum L.	15	9.1	0	0	0	0	0
Ephedra alata Decne.	10	9.1	0	0	0	0	0
Fagonia tristis Sickenb.	20	4.5	0	0	0	0	0
Gymnocarpos decanter Forssk.	5	9.1	0	0	0	0	0
Haplophyllum tuberculatum (Forssk.) A. Juss.	10	9.1	0	0	0	0	0
Lycium shawii Roem. et Sch.	10	18.2	0	0	0	0	0
Nauplius graveolens (Forssk.) Wiklund	10	31.8	0	0	0	0	0
Agathophora alopecuroides (Delile) Fenzl ex Bunge	0	13.6	0	0	0	0	0
Astragalus sieberi DC.	0	9.1	0	0	0	0	0
Cullen plicatum (Delile) C. H Stirt.	0	4.5	0	0	0	0	0
Helianthemum kahiricum Delile	0	4.5	0	0	0	0	0
Reaumuria hirtella Jaub. et Sp.	0	31.8	0	0	0	0	0
Ephedra aphylla Forssk.	10	0	0	0	0	0	0
Artemisia monosperma Del.	20	0	0	0	0	0	0
Convolvulus lanatus Vahl	5	0	0	0	0	0	0
Helianthemum lipii (L.) Dum.-Cours.	5	0	0	0	0	0	0
Kickxia aegyptiaca (Dum.) Nabelek	45	0	0	0	0	0	0

(continued)

Table 4.14 (continued)

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Phagnalon barbeyanum Asch. & Schweinf.	5	0	0	0	0	0	0
Pluchea dioscoridis (L.) DC.	15	0	0	0	0	0	0
Zygophyllum decumbens Del.	10	0	0	0	0	0	0
Species present in the southern part							
Convolvulus hystrix Vahl	0	0	0	0	0	2.2	8.7
Fagonia thebaica Boiss.	0	0	0	18.2	46.4	0	2.2
Limonium axillare (Forssk.) Kuntze	0	0	0	0	0	0	21.7
Arthrocnemum macrostachyum (Moric.) K. Koch	0	0	0	0	0	0	13
Farsetia stylosa R. Br.	0	0	0	0	10.7	17.4	0
Oxystelma esculentum (L.F.) R. Br.	0	0	0	0	0	2.2	0
Salvadora persica L.	0	0	0	0	0	8.7	0
Senna holosericea (Freseu) Greuter	0	0	0	0	0	4.3	0
Salsola villosa Schult.	0	0	0	4.5	0	0	0
Perennial herbs							
Species present in both parts							
Phragmites australis (Cav.) Trin. ex Steud.	10	13.6	3.3	18.2	3.6	0	13
Cynodon dactylon (L.) Pers.	10	0	0	13.6	0	0	4.3
Leptochloa fusca (L.) Kunth	0	9.1	0	0	0	0	2.2
Citrullus colocynthis (L.) Schrad.	5	27.3	16.7	22.7	35.7	32.6	0
Stipagrostis plumosa (L.) Munro ex T. Anderson	0	4.5	3.3	4.5	0	0	0
Imperata cylindrica (L.) Raeusch	0	13.6	0	9.1	0	0	0
Species present in the northern part							
Lavandula stricta Del.	5	4.5	0	0	0	0	0
Erodium glaucophyllum (L.) L'Hér.	20	4.5	0	0	0	0	0
Erodium oxyrrhynchum M. Bieb.	10	18.2	0	0	0	0	0
Lasiurus scindicus Henrad	5	18.2	0	0	0	0	0
Launaea mucronata (Forssk.) Muschl.	40	31.8	0	0	0	0	0
Aeluropus lagopoides (L.) Trin. ex Thwaites	0	4.5	0	0	0	0	0
Pennisetum divisum (Forssk. ex J. F. Gmel.) Henrard	10	0	0	0	0	0	0
Species present in the southern part							
Monsonia heliotropioides (Cav.) Boiss.	0	0	0	0	3.6	10.9	2.2
Aeluropus littoralis (Gouan) Parl.	0	0	0	0	0	0	6.5
Juncus rigidus C. A. Mey.	0	0	0	0	0	0	2.2
Cyperus rotundus L.	0	0	0	0	0	0	2.2
Polygonum equisetiforme Sm.	0	0	0	4.5	0	0	0
Dichanthium annulatum (Forssk.) Stapf	0	0	0	4.5	0	0	0
Typha domingensis (Pers.) Poir. ex Steud.	0	0	0	4.5	0	0	0

(continued)

Table 4.14 (continued)

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Annual herbs							
Species present in both parts							
Zygophyllum simplex L.	60	18.2	30	9.1	28.6	8.7	2.2
Astragalus vogelii (Webb) Bornm.	0	9.1	10	9.1	21.4	13	6.5
Launaea nudicaulis (L.) Hook.	25	59.1	6.7	0	0	13	8.7
Reseda pruinosa Del.	5	4.5	10	0	0	2.2	2.2
Malva parviflora L.	15	0	0	0	0	2.2	10.9
Sonchus oleraceus L.	15	45.5	0	0	0	0	2.2
Chenopodium murale L.	10	0	0	0	0	0	2.2
Cotula cinerea Delile	10	31.8	13.3	9.1	3.6	19.6	0
Forsskaolea tenacissima L.	10	4.5	10	18.2	3.6	6.5	0
Trichodesma africanum (L.) R. Br.	25	40.9	20	22.7	25	4.3	0
Eremobium aegyptiacum (Spreng.) Asch. & Schweinf. ex Boiss.	0	4.5	0	4.5	10.7	2.2	0
Cleome amblyocarpa Barratte & Murb.	25	22.7	6.7	0	3.6	10.9	0
Euphorbia granulata Forssk.	0	9.1	0	0	3.6	4.3	0
Asphodelus tenuifolius Cav.	20	0	0	0	7.1	15.2	0
Senecio glaucus L.	25	36.4	3.3	4.5	0	2.2	0
Polypogon monspeliensis (L.) Desf.	0	13.6	0	4.5	0	2.2	0
Tribulus megistopterus Kralik	0	4.5	0	4.5	0	2.2	0
Glinus lotoides L.	0	40.9	6.7	0	0	2.2	0
Polycarpaea robbairea (Kuntze) Greuter & Burdet	0	0	6.7	0	0	6.5	0
Hippocrepis constricta Knuze	0	4.5	0	0	0	6.5	0
Launaea capitata (Spreng.) Dandy	0	36.4	0	0	0	2.2	0
Cistanche phelypaea (L.) Cout.	15	31.8	6.7	4.5	3.6	0	0
Diplotaxis acris (Forssk.) Boiss.	10	4.5	0	8.3	0	0	0
Rumex vesicarius L.	30	22.7	0	4.5	0	0	0
Reichardia tingitana (L.) Roth	25	18.2	0	4.5	0	0	0
Filago desertorum Pomel	0	9.1	0	4.5	0	0	0
Chenopodium album L.	5	0	0	4.5	0	0	0
Species present in the northern part							
Anastatica hierochuntica L.	10	40.9	16.7	0	0	0	0
Bassia muricata (L.) Murr. var. brevispina Bornm.	30	18.2	3.3	0	0	0	0
Trigonella stellata Forssk.	35	54.5	3.3	0	0	0	0
Centaurea aegyptiaca L.	5	13.6	10	0	0	0	0
Euphorbia retusa Forssk.	35	22.7	13.3	0	0	0	0
Bassia indica (Wight) A.J. Scott	15	0	13.3	0	0	0	0
Lotus glinoides Delile	15	0	3.3	0	0	0	0
Lotononis platycarpa (Viv.) Pic. Serm.	0	0	3.3	0	0	0	0

(continued)

Table 4.14 (continued)

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Suaeda altissima (L.) Pall.	0	0	3.3	0	0	0	0
Althaea ludwigii L.	5	27.3	0	0	0	0	0
Anchusa hispida Forssk.	20	18.2	0	0	0	0	0
Diplotaxis harra (Forssk.) Boiss.	45	36.4	0	0	0	0	0
Centaurea calcitrapa L.	40	31.8	0	0	0	0	0
Astragalus bombycinus Boiss.	10	4.5	0	0	0	0	0
Conyza bonariensis (L.) Cronquist	5	4.5	0	0	0	0	0
Echinops spinosissimus Turra	70	22.7	0	0	0	0	0
Emex spinosus (L.) Campd.	5	4.5	0	0	0	0	0
Erodium malacoides (L.) L'Hér.	5	9.1	0	0	0	0	0
Matthiola livida (Del.) DC.	35	4.5	0	0	0	0	0
Paronychia arabica (L.) DC.	10	18.2	0	0	0	0	0
Plantago ovata Forssk.	5	27.3	0	0	0	0	0
Pteranthus dichotomus Forssk.	10	18.2	0	0	0	0	0
Convolvulus pilosellifolius Desr.	0	4.5	0	0	0	0	0
Astragalus hamosus L.	0	4.5	0	0	0	0	0
Astragalus schimperi Boiss.	0	4.5	0	0	0	0	0
Atractylis mernephtae Asch.	0	9.1	0	0	0	0	0
Avena sterilis L.	0	4.5	0	0	0	0	0
Cannabis sativa L.	0	4.5	0	0	0	0	0
Caylusea hexagyna (Forssk.) M.L. Green	0	4.5	0	0	0	0	0
Crypsis aculeata (L.) Aiton	0	4.5	0	0	0	0	0
Glossostemon bruguieri Desf.	0	4.5	0	0	0	0	0
Herniaria hemistemon J. Gay	0	4.5	0	0	0	0	0
Ifloga spicata (Forssk.) Sch.-Bip.	0	22.7	0	0	0	0	0
Lappula spinocarpos (Forssk.) Asch. ex Kuntze	0	13.6	0	0	0	0	0
Medicago laciniata (L.) Mill.	0	27.3	0	0	0	0	0
Phalaris paradoxa L.	0	4.5	0	0	0	0	0
Plantago amplexicaulis Cav.	0	9.1	0	0	0	0	0
Plantago ciliata Desf.	0	22.7	0	0	0	0	0
Spergularia marina (L.) Griseb.	0	13.6	0	0	0	0	0
Volutaria lippii (L.) Cass. ex Maire	0	18.2	0	0	0	0	0
Gypsophila capillaris (Forssk.) C.Chr.	10	0	0	0	0	0	0
Lolium perenne L.	5	0	0	0	0	0	0
Atractylis carduus (Forssk.) Christens	10	0	0	0	0	0	0
Fagonia glutinosa Delile	10	0	0	0	0	0	0
Aizoon canariense L.	30	0	0	0	0	0	0
Amaranthus viridis L.	5	0	0	0	0	0	0
Anthemis melampodina Delile	20	0	0	0	0	0	0
Astragalus annularis Forssk.	15	0	0	0	0	0	0

(continued)

Table 4.14 (continued)

Species	North[a]			South			
	T1N	T2N	T3N	T1S	T2S	T3S	T4S
Avena fatua L.	5	0	0	0	0	0	0
Bromus madritensis L.	5	0	0	0	0	0	0
Cichorium pumilum Jacq.	5	0	0	0	0	0	0
Eruca sativa Miller	10	0	0	0	0	0	0
Lotus halophilus Boiss. & Spruner	10	0	0	0	0	0	0
Mesembryanthemum forsskalei Hochst.	15	0	0	0	0	0	0
Neurada procumbens L.	20	0	0	0	0	0	0
Plantago cylindrica Forssk.	15	0	0	0	0	0	0
Reseda arabica Boiss.	25	0	0	0	0	0	0
Reseda decursiva Forssk.	5	0	0	0	0	0	0
Savignya parviflora (Del.) webb	5	0	0	0	0	0	0
Tribulus terrestris L.	5	0	0	0	0	0	0
Species present in the southern part							
Polycarpaea repens (Forssk.) Asch. & Schweinf.	0	0	0	4.5	3.6	4.3	6.5
Arnebia hispidissima (Lehm.) DC.	0	0	0	4.5	0	0	4.3
Oligomeris linifolia (Hornem) J. F. Macbr.	0	0	0	0	0	0	2.2
Morettia philaeana (Delile) DC.	0	0	0	31.8	60.7	39.1	0
Schouwia purpurea (Forssk.) Schweinf.	0	0	0	9.1	35.7	8.7	0
Tribulus pentandrus Forssk.	0	0	0	0	14.3	10.9	0
Lactuca serriola L.	0	0	0	4.5	0	2.2	0
Solanum nigrum L.	0	0	0	4.5	0	2.2	0
Astragalus eremophilus Boiss.	0	0	0	0	0	30.4	0
Amaranthus graecizans L.	0	0	0	0	0	2.2	0
Lupinus digitatus Forssk.	0	0	0	0	0	6.5	0
Launaea cassiniana (Boiss.) Kuntze	0	0	0	0	0	4.3	0
Euphorbia prostrata Aiton.	0	0	0	4.5	0	0	0
Sisymbrium irio L.	0	0	0	4.5	0	0	0
Trigonella hamosa L.	0	0	0	4.5	0	0	0
Echium horridum Batt.	0	0	0	4.5	0	0	0

T1N Cairo–Suez transect, *T2N* Korimat–Zafarana transect, *T3N* Sheikh Fadl–Ras Gharib transect, *T1S* Qena–Safaga transect, *T2S* Edfu–Marsa Alam transect, *T3S* Aswan–Kharit–Gimal transect, *T4S* Red Sea transect

[a]Data from Abdel-Aleem (2013)

Aeluropus littoralis) which inhabited wet and saline habitats. The annual herbs (96 species) constituted the major component of the floristic diversity and structure; 22 were in common, 64 species confined to the northern part, and 10 species confined to the southern part. The northern part included *Conyza bonariensis*, *Emex spinosa*, *Phalaris paradoxa*, *Lolium perenne*, *Cichorium endivia*, *Amaranthus viridis*, *Spergularia marina*, and *Avena fatua* which are among the common weeds of the Egyptian arable lands.

4.2.3.7 Soil–Vegetation Relationships Among the Four Transects

The inter-set correlations of CCA analysis for the soil variables, together with eigenvalues and species–environment correlation in the studied four transects, are demonstrated in Table (4.15). For T1, CCA axis 1 was highly positively correlated with silt and highly negatively correlated with pH. So, this axis can be interpreted as silt–pH gradient. CCA axis 2 was highly positively correlated with EC and highly negatively with OM. Thus, this axis can be interpreted as EC–OM gradient. CCA axis 1 for T2 was highly positively correlated with Na^+ and highly negatively correlated with silt, and this axis can be inferred as Na^+–silt gradient. CCA axis 2 for the same transect was correlated highly positively with Mg and highly negatively

Table 4.15 Inter-set correlation of CCA analysis for the soil variables, together with eigenvalues and species–environment correlation in the studied transects

Transect	Unit	T1		T2		T3		T4	
Axes		1	2	1	2	1	2	1	2
Eigenvalues		0.563	0.457	0.55	0.4	0.593	0.565	0.674	0.508
Species–environment correlations		0.986	0.988	0.948	0.98	0.963	0.942	0.957	0.927
Gravels	(%)	NI	NI	-0.233	0.239	0.727	0.246	−0.403	0.179
Coarse sand	(%)	−0.41	−0.37	0.32	0.02	0.26	−0.02	0.30	0.43
Fine sand	(%)	NI	NI	0.307	−0.08	−0.19	−0.07	0.28	−0.17
Silt	(%)	0.39	0.28	−0.35	−0.47	−0.49	−0.19	0.15	−0.24
Clay	(%)	−0.23	0.26	0.11	0.24	−0.3	0.04	−0.28	−0.25
WC	(%)	0.31	0.3	0.26	0.16	−0.01	−0.63	0.5	−0.01
OM	(%)	−0.37	−0.51	0.13	0.42	0.002	−0.1	−0.16	−0.35
pH		−0.76	0.04	0.09	0.03	0.16	0.003	−0.59	0.64
EC ($mS\ cm^{-1}$)		0.14	0.51	0.17	0.02	−0.12	0.22	0.35	−0.53
Na	($mg\ g^{-1}$ dry soil)	NI	NI	0.72	−0.27	−0.05	0.34	0.38	−0.51
K	($mg\ g^{-1}$ dry soil)	−0.06	0.441	0.49	0.04	−0.14	0.23	NI	NI
Ca	($mg\ g^{-1}$ dry soil)	NI	NI	−0.1	−0.05	−0.14	−0.07	NI	NI
Mg	($mg\ g^{-1}$ dry soil)	−0.53	−0.06	0.06	0.45	−0.19	−0.79	0.44	−0.32
Cl	($mg\ g^{-1}$ dry soil)	NI	NI	0.38	0.43	−0.12	0.17	0.31	−0.54
HCO_3	($mg\ g^{-1}$ dry soil)	−0.21	0.19	−0.23	−0.08	−0.04	0.02	−0.03	−0.14
SO_4 ($\mu g\ g^{-1}$ dry soil)		0.51	0.35	0.09	0.41	−0.34	0.37	0.56	−0.24
Species richness (SR)		−0.34	0.31	−0.25	−0.38	0.71	−0.49	−0.63	−0.16
Shannon index (H′)		−0.45	0.23	−0.21	−0.31	0.57	−0.56	−0.55	−0.17

NI not included due to high inflation factor

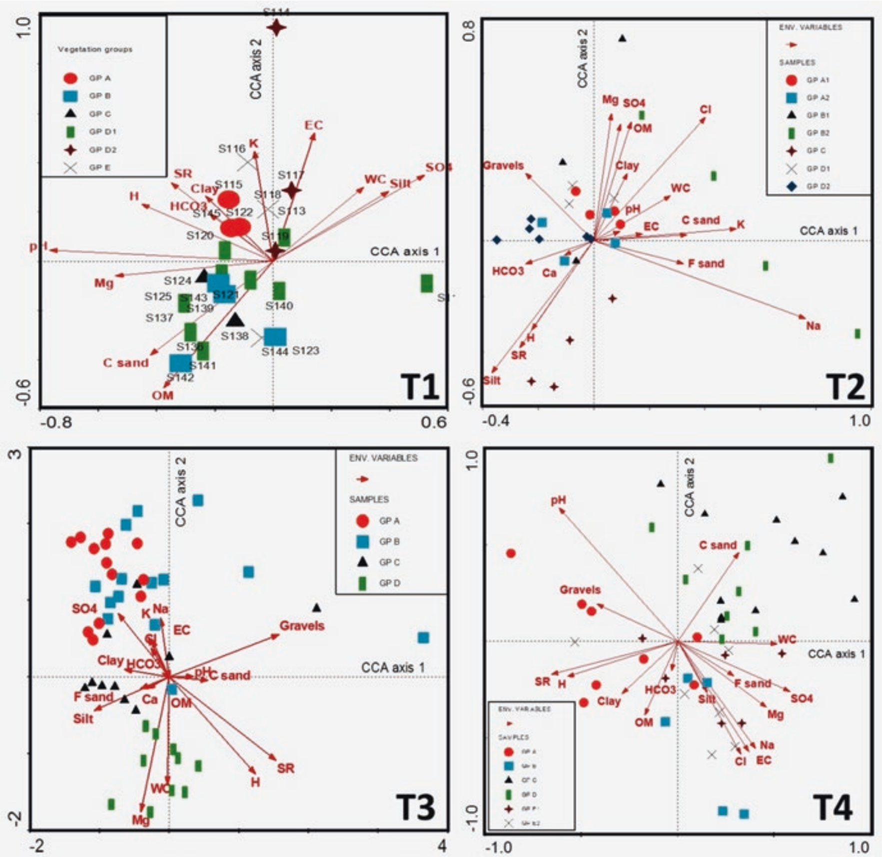

Fig. 4.19 CCA biplot of axes 1 and 2 showing the distribution of the studied stands of each transect, together with their vegetation groups and soil variables

with silt (Mg–silt gradient). CCA axis 1 for T3 can be interpreted as gravel–silt gradient, and CCA axis 2 can be interpreted as SO_4–Mg gradient. For Red Sea coast transect (T4), the inter-set correlations between the first two axes of CCA biplot revealed that SO_4^{-2}, pH, and Cl^- were the main operating factors for the vegetation of this transect.

The species–environment correlations were high for the first two axes, explaining 51.5%, 49.9%, 51.5%, and 46.7% of the cumulative variance for T1, T2, T3, and T4, respectively. These results suggested an association between the vegetation and the measured soil parameters presented in the biplot (Fig. 4.19). The species–environment correlations were high for the first two axes for all the studied transects (T1, 0.986 and 0.988; T2, 0.948 and 0.98; T3, 0.963 and 0.942; and T4, 0.957 and 0.927for axis 1 and 2, respectively) indicating that the species data were related to the measured environmental variables. A test for significance with an unrestricted Monte Carlo permutation test (499 permutation) for the eigenvalue of axis 1 was found to be significant ($P = 0.026$, 0.038, 0.004, and 0.002 for T1, T2, T3, and T4, respectively), indicating that the observed patterns did not arise by chance.

4.3 Concluding Remarks

1. The classification and ordination analyses proposed that the vegetation of the surveyed area can be divided into seven major vegetation groups (plant communities): (A) *Zilla spinosa–Morettia philaeana*, (B1) *Zilla spinosa–Citrullus colocynthis–Morettia philaeana*, (B2) *Zilla spinosa*, (C1) *Zygophyllum album–Tamarix nilotica*, (C2) *Zygophyllum coccineum–Tamarix nilotica*, (D1) *Zilla spinosa–Zygophyllum coccineum*, and (D2) *Zilla spinosa–Acacia tortilis* subsp. *raddiana–Tamarix aphylla–Balanites aegyptiaca*. The members of each pair of groups are, in some cases, linked together by having one of the dominant species in common. It can be noted that certain vegetation groups characterized one or more of the studied transects: group (A) in Edfu–Marsa Alam transect (T2); groups (B1), (B2), and (D2) in Aswan–Kharit–Gimal transect (T3); groups (C1) and (C2) in Quseir–Safaga transect along Red Sea coast (T4); and group (D1) widely distributed in the study area including T1, T2, and T4. It can be noted that the salt-tolerant plant *Tamarix nilotica* characterized vegetation group (C1) and (C2) forming hillocks of considerable sizes characterizing the Red Sea coast transect (T4) and vigorously growing southwards (Springuel et al. 1991) representing the natural climax community type of the desert wadis with deep deposits and an underground water reserve (Kassas and Zahran 1962). *Tamarix* has been identified as a major cause of salt accumulation on the soil surface (Springuel and Ali 1990) and concentrating a high amount of sodium chloride in specialized glands within its leaves (Bosabalidis 1992). In addition, there is a relationship between the amount of *Tamarix* litter and the electric conductivity of soil (Briggs et al. 1993). Meanwhile, the lower number of recorded species in vegetation group (C1) inhabiting the coastal plains of the Red Sea may be related to its high soil salinity. Such salinity stress on floristic diversity in the study area and related areas was reported by Moustafa and Klopatek (1995) and Shaltout et al. (1997). Most of the identified vegetation groups have very much in common with that recorded in some wadis of the Eastern Desert (Salama et al. 2012, 2013), the Western Desert (Bornkamm and Kehl 1990; Abd El-Ghani 2000), in south Sinai region (Moustafa and Zaghloul 1996), and in northwestern Negev, Israel (Tielbörger 1997).
2. In extreme deserts, as in the study area, the plant growth is triggered mainly by rain and thus is as scarce and unpredictable as the precipitation itself. Vegetation develops in "contracted mode" (Monod 1954), only in habitats receiving runoff water including wadis, depressions, and channels (contracted desert; Shmida 1985). This highly dynamic vegetation is neither permanent nor seasonal but is accidental (Kassas 1966; Bullard 1997; Bornkamm 2001). The vegetation structure in the study area is relatively simple, in which the species have to withstand

the harsh environmental conditions. This is can be reflected by the presence of several highly adapted, drought-resistant species. The floristic diversity of the study area included 94 species of the vascular plants (67 perennials and 27 annuals) indicating the predominance of perennials. Asteraceae, Fabaceae, Poaceae, Zygophyllaceae, and Chenopodiaceae were the species-rich families which formed the major component of the flora. The first three families represent the most common in the Mediterranean North African flora (Quézel 1978; White 1993). These findings were in line with those of Salama et al. (2012, 2013) in the Eastern Desert and Abd El-Ghani and Fahmy (1998) in south Sinai and Salama et al. (2005) along the western Mediterranean coast.

3. Chorological analysis revealed that the Saharo–Arabian element (37.2% monoregional, 28.7% biregional, and 11.7% as pluriregional floras) forms the major component of the floristic structure along the four transects. That is because the study area lies within the Saharo–Arabian region of the Holarctic Kingdom (White 1993). The results were in agreement with those of El-Demerdash et al. (1990), Fossati et al. (1998), and Salama et al. (2012) who concluded that plants of Saharo–Arabian region constituting the shrub layer are good indicators for desert environmental conditions, while Mediterranean taxa (as mono-, bi-, or pluriregional) flourish in more mesic conditions.
4. Comparing the results of floristic diversity in the study area (south of the Eastern Desert) with that in the northern part (Abdel-Aleem 2013) indicated that 60 species were in common, 103 confined to the northern part, while 34 species were consistent to the southern part. So, the floristic diversity in the northern part is three times higher than that of the southern part of the Eastern Desert, which may be attributed to the mild climatic conditions prevailing in the north. Also, increasing the aridity southwards plays a paramount role in reducing floral diversity. On the other hand, 60% of the northern vegetation (not present in the south) was represented as annual herbs. Decreased numbers of annuals in the southern part of the Eastern Desert can be attributed to the environmental aridity and thermal continentality which increases from north to south (Abd El-Ghani 1998).
5. Vast areas in the Egyptian deserts (Western, Eastern, and Sinai) were subjected to land reclamation due to increased population growth (Biswas 1993). In the study area, agricultural processes were practised in the deltaic parts of several wadis such as Wadi Kherit, W. Natash, and W. El-Sheikh. As the land reclamation processes entail an almost complete change of the environmental factors, several common weeds of the agroecosystem were recorded (e.g. *Cynodon dactylon*, *Malva parviflora*, *Dicanthium annulatum*, *Cyperus rotundus*, *Sonchus oleraceus*, and *Chenopodium murale*). Thus, weeds find the new conditions favourable for their growth. Close to the boundaries of the desert in this study, xerophytic species naturally grow among the weeds of the cultivation. This indicated that these species are native to the natural desert vegetation and can remain after the reclamation process. Therefore, the reclaimed lands found at the desert outskirts can be considered as transitional areas of the succession process between the old cultivated lands and that of the desert (Shaheen 2002; Abd El-Ghani et al. 2013b).

6. As for species abundance, *Zilla spinosa*, *Acacia tortilis* subsp. *raddiana*, *Morettia philaeana*, *Zygophyllum coccineum*, *Caroxylon imbricatum*, and *Citrullus colocynthis* (especially in Wadi Natash) had the highest Q-values (*P* = 0.61%, 0.36%, 0.3%, 0.23%, 0.22%, and 0.21%, respectively). This result was in line with that obtained by Abd El-Ghani et al. (2013a) and Salama et al. (2012) in the northern and central parts of the Eastern Desert and Springuel et al. (2006) in the southeastern part of this desert. *Acacia tortilis* subsp. *raddiana*, *Morettia philaeana*, and *Citrullus colocynthis* were completely absent in the Red Sea transect, while the presence of the salt-tolerant species such as *Tamarix nilotica*, *Limonium axillare*, *Arthrocnemum macrostachyum*, *Juncus rigidus*, and *Nitraria retusa* with high presence values in the Red Sea transect indicated its salinized habitat. The record of *Avicennia marina* dominating the mangal vegetation along the Red Sea coast (T4) is notable and was documentd by Zahran and Willis (2009).

4.3.1 Biogeographical Analysis of the Eastern Desert

Five hundred sites (full-detailed data can be requested from the first author) were located with GPS representing 34 sectors covering as much as possible the different landforms in the study area that were studied between 2009 and 2012. The occurrence of species was organized into five constancy (% occurrence of a certain species in its sites/total number of sites) classes: dominant (81–100%), very common (61–80%), common (41–60%), occasional (21–40%), and sporadic (1–20%).

4.3.1.1 Floristic Analysis

This study confirmed the record of 14 species, mostly weeds, which can be considered as new additions to the flora of the study area. Altogether, 328 species were recorded from various landforms through 34 sectors representing 206 genera in 55 families (Fig. 4.20; Table 4.16) . More than 50% (188 species) of the recorded species belong to 8 families (Table 4.17); these are the species-rich families: Asteraceae (41 species), Poaceae (27 species), Fabaceae (34 species), Chenopodiaceae (24 species), Brassicaceae and Zygophyllaceae (18 species for each), and Boraginaceae and Caryophyllaceae (13 species for each). These families represent the most common in the Mediterranean North African flora (Quézel 1978; Funk et al. 2009). Asteraceae (the largest family in our list) is not only the largest family in the flora of Egypt (Täckholm 1974; Shaltout et al. 1999; Boulos 2002) but also the largest and most widespread of the flowering plants in the world (Good 1974; Funk et al. 2009). It can also be noted that *Astragalus* (ten species), *Plantago* (nine species), *Fagonia* (eight species), *Erodium* (seven species), and *Atriplex*, *Cleome*, *Heliotropium*, and *Zygophyllum* (five species for each) were the largest genera. The highest numbers of species (72, 71, and 68) were recorded in sectors 1, 8, and 3, respectively, while the lowest numbers (10, 8) were in sectors 25 and 34, respectively.

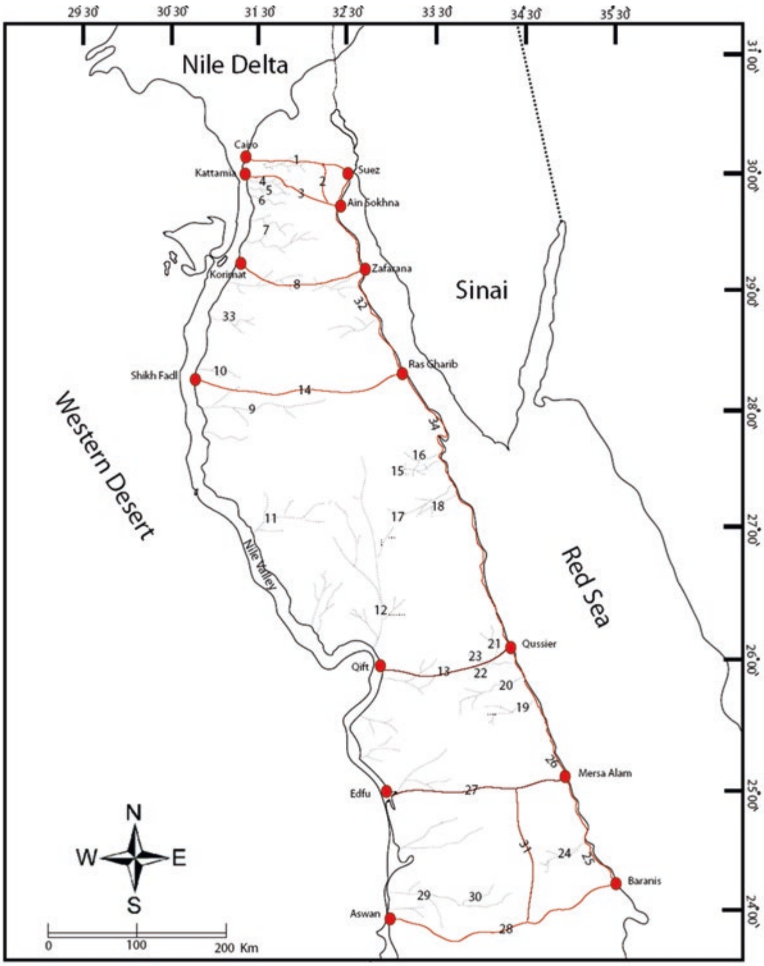

Fig. 4.20 Map of the Eastern Desert showing the location of the 34 studied sectors

Taking into account the Q-values of the recorded species, ten species showed dominancy with their Q-values ranged between 0.802 and 0.2 (Table 4.17). The highest among others were *Zilla spinosa* and *Zygophyllum coccineum* which recorded in more than 65% of the studied sites and spread their dominancy all over the Eastern Desert of Egypt. Their dominance over the communities of the Eastern Desert was documented by many scholars, among others Montasir (1938), Hassib (1951), Kassas and Imam (1954), Kassas and El Abyad (1962), Kassas and Girgis (1964), Salama and El-Naggar (1991), Abd El-Ghani (1998), and Galal and Fahmy (2012). In his account on the northern wadies of the Eastern Desert of Egypt, Fossati (1998) recorded *Zilla spinosa* and *Zygophyllum coccineum* on more than half of his reléves and indicated their wide range of distribution, often on fine calcareous neu-

Table 4.16 Characteristics of the 34 sectors, together with their names and the total number of studied sites

Symbol	Sector	Total number of sites
T1	Cairo–Suez road	20
T2	Wadi Hagul	10
T3	Kattamia–Ain Sokhna road	15
T4	Wadi Degla	20
T5	Wadi Hof	20
T6	Wadi Garawi	10
T7	El-Saff Desert	20
T8	Korimat–Zafarana road	22
T9	Wadi Tarfa	11
T10	Wadi El-Tahnawi	10
T11	Wadi Assiuty	12
T12	Wadi Qena	21
T13	Qift–Quseir road	32
T14	Ras Gharib–Sheikh Fadl road	30
T15	Wadi Abu Had	16
T16	Wadi Deb	9
T17	Wadi El-Qattar	16
T18	Wadi Beli	9
T19	Wadi Um Ghig	13
T20	Wadi Assal	12
T21	Wadi El-Nakhil	7
T22	Wadi Karim	6
T23	Wadi El-Hammaria	11
T24	Wadi El-Gemal	20
T25	Marsa Alam–Hammata road	11
T26	Marsa Alam–Quseir road	25
T27	Edfu-Marsa Alam road	26
T28	Aswan–Baranis road	7
T29	Wadi Kherit	6
T30	Wadi Natash	10
T31	El-Sheikh Salem road	6
T32	Suez–Ras Gharib road	15
T33	Wadi El-Sheikh	12
T34	Gharib–Quseir road	10

tral or alkaline substratum. The remaining eight dominant species (*Pulicaria undulata*, *Ochradenus baccatus*, *Zygophyllum simplex*, *Acacia tortilis*, *Trichodesma africanum*, *Morettia philaeana*, *Farsetia aegyptia*, and *Tamarix nilotica*) showed a regional dominancy over certain sectors. Fifty-six very common and common species with Q-values that ranged from 0.198 to 0.05 were identified and included *Haloxylon salicornicum*, *Launaea nudicaulis*, *Echinops spinosus*, *Fagonia mollis*, *Atriplex halimus*, *Euphorbia retusa*, and *Calotropis procera*. Occasional (rare) spe-

Table 4.17 Species composition of the study area arranged according to their Q-values, together with their floristic groups, status, life forms, and chorotypes

Chenopodiaceae	*Halocnemum strobilaceum* (Pall.) M.Bieb.	A1	0.002	Spo.	Ch.	Med., Sa–Si, Ir–Tu
Chenopodiaceae	*Halopeplis perfoliata* (Forssk.) Bunge ex Asch.	A1	0.002	Spo.	Ch.	Sa–Si
Cistaceae	*Helianthemum schweinfurthii* Grosser	A2	0.002	Spo.	Ch.	End.
Cleomaceae	*Cleome arabica* L.	A2	0.002	Spo.	H.	Sa–Si
Cleomaceae	*Cleome brachycarpa* DC.	D2	0.002	Spo.	Th.	Sa–Si
Convolvulaceae	*Convolvulus arvensis* L.	A2	0.002	Spo.	Geo.	Pal.
Cucurbitaceae	*Cucumis prophetarum* L.	D2	0.002	Spo.	H.	Sa–Si
Cyperaceae	*Cyperus alopecuroides* Rottb.	A2	0.002	Spo.	Hel.	Un
Cyperaceae	*Cyperus articulata* L.	A2	0.002	Spo.	H.	Pal.
Cyperaceae	*Cyperus conglomeratus* Rottb.	D2	0.002	Spo.	H.	Med., Sa–Si, Su–Za
Ephedraceae	*Ephedra ciliata* Fisch, ex C.A.Mey.	A2	0.002	Spo.	Ph.	Su–Za
Euphorbiaceae	*Chrozophora plicata* (Vahl) Spreng.	A2	0.002	Spo.	Ch.	Med., Sa–Si
Euphorbiaceae	*Euphorbia peplus* L.	A1	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si
Euphorbiaceae	*Ricinus communis* L.	A1	0.002	Spo.	Ph.	Pal.
Fabaceae	*Acacia saligna* (Labill.) Wendl.f.	B	0.002	Spo.	Ph.	Aus.
Fabaceae	*Cullen plicata* (Delile) C. H. Stirt.	A1	0.002	Spo.	H.	Sa–Si
Fabaceae	*Lotus creticus* L.	A2	0.002	Spo.	Ch.	Med.
Fabaceae	*Sesbania sesban* (L.) Merr.	A2	0.002	Spo.	Ph.	Su–Za
Fabaceae	*Tephrosia purpurea* (L.) Pers.	D2	0.002	Spo.	Ch.	Sa–Si
Frankeniaceae	*Frankenia hirsuta* L.	A1	0.002	Spo.	Ch.	Med., Eu–Si
Frankeniaceae	*Frankenia pulverulenta* L.	A1	0.002	Spo.	Th.	Med., Sa–Si, Ir–Tu
Geraniaceae	*Erodium cicutarium* (L.) L'Her.	A1	0.002	Spo.	Th.	Ir–Tu, Med.
Juncaceae	*Juncus acutus* L.	A2	0.002	Spo.	H.	Ir–Tu, Med.
Molluginaceae	*Glinus lotoides* L.	C1	0.002	Spo.	Th.	Ir–Tu, Med.
Moraceae	*Ficus palmata* Forsk.	A2	0.002	Spo.	Ph.	Sa–Si

(continued)

Table 4.17 (continued)

Orobanchaceae	*Orobanche ramosa* L.	B	0.002	Spo.	Pa.	Un
Oxalidaceae	*Oxalis corniculata* L.	A1	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago afra* L.	A1	0.002	Spo.	Th.	Med., Sa–Si, Ir–Tu
Plantaginaceae	*Plantago crypsoids* Boiss.	A2	0.002	Spo.	Th.	Near End.
Plantaginaceae	*Plantago exigua* Murray	D2	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago major* L.	A2	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si
Poaceae	*Cenchrus ciliaris* L.	A1	0.002	Spo.	H.	Su–Za, Ka–Na, Cape, Sa–Si
Poaceae	*Crypsis schoenoides* (L.) Lam.	A1	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si
Poaceae	*Dactyloctenium aegyptium* (L.) Willd.	A2	0.002	Spo.	Th.	Pal.
Poaceae	*Desmostachya bipinnata* (L.) Stapf.	A2	0.002	Spo.	Geo.	Sa–Si
Poaceae	*Dichanthium annulatus* (Forssk.) Stapf	A2	0.002	Spo.	H.	Pal.
Poaceae	*Echinochloa colona* (L.) Link.	C1	0.002	Spo.	Th.	Sa–Si, Ir–Tu
Poaceae	*Hordeum murinum* L.	A1	0.002	Spo.	Th.	Sa–Si, Ir–Tu
Chenopodiaceae	*Halocnemum strobilaceum* (Pall.) M.Bieb.	A1	0.002	Spo.	Ch.	Med., Sa–Si, Ir–Tu
Chenopodiaceae	*Halopeplis perfoliata* (Forssk.) Bunge ex Asch.	A1	0.002	Spo.	Ch.	Sa–Si
Cistaceae	*Helianthemum schweinfurthii* Grosser	A2	0.002	Spo.	Ch.	End.
Cleomaceae	*Cleome arabica* L.	A2	0.002	Spo.	H.	Sa–Si
Cleomaceae	*Cleome brachycarpa* DC.	D2	0.002	Spo.	Th.	Sa–Si
Convolvulaceae	*Convolvulus arvensis* L.	A2	0.002	Spo.	Geo.	Pal.
Cucurbitaceae	*Cucumis prophetarum* L.	D2	0.002	Spo.	H.	Sa–Si
Cyperaceae	*Cyperus alopecuroides* Rottb.	A2	0.002	Spo.	Hel.	Un
Cyperaceae	*Cyperus articulata* L.	A2	0.002	Spo.	H.	Pal.
Cyperaceae	*Cyperus conglomeratus* Rottb.	D2	0.002	Spo.	H.	Med., Sa–Si, Su–Za
Ephedraceae	*Ephedra ciliata* Fisch. ex C.A.Mey.	A2	0.002	Spo.	Ph.	Su–Za
Euphorbiaceae	*Chrozophora plicata* (Vahl) Spreng.	A2	0.002	Spo.	Ch.	Med., Sa–Si
Euphorbiaceae	*Euphorbia peplus* L.	A1	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si

Euphorbiaceae	*Ricinus communis* L.	A1	0.002	Spo.	Ph.	Pal.
Fabaceae	*Acacia saligna* (Labill.) Wendl.f.	B	0.002	Spo.	Ph.	Aus.
Fabaceae	*Cullen plicata* (Delile) C. H. Stirt.	A1	0.002	Spo.	H.	Sa–Si
Fabaceae	*Lotus creticus* L.	A2	0.002	Spo.	Ch.	Med.
Fabaceae	*Sesbania sesban* (L.) Merr.	A2	0.002	Spo.	Ph.	Su–Za
Fabaceae	*Tephrosia purpurea* (L.) Pers.	D2	0.002	Spo.	Ch.	Sa–Si
Frankeniaceae	*Frankenia hirsuta* L.	A1	0.002	Spo.	Ch.	Med., Eu–Si
Frankeniaceae	*Frankenia pulverulenta* L.	A1	0.002	Spo.	Th.	Med., Sa–Si, Ir–Tu
Geraniaceae	*Erodium cicutarium* (L.) L'Her.	A1	0.002	Spo.	Th.	Ir–Tu, Med.
Juncaceae	*Juncus acutus* L.	A2	0.002	Spo.	H.	Ir–Tu, Med.
Molluginaceae	*Glinus lotoides* L.	C1	0.002	Spo.	Th.	Ir–Tu, Med.
Moraceae	*Ficus palmata* Forsk.	A2	0.002	Spo.	Ph.	Sa–Si
Orobanchaceae	*Orobanche ramosa* L.	B	0.002	Spo.	Pa.	Un
Oxalidaceae	*Oxalis corniculata* L.	A1	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago afra* L.	A1	0.002	Spo.	Th.	Med., Sa–Si, Ir–Tu
Plantaginaceae	*Plantago crypsoids* Boiss.	A2	0.002	Spo.	Th.	Near End.
Plantaginaceae	*Plantago exigua* Murray	D2	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago major* L.	A2	0.002	Spo.	Th.	Med., Tr–Tu, Eu–Si
Poaceae	*Cenchrus ciliaris* L.	A1	0.002	Spo.	H.	Su–Za, Ka–Na, Cape, Sa–Si
Poaceae	*Crypsis schoenoides* (L.) Lam.	A1	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si
Poaceae	*Dactyloctenium aegyptium* (L.) Willd.	A2	0.002	Spo.	Th.	Pal.
Poaceae	*Desmostachya bipinnata* (L.) Stapf.	A2	0.002	Spo.	Geo.	Sa–Si
Poaceae	*Dichanthium annulatus* (Forssk.) Stapf	A2	0.002	Spo.	H.	Pal.
Poaceae	*Echinochloa colona* (L.) Link	C1	0.002	Spo.	Th.	Sa–Si, Ir–Tu
Poaceae	*Hordeum murinum* L.	A1	0.002	Spo.	Th.	Sa–Si, Ir–Tu
Poaceae	*Lolium rigidum* Gaudin	A1	0.002	Spo.	Th.	Ir–Tu, Med.

(continued)

Table 4.17 (continued)

Poaceae	*Pennisetum setaceum* (Forssk.) Chiov.	A1	0.002	Spo.	H.	Un
Poaceae	*Schismus barbatus* (L.) Thell.	A1	0.002	Spo.	Th.	Med., Ir–Tu, Eu–Si
Poaceae	*Stipa capensis* Thunb.	B	0.002	Spo.	Th.	Sa–Si, Ir–Tu
Polygonaceae	*Rumex cyprius* Murb.	A1	0.002	Spo.	Th.	Sa–Si
Polygonaceae	*Rumex dentatus* L.	A2	0.002	Spo.	Th.	Sa–Si
Polygonaceae	*Rumex simpliciflorus* Murb.	A1	0.002	Spo.	Th.	Sa–Si
Portulacaceae	*Portulaca oleracea* L.	C1	0.002	Spo.	Th.	Cosm.
Primulaceae	*Anagallis arvensis* L.	C1	0.002	Spo.	Th.	Cosm.
Resedaceae	*Reseda decursiva* Forssk.	A1	0.002	Spo.	Th.	Sa–Si
Scrophulariaceae	*Kickxia* acerbiana (Boiss.) Taeckh. & Boulos	D1	0.002	Spo.	Ch.	Sa–Si
Scrophulariaceae	*Lindenbergia indica* (L.) Vatke	C1	0.002	Spo.	Ch.	Sa–Si
Solanaceae	*Datura stramonium* L.	B	0.002	Spo.	Th.	Un
Solanaceae	*Hyoscyamus baveanus* L.	D2	0.002	Spo.	H.	End.
Solanaceae	*Hyoscyamus desertorum* (Aschers. ex Boiss.) Täckholm	A1	0.002	Spo.	H.	Med.
Solanaceae	*Withania somnifera* (L.) Dunal	B	0.002	Spo.	Ch.	Ir–Tu, Med.
Sterculiaceae	*Glossostemon bruguieri* Desf.	A1	0.002	Spo.	Th.	Ir–Tu
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	A1	0.002	Spo.	Th.	Sa–Si
Urticaceae	*Urtica urens* L.	B	0.002	Spo.	Th.	Med., Eu–Si
Zygophyllaceae	*Zygophyllum propinquum* Decne.	A2	0.002	Spo.	Ch.	Sa–Si
Amaranthaceae	*Amaranthus viridis* L.	A1,C1	0.004	Spo.	Th.	Cosm.
Asteraceae	*Asteriscus pygmaeus* (DC.) Coss. & Durieu	A2	0.004	Spo.	Th.	Sa–Si
Asteraceae	*Atractylis mernephthae* Asch.	A1	0.004	Spo.	Th.	Sa–Si
Asteraceae	*Filago desertorum* Pomel	A1	0.004	Spo.	Th.	Sa–Si, Ir–Tu
Asteraceae	*Iphiona scabra* DC.	D2	0.004	Spo.	Ch.	Sa–Si
Asteraceae	*Senecio flavus* (Decne.) Sch. Bip.	D2	0.004	Spo.	Th.	Sa–Si
Asteraceae	*Seriphidium herba-album* (Asso) Soják	A2	0.004	Spo.	Ch.	Sa–Si, Ir–Tu

Avicenniaceae	*Avicennia marina* (Forssk.) Vierh.	C2	0.004	Spo.	Hy.-Hel.	Sa-Si
Boraginaceae	*Arnebia hispidissima* (Lehm.) A. DC.	B	0.004	Spo.	Th.	Sa–Si
Boraginaceae	*Heliotropium ramosissimum* (Lehm.) Sieb. ex. A. DC.	A1	0.004	Spo.	Ch.	Sa–Si, Ir–Tu
Caryophyllaceae	*Sclerocephalus arabicus* Boiss.	D1	0.004	Spo.	Th.	Sa–Si
Chenopodiaceae	*Atriplex lindleyi* Moq.	A1	0.004	Spo.	Ch.	Med., Sa–Si
Chenopodiaceae	*Salsola villosa* Delile ex Schult.	C2	0.004	Spo.	Ch.	Sa–Si, Ir–Tu
Chenopodiaceae	*Suaeda monoica* Forssk. ex J. Gmelin	A1	0.004	Spo.	Ph.	Sa–Si, Su–Za
Convolvulaceae	*Convolvulus lanatus* Vahl	A1,A2	0.004	Spo.	Ch.	Sa–Si
Convolvulaceae	*Cressa cretica* L.	A1	0.004	Spo.	H.	Cosm.
Convolvulaceae	*Cuscuta pedicellata* Ledeb	A2	0.004	Spo.	Pa.	Sa–Si
Fabaceae	*Astragalus spinosus* (Forssk.) Muschl.	A2	0.004	Spo.	Ch.	Ir–Tu
Fabaceae	*Senna holosericea* (Freseu.) Greuter	C1	0.004	Spo.	H.	Af-Mo
Juncaceae	*Juncus rigidus* Desf.	A1,C1	0.004	Spo.	Hel.	Med., Sa–Si, Ir–Tu
Lamiaceae	*Lavandula pubescens* Decne.	A2	0.004	Spo.	H.	Med., Sa–Si
Plantaginaceae	*Plantago ciliata* Desf.	A1	0.004	Spo.	Th.	Sa–Si, Ir–Tu
Poaceae	*Aeluropus lagopoides* (L.) Trin. ex Thwaites	A1	0.004	Spo.	H.	Med., Ir–Tu, Eu–Si, Sa–Si
Poaceae	*Bromus madritensis* L.	A1,A2	0.004	Spo.	Th.	Med., Sa–Si, IrTu
Poaceae	*Leptochloa fusca* (L.) Kunth	A1,C1	0.004	Spo.	H.	Pal.
Poaceae	*Lolium perenne* L.	A1,B	0.004	Spo.	H.	Med., IrTu, EuSi
Polygonaceae	*Polygonum equisetiforme* Sm.	A1	0.004	Spo.	Ch.	Med., SaSi, IrTu
Solanaceae	*Solanum nigrum* L.	A2,C2	0.004	Spo.	Th.	Cosm.
Zygophyllaceae	*Peganum harmala* L.	A1	0.004	Spo.	H.	Med., IrTu, EuSi,SaSi
Zygophyllaceae	*Tribulus bimucronatus* Viv.	A2,D1	0.004	Spo.	Th.	SuZa
Zygophyllaceae	*Tribulus megistopterus* Kralik	A1,C1	0.004	Spo.	Th.	SaSi

(continued)

Table 4.17 (continued)

Arecaceae	*Phoenix dactylifera* L.	A2,C2,D1	0.006	Spo.	Ph.	SaSi
Asteraceae	*Atractylis carduus* (Forssk.) Christens.	A1,A2	0.006	Spo.	H.	SaSi
Boraginaceae	*Lappula spinocarpos* (Forssk.) Asch. ex Kuntze	A1	0.006	Spo.	Th.	SaSi, IrTu
Caryophyllaceae	*Herniaria hemistemon* J. Gay	A1,A2	0.006	Spo.	Th.	SaSi, IrTu
Chenopodiaceae	*Chenopodium album* L.	A1,A2	0.006	Spo.	Th.	Cosm.
Convolvulaceae	*Convolvulus pilosellifolius* Desr.	A1,B	0.006	Spo.	H.	SaSi, IrTu
Fabaceae	*Astragalus annularis* Forssk.	A1	0.006	Spo.	Th.	SaSi, Ir–Tu
Fabaceae	*Astragalus schimperi* Boiss.	A1,D2	0.006	Spo.	Th.	SaSi
Fabaceae	*Lotus glinoides* Delile	A1	0.006	Spo.	Th.	SaSi
Fabaceae	*Lotus halophilus* Boiss. & Spruner	A1,A2	0.006	Spo.	Th.	Med., SaSi, IrTu
Fabaceae	*Lupinus digitatus* Forssk.	C1	0.006	Spo.	Th.	Med.
Fabaceae	*Melilotus indica* (L.) All.	B	0.006	Spo.	Th.	Cosm.
Lamiaceae	*Salvia aegyptiaca* L.	A2,B	0.006	Spo.	Ch.	SaSi, IrTu
Menispermaceae	*Cocculus pendulus* (J.R. & G. Forst.) Diels	A2	0.006	Spo.	Ph.	SaSi
Orobanchaceae	*Cistanche tubulosa* (Schenk) Hook.f.	A1	0.006	Spo.	Pa.	SaSi, Ir–Tu
Poaceae	*Aeluropus littoralis* (Gouan) Parl.	C2	0.006	Spo.	H.	Sa–Si
Poaceae	*Avena sterilis* L.	A1,B	0.006	Spo.	Th.	Ir–Tu, Med.
Poaceae	*Phalaris paradoxa* L.	A1,B	0.006	Spo.	Th.	Ir–Tu, Med.
Polygonaceae	*Emex spinosa* (L.) Campd.	A1,A2	0.006	Spo.	Th.	Ir–Tu, Med.
Resedaceae	*Caylusea hexagyna* (Forssk.) M.L. Green	A1,A2	0.006	Spo.	Th.	Sa–Si
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	A2	0.006	Spo.	Ph.	Sa–Si
Solanaceae	*Hyoscyamus albus* L.	A1,D1	0.006	Spo.	H.	Med.
Typhaceae	*Typha domingensis* (Pers.) Poir. ex Steud.	A1,A2,B	0.006	Spo.	Hy.-Hel.	Pan.
Asteraceae	*Anthemis melampodina* Delile	A1	0.008	Spo.	Th.	Sa–Si, Ir–Tu
Asteraceae	*Centaurea scoparia* Sieber ex Spreng.	A1,C1	0.008	Spo.	Ch.	Sa–Si
Asteraceae	*Conyza bonariensis* (L.) Cronquist	A1	0.008	Spo.	Th.	Un

Asteraceae	*Echinops galalensis* Schweinf	A2	0.008	Spo.	H.	Near End.
Asteraceae	*Phagnalon barbeyanum* Asch. & Schweinf.	A1,A2	0.008	Spo.	Ch.	Sa–Si
Caryophyllaceae	*Cometes abyssinica* R. Br.	D2	0.008	Spo.	Ch.	Af-Mo
Caryophyllaceae	*Spergularia diandra* (Guss.) Boiss.	A1,A2	0.008	Spo.	Th.	Med., Sa–Si, Ir–Tu
Chenopodiaceae	*Chenopodium ficifolium* Sm.	A1,A2,B	0.008	Spo.	Th.	Un
Cistaceae	*Helianthemum kahiricum* Delile	A2	0.008	Spo.	Ch.	Sa–Si
Cistaceae	*Helianthemum lipii* (L.) Dum. Cours.	A1,A2,B	0.008	Spo.	Ch.	Sa–Si
Cleomaceae	*Cleome chrysantha* Decne.	C1,D1,D2	0.008	Spo.	H.	Sa–Si
Ephedraceae	*Ephedra aphylla* Forssk.	A1	0.008	Spo.	Ph.	Sa–Si
Fabaceae	*Astragalus sieberi* DC.	A1,D1	0.008	Spo.	Ch.	Sa–Si
Fabaceae	*Astragalus tribuloides* Delile	A1,A2	0.008	Spo.	Th.	Sa–Si, Ir–Tu
Fabaceae	*Astragalus trigonus* DC.	A1	0.008	Spo.	Ch.	Sa–Si
Fabaceae	*Hippocrepis constricta* Knuze	A1,C1	0.008	Spo.	Th.	Med.
Fabaceae	*Lotononis platycarpos* (Viv.) Pichi-Serm.	A1,C1,D1	0.008	Spo.	Th.	Su–Za
Geraniaceae	*Erodium malacoides* (L.) L'Hér.	A1	0.008	Spo.	Th.	Ir–Tu, Med.
Geraniaceae	*Erodium touchyanum* Delile	A1,B	0.008	Spo.	Th.	Sa–Si
Orobanchaceae	*Orobanche cernua* Loefl.	A2	0.008	Spo.	Pa.	Med., Sa–Si, Ir–Tu
Poaceae	*Avena fatua* L.	A1,B,C2	0.008	Spo.	Th.	Cosm.
Zygophyllaceae	*Fagonia scabra* Forssk.	A1,A2,B	0.008	Spo.	Chas.	Sa–Si
Zygophyllaceae	*Tribulus terrestris* L.	A1,B,C1	0.008	Spo.	Th.	Pan.
Asteraceae	*Artemisia monosperma* Delile	A1	0.01	Occ.	Ch.	Sa–Si
Brassicaceae	*Eruca sativa* Miller	A1,B,C1	0.01	Occ.	Th.	Sa–Si, Ir–Tu
Capparidaceae	*Capparis cartilaginea* Decne.	D1,D2	0.001	Occ.	Ph.	Sa–Si
Capparidaceae	*Capparis decidua* (Forssk.) Edgew.	D2	0.001	Occ.	Ph.	Su–Za
Euphorbiaceae	*Euphorbia granulata* Forssk.	A1,C1	0.01	Occ.	Th.	Sa–Si
Fabaceae	*Astragalus bombycinus* Boiss.	A1	0.01	Spo.	Th.	Sa–Si, Ir–Tu

(continued)

Table 4.17 (continued)

Geraniaceae	*Erodium arborescens* (Desf.) Willd.	A2	0.01	Occ.	H.	Sa–Si
Aizoaceae	*Aizoon canariense* L.	A1	0.012	Occ.	Th.	Su–Za
Asteraceae	*Pluchea dioscoridis* (L.) DC.	A1,A2	0.012	Occ.	Ph.	Sa–Si, Su–Za, Ka–Na
Fabaceae	*Acacia ehrenbergiana* Hayne	C1	0.012	Occ.	Ph.	Sa–Si
Fabaceae	*Medicago laciniata* (L.) Mill.	A1	0.012	Occ.	Th.	Sa–Si
Geraniaceae	*Monosonia nivea* (Decne.) Webb	B,C1,D1	0.012	Occ.	H.	Sa–Si
Orobanchaceae	*Orobanche crenata* Forssk.	A1,A2,B	0.012	Occ.	Pa.	Med., Sa–Si, Ir–Tu
Plantaginaceae	*Plantago amplexicaulis* Cav.	A1,D2	0.012	Occ.	Th.	Med., Sa–Si, Ir–Tu
Plantaginaceae	*Plantago cylindrica* Frossk.	A1,A2,C1,D1	0.012	Occ.	Th.	Sa–Si
Poaceae	*Imperata cylindrica* (L.) Raeusch.	A1,B,C1	0.012	Occ.	H.	Med., Sa–Si, Ir–Tu
Poaceae	*Stipagrostis ciliata* (Desf.) De Winter	A1,B,C1	0.012	Occ.	H.	Sa–Si, Ka–Na, Cape
Aizoaceae	*Mesembryanthemum forsskalei* Hochst.	A1	0.014	Occ.	Th.	Sa–Si
Brassicaceae	*Pseuderucaria clavata* (Boiss. & Reut.) O.E. Schulz	A1,A2	0.014	Occ.	Th.	Sa–Si
Caryophyllaceae	*Spergularia marina* (L.) Griseb.	A1,A2	0.014	Occ.	Th.	Med., Ir–Tu, Eu–Si
Chenopodiaceae	*Chenopodium murale* L.	A1,A2,B,C1	0.014	Occ.	Th.	Cosm.
Convolvulaceae	*Convolvulus hystrix* Vahl	A1,C1,C2,D1,D2	0.014	Occ.	Ch.	Sa–Si
Fabaceae	*Taverniera aegyptiaca* Boiss.	A1,D1,D2	0.014	Occ.	Ch.	Near End.
Lamiaceae	*Stachys aegyptiaca* Pers.	A2	0.014	Occ.	H.	Sa–Si
Resedaceae	*Reseda arabica* Boiss.	A1,A2	0.014	Occ.	Th.	Sa–Si
Rutaceae	*Haplophyllum tuberculatum* (Forssk.) Juss.	A1,A2,D2	0.014	Occ.	Ch.	Sa–Si
Scrophulariaceae	*Scrophularia deserti* Delile	A1,A2	0.014	Occ.	H.	Sa–Si
Caryophyllaceae	*Polycarpaea repens* (Forssk.) Asch & Schweinf.	A2,C1,C2	0.016	Occ.	Th.	Sa–Si
Caryophyllaceae	*Pteranthus dichotomus* Forssk.	A1,A2	0.016	Occ.	Th.	Sa–Si
Chenopodiaceae	*Atriplex dimorphostegia* Kar. & Kir.	A1,A2,C1	0.016	Occ.	Th.	Ir–Tu
Euphorbiaceae	*Chrozophora oblongifolia* (Delile) Spreng.	A1,D1	0.016	Occ.	Ch.	Med., Sa–Si
Malvaceae	*Althaea ludwigii* L.	A1	0.016	Occ.	Th.	Sa–Si
Plantaginaceae	*Plantago ovata* Forssk.	A1,A2	0.016	Occ.	Th.	Med., Sa–Si, Ir–Tu

Plumbaginaceae	*Limonium axillare* (Forssk.) Kuntze	C1,C2	0.016	Occ.	H.	Sa–Si
Chenopodiaceae	*Suaeda vermiculata* Forssk. ex J.F.Gmel.	A2	0.018	Occ.	Ch.	Sa–Si
Fabaceae	*Trifolium alexandrinum* L.	A1,A2,B	0.018	Occ.	Th.	Sa–Si
Geraniaceae	*Monsonia heliotropoides* (Cav.) Boiss.	C1,D2	0.018	Occ.	H.	Sa–Si
Poaceae	*Polypogon monspeliensis* (L.) Desf.	A1,C1,C2	0.018	Occ.	Th.	Cosm.
Acanthaceae	*Blepharis edulis* (Forssk.) Pers.	D1	0.02	Occ.	H.	Sa–Si
Chenopodiaceae	*Traganum nudatum* Delile	A1,A2	0.02	Occ.	Ch.	Sa–Si
Geraniaceae	*Erodium oxyrhynchum* M.Bieb.	A1,A2	0.02	Occ.	H.	Sa–Si
Moringaceae	*Moringa peregrina* (Forssk.) Fiori	D2	0.02	Occ.	Ph.	Su–Za, Gu–Co
Plantaginaceae	*Plantago coronopus* L.	A1,B	0.02	Occ.	Th.	Med., Sa–Si, Ir–Tu
Brassicaceae	*Farsetia stylosa* R. Br.	C1,D2	0.022	Occ.	Ch.	Su–Za
Salvadoraceae	*Salvadora persica* L.	D1,D2	0.022	Occ.	Ph.	Sa–Si
Zygophyllaceae	*Fagonia tristis* Sickenb.	A1	0.022	Occ.	Ch.	Sa–Si
Asteraceae	*Launaea capitata* (Spreng.) Dandy	A1,B,C1	0.024	Occ.	Th.	Sa–Si
Boraginaceae	*Anchusa hispida* Forssk.	A1,A2	0.024	Occ.	Th.	Sa–Si, Ir–Tu
Chenopodiaceae	*Arthrocnemum macrostachyum* (Moric.) K. Koch	A1,C2	0.024	Occ.	Ch.	Med., Sa–Si
Liliaceae	*Asphodelus tenuifolius* Cav.	A1,C1,D2	0.024	Occ.	Th.	Med., Sa–Si, Ir–Tu
Caryophyllaceae	*Paronychia arabica* (L.) DC.	A1,A2,B	0.026	Occ.	Th.	Sa–Si, Ir–Tu
Chenopodiaceae	*Suaeda altissima* (L.) Pall.	A1,A2,C1,C2	0.026	Occ.	Th.	Med., Ir–Tu, Eu–Si
Fabaceae	*Astragalus hamosus* L.	A1,B,C1	0.026	Occ.	Th.	Med.
Zygophyllaceae	*Fagonia thebaica* Boiss.	C1	0.026	Occ.	Ch.	Sa–Si
Asteraceae	*Ifloga spicata* (Forssk.) Sch.-Bip.	A1,A2,C1	0.028	Occ.	Th.	Med., Sa–Si, Ir–Tu
Fabaceae	*Senna italica* Mill.	A1,C1,D2	0.028	Occ.	H.	Su–Za
Neuradaceae	*Neurada procumbens* L.	A1,B	0.028	Occ.	Th.	Sa–Si
Plumbaginaceae	*Limonium pruinosum* (L.) Kuntze Charz.	A2	0.028	Occ.	H.	Sa–Si
Asteraceae	*Volutaria lippii* (L.) Cass. ex Maire	A1,A2,B	0.03	Occ.	Th.	Med., Sa–Si
Chenopodiaceae	*Atriplex leucoclada* Boiss.	A1,A2,C1	0.03	Occ.	Ch.	Sa–Si, Ir–Tu

(continued)

Table 4.17 (continued)

Ephedraceae	*Ephedra alata* Decne.	A1,A2,D1	0.03	Occ.	Ph.	Med., Sa–Si
Asteraceae	*Pulicaria incisa* (Lam.) DC.	A1,C1,D2	0.032	Occ.	H.	Sa–Si, Gu–Co
Boraginaceae	*Heliotropium arbainense* Fresen.	A2,B,C2	0.032	Occ.	Ch.	Ir–Tu
Lamiaceae	*Lavandula coronopifolia* Poir.	A1,A2,D2	0.032	Occ.	Ch.	Sa–Si
Apiaceae	*Deverra triradiata* Hochst. ex Boiss.	A2,B	0.034	Occ.	Ch.	Sa–Si
Asteraceae	*Nauplius graveolens* (Forssk.) Wilklund	A1,A2	0.034	Occ.	H.	Sa–Si
Chenopodiaceae	*Agathophora alopecuroides* (Delile) Fenzl ex Bunge	A1,A2	0.034	Occ.	Ch.	Sa–Si
Chenopodiaceae	*Bassia indica* (Wight) A.J.Scott	A1,B,C2	0.034	Occ.	Th.	Sa–Si, Ir–Tu
Geraniaceae	*Erodium crassifolium* L'Her.	A1,A2,B,D2	0.034	Occ.	Geo.	Sa–Si
Malvaceae	*Malva parviflora* L.	A1,B,C1,C2	0.034	Occ.	Th.	Med., Ir–Tu, Eu–Si
Poaceae	*Cynodon dactylon* (L.) Pers.	A1,A2,B,C1	0.034	Occ.	Geo.	Cosm.
Zygophyllaceae	*Fagonia arabica* L.	A1,A2,B,C1	0.034	Occ.	Ch.	Sa–Si
Zygophyllaceae	*Fagonia glutinosa* Delile	A1,A2	0.034	Occ.	H.	Sa–Si
Apocynaceae	*Cynanchum acutum* L.	A1,A2	0.036	Occ.	Ch.	Sa–Si
Caryophyllaceae	*Gypsophila capillaris* (Forssk.) C. Chr.	A1,A2	0.036	Occ.	H.	Med., Sa–Si
Fabaceae	*Crotalaria aegyptiaca* Benth.	A1,A2,C1,C2	0.036	Occ.	H.	Sa–Si
Tamaricaceae	*Tamarix tetragyna* Ehrenb.	A1,A2,C1,C2,D1,D2	0.036	Occ.	Ph.	Med., Sa–Si, Ir–Tu
Zygophyllaceae	*Balanites aegyptiaca* (L.) DC.	D1,D2	0.036	Occ.	Ph.	Sa–Si, Su–Za
Asteraceae	*Launaea spinosa* (Forssk.) Sch. Bip.	A1,A2,D2	0.038	Occ.	Ch.	SaSo
Caryophyllaceae	*Polycarpaea robbairea* (Kuntze) Greuter & Burdet	A1,C1,D1,D2	0.038	Occ.	Th.	SaSi
Fabaceae	*Astragalus eremophilus* Boiss.	A1,C1	0.038	Occ.	Th.	SaSi
Geraniaceae	*Erodium glaucophyllum* (L.) L'Hér.	A1,A2,B	0.038	Occ.	H.	SaSi
Scrophulariaceae	*Kickxia aegyptiaca* (Dum.) Nabelek	A1,A2,B	0.038	Occ.	Ch.	SaSi
Asteraceae	*Centaurea aegyptiaca* L.	A1,A2,B	0.04	Occ.	H.	SaSi
Fabaceae	*Alhagi graecorum* (DC.) Alef.	A1,A2,C1,C2	0.04	Occ.	H.	SaSi, IrTu
Asteraceae	*Reichardia tingitana* (L.) Roth	A1,A2,B	0.042	Occ.	Th.	Med., SaSi, IrTu
Boraginaceae	*Heliotropium bacciferum* Forssk.	A1,A2,D1,D2	0.042	Occ.	Ch.	SaSi

Capparidaceae	*Capparis spinosa* L.	A1,A2,C2	0.042	Occ.	Ch.	Med., SaSi, IrTu
Poaceae	*Lasiurus scindicus* Henrard	A1,A2,B,C2	0.044	Occ.	H.	SaSi
Zygophyllaceae	*Zygophyllum decumbens* Delile	A1,A2	0.046	Occ.	Ch.	SaSi
Poaceae	*Phragmites australis* (Cav.) Trin. ex Steud.	A1,A2,B,C1,C2,D1	0.048	Occ.	Hy.-	Pan.
Resedaceae	*Oligomeris linifolia* (Vahl) Macbr.	A1,A2,B,C1,C2	0.05	Com.	Th.	SaSi
Asteraceae	*Centaurea calcitrapa* L.	A1,A2,C2	0.052	Com.	H.	Med., SaSi, IrTu
Chenopodiaceae	*Bassia muricata* (L.) Murr.	A1,A2,B	0.052	Com.	Th.	SaSi, IrTu
Poaceae	*Pennisetum divisum* (Forssk. ex J. F. Gmel.) Henrard	A1,A2,C2	0.052	Com.	H.	SaSi
Solanaceae	*Hyoscyamus muticus* L.	A1,A2,B,D1,D2	0.052	Com.	H.	SaSi, IrTu
Boraginaceae	*Heliotropium digynum* (Forssk.) Asch.	A1,A2,B,C1,C2	0.054	Com.	Ch.	SaSi
Nitrariaceae	*Nitraria retusa* (Forssk.) Asch.	A1,A2,C2	0.054	Com.	Ph.	SaSi
Asteraceae	*Sonchus oleraceus* L.	A1,A2,B,C1	0.056	Com.	Th.	Cosm.
Brassicaceae	*Anastatica hierochuntica* L.	A1,A2,B	0.056	Com.	Th.	SaSi
Chenopodiaceae	*Cornulaca monacantha* Delile	A1,A2,B,C2,D1	0.06	Com.	Ch.	SaSi
Fabaceae	*Acacia seyal* Delile	A1,C1,C2	0.06	Com.	Ph.	Un
Apocynaceae	*Calotropis procera* (Ait.) Ait. f.	A1,A2,B,C1,C2,D2	0.062	Com.	Ph.	SaSi
Brassicaceae	*Eremobium aegyptiacum* (Spreng) Asch. & Schweinf. ex Boiss	A1,A2,B,C1	0.064	Com.	Th.	SaSi
Zygophyllaceae	*Zygophyllum album* L.f.	A1,A2,C2	0.066	Com.	Ch.	SaSi, IrTu
Euphorbiaceae	*Euphorbia retusa* Forssk.	A1,A2,B	0.068	Com.	H.	SaSi
Brassicaceae	*Schouwia purpurea* (Forssk.) Schweinf.	B,C1	0.07	Com.	Th.	SaSi
Fabaceae	*Astragalus vogelii* (Webb) Bomm.	A1,C1,C2,D1,D2	0.07	Com.	Th.	SaSi
Orobanchaceae	*Cistanche phelypaea* (L.) Count.	A1,A2,C1,D1	0.07	Com.	Pa.	Med., SaSi, IrTu
Polygonaceae	*Calligonum polygonoides* L.	A1,B,C1	0.07	Com.	Ch.	Med., SaSi
Asteraceae	*Achillea fragrantissima* (Forssk.) Sch. Bip.	A1,A2	0.072	Com.	Ch.	SaSi, IrTu
Tamaricaceae	*Tamarix aphylla* (L.) H. Karst.	A1,A2,C1,C2,D1,D2	0.072	Com.	Ph.	SaSi
Zygophyllaceae	*Fagonia indica* Burm.f.	A1,C1,D1,D2	0.072	Com.	Ch.	SaSi

(continued)

Table 4.17 (continued)

Chenopodiaceae	*Anabasis articulata* (Forssk.) Moq.	A1,A2,C1	0.074	Com.	Ch.	SaSi, IrTu
Cleomaceae	*Cleome droserifolia* (Forssk.) Delile	A1,A2,C1,C2,D1,D2	0.074	Com.	H.	SaSi
Amaranthaceae	*Aerva javanica* (Burm. f.) Spreng.	A1,C1,D1,D2	0.076	Com.	Ch.	SaSi
Asteraceae	*Artemisia judaica* L.	A1,A2,B,C1,C2,D2	0.076	Com.	Th.	SaSi
Solanaceae	*Lycium shawii* Roem. & Sch.	A1,A2,C2	0.078	Com.	Ph.	SaSi
Asteraceae	*Launaea mucronata* (Forssk.) Muschl.	A1,A2,B,C1,D1,D2	0.082	Com.	H.	SaSi
Cleomaceae	*Cleome amblyocarpa* Barratte & Murb.	A1,A2,B,C1	0.082	Com.	Th.	SaSi, SuZa
Brassicaceae	*Matthiola livida* (Delile) DC.	A1,A2,B,C1	0.09	Com.	Th.	SaSi
Fabaceae	*Retama raetam* (Forssk.) Webb & Berthel.	A1,A2,C1,C2	0.09	Com.	Ph.	SaSi
Asteraceae	*Senecio glaucus* L.	A1,A2,B	0.092	Com.	Th.	Med., SaSi, IrTu
Fabaceae	*Trigonella stellata* Forssk.	A1,A2,B	0.092	Com.	Th.	SaSi, IrTu
Apocynaceae	*Leptadenia pyrotechnica* (Forssk.) Decne.	A1,A2,B,C1,C2,D2	0.094	Com.	Ph.	SaSi
Tamaricaceae	*Reaumuria hirtella* Jaub. & Spach	A1,A2,B,D1	0.094	Com.	Ch.	SaSi
Caryophyllaceae	*Gymnocarpos decandrum* Forssk.	A1,A2,B	0.098	Com.	Ch.	SaSi
Poaceae	*Panicum turgidum* Forssk.	A1,A2,B,C1, C2,D2	0.104	V. Com.	Geo.	Med., SaSi, IrTu
Polygonaceae	*Rumex vesicarius* L.	A1,A2,B,C1	0.108	V. Com.	Th.	SaSi, IrTu
Urticaceae	*Forsskaolea tenacissima* L.	A1,A2,C1,D1,D2	0.108	V. Com.	H.	SaSi, Su–Za
Fabaceae	*Lotus hebranicus* Brand	A1,C1,C2,D1,D2	0.11	V. Com.	H.	Near End.
Asteraceae	*Iphiona mucronata* (Forssk.) Asch. & Schweinf.	A1,A2,C1	0.112	V. Com.	Ch.	SaSi
Asteraceae	*Cotula cinerea* Delile	A1,A2,B,C1	0.114	V. Com.	Th.	SaSi
Brassicaceae	*Diplotaxis acris* (Forssk.) Boiss.	A1,A2,B,C1	0.114	V. Com.	Th.	SaSi
Brassicaceae	*Diplotaxis harra* (Forssk.) Boiss.	A1,A2	0.114	V. Com.	H.	SaSi
Resedaceae	*Reseda pruinosa* Delile	A1,A2,C1,D1,D2	0.116	V. Com.	Th.	SaSi
Apocynaceae	*Pergularia tomentosa* L.	A1,A2,B,C1,C2,D1,D2	0.118	V. Com.	Ch.	SaSi
Apiaceae	*Deverra tortuosa* (Desf.) DC.	A1,A2,C2	0.132	V. Com.	Ch.	SaSi
Chenopodiaceae	*Anabasis setifera* Moq.	A1,A2,C1	0.134	V. Com.	Ch.	SaSi, IrTu
Chenopodiaceae	*Atriplex halimus* L.	A1,A2,B,C2	0.142	V. Com.	Ph.	Med., Sa–Si, Ir–Tu

Zygophyllaceae	*Fagonia mollis* Delile	A1,A2,B,D1,D2	0.146	V. Com.	Ch.	Near End.
Asteraceae	*Echinops spinosus* L.	A1,A2,B,C2	0.156	V. Com.	Ch.	Sa–Si, Ir–Tu
Asteraceae	*Launaea nudicaulis* (L.) Hook. f.	A1,A2,B,C1,C2,D1	0.16	V. Com.	H.	Sa–Si, Ir–Tu
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	A1,A2,C1,C2,D1,D2	0.17	V. Com.	H.	Med., Sa–Si, Ir–Tu
Chenopodiaceae	*Haloxylon salicornicum* (Moq.) Bunge ex Boiss.	A1,A2,B,C2,D1	0.188	V. Com.	Ch.	Sa–Si, Ir–Tu
Chenopodiaceae	*Salsola imbricata* Forssk.	A1,A2,B,C1,C2,D1,D2	0.198	V. Com.	Ch.	Sa–Si
Zygophyllaceae	*Fagonia bruguieri* DC.	A1,A2,C1,D1,D2	0.198	V. Com.	H.	Sa–Si, Ir–Tu
Tamaricaceae	*Tamarix nilotica* (Ehrenb.) Bge	A1,A2,B,C1,C2,D1,D2	0.2	Dom.	Ph.	Sa–Si, Ir–Tu
Brassicaceae	*Farsetia aegyptia* Turra	A1,A2,B	0.202	Dom.	Ch.	Sa–Si
Brassicaceae	*Morettia philaeana* (Delile) DC.	C1,D1,D2,C1	0.21	Dom.	H.	Sa–Si
Boraginaceae	*Trichodesma africanum* (L.) R. Br.	A1,A2,B,C1,C2,D1,D2	0.214	Dom.	Ch.	Sa–Si, Su–Za, Gu–Co
Fabaceae	*Acacia tortilis* (Forssk.) Hayne	A1,A2, B,C1,C2,D1,D2	0.244	Dom.	Ph.	Sa–Si, Su–Za
Zygophyllaceae	*Zygophyllum simplex* L.	A1,A2,B,C1,C2,D1,D2	0.308	Dom.	Th.	Sa–Si, Ka–Na
Resedaceae	*Ochradenus baccatus* Delile	A1,A2,B,C1,C2,D1,D2	0.336	Dom.	Ph.	Sa–Si
Asteraceae	*Pulicaria undulata* (L.) Kostel	A1,A2,B,C1,C2,D1,D2	0.348	Dom.	Ch.	Sa–Si
Zygophyllaceae	*Zygophyllum coccineum* L.	A1,A2,B,C1,C2,D1,D2	0.696	Dom.	Ch.	Sa–Si
Brassicaceae	*Zilla spinosa* (L.) Prantl	A1,A2,B,C1,C2,D1,D2	0.802	Dom.	Ch.	Sa–Si

For status and life form abbreviations, see text. *Med.* Mediterranean, *EuSi* Euro–Siberian, *Sa–Si* Saharo–Sindian, *IrTu* Irano–Turanian, *Su–Za* Sudano–Zambezian, *Pal.* Palaeotropical, *Pan.* Pantropical, *Cosm.* Cosmopolitan, *Af-Mo* Afromontane, *Aus.* Australian, *End.* endemic, *Near End.* near endemic, *Ka–Na* Karoo–Namib, *GuCo* Guineo-Congo, *Un* undetermined cies were represented by 90 species such as *Zygophyllum decumbens*, *Heliotropium bacciferum*, *Capparis spinosa*, *Centaurea aegyptiaca*, *Launaea spinosa*, and *Kickxia aegyptia*ca. Sporadic (very rare) that have Q-values less than 0.01 constituted the main bulk of the recorded flora (172 species, ca. 49.5% of the total species) and included among others *Cometes abyssinica*, *Helianthemum kahiricum*, *Cleome arabica*, *Halopeplis perfoliata*, *Calendula arvensis*, and *Xanthium strumarium*.

Ninety-two historical records (61 perennials, 31 annuals) were documented, and there was no other indication about their presence till to date. These included Schweinfurth's records of *Krascheninnikovia ceratoides* from Wadi El-Abiad and *Galium spurium* from South Galala in 1887; Keller's record of *Echium longifolium* from Wadi Hof in 1904; Simpson's records of *Colchicum cornigerum*, *Heteroderus pusilla*, *Origanum syriacum*, and *Volutaria crupinoides* in 1924; and Simpson's record of *Schimpera arabica* from Wadi Araba in 1928. Of the remarkable records, the stem parasite *Cusuta brevistyle* and the water-loving species *Ruppia maritima*, *Veronica anagallis-aquatica*, and *V. beccabunga* can be mentioned (full information about these records are ready upon direct request from the authors). The endemic *Fagonia täeckhomiana* was the only species that was reported as extinct by El Hadidi (1979) and El Hadidi (2000). The establishment of new settlements and resorts along the Red Sea coast, building new cities beside the old one along the Nile Valley and its expansion to the desert fringes, and the construction of highways that connect the Nile Valley with most of the cities along the Red Sea coast may explain the disappearance of many species and the remarkable changed flora and vegetation that occurred in the study area (El Hadidi (2000b).

The comparison between the results of this study with that of Hassan (1987) revealed that 270 species were in common out of the total of 496 species recorded. The index of similarity (Cs) is therefore 80.9%. This high value can be attributed to the stability of the flora in this area, with limited changes that occurred. Seventy-four species characterized the study of Hassan (1987) on the flora of the Eastern Desert, which have not been recorded in this investigation. Forty-eight species in the seven largest families: Asteraceae (ten species), Caryophyllaceae (eight species), Chenopodiaceae and Poaceae (seven species for each), Aizoaceae (six species), and Brassicaceae and Lamiaceae (five species for each), formed the major part of the characteristic species. On the other hand, 14 species, mostly weeds, characterized the present study that neither recorded in previous studies nor in the literature. These may be considered as new additions to the flora of the Eastern Desert of Egypt. Recorded weeds included *Ammi majus*, *Convolvulus arvensis*, *Plantago major*, *Lolium rigidum*, and *Rumex dentatus* which are among the most common weeds of Egyptian arable lands (El Hadidi and Kosinova 1971; Abd El-Ghani and Amer 1990; Abd El-Ghani and El-Sawaf 2004; Abd El-Ghani et al. 2011).

Reclamation of the desert appears natural due to population growth and increased congestion in the so-called old lands in the Nile Valley and the Delta. Since the early 1960s, vast areas in the Egyptian deserts (Western, Eastern, and Sinai) were subjected to land reclamation. Not surprisingly, 61% of the priority reclaimable land through the Nile waters is located on the fringes of the Valley and Delta regions where soil, in parts of these areas, is loamy in nature; cultivation can be relatively successful (Biswas 1993). In the study area, agricultural processes were practised in the deltaic parts of several wadis such as Wadi El-Assiuty, W. Qena, W. Kherit, W. Natash, and W. El-Sheikh. The land reclamation processes entail an almost complete change of the environmental factors. Thus, weeds find the new conditions favourable for their growth. Close to the boundaries of the desert in this study, xerophytic species naturally grow among the weeds of the cultivation. This indicated that these species are native to the natural desert vegetation and can remain after the reclamation process. Therefore, the reclaimed areas of this study can be considered as transitional areas of the succession process between the old cultivated lands and that of the desert (Bennoba 2011).

The floristic similarities between the two adjacent deserts (the Eastern and Sinai) resulted in 141 species in common out of the total of 1378, with an index of similarity of about 20.5%. This low similarity may be attributed to the geographical position of both deserts where Sinai Desert is part of the Irano–Turanian region, while the Eastern Desert is a part of the Saharo–Sindian region. Notably, 335 species were consistent to the Sinai Desert, while the Eastern Desert is characterized by 64 species. The similarities in the flora of the Eastern Desert and Sinai accounted for 56.5% at the family level and 64.6% at the generic level.

4.3.1.2 Spatial Distribution Patterns of Species

The application of cluster analysis (Fig. 4.21) and Detrended Correspondence Analysis (DCA; Fig. 4.22) produced four major floristic groups (A–D) at the second level of classification and yielded seven subgroups at the third level. The total number of species varied from one subgroup to another. Floristic group (A) was

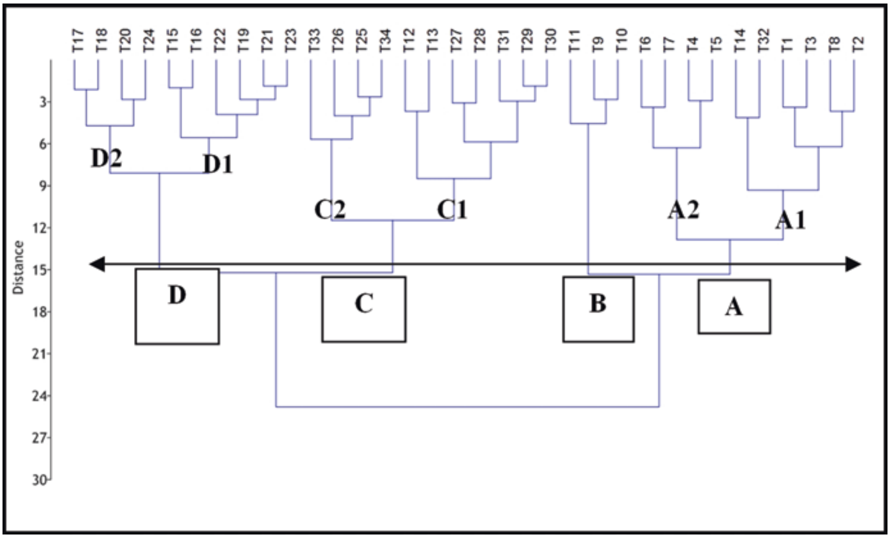

Fig. 4.21 A dendrogram shows the four major floristic groups (*A*–*D*) at the second level of classification and their subgroups (third level of classification) resulting from the cluster analysis of the 34 sampled sectors

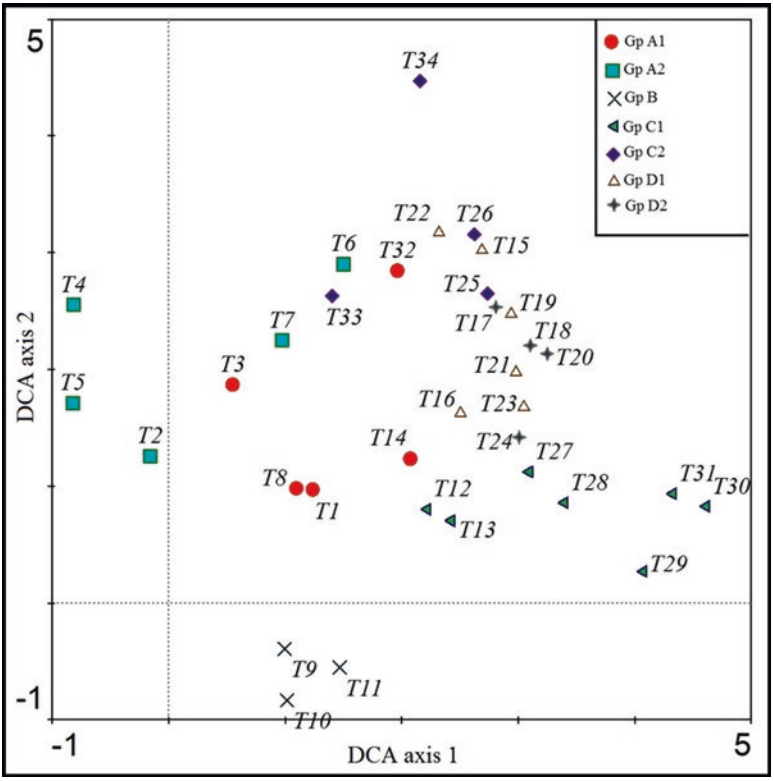

Fig. 4.22 DCA ordination diagram of the 34 sectors on the first two axes as classified by cluster analysis, with the floristic subgroups indicated

dominated by *Zilla spinosa* and *Zygophyllum coccineum* and comprised of ten sectors representing the northern part (Lat. 30° 05′–28°18′ N) of the study area. *Zygophyllum coccineum–Zilla spinosa* communities are among widespread communities within the limestone habitat with different floristic composition. It is plentiful in the affluent of the drainage systems and in the parts of the main channels where the deposits are shallow and coarse. It is less common in the basement complex and is absent from the sandstone habitat (Zahran and Willis 1992).This first group can be divided into two subgroups; the first (A_1) comprised of five desert roads in the northern part of the Eastern Desert (Cairo–Suez road, Kattamia–Ain Sokhna road, Korimat–Zafarana road, Sheikh Fadl–Ras Gharib road, Suez–Ras Gharib road) and Wadi Hagul. It is the most diversified subgroup (92 species), dominated by 23 species (P = 100%) including *Atriplex halimus*, *Farsetia aegyptia*, *Ochradenus baccatus*, *Pergularia tomentosa*, and *Trichodesma africanum*. Other associates of remarkable presence included *Anabasis articulata*, *Citrullus colocynthis*, *Echinops spinosus*, and *Iphiona mucronata*. The second subgroup (A_2) included the flora of the northern wadis of the Eastern Desert (Wadi Degla, W. Hof, W. Garawi, and El-Saff desert). It comprised of 80 species, with 16 species dominated with

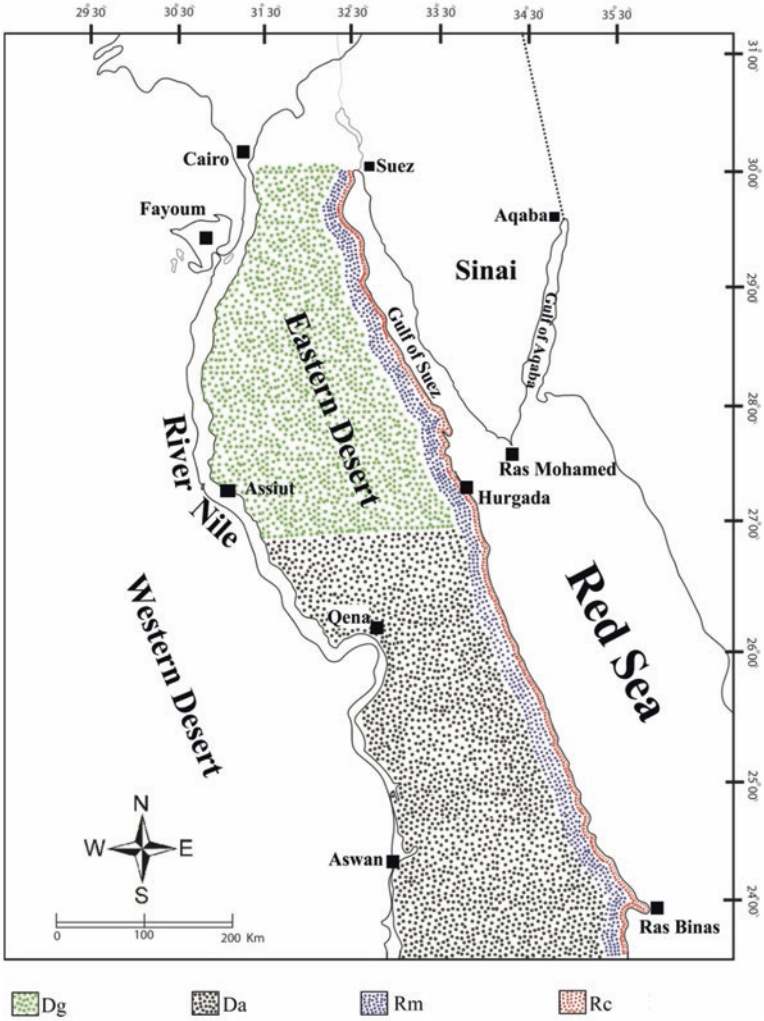

Fig. 4.23 Map of the study area showing the proposed phytogeographical sub-territories of the study area, *Dg* Galala Desert, *Da* Arabian Desert, *Rm* Red Sea Mountain, *Rc* Red Sea coastal plain

100% presence value such as *Anabasis setifera*, *Deverra tortuosa*, *Echinops spinosus*, and *Retama raetam*. Nineteen species were recorded in only one sector of this subgroup with 20% presence value which included *Centaurea calcitrapa*, *Cleome droserifolia*, *Ifloga spicata*, *Leptadenia pyrotechnica*, and *Suaeda altissima*.

Floristic group (B) consisted of 53 species that is dominated *by Calligonum polygonoides* and *Diplotaxis acris* representing the desert vegetation in three sectors in the riverine zone (close to the Nile) of Minya–Assiut area of the Eastern Desert. Twenty species shared the dominance, among others *Cornulaca monacantha*, *Rumex vesicarius*, *Zygophyllum coccineum*, and *Zygophyllum simplex*. Other associates included *Centaurea aegyptiaca*, *Fagonia indica*, *Pergularia tomentosa*, *Salsola imbricata* subsp. *imbricata*, and *Schouwia purpurea*.

Citrullus colocynthis and *Zygophyllum coccineum* dominated floristic group (C) that included 11 sectors representing the southern zone and Red Sea coastal land (Lat. 27° 24′–24° 00′ N). Two subgroups can be identified; the first (C_1; 59 species) included six sectors and dominated by *Citrullus colocynthis* associated with *Astragalus vogelii*, *Cotula cinerea*, *Lotus hebranicus*, *Morettia philaeana*, *Zilla spinosa*, and *Zygophyllum simplex* ($P = 85\%$). Among sporadic species, *Artemisia judaica*, *Heliotropium digynum*, *Ifloga spicata*, *Oligomeris linifolia*, and *Reseda pruinosa* can be noted. The second subgroup (C_2; 42 species) included four sectors that are dominated by *Zygophyllum coccineum* and *Zygophyllum album*. Notably, *Nitraria retusa* and *Salsola imbricata* subsp. *imbricata* were the most represented associates ($P = 75\%$). Other associates included *Atriplex halimus*, *Haloxylon salicornicum*, *Panicum turgidum*, *Suaeda altissima*, *Tamarix nilotica*, and *Tamarix aphylla*.

Floristic group (D) was dominated by *Aerva javanica* and *Zilla spinosa* and can be identified as the Red Sea highland zone of the study area. Two subgroups can be recognized; the first (D_1) is dominated by nine species such as *Acacia tortilis*, *Fagonia mollis*, *Pulicaria undulata*, *Zilla spinosa*, and *Zygophyllum coccineum*. Occasional species included *Heliotropium bacciferum*, *Hyoscyamus muticus*, *Launaea mucronata*, and *Tamarix aphylla*. Ten species shared the dominancy of the second subdivision (D_2), including *Aerva javanica*, *Cleome droserifolia*, *Leptadenia pyrotechnica*, and *Ochradenus baccatus*. It can be noted that *Forsskaolea tenacissima*, *Lotus hebranicus*, and *Trichodesma africanum* were of remarkable presence ($P = 75\%$). Both subgroups comprised of approximately the same number of species (37 for D_1 and 38 for D_2). The correlation coefficients (r) between the different subgroups revealed high significant correlations ($P = 0.01$) between floristic group (B) and subgroup (C_2) and between subgroups (D_1) and (D_2). Significant correlations ($P = 0.05$) occurred between subgroup (D_1) and both of (A_1) and (C_2).

4.4 Phytogeographical Reassessment

4.4.1 The Saharo–Sindian Chorotype

Phytogeographically, the Saharo–Sindian region is the great desert belt. It extends from the Atlantic coasts of Morocco and Mauritania eastwards across the Sahara, Sinai, and extratropical Arabia, Southern Iraq, Iran, and Balochistan to the deserts of Sind, Thar, the Punjab, and South of Afghanistan (Zohary 1973). It has extreme dryness of the air, high temperature, and low rainfall.

The Saharo–Sindian (mono-, bi-, and pluriregional) chorotype constituted the largest group of species (226 species or about 68.9% of the total flora), with variations in their growth habits and life span. The pure (monoregional) Saharo–Sindian chorotype was represented by 137 species (60.6% of the total chorotype). These species showed different geographical distribution patterns in the proposed local subtypes.

4.4.1.1 Local Subtype 1: Widely Distributed Species

This group included ten species with wide distribution patterns and environmental tolerances throughout the study area. *Zilla spinosa* and *Zygophyllum coccineum* were the most dominant species that showed a wide range of conjunct distribution pattern all over the study area. Other species that showed a considerable wide range of distribution included *Pulicaria undulata*, *Trichodesma africanum*, *Acacia tortilis*, *Ochradenus baccatus*, *Tamarix nilotica*, and *Zygophyllum simplex*. (Fig. 4.24)

4.4.1.2 Local Subtype 2: Northerly Distributed Species

This group of species included 119 species (3 very common, 12 common, 45 occasional, 59 occasional), mostly restricted and characteristic to the inland wadis of the study area and not recorded eastwards along the Red Sea coast. *Agathophora alopecuroides*, *Deverra triradiata*, *Limonium pruinosum*, *Stachys aegyptiaca*, and *Traganum nudatum* are confined to Helwan and El-Saff desert, while *Pseuderucaria clavata* showed a higher presence along Kattamia–Ain Sokhna road and its surrounding wadis.

Some species showed certain degree of consistency to certain localities in the northern part of the study area. These species were not recorded since several years and hence

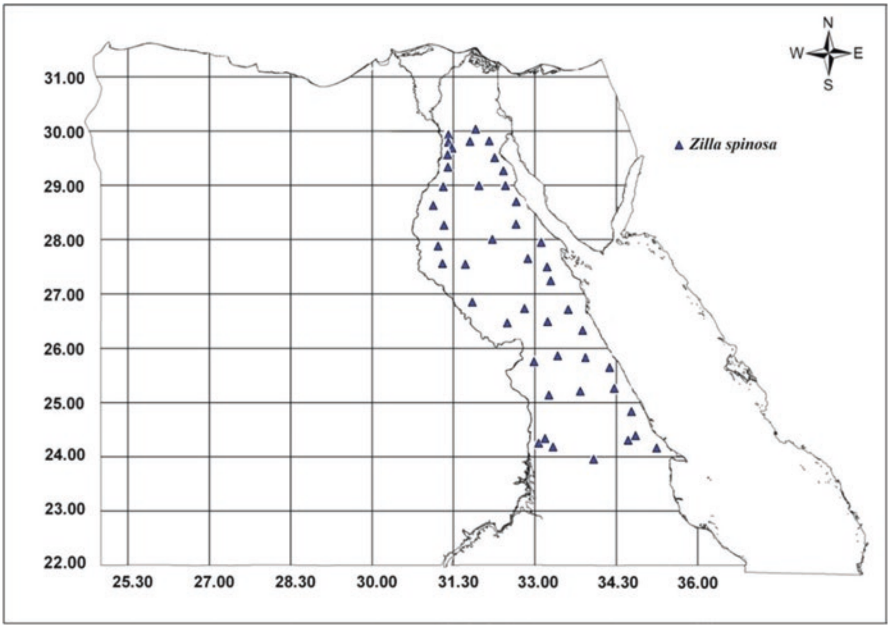

Fig. 4.24 Distribution map of *Zilla spinosa* (widely distributed Saharo–Sindian species)

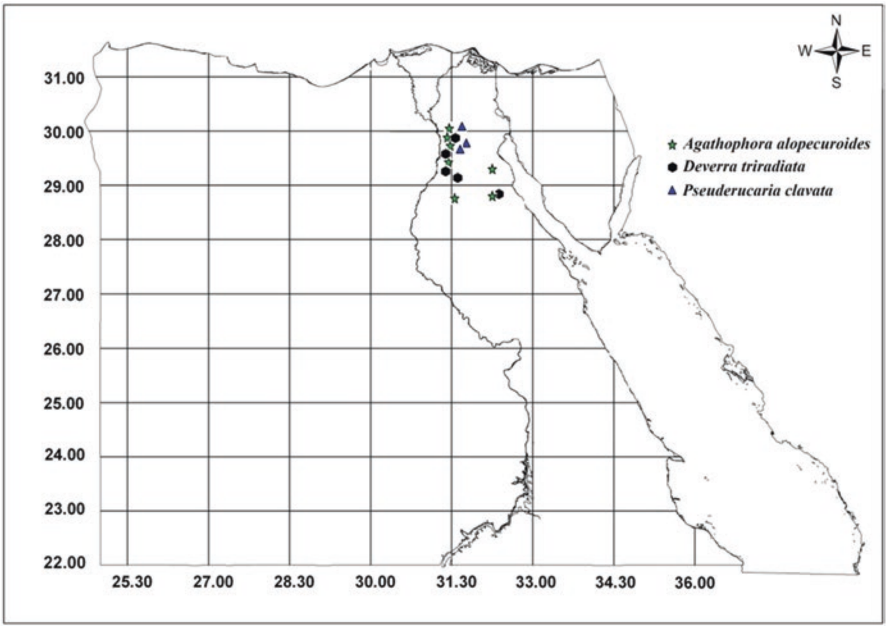

Fig. 4.25 Distribution map of *Agathophora alopecuroides*, *Deverra triradiata*, and *Pseuderucaria clavata* (northerly distributed Saharo–Sindian species)

can be considered as historical records, among others *Abutilon pannosum*, *Echium longifolium*, *Fagonia latifolia*, *Haloxylon persicum*, *Helianthemum sancti-antonii*, *Kickxia acerbiana*, *Onobrychis ptolemaica*, and *Scabiosa eremophila* (Fig. 4.25).

4.4.1.3 Local Subtype 3: Southerly Distributed Species

Eight species of the Saharo–Sindian chorotype showed certain degree of consistency to the southern part of the study area; in the meantime, they were characteristic to the southern inland wadis. For example, *Morettia philaeana*, *Salsola villosa*, and *Schouwia purpurea* showed high presence in this area, while *Acacia ehrenbergiana*, *Fagonia thebaica*, and *Iphiona scabra* were of low presence (Fig. 4.26).

4.4.1.4 Local Subtype 4: Easterly Distributed Species

This group of species were distributed along the eastern part of the study area and not penetrated westwards. These species can be considered as the Red Sea characteristic species such as *Atriplex farinosa*, *Avicennia marina*, and *Halopeplis perfoliata* that were distributed along the southern part of the Red Sea coastal plain. *Blepharis edulis*, *Capparis cartilaginea*, *Cleome chrysantha*, *C. droserifolia*, *Convolvulus hystrix*, and *Periploca aphylla* are recorded from the Red Sea wadis and mountains (Fig. 4.27).

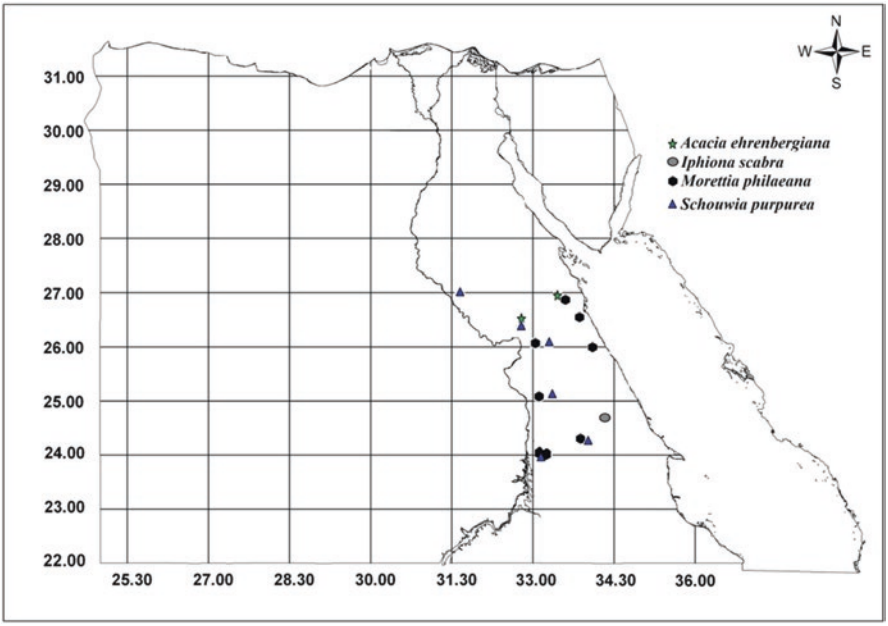

Fig. 4.26 Distribution map of *Acacia ehrenbergiana, Iphiona scabra*, *Morettia philaeana*, and *Schouwia purpurea* (southerly distributed Saharo–Sindian species)

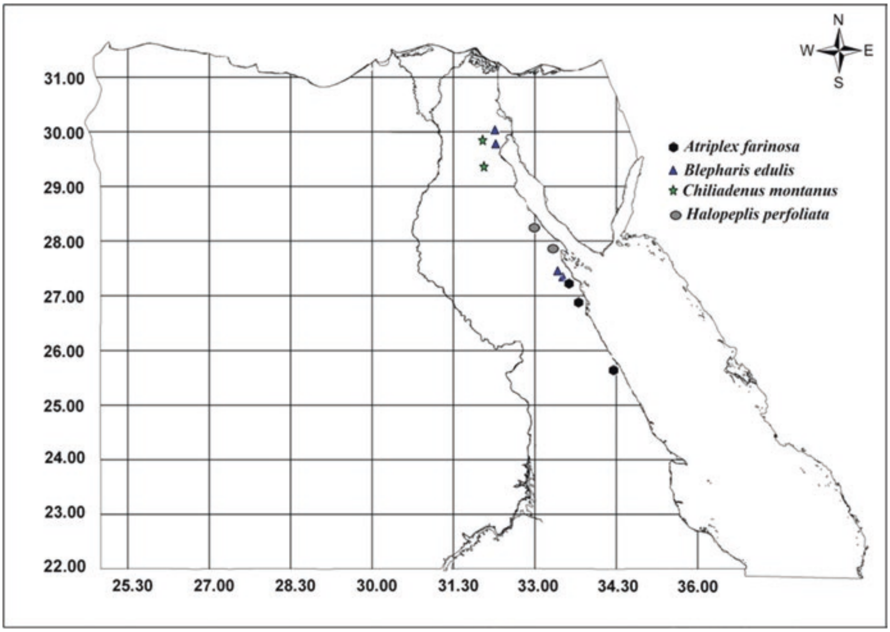

Fig. 4.27 Distribution map of *Atriplex farinosa*, *Blepharis edulis*, *Chiliadenus montanus*, and *Halopeplis perfoliata* (easterly distributed Saharo–Sindian species)

4.4.1.5 Local Subtype 5: Westerly Distributed Species

This group was represented by 57 species, mainly distributed in the desert wadis close to the River Nile Valley. The very common, common, and the sporadic species were represented by relatively equal numbers of species (15, 18, and 17, respectively). The highest occurrences were for *Fagonia bruguieri* and *Caroxylon imbricatum*, followed by *Haloxylon salicornicum* and *Citrullus colocynthis*. Conspicuous stratification (layering) of different life-form categories in this subtype was noted: phanerophytes (*Phoenix dactylifera*), chamaephytes (*Centaurea scoparia* and *Heliotropium ramosissimum*), hemicryptophytes (*Cucumis prophetarum*), and therophytes (*Arnebia hispidissima, Lotus halophilus*, and *Tribulus megistopterus*) .

4.4.2 The Mediterranean Chorotype

As defined by Zohary (1973), the Mediterranean region includes the most northern part of the African continent and the southern part of Europe surrounding the Mediterranean Sea. It bounded from south by the desert and semi-desert of Saharo–Sindian region and from the east by Irano–Turanian region. It is characterized by mild winter rich in rainfall and dry summer. In this investigation, a total of 32 species were of Mediterranean origin, of which 7 were monoregional (pure) Mediterranean chorotype. Therophytes (24 species) were the dominant life form. The following shows the patterns of their distribution in the different local subtypes. Generally, the species comprising the subtypes were either occasional or sporadic.

4.4.2.1 Local Subtype 1: Widely Distributed Species

Not represented.

4.4.2.2 Local Subtype 2: Northerly Distributed Species

The majority (21 species) of the Mediterranean chorotype was restricted in their distribution to the northern part of the study area and not extended or recorded southwards. Notably, 16 species were therophytes and known among the common weeds of Egyptian arable lands (El Hadidi and Kosinová 1971) among others *Cichorium pumilum*, *Emex spinosa*, *Euphorbia peplus*, and *Plantago major*. Meanwhile some desert annuals were recorded such as *Astragalus hamosus*, *Schismus barbatus*, and *Mesembryanthemum crystallinum*. (Fig. 4.28)

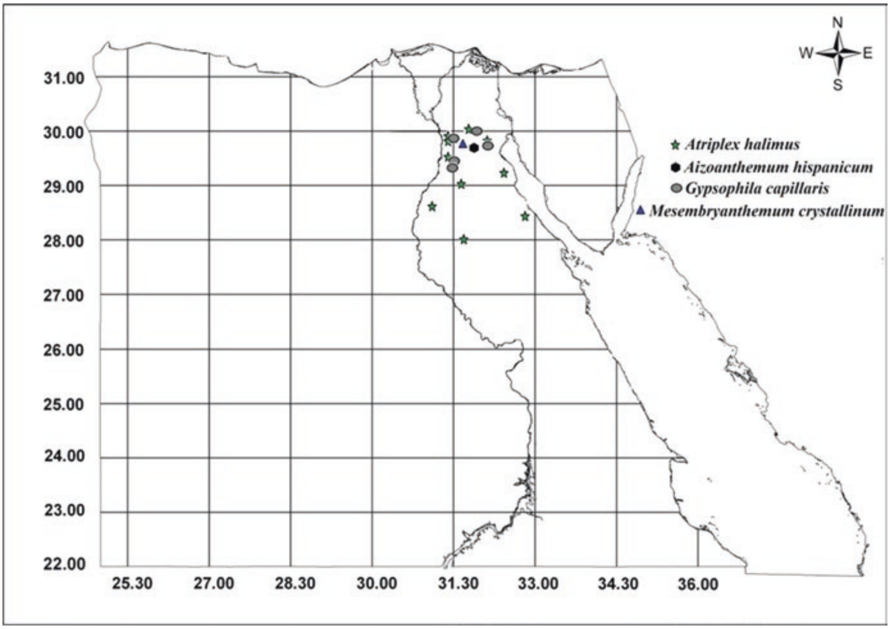

Fig. 4.28 Distribution map of *Atriplex halimus*, *Aizoanthemum hispanicum*, *Gypsophila capillaris*, and *Mesembryanthemum crystallinum* (northerly distributed Mediterranean species)

4.4.2.3 Local Subtype 3: Southerly Distributed Species

Mediterranean chorotype showed fewer (three) species in the southern part of the study area. Only three weedy species, *Hippocrepis constricta*, *Lactuca serriola*, and *Lupinus digitatus*, were recorded in this part. (Fig. 4.30)

4.4.2.4 Local Subtype 4: Easterly Distributed Species

These species were confined to the eastern part of the study area and characteristic to the Red Sea region. Most of these species were rare and very rare (Täckholm 1974) and collected from certain localities along the Red Sea coastal lands such as *Koelpinia linearis*, *Malabaila suaveolens*, and *Umbilicus intermedia* (El Hadidy and Fayed 1994/1995). In this subtype, some salt-tolerant species *Frankenia hirsuta*, *Sarcocornia fruticosa*, and *Suaeda altissima* were recorded (Fig. 4.29).

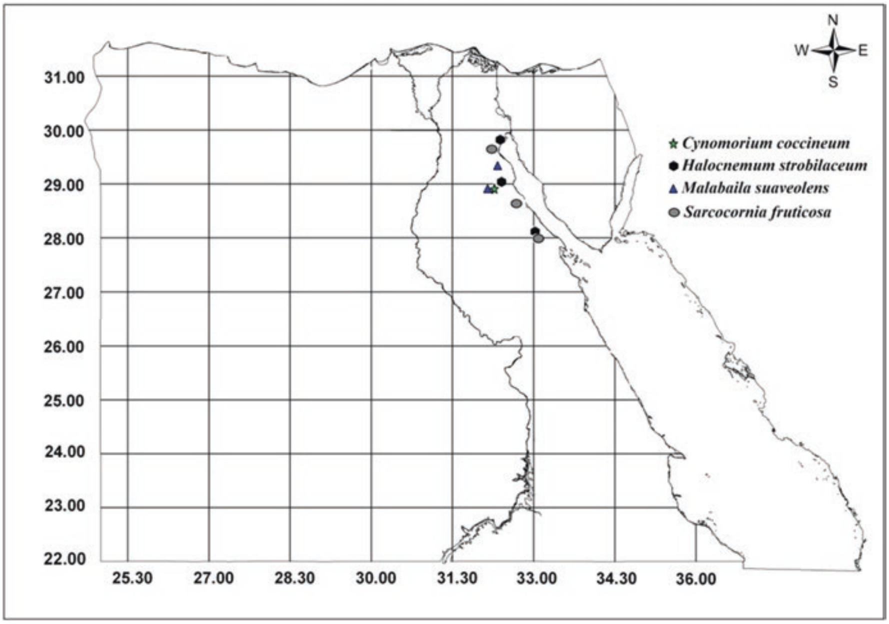

Fig. 4.29 Distribution map of *Cynomorium coccineum*, *Halocnemum strobilaceum*, *Malabaila suaveolens*, and *Sarcocornia fruticosa* (easterly distributed Mediterranean species)

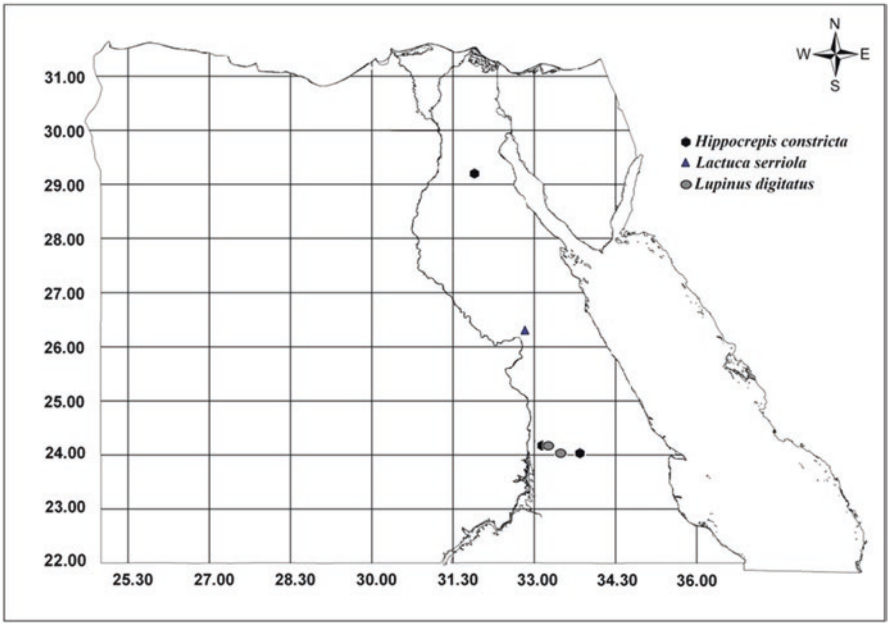

Fig. 4.30 Distribution map of *Hippocrepis constricta*, *Lactuca serriola*, and *Lupinus digitatus* (southerly distributed Mediterranean species)

4.4.2.5 Local Subtype 5: Westerly Distributed Species

Three species were recorded in this subtype; all are among the common weeds of arable lands that were reclaimed in the western part close to the Nile River Valley.

4.4.3 The Irano–Turanian Chorotype

According to Zohary (1973), the Irano–Turanian region covered a large area stretching from east towards China–Japan, west to Mediterranean, north to northern extra-tropical, and south to north African–Indian desert region. In this study, it was represented by six species, all confined to the northern part of the study area.

4.4.3.1 Local Subtype 1: Widely Distributed Species

Not represented.

4.4.3.2 Local Subtype 2: Northerly Distributed Species

All the six recorded species were confined to the northern part, among others *Atriplex dimorphostegia*, *Glossostemon bruguieri*, *Heliotropium arbainense*, and *Paronychia sinaica* were found (Fig. 4.31).

4.4.3.3 Local Subtype 3: Southerly Distributed Species

Not represented.

4.4.3.4 Local Subtype 4: Easterly Distributed Species

A total of 23 species belonged to this group. Most of these species were considered as historical records such as; A*traphaxis spinosa, Ballota saxatilis, Galium spurium, Heliotropium rotundifolium, Heteroderus pusilla, Krascheninnikovia ceratoides, Matricaria aurea* and *Teucrium polium* (Fig. 4.32).

4.4.3.5 Local Subtype 5: Westerly Distributed Species

Not represented.

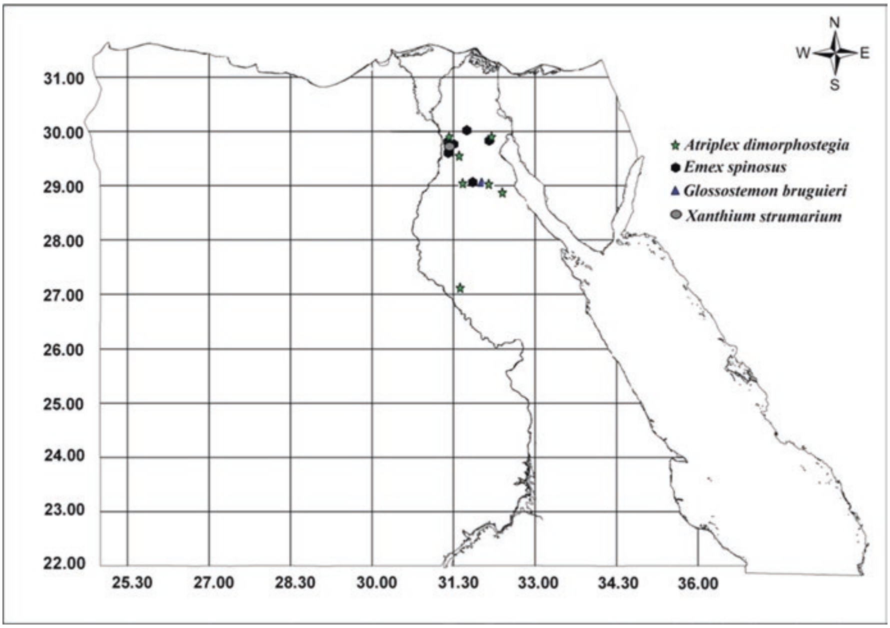

Fig. 4.31 Distribution map of *Atriplex dimorphostegia*, *Emex spinosa*, *Glossostemon bruguieri*, and *Xanthium strumarium* (northerly distributed Irano–Turanian species)

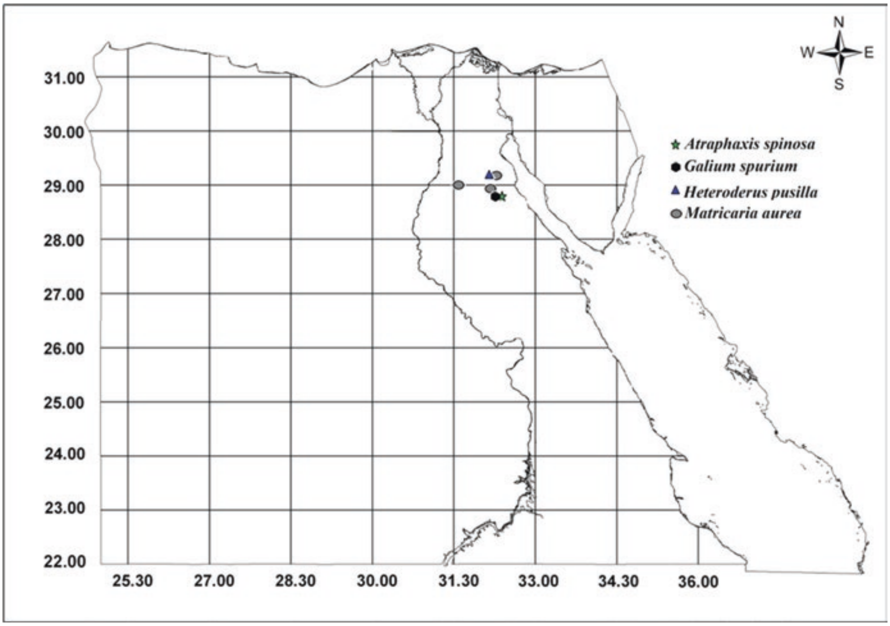

Fig. 4.32 Distribution map of *Atraphaxis spinosa*, *Galium spurium*, *Heteroderus pusilla*, and *Matricaria aurea* (easterly distributed Irano–Turanian species)

4.4.4 *The Sudano–Zambezian Chorotype*

The Sudano–Zambezian region corresponds to largest ecological formation in Africa, the tropical savanna to the north. It is bounded by the desert and semi-desert of the Saharo–Sindian region (Zohary 1973).

4.4.4.1 Local Subtype 1: Widely Distributed Species

Among these species *Senna italica* had a relatively wide range of distribution (Fig. 4.33 for all subtypes).

4.4.4.2 Local Subtype 2: Northerly Distributed Species

Four Sudano–Zambezian species showed consistency to the eastern part of the study area, e.g. *Ephedra ciliata* (gymnosperm) and the shrubs of *Farsetia longisiliqua* and *Abutilon fruticosum*.

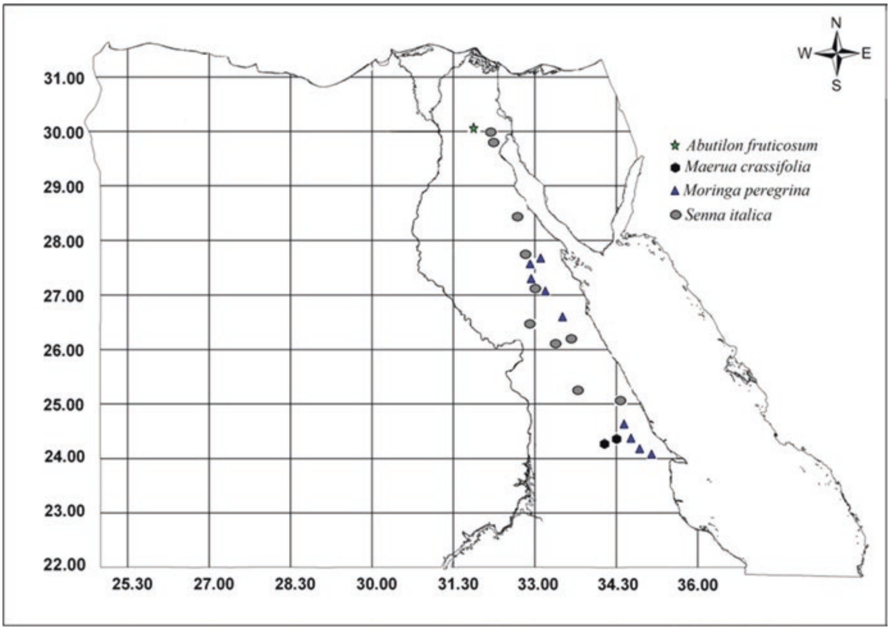

Fig. 4.33 Distribution map of Sudano–Zambezian species: *Senna italica* (widely distributed), *Maerua crassifolia* (southerly distributed), *Abutilon fruticosum* (northerly distributed), and *Moringa peregrina* (easterly distributed)

4.4.4.3 Local Subtype 3: Southerly Distributed Species

The common recorded was *Acacia seyal* (tree). Another two occasional trees were also recorded in the southern stretches of the surveyed area: *Hyphaene thebaica* and *Maerua crassifolia*.

4.4.4.4 Local Subtype 4: Easterly Distributed Species

Altogether, two occasionals (*Capparis deciduas* and *Farsetia stylosa*) and one sporadic (*Tribulus bimucronatus*) occurred in the eastern part.

4.4.4.5 Local Subtype 5: Westerly Distributed Species

Senna italica was the only occasional species that was recorded from the western part.

4.4.5 The Cosmopolitan, Palaeotropical, and Pantropical Species

Altogether, 27 species were recorded, of which 16 (ca. 59%) were Cosmopolitans. This group included some of the most common weeds of the arable lands in Egypt such as *Sonchus oleraceus* (common), *Chenopodium murale*, *Cynodon dactylon*, and *Polypogon monspeliensis* (occasional), and the remaining were sporadic (Fig. 4.34).

4.4.5.1 Local Subtype 1: Widely Distributed Species

Not represented.

4.4.5.2 Local Subtype 2: Northerly Distributed Species

Seventeen species (10 Cosmopolitan, 4 Palaeotropical, and 3 Pantropical) were included. Therophytes (12 species) dominated the other life forms and were found in northern inland wadis of the study area. The salt-tolerant species *Cressa cretica* which characterizes the salinized soils was recorded.

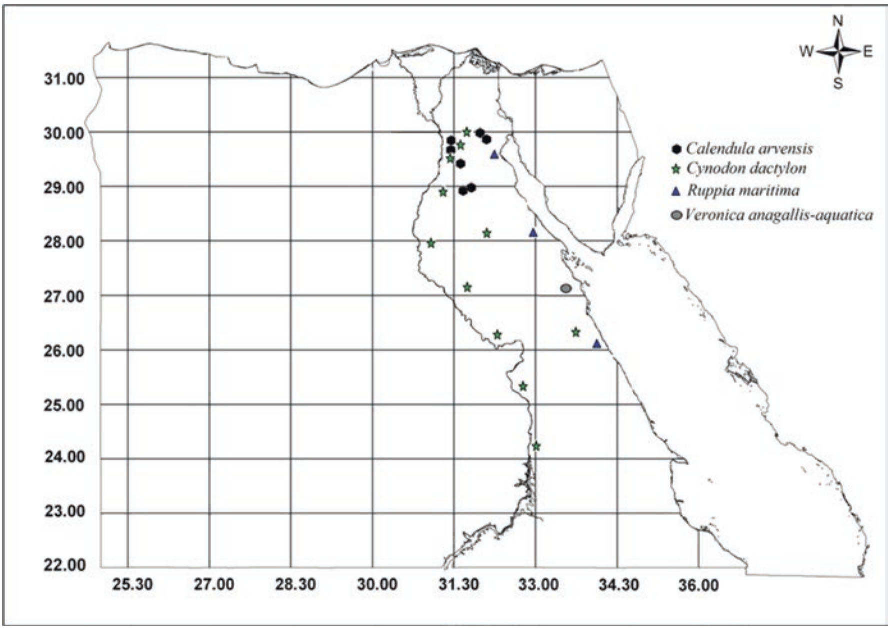

Fig. 4.34 Distribution map of Cosmopolitan species: *Cynodon dactylon* (widely distributed), *Calendula arvensis* (northerly distributed), *Ruppia maritima*, and *Veronica anagallis-aquatica* (easterly distributed)

4.4.5.3 Local Subtype 3: Southerly Distributed Species

Not represented.

4.4.5.4 Local Subtype 4: Easterly Distributed Species

Leptochloa fusca was the only Palaeotropical species included. It was found in water catchment areas where water is collected. On the other hand, *Brassica nigra*, *Pseudognaphalium luteoalbum*, *Ruppia maritima*, *Veronica anagallis-aquatica*, and *V. beccabunga* were recorded once from the eastern part of the study area (Cairo University Herbarium records, in the year 1938) and not recorded in this work. These can be considered as historical records.

4.4.5.5 Local Subtype 5: Westerly Distributed Species

Nine species were recorded, with *Sonchus oleraceus* (common); *Cynodon dactylon*, *Phragmites australis*, and *Polypogon monspeliensis* (occasional); and *Amaranthus viridis*, *Avena fatua*, *Ricinus communis*, *Solanum nigrum*, and *Typha domingensis* (sporadic).

Based on the presented distribution patterns of the recorded species, the geographical distribution maps, the biogeographical relationships, and the vegetation analysis (Abd El-Ghani et al. 2013a), it is suggested to divide the study area into two major phytogeographical divisions: the Eastern Desert and the Red Sea (Fig. 4.23), each of which can be further split into other subdivisions as follows.

4.4.5.6 Division 1: The Eastern Desert

This division comprised the inland desert of the study area from River Nile Valley eastwards to the limits of the Red Sea Mountains. Taking into account variations in the floristic composition and species distribution, it is suggested to divide this division into two subdivisions: Galala (northern) and Arabian (southern).

Subdivision 1: The Northern Galala Desert (Dg)

This sub-territory comprised the northern part of the study area. It extends from the northern limits of the study area at latitude 30°N southwards to Minya–Assiut desert at latitude 27°N. This sub-territory is most rich with plant species and characterized by restriction of numerous families including Aizoaceae, Alliaceae, Amaryllidaceae, Anacardiaceae, Cannabaceae, Cistaceae, Dipsacaceae, Ephedraceae, Neuradaceae, Orobanchaceae, Oxalidaceae, Portulacaceae, Primulaceae, Rutaceae, Sterculiaceae, and Thymelaeaceae.

Subdivision 2: The Southern Arabian Desert (Da)

It occupied the southern part of the study area, south of latitude 27°N. This sub-territory was characterized by low diversity of species (25 species) and absence of restricted families.

4.4.5.7 Division 2: The Red Sea Coast (R)

This territory included the area between Red Sea coasts westwards to Red Sea Mountains. This territory can be subdivided into two main sub-territories: Red Sea coastal plain and Red Sea Mountains.

Subdivision 1: The Red Sea Coastal Plain (Rc)

This sub-territory occupied the coastal plain of the Red Sea. It varies from 8 to 35 km from the coast (Zahran and Willis 1992). Here, very few characteristic species were represented: *Avicennia marina*, *Halocnemum strobilaceum*, *Atriplex* *farinosa*, *Arthrocnemum glaucum*, *Halopeplis perfoliata*, *Limonium axillare*, *Aeluropus lagopoides*, *Sporobolus spicatus*, and *Suaeda monoica*.

Subdivison 2: The Red Sea Mountains (Rm)

It occupied the area from the limit of Red Sea coastal plain westwards to the west limit of the Red Sea Mountain. This area is characterized by large number of coastal wadis and high diversity of plant.

4.5 Concluding Remarks

1. From a phytogeographical point of view, and according to Takhtajan (1969) and Wickens (1976), the study area lies within the Saharo–Sindian region of boreo-subtropical zone of the Tropical Kingdom. This area is influenced by its inclusion in the Mediterranean, Sudano–Zambezian, and Irano–Turanian regions (White 1993). These facts were obvious from the detailed chorological analysis of the recorded species, where the Saharo–Sindian constituted the majority of mono-, bi-, and pluriregional chorotypes. Species of the Saharo–Sindian region are known as good indicators of the harsh environments of the arid desert (Hegazy et al. 1998; Abd El-Ghani and Amer 2003). The dominance of Saharo–Sindian chorotype in the study area is coinciding with the results of El Hadidi (1993), Fossati (1998), and Hassan (2003).
2. The relationship between the life forms and chorological affinities in floristic studies contributed significantly to the prevailing climatic conditions and human impacts as well. Several studies can be reported, among others, Batalha and Martins (2002) in Brazilian cerrado sites, Klimeš (2003) in NW Himalayas, Becker and Müller (2007) in semiarid regions of West and Southern Africa, Gouvas and Theodoropoulos (2007) in Mount Hymettus (Central Greece), Carvalho da Costa et al. (2007) in deciduous thorn woodland (caatinga) in north-eastern Brazil, and Al-Sherif et al. (2013) in the arid region of Saudi Arabia. In the present study, the life-form spectrum is characteristic of an arid desert region with the dominance of therophytes, followed by chamaephytes, hemicryptophytes, and phanerophytes over other life forms that seem to be a response to the hot dry climate, topographic variations, and/or human and animal interference. A comparison of the life-form spectra of the Eastern Desert of Egypt and those in the Tihama coastal plains of Jazan region in southwestern Saudi Arabia (El-Demerdash et al. 1994) showed the same results. Similar conclusions were also reported by Arshad et al. (2008) in various locations of the Cholistan Desert in Pakistan.

3. In hyperarid deserts, as in the study area, plant growth is triggered mainly by rain, as it is scarce, patchy, and restricted to wadis, runnels, and depressions with deep fine sediments where runoff water collects and provides sufficient moisture for plant growth (Shmida 1985; Bornkamm 2001). Consequently, several highly adapted, drought-resistant species such as *Acacia tortilis* subsp. *raddiana*, *Tamarix aphylla*, and *Ziziphus spina-christi* (trees) and *Capparis spinosa*, *Convolvulus hystrix*, *Fagonia bruguieri*, *Zygophyllum coccineum*, and *Zilla spinosa* (shrubs) were among the widely distributed and very common species in this desert.
4. Results on the distribution of different biological spectrum confirmed the dominance of therophytes, mostly of Saharo–Sindian affinities. Frequent occurrence of therophytes may be attributed to their short life cycle, water availability, and the prevailing climatic conditions (Shaltout and El-Fahar 1991). The preponderance of therophytes could be related to their high reproductive capacity and ecological, morphological, and genetic plasticity under high level of disturbance (Grime 1979). This spectrum strongly resembles that reported by Danin and Orshan (1990) for corresponding environments in Israel.
5. The notable decrease of the recorded species from the northern part to the southern part can be attributed to the decrease of the mean annual averages of rainfall along this gradient from 25 mm^{-1} in Suez to almost 0 mm^{-1} in Marsa Alam along the Red Sea coast (Abd El-Ghani 1998). However, the Red Sea coast (eastern border of the Eastern Desert) and its mountains receive more precipitation than the Nile Valley (western border of the Eastern Desert). Most of the studied wadis (valleys) crossing the Eastern Desert in E–W direction debouch their water in the Nile River. This may explain the increase of the recorded species along E–W direction. Plant species growth in the desert wadis, as water catchment areas, other than surrounding areas, was reported by several authors (El Hadidi et al. 1986; El-Bana and Al-Mathnani 2009; Abdel Khalik et al. 2013; Salama et al. 2016).
6. The results showed that some weeds of the arable lands of Egypt were recorded. These weeds belonged to the common weeds of Egypt (El Hadidi and Kosinová 1971; Abd El-Ghani and El-Sawaf 2004). That could be explained by the proximity of the study area to the boundaries of the agroecosystem of the Nile Valley, where many land stretches have been reclaimed and recently considered under cultivation. Thus weeds have found new favourable conditions for their growth, and their invasion has expanded.
7. The phytogeographical divisions of Egypt, and especially for the Eastern Desert, were a matter of controversy. Hassib (1951) divided the study area into three main phytogeographical regions: (1) Northern Arabian Desert from Wadi Tumilat to Qena–Quseir region (Da. Sept.); (2) Southern Arabian Desert from Qena–

Quseir southwards to Sudanian borders (Da. mer); and (3) Red Sea coast comprising the coast of Red Sea from Suez Gulf southwards to Gebel Elba region. On the other hand, El Hadidi (1980) included the Eastern Desert in two phytogeographical units: (1) Eastern Desert region (D) and (2) Red Sea region (R). The former can be further subdivided into Galala Desert (Dg) and Arabian Desert (Da). While the latter can be subdivided into the Arabian sector (Ra) that lies between latitudes 22°N–28°N and the Suez Gulf sector (Rz) that lies between latitudes 28–30°N.

Photo Gallery

Photo 4.1 Mixed plant growth of *Zygophyllum coccineum* (dominant) and *Tamarix aphylla* (background) which forms huge hillocks at Wadi Matuli, Eastern Desert

Photo 4.2 Mixed desert vegetation of *Zilla spinosa* (dry, foreground), *Zygophyllum coccineum*, and *Tamarix nilotica* (background) at Wadi El-Qarn, Eastern Desert

Photo 4.3 A water-collecting area along Qift-Quseir road, showing dense cover of *Juncus rigidus*, *Tamarix nilotica*, and *Phragmites australis* (green colour in the backround)

Photo 4.4 *Salsola imbricata* subsp. *imbricata* dominating the desert vegetation at Wadi El-Qarn, Eastern Desert

Photo 4.5 Dense growth of *Schouwia thebaica* and *Zygophyllum coccineum* at Wadi Habib, Eastern Desert (April 14, 2011)

Photo 4.6 After rainfall at Wadi El-Assiuty (Eastern Desert), mixed growth of *Zilla spinosa*, *Schouwia thebaica*, and *Rumex vesicarius* (red flowers) forms the desert vegetation (April 10, 2011)

Photo 4.7 A scrubland of *Acacia seyal* forms part of the vegetation at Wadi Kharit, Eastern Desert (January 22, 2011)

Photo 4.8 A camel browsing *Acacia seyal* at Wadi Kharit, Eastern Desert (January 22, 2011)

Photo 4.9 A mangrove of *Avicennia marina* (note the long respiratory roots) at Marsa Alam along the Red Sea coast (January 25, 2011)

Photo 4.10 General view of Wadi El-Mallaha (in Arabic = salt marsh) at the northern part of the Eastern Desert.Date palm trees together with *Tamarix nilotica* and *Nitraria retusa* form the vegetation of this salinized land (March 07, 2017)

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