Phytocoenologia	19 (2)	149 - 231	Berlin-Stuttgart, December 17, 1990

The plant communities of the Western Desert of Egypt*

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with 18 photos, 20 figures and 21 tables

Abstract. The Western Desert (formerly called the eastern part of the Libyan Desert) extends from the Mediterranean to the Sudanian border, and from the Libyan border to the Nile, thus comprising two thirds of the Egyptian territory. Much vegetation research has already been done in this region, but has mainly been restricted to the coastal area and the oases. The present investigation was carried out in the frame work of the Special Research Project "Geoscientific problems in arid areas" and will contribute to close the gaps of knowledge. We describe 89 vegetation units, belonging to 47 associations or monotypic stands. The specific (dwarf-)shrubby desert communities belong to two alliances, the Thymelaeion hirsutae Eig 1946 and the Zygophyllion coccinei El-Sharkawi et al. 1984, here combined into the new order Pituranthetalia tortuosi.

In summary, 5 desert zones can be discerned: I) Semidesert (settled, grazed, dry farming, vegetation diffuse), close to the coast, II) full desert (grazed, vegetation permanent but becoming contracted), III) extreme desert 1 (vegetation at least partially permanent), IV) extreme desert 2 (vegetation completely accidental), V) extreme 3 (allochthonous ecosystems). Deviations from the zonal arrangement are caused by the geomorphological conditions in the Farafra depression and the geomorphological-climatological conditions in the Qattara depression.

Zusammenfassung. Die Westliche Wüste, oft auch als östlicher Teil der Libyschen Wüste bezeichnet, erstreckt sich vom Mittelmeer bis an die sudanesische Grenze sowie von der libyschen Grenze bis zum Nil und nimmt somit etwa 2/3 des ägyptischen Staatsgebietes ein. Zwar wurden schon zahlreiche Vegetationsuntersuchungen in diesem Gebiet vorgenommen, jedoch erstreckten sich diese ganz überwiegend auf die Küstenregion einerseits und die Oasen andererseits. Die vorliegende Untersuchung, die im Rahmen des Sonderforschungsbereichs „Geowissenschaftliche Probleme in ariden Gebieten" vorgenommen wurde, will dazu beitragen, die Kenntnislücken zu schließen. Es werden 89 Vegetationseinheiten beschrieben, die sich auf 47 Assoziationen und monotypische Bestände verteilen. Die eigentlichen Wüsten-(Zwerg-)strauchgesellschaften lassen sich zwei Verbänden zuordnen, dem Thymelaeion hirsutae Eig 1946 und dem Zygophyllion coccinei El-Sharkawi et al. 1984 und werden in der neuen Ordnung Pituranthetalia tortuosi zusammengefaßt.

Großräumig ergeben sich 5 Zonen der westlichen Wüste: I) Halbwüste (besiedelt, beweidet, Trockenfeldbau, diffuse Vegetation) in Küstennähe, II) Vollwüste (beweidet, Vegetation permanent, aber in kontrahierte Anordnung übergehend, III) Extremwüste 1 (Vegetation in geringem Umfang noch permanent), IV Extremwüste 2 (Vegetation vollständig akzidentell), V) Extremwüste 3 (allochthone Ökosysteme). Abweichungen von der zonalen Ordnung ergeben sich besonders durch die geomorphologischen Bedingungen der Farafra-Senke und die geomorphologisch-klimatischen Bedingungen der Qattara-Senke.

* Dedicated to Dr. Erna WALTER on the occasion of the 97th anniversary of her birthday

0340-269X/90/0019-0149 $ 20.75

Contents

1. Introduction

1.1. Previous vegetation studies

The Western Desert of Egypt, formerly called the eastern part of the Libyan Desert, extends more than 1000 km from the Mediterranean in the north to the Sudanian border in the south, and from the Libyan border in the west to the Nile valley in the east. It thus covers approximately two thirds of the Egyptian territory. The vegetation of the Western Desert was the object of floristic, taxonomic, phytosociological, and plant ecological studies for many years. As can be seen by the local investigations (see bibliographies of DRAR 1955 and KNAPP 1974, and literature cited in the following chapters), and by the summarizing reviews (KASSAS 1971; KNAPP 1973; BATANOUNY 1979; KASSAS & BATANOUNY 1984; see also QUÉZEL 1965; ZOHARY 1973, 1982; WALTER 1973 with impressive vegetation views photographed by Dr. Erna WALTER; WALTER & BRECKLE 1984), most of the research has been done in the coastal area, and later on, especially after the opening of the oases road, in the different oases. Great parts of the Western Desert are very remote, and were virtually unknown still in the beginning of our century. This is especially true for the southwest (ALAILY et al. 1987a). The gradient of the human impact (BATANOUNY 1983) from the agriculturally used coastal area to the practically inaccessible south is also a gradient of the scientific knowledge.

The present investigation aims at filling some of these gaps. The opportunity to do so arose by joining the Special Research Project "Geoscientific problems in arid areas", funded by the Deutsche Forschungsgemeinschaft. This gave the opportunity to carry out investigations in many parts of the Western Desert, especially the central parts (see chapter 2.). The westernmost and the easternmost sectors deserve further studies.

1.2. Geomorphology and geology

Regarding geomorphology (SCHIFFERS 1971) and geology (THE EGYPTIAN GEOLOGICAL SURVEY AND MINING AUTHORITY 1981), the Western Deserts seems rather uniform as compared with other parts of North Africa. The main landscapes and their geological conditions can be described as follows (Fig. 1):

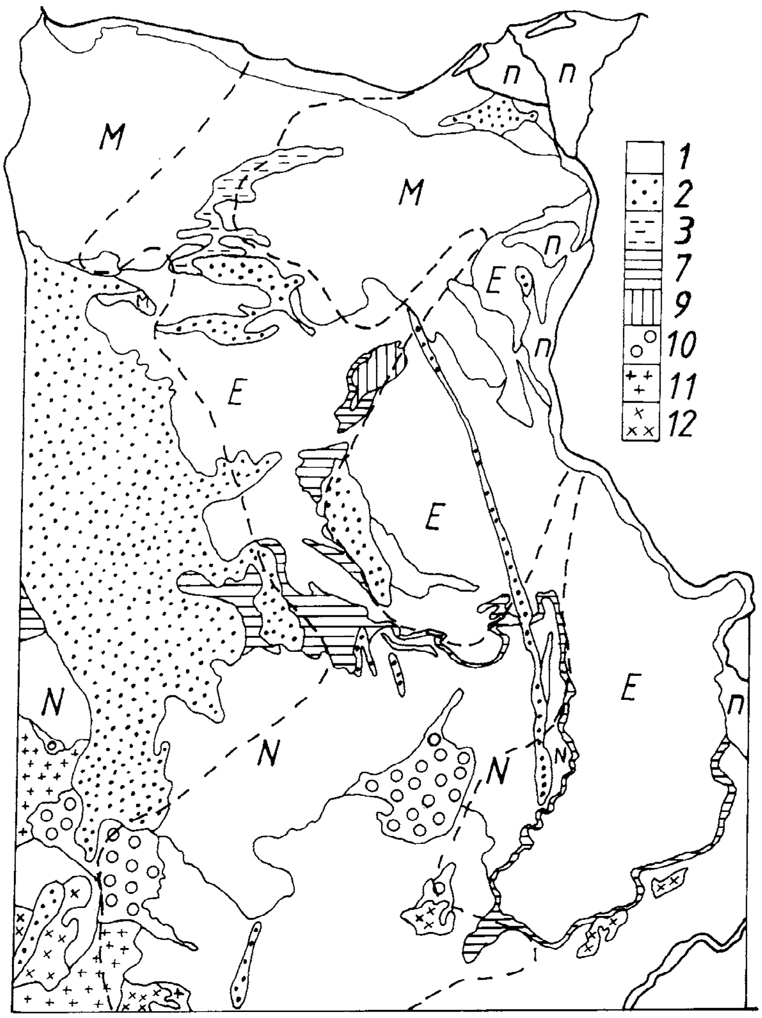

Fig. 1. Geological map, designed on the base of THE EGYPTIAN GEOLOGICAL SURVEY AND MINING AUTHORITY (1981, the abbreviations refer to this map). – A) Quaternary: 1) littoral dunes and salt marshes, coastal wadi and playa deposits, raised beaches, inland playa deposits and sheets (Q, Qc); 2) large sand dune areas (Qd); 3) Sebkha deposits (Qsb); 4) = n: Nile deposits (Qn). B) Tertiary: 5) = M: miocene clastics and carbonates, marginally also pliocene and oligocene (Tpl, Tm, To); 6) = E: eocene limestone and paleocene shale and chalk (Te, Tp). C) Cretaceous: 7) upper cretaceous clastics, phosphate and carbonate rocks (ku); 8) = N: Nubia formation (Kn); 9) Cenomanian and Turonian clastics with thin carbonates (Km). D) Other: 10) jurassic clastics (J); 11) precarboniferous clastics (PZ); 12) granitoids and gneiss (gy, go, gn). The dashed line indicates the surveyed area.

Adjacent to the littoral zone, the coastal zone with an elevation up to appr. 150 m shows quaternary wadi deposits and raised beaches with calcrete formation (STAHR et al. 1985). Located between the coastal zone and the Siwa-Qattara depressions, the Marmarica plateau is made up of Tertiary limestone, forming a steep escarpment especially around the western and northern parts of the Qattara depression. Here, at altitudes between -60 and -130 m Sebkha deposits prevail. The limestone plateau extends further east to the Bahariyah-

Giza road and extends altitudes from below sea level (in parts of the Qattara depression) up to 230 m. These landscapes are parts of the Northern Sahara in the sense of SCHIFFERS (1971).

Large dune systems of different orientations occur between the Qattara and Sitra depressions and south of the latter. Larger NNW-SSE directed dunes occur in the Great Sand Sea southward up to the Gilf Kebir plateau, with some also crossing the eocene limestone plateau. The latter extends from the Siwa, Sitra and Faiyum regions southward to the New Valley, where it forms a high and steep escarpment. Depressions contain the Bahariyah, Farafra, Ain Dalla and Abu Minqar oases. Near the escarpment and around the oases paleocene limestones occur, some of them forming the spectacular chalk rocks ('white desert') near Farafra. The plateau ascends from 0 m in the north to 500–600 m in the south. All these landscapes are part of the Central Sahara in the sense of SCHIFFERS (1971).

The remaining landscapes in the very south and the southwest are part of the Southern Sahara. The New Valley oases and the small wild oases of the Darb el-Arba'in region are situated in the area of the Nubia formation. This formation, consisting mainly of clastics and sandstones, extends in a broad belt between the Kharga oasis and the Great Sand Sea, and is mixed up with large sand sheets. The same is true for the adjacent belt of Jurassic clastics, which forms a series of hills, and the Gilf Kebir plateau as well. The southernmost belt is characterized by extremely large and very uniform sand sheets, with some, like the Great Selima sand sheet, continuing to Northern Sudan. Here young granitoids can be found, in the southwestern corner also old granitoids, gneiss, and paleozoic (precarboniferous) rocks. Very important for the development of plant life are different kinds of volcanites which occur locally in most parts of the Western Desert. The depression of the Kharga oasis is deeper (10 m) than that of the Dakhla oasis (appr. 120 m). The sand sheets range between 300 m in the east to 600 m in the west whereas the Gilf Kebir plateau reaches nearly 1100 m above sea level.

1.3. Climate

The Western Desert in its full extension is part of Zonobiome III, the zone of subtropical arid deserts (WALTER & BRECKLE 1984). The temperature regime is characterized by mild winters and very hot summers, and by increasing continentality from north to south. Whereas the average January temperatures (data from WALTER & LIETH 1967) remain rather constant between 12 and 14 °C (Fig. 2), the July mean rises from appr. 25 °C at the Mediterranean coast to appr. 31 °C in the south. For this reason the mean annual temperature increases from appr. 19 °C at the coast to appr. 24 °C (Kharga 23.6 °C) in the south. Occasional temperature measurements in the Gilf Kebir area lead to the conclusion, that this mountaineous area is several degrees cooler than the Kharga oasis (ALAILY et al. 1987a). Unfortunately, northing is known about the climate of Qara oasis, which is situated below sea level and is surrounded by a desert vegetation rich in Sudanian species (BORNKAMM & KEHL 1985, for further discussion see chapter 3.3.3.).

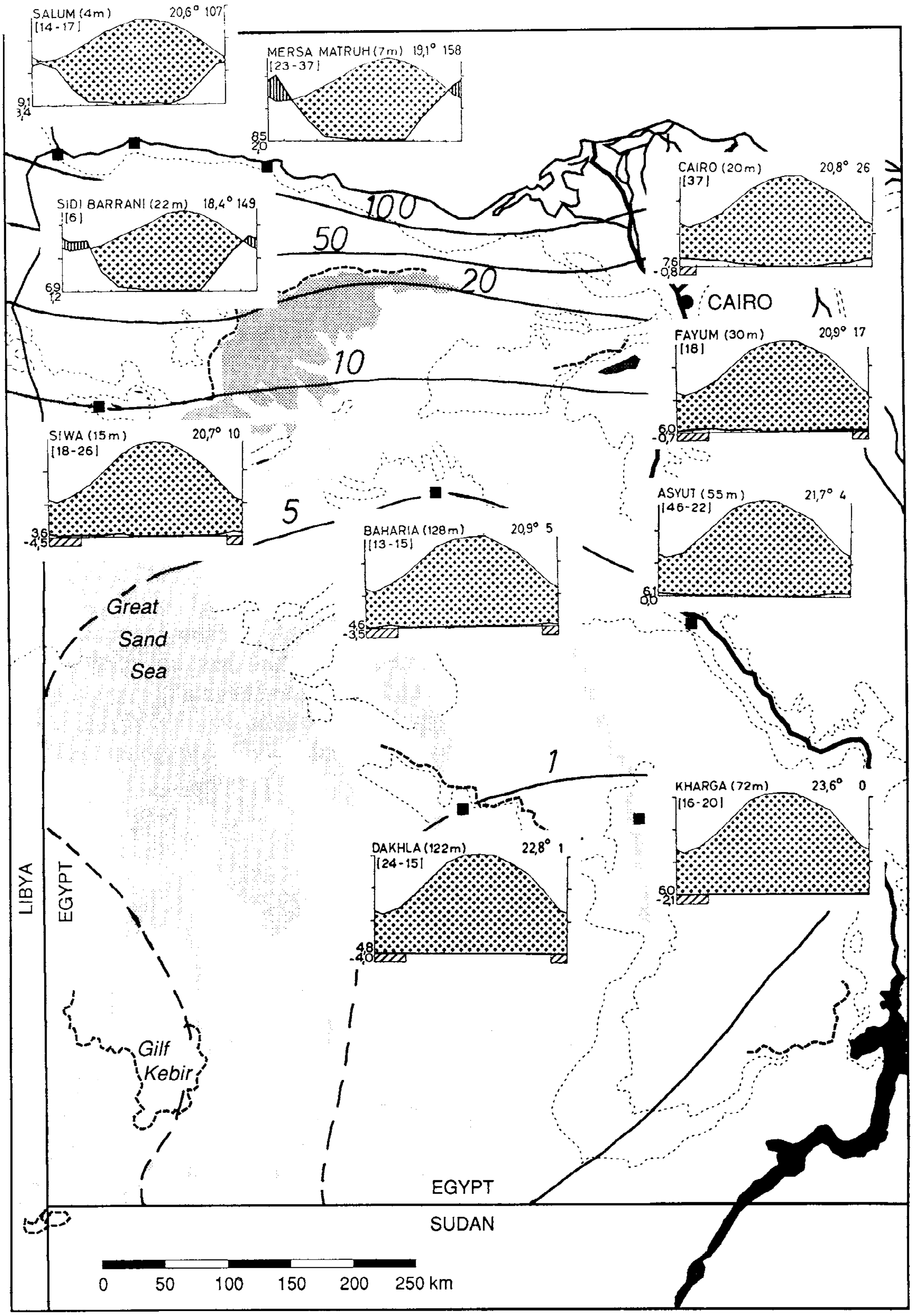

Fig. 2. Climatological map with isohyetes in mm/year and climatic diagrams from WALTER & LIETH (1967). Thick broken lines: prominent escarpments; weak broken lines: other geomorphological features; dark shadow: Qattara depression and lakes; leight shadow: sand dune areas.

The recently erected climatological station in the Camp East Oweinat fills a large gap. An evaluation of the measurements of the first three yerars (Ruck 1989) showed close relationship to the climate in Dakhla. The winter was slightly colder, the summer probably very slightly hotter, and the relative humidity was 8 % lower than in Dakhla (18 vs 26 % at 14 hrs). Temperatures below zero can be reached in the more continental parts of the Western Desert; soil surface frost is a regular phenomenon in the mid-winter months. This is even true for the oases (Abd El-Ghani 1985) and for East Oweinat (Ruck 1989). The absolute maxima of the southern stations are around 49 °C. The most striking climatological feature is the precipitation gradient. As a consequence of the scarcity of settlements precipitation maps of the Western Desert are arbitrary. The map in Fig. 2 was designed according to the data from Walter & Lieth (1967), comparing the map with Sundborg & Nilsson (1985) for the north, and of Dubief (1971) for the south. Nevertheless it can be stated that the ratio between the northern and the southern stations amounts to more than 100. Near the Mediterranean the annual precipitations is in the range of 150 mm, decreases in the Qattara depression to appr. 20 mm, and 5 mm or less in the central parts of the area under investigation (probably also in the Gilf Kebir plateau, see Alaily et al. 1987a). The south, with 1 mm/year or less, is practically rainless – in the Camp East Oweinat no measurable rainfall has been detected yet. Such low figures indicate the low frequency and amount of rainfall. All parameters (extremely low rainfall, minimum of cloudiness, highest isolation time in July, Dubief 1971) show that SW-Egypt is the driest part of the Sahara and therefore is the driest location in the world. It will be shown, however, that even under these special conditions, eventual precipitation events cause plant life.

2. Material and methods

The botanical investigations were carried out over several expeditions, covering a large part of the Western Desert (as indicated in Fig. 1). The following lists the travels and botanical participants (authors with initials, others by name):

1) Cairo-Mersa Matruh-Qattara depression and back, III 1982 (R.B., H.K.)
2) Cairo-Kharga oasis-Dakhla oasis – Abu Ballas-Gilf Kebir plateau – Bir Tarfawi – Six Hills-Kharga oasis – Cairo, XI/XII 1982 (R.B., H.K.)
3) Cairo-Mersa Matruh – Marmarica plateau – Qara – Mersa Matruh – Cairo, III/IV 1983 (H.K.)
4) Cairo-Kharga oasis – Six hills – Camp East Oweinat – Abu Ballas region and back – Bir Dibis region – Bir Nakhlai – Bir Kiseiba – Camp East Oweinat – Kharga oasis – Cairo, III/IV 1984 (R.B.)
5) Cairo-Kharga oasis – Dakhla oasis – Abu Minqar and Farafra regions – Ain Dalla – Sitra region – Bahariya oasis – Cairo, III/IV 1985 (R.B., H.K.)
6a) Camp East Oweinat – Gilf Kebir plateau – Gebel Kamil – Camp East Oweinat, IV 1986 (H.K., F. Darius)
6b) Camp East Oweinat – Bir Nakhlai – Lake Nasser – Bir Kiseiba – Camp East Oweinat, IV 1986 (K.H., U. Schneider)

7) Cairo-Bahariya oasis – Sitra region – Qara region – Mersa Matruh – Cairo, IX/X 1986 (R.B., F. DARIUS)
8) Cairo – Mersa Matruh – Siwa and back, XI/XII 1988 (R.B., H.K., F. DARIUS, U. SCHNEIDER)

The sampling followed the procedure of phytosociological relevés, but it was necessary to adapt the methods to the specific characters of the desert. For all species, height and vitality were recorded. Three classes of vitality were adopted:

1 plant crown to at least 50 % with greening branches
2 plant crown more than 50 % dead
3 plant completely dead.

Therophytes which were encountered dead but had performed their life cycle in the same season were attributed to class 1. In the tables average values for the percentage of every class of the total number of plant records were given. In vegetation types, where the majority of the plant specimens were dead, no cover values were used because cover estimations would have been misleading.

The size of the sampling plots was 25 m^2 throughout. The shape fo the plots was adapted to the shape of the vegetation stand (5 m x 5 m, 2.5 m x 10 m or even 1 m x 25 m). This seems to be a very small size, but it has to be taken into account that in desert vegetation small scale variation can be detected. According to NOY-MEIR et al. (1970) variation of quadrat size over the rang 4–256 m^2 hardly affected association analysis in desert vegetation. Furthermore, some stands consisted of only a single specimen or small group of plants. Our estimations of the minimum area showed a first level of homogeneity at about 25 m^2. Slightly higher values were found by MIGAHID & AYYAD (1959). For this reason, other researchers also worked with similar or even smaller plots (e.g. AL-NOWAIHI et al. 1976, DANIN 1978, KENNENNI in print). Other homogeneity levels are reached with larger sizes (KASSAS 1953). As a consequence of the small plots, the frequency figures become rather low. To overcome this difficulty, species occurring outside the plot in the same stand were carefully recorded. These additional species were not used for the calculation of cover and of species number, so that the species numbers in all vegetation units refer to the same area of 25 m^2. They were however, included in the calculations of life forms and the phytogeographic elements. The large numbers of transects or small maps (see Figs. 4, 5, 7, 8, 16, 17, 18 and 19) make clear the position of the single vegetation units within the vegetation islands or within the landscape.

For the calculation of life forms the following classes were discerned: 1) macrophanerophytes = trees, 2) nanophanerophytes = shrubs, 3) chamaephytes = low shrubs, dwarf shrubs, half shrubs and woody perennials, 4) perennial herbs, 5) annuals or biennials. For a given species no overlapping between the classes was allowed. The attribution to the life forms and phytogeographic elements mostly followed ZOHARY (1966, 1972) and FEINBRUN-DOTHAN (1978, 1986). The calculation of the mean values for the phytogeographic elements followed the procedure of BORNKAMM & KEHL (1985). Four classes were discerned: 1) Mediterranean (and species extending further into the Euro-Sibirian region), 2) Irano-Turanian, 3) Saharo-Arabian and 4) Sudanian (or extending further into tropical regions). Azonal or plurizonal species were split into the classes they cover, i.e. cosmopolitan species were attributed to each class by 25 %. In Table 19, therefore only the four classes are listed, and not their combinations. Because the more unizonal or the more plurizonal character also is an important information on a vegetation unit, the contribution of plurizonal species in percentage of the total species records was presented separately (Table 19).

Vegetation units of more than local importance were described as associations, subassociations or variants. If the average species number was lower than 2.0 they were described only as stands. A problem in the species-poor desert vegetation is that only very few character species are available (DANIN et al. 1975). Another problem is that the associations sometimes are disintegrated, which means that some species occur in monotypic stands without growing together at the same place. An outstanding example is *Anabasis articulata* which was associated with different species in different regions. Pure stands of *Anabasis*, therefore, can only be understood in a regional context and do not give cause in every case to create an 'Anabasetum'. To a lesser extent this is also true for *Zygophyllum album* and *Francoeuria crispa*.

The nomenclature followed TÄCKHOLM (1974) as far as possible, but the nomenclature of the Chenopodiaceae followed FREITAG (1989). The Chenopodiaceae were kindly determined by H. FREITAG (Kassel), the Poaceae by H. SCHOLZ (Berlin/W.). Since both scientists received representative specimens from some, but not from all sampling localities they are not responsible for the data given in the distribution maps. The specimens collected will be deposited in the Herbarium of the Botanical Museum Berlin/W.

The *Tamarix* species were determined according to BAUM (1978) with the exception of *Tamarix nilotica*, which was taken as a complex (in accordance with ZOHARY 1972). *Zilla biparmata* was found in NW, *Zilla spinosa* in other parts; but since the characters not always were clearly developed, in the tables only *Zilla spinosa* s.l. was recorded.

3. Results

3.1. Introduction

As in other deserts, the vegetation in the Eastern Desert can be differentiated into vegetation dependent on precipitation, on groundwater and/or irrigation (WALTER 1963, 1973; BATANOUNY 1973, 1979). This scheme was also useful in the present investigation in spite of the fact that feeding by precipitation is not always clearly discernible from feeding by groundwater (KEHL 1987). Precipitation means direct effects of rain, as well as run-off (BATANOUNY 1979) and transient storage of water bodies in the soil or subsoil (ABDEL RAHMAN & BATANOUNY 1965, BATANOUNY 1973). The drier the climate is, the more important are the run-off conditions and characters which enable the soil to protect buried water resources. These include sand cover (WALTER 1963), geomorphology (KASSAS & ZAHRAN 1965), and water capacity (ALAILY et al.

1987a, BORNKAMM 1987a). Here, relatively long-lasting water bodies can be developed which support at least some specimens of woody species (*Acacia raddiana* or *Tamarix* spec.), as in groundwater-influenced habitats. Concerning life forms the investigated areas shows 5 very different types: 1) Trees occur near groundwater or under irrigation only. Precipitation-dependent perennial vegetation can be separated into 2) diffuse or 3) contracted vegetation (MONOD 1954, WALTER 1963). 4) Accidental vegetation (KASSAS 1952) is composed of ephemerals or perennials aquiring an ephemeral growth form (HAINES 1951, BATANOUNY 1979) whereas 5) allochthonous ecosystems (BORNKAMM 1987b) are void of green plants.

3.2. Precipitation-dependent diffuse vegetation

3.2.1. Plant communities of the littoral dunes

Near Bourg El-Arab TADROS (1956) distinguished between communities of young dunes dominated by *Ammophila arenaria* and *Euphorbia paralias*, and those of older dunes, dominated by *Crucianella maritima* and *Ononis vaginalis*. AYYAD (1973) refined this classification into 5 units (see also AYYAD & EL-BAYYOUMI 1980, KAMAL 1983, EL-GHONEMY et al. 1977). Similar associations have been described from Ras El-Hikma (TADROS & EL SHARKKAWI 1960, EL-SHARKAWI 1961) and Sidi Barrani (MIGAHID et al. 1971, table III; MIGAHID et al. 1974: Ammophila arenaria ass.; EL-KADY 1987: Elymus farctus-Echinops spinosissimus ass.). Since we do not have our own relevés, these communities will not be discussed here.

3.2.2. Atriplex halimus-Lycium europaeum ass. (Table 1)

Most types of precipitation-dependent vegetation exhibit an average height of less than 1 m with the exception of the Atriplex-Lycium ass. where especially *Lycium* itself can reach 3 m or more. It is therefore the most apparent association which occurs in the Mediterranean coastal zone in the most favorite sites, namely center (bed) of small wadis, edges of larger wadis and upstream parts of wadis. As the figures of vitality show it is definitely a perennating association. The association shows considerable floristic variation. In the wadi origins in 'pseudo-spring' situations, the Phlomis floccosa subass. (also with *Periploca angustifolia*) is developed (1 in Table 1). Here both species number and height attain maximum values. the subass. of Salsola schweinfurthii (3) exhibits several indicators of salinity, the subass. of Plantago albicans (4) a great number of grazing indicators which are less frequent in the typical subass. (2) but occur regularly in the following ass. (Thymelaea-Plantago ass., see 3.2.3.). The phytogeographical analysis makes clear that already here the Saharo-Arabian element is the dominant one, but the Mediterranean element is a strong codominant in the typical subassociation which shifts to the Irano-Turanian element in the Salsola and Plantago subassociations (Table 19). Already here, as in nearly all other associations, the

Table 1. Atriplex halimus-Lycium europaeum ass. (AL): 1 AL-Ph subass. of Phlomis floccosa; 2 AL-t typical subass.; 3 AL-S subass. of Salsola schweinfurthii; 4 AL-PL subass. of Plantago albicans.
Vitality: species living/predominantly dead/completely dead in % of all records; T typical relevé (= nomenclatural type for new vegetation units); C cover (%); P presence (%).

	-1- AL-Ph			-2- AL-t			-3- AL-S			-4- AL-PL		
average species number		28.0			5.7			12.8			11.0	
average height (dm)		19			11			12			13	
number of relevés		3			11			6			11	
vitality		99/0/1			100/0/0			100/0/0			100/0/0	
	T	C	P	T	C	P	T	C	P	T	C	P
Phlomis floccosa	2	4.3	100									
Periploca angustifolia	1	1.7	100									
Lophochloa cristata	+	0.5	100									
Micromeria nervosa	+	1.0	67									
Paronychia arabica	+	0.3	67									
Bromus fasciculatus	+	1.0	67									
Prasium majus	+	0.3	67									
Lycium europaeum	1	16.7	100	3	9.7	100	+	10.2	100	3	16.0	100
Atriplex halimus	1	5.0	100	1	0.7	64	3	8.8	83	1	1.3	100
Salsola schweinfurthii							+	1.1	83			
Salsola tetrandra					0.1	27	+	0.4	83		0.2	36
Echinops spinosissimus							+	0.3	83		0.0	9
Anacyclus alexandrinus	+	0.5	100					0.3	67		0.1	27
Plantago albicans	+	0.5	67					0.3	17	+	0.2	45
Adonis dentatus	+	0.5	67					0.3	67	+	0.5	64
Pituranthos tortuosus		0.2	67					0.3	50		0.2	36
Lobularia arabica										+	0.3	55
Launea nudicaulis	+	0.3	67		0.0	9		0.1	17			
Noaea mucronata	+	0.3	67		0.1	18					0.1	27
Verbascum letourneuxii	+	0.3	67								0.0	9
Ephedra aphylla	+	0.3	67		0.0	9						
Erodium hirtum	+	0.2	33		0.0	9					0.1	18
Anabasis articulata		0.2	33		0.0	9		0.6	50		0.1	18
Gymnacarpos decandrum	1	0.8	33		0.1	18		0.1	17	+	0.1	18
Salsola vermiculata ssp. villosa		0.2	33		0.1	27		0.3	50		0.1	18
Iris sisyrhinchium	+	0.2	33							+	0.0	9
Traganum nudatum					0.9	73		0.6	50	+	0.6	55
Thymelaea hirsuta				(+)	0.4	36		0.2	33		2.2	55
Haloxylon scoparium					0.1	27					0.2	9
Helianthemum lippii					0.1	27		0.2	33		0.0	9
Echiochilon fruticosum					0.1	18		0.2	33			
Peganum harmala					0.0	9					0.0	9
Scorzonera alexandrina								0.2	33		0.1	18
Salvia lanigera								0.1	17		0.1	18
Schismus barbatus	+	0.5	100					0.1	17	+	0.1	27
Trigonella stellata	+	0.5	100					0.2	37	+	0.2	36
Ifloga spicata	+	0.3	67		0.0	9		0.2	33		0.2	36
Cutandia dichotoma	+	0.3	67		0.0	9		0.3	50		0.2	36
Malva parviflora		0.2	33		0.2	27	+	0.3	67	+	0.4	100
Emex spinosus		0.2	33								0.0	9
Ammochloa palaestina		0.2	33					0.1	17			
Allium spec.					0.2	27		0.3	67		0.4	100
Lappula spinocarpos				+	0.0	9	+	0.3	50		0.0	9
Filago desertorum								0.1	17		0.1	18
Maresia pygmaea								0.1	17		0.0	9

In only one of the units occurred: AL-Ph: Matthiola longipetala +/0.3/67; Calendula micrantha +/0.3/67; Erodium spec. +/0.3/67; Spergularia diandra -/0.3/67; Moricandia nitens 1/0.8/33; Phagnalon barbeyanum +/0.3/67; Carrichtera annua +/0.3/67; Asphodelus microcarpus +/0.3/67; Dactylis hispanica +/0.3/67; Fagonia cretica +/0.3/67; Reichardia tingitana +/0.3/67; Gymnarrhena micrantha +/0.3/67; Diplotaxis viminea +/0.3/67; Euphorbia peplus +/0.3/67; Althaea ludwigii +/ 0.3/67; Plantago crypsoides -/0.3/67; Medicago aschersoniana -/0.3/67; Aegilops kotschyi -/0.3/67; Hordeum leporinum -/0.3/67; Hippocrepis cyclocarpa -/0.3/67; Rumex vesicarius -/0.3/67; Valantia hispida -/0.3/67; Astragalus asterias -/0.3/67; Reseda decursiva -/0.3/67; Herniaria hemistemon -/0.3/67.
AL-T: Kickxia aegyptiaca -/0.0/18; Stipa parviflora -/0.1/18; Arnebia linearis -/0.0/9; Asparagus stipularis -/0.0/9; Lotus creticus -/0.0/9. AL-S: Astragalus annularis -/0.2/17. AL-PL: Astragalus gyzensis -/0.1/18; Cynodon dactylon -/0.1/18; Artemisia inculta -/0.0/9; Launaea tenuiloba -/0.0/9; Carduncellus mareoticus -/0.0/9; Enarthocarpus lyratus -/0.0/9.

formation of phytogenic hillocks plays a role (BATANOUNY & BATANOUNY 1968, 1969).

The Atriplex-Lycium ass. clearly shows the physiognomy of a shrub community, yet calculations based on the presence data show that the shrubby life form is the most frequent one only in the typical subass. (Table 1, Photo 1). The reason for this is the fact that this association (like the following ones) is heavily grazed, especially by goats, and thus lives in a process of degradation. *Periploca angustifolia* also can grow outside *Lycium* shrubs where it might be an indicator of former *Atriplex-Lycium* stands. But since the degradations in this area lasted for thousands of years and since both *Atriplex halimus* and *Lycium europaeum* show considerable hemerochory we do not know whether our association was a part of the original natural vegetation or not. *Prasium majus* usually is hidden inside shrubs of *Periploca* where it can not be browsed.

Fig. 3 makes clear that this association is distributed only in short distance to the coast of the Mediterranean. Fig. 4 shows an example of local distribution: the typical subass. surrounds the center of a shallow depression, the Salsola subass. covers the upstream part of the depression whereas the Plantago subass. occurs in a transition zone to the vegetation of the plateau (see also Fig. 5A).

Photo 1. Atriplex halimus-Lycium europaeum ass. typical subass. (2) in a small tributary to the Wadi Garawla. The right side of the wadi bed is covered with up to 2 m high shrubs of *Lycium europaeum* (dark colour), on the left (lighter colours) *Thymelaea hirsuta* grows up to 1.5 m high. The plateau surrounding the wadi is covered by different types of the Thymelaea hirsuta-Plantago albicans ass.

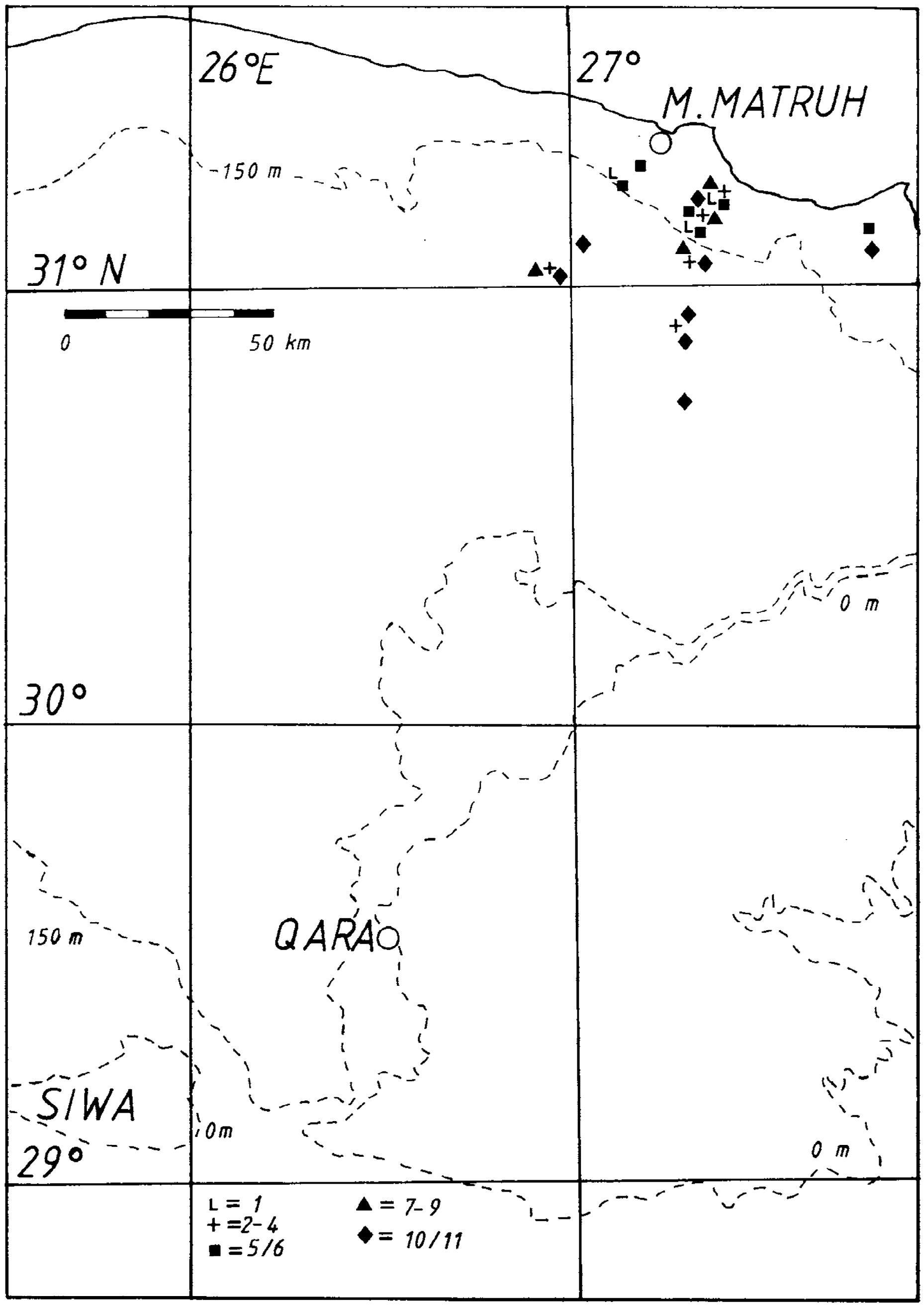

Fig. 3. Sampling places of vegetation units 1–11.
Atriplex halimus-Lycium europaeum ass.: 1 subass. of Phlomis floccosa; 2–4 typical, Salsola schweinfurthii and Plantago albicans subass.
Thymelaea hirsuta-Plantago albicans ass.: 5/6 Ammochloa palaestina subass.; 7–9 typical subass.; 10/11 Salsola schweinfurthii subass.
For further information see Fig. 2.

Lycium shrubs are widespread around the Mediterranean and have been observed near Mersa Matruh earlier (GIRGIS & DESOUKY 1977). Nevertheless our association seems not yet to have attracted much attention. EL-HADIDI &

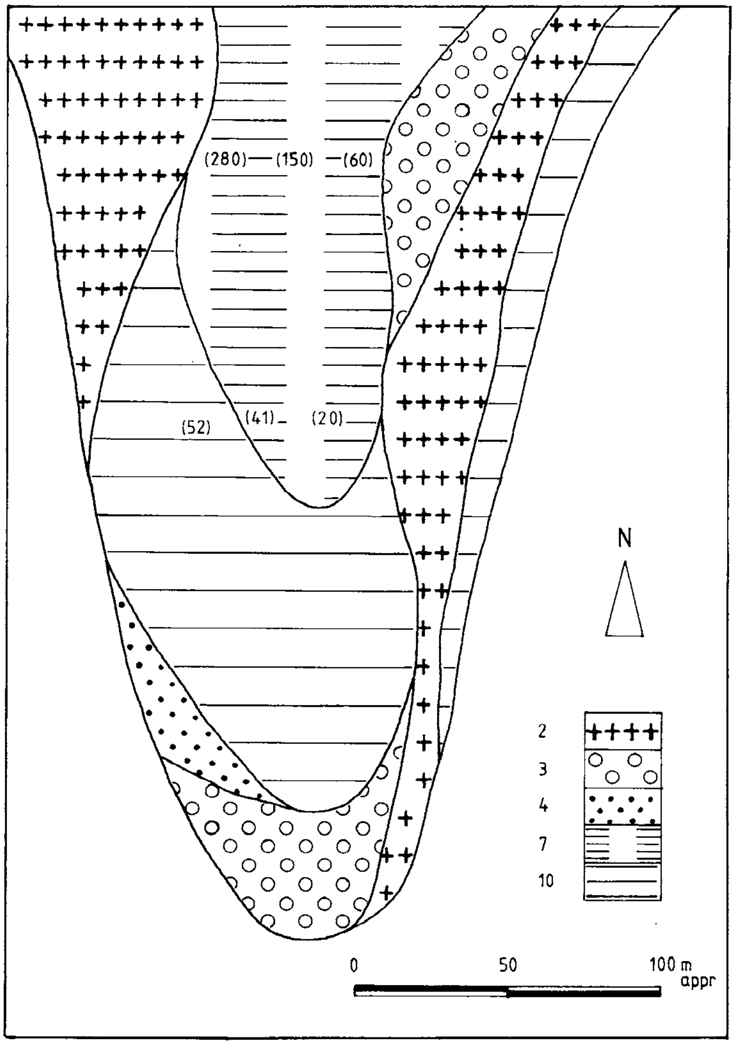

Fig. 4. Vegetation map at Raqabet el Sikka, 31°06'N, 27°18'E (40 relevés, 11.4.83).
Atriplex halimus-Lycium europaeum ass.: 2 typical subass.; 3 Salsola schweinfurthii subass.; 4 Plantago albicans subass.
Thymelaea hirsuta-Plantago albicans ass.: 7 typical subass. var. of Traganum nudatum; 10 subass. of Salsola schweinfurthii var. of Atriplex halimus.
The center is cultivated, the figures indicate the number of barley plants per sqm.

AYYAD (1975) published three relevés from Wadi Habis – two of them (upper slope and plateau) apparently belonging to the Phlomis subass., one (middle slope) to the Plantago subass. The Phlomis subass. is also documented from Ras El Hikma (MIGAHID et al. 1955 in sand plains, table 8) and Wadi Hashem near Fuka (KAMAL 1983). It is interesting to note that in contact with this community *Ceratonia siliqua* and *Rhamnus oleoides* were found (GAUBA 1935, LONG 1955). LONG (1955) believed that these stands may be reminiscent of degradated maquis of the Oleo-Ceratonion type. Because in the meantime no further evidence has yet been found, this hypothesis must be tested carefully in future.

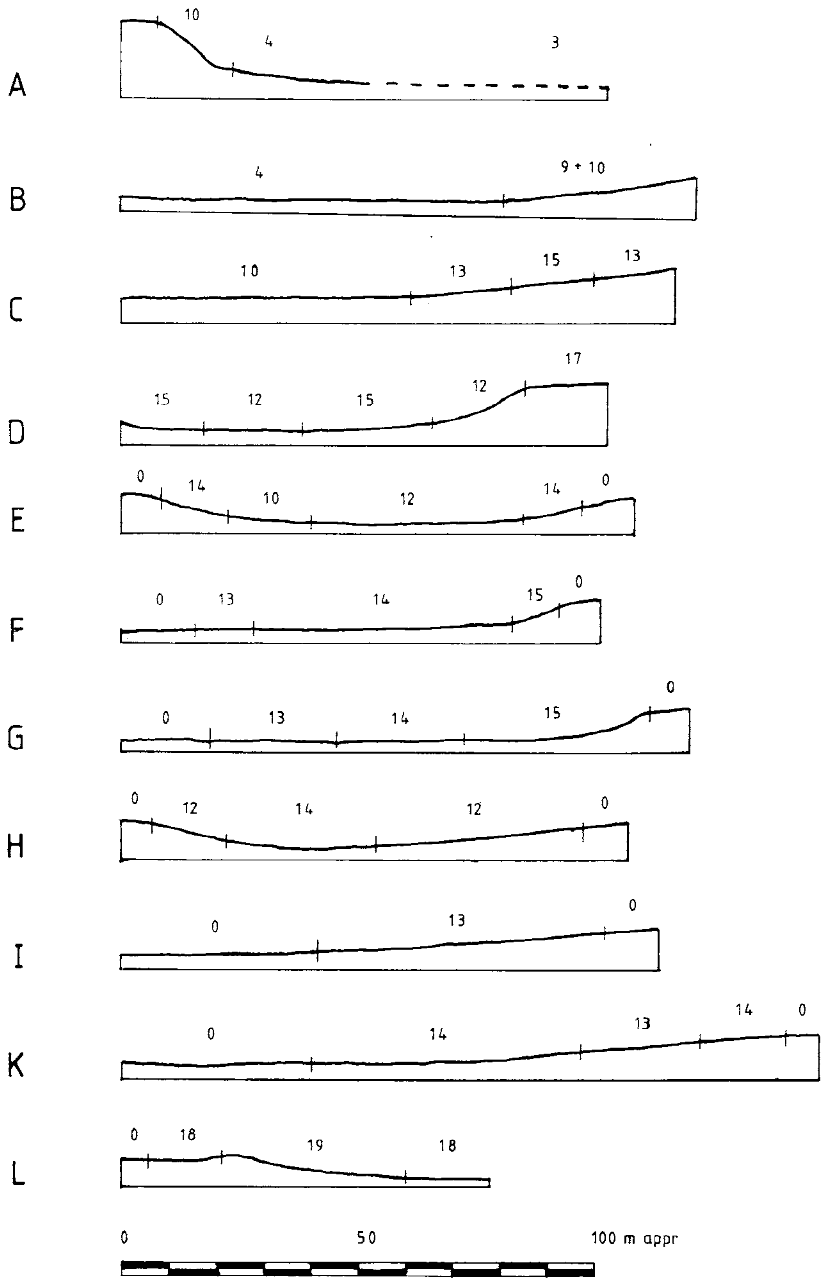

Fig. 5. Vegetation transects between the Mediterranean coast and the Qattara depression. The height scale is arbitrary. - A) 31°06'N, 27°19'E, close to Raqabet el Sikka (4 relevés, 12.-14.4.83); B) small depression, near Raqabet el Sikka, 31°06'N, 27°19'E (7 relevés, 7., 25.3.82); C) very shallow depression, 30°57'N, 27°16'E (6 relevés, 24.3.82); D) shallow depression, 30°53'N, 27°17'E (7 relevés, 24.3.82); E) shallow depression, 30°46'N, 27°15'E (7 relevés, 23.3.82); F) shallow depression, transect through the vegetation belt around a vegetation-free center, 30°42'N, 27°18'E (7 relevés, 23.3.82); G) like F, 30°39'N, 27°18'E (6 relevés, 23.3.82); H) transect through a vegetation stand, 30°58'N, 26°50'E (10 relevés, 28.3.83); I) like F, 30°35'N, 27°18'E (7 relevés, 8.4.83); K) like F, 30°38'N, 27°18'E (5 relevés, 8.4.83); L) transect through a shallow depression and part of the plateau, 30°15'N, 27°15'E (8 relevés, 21.3.83).
Plant communities: 0 vegetation-free.

KASSAS & GIRGIS (1965) describe an *Atriplex* unit and a *Lycium arabicum* unit from the Eastern Desert which are floristically so closely related that they probably belong to one association. They differ in a number of species from our association but the *Atriplex* unit is a counterpart to our Salsola subass.

3.2.3. Thymelaea hirsuta-Plantago albicans ass. (Table 2)

This association is the main association on plateaus or slopes, and in depressions and runnels in the Mediterranean coastal region of the Marmarica. Although *Thymelaea hirsuta* can reach a height of 1.5 m, the average height is less than 1 m in all units. Next to grazing, the main determinants of vegetation are sand cover and salinity. Accumulations of loose sand favour the occurrence of psammophytes (Ammochloa palaestina subass., 5), many of which are widespread in Mediterranean countries. The life form spectrum, therefore, shows a maximum of annuals, and the Mediterranean geoelement holds a codominating position next to the Saharo-Arabian element (Table 19). Species richness attains maximum values here, whereas in the other units of this association it is two to five times lower.

In the fields of barley cultivated under such conditions we do not find a special weed community but a psammophytic var. (Anagallis var.) of the Thymelaea-Plantago ass. (6). One of the most important plants of this vegetation unit is *Asphodelus microcarpus* which uses to grow in deep soils with relatively good water and nitrogen supply (AYYAD & HILMY 1974). At more intensely used sites the vegetation differs: In agricultural fields from several places in NW-Egypt an Achillea santolina ass. has been described as weedy vegetation unit (TADROS & ATTA 1958b, KAMAL 1983). We have seen this association in settlements bud did not make our own relevés.

The typical subass. does not contain a large number of Mediterranean annuals. If there is sufficient sand cover, Saharo-Arabian annual psammophytes occur. Crop cultivation is not frequent any more, but it is possible, as can be seen by the example of the Traganum var. (7) which occurs in the very center of a shallow depression (Fig. 4). Certainly only a minority of the potential vegetation units (first four columns of Table 2) are comprised which may be caused by the interaction of ploughing and grazing. In most variations of the typical subass. (and the following units) grazing prevails. Local

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Fig. 5. (cont.)
Atriplex halimus-Lycium europaeum ass.: 3 Salsola schweinfurthii subass.; 4 Plantago albicans subass.
Thymelaea hirsuta-Plantago albicans ass.: 9 typical subass.; 10 Salsola schweinfurthii subass.
Artemisia inculta-Carduncellus mareoticus ass.: 12 Thymelaea hirsuta subass.; 13 Atriplex halimus subass.; 14 typical subass. typical var.; 15 typical subass. Haloxylon scoparium var.
Pituranthos tortuosus-Gymnocarpos decandrum ass.: 17 typical subass.
Anastatica hierochuntica-Anabasis articulata ass.: 18 Anastaticetum nudum; 19 Anabasis articulata subass.

Table 2. Thymelaea hirsuta-Plantago albicans ass. (TP): 5/6 TP-A Ammochloa palaestina subass.: 5 TP-AA Anagallis var., 6 TP-At typical var.; 7–9 TP-t typical subass.: 7 TP-tT var. of Traganum nudatum, 8 TP-tP var. of Peganum harmala, 9 TP-tt typical var.; 10/11 TP-S subass. of Salsola schweinfurthii: 10 TP-SA var. of Atriplex halimus, 11 TP-St typical var.
For further information see Table 1.

		-5-			-6-			-7-			-8-			-9-			-10-			-11-	
		TP-AA			TP-At			TP-tT			TP-tP			TP-tt			TP-SA			TP-St	
average species number		28.1			24.8			5.2			11.3			10.5			13.3			5.6	
average height (dm)		nn			nn			3			7			9			9			3	
number of relevés		17			5			6			6			12			41			14	
vitality		100/0/0			98/2/0			97/0/0			100/0/0			97/1/2			99/1/0			100/0/0	
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Hordeum sativum			100						100												
Pisum sativum			24																		
Anagallis arvensis	+	0.2	47																		
Lophochloa cristata	+	0.4	41		0.1	20															
Bupleurum lancifolium		0.2	35							+	0.2	33		0.0	8		0.0	2			
Chrysanthemum coronatum	+	0.1	24																		
Centaurea calcitrapa	+	0.1	24											0.1	25						
Ammochloa palaestina	+	0.1	29	+	0.4	80															
Medicago aschersoniana		0.1	29	+	0.3	60															
Astragalus asterias		0.0	12	+	0.3	60															
Marrubium alysson	+	0.1	24		0.1	40					0.1	17					0.0	2			
Hippocrepis bicontorta	+	0.1	29		0.1	20															
Linaria haelava		0.1	29		0.2	40											0.0	2			
Gymnarrhena micrantha		0.0	12	+	0.2	40											0.0	7			
Medicago littoralis		0.1	29		0.2	40								0.0	8		0.0	7			
Traganum undatum		0.0	6				1	8.1	100		0.1	17					0.6	44			
Echiochilon fruticosum	+	0.1	12				+	0.3	50							+	0.1	17			
Peganum harmala		0.1	24					0.2	17	2	5.0	83									
Lobularia arabica	+	0.3	65							+	0.4	83					0.0	2			
Centaurea glomerata										1	0.9	67									
Reichardia tingitana		0.1	18		0.2	40					0.2	33									
Salsola schweinfurthii				+	0.7	60								0.1	17	+	0.3	56	+	0.1	29
Salsola tetrandra														0.0	8		0.3	41	+	0.3	64
Atriplex halimus		0.2	18		4.0	40		0.1	17		0.2	33				1	1.5	80			
Haloxylon scoparium		0.1	18		0.6	40											0.2	37	+	0.3	29
Thymelaea hirsuta	+	3.3	100	(+)	0.6	80				1	5.0	100	+	1.1	100	+	1.5	73			
Salvia lanigera	+	0.4	88		0.3	60					0.2	33		0.3	58		0.2	34		0.0	7
Adonis dentatus	1	0.7	88		0.3	80		0.1	17	+	0.3	83	+	0.3	58		0.3	32			
Pituranthos tortuosus	+	0.4	76				+	0.1	17	+	0.2	67		0.4	75	+	0.1	76		0.1	29
Anacyclus alexandrinus	+	0.7	71	+	0.8	80								0.0	8		0.2	39			
Echinops spinosissiumus		0.4	65							+	0.1	17		0.0	8		0.1	32			
Herniaria hemistemon	+	0.2	59		0.3	60								0.0	8		0.0	7			
Launaea tenuiloba	+	0.5	53								0.1	17		0.1	25		0.1	17		0.0	17
Plantago albicans	+	1.7	53		0.6	40	+	0.2	33				+	0.3	33	+	0.2	49		0.0	7
Asphodelus microcarpus		1.0	47		0.3	60					0.1	17		1.2	50		0.0	5			
Noaea mucronata		0.3	41					0.1	17		0.1	33	+	0.2	42		0.0	5		0.0	7
Carduncellus mareoticus	+	0.2	41											0.1	17		0.1	22			
Gymnocarpos decandrum		0.2	41					0.3	50				+	0.6	92		0.2	37	(+)	0.3	64
Scorzonera alexandrina		0.5	35	+	0.3	60							+	1.8	92		1.0	46	+	0.3	64
Iris sisyrhinchium		0.2	35		0.1	20								0.0	8		0.1	15		0.0	7
Launaea nudicaulis		0.1	35		0.1	20		0.1	17	+	0.2	33		0.0	8		0.1	20			
Helianthemum lippii	+	0.1	29					0.1	17		0.1	17		0.3	67		0.1	29		0.0	7
Anabasis articulata		0.3	29	1	0.9	100		0.1	17		0.1	17	1	0.5	83		0.3	46	+	1.1	86
Stipa parviflora		0.1	24											0.1	17		0.1	15			
Kickxia aegyptiaca	+	0.1	24											0.0	25		0.1	10			
Lycium europaeum		0.3	18		0.0	20								0.0	8						
Salsola vermiculata ssp. villosa		0.1	18		0.3	60		0.1	17					0.2	33		0.1	22			
Limonium tubiflorum		0.0	18														0.0	2			

nutrient enrichment by faeces causes the development of the Peganum var. (8) (faeces sometimes cover more than 20 % of the soil surface!). The typical var. (9) grows on plateaus and in margins of depressions, or wadis, which are not saline (see Fig. 4 and 5C). Very frequently (as can be seen by the large numbers of relevés) vegetation in these kinds of habitat contain indicators of salinity so that the Salsola subass. is developed. In the Atriplex var. (10) which occurs in contact with the Lycium-Atriplex ass. (Fig. 4), *Atriplex halimus* attains the highest presence values in our

Polygonum equisetiforme	+ 0.0	12			0.1	17								
Verbascum letourneuxii	+ 0.0	12	+ 0.7	70							0.0	5		
Lotus creticus	0.0	12									0.0	10	0.0	7
Gagea reticulata	0.0	12							0.1	17			0.0	7
Suaeda palaestina	+ 0.0	6											0.0	7
Erodium hirtum			0.1	20							0.0	7	0.0	14
Poa spec.									0.0	8	0.0	2		
Zygophyllum album											0.1	7	0.1	21
Ifloga spicata	+ 0.5	94	0.2	40	0.1	17	+ 0.3	67	0.0	8	0.2	34		
Cutandia dichotoma	+ 0.5	82	0.1	20	0.1	17	+ 0.3	50	0.2	33	0.1	27		
Trigonella stellata	+ 0.5	82	0.4	80	0.1	17	0.1	17	0.1	17	0.3	34	0.0	7
Malva parviflora	0.3	65	0.2	40	0.1	17	+ 0.3	67	0.1	17	0.2	44	0.0	7
Filago desertorum	0.4	59	0.9	100	0.1	17	+ 0.2	33	+ 0.1	25	0.2	44		
Spergularia diandra	0.5	53	0.2	40							0.0	7		
Schismus barbatus	+ 0.6	47	0.6	60			+ 0.1	17			0.0	5		
Matthiola longipetala	0.2	41	0.3	60							0.0	2		
Emex spinosus	+ 0.1	35	0.6	60			+ 0.1	17			0.1	12	0.0	7
Astragalus tribuloides	0.1	29	0.1	20	0.1	17					0.0	5		
Bromus rubens	0.1	29	0.1	20										
Daucus syrticola	0.1	29	0.1	20										
Plantago crypsoides	0.1	29	0.7	60			(+) 0.0	17	+ 0.0	8	0.0	2		
Paronychia arabica	0.1	24	0.1	20										
Gastrocotyle hispida	0.1	24	0.1	20							0.0	5		
Astragalus peregrinus	+ 0.1	24	0.1	20			0.1	17	0.0	8	0.0	5		
Mesembryanthemum nodiflorum	+ 0.1	24	0.1	20			0.2	17			0.1	10		
Maresia pygmaea	0.1	18					0.1	17			0.0	2		
Pseudorlaya pumila	0.0	18							0.0	8	0.0	2		
Hedypnois cretica	0.1	18					0.1	17						
Reseda decursiva	0.0	12	0.1	20							0.0	7	0.1	14
Hordeum leporinum	0.0	12	0.1	20			+ 0.1	17						
Enarthocarpus lyratus	0.0	12	0.1	20										
Medicago coronata	0.0	12	0.1	20			0.1	17						
Asteriscus pygmaeus	0.0	12	0.2	40					0.0	8				
Polycarpon succulentum	+ 0.0	12					0.1	17						
Allium spec.	0.0	12							0.1	17	0.0	10	0.1	14
Medicago minima	0.0	6	0.1	20							0.0	10		
Lappula spinocarpos	0.0	6			0.1	17			0.1	17	+ 0.2	49		
Cynodon dactylon	0.0	6					0.1	17						
Stipa capensis	0.0	6	0.2	40							0.0	10		
Astragalus annularis	0.0	6							0.0	8	0.0	5		
Aizoon canariense	0.0	6									0.0	2		
Astragalus spec.							+ 0.1	33			0.0	5		
Astragalus gyzensis											0.0	5	0.0	7

In only one of the units occurred: TP-AA: Convolvulus althaeoides -/0.0/6; Parapholis incurva -/0.0/12; Roemeria hybrida -/0.1/18< Avena wiestii -/0.0/12; Aegilops kotschyi -/0.1/18; Linaria albifrons -/0.0/12; Lotus halophilus -/0.0/12; Trachynia distachya -/0.0/18; Papaver hybridum -/0.0/6; Diplotaxis erucoides -/0.0/18; Calendula micrantha -/0.0/6; Leptaleum filifolium -/0.0/6; Koelpinia linearis -/0.0/6; Bupleurum semicompositum -/0.0/6; Onobrychis crista -galli +/0.0/6; Astragalus stella +/0.0/6; Atractylis cancellata -/0.0/6; Bromus fasciculatus -/0.0 /6; Sonchus oleraceus +/0.0/6; Hippocrepis cyclocarpa -/0.0/6; Carduus getulus -/0.0/6; Didesmus bipinnatus -/0.0/6; Trisetaria glumacea -0.1//6; Astragalus hamosus -/0.0/6; TP-At: Cutandia memphitica -/0.2/40; Picris radicata -/0.1/20; Telephium sphaerocephalum -/0.0/20; Astragalus hispidulus -/0.1/20; Bromus scoparius -/0.1/20; TP-SA: Zilla spinosa -/0.0/2; Farsetia aegyptiaca -/0.0/2; Arnebia linearis -/0.0/2; Matricaria aurea -/0.0/2; Mesambryanthemum crystallinum -/0.0/2; Teucrium polium -/0.0/2; Lophochloa cf. pumila -//0.0/2; Centaurea cf. alexandrina -/0.0/2; Althaea ludwigii -/0.0/2; Suaeda vera -/0.0/2. TP:St: Limonium pruinosum -/0.0/7; Astragalus trigonus -/0.0/7. Bassia arabica -/0.0/7; Fagonia glutinosa -/0.0/7; Reaumuria hirtella -/0.0/7; Salsola tetrandra -/0.0/7; Erodium laciniatum -/0.0/7; Matthiola livida -/0.1/7.

association, but vanishes on the upper slopes in the direction of the plateau where it is not represented any more in t y p i c a l v a r. (11) of the S a l s o l a s u b a s s. (Table 2). This agrees with the findings of SHALTOUT & AYYAD (1988) that the biomass production of *Thymelaea* reaches maximum values in non-saline depression and on inland siliceous deposits but decreases with salinity.

The map (Fig. 3) shows that the T h y m e l a e a - P l a n t a g o a s s. occurs only in the northernmost part of the area under investigation. Phytogeographically the Saharo-Arabian elements prevail in all subunits (see Table 19), but in some cases the Mediterranean elements comprise more than 20 %. This is mainly due to the occurrence of plurizonal species which are nearly as frequent as in the Atriplex-Lycium ass., except for the typical var. of the Salsola subass.

In both associations the frequency of the Irano-Turanian element equals the frequency of the Mediterranean element (ca. 20 %). Concerning life forms, annuals – as mentioned earlier – were the most abundant life form in the Ammochloa subass. and the Peganum var. In all other cases dwarf shrubs prevail. In contrast to the Atriplex-Lycium ass. shrubs are reduced to only 14 % on the average. Nevertheless the shrub *Thymelaea hirsuta* determines the shrubby physiognomy of this vegetation units as has been reported by RIKLI & RÜBEL (1928) and RIKLI (1929).

The Thymelaea-Plantago ass. is one of the most widespread vegetation units of the coastal area and has been described under different names from different places. Most relevés in the literature are similar to our typical var. of the tyipcal subass. e.g. MIGAHID et al. (1955, on slopes, Table 5), TADROS & ATTA (1958b), TADROS & EL-SHARKAWI (1960), EL-SHARKAWI (1961, Plantago albicans ass.), BATANOUNY & ABU EL SOUOD (1972), *Helianthemum lippii* community), AYYAD 1976 and SHALTOUT 1985 (non-saline depressions), EL KADY (1987 vegetational groupings II and IV which are closely related). In several cases further differentiations were made: In Sidi Barrani MIGAHID et al. (1971, 1974, 1975a, b) separated between the Plantago albicans-Echiochilon fruticosum ass. from the Anabasetum articulatae, the former one growing on deeper, the latter on shallower soils (BATANOUNY & ZAKY 1974, see also TADROS & EL-SHARKAWI 1960, EL-SHARKAWI 1961). The shallowest sites are covered with the Gymnocarpos decandrum ass. (TADROS & ATTA 1958b; MIGAHID et al. 1971, 1974; BATANOUNY & ZAKY 1974), which at least partly corresponds to our Pituranthos-Gymnocarpus ass. and will be discussed later. In contrast in the Omayed area, AYYAD & AMMAR (1973) found a differentiation in the density values exhibiting higher density values of *Thymelaea hirsuta* on deeper soils, and *Plantago albicans* on more rocky sites (see also AYYAD & EL-GHONEMY 1976, vegetational groupings B and C, and KAMAL 1983).

Some units have been described which are similar to our Salsola subass., namely the Anabasis articulata ass. with TADROS & ATTA (1958b) and stands near roadsides at Ras El Hikma with MIGAHID et al. (1955, Table 5 corresponds to the Atriplex var.) and the Anabasis articulata ass. with BATANOUNY & ABU EL SOUOD (1972) vegetational grouping E with AYYAD & EL-GHONEMY (1976), the Salsoletum tetrandrae with TADROS & EL-SHARKAWI (1960), EL-SHARKAWI (1961), and MIGAHID et al. (1971) (corresponds to the typical var.). Similar associations also occur in Sinai and Israel (EIG 1939b, 1946; ZOHARY 1944; ZOHARY & FEINBRUN 1951; DANIN et al. 1975; DANIN 1983).

The Thymelaea-Plantago ass. is not only widespread but also (together with the salt marshes) one of the main bases for bedouin animal production as well. It shows not only relatively high biomass production but also a great proportion of palatable species and shows, therefore, considerable range potential (BATANOUNY & ZAKI 1973; MIGAHID et al. 1975c; AYYAD & EL-KADY 1982; SHALTOUT 1983; EL-KADY 1983, 1987). The special role of *Thymelaea hirsuta* can be explained by the fact, that this species is not browsed when green (EL-KADY 1987). It is, however, used for fuel, timber and shelter (AYYAD 1978, AYYAD 1980, DANIN 1983, SHALTOUT 1983). Enclosure experiments at Omayed show considerable variability of floristic composition and productivity under differing grazing pressure (AYYAD 1978, AYYAD & EL-KADI 1982, SHALTOUT & EL-GHAREEB 1985).

3.2.4. Pituranthos tortuosus-Gymnocarpos decandrum ass. (Table 3: 16 + 17)

This association grows on the miocene and quaternary plateaus of the Northern Marmarica on very shallow soils, which at least in the Zygophyllum subass. are saline. From here the species number and height decrease to the typical subass. (Photo 2). Although the shoots are browsed down to nearly undistinguishable knotlike cushions the subterranean part of the community seems to be closed. It is the last and most extreme part of the diffuse vegetation (Fig. 6). *Pituranthos tortuosus* is able to grow on very different soils (BATANOUNY 1969) but in this ass. attains maximum values.

Photo 2. *Salsola tetragona* in the Pituranthos tortuosus-Gymnocarpus decandrum ass. typical subass. (17) ca. 10 km S of Garawla.

Table 3. Artemisia inculta-Carduncellus mareoticus ass. (AC): 12 ACT subass. of Thymelaea hirsuta; 13 AC-A subass. of Atriplex halimus; 14/15 AC-t typical subass.: 14 AC-tt typ. var., 15 AC-tH Haloxylon scoparium var.
Pituranthos tortuosus-Gymnocarpos decandrum ass.: 16 PG-Z subass. of Zygophyllum album; 17 PG-t typical subass.
For further information see Table 1.

	12			13			14			15			16			17		
	AC-T			AC-A			AC-tt			AC-tH			PG-Z			PG-t		
average species number	9.1			7.4			5.7			6.4			6.1			4.5		
average height (dm)	9			6			3			3			4			3		
number of relevés	34			33			29			21			30			38		
vitality	99/1/0			98/0/2			99/0/1			100/0/0			95/5/0			96/2/2		
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Thymelaea hirsuta	1	2.1	100		0.2	3												
Atriplex halimus		0.2	15	2	2.4	100												
Artemisia inculta	+	1.0	97	+	0.4	73	1	0.6	83	+	1.1	95						
Carduncellus mareoticus	1	1.0	100	+	0.8	82	1	1.0	100	+	0.2	33	+	0.1	30	+	0.2	34
Pituranthos tortuosus	1	1.1	94	+	0.7	91	1	1.2	97	+	0.8	90	+	1.3	83	1	0.8	50
Gymnocarpos decandrum	+	0.3	53		0.1	18	+	0.1	28	+	0.4	38		0.2	40	+	0.4	53
Haloxylon scoparium		1.8	29							+	1.4	52						
Zygophyllum album								0.1	14				2	2.5	80		0.1	13
Salsola tetrandra		0.0	6	+	0.3	49		0.0	7		0.0	5	+	1.4	67			
Heliotropium bacciferum													+	0.2	30			
Scorzonera alexandrina		0.4	50		0.2	18					0.1	24					0.0	3
Helianthemum lippii	+	0.2	44	+	0.2	39	+	0.2	38	+	0.4	67	+	0.3	47		0.1	8
Zilla spinosa		0.3	38		0.0	12		0.1	14		0.1	24						
Salvia lanigera		0.2	32		0.0	6	+	0.1	10		0.0	10						
Launaea nudicaulis		0.2	26		0.2	33	+	0.3	66	+	0.2	38	+	0.2	33		0.0	3
Astragalus trigonus		0.1	26	+	0.2	49	+	0.1	35		0.1	19	+	0.2	47			
Plantago albicans		0.1	21		0.0	3												
Salsola schweinfurthii		0.1	21		0.1	12											0.0	3
Erdium hirtum		0.1	18								0.0	14		0.0	3			
Salvia aegyptiaca		0.1	18		0.0	3		0.1	10								0.3	21
Farsetia aegyptiaca		0.1	15		0.2	39		0.1	10	+	0.2	48						
Limonium pruinosum		0.0	12					0.0	7									
Asparagus stipularis		0.0	9								0.0	10					0.1	13
Anabasis articulata		0.0	6		0.0	3				+	0.1	29		0.2	53		0.0	3
Verbascum letourneuxii		0.0	3		0.0	6											0.0	3
Randonia africana		0.0	3											0.1	10		0.0	8
Francoeuria crispa					0.1	18							+	0.0	3			
Suaeda palaestina					0.1	12								0.0	3			
Kickxia aegyptiaca					0.0	6		0.0	3				+	0.0	3			
Stipagrostis plumosa								0.0	7					0.1	13			
Echinops spinosissimus								0.0	3					0.0	7			
Calligonum comosum											0.0	5		0.1	13			
Malva parviflora		0.1	12					0.0	3									
Allium spec.		0.0	12								0.0	10						
Anacyclus alexandrinus		0.0	6					0.0	3									
Euphorbia retusa		0.0	6		0.0	3							(+)	0.1	17			
Althaea ludwigii		0.0	6					0.0	3									
Trigonella stellata	+	0.0	3		0.1	15	+	0.0	7		0.0	5		0.0	7		1.4	26
Lappula spinocarpos		0.0	3								0.0	10					0.1	26
Schismus barbatus		0.0	3		0.0						0.0	5					0.2	24
Astragalus peregrinus		0.0	3		0.0	3												
Astragalus tribuloides		0.0	3		0.0	3					0.0	5						
Reseda lutea					0.0	3					0.0	5						
Erodium bryoniaefolium								0.0	7		0.0	5						
Ifloga spicata											0.0	5		0.0	7		0.1	24

In only one of the units occurred: AC-T: Lotus creticus -/0.0/9; Launaea tenuiloba +/0.2/21; Vicia sativa-/0.0/6; Matricaria aurea -/0.0/3; Retama raetam -/0.0/3; Linaria haelava -/0.0/6. Emex spinosus -/0.1/18. AC-A: Minuartia procumbens -/0.0/3; Paronychia arabica -/0.0/6; Bupleurum semicompositum -/0.0/3. AC-tt: Echiochilon fruticosum -/0.0/3; Astragalus spinosus -/0.1/10. AC-tH: Filago desertorum -/0.0/5; Lotus halophilus -/0.0/5. PG-Z: Cornulaca monacantha -/0.0/7; Hyoscyamus muticus -/0.2/30; Cotula cinerea -/0.1/10; Herniaria hemistemon +/0.1/10. PG-t: Fagonia bruguieri -/0.3/8; Stipa parviflora -/0.0/8; Rumex cyprius -/0.1/21; Capparis aegyptia-/0.0/3; Ephedra alata -/0.0/5; Pergularia tomentosa -/0.0/3; Poa spec. -/0.0/3; Astragalus gyzensis -/0.0/3.

Phytogeographically the Saharo-Arabian element dominates overwhelmingly, and the amount of plurizonal species is rather low (Table 19). Concerning life forms, there is a clear domination of chamaephytes, but a considerable contribution of herbaceous perennials – especially in the Zygophyllum album var. (6). It is arranged on the plateau around depressions with