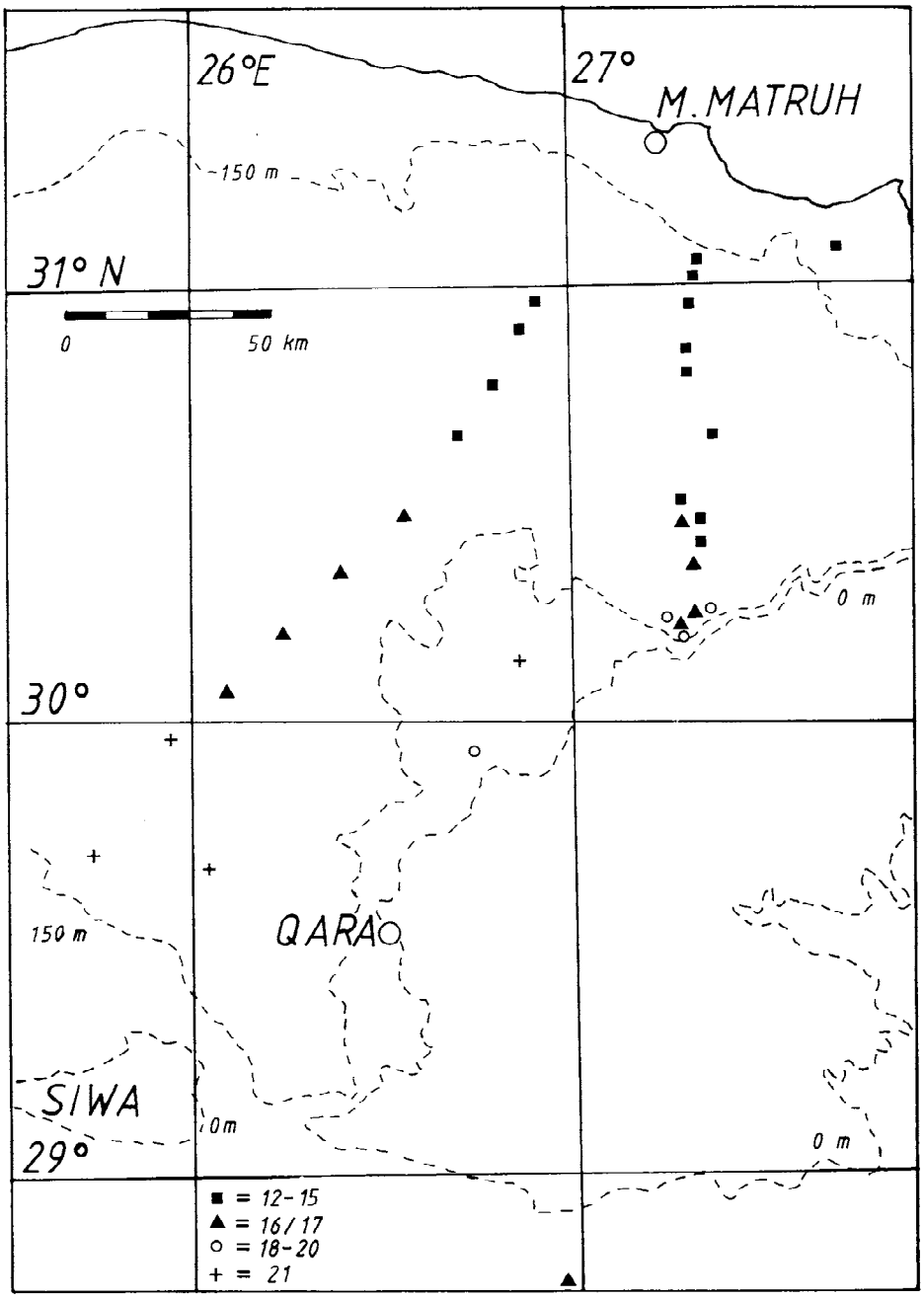

Fig. 6. Sampling places of vegetation units 12–21.
12–15 Artemisia inculta-Carduncellus mareoticus ass.; 16/17 Pituranthos tortuosus-Gymnocarpos decandrum ass.; 18–20 Anastatica hierochuntica-Anabasis articulata ass.; 21 Capparis aegyptia-Randonia africana ass.
For further information see Fig. 2.

Thymelaea-Plantago ass. or Artemisia-Carduncellus ass. (Fig. 5D and 6). The occurrence of the Pituranthos-Gymnocarpos decandrum ass. on cliffs, of the Thymelaea-Plantago ass. on less exposed habitats has already been pointed out by GIRGIS & DESOUKY (1977).

Similar communities have been described from Ras El-Hikma (TADROS & EL-SHARKAWI 1960, EL-SHARKAWI 1961) and from the Sidi-Barrani area (MIGAHID et al. 1971 as Gymnocarpetum), where it grows on shallow soils (BATANOUNY & ZAKI 1974) and, as a consequence of low biomass production, has low range value (BATANOUNY & ZAKI 1973, MIGAHID et al. 1975c). The *Anabasis* community type of KASSAS & GIRGIS (1965) is also comparable.

3.3. Precipitation-dependent permanent contracted vegetation

3.3.1. Artemisia inculta-Carduncellus mareoticus ass. (Table 3: 12–15)

In the zone south of the Thymelaea-Plantago ass., *Artemisia inculta* (= *A. herba-alba*) plays an important role. Frequently it is associated with *Carduncellus mareoticus*. The two shrubs *Thymelaea hirsuta* and *Atriplex halimus* fade out, but there is an overlap with both of them. The area of *Thymelaea* extends south in non-saline depressions with varying sand dynamics and is associated with *Scorzonera alexandrina* and *Gymnocarpus decandrum* (Thymelaea subass., 12). *Atriplex* reaches its southern limit in saline depressions and is associated with *Salsola tetrandra* and others (Atriplex subass., 13). In the typical subass. a difference exists between stands exhibiting maximum values of *Carduncellus* (typical var., 14) on the one hand, and maximum values of *Haloxylon scoparium* (and *Atriplex halimus*) on the other hand (Haloxylon var., 15). As the number of relevés shows all four subunits are very frequent, and the vitality number again indicates perennating vegetation. In the Thymelaea and Atriplex subass. height exceeds 5 dm. The species number is highest in the Thymelaea subass.; otherwise it ranges only around 6 and 7.

The phytogeographical analysis (Table 19) shows that – as in the preceeding association – the Saharo-Arabian element strongly dominates, but in contrast to the former, the Mediterranean element is weakly represented (7.5 % on the average), whereas the Irano-Turanian element (18 %) did not change much, the Sudanian element (6 %) increased, and the plurizonal species decreased. The Irano-Turanian element therefore exceeds the Mediterranean one, as has been pointed out already by BORNKAMM & KEHL (1985). This shows the closer relationship to the Mediterranean vegetation in the coastal strip only, but a closer relationship to steppe vegetation further south. Irano-Turanian elements here enter desert vegetation but do not perform real steppe vegetation. The eventual occurrence of special ecotypes should be checked (e.g. *Artemisia inculta* usually shows dwarf populations). In life forms, chamaephytes prevail, but herbaceous perennials are the codominant group. Shrubby life forms are still remarkably common (18.5 %) in the first two subass. but the annuals are drastically reduced in all four subunits. The latter figure will vary with the yearly precipitation rates, but the decrease of annuals in southern direction certainly is a constitutive character of our vegetation type (STAHR et al. 1985).

Fig. 6 shows the distribution of the community on the miocene plateau south of the Thymelaea-Plantago ass. Some examples of local

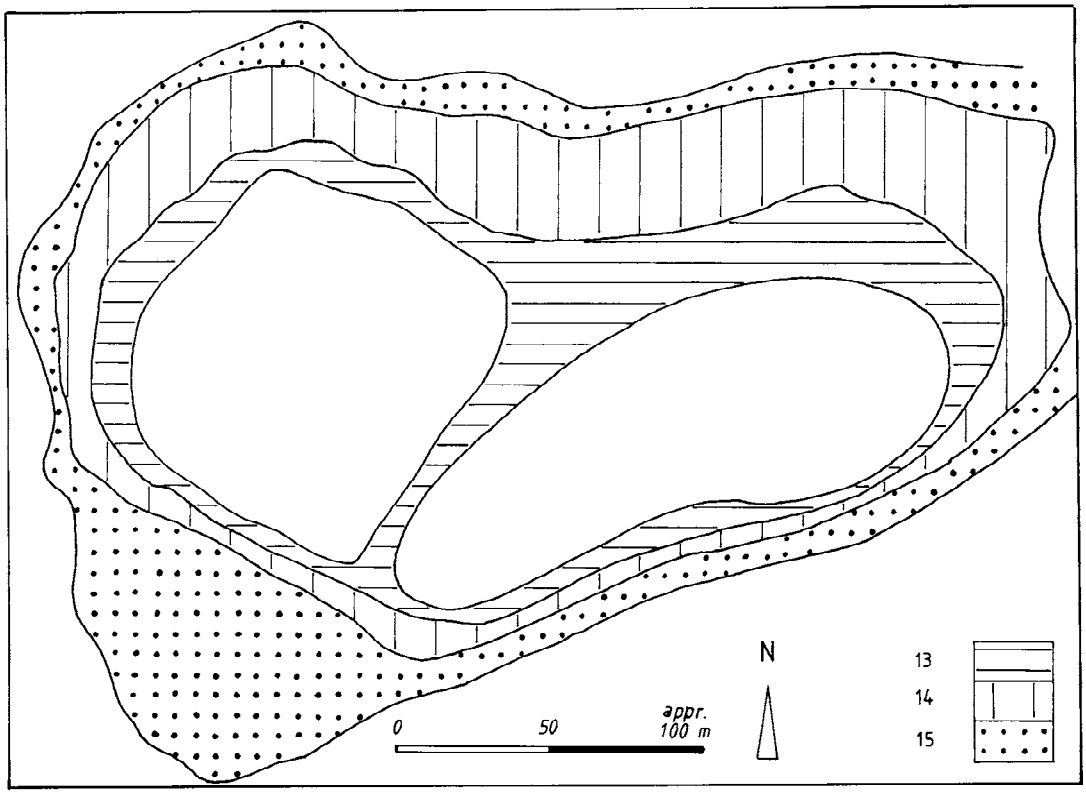

Fig. 7. Vegetation spot close to Abu Mukhaiyat, 30°42'N, 27°18'E (18 relevés, 29.3.83). Artemisia inculta-Carduncellus mareoticus ass.: 13 Atriplex halimus subass.; 14 typical subass. typical var.; 15 typical subass. Haloxylon var.

distributions are given in Fig. 5, 7 and 8. An open transect through a shallow depression starts with the typical Thymelaea-Plantago ass. (and Artemisia-Carduncellus ass. Thymelaea subass.) in the center, ending with the Atriplex subass. at the margin (Fig. 5C). In other cases (see Fig. 5D–K) the margins are covered with typical subass. Haloxylon var. on the margin, with the typical var. in the center. This pattern may be explained by the harsh conditions of outblowing sands in the center, sand accumulation on the slope foothill or gentle margin and again harsh conditions on the plateau. In most cases the typical subass. (especially in its Haloxylon var.) characterizes the outer zones of vegetation spots, the Thymelaea subass. the lower parts of the slopes with small dunes, whereas the Atriplex subass. grows in the central parts or forms the inner zone of ring shaped stands. But this may vary according to the local conditions, e.g. in Fig. 5I the Atriplex subass. is the only vegetation unit developed. The small vegetation maps in Fig. 7 show vegetation-free centers surrounded by three belts in the following sequence: Atriplex subass. typical subass. typical var., typical subass. Haloxylon var. The figures make clear, that this association characterizes the transition from diffuse vegetation to contracted vegetation where the plant communities are developed in the form of vegetation islands. Locally more

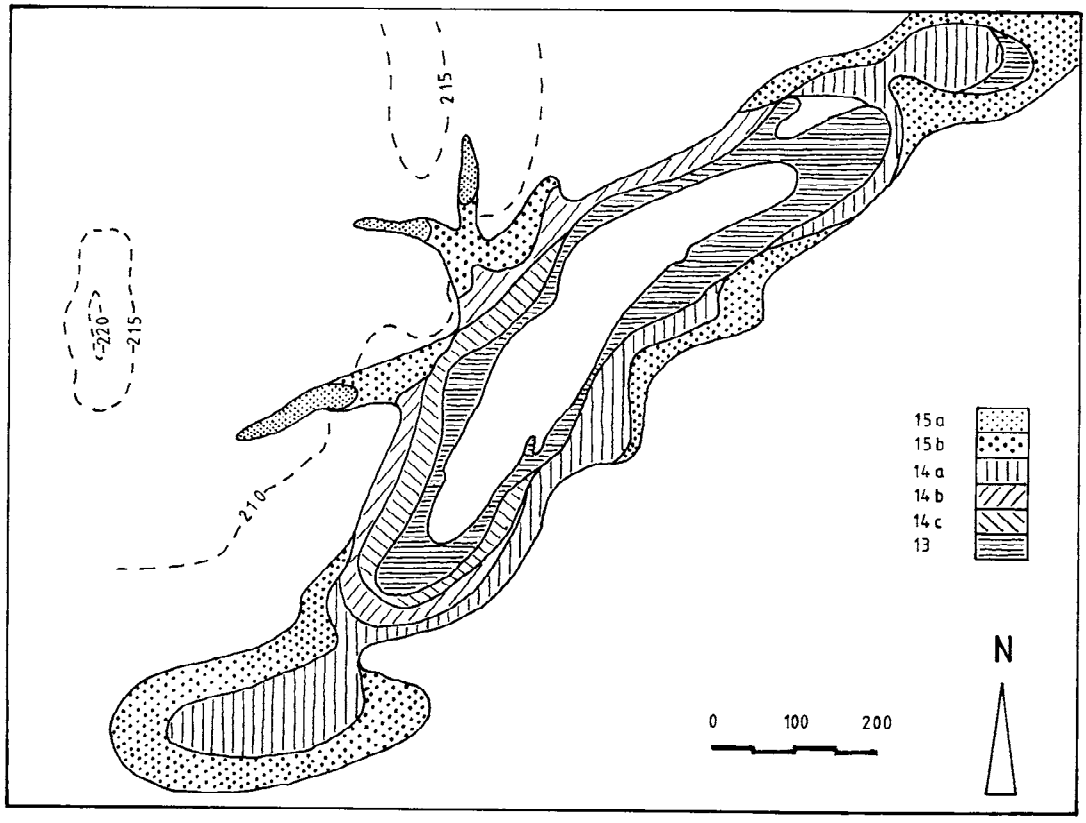

Fig. 8. Vegetation map of Abu Mukhaiyat 30°42'N, 27°19'E, after KEHL et al. (1984), changed (77 relevés, 23.-25.3.83). Explanation of symbols see Table 4.

Table 4. Diagnostic species of the plant communities in Abu Mukhaiyat (30°42'N, 27°19'E, see Fig. 7).
Artemisia inculta-Carduncellus mareoticus ass.: 15 type with Gymnocarpus decandrum (close to Haloxylon var. in Table 3), 15a typical subvar., 15b subvar. of Carduncellus mareoticus; 14 typical subass. typical var., 14a Pituranthos-facies, 14b typical facies, 14c Carduncellus facies; 13 subass. of Atriplex halimus.
The relevés of the present table are not comprised in Table 3. For details see KEHL et al. 1984. For further information see Table 1.

plant community	15a		15b		14a		14b		14c		13	
number of relevés	8		15		7		12		11		24	
	C	P	C	P	C	P	C	P	C	P	C	P
Artemisia inculta	2,5	100	3,7	100	1,7	100	1,0	58	1,7	100	1,4	83
Pituranthos tortuosus	4,9	100	12,5	100	15,0	100	2,0	92	2,2	100	2,1	100
Astragalus trigonus	2,5	86	2,5	93	3,7	86	0,5	42	2,6	100	1,3	50
Launaea nudicaulis	0,9	75	2,1	93	1,9	100	1,0	42	3,4	100	2,2	88
Trigonella stellata	1,7	75	2,2	87	2,9	43	0,1	17	3,5	73	1,8	54
Schismus barbatus	1,0	63	1,2	80	4,9	71	0,5	25	1,3	73	0,9	54
Helianthemum lippii	2,5	100	2,5	100	1,2	100	1,1	83	1,1	73	0,0	4
Gymnocarpus decandrum	1,6	88	1,1	73			0,1	8				
Farsetia aegyptiaca	1,0	63	0,9	67			0,2	17				
Euphorbia retusa	1,2	63	1,7	67								
Carduncellus mareoticus			1,7	100	2,5	100	2,5	100	15,0	100	11,8	100
Gastrocotyle hispida			0,7	73	0,3	29	0,2	17	0,1	9	0,1	17
Astragalus hispidulus			0,7	40	0,1	29			0,3	18	0,1	17
Atriplex halimus											5,4	100

subunits are to be distinguished as can be shown by the example of Abu Mukhaiyat (KEHL et al. 1984, see Fig. 8 and Table 4).

The Thymelaea subass. was described from Sidi Barrani (Artemisietum herbae-albae) by MIGAHID et al. (1971, 1974; see also MIGAHID et al. 1975b, c). The range value of this community is lower than that of the Thymelaea-Plantago ass. but higher than that of the Pituranthos-Gymnocarpus ass. (BATANOUNY & ZAKI 1973, MIGAHID et al. 1975c). The same is true for soil depth and plant cover (BATANOUNY & ZAKI 1974). Other *Thymelaea-Artemisia* communities grow further east (SHARAF EL-DIN & SHALTOUT 1985), in Sinai and Israel (ZOHARY & FEINBRUN 1951, DANIN et al. 1975, ZOHARY 1982, DANIN 1983). The same is true for other associations dominated by *Artemisia inculta* (EL GHONEMY et al. 1977, SHARAF EL-DIN & SHALTOUT 1985, ZOHARY 1982).

3.3.2. Anastatica hierochuntica-Anabasis articulata ass. (Table 5: 18–20)

The vegetation islands south of the Artemisia-Carduncellus ass. zone are very poor in species. *Anastatica* and *Anabasis* usually grow together in

Table 5. Anastatica hierochuntica-Anabasis articulata ass. (A): 18 A-n pure *Anastatica* stands (Anasticetum nudum); 19/20 A-A subass. of Anabasis articulata: 19 A-At typical var., 20 A-AA var. of Atriplex leucoclada; 21 Capparis aegyptica-Randonia africana ass. (CR). For further information see Table 1.

	-18-			-19-			-20-			-21-		
	A-n			A-At			A-AA			CR		
average species number	1.4			3.7			7.4			5.0		
average height (dm)	1			3			5			3		
number of releves	16			28			12			18		
vitality	88/0/12			82/5/13			74/25/1			69/10/21		
	T	C	P	T	C	P	T	C	P	T	C	P
Anastatica hierochuntica	2	9.6	100	1	3.0	9.3	1	3.6	75		0.2	17
Anabasis articulata				1	2.9	93	+	3.2	67			
Pituranthos tortuosus					0.7	36		0.8	17	(+)	0.5	67
Zygophyllum coccineum					0.1	18	+	1.8	92		0.1	11
Cotula cinerea							1	1.9	92			
Atriplex leucoclada							1	4.7	75	+	0.1	28
Mesembryanthemum forsskalii							+	0.3	50			
Pseuderucaria teretifolia							+	0.2	33			
Capparis aegyptia										1	1.5	100
Randonia africana										(+)	0.3	50
Ephedra alata								0.2	17	+	0.1	28
Salsola baryosma ssp. gaetula		0.2	25	+	0.2	46	(+)	0.3	25	1	0.4	44
Zygophyllum album		0.0	6	+	0.1	21	+	0.1	25			
Trigonella stellata		0.2	65		0.3	43	1	0.7	58		0.1	28
Stipagrostis plumosa					0.0	4	+	0.1	25	+	0.0	6
Salsola tetrandra					0.0	7					0.1	17
Helianthemum lippii					0.0	4		0.0	8			
Astragalus trigonus					0.0	7		0.1	25		0.0	6
Fagonia arabica								0.0	8	+	0.0	6

In only one of the units occurred:
A-At: Calligonum comosum -/0.0/4; Pergularia tomentosa -/0.0/4; Franoeuria crispa -/0.0/4; Emex spinosus -/0.0/4; Salvia aegyptiaca -/0.0/4. A-AB: Frankenia pulverulenta -/0.0/98; Oligomeris linifolia +/0.5/42; Coronopus niloticus -/0.0/8. Cornulaca monacantha -/0.2/8; Heliotropium bacciferum +/0.0/8. Stipagrostis zittelii -/0.0/8; CR: Tamarix nilotica -/0.0/6; Carduncellus mareoticus -/0.1/22; Matthiola livida -/0.0/6; Pulicaria undulata +/0.1/11; Zilla spinosa (+)/0.1/22; Verbascum letourneuxii -/0.0/17; Telephium sphaerospermum -/0.0/6; Cleome africana -/0.0/6.

the typical (19) and Atriplex leucoclada subass. (20) but at the most extreme sites pure *Anastatica* stands are developed (Anastaticetum nudum, 18). The difference between the typical and the Atriplex subass. probably also reflects the variability of the association caused by the precipitation regime. The relevés of the Atriplex subass. were recorded in 1986 which, after a heavy winter rain, was a very favourable year.

This association is distributed on miocene limestone in the north and northwest of the Qattara depression (Fig. 6). The pure *Anastatica* stands cover the small terraces (marginal habitats) of runnels and of depressions, as well as the very center of depressions (Fig. 5L). The inner margins of depression and the runnel centers, where more sand is accumulated, bear the typical subass.

The Anastatica-Anabasis ass. is not grazed by sheep or goat any more, probably because it grows too far outside the settlements and the phytomass production is unpredictable. But it is grazed by camels (from the north). Signs of this land use are the trampling weeds occurring here like *Trigonella stellata*, *Atriplex leucoclada* var. *inamoena*, *Emex spinosus* and *Coronopus niloticus*. The transitional character is clearly indicated by the fact that a group of species reaches its southern limit, another group its northern limit of distribution. The decreasing vitality figures show that permanent vegetation still exists here but that a larger portion of the standing crop is dead. The average height does not exceed 5 dm, and the average species number usually is lower than 5 species/25 sqm (Table 5).

The phytogeographical analysis (Table 19) shows again a strong dominance of the Saharo-Arabian element, the Sudanian element increased slightly (to 7 %) whereas the Irano-Turanian element is nearly lacking. This, together with the very low production of plurizonal species, indicates that here and in the preceding associations we are in the very center of the Saharo-Arabian belt. As a special feature of this association, note that annuals (50 %) are more abundant than chamaephytes (33 %).

Plant communities with *Anabasis articulata* and *Anastatica hierochuntica* are widely distributed in our region (see ZOHARY 1982, Anabasetum anastaticetosum).

3.3.3. Zygophyllum coccineum-Schouwia thebaica ass. (Table 6)

This association is the main vegetation tpe of a large area of the Western Desert, especially in and around the Qattara depression. In many cases, especially in smaller runnels, *Zygophyllum coccineum* is the pioneer species forming pure stands (Zygophylletum nudum, 22; Photo 3). Sometimes it is associated with *Zygophyllum album*, which also tends to grow at the margins of the vegetation islands. This type (Zygophylletum nudum Zygophyllum album var., 23) marks the transition to groundwater-dependent habitats where the soil is strictly saline. The remaining units can be divided into two large groups, the Zygophyllum simplex subass. and the typical subass. The Zygophyllum subass. (24, 25) grows in runnels, and in affluents or margins of depressions. Smaller flat areas

Table 6. Zygophyllum coccineum-Schouwia thebaica ass. (ZS): 22/23 ZS-n pure *Zygophyllum* stands (Zygophylletum nudum): 22 ZS-nt typical var., 23 ZS-nZ Zygophyllum album var.; 24/25 ZS-Z subass. of Zygophyllum simplex: 24 ZS-Zt typical var., 25 ZS-ZP var. of Pergularia tomentosa; 26–28 ZS-t typical subass.: 26 ZS-tt typical var., 27 ZS-tC var. of Capparis leucophylla, 28 ZS-tA var. of Acacia raddiana.
For further information see Table 1.

	-22- ZS-nt			-23- ZS-nZ			-24- ZS-Zt			-25- ZS-ZP			-26- ZS-tt			-27- ZS-tC			-28- ZS-tA		
average species number	1.4			2.4			5.6			9.3			5.1			6.2			6.5		
average height (dm)	3			3			5			6			5			7			5		
number of relevés	29			7			60			4			32			5			18		
vitality	72/14/14			81	1	18	86/8/6			93/0/7			85/7/8			82/6/12			94/0/6		
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Zygophyllum coccineum	2	8.7	100	2	4.6	100	+	2.3	97		91.0	25	1	3.7	72	1	9.1	100	2	2.9	56
Schouwia thebaica		0.0	3				(+)	0.2	35	(+)	0.0	50	1	1.1	50	1	7.0	80	+	0.8	33
Zygophyllum simplex							+	0.9	75	+	0.1	50		0.0	3					0.0	6
Stipagrostis plumosa		0.0	3				+	0.4	40	2	2.9	100								0.0	6
Farsetia aegyptiaca								0.1	5	+	0.3	50									
Frankenia pulverulenta				+	0.2	43		0.0	3											0.0	6
Juncus rigidus				+	0.3	57		0.0	3	+	0.1	25									
Zygophyllum album				+	0.2	43															
Pergularia tomentosa								0.0	2	1	0.4	100								0.1	22
Pituranthos tortuosus								0.1	7		0.4	75		0.0	3		0.5	20		0.6	33
Anastatica hierochuntica								0.1	15	+	0.5	100		0.5	13					0.4	28
Capparis leucophylla																2	8.1	100		0.2	39
Reseda kahirina								0.2	3							+	0.4	80	+	0.1	17
Haplopyllum tuberculatum														0.0	3		0.2	60		0.0	6
Acacia raddiana, juv.														0.0	3				+	0.7	100
Salsola baryosma ssp. gaetula		0.3					1	0.9	75		0.7	47		0.7	60		0.3	33			
Fagonia bruguieri		0.0						0.1	25					0.1	20		0.0	6			
Astragalus trigonus								0.1	12		0.1	25		0.0	9						
Heliotropium bacciferum								0.2	7											0.1	6
Francoeuria crispa								0.0	7				(+)	0.4	16					0.1	11
Monsonia nivea								0.2	15	+	0.1	50		0.0	3					0.1	28
Launaea mudicaulis								0.0	5				(+)	0.1	22		0.1	20		0.0	6
Randonia africana								0.1	3		0.1	13					0.0	6			
Fagonia arabica								0.0	2					0.1	3						
Cleome droserifolia								0.0	2					0.2	6	+	0.2	40		0.2	11
Calligonum comosum								0.0	2		0.8	50									
Helianthemum lippii								0.0	2											0.0	6
Cotula cinerea							+	0.5	60	+	2.6	50		0.4	59		0.1	20		0.8	28
Astragalus vogelii							+	0.2	33				+	0.8	50	+	0.2	40		0.1	11
Oligomeris linifolia								0.4	33				+	0.1	25					0.0	11
Pulicaria undulata								0.3	25		0.1	25	+	0.4	44					0.0	6
Atriplex leucoclada								0.3	18	(+)	0.3	75		0.9	47					0.1	22
Torularia torulosa								0.1	17	+	0.1	25		0.0	6						
Trigonella stellata								0.1	12		0.4	75	+	0.8	34		0.1	20	+	0.4	50
Lotus glinoides								0.1	5	+	0.1	25		0.3	25					0.0	6
Astragalus eremophilus							+	0.0	5		0.0			0.0	6						
Cleome africana								0.0	3					0.0	3						
Euphorbia chamaesyce								0.0	2					0.0	3						

In only one of the tables occurred: ZS-Zt: Convolvulus pilosellifolius -/0.1/3; Alhagi mannifera -/0.0/2; Hyoscyamus muticus -/0.0/3; Carduncellus mareoticus -/0.0/2; Phoenix dactylifera juv.-/0.0/5; Zilla spinosa -/0.2/3; Fagonia glutinosa -/0.1/3; Senecio desfontainei -/0.0/2; Kochia indica -/0.0/2; Aeluropus lagopoides -/0.0/2. ZS-tA: Minuartia spec. -/0.0/6; Anabasis articulata -/0.1/22; Ephedra alata -/0.1/22; Nitraria retusa -/0.4/28; Frankenia pulverulenta -/0.0/6; Salsola tetrandra -/0.1/11.

may bear *Pergularia tomentosa* in their center, and a variety of other species (Pergularia var., 25). The typical subass. grows in larger depressions with or without sand cover. In the inner margins large depressions give rise to the establishment of young *Acacia raddiana* plants without changing the community much (Acacia var., 28). The deepest part of the depression, where water stays longest, bear the Capparis leucophylla var. (27), where also *Schouwia thebaica* and *Zygophyllum coccineum* reach maximum values. The last two variations mainly grow northeast of Qara (Fig. 9).

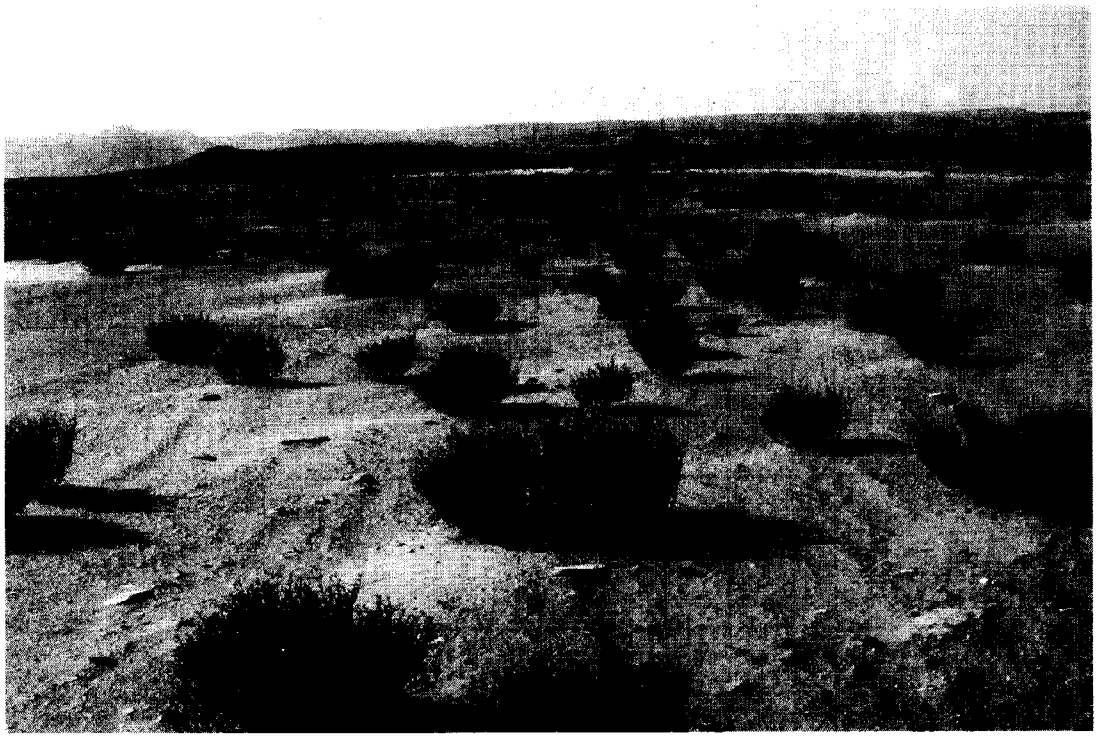

Photo 3. Pure *Zygophyllum coccineum* stands (22) in the downstream part of Wadi Hamid S of Qara.

This association shows some similarity to the Anastatica-Anabasis ass., especially in the Pergularia and Capparis var.s, but the differences are obvious regarding the large number of species which did not occur in any of the associations discussed earlier. This can be explained by the special situation in the Qattara depression which shows altitudes up to 135 m below sea level. In addition the up to 150 m high cliff escarpments, surrounding the depression provide surplus water to the adjacent areas. We encounter here, to a smaller extent, natural conditions which are very well known from the Arava valley and the Dead Sea area in Israel and Jordan (ZOHARY & ORSHANSKY 1949, ZOHARY 1973, DANIN 1983), where many Sudanian species reach their northernmost limits. The same is true in the Qattara area. It would therefore be interesting to gather climatological measurements from the Qara oasis. Many species have their northwestern linit in the Zygophyllum-Schouwia ass. (Photo 4), but some are lacking direct connection to the main areas, i.e. they show a disjunction. In most of the subunits of this association (except the marginal ones) height exceeds 5 dm, and species number exceeds 5 species per plot. The vitality numbers show that we here deal with permanent vegetation. The height of these figures may be misleading, because the herbaceous perennials among the species tend to "accidental" behaviour and may be overrepresented in our relevés dating mainly from the favourable year 1986.

The pattern of the vegetation is strictly contracted. As in the preceding

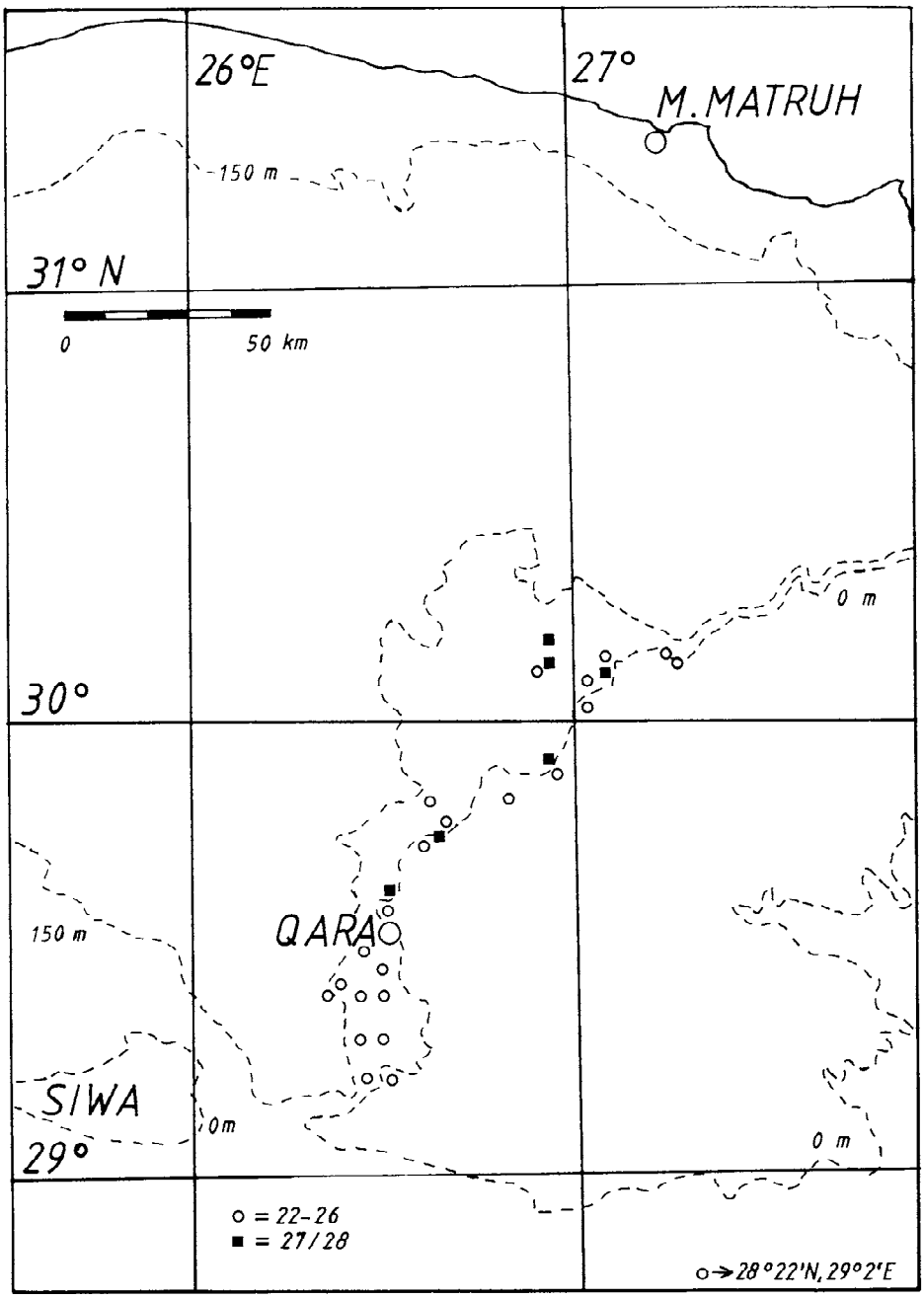

Fig. 9. Sampling places of vegetation units 22–28.
Zygophyllum coccineum-Schouwia thebaica ass.: 22–26 Zygophylletum nudum, Zygophyllum simplex subass. and typical subass. typical var.; 27/28 typical subass. Capparis leucophylla var. and Acacia raddiana var.
For further information see Fig. 2.

associations it is not the center of the depression that bears the most highly developed vegetation but the inner margin (Fig. 10A–D). Under these conditions also tree groves of *Acacia raddiana* occur which will be discussed later (see chapter 3.3.12.).

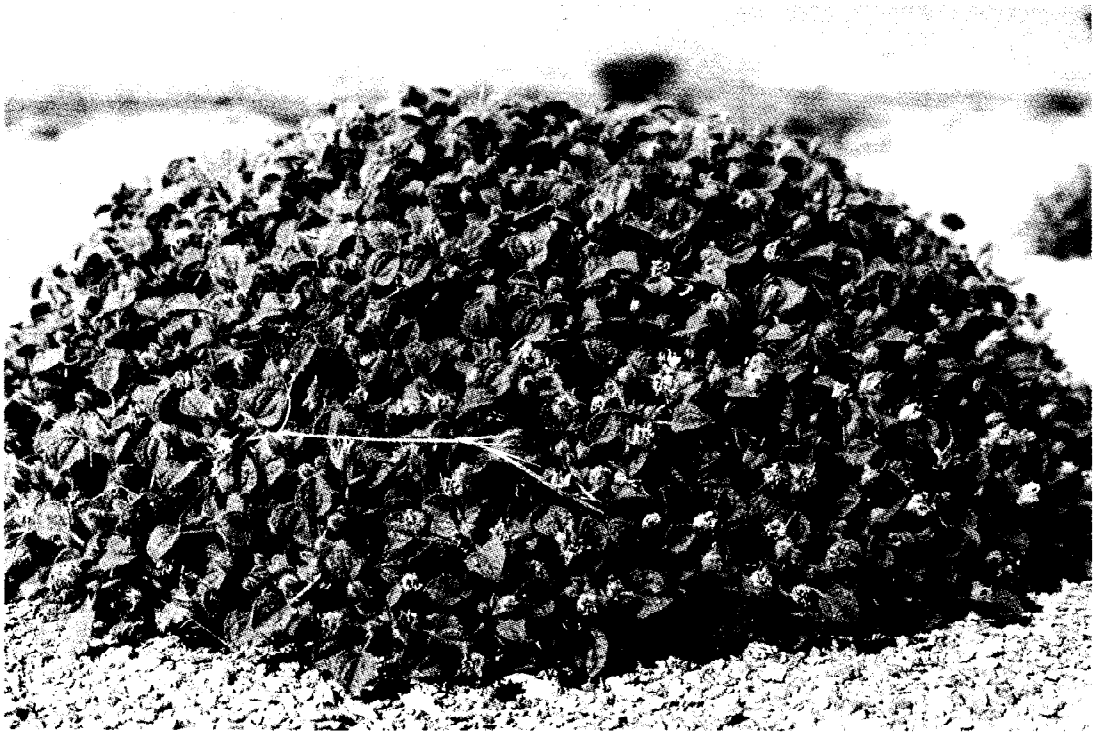

Photo 4. *Cleome droserifolia* in the Zygophyllum-Schouwia ass., typical subass., var. of Capparis leucophylla in Talh-El-Fawakhir NE of Qara.

Phytogeographically the Saharo-Arabian element still prevails (Table 19), but there is a dramatic increase of the Sudanian element (to 28 % on the average) whereas the Irano-Turanian element remains rather unchanged. Concerning life forms, both annuals (40 %) and perennials (36 %) show nearly equal amounts, whereas chamaephytes come up to only 20 % on the average. This again reflects the very special situation of this community. We have been told by the Skeikh of Qara that grazing by the camels of the bedouins extends into our association whereas the Qara population itself lives mainly from crop cultivation.

Communities dominated by *Zygophyllum coccineum* have been described of several parts from the Eastern Desert, preferably on limestone (BATANOUNY & EZZAT 1971). The species composition differs widely from our association (see KASSAS & GIRGIS 1964), but type III (*Zygophyllum coccineum*) in KASSAS & GIRGIS 1965, type IX (*Zygophyllum coccineum*) in KASSAS & GIRGIS 1970 and type III in the wadi El-Miyah (EL-SHARKAWI et al. 1982b) have some features in common with our typical subass., type II (*Zygophyllum decumbens*) in KASSAS & GIRGIS 1965 with our Zygophyllum simplex subass. Vegetation type 1 in Wadi Gimal is very similar to our Zygophyllum album var. of the Zygophylletum nudum, but contains *Limonium axillare* as additional species (EL-SHARKAWI et al. 1982b, 1984; see also EL SHARKAWI & RAMADAN 1983, 1984).

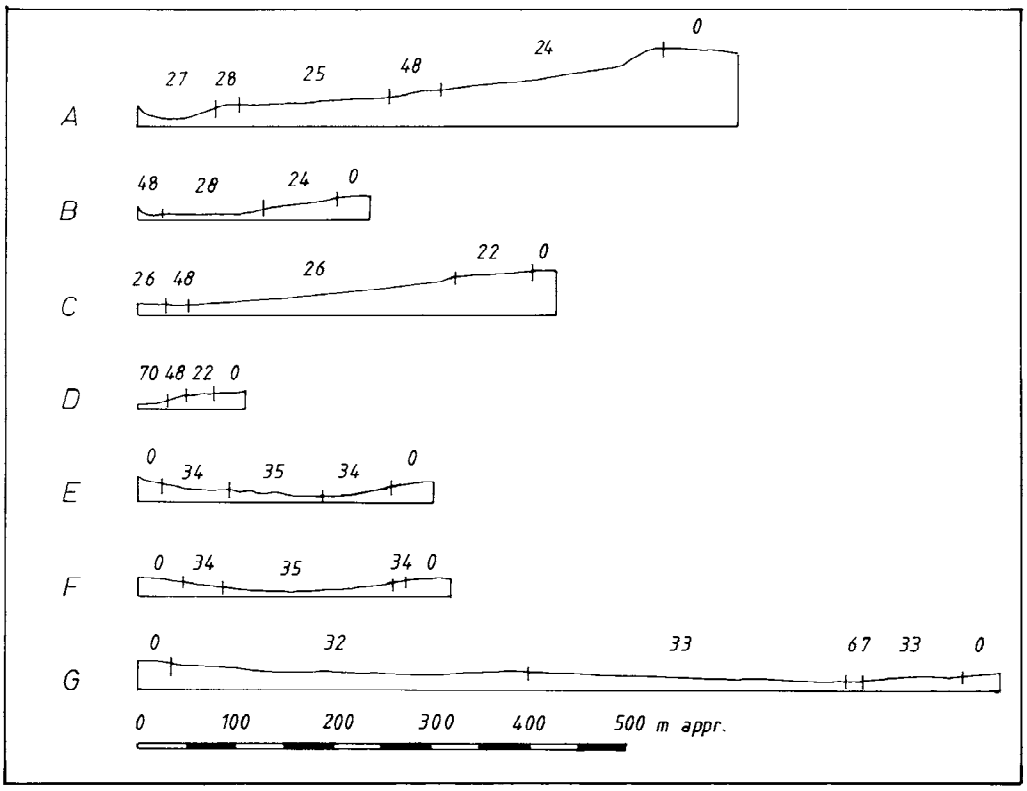

Fig. 10. Transects through vegetation in the Qattara and Sitra regions. The height scale is arbitrary. - A) Talh-El-Fawakhir, 20°49'N, 26°39'E (25 relevés, 10.10.1986); B) small depression W of Bir Abd El Nabi, 29°52'N, 26°53'E (8 relevés, 12.10.86); C) Wadi Ghuweidir, 29°11'N, 26°32'E (17 relevés, 8.10.86); D) Wadi Ghuweidir, locality like C (9 relevés, 8.10.86); E) depression south of the Sitra region, 28°30'N, 26°44'E (43 relevés, 12.4.85); F) transect through a vegetation field south of the Sitra region, 28°32'N, 26°55'E (8 relevés, 12.4.85); G) large depression north of the Sitra lake, 28°44'N, 26°58'E (33 relevés, 6.10.86). Plant communities: 0 vegetation-free.
Zygophyllum coccineum-Schouwia thebaica ass.: 22 Zygophylletum nudum; Zygophyllum simplex subass.: 24 typical var., 25 Pergularia tomentosa var.; typical subass.: 26 typical var., 27 Capparis leucophylla var., 28 Acacia raddiana var.
Suaeda fruticosa ass. Fagonia arabica subass.: 32 typical var., 33 Calligonum comosum var.
Cornulaca monacantha-Fagonia arabica ass.: 34 Cornulacetum nudum, 35 typical subass.; 48 Zygophyllum coccineum-Acacia raddiana ass.: 67 Tamarix passerinoides ass., 70 *Nitraria retusa* stands.

3.3.4. Capparis aegyptia-Randonia africana ass. (Table 5: 21)

Some of the Sudanian species in the Qara region associated with *Zygophyllum coccineum* and *Schouwia thebaica* are distributed further West, and reach the Siwa region. Here they are components of the Capparis aegyptia-Randonia africana ass., which covers the southern part of the Marmarica plateau (Fig. 11). The distribution and variability of this association deserves further study especially since *Capparis leucophylla* and *Capparis deserti* also grow in this region, and *Randonia* here lives at its eastern border (QUÉZEL 1978, fig. 9, p. 514).

The transitional character of the Capparis-Randonia ass. is indicated by the higher number of plurizonal species; otherwise the Saharo-Arabian element and the chamaephytic life form prevail (Table 19).

3.3.5. Stipagrostis plumosa ass. (Table 7: 29–30)

Vegetation types dominated by *Stipagrostis plumosa* can be observed in the Bahariyah, Sitra and Farafra regions on eocene limestone (Fig. 11). Dominance here means high presence values and cover of >1 %. The typical subass. (29) is developed under the most extreme conditions. In the northern part it grows in rocky areas or on roadsides of the Giza-Bahariyah road, where *Stipagrostis* is watered by the road run-off, a water source which is very important in deserts with higher precipication (GABRIEL & SCHMID 1981, WALTER & BRECKLE 1984). Further south, in the northern part of the Farafra oasis where the surface is made up by extremely smooth limestone, the typical subass. grows in deep (karstic) holes filled with sand ('flowerpot vegetation'). In this area *Stipagrostis plumosa* frequently is associated with

Table 7. Stipagrostis plumosa ass. (St): 29 St-t typical subass.; 30 St-F subass. of Fagonia arabica.
Suaeda fruticosa ass. (S): 31 S-t typical subass.; 32/33 S-F subass. of Fagonia arabica: 32 S-Ft typical var., 33 S-FC var. of Calligonum comosum.
For further explanation see Table 1.

	-29- St-t			-30- St-F			-31- S-t			-32- S-Ft			-33- S-FC		
average species number	2.4			3.8			2.5			5.0			7.0		
average height (dm)	5			3			5			3			6		
number of relevés	25			23			33			12			23		
vitality	80/5/15			69/8/23			59/17/24			90/4/6			99/0/1		
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Stipagrostis plumosa	1	1.2	88	1	1.8	65									
Salsola baryosma ssp. gaetula		0.1	4	+	1.6	78		0.0	6	+	1.2	100	+	0.3	83
Fagonia arabica		0.0	8	+	0.7	65		0.1	12	+	0.4	100	+	0.9	96
Hyoscyamus muticus					0.3	35									
Cotula cinerea		0.0	4	+	0.3	30				+	1.2	100	1	2.0	91
Suaeda vermiculata							1	4.2	88	1	1.0	100	2	1.6	100
Convolvulus pilosellifolius										1	0.5	83	1	7.1	100
Calligonum comosum		0.0	4		0.2	13								0.7	78
Cornulaca monacantha		0.2	20		0.0	9		0.1	9		0.1	33	+	0.5	87
Astragalus trigonus					0.0	4	+	1.4	27					1.8	83
Farsetia aegyptiaca	+	0.1	16		0.1	13									
Zygophyllum album		0.0	8	+	0.2	26	+	2.9	67					0.0	4
Launaea nudicaulis		0.0	4		0.0	4									
Anabasis articulata	+	0.5	32		0.1	4									
Pituranthos tortuosus					0.0	9					0.0	17		0.2	48
Astragalus vogelii								0.1	15	+	0.1	33		0.4	57
Stipagrostis zittelii								0.3	18		0.0	8			
Tamarix passerinoides											0.0	8		0.2	30

In only one of the units occurred:
St-t: Monsonia nivea -/0.2/24; Asthenatherum forsskalii -/0.0/4; Fagonia glutinosa -/0.0/8; Ephedra alata -/0.1/8; Alhagi mannifera -/0.1/4; Fagonia bruguieri -/0.1/4. St-F: Tamarix nilotica +/0.0/4; Francoeuria crispa +/0.1/17; Heliotropium bacciferum -/0.0/4./4.
S-t: Astragalus eremophilus -/0.0/6; Tribulus orientalis -/0.0/3.

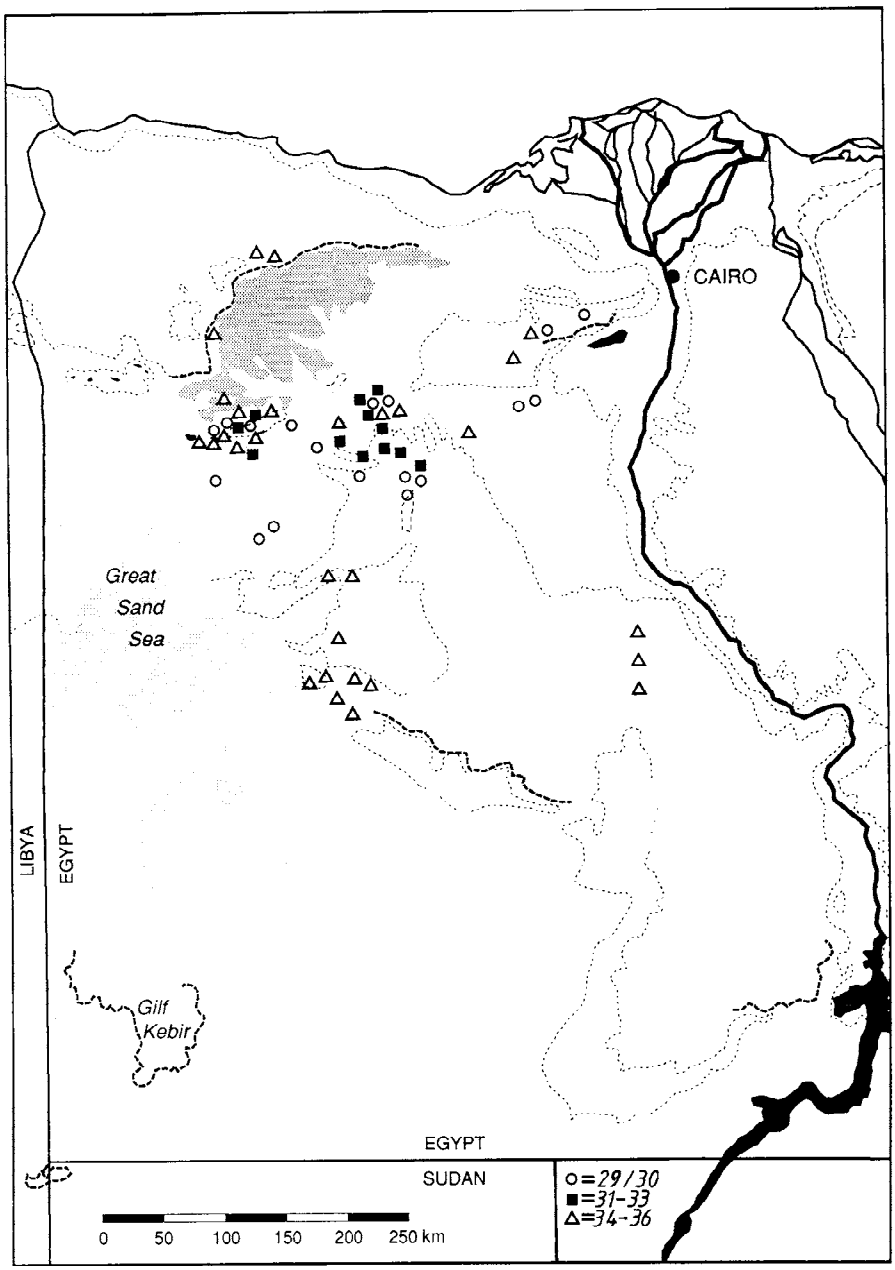

Fig. 11. Sampling places of vegetation units 29–36.
29/30 Stipagrostis plumosa ass.; 31–33 Suaeda fruticosa ass.; 34–36 Cornulaca monacantha-Fagonia arabica ass.
For further information see Fig. 2.

Anabasis articulata and *Monsonia nivea*. The Fagonia subass. (30; Photo 5) grows in small depressions and exhibits a higher species number. The vitality figures are rather low, but the vegetation is still permanent although the *Stipagrostis* tussocks may produce only a very few narrow leaves per year or even seem to be dormant. *Stipagrostis plumosa* also enters other associations. In larger depressions where the center is outblown but not yet denuded, it

Photo 5. Stipagrostis plumosa ass. subass. of Fagonia arabica (30) ca. 90 km NW of Buwiti.

becomes am important component of the Pergularia var. of the Zygophyllum Shouwia ass. (Table 6).

Phytogeographically the association is clearly dominated by the Saharo-Arabian element (Table 19). The proportion of plurizonal species is rather high indicating some relationship to the Irano-Turanian region which can also be recognized by the higher proportion of the Irano-Turanian (17 %), and the lower proportion of the Sudanian element (14 %) as compared with the preceding association. The life forms comprise predominantly herbaceous perennials in the typical subass., but chamaephytes in the Fagonia subass.

Stipagrostis plumosa communities have been described especially from the north of Egypt along the Cairo-Alexandria road. Here the *Aristida plumosa* community of BATANOUNY & ABU EL-SOUOD (1972) is similar to our typical subass., the *Pituranthos tortuosus* community to our Fagonia subass. The *Stipagrostis plumosa* complex is distributed throughout nearly all parts of the northern Sahara (SCHOLZ 1972, BATANOUNY 1987, FRANKENBERG & KLAUS 1980). In the different regions different desertic vegetation units with this species have to be expected; they deserve further study. In the northwestern Sahara it is a component of steppe communities e.g. in Algeria (WOJTERSKI 1985).

3.3.6. **Suaeda fruticosa ass.** (Table 7: 31–33; Photo 6)

This association is mainly developed south and southeast of the Qattara depression (Fig. 11). The typical subass. (31), with *Zygophyllum album*

Photo 6. Suaeda fruticosa ass. typical subass. (31) at the SE border of the Qattara depression ca. 120 km NW of Buwiti. *Suaeda fruticosa* shows many juvenile plants and large shrubs up to 140 cm high (dark colour). *Zygophyllum album* grows as codominant up to 65 cm high (light colour).

as a codominant, grows under the most severe conditions, which is indicated by the low species number and low vitality figures. The Fagonia subass. (32, 33) grows where larger catchment areas are provided. This is especially true for the var. of Calligonum comosum (33). *Convolvulus pilosellifolius* is an interesting component of this subass. Fig. 10G shows a transect through a vegetation island, where the Fagonia var. forms an outer belt and the Calligonum var. an inner zone surrounding a small stand of *Tamarix passerinoides*. Here, again, the Saharo-Arabian element is dominating. Concerning life forms, chamaephytes prevail (Table 19).

Plant communities dominated by *Suaeda fruticosa* (under the name of *S. vermiculata*) have been reported from Sinai (GIBALI 1988) and Qatar (BATANOUNY 1981, BATANOUNY & TURKI 1983).

3.3.7. Cornulaca monacantha-Fagonia arabica ass. (Table 8: 34–36)

With this and the following associations we reach the middle part of our investigation area. These vegetation types are distributed mainly around the Farafra oasis, although some of them (like *Cornulaca monacantha* stands) are more widely distributed in Egypt and neighbouring countries as well (FRANKENBERG & KLAUS 1980, WOJTERSKI 1985), and occur on different geological substrates.

Table 8. Comulaca monacantha-Fagonia arabica ass. (CF): 34 CF-n pure *Cornulaca* stands; 35 CF-P var. of Pituranthos tortuosus; 36 CF-Z var. of Zygophyllum coccineum; 37 *Traganum nudatum* stands (Tr); 38 *Calligonum comosum* stands (C); 39 *Zygophyllum album* stands (Z).
For further explanation see Table 1.

	-34- CF-n			-35- CF-P			-36- CF-Z			-37- Tr			-38- C			-39- Z		
average species number	1.7			2.7			2.5			1.7			3.2			1.6		
average height (dm)	6			5			4			8			6(2-16)			4		
number of relevés	53			33			50			9			45			20		
vitality	45/33/22			82/13/4			75/16/9			0/67/33			69/10/21			65/16/19		
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Cornulaca monacantha	2	14.0	91	1	0.4	42	1	2.1	88		0.1	11		0.1	9			
Fagonia arabica	(+)	0.3	23	+	0.9	61	+	0.2	38					0.3	29		0.0	5
Cistanche phelypaea		0.0	2	+	0.1	15		0.0	2									
Pituranthos tortuosus				1	1.8	55								0.0	4			
Convolvulus pilosellifolius					0.7	45												
Zygophyllum coccineum							+	1.6	80					0.0	2			
Traganum nudatum		0.1	8							2	5.2	100					0.0	5
Calligonum comosum		0.1	6					0.2	12				2	6.6	80			
Zygophyllum album		0.3	13		0.0	6		0.1	12		0.0	11	2	0.6	42	2	7.1	100
Anabasis articulata		0.3	11		0.7	15		0.0	6		0.1	11		0.2	27		0.1	5
Stipagrostis zittelii		0.0	4	+	0.0	6								0.0	7			
Stipagrostis plumosa		0.1	6					0.0	4					0.0	4			
Cotula cinerea		0.0	2					0.3	14					0.0	2			
Francoeuria crispa		0.0	4											0.1	2		0.0	5
Phragmites australis		0.0	2														0.1	10
Salsola baryosma ssp. gaetula					0.1	6		0.1	8					0.2	32		0.0	5
Astragalus trigonus					0.1	21		0.0	2									0
Fagonia bruguieri								0.0	2				+	0.0	2			
Stipagrostis vulnerans											0.1	11		0.0	4			
Suaeda vermiculata														0.0	2		0.0	5

In only one of the units occurred: CF-n: Tamarix spec. -/0.1/2; CF-Z: Echinops spinosissimus -/0.0/4; Phoenix dactylifera -/0.0/2.
Tr: Helianthemum lippii -/0.3/11; Panicum turgidum -/0.3/11.
C: Anastatica hierochuntica -/0.1/4; Salsola tetrandra -/0.7/11; Gymnocarpos decandrum -/0.1/4; Farsetia aegyptiaca -/0.0/2; Trigonella stellata -/0.0/9; Imperata cylindrica -/0.0/2; Nitraria retusa -/0.1/2; Bassia muricata -/0.0/2; Blackiella inflata -/0.0/7; Tamarix amplexicaulis -/0.0/2. Z: Tamarix nilotica -/0.1/10; Juncus rigidus -/0.2/5; Hyoscyamus muticus -/0.0/5.

The Cornulaca-Fagonia ass. shows three subunits: Very frequently *Cornulaca* is the pioneer (or relic) species, scarcely accompanied by any other species (Cornulacetum nudum, 34; Photo 7). Low species numbers and low vitality figures reflect the harsh conditions. The Pituranthos

Photo 7. *Cornulaca monacantha* and the parasite *Cistanche phelypaea* in the Cornulaca-Fagonia ass. (31) NE of Abu Minqar.

subass. (35) grows in habitats with larger catchment areas and is a link to the Suaeda fruticosa ass., Fagonia subass. (Table 7). Consequently the Pituranthos subass. forms the central parts of vegetation island, whereas pure stands cover the margins (see Fig. 10E, F). The Zygophyllum coccineum var. is distributed in the vicinity of *Zygophyllum coccineum* communities (Fig. 9). We encountered *Cistanche phelypaea* always on *Cornulaca monacantha* as only host, thus becoming a characterizing species of the Cornulaca-Fagonia ass.

3.3.8. Traganum nudatum stands (Table 8: 37)

Traganum nudatum has already been mentioned as a component of the Thymelaea-Plantago ass., especially on deep soils (see chapter 3.2.3.). Pure *Traganum* stands are developed under special conditions, namely on very smooth limestone with low sand cover. They are poor in species and show low vitality figures but attain considerable height, and seem to be a special feature in the northern part of the Farafra oasis. Like *Stipagrostis plumosa* this species is frequently represented in other parts of North Africa, e.g. Algeria (LEIPPERT & ZEIDLER 1984, WOJTERSKI 1985) and in Saudi Arabia (BAIERLE et al. 1985, BAIERLE & FREY 1986). In general *Traganum nudatum* seems to be a calciphilic species (AYYAD & KAMAL 1980).

3.3.9. Calligonum comosum ass. (Table 8: 38)

Calligonum comosum occurs regularly in a number of vegetation units (especially in the Calligonum var. of the Suaëda fruticosa ass. Fagonia subass. (Table 7) but frequently forms separate stands accompanied by only a few other species. The height may vary from 3 to 16 dm and the vitality figures are rather low. *Calligonum* stands occur mainly in the central part of our area of investigation but have also been described from other regions like the Eastern Desert (KASSAS & GIRGIS 1970), Israel, Algeria (LEIPPERT & ZEIDLER 1984), and Arabia (BAIERLE et al. 1985, BAIERLE & FREY 1986, BATANOUNY 1987, ZOHARY 1982).

3.3.10. Zygophyllum album stands (Table 8: 39)

Pure stands of *Zygophyllum album* (cf. Zygophyllum album ass. Tadros 1953) often form the outermost zone of a vegetation island in or outside the main salt concretions or mark basal plants of dunes. Sometimes it is the only rain-fed zone around a groundwater-dependent or irrigated area. A good example can be found in the 'artificial oasis' north of El-Bahrein (see chapter 3.5.3.2.).

Zygophyllum album occurs in a wide variety of other vegetation units mostly characterizing a subass. or var. on saline soil. As with *Calligonum comosum* stands, the lack of associated species does not allow these stands to be joined to any other association. Maybe further investigation may bring about a plausible solution. *Zygophyllum album* stands are very widespread in most parts of Egypt and have also been described from many parts of NW Egypt including Wadi El-Natrun (ZAHRAN & GIRGIS 1970), Moghra Oasis (GIRGIS et al. 1971) and Siwa Oasis (ZAHRAN 1972), and also from the Eastern Desert (KASSAS & TIRGIS 1965, type IV), Sinai (ZOHARY 1944), Israel (DANIN 1983), Libya (GIMINGHAM 1955), and Algeria (LEIPPERT & ZEIDLER 1984).

3.3.11. Francoeuria crispa ass. (Table 9: 44–45)

In a similar way as *Zygophyllum album* stands the Francoeuria crispa ass. occurs on both groundwater-dependent and precipitation-dependent habitats. Consequently such stands are developed in two different forms: In the north (especially NW of the Bahariya oasis) it grows in depressions where no influence of groundwater is detectable (typical subass., 44). In the south it prefers the margins of oases where the influence of groundwater can not be excluded (Fig. 12). This is also indicated by the combination with *Tamarix nilotica* in the Tamarix subass. (45) where the average height of the vegetation is not much less than 1 m and the vitality figure are considerably higher than in the typical subass. and the preceding associations. Usually they form rather high phytogenic mounds.

Phytogeographically the Saharo-Arabian element prevails (Table 19) but since *Francoeuria* itself also grows in the Sudanian zone the Sudanian element is enhanced (27 %) and the proportion of plurizonal species is very high. *Francoeuria* by us is regarded as a dwarf shrub. Thus chamaephytes prevail, but

Table 9. Zygophyllum coccineum-Salsola baryosma ass. (ZS): 40 ZS-t typical subass.; 41 ZS-Z subass. of Zilla spinosa; 42 ZS-T subass. of Trichodesma africanum; 43 ZS-A subass. of Astragalus vogelii.
Francoeuria crispa ass. (F): 44 F-t typical subass.; 45 F-T subass. of Tamarix nilotica.
For further explanation see Table 1.

	-40-			-41-			-42-			-43-			-44-			-45-		
		ZS-t			ZS-Z			ZS-T			ZS-A			F-t			F-T	
average species number		2.2			2.5			4.6			2.8			2.1			3.4	
average height (dm)		6			8			4			5			7			9	
number of relevés		15			25			13			33			12			5	
vitality		0/24/76			10 /21/69			5 /3/92			15/9/76			32/20/48			82/0/18	
	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P	T	C	P
Zygophyllum coccineum	1	15.5	80	1	9.2	68	1	1.3	100	2	7.6	48		0.0	8			
Salsola baryosma ssp. baryosma	2	1.8	33		0.6	40		0.9	31		0.7	6						
Zilla spinosa				1	0.5	40								0.1	17			
Anabasis articulata				2	2.7	40		0.2	8									
Cornulaca monacantha					4.4	32		0.2	8		0.0	3		0.5	25			
Trichodesma africanum							1	2.3	92									
Astragalus vogelii								0.2	31	1	4.8	82						
Francoeuria crispa					0.4	4		0.0	15				2	12.7	100	2	4.0	100
Tamarix nilotica		0.0	7								0.1	6				+	0.9	100
Aeluropus lagopoides																+	0.3	60
Bassia muricata		0.7	7		0.0	4												
Fagonia bruguieri	+	0.2	47					0.5	31		0.1	9						
Schouwia thebaica		0.1	27								0.2	15						
Fagonia indica		0.5	20							2	9.0	55						
Psoralea plicata					0.0	4		0.5	31					0.0	8			
Astragalus trigonus					0.0	4	+	1.7	38									
Torularia torulosa								1.0	15		0.0	6						
Farsetia ramosissima								0.0	8		0.4	21						
Stipagrostis plumosa								0.1	15					0.2	33		0.1	20

In only one of the units occurred: ZS-Z: Cistanche phelypaea -/0.1/12; ZS-T: Calligonum comosum +/0.4/38; ZS-A: Cotula cinerea -/0.0/6; Morettia philaeana -/0.1/9; Amaranthus graecizans -/0.0/6; Stipagrostis vulnerans -/0.0/3. F-t: Salsola baryosma ssp. gaetula -/0.3/17; F-T: Alhagi mannifera +/0.2/40; Sporobolus spicatus -/0.1/20.

the second subass. with *Tamarix nilotica* shows a shrubby codominant. Stands of *Francoeuria* from the Eastern Desert (KASSAS & GIRGIS 1970, type VII *Pulicaria crispa*) are related to our typical subass. Since *Francoeuria crispa* is widespread (FRANKENBERG & KLAUS 1980) it is not astonishing that similar communities have been described from other countries like Saudi Arabia

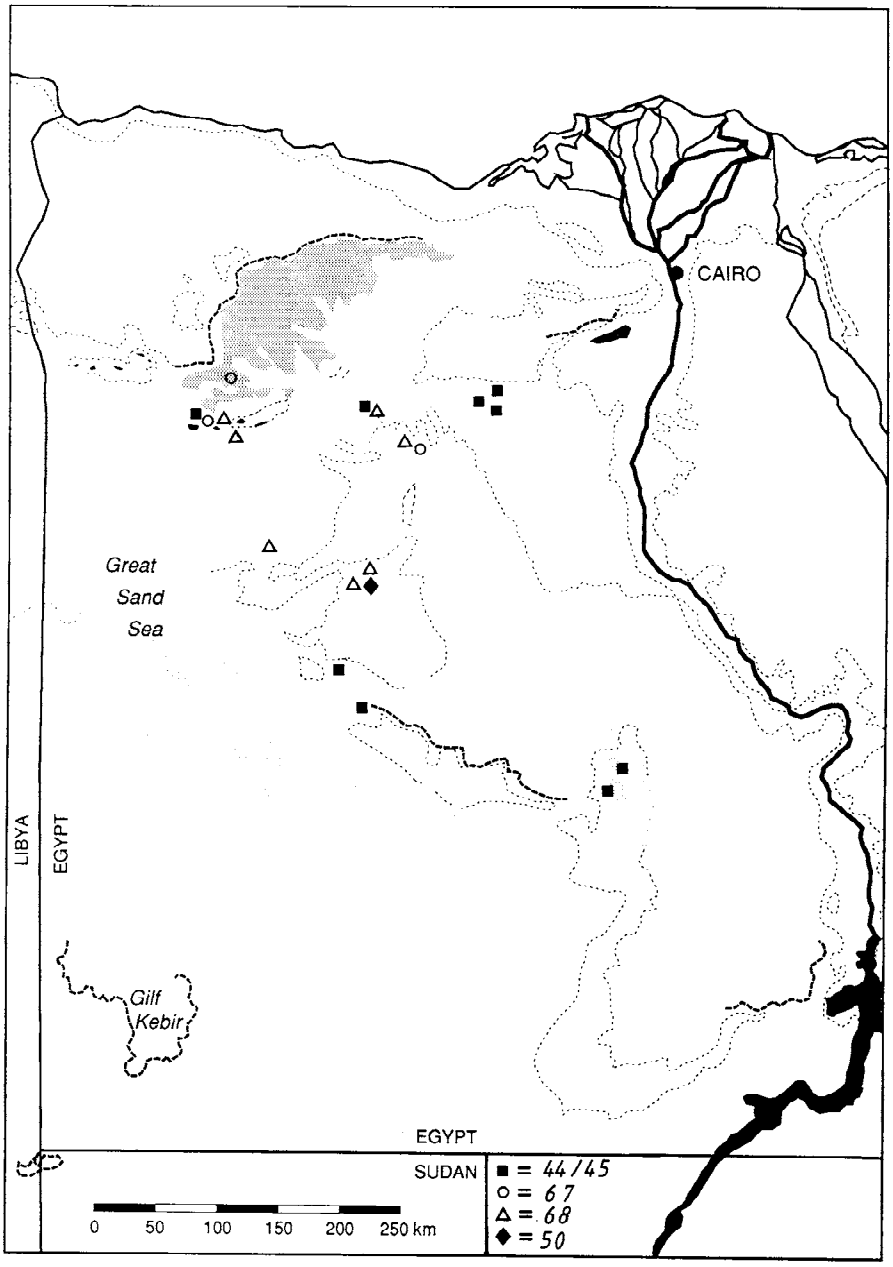

Fig. 12. Sampling places of vegetation units 44/45, 50, 67 and 68.
44/45 Francoeuria crispa ass.; 50 *Cocculus pendulus* stands; 67 Tamarix passerinoides ass., 68 *Tamarix amplexicaulis* stands.
For further information see Fig. 2.

(BATANOUNY & BAESHIN 1983, BATANOUNY 1987) and Qatar (BATANOUNY 1981).

3.3.12. Woodlands

The most important tree in the precipitation-dependent vegetation of the Western Desert is *Acacia raddiana*. Usually it is associated with *Zygophyllum*