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Drought and changes in the bryoflora and angiosperm flora in Kuwait in the years 1974–1990

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SUMMARY

The bryoflora and angiosperm flora in one of the main desert wadis, in the State of Kuwait on the western side of the Arabian Gulf, has been studied during two periods separated by an interval of 9 years. The first period lasted for four successive seasons; 1974/75–1977/78. The second period lasted for only three successive seasons; 1987/88–1989/90. Drastic changes both in rate of growth and diversity of the bryoflora and angiosperm flora were observed and recorded. These changes, which are due mainly to successive years of drought, are described here and discussed in detail.

Key-words: bryoflora, desert flora, desertification, drought, Kuwait.

INTRODUCTION

The State of Kuwait occupies the northeastern part of the Arabian peninsula (Fig. 1). It is a flat to gently rolling open desert with very few minor elevations, wadis, depressions, some low dunes, coastal salt marshes and small off-shore islands. The oldest rocks are sedimentary, of Upper Triassic age. They are overlain by a sequence of sedimentary strata ending in the Pleistocene. This is covered here and there by recent deposits. The climate is arid with very hot dry summers and cool to mild rainy winters. The average maximum temperature during the summer months (June–August) is around 45°C while the average minimum for these same months is around 35°C. The coldest month is January, its average maximum temperature is around 18°C and average minimum is 9°C, while its absolute minimum is slightly below 0°C. The average annual rainfall is about 107 mm, however, it shows great variability in time and space (Fig. 2). The rains fall usually between November and May. Relative humidity is, as well, highest in winter and lowest in summer. Fog and mist occur more frequently in winter. Winds blow usually from the northwest, less frequently from the southeast. Severe winds may cause dust and sandstorms (see Milton 1967; Fuchs *et al.* 1968; Ergon 1969; Halwagy 1973; Halwagy & Halwagy 1974a,b; Halwagy 1986).

Bryophytes growing in one of the main desert wadis of Kuwait, namely wadi Umm-Al-Rimam (about 30 000 m^2 in area), were recorded in detail during the period 1974/75–1977/78 by El-Saadawi (1976, 1978, 1979a,b). Angiosperms of the same wadi were recorded, by regular seasonal visits, during the same period, by the first author of this paper.

The object of the present work is to describe changes in the flora of the whole of the same wadi observed after one decade, during a second period of study from 1987/88 to 1989/90,

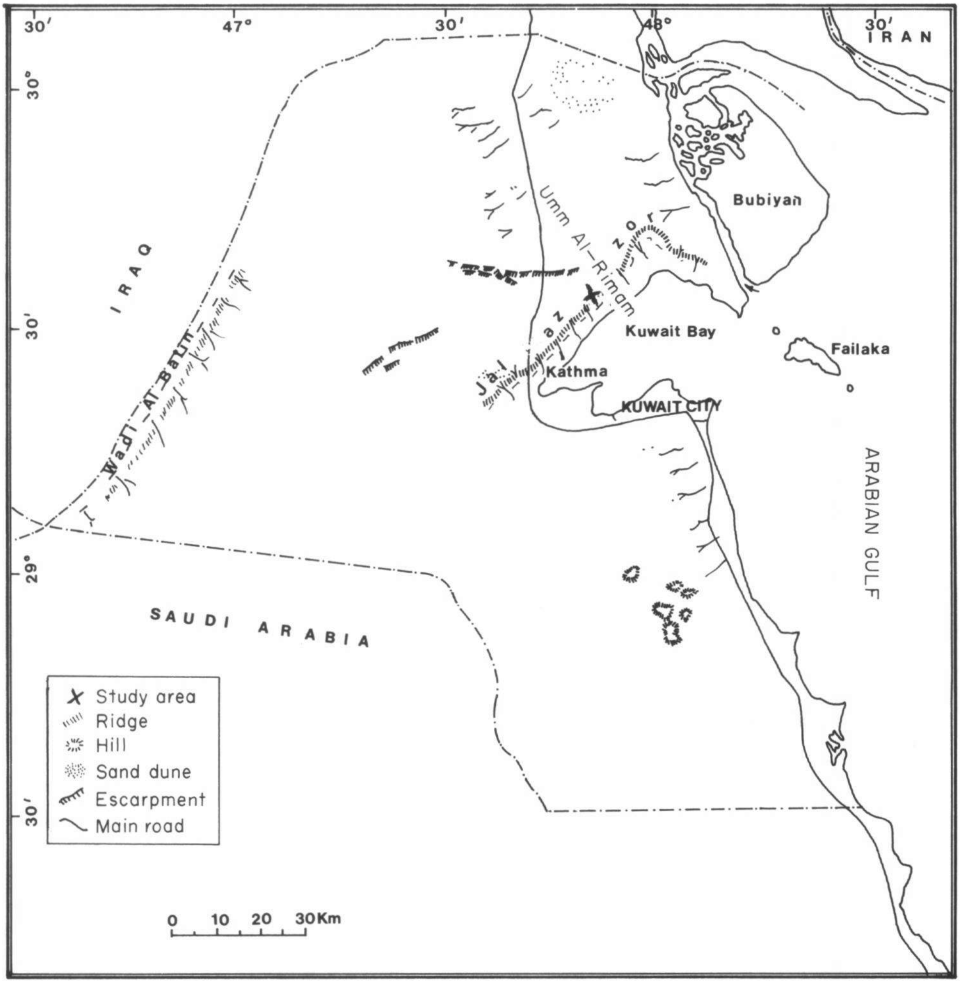

Fig. 1. District map of Kuwait showing location, boundaries, Jal-Az-Zor escarpment, and wadi Umm-Al-Rimam.

and to find out the causal factors leading to the observed drastic changes both in the rate of growth and diversity of the angiosperms and bryophytes.

STUDY AREA

Jal-Az-zor escarpment (Fig. 1) borders the northern shore of Kuwait Bay, extends for some 80 km, and reaches a maximum height of 145 m above sea level. The escarpment is dissected by several dry wadis; lines of surface drainage of different sizes and patterns which drain mostly to Kuwait Bay. The largest of these wadis is wadi Umm-Al-Rimam (Fig. 1). Three different habitats are easily recognized in this wadi; a sandy south-facing slope, a rocky north-facing slope, and wadi bed (Fig. 3). Data collected during the first period of study (from 1974/75 to 1977/78) show that the soil of the southern face generally consists of newly redeposited, loose, medium to fine sands drifted by north and

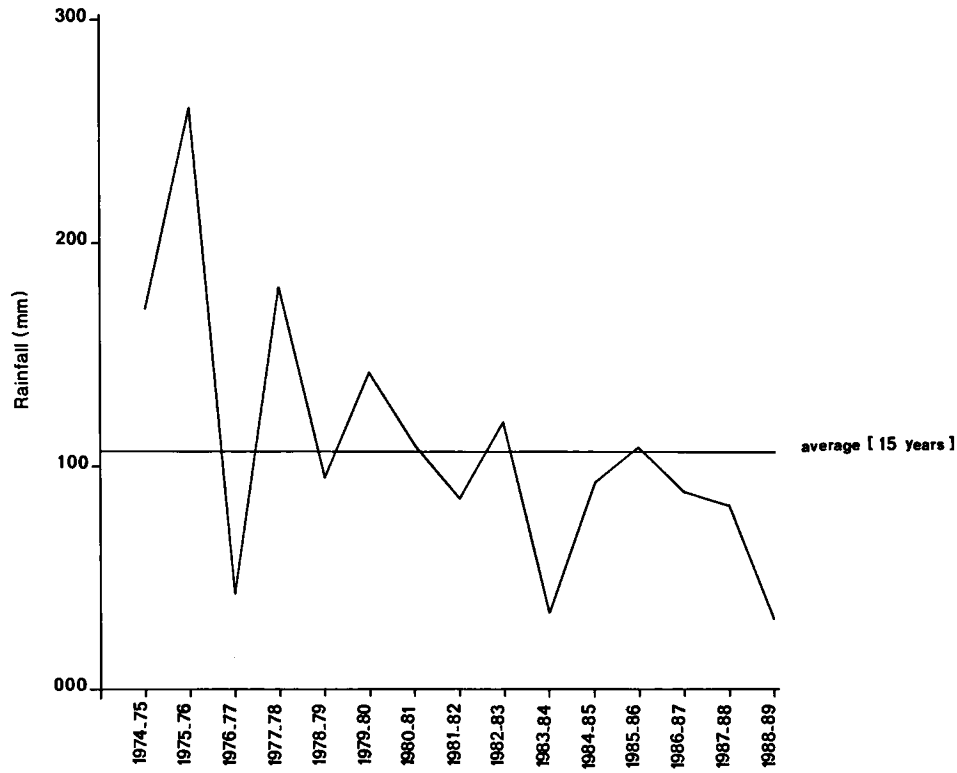

Fig. 2. Curve showing yearly amounts of rainfall in the seasons from 1974/75 to 1988/89.

north-westerly winds. The soil is deep and the profile does not show any horizon for more than 2 metres. Its pH (1:5 water–soil extract) is around 7·8 with very poor organic carbon content (about 0·01 g/100 g oven-dry soil). The northern face has shallow sandy soil derived partially from drifted sands and partially from the weathered sandstone rocks of the escarpment which redeposit between rocks and in cracks. Organic carbon content of this soil reaches 0·12 g/100 g oven-dry soil and its pH value is 7·6. The soil of the wadi bed is loamy sand, shallow (0–40 cm deep) overlying consolidated sandstone layers which outcrop in several parts of the bed (Fig. 3), i.e. it shows an AC profile with pH 7·8 and organic carbon content of 0·12 g/100 g oven-dry soil.

VEGETATION COMPOSITION AND CHANGE

During the first period of study, perennial angiosperms grew only on north-facing slopes (11 species recorded in at least 2 years) and in the wadi bed (16 species; Table 1). In the second period of study, their numbers were reduced to four and eight species respectively. Almost all species were rare in the second period. Many more annuals and biennials were reported in the first period: 24 species on the southfacing slope, 54 species on the north-facing slope and 55 species in the wadi bed (Table 1). Only 16 annuals and biennials were seen in the three habitats of the wadi in the second period (Table 1). The rate of growth of angiosperms in general was highest in the season 1977/78 although it had less rainfall than

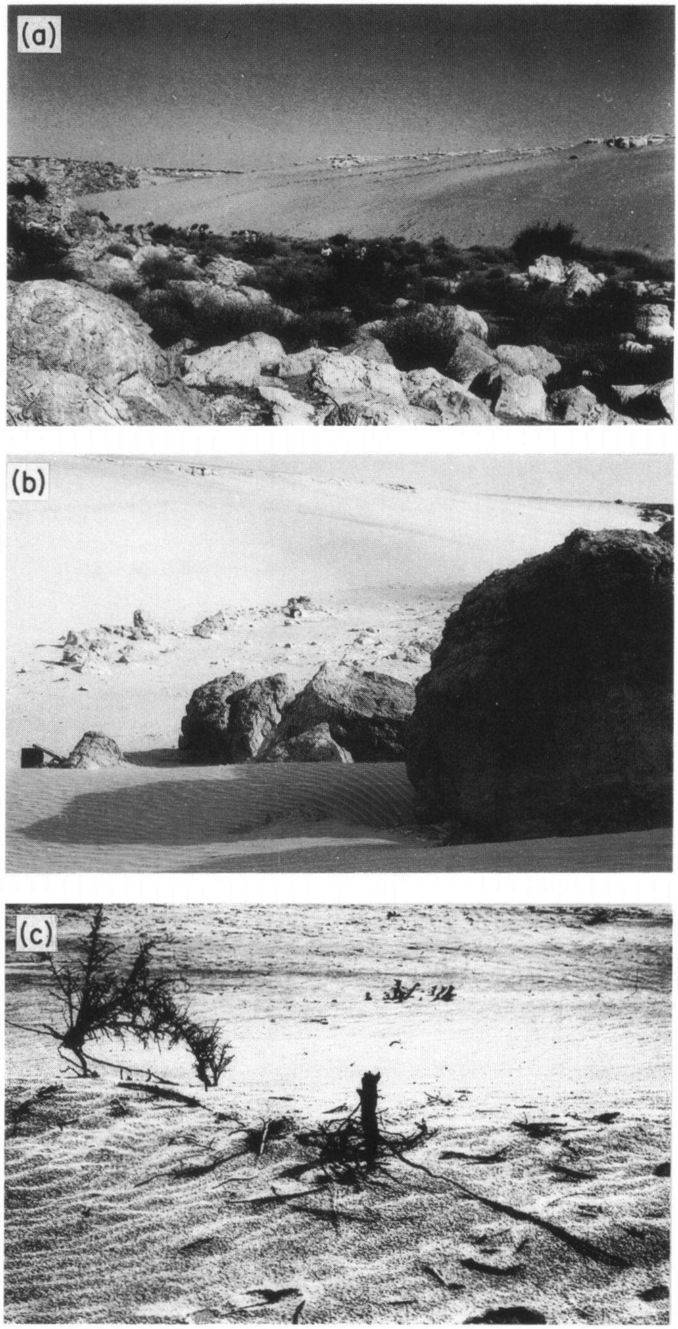

Fig. 3. (a). A photograph of part of wadi Umm-Al-Rimam during the 1970s showing a sandy south-facing slope in the background, wadi bed with vegetation in the centre and a small part of the rocky north-facing slope in the foreground and in the top left. (b) A photograph of wadi Umm-Al-Rimam during the 1980s; sand covering spaces between rocks, filling rock crevices, and accumulating in wadi bed. (c) A photograph of *Lycium shawii* shrubs showing clearly the effect of soil erosion; roots being uncovered, which results in subsequent death of the plants.

the season 1975/76 (Fig. 2). In the second period, the persisting perennials were thin, short and defoliated.

During the first period, the growth of mosses was luxuriant in a large number of sites but only on the north-facing slopes of the wadi and usually in association with good growth of diverse lichens. The maximum vitality, diversity, cover area, fertility, and fruit production of mosses were in the season 1975/76 (Table 2) which had the highest amount of rainfall ever recorded in Kuwait (Table 3 and Fig. 2). That season witnessed also the production of peculiar aerial rhizoids that grew vertically upwards in the axils of the upper leaves of a number of the wadi mosses, subscribed to the effect of increased moisture content in their microhabitats (El-Saadawi 1979b). The 12 recorded wadi mosses could be easily classified into three groups regarding habitat preference (see Table 2).

(i) Mosses restricted to wet crevices (*Timmiella* and *Fissidens*) or extending to just outside crevices (*Gymnostomum*).

(ii) Mosses growing mainly between rocks (may grow on rocks or extend to just inside wet crevices; mosses numbers 4–9 in Table 2).

(iii) Mosses growing mainly on exposed rock surfaces (may extend between rocks; mosses numbers 10–12 in Table 2); their cover area is largest among the three groups (El-Saadawi 1978).

In the second period of study, mosses were either almost entirely undetectable (1988/89 season, Table 2) or barely recognizable in a few spots (1987/88 and 1989/90 seasons). No sporophytes were seen, only sterile tips of gametophytic shoots just emerging from soil surface and disappearing later in the season. The five persisting moss species are those inhabiting exposed rock surfaces (mosses numbers 10–12 in Table 2) and the two abundant mosses of the group that grows mainly between rocks (mosses numbers 8–9 in Table 2).

COMPARISONS AND DISCUSSION

The first study period (1974/75–1977/78)

There is a poor vegetation on the south-facing slope of wadi Umm-Al-Rimam: no bryophytes and angiosperm perennials and some angiosperm annuals. This is due to a number of factors.

(i) This slope is composed, to a relatively great depth, of continually accumulating loose drift sand which is very poor in organic carbon content.

(ii) This slope gains less water from rain being in the leeward side of the prevailing cold rainy winter winds blowing mainly from the northwest.

(iii) Evapotranspiration must be stronger on a southfacing slope.

Contrary to this, the north-facing slopes, are more shaded, gain more water from rain which is driven against them by the prevailing winds, are able, inspite of their shallow soil, to retain the gained water for a considerable time in the crevices and in the narrow pathways between rocks, and have higher organic carbon content in their soil. These factors sustain the growth of the reported mosses (12 species) and the angiosperms (11 perennials and 54 annuals and biennials). The wadi bed also has shallow soil but acts as a catchment area and collects higher amounts of water, retains it for longer periods, being loamy, and allows it to penetrate into the soil. This enables a more vigorous growth of a larger number of angiosperm perennials (16 species) and annuals and biennials (55 species). However, this last habitat is not suitable for growth of mosses due to lack of shaded and sheltered niches and superficial drying out of the loam.

Table 1. Floristic composition at wadi Umm-Al-Rimam (1974–1990)

	1974–78			1987–90		
	s	n	b	s	n	b
Perennials						
Astragalus spinosus	—	—	r	—	—	—
Asthenatherum forsskalii	—	—	r	—	—	—
Calligonum comosum	—	c	c	—	r	—
Citrullus colocynthis	—	—	r	—	—	—
Cynodon dactylon	—	—	r	—	—	r
Fagonia glutinosa	—	r	r	—	—	r
Helianthemum lippii	—	—	r	—	—	r
Launaea mucronata	—	r	r	—	—	—
Lycium shawii	—	o	o	—	r	r
Moltkiopsis ciliata	—	r	r	—	—	r
Ochradenus baccatus	—	d	c	—	r	r
Onobrychis ptolemaica	—	r	c	—	—	—
Pennisetum divisum	—	r	o	—	—	r
Polycarpaea repens	—	r	r	—	—	r
Rhanterium epapposum	—	o	o	—	r	—
Stipagrostis plumosa	—	r	r	—	—	—
Annuals and Biennials						
Anisosciadium lanatum	r	r	r	—	—	—
Anthemis deserti	r	a	a	—	—	—
Arnebia decumbens	a	r	o	r	r	r
Asphodelus viscidulus	—	r	r	—	—	—
Astragalus annularis	r	r	r	—	—	—
Astragalus hauarensis	r	r	o	—	—	—
Astragalus schimperi	r	o	o	r	—	—
Atractylis flavus	—	r	a	—	—	—
Avena fatua	r	r	a	—	—	—
Bassia eriophora	—	r	r	—	—	—
Brassica tournefortii	—	r	r	—	—	—
Bupleurum semicompositum	—	r	r	—	—	—
Cakile arabica	r	r	a	r	—	r
Calendula aegyptiaca	—	r	r	—	—	—
Carduus pycnocephalus	—	r	r	—	—	—
Centaurea aegyptiaca	—	r	r	—	r	—
Chenopodium murale	—	r	r	—	—	—
Cutandia memphtica	a	r	r	r	r	r
Emex spinosus	—	r	r	—	—	—
Erodium laciniatum	r	r	r	—	r	—
Erodium deserti	r	r	r	—	—	—
Filago desertorum	r	r	r	—	r	r
Gastrocotyle hispida	r	a	r	—	—	—
Gypsophila antari	—	r	r	—	—	—
Hordeum glaucum	—	r	r	—	—	—
Ifloga spicata	r	r	r	—	—	—
Koelpinia linearis	—	r	r	—	—	—
Launaea capitata	—	r	r	—	—	r
Lappula spinocarpos	—	r	r	—	—	r
Lotus halophilus	r	r	r	—	r	r
Lophochloa pumila	—	r	r	—	—	—

Table 1. continued

	1974–78			1987–90		
	s	n	b	s	n	b
Annuals and Biennials (*Continued*)						
Malcolmia grandiflora	—	r	r	—	—	—
Malva parviflora	—	r	r	—	—	—
Medicago laciniata	r	r	r	—	—	—
Monsonia nivea	—	r	r	—	—	—
Neurada procumbens	—	r	r	—	—	—
Oligomeris linifolia	—	r	r	—	—	r
Ononis serrata	—	r	r	—	—	—
Paronychia arabica	r	r	r	—	—	—
Phalaris minor	—	r	r	—	—	—
Picris babylonica	—	—	r	—	—	r
Plantago boissieri	r	r	r	—	—	—
Plantago ciliata	r	r	r	—	—	—
Plantago ovata	r	r	r	—	—	—
Reichardia tingitana	—	r	r	—	—	—
Reseda arabica	—	r	r	—	—	—
Rumex pictus	—	r	r	—	—	—
Rumex vesicarius	—	r	r	—	r	—
Savignya parviflora	vr	r	r	—	—	vr
Senecio desfontainei	vr	r	r	—	—	—
Schimpera arabica	—	r	r	—	—	—
Schismus barbatus	vr	r	r	—	—	—
Stipa capensis	—	r	r	—	—	r
Torularia torulosa	—	r	r	—	—	—
Trigonella stellata	vr	r	r	—	—	r

Nomenclature is based on Rechinger 1964, Daoud 1985 and Al-Rawi 1987.
n = north face slope s = south face slope b = bed of wadi vr = very rare r = rare o = occasional c = common a = abundant d = dominant.

Although the vigorous growth (density and height) of vegetation is generally closely and directly related to the amount and duration of annual rainfall, the rhythm of the response of angiosperms to rainfall differs to some extent from that of bryophytes. For example, the highest diversity and the most vigorous growth of mosses were recorded in the 1975/76 season which coincided with the largest amount of annual rainfall (260·2 mm) ever recorded in Kuwait (Fig. 2 and Table 3) whereas the most vigorous growth of angiosperms was in the 1977/78 season which had only 181·2 mm annual rainfall (still above the average of 107 mm). It must be mentioned that the two rainy seasons 1975/76 and 1977/78 were of the same length, being 6 months each (Table 3), which makes it clear that there must be some other factors besides the total amount of rainfall and the length of the rainy season that affect the rhythm of growth of mosses and angiosperms. The factor that seems to benefit and favour the growth of mosses rather than angiosperms, is the rains that are not interrupted by long, dry spells. This was the case in the 1975/76 but not in the 1977/78 season (see Table 3). Another factor, also stated by Halwagy (1986) is the date of the first rains. If the first rains fall while warm weather still prevails, they will bring about seed germination and bud development but if they are delayed to December or January

Table 2. Mosses recorded in wadi Umm-Al-Rimam in the two periods of study. Species are arranged into three groups according to habitat preference. Species, within each group, are arranged according to degree of abundance where: vr = very rare, r = rare, o = occasional, c = common, a = abundant

Moss species and habitat preference	Degree of abundance						
Group I: mosses 1–3 mosses 1 and 2: only in crevices moss 3: extends outside crevices	First period				Second period		
Group II: mosses 4–9 mainly among rocks Group III: mosses 10–12 mainly on exposed rock surface	1974/75	75/76	76/77	77/78	87/88	88/89	89/90
1. *Timmiella anomala* (B.S.G.) Limpr.	—	r	—	—	—	—	—
2. *Fissidens obtusifolius* Wils.	a	a	—	a	—	—	—
3. *Gymnostomum calcareum* Nees et Hornsh	a	a	—	a	—	—	—
4. *Trichostomopsis haussknechtii* (Jur. et Milde) S. Agnew & Townsend	—	r	—	—	—	—	—
5. *Pottia davalliana* (Sm.) C. Jens.	o	o	—	o	—	—	—
6. *Barbula* sp.	c	c	c	c	—	—	—
7. *Tortula atrovirens* (Sm.) Lindb.	c	c	c	c	—	—	—
8. *Barbula vinealis* Brid.	a	a	a	a	r	—	r
9. *Bryum bicolor* Dicks.	a	a	a	a	r	vr	r
10. *Aloina rigida* (Hedw.) Limpr.	a	a	a	a	r	—	r
11. *Crossidium chloronotus* (Brid.) Limpr.	a	a	a	a	r	—	r
12. *C. squamigerum* (Viv.) Jur.	a	a	a	a	r	—	r
Total number of species recorded	10	12	7	10	5	1	5

Table 3. Monthly and annual rainfall (mm) recorded at Kuwait International Airport (1958–1990)

	S	O	N	D	J	F	M	A	M	J	J	A	Annual
1958–59	0·0	0·0	19·3	52·9	39·1	15·8	8·7	9·0	4·8	0·0	0·0	0·0	149·6
1959–60	0·0	0·0	10·9	27·5	12·1	1·8	11·4	4·2	0·0	0·0	0·0	0·0	67·9
1960–61	0·0	0·0	9·9	0·7	19·4	21·1	50·5	56·4	0·0	0·0	0·0	0·0	158·0
1961–62	0·0	0·0	45·9	18·0	27·2	3·3	5·7	15·1	T	0·0	0·0	0·0	115·0
1962–63	0·0	0·0	18·2	10·9	0·2	24·1	0·4	16·3	17·6	0·0	0·0	0·0	87·7
1963–64	0·0	T	8·1	0·5	15·2	3·1	1·0	0·2	T	0·0	0·0	0·0	28·1
1964–65	0·0	T	0·4	11·4	63·0	T	5·0	3·0	4·4	0·0	0·0	0·0	87·2
1965–66	T	5·4	7·6	T	14·3	27·6	9·3	3·5	T	0·0	0·0	0·0	67·6
1966–67	0·0	T	0·0	6·0	18·5	21·1	0·9	3·2	19·0	0·0	0·0	0·0	68·7
1967–68	0·0	T	107·6	0·2	0·7	14·1	5·4	20·2	13·6	0·0	0·0	0·0	161·4
1968–69	0·0	0·2	11·4	13·2	38·6	11·4	2·5	35·7	3·4	0·0	0·0	0·0	116·4
1969–70	0·0	12·9	1·2	0·0	36·3	4·3	1·9	2·9	T	0·0	0·0	0·0	59·4
1970–71	0·0	0·0	1·4	33·8	13·8	11·6	11·3	53·9	2·4	0·0	0·0	0·0	128·2
1971–72	0·0	T	10·9	10·0	73·2	8·5	33·6	67·0	0·4	T	0·0	0·0	203·6
1972–73	0·0	0·0	17·1	18·7	0·6	0·8	1·7	0·8	T	0·0	0·0	0·0	39·7
1973–74	0·0	0·0	T	30·9	48·9	21·2	38·6	0·3	0·1	0·0	0·0	0·0	140·0
1974–75	0·0	1·4	0·0	57·9	29·2	21·0	4·1	46·6	11·0	0·0	0·0	0·0	171·2
1975–76	0·0	0·0	3·0	25·6	40·1	95·9	18·9	61·8	14·9	0·0	0·0	0·0	260·2
1976–77	0·0	0·6	1·2	9·0	20·9	T	7·0	2·7	2·1	0·0	0·0	0·0	43·5
1977–78	0·0	56·6	2·2	44·8	44·0	3·1	29·3	0·6	0·6	0·0	0·0	0·0	181·2
1978–79	0·0	0·0	15·1	14·1	51·8	0·5	4·1	0·1	10·9	T	0·0	0·0	96·6
1979–80	0·0	3·2	T	50·4	16·8	54·1	16·8	0·6	0·2	0·0	0·0	0·0	142·1
1980–81	0·0	T	1·8	41·6	29·7	29·4	6·3	1·7	0·4	0·0	0·0	0·0	110·9
1981–82	0·0	1·8	9·0	2·1	31·1	17·7	16·7	2·8	4·8	0·0	0·0	0·0	86·0
1982–83	0·0	7·8	32·8	15·1	23·5	6·0	12·6	18·9	3·1	T	0·0	0·0	119·8
1983–84	0·0	0·0	0·2	0·6	14·8	1·8	17·3	T	T	0·0	0·0	0·0	34·7
1984–85	0·0	T	41·2	8·2	27·4	T	6·0	10·1	T	0·0	0·0	0·0	92·9
1985–86	0·0	25·0	10·6	11·9	16·7	20·1	17·2	5·6	0·0	0·0	0·0	0·0	107·1
1986–87	0·0	0·0	18·6	20·4	0·3	9·6	43·0	1·0	T	0·0	0·0	0·0	92·9
1987–88	0·0	4·9	0·0	16·2	37·8	9·2	13·3	0·8	T	0·0	0·0	0·0	82·2
1988–89	0·0	0·0	0·4	8·0	2·0	10·1	9·9	1·2	T	0·0	0·0	0·0	31·6
1989–90	0·0	0·0	20·5	23·8	14·4	18·3	6·5	—	—	—	—	—	

they coincide with cold weather which only benefits the activity of bryophytes. The first rains in the two mentioned seasons 1975/76 and 1977/78 came in December and October respectively (Table 3) which explains this difference in the vigour of growth between mosses and angiosperms in the two seasons.

The second study period (1987/88 and 1989/90)

The rainy seasons of the second period were either below average or at a minimum value thus sharply contrasting with the seasons of the first period (Fig. 2). In addition to this, the 9-year interval between the two periods, was also mainly poor in rain (Table 3 and Fig. 2). Poor rain, together with high evapotranspiration rate resulted in severe drought during the second period. Absolute maximum air temperature in the prolonged summer of Kuwait exceeds 50°C, soil temperature frequently exceeds 70°C, air humidity is at a minimum, while rate of evaporation is maximum. The successive years of drought explain the sharp reduction in the number of annuals, the thinning and defoliation of the persisting perennials and the impoverishment of mosses. The main sources of water supply for mosses growing on exposed rock surfaces (unsheltered) are rain and dew whereas for mosses growing in relatively sheltered sites (among rocks and in crevices) they are heavy rains and percolating or seepage water. The few rain showers of the successive dry seasons of the second study period, hardly sustained the life of the unsheltered mosses which have more access to the rain (also to fog and mist) rather than those sheltered among rocks and there was not enough water to percolate and gather in the crevices. This explains the survival of unsheltered mosses and the disappearance of almost all sheltered mosses especially those restricted to inside crevices. Survival may be due, besides interception of rain showers, to structural adaptations to xeric conditions; leaves of *Aloina* are partially succulent with adaxial chlorophyllose filaments, cucullate apex and infolded wings; leaves of *Crossidium* are partially succulent with adaxial chlorophyllose filaments and hair points (see for example Proctor 1979, 1980, 1984; Schofield 1981; Scott 1982). Such structural features are not well-expressed in the other two surviving mosses: *Bryum* and *Barbula vinealis*. These two mosses display features considered to be for drought resistance. *B. vinealis* has closely set overlapping leaves with clearly sheathing bases. The leaves twist readily on drying, thus tightly covering and protecting the growing points of their shoots which grow in cushions. The cushion habit of growth seems to be a very successful means for drought resistance. *Bryum* has crowded concave imbricate leaves which efficiently protect the growing points of the shoots. Recently El-Saadawi & Zanaty (1990) have shown that *Bryum* in Kuwait develops remarkable persisting structures and shows both avoidance and tolerance survival strategies (*sensu* During 1979) at the same time. Some bryologists (for details see El-Saadawi 1978) however, see that xerophytes among bryophytes are closely related to their microclimate that is distinctly different from the arid macroclimate and consequently the features they possess are not really xeromorphic.

It must be mentioned that poor rain and high evapotranspiration rate were accompanied by sand-loaded speedy winds which blasted the weathered fragile surface layers of the already loosened and cracked rocks of the north-facing slopes, thus accelerating their weathering to a great extent. The finer particles of the weathered materials of the surface layers of the affected rocks are removed by erosion and transported by agents of erosion, but coarser particles accumulate on the ground at the foot of big rocks (produce of *in situ* weathering). There were enough drifted sands to fill rock crevices, to cover interstices between rocks and to cover most of the wadi bed accumulating to a height reaching about 4 metres at places (Fig. 3b). Soil erosion (Fig. 3c) and grazing animals completed the job of the cumulative years of drought and extinguished the few persisting palatable angiosperms. Nevertheless, a few angiosperms remained. These remaining species are either rhizomatous (*Cynodon*), thorny (*Lycium*) and/or spiny with high osmotic pressure (*Fagonia*), with deep-penetrating roots (*Helianthemum, Ochradenus*) or with C_4 photosynthesis (*Calligonum*) (see also Walter 1964; Winter *et al.* 1976; Ziegler *et al.* 1981).

A number of artificial concrete blocks (Fig. 4a) were laid down, in a nearby area in 1970, for the purpose of studying the desert vegetation of Kuwait (Halwagy 1973). They indicated the effect of the mechanisms of soil erosion at certain sites and redeposition and accumulation at other sites (Fig. 4a–c). Soil erosion and redeposition occurred intensively in association with drought during the past 8 years (1982–1989). It must be mentioned however, that changes in vegetation in response to alternating wet and dry seasons (regular or haphazard cycles of climate) which is part of the studied and other similar environments, is well known in the present as well as in past ages (see also Thalen 1979; Warren 1984; Le Houérou 1986). The question is would this prolonged drought trigger

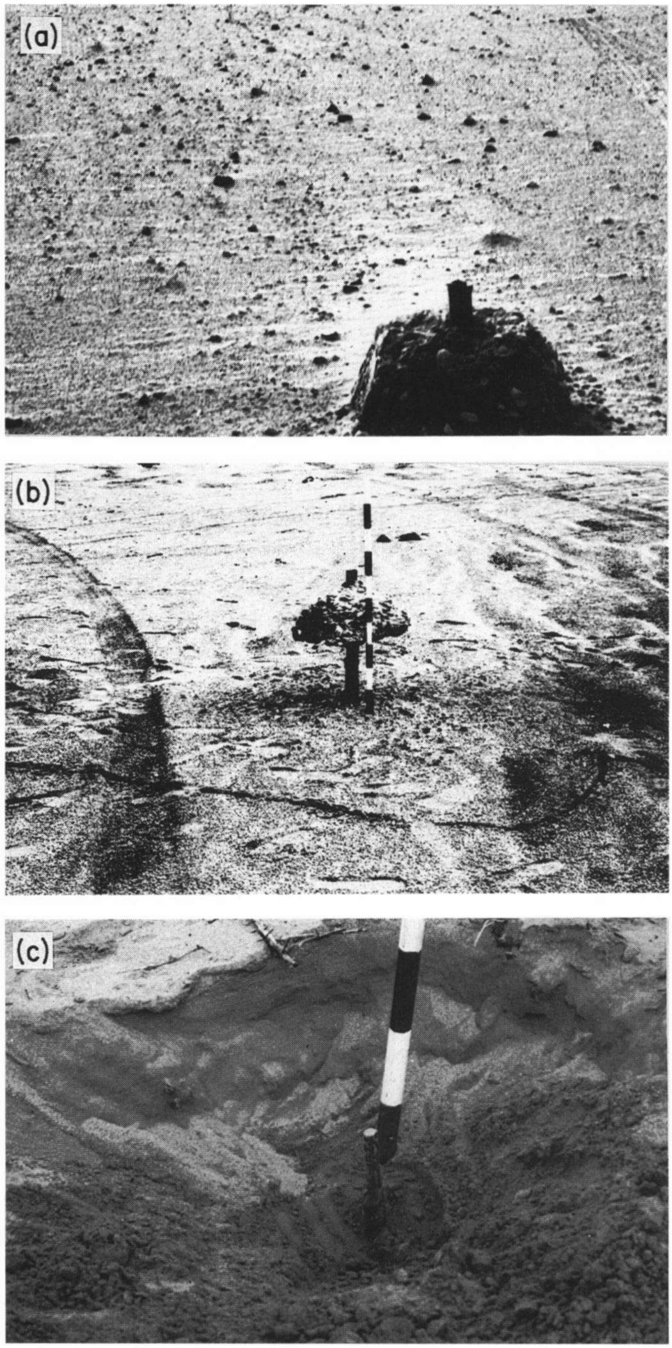

Fig. 4. (a) One of the artificial concrete blocks (20 × 40 × 40 cm) only slightly affected, 12 years after it was laid down (photo taken in 1982). (b) Another block several years later, the coloured scale bar shows that about 30 cm thickness of surface soil has been removed from under the block due to intensive erosion. Part of the fallen off weathered material of the block is seen on the ground surface. (c) A third block deeply buried under accumulating soil, photographed in 1986.

desertification? The answer however, requires a longer amplitude of yearly observations. Fortunately, until the end of the present study some of the plants (angiosperms and bryophytes) survived the drought, i.e. the ability of the studied ecosystem to recover is not entirely damaged. In this connection it may be of interest to quote a comment made by El-Saadawi (1976) about the isolated bryoflora of Kuwait and its elements 'A comparison of the poor moss flora of Kuwait with that of Iraq shows clearly that all mosses of Kuwait occur also in Iraq except the two species confined to deep positions inside wet crevices, namely, *Fissidens obtusifolius* and *Timmiella anomala.* This probably means that the relatively poor moss flora of Kuwait represents relics of a previous more rich and widely distributed flora like that of Iraq. The remaining species might have become isolated by the development of deserts around them. Being sheltered by clefts in the rocks, they apparently escaped destruction. The presence for example, of the species *Fissidens obtusifolius* in Kuwait as well as in Europe and America (Wijk 1962) and in Mexico (Norris 1969) may be interpreted as being due to separation by intercalation of arid regions and by shifting of continents, of a once more spread and continuously represented species.'

The present study shows that plant life even in these sheltered niches is endangered by prolonged droughts. It is hoped that the recent (started on 2 August 1990) military operations in Kuwait in addition to pollution resulting from destruction of oil wells and other natural resources do not cause further damage to the surviving biota.

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