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Seasonal fluctuations of soil fungi of Wadi Qena at eastern desert of Egypt

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The results of the studies on seasonal fluctuations in number and occurrence of glucophilic, osmophilic and halophilic fungi inhabiting soils one wadi in eastern Egypt (conducted in 1985) are presented.

INTRODUCTION

The term "seasonal fluctuation" of soil fungi means studying the number and occurrence of soil fungi during different seasons of a year which are expected to rare depending upon big changes in climatic factors. In Egypt, some investigations were conducted on the seasonal fluctuations of fungi in cultivated soils from Upper Egypt (Moubasher et El-Dohlob 1970; Moubasher et Abdel-Hafez 1978; Mazen et Shaban 1983) but only those of Moubasher et al. (1985a) dealt with seasonal fluctuations of glucophilic soil fungi of one of the Wadies (Bir-El-Ain) located in Egyptian deserts. The present analysis aims to be an intense study of the seasonal periodicity in numbers of glucophilic, osmophilic (or osmotolerant) and halophilic (or halotolerant) fungi inhabiting soils of Wadi Qena.

Wadi Qena is one of the largest wadies crossing the Eastern Desert Plateau and has its deltaic mouth at the town of Qena (latitude 26° 10' north); it takes course towards North-South (N-S) to its source at 28° 5' north and is some 170 km long. The channel of the Wadi occupies the floor of an extensive valley. This is bounded on the west by precipitous cliffs of the limestone plateau which extends westward till the border of Nile Valley. By contrast to this uniform flat-topped limestone plateau, the vaely is bounded on the east by the serrated and multi-coloured granitic peaks that form the

Red Sea range. The flora of the wadi includes numerous plants such as *Aerva persica*, *Artemisia judaica*, *Cleome droserifolia*, *Fagonia indica*, *Leptadenia pyrotechnica*, *Pulicaria crispa*, *Salsola vermiculata* and *Zilla spinosa*.

MATERIALS AND METHODS

Twenty-four soil samples were collected fortnightly from Wadi Qena under *Salsola vermiculata* during January-December 1985, by the method described by Johnson et al. (1959). Samples were placed in polyethylene bags and transferred immediately to the Mycological laboratory and stored at 3-5°C.

The soil samples were analysed for the estimation of total soluble salts, elements (Ca, Mg, K and Na) and organic matter contents. A pH-meter (WGPYE model 290) was used for the determination of soil pH. The soil type was found by the hydrometer method (Piper 1955), and all samples were sandy-clay.

The fungal flora of samples was determined by the dilution-plate method (Johnson et al. 1959), modified by Moubasher and Abdel-Hafez (1978). Fifteen plates were used for each sample, five plates were poured with each of the following media; glucose- (10 g/L), 50% sucrose- and 10% NaCl-Czapek's agar. Then rose-bengal (1/15000) was added as a bacteriostatic agent (Smith et Dawson 1944). The plates were incubated at 28°C for 1-2 weeks (glucophilic and osmophilic or osmotolerant fungi), and for 4-6 weeks (halophilic or halotolerant fungi) and the developing fungi were counted, identified, and their numbers were calculated per g dry soil. The colonies of slow growing fungi, which were about to be overgrown, as well as mycelial fragments of some colonies, were transferred to yeast extract or malt extract agar or to the previous two media supplemented with 50% sucrose or 10% NaCl.

RESULTS AND DISCUSSION

Wadi Qena represents an interesting arid habitat within eastern desert of Egypt, hence any information on the seasonal fluctuations of fungi in Wadi soils is of great importance.

The soil samples tested were generally poor in organic matter (0.01-0.99% of dry soil), carbonate (0.02-0.07%) and bicarbonate (0.02-0.17%) contents. The total soluble salts varied from 0.02-2.09%; Ca, 0.04-0.92 mg; Mg, 0.03-0.69 mg; K, 0.01-0.12 mg and Na, 0.1-0.97 mg/g dry soil. Moubasher et al. (1985a) found that the organic matter content of Wadi Bir-El-Ain soils fluctuated between 0.2-1.22% of dry soil; in total soluble salts: 0.5-

4.2%, Ca: 0.01-4.5 mg, Mg: 0.01-0.48 mg, K: 0.04-2 mg, and Na: 0.04-3.5 mg/g dry soil.

The water contents of the soil samples tested were very low (1.8 to 2.1% W.H.C.). The maximum temperature during the studies (46-48.4 C) was recorded in summer and the minimum in winter (4-6°C). The highest relative humidity of the sir occurred during December (75% r.h.) and the lowest during March (23.5% r.h.).

Seasonal fluctuations of glucophilic soil fungi

Thirty-two glucophilic species and 3 varieties which belong to 16 genera vere isolated from 24 soil samples on 1% glucose-Czapek's agar at 28°C (Table 2).

Monthly average total count and the maximum number of glucophilic fungi varied from 12143-24993; and 22000-43050 colonies/g dry soil, respectively (Table 1). The average total count of fungi did not show any seasonal fluctuations, their maxima were recorded in February (24527 colonies) and May (24993 colonies), while the minima in January (13015 colonies) and July (12143 colonies). Moubasher et al. (1985b) found that the soil fungi of Wadi Bir-El-Ain fluctuated irregularly and their highest counts were in August and September 1978, and May, July, October and November 1979.

Aspergillus (12 species + 3 varieties), *Penicillium* (6 species) and sterile mycelia occurred with seasonal frequency, in 100%, and 88% of the samples comprising 42.7%, 43.1% and 4.7% of total fungi, respectively. Their number irregularly fluctuated and the maxima were obtained in February (13240 colonies) and September (12875 colonies); March (10725 colonies), Mai (11960 colonies), June (11125 colonies), October (12310) and November (9845); and May (2390), respectively (Fig. 1). Moubasher et al. (1985b) also found that these two genera did not display any seasonal periodicity in soils of Wadi Bir-El-Ain. However, according to Moubasher et Abdel-Hafez (1978) and Moubasher et El-Dohlob (1970) *Aspergillus* dominated in cultivated soils in summer and *Penicillium* in winter. From the above genera *A. flavus*, *A. niger*, *A.* (*Emericella*) *nidulans*, *A. fumigatus*, *A. ustus*, *A. ochraceus*, *A. terreus*, *A. sydowi*, *P. chrysogenum*, *P. aurantiogriseum*, *P. puberulum*, *P. citrinum* and *P. janczewskii* occurred with high seasonal frequency; they were encountered in 54-100% of the samples constituting 1-28.4% of total fungi. The number of these species also fluctuated irregularly and the maxima were recorded during different months of a year (Fig. 1).

Ulocladium (*U. botrytis* and *U. atrum*), *Rhizopus* (*R. stolonifer*), *Stemphylium* (*S. botryosum*) and *Microascus* (*M. cinereus*) were found to occur with moderate seasonal frequency, they emerged in approximately 33-46% of the samples comprising 0.7-2.7% of total fungi. The peaks of these fungi were

Table 1

Monthly average total count and its maximum value /calculated per g dry soil in every sample/ and number of genera and species isolated from soil samples during January-December 1985, on glucose-, 50 % sucrose-, and 10 % sodium chloride glucose-Czapek´s.agar at 28°C /± 2°C/

Months	1 % glucose-Czapek´s agar			50 % sucrose-Czapek´s agar			10% NaCl glucose-Czapek´s agar		
	ATC + SD /MV/	NG	NS	ATC ± SD /MV/	NG	NS	ATC±SD/MV/	NG	NS
January	13015±15689/43050/	9	22	9835±4639/11950/	5	15	315±175/445/	2	5
February	24527±9623/22775/	9	25	34227±24662/66700/	5	19	354±157/380/	2	4
March	18935±12917/30875/	10	20	16355±9722/24875/	4	12	165±144/300/	2	4
April	16730±8788/22000/	4	15	10265±7235/16950/	2	11	228±127/320/	2	5
May	24993±13698/35150/	6	16	18212±11592/27200/	6	16	108±93/240/	2	4
June	22880±15208/41125/	6	14	10615±9386/20175/	4	8	233±137/350/	2	5
July	12143±9288/22775/	9	20	11365±7614/17500/	5	13	207±164/395/	2	5
August	18600±12068/30775/	12	25	14860±12135/30975/	3	9	308±220/485/	2	5
September	21946±13090/31300/	9	20	9625±6067/14655/	3	12	62±36/95/	2	3
October	21050±13173/31400/	6	21	9575±9337/23575/	4	13	250±139/370/	2	5
November	21380±12774/30500/	8	19	17005±10879/26825/	3	12	283±145/360/	2	5
December	16150±9955/25250/	7	18	8888±4923/11550/	3	11	192±114/305/	2	5

ATC ± SD /MV/ - Average total count in every sample ± standard deviation /the maximum in brackets/.

HC - Number of genera.

HS - Number of species.

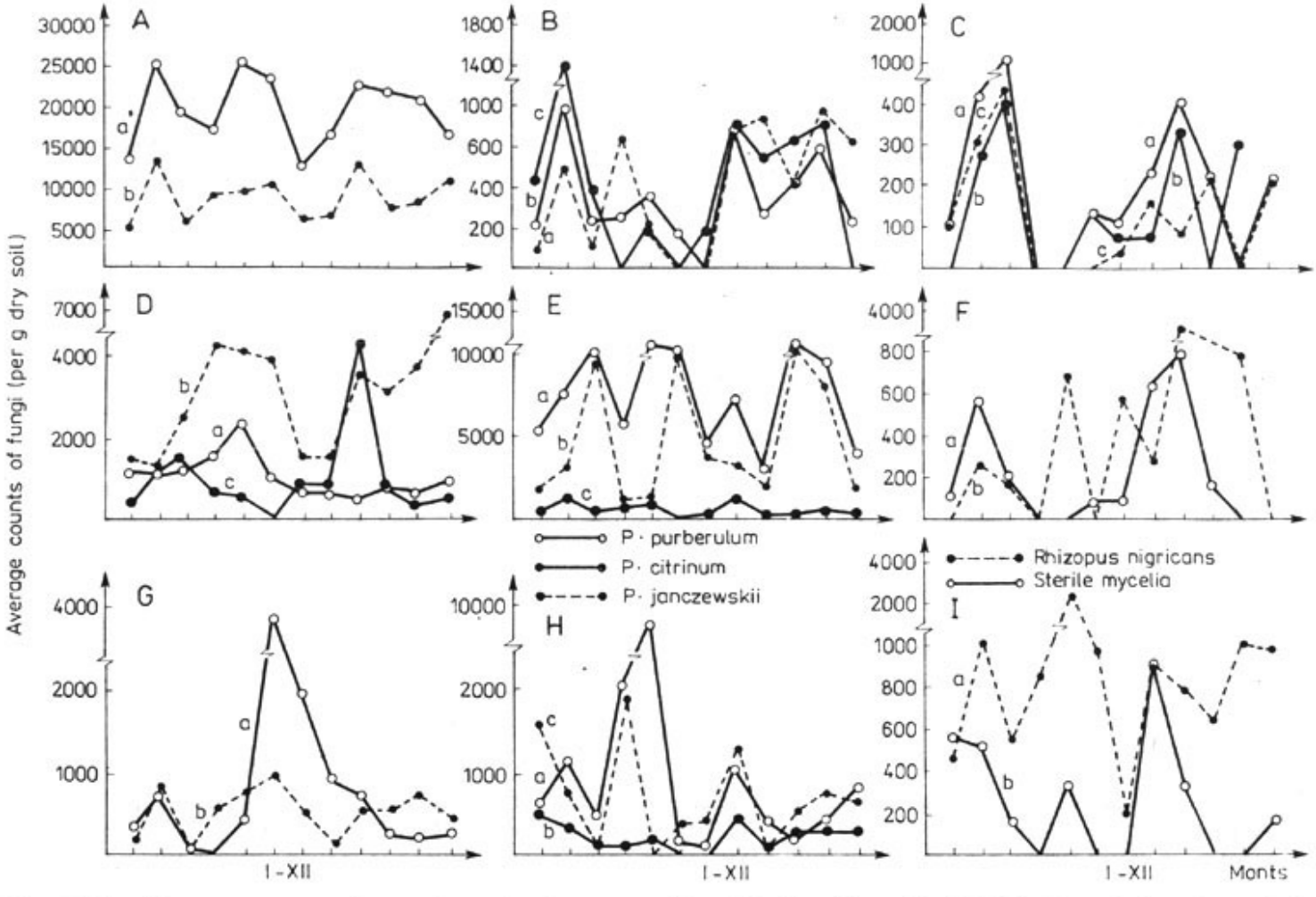

Fig. 1. Monthly average counts (per g dry soil) of common glucophilic fungi in soils of Wadi Qena during the periods I-XII 1985

A. a. – Total count, *b* – *Aspergillus* sp.; *B. a* – *A. ochraceus*, *b* – *A. sydowi*, *c* – *A. terreus*; *C. a.* – *Ulocladium* sp., *b* – *U. atrum*, *c* – *U. botrytis*; *D. a* – *Aspergillus flavus*, *b* – *A. niger*, *c* – *A. nidulans*; *E. a* – *Penicillium* sp., *b* – *P. chrysogenum*, *c* – *P. aurantogriseum*; *F. a* – *Stemphylium* botryosum, *b* – *Microascus cinereus*; *G. a.* – *A. fumigatus*, *b* – *A. ustus*; *H. a* – *P. puberulum*, *b* – *P. citrinum*, *c* – *P. janczewskii*; *I. a* – *Rhizopus nigricans*, *b* – *Sterile mycelia*

Table 2

Average total count and its maximum value /calculated per g dry soil in every sample/, and the number genera and species isolated from 24 soil samples during January-December 1985, on 1 % glucose, 50 % sucrose, and 10 % NaCl glucose-Czapek's agar at 28°C /±2°C/

Genera et species	1 % glucose-Czapek's agar			50 % sucrose-Czapek's agar			10 % NaCl-Czapek's agar		
	ATC±SD	NCI	OR	ATC±SD/MV/	NCI	OR	ATC±SD/MV/	NCI	OR
Aspergillus	88415±55064/141325/	24	H	74784±43025/138715/	24	H	1122±872/1660/	23	H
A. flavus Link	9155± 5594 /14675/	24	H	7920± 4800 /13100/	20	H			
A. niger Van Tieghem	35680±26609 /59850/	24	H	28906±20043 /49570/	24	H			
A. nidulans /Eidam/ Winter	11560± 7594 /19625/	20	H	20750±22035 /35400/	14	H			
A. fumigatus Fresenius	8015± 5004 /12975/	17	H	1725± 1212 / 3075/	9	M			
A. ustus /Bainier/ Thom et Church	4980± 2848 / 7100/	16	H						
A. ochraceus Wilhelm	3940± 2648 / 6975/	14	H	2170± 1277 / 3375/	10	M			
A. terreus Thom	3930± 2381 / 6100/	14	H	2215± 1563 / 3800/	11	M	331±192/ 475/	21	H
A. sydowi /Bain.et Sart./ Thom et Church	3450± 2003 / 5050/	13	H	1155± 746 / 2025/	6	M	791±480/1185/	23	H
A. candidus Link	1275± 746 / 1875/	5	L	760± 441 / 1400/	4	L			
A. flavus var. columnaris Raper et Pennell	605± 510 / 1325/	4	L	400± 306 / 700/	3	L			
A. carneus /V. Tiegh./ Blochwtiz	350± 254 / 700/	3	L						
A. clavatus Desmazieres	375± 441 / 1125/	2	R	250± 153 / 375/	1	R			
A. terreus var. aureus Thom et Raper	710± 466 / 1200/	2	R						
A. nidulans var. cristatus Pennell et Raper	4390± 3491 / 7250/	1	R	8408± 3618 / 8520/	1	R			
A. amstelodami /Mangin/ Thom et Church				125± 176 / 375/	2	R			
Penicillium	89190±59335/134600/	24	H	73025±51927/115600/	24	H	1215±705/2020/	22	H
P. chrysogenum Thom	58655±44970/ 88525/	24	H	52930±35903/ 84875/	24	H	747±440/1135/	22	H

P. aurantiogriseum Dierck	5745±	3266/	7800/	22	H	1375±	1000/	2750/	9	M					
P. puberulum Baininer	16030±	10348/	24975/	19	H	11425±	7361/	17500/	15	H	295±185/	495/	19	H	
P. citrinum Thom	5845±	3548 /	9400/	15	H	3135±	1820/	4750/	11	M	173±144/	390/	12	H	
P. janczewskii Zaleski	2040±	1155/	2875/	14	H	2045±	1156/	3000/	13	M					
P. funiculosum Thom	875±	561/	1025/	5	L	2065±	1161/	2725/	11	M					
Ulocladium	2765±	1664/	4025/	11	M										
U. botrytis Preuss	1440±	907/	2250/	11	M										
U. atrum Preuss	1325±	768/	1900/	8	M										
Rhizopus stolonifer Ehrenb. ex Fr. Lindt.	1790±	1084/	4375/	10	M	655±	446/	1150/	6	H					
Stemphylium botryosum Wallroth	2375±	1418/	3675/	10	M	375±	353/	750/	3	L					
Microascus cinereus /Emile-Weilet/ et Gaudin/ Curzi	5643±	4272/	10825/	8	M	250±	197/	500/	1	R					
Papulospora chartarum Immersa Hotson	1225±	700/	1800/	5	L										
Drechslera spicifera /Bainiver/ Von Arx anamorph of Cochliobolus spicifer Nelson	950±	543/	1250/	4	L										
Fusarium solani /Hart./ Sacc.	990±	675/	1800/	4	L										
Circinella muscae /Sorok./ Berl. et Detoni	1460±	933/	2425/	3	L										
Curvularia lunata /Wakker/Bojedijn anamorph of Cochliobolus lunatus Nelson et Haasis	605±	397/	1075/	3	L										
Exserohilum halodes /Drechsler/ Leonard et Suggs anamorph of Setosphaeria rostrata Leonard	344±	371/	970/	2	R										
Paecilomyces variotii Bainier	325±	301/	625/	2	R										
Trichoderma hamatum /Bonord./ Bain	340±	234/	575/	2	R										
Phoma herbarum Wested.	450±	335/	900/	1	R										
Scopulariopsis brevicaulis /Sacc./ Bainier	150±	106/	300/	1	R										
Chaetomium olivacium Cooke et Ellis						1130±	725/	1875/	3	L					

Epicoccum purpurascens Ehrenb. ex ex Schlecht.						575±	325/	2750/	2	R
Hypomyces chrysospermae Tul.						200±	189/	500/	1	R
Sterile mycelia /white et dark colour/	9807±	5779/	6275/	21	H	4140±	2380/	6125/	21	H
Gross total count	206824±128780/309460/					155134±93549/230715/				2337±1368/3410/

ATC+SD/MV/ - Average total count in every sample ±standard deviation the maximum in brackets, in all cases the minimum being zero/;

OR - frequency: H - high, between 12-24 cases /out of 24 samples/; M - moderate, between 6-11 cases; L - low, between 3-5 cases; R - rare, less than 3 cases.

estimated in May (1050 colonies); August (505); February (565), August (630) and September (775); and September (3491), respectively (Fig. 1). The remaining genera and species were less common (Table 2).

Seasonal fluctuations of osmophilic (or osmotolerant) fungi

Twenty-two osmophilic (or osmotolerant) species in addition to 2 species varieties belonging to 8 genera were collected from 24 soil samples on 50% sucrose-Czapek's agar at 28°C.

Monthly average total count and its maximum for osmophilic (or osmotolerant) fungi irregularly fluctuated and varied widely from 8888-34227; and 11550-66700 colonies per g dry soil, respectively. The peak was recorded in February and the trough in January, September, October and December (Table 1, Fig. 2). Mazen et Shaban (1983) found that the highest total counts of osmophilic fungi in soils from wheat field in Upper Egypt were estimated for May and April 1978.

The results obtained on 50% sucrose-agar plates were basically similar to those on glucose with the most frequent genera being *Aspergillus* (10 species + 2 varieties), *Penicillium* (6 species) and sterile mycelia (white and dark colour); these were encountered in 100%, 100% and 88% of the samples contributing 48.2%, 47.1% and 2.7% of total fungi, respectively. The counts irregularly fluctuated and their maxima were recorded in February (27587 colonies); March (10840), May (10285) and November (11790); and August (705), September (675) and November (720), respectively. *A. niger*, *A. flavus*, *A.* (*Emericella*) *nidulans*, *P. chrysogenum*, *P. puberulum* and *P. janczewskii* were encountered with high seasonal frequency; they occurred in about 54-100% of the samples giving rise to 1.3-34.2% of total fungi. The highest counts of these species were recorded for May (4127 colonies) and July (3490); April (1340) and July (1500); February (14950); March (10325), August (9100) and November (9190); May (4410); and February (700) and December (750), respectively (Fig. 2). *A. fumigatus*, *A. ochraceus*, *A. terreus*, *A. sydowi*, *P. aurantiogriseum*, *P. citrinum*, *P. funiculosum* and *Rhizopus stolonifer* occurred with moderate seasonal frequency, they emerged in about 25-46% of the samples constituting 0.4-2% of total fungi. The maxima to these species were obtained during various months (Fig. 2). Most to the preceding species were encountered, but with variable seasonal frequency and number, from soil of Egyptian wheat field on 50% sucrose-Czapek's agar at 28°C (Mazen et Shaban 1983). The remaining genera and species were less frequent. Also, the most species were encountered on osmophilic medium, but with variable number, frequency and osmophilic abilities, from cultivated, desert and saline soils of some Arab countries (Moustafa 1975; Moustafa

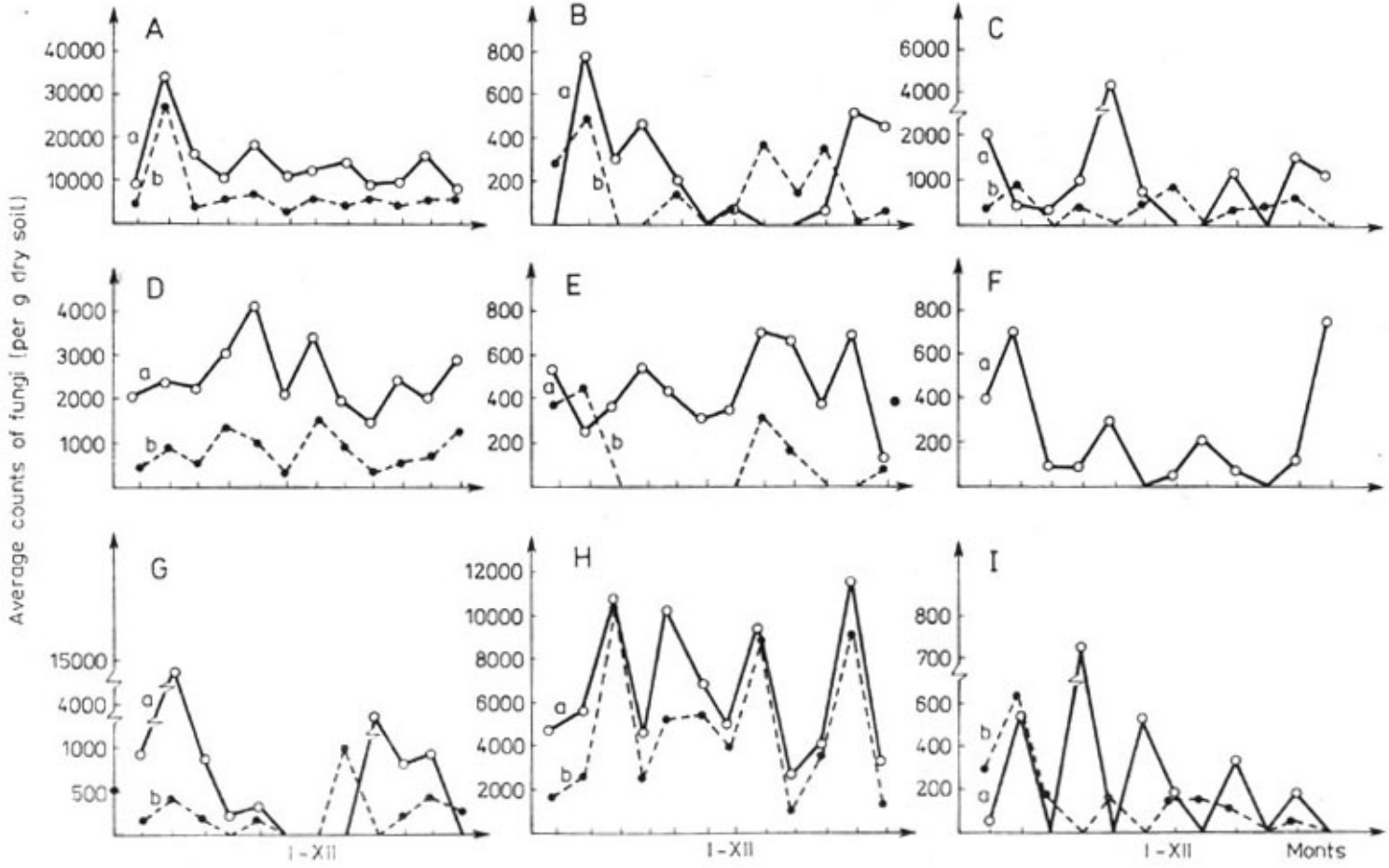

Fig. 2. Monthly average counts (per g dry soil) of common osmophilic and osmotolerant fungi in soils of Wadi Quena during the periods 1985 I-XII 1985

A. a – Total count, *b* – *Aspergillus* sp.; *B. a* – *A. ochraceus*, *b* – *A. fumigatus*; *C. a* – *P. puberulum*, *b* – *P. citrinum*; *D. a* – *A. niger*, *b* – *A. flavus*; *E. a* – *Sterile mycelia*, *b* – *A. sydowi*; *F. a* – *P. janczewskii*; *G. a* – *A. nidulans*, *b* – *A. terreus*; *H. a* – *Penicillium* sp., *b* – *P. chrysogenum*; *I. a* – *P. funiculosum*, *b* – *P. aurantiogriseum*

et Al-Musallam 1975; Mazen et al. 1981; Moubasher et al. 1981 et 1985a). Raper et Fennell (1965) reported that numerous species of *Aspergillus* are of osmophilic nature.

Seasonal fluctuations of halophilic (or halotolerant) fungi

Five halophilic (or halotolerant) species representing two genera were encountered on 10% NaCl-Czapek's agar at 28°C. The average total count and maximum value of these fungi varied widely from 62-353; and 95-485 colonies/g dry soil, respectively. The count of halophilic (or halotolerant) fungi irregularly fluctuated and their maxima were estimated for January (315 col.), February (354 col.) and August (308) which the minimum was recorded in September (62 col.) (Fig. 3).

Aspergillus (2 species) and *Penicillium* (3) were isolated during all months contributing approximately 48% and 52% of total fungi, respectively. The highest counts of the above genera were estimated for February (292 col.) and November (170); and January (182) and August (225), respectively. *A.*

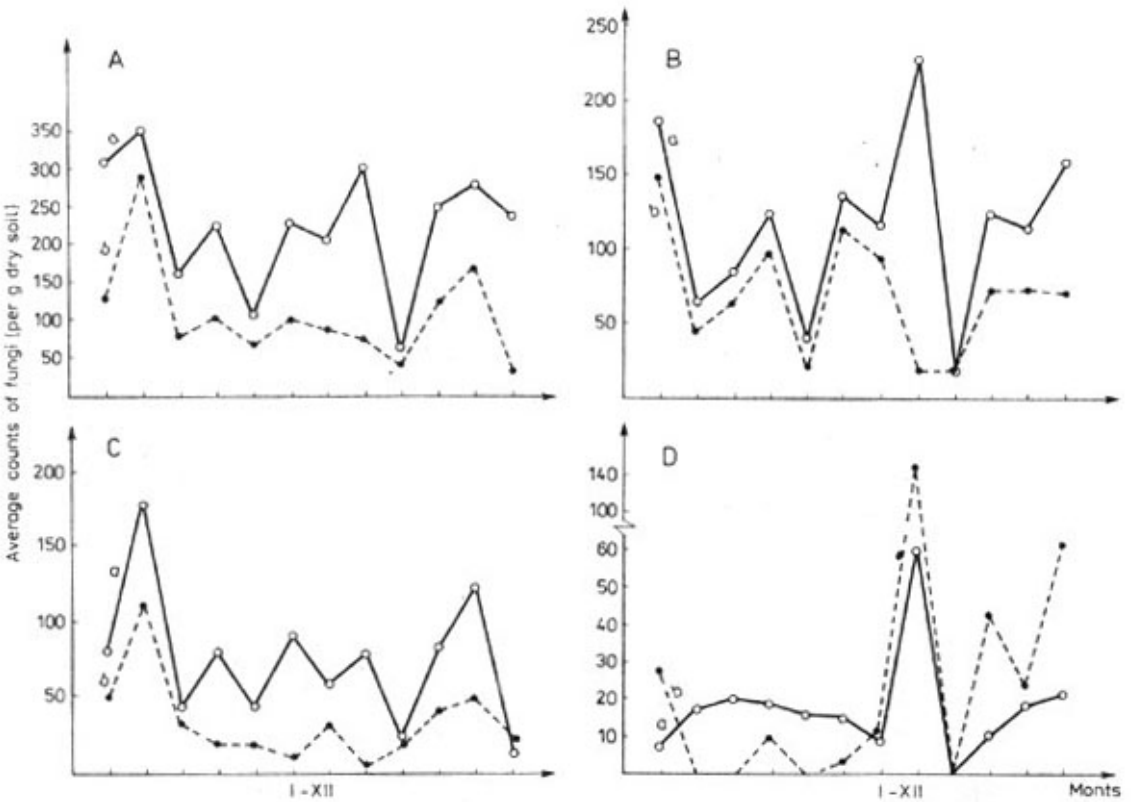

Fig. 3. Monthly average counts (per g dry soil) of common halophilic and halotolerant fungi in soils of Wadi Qena during the periods I-XII 1985

A. a – total count, *b* – *Aspergillus* sp.; *B. a* – *Penicillium* sp., *b* – *P. chrysogenum*; *C. a* – *A. sydowi*, *b* – *A. terreus*; *D. a* – *P. citrinum*, *b* – *P. puberulum*

sydowi, *A. terreus*, *P. citrinum*, *P. chrysogenum* and *P. puberulum* were isolated with high seasonal frequency; they occurred during 8-12 months comprising 7.4-32% of total fungi. Their counts were almost parallel to those of the genus counts, and their peaks were estimated for February (180 colonies) and November (129); February (112); August (60); January (149) and June (114); and August (147), respectively (Fig. 3). Abdel-Hafez (1981) isolated the previous species, but with variable number and frequency, from Saudi Arabian desert soils on 5% NaCl agar plates at 28°C. Abdel-Sater (1937) considered *A. sydowi*, *A. terreus*, *P. citrinum* and *P. chrysogenum* as fairly (moderately) halophilic (growth on 5 to 15 or 20% NaCl, with the best growth at 10 or 15% NaCl); and *P. puberulum* as weakly halophilic (growth on 5 to 10 or 15% NaCl and gave their best growth at 5% NaCl). Tresener et Hayes (1971) found that *Penicillia* (273 strains of 124 species) and *Aspergilli* (196 strains of 81 species) were outstandingly more resistant to NaCl than any of the other organisms studied.

Range of genera and species

Table 1 shows that the number of genera and species of glucophilic and osmophilic (or osmotolerant) fungi irregularly fluctuated while the widest amplitude were recorded for August (12 genera and 25 species); and February (5 genera and 19 species) and May (6 genera and 16 species), respectively. The narrowest amplitude of two groups were found in April and June. In case of halophilic (or halotolerant) fungi, the number of genera was two all the time but the widest amplitudes for 5 species were obtained during 8 months (out of 12) representing four seasons of year. Also, the number of genera and species did not always follow the average and maximum total counts of fungi. But in numerous cases the wide range of genera and species were estimated in months with high numbers of fungi and vice versa. This is almost in agreement with the results obtained from Wadi Bir-El-Ain soils examined by Moubasher et al. (1985b).

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