Spatial relationship of ephemeral plants to *Artemisia monosperma* (Asteraceae) canopy in Egyptian deserts

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In desert plant communities, annual plant species interact both positively and negatively with perennial shrubs. In this study, the influence of *Artemisia monosperma* shrubs on soil nutrients, plant density and biomass of annual plants underneath and outside the canopy was examined. Two desert habitats were compared with similar soil texture but with different climatic attributes. Levels of soil nitrogen, phosphorus and organic matter were significantly higher underneath than between shrubs, but differed between the two habitats which may be attributed to differences in climatic conditions. Despite higher availability of nutrients underneath the canopy, density and biomass of most ephemerals were lower than between shrubs. An hypothetic explanation could be the difference in canopy shading or water supply as well as allelopathic effects of oil leachates from the shrubs.

Key words: Allelopathy, *Artemisia monosperma*, nitrogen, phosphorus, soil nutrients.

Introduction

The spatial distribution of desert plants is controlled by a number of unfavourable abiotic conditions as the limited water supply, extreme temperatures and low mineral nutrient availability (Aronson & Shmida 1992, Shaltout *et al.*, 1995). As part of adaptation to periodic unfavourable conditions, annual plant species are the widespread life form on the countryside and regional scales in desert areas around the Mediterranean Basin. In addition, some perennial shrubs are common in desert vegetation. One of these perannials; *Artemisia monosperma,* is a dominant desert shrub occurring on active sand dunes and stabilized sand fields. It is well known that *A. monosperma* is well adapted to arid conditions with low winter rainfall and high evaporation. Nevertheless, water supply seems to be the main controlling factor that affects its distribution in both habitats (Kutiel 1998, Huang & Gutterman 1999).

Both shrubs and ephemeral desert plants form characteristic communities, since canopy offers microhabitat conditions different from open desert areas. Composition and structure of these plant communities can be strongly influenced by plant interactions, which can commonly comprise positive and negative effects (Holzapfel & Mahall 1999). On the microhabitat scale, shrubs may provide special niches in terms of shade and accumulation of organic soil matter including mineral nutrients. Regarding the influence of soil nutrients, supply of available nitrogen and phosphorus depends on the turnover of organic matter and results immediately from the mineralisation of organic compounds of

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these elements (Aerts & Chapin III 2000). In principle the supply with these nutrients is positively correlated to the amount and turnover rates of above- and below- ground organic matter. Both amounts and turnover rate of soil organic matter are very low in desert areas, which being due to the aridity of these regions. As a consequence, the production of biomass and the decomposition of organic substances (thus formation of soil organic matter) occur at very low rates compared to ecosystems in humid regions (Noy-Meir, 1985). In addition, desert ecosystems frequently loose organic matter and nutrients by wind drift of the dead biomass.

This investigation was intended to investigate to what extent differences in soil nutrients can affect plant community structure in desert microhabitats. Ephemeral plant growth underneath the canopy and between *A. monosperma* shrubs was examined in two different desert habitats and compared with the availability of plant nutrients in the soil underneath and away from the shrub canopy.

Methods

The study areas

Two different habitats of different in climatic conditions, and accordingly of different plant distribution and species composition were compared. The site of the first habitat is located at the Arish-Wadi 335 km north east (NE); Cairo; its soils belong to the gravely ermolithosols. The site of the second habitat is located 70 km east from Cairo around the Suez desert road, its soil belong to the limestone lithic ermolitosols (El-Gabaly & *et al.*, 1969). Although the annual rainfall does not exceed 25 mm year $^{-1}$ in Suez, it is about 100 mm year $^{-1}$ in Wadi El- Arish (Fig.1). The rainy season begins in October, and ends in March. The plants under study begin to shed their leaves shortly after the end of the rainy season.

Soil sampling

Two samples were collected each of about 1 Kg from the soil surface under the canopy of each of five randomly chosen *A. monosperma* shrubs at each of the selected sites. A similar number of soil samples was taken from the middle of the area between the shrubs. The samples were transported immediately to the laboratory for chemical analysis. The pH was determined after dilution of soil samples with distilled water (1:5, W/V). Organic matter was calculated from organic carbon estimation by oxidation with dichromate in the presence of H_2SO_4. Nitrogen content was analysed with a N-Carbon analyser (Modell Na 1500). Phosphorus was determined colourimetrically (Gericke & Kurmies, 1952).

Plant sampling

Samples of plant species were collected in spring (at the end of the growing season), from the same locations where the soil was sampled. The samples were transported immediately to the laboratory where it was oven-dried at 65 °C for 48 h. or to constant weight. The dried material was ground in a Wiley mill to pass a 0.1 mm mesh sieve, and was then kept in closed bottles ready for the chemical analysis.

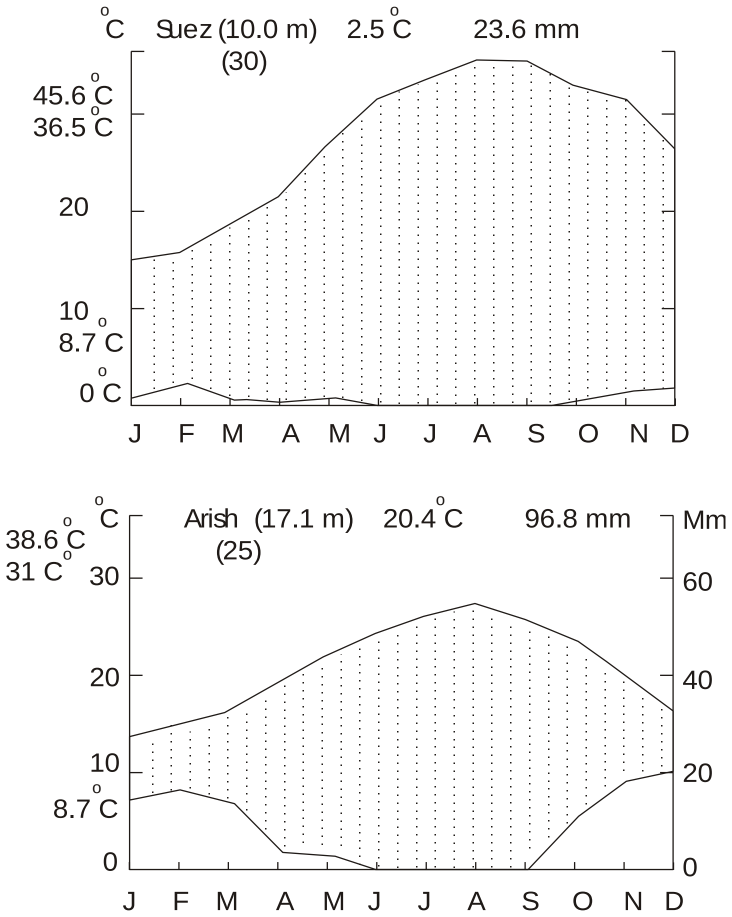

Fig. 1: Climatic diagrams of two stations in areas inhabited by *Artemisia monosperma*.

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Statistical analyses

Raw data of biomass and plant density were analyzed for significant differences of the mean value by one-way-ANOVA with the software program SIGMASTAT. Two-tailed significance levels were given for $P < 0.05$

Results

Chemical and physical characteristics of the soils

The concentrations of nitrogen (N), as well as of phosphorus (P), and of organic matter (OM) were significantly higher underneath than between the canopies (Table 2); under the canopies was approximately two times higher OM, two times higher nitrogen and 1½ times higher phosphorus in the soils of El-Arish region. Lower differences but significant were recorded in Suez region. However, soil nutrients and organic matter were significantly higher in Arish region.

Differences in the pH between the two habitats were insignificant although soils between shrubs were slightly less alkaline than underneath the canopies in Arish (Table 2). Soils underneath as well as between the shrubs are sandy soils, but there was a slight difference between the two habitats; the soils underneath the canopies were less gravelly than between shrubs (Table 1).

Table 1: Oil particle distribution (texture) (%) underneath the canopies and between *A. monosperma* shrubs (Mean ± SEM)

	Gravel		Sand		Silt		Clay	
Location	Suez	Arish	Suez	Arish	Suez	Arish	Suez	Arish
Between	6.8 ± 0.2	6.9 ± 0.2	79.2 ± 4.0	83.1 ± 3.1	9.1 ± 0.4	8.3 ± 0.4	4.9 ± 0.3	2.7 ± 0.1
Underneath	7.9 ± 0.3	8.3 ± 0.4	80.4 ± 3.8	82.2 ± 3.9	8.5 ± 0.4	7.6 ± 0.3	3.2 ± 0.1	1.9 ± 0.1

Table 2: pH, organic matter, Nitrogen and Phosphorus contents of soil samples taken underneath the canopies and between *A. monosperma* shrubs in spring 1995 (Mean ± SD)

	pH		Organic matter [%]		N [ppm]		P [ppm]	
Location	Suez	Arish	Suez	Arish	Suez	Arish	Suez	Arish
Between	7.7 ± 0.3	6.3 ± 0.3	3.1 ± 0.2	4.6 ± 0.2	293 ± 12	411 ± 20	176 ± 9	294 ± 11
Underneath	7.8 ± 0.4	7.3 ± 0.3	5.5 ± 0.2	6.8 ± 0.3	416 ± 24	789 ± 47	225 ± 13	441 ± 21

Species composition, density and biomass

A total of 12 ephemeral plants were recorded in the *A. monosperma* community. Eight of the 9 species of the Suez area, and 6 of the 7 species of Arish respectively were recorded either between shrubs or underneath the canopies (Fig. 2). The species found between shrubs was *Silene* sp. Only 4 species only were found to be common to both sites (*Silene* sp., *Trigonella stellata*, *Filago desertorum* and *Plantago ovata*), 5 were restricted to the Suez site (*Centaurea pallescens*, *Matthiola livida*, *Cotula cinerea*, *Bassia muricata*, *Senecio desfontainei*) and 3 were restricted to Arish (*Schismus barbatus*, *Erodium laciniatum*, *Ononis serrata*).

As a rule, the total biomass and density of all ephemerals was greater between shrubs than underneath the canopies. However, a differential analyses demonstrated that this effect was based on 8 out of the 11 species found in both microhabitats: *Erodium laciniatum*, *Ononis serrata*, *Senecio desfontainei*, *Trigonella stellata*, *Filago desertorum*, *Plantago ovata,* which exhibited greater biomass, and that *Schismus barbatus*, *Erodium laciniatum*, *Bassia muricata*, *Senecio desfontainei*, *Filago desertorum*, *Plantago ovata*) exhibited higher density between the shrubs. The other species (*Centaurea pallescens*, *Cotula cinerea*, *Matthiola livida*) exhibited no differences in biomass and plant density (Fig. 2).

Discussion

Despite the observed higher soil fertility, regarding organic compounds and nutrients underneath the canopies (Table 2), the ephemerals growth was significantly lower at these microsites (Fig. 1). It is well known that plant biomass and species richness increases in desert habitats with the increase in organic matter content and field capacity (Kutiel 1998). In contrast to these observations the present results show higher plant density in the nutrient poor sites outside between shrubs than underneath the canopies of *A. monosperma.* This effect can partially be explained due to soil texture, which may have an obvious effect on seedling emergence. Coarse -textured soil has been found to be favourable for seedling emergence, which aggreed with analyses of both habitats of the present study. At the same time silt and clay percentage underneath the canopies was much higher than outside the canopies (Table 1).

An hypothetic explanation for the spatial plant pattern could be the difference in canopy shading or water supply as well as allelopathic effects of oil leachates from the shrubs. Went (1942) observed that, while some herbs were strongly associated with specific shrubs, others were not. This association appeared to be related to the organic matter accumulation under shrubs, which provided a nutrient rich microhabitat for annuals. The shedding of plant parts is an essential source of the minerals which are necessary for plant life. Release of mineral elements during decomposition of plant litter alters the chemical properties of deserts and increases the fertility of soils under shrub canopies (Charley 1972, Charley & West 1975, Romney *et al.,* 1977). *Artemisia monosperma* contains many volatile substances that retard germination of many seeds. Fahmy *et al.* (1962) isolated four crystalline compounds from powdered leaves and flowering tops of *A. monosperma.* Maksudov *et al.,* (1962) determined essential oils, organic acids, tannins and sugars in blooms of *Artemisia* sp. Soleh *et al.,* (1985) identified and isolated a number of flavone compounds from *A. monosperma*. Hammouda *et al.,* (1978) isolated an acetophenone derivative cumarin from *A. monosperma*. Some of the above compounds can retard the seed germination of some plant species. The establishment of ephemeral seedlings and the plant growth underneath these shrubs might be negatively affected by volatile oil which is released from shrubs (Julio *et al.,* 1993). This would be an explanation for lower plant density and biomass production underneath the canopies than between the shrubs especially in the Arish region, where the leaching may be stronger (rainfall 4 times higher than in the Suez region). Some other plant species found at the examined sites contain also chemical protectants against pest, e.g. *Cotula cinerea* (Markouk *et al.,* 1999) and *Trigonella stellata* (Kawashty *et al.,* 1998). However, soil microbial biomass is usually increased under *A. monosperma* shrubs despite this potential unfavourable chemical release (Elgamal *et al.,* 1997, Sarig *et al.,* 1999).

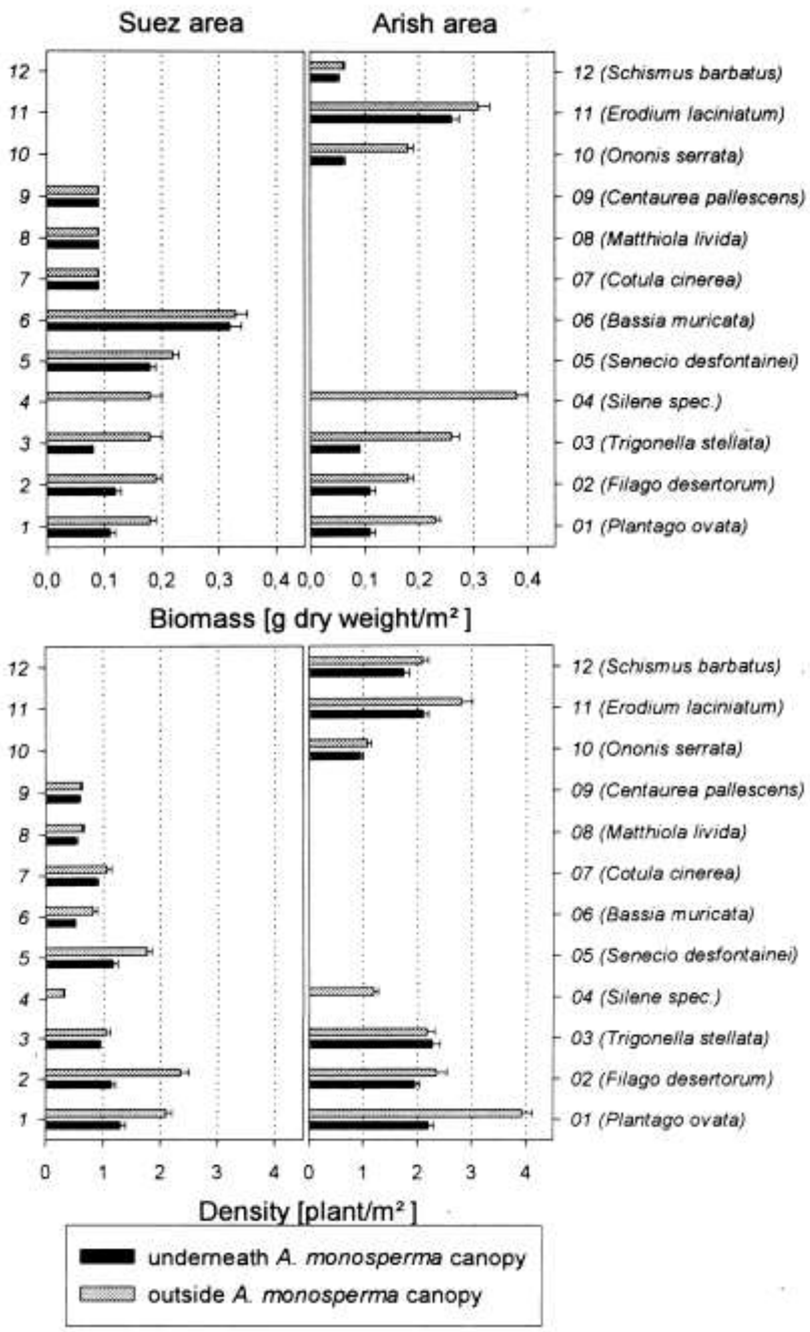

Fig. 2: Density (plant/m²) and biomass (g dry weight/m²) of different species underneath the canopies and between *A. monosperma* shrubs growing in the two study sites(Mean ± SEM).

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References

Aerts R. & Chapin III F.S. 2000. The mineral nutrition of wild plants revisited: A re-evaluation of processes and patterns. Pg. 1-67. In Fitter, A.H. & Raffaellui, D.G. (eds), *Advances in Ecological Research* **30**. Academic Press San Diego USA.

Aronson J. & Shmida A. 1992. Plant species diversity along a Mediterranean-desert gradient and its correlation with interannual rainfall fluctuations. *J. Arid. Environ*. **23:**235-247.

Charley J.L. 1972. The role of shrubs in nutrient cycling. pp. 182-203. In Mckell, C., Blaisdell J.P. & Goodin, J.R. (eds), Wildland shrubs-their biology and utilization. Forest Service General Technical Report INT-1, United States Department of Agriculture Report Technical Information Service, Springfield, Virginia USA.

Charley J.L. & West N.E. 1975. Plant-induced soil chemical patterns in some shrub-dominated semi-desert ecosystems of Utah. *Journal of Ecology* **63**: 945-963.

El-Gabaly M., Gewaifel I.M., Hassan M.N. & Rozanov G. 1969. Soil map and land recources of the United Arab Rebublic. *Res. Bull*. **32:**1-14.

Elgamal M.H.A., Ouf S.A., Hanna A.G. & Yassin F.Y. 1997. *Phytochemical and mycological investigation of Artemisia monosperma*. *Folia Microbiologica*, 203-210.

Fahmy I.R., Ahmed Z.F. & Abdel Moneim F. 1960. A phytochemical investigation of *Artemisia monosperma*. *Journal of Pharmacology* United Arabic Republic **1**: 83-95.

Gericke S. & Kurmies B. 1952. Kolorimetrische Bestimmung der Phosphorsaure mit Vanadat-Molybdat (VM-Methode). *Zeitschrift Analytische Chemie* **137**: 15-22.

Hammouda F.M., Rizr A.M., Ismall S.I. & Hassan N.M. 1978. Isolation of an acetophenone derivative and coumarins from *Artemisia monosperma*. *Fitoterapia* **49**: 53-55.

Holzapfel C. & Mahall B. 1999. Bidirectional facilitation and interference between shrubs and annuals in the Mohave Desert. *Ecology* **80:**1747-1761.

Huang Z. & Gutterman Y. 1999. Water absorption by mucilaginous achens of *Artemisia monosperma*: Floating and germination as affected by salt concentrations. *Israel Journal of Plant Sciences* **47**:27-34.

Julio R., Guitierrez P.L., Meserve L.C., Contreras C., Vasquez H.V. & JAKSIC F.M. 1993. Spatial distribution of soil nutrients and ephemeral plants underneath and outside the canopy of *Porlieria chlieneral* shrubs (*Zygophyllaceae*) in arid coastal Chile, *Oecologia* **95**:347-352.

Kutiel P. 1998. Annual vegetation of the coastal sand dunes of the northern sharon, Israel. *Israel Journal of Plant Sciences* **46**:287-298.

Kawashty S.A., Abdalla M.F., Gamal El Din E.M. & Saleh N.A.M. 1998. The chemosystematics of Egyptian *Trigonella* species. *Biochem. Syst. & Ecol.* **25**:851-856.

Maksudov N., Pogorelko I.P. & Yuldsshev P. 1962. A chemical investigation of *Artemisia scoparia*. *Usbeksk. Khi. Zh*. **6(5):** 84-86.

Markouk M., Redwane A., Lazrek H.B., Jana M. & Benjama A. 1999. Antibacterial activity of *Cotula cinerea* extracts. *Fitoterapia* **70:**314-316.

Noy-Meir I. 1985. Desert ecosystem structure and function, pp. 93-103. In: Evenari M., Noy-Meir I. & Goodall D.W. (eds): Hot deserts and arid shrublands, *A (Ecosystems of the World 12A)* Elsevier, Amsterdam, Oxford, New York, Tokyo.

Saleh N.A.M., El Negumy S.I., Abd Alla M.F., Abou M.M., Dellamonica G. & Chopin J. 1985. Flavonoid glycosides of *Artemisia monosperma* and *A. herba alba*. *Phytochemistry* **24**: 201-203.

Sarig S., Fliessbach A. & Steinberger Y. 1999. Soil microbial biomass under the canopy of coastal sand dune shrubs. *Arid Soil Research & Rehabilitation* **13**:75-80.

Shaltout K.H., El-Kady H.F. & Al-Sodany Y.M. 1995. Vegetation analysis of the Mediterranean region of Nile Delta. *Vegetatio* **116**: 73-83.

Went F.W. 1942. The dependence of certain annual plants on shrubs in southern California deserts. *Bulletin Torrey Botanical Club* **69**: 100-114.