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ORIGINAL ARTICLE

A Study on Vegetation Changes under Drought Conditions in Western Mediterranean Desert, Egypt

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ABSTRACT

We investigated the effects of a severe drought in year 2010 of about 33% of the long-term average rainfall, on annual plant communities in the rocky ridges of Western Mediterranean costal belt, Egypt. The study was carried out in two sites, in a field survey and in a manipulative field experiment. Plant density and species richness significantly decreased in both sites with the reduced amount of rainfall from very rainy year 2009 to the drought year 2010. Recovery in species richness in the post-drought year 2011 was not dependent on the number of dominant but rare species.

Keywords: *Drought, Vegetation, Western Mediterranean Desert*

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INTRODUCTION

Deserts cover about one fifth of the Earth's surface and occur where rainfall is less than 50 cm/year. Precipitation is among the most temporally variable climate factors. In arid zones, rainfall is irregular and unevenly distributed both temporally and spatially. The seasonal and year-to-year fluctuation of rainfall affects the plant growth of this environment. Variable precipitation is known to drive particularly large variation in the populations of annual plants [1-8]. Deserts have limited water supplies. Precipitation varies greatly during the year with wide fluctuations occur over years and decades, frequently leading to drought [9]. Tilman and Haddi [10] state that the instability caused by environmental fluctuations may limit species richness, density, and above-ground biomass (productivity). Climatically extreme conditions, such as drought, may periodically lower population densities [10], and suggest that rapid local and regional climatic change may be occurring, and may impact the biodiversity of otherwise undisturbed environments. In addition to the large shrubs and perennial plants that can dominate our view of a desert, the flora in Western Mediterranean deserts of Egypt includes a large proportion of annual (ephemeral) species. The conditions under which the desert plants grow change radically when rain falls. Many annual species will take advantage of the brief period of high moisture in order to complete as much as possible their life cycle before harsh environmental conditions.
The objective of this study was to evaluate how density and species richness of these communities responded to drought and how they recovered under harsh environmental conditions.

SITE DESCRIPTION

The Mediterranean coastal land of Egypt (the northern coast) extends from Sallum eastward to Rafah for about 970 km (Fig. 1). It is a narrow, less arid belt of Egypt, which is divided, ecologically, into three sections: western, middle and eastern. The western section (Mariut coast) extends from Sallum to Alexandria for about 550 km [11]. It is a thin belt of land parallel to the Mediterranean Sea that narrows or widens according to the position of its southern boundary – the Western Desert Plateau. Its average north-south width, from sea landward, is about 20 km and it is bordered by Lake Mariut on the east.
The most remarkable feature of the Mediterranean coast west of Alexandria is the prevalence of ridges of soft oolitic limestone, often 20m or higher, extending parallel to the shore for long distance. Commonly one of line of ridges skirts the coast closely, while another runs parallel with it a few kilometers inland, and there's sometimes a third ridge between the second and the edge of the Western Desert Plateau.

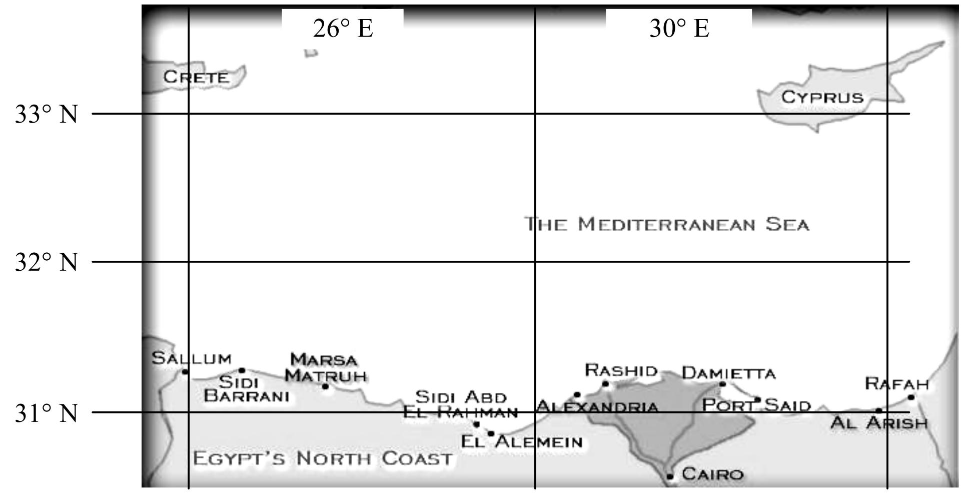


Fig. 1: The Western Mediterranean coastal belt of Egypt.

Rainfall, which only occurs in winter between November and February, has a long-term annual average of about 200mm (Fig. 2). Average daily minimum winter temperatures are 8.1-18.1°C, and average daily maximum summer temperatures are 20-29.2°C [12].

In the drought year of 2010, total rainfall was 65 mm, amounting to 43% of the average over the last ten years (150 mm, Fig. 2). It came after a rather rainy year of 2009 with 170 mm (113 %), and was followed by a relatively dry year of 2011 with 104 mm (69%).

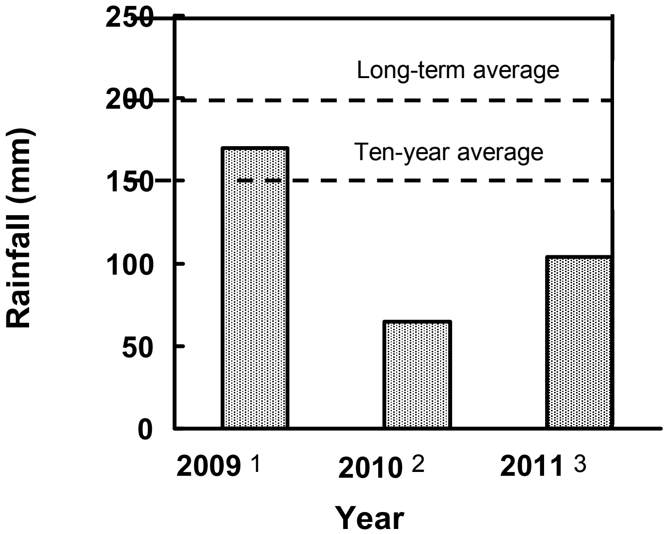


Fig. 2. Annual rainfall amounts in 2009-2011 in the rocky ridges, with long-term and 10-yr averages [13].

METHODS

The research was done in the area of rocky ridges, the Western Mediterranean coastal belt of Egypt. The soil surface is covered with scattered plots of the perennials *Arisarum vulgare*, *Limonium tubiflorum*, *Lotus corniculatus*, *L. creticus* and *Lygeum spartum*. Besides perennials, the vegetation contains annual plant communities, which are responsible for most of the biomass production. The annuals grow abundantly in the understorey of the perennial plots, and at significantly lower density (D = No. of plants/ plot), on inter-perennial matrix (I.P. M.). The annual plant communities consist of a few common or dominant species, and many of less common or rare species. The dominants *Aegilops kotschyi*, *Bupleurum nodiflorum*, *Caduus getulus*, *Erodium cicutarium*, *Malva aegyptia*, *Medicago minima*, *Orlaya maritima*, *Plantago notata* and *Stipa capensis* determine vegetation density, while the latter are responsible for species richness and diversity (number of species N and species richness R = N / Log D).

Field samples

We sampled annual plant communities non-destructively, by identifying and counting all plants in delineated pairs of a perennial and a I.P. matrix plots, in both sites. In Site A, no manipulations were done on 50 pairs of samples of 20 x 40 cm per plot type. In Site B, 50 pairs of perennial and I.P. matrix plots were sampled (sample area 0.5 and 1.0 m^2, for perennial and matrix, respectively), 20 undisturbed and 30 disturbed. This entailed cutting off all aboveground vegetation and crushing the soil surface during the previous years since 2007.

Statistical analysis

Analysis of variance of data for all the parameters was computed using COSTAT computer package (CoHort Software, Berkeley, CA). The least significant differences between the mean values were calculated following Snedecor and Cochran [13].

RESULTS

In both datasets, plant density (D) significantly ($P < 0.05$) decreased from the very rainy year of 2009 to the drought year of 2010 (Fig. 3A and 4A). In the survey (Fig. 3A), it kept dropping in the low-rainfall year 2010, but not in the experiment (Fig. 4A), where plant density increased again from 2010 to 2011.

Although perennial plots have higher density than I.P. matrix plots, both show similar changes, in both studies. In the survey species number (N) dropped during the drought year of 2010 to half of the pre-drought values, but increased significantly during the next year, in spite of lower plant density (Fig. 3B).

The variation in species number seems to follows that of the annual amount of rainfall. Both the drop in species number from 2009 to 2010 and its increase from 2010 to 2011 are more than expected based on density per se, so that species richness (R) corrected for density decreases and then increases (Fig. 3C). This illustrates that the changes in plant density and species number are based on different groups of species, the dominants and the sparser or rare species. The dominants and rare species suffer similarly during the drought year, but the sparser species, though still with lower numbers than before the drought, recover faster.

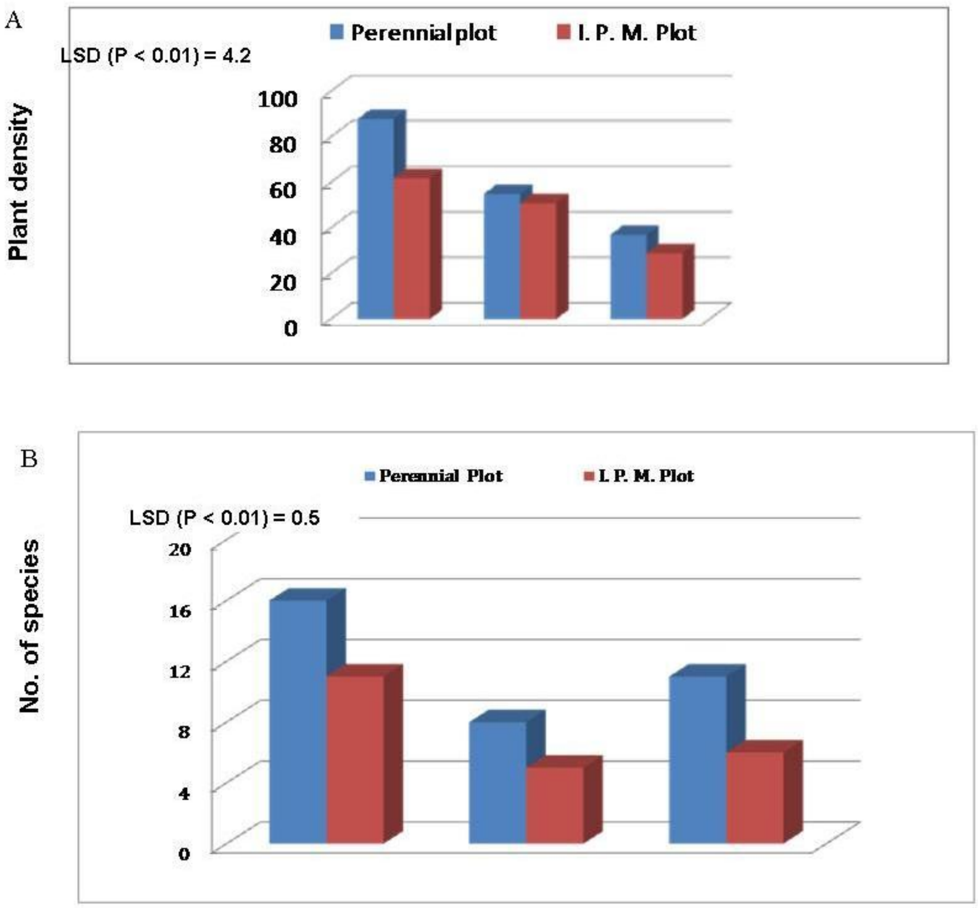
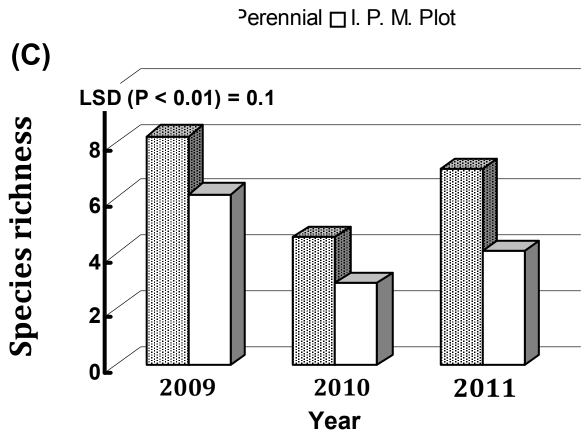
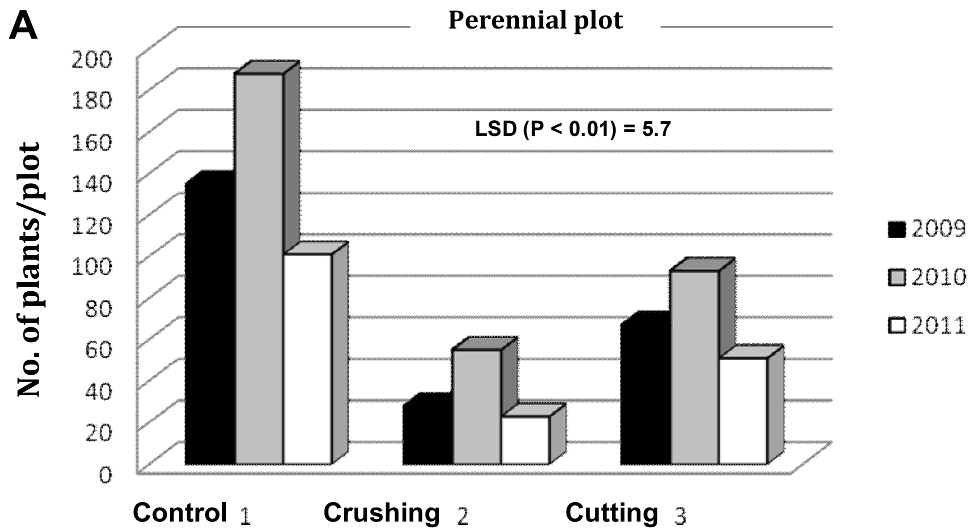
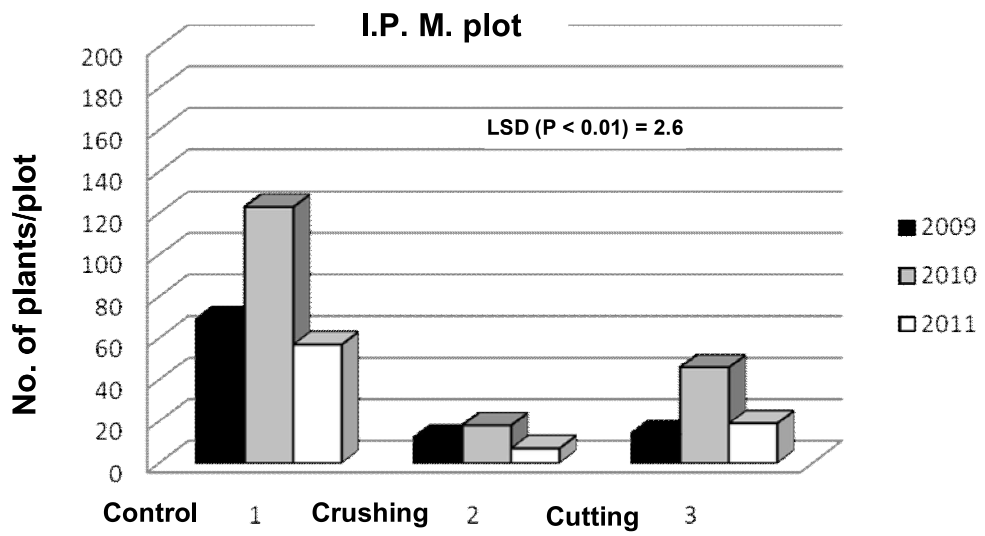


Fig.3. Plant density (D = No. of plants/ plot), number of species (N) and species richness (R = N / Log D) corrected for plant density in two plot types during three years.


Perennial □ I. P. M. Plot
(C)
LSD (P < 0.01) = 0.1
Species richness
0
2
4
6
8
2009
2010
2011
Year


A
Perennial plot
LSD (P < 0.01) = 5.7
No. of plants/plot
0
20
40
60
80
100
120
140
160
180
200
2009
2010
2011
Control 1
Crushing 2
Cutting 3


I.P. M. plot
LSD (P < 0.01) = 2.6
No. of plants/plot
0
20
40
60
80
100
120
140
160
180
200
2009
2010
2011
Control 1
Crushing 2
Cutting 3

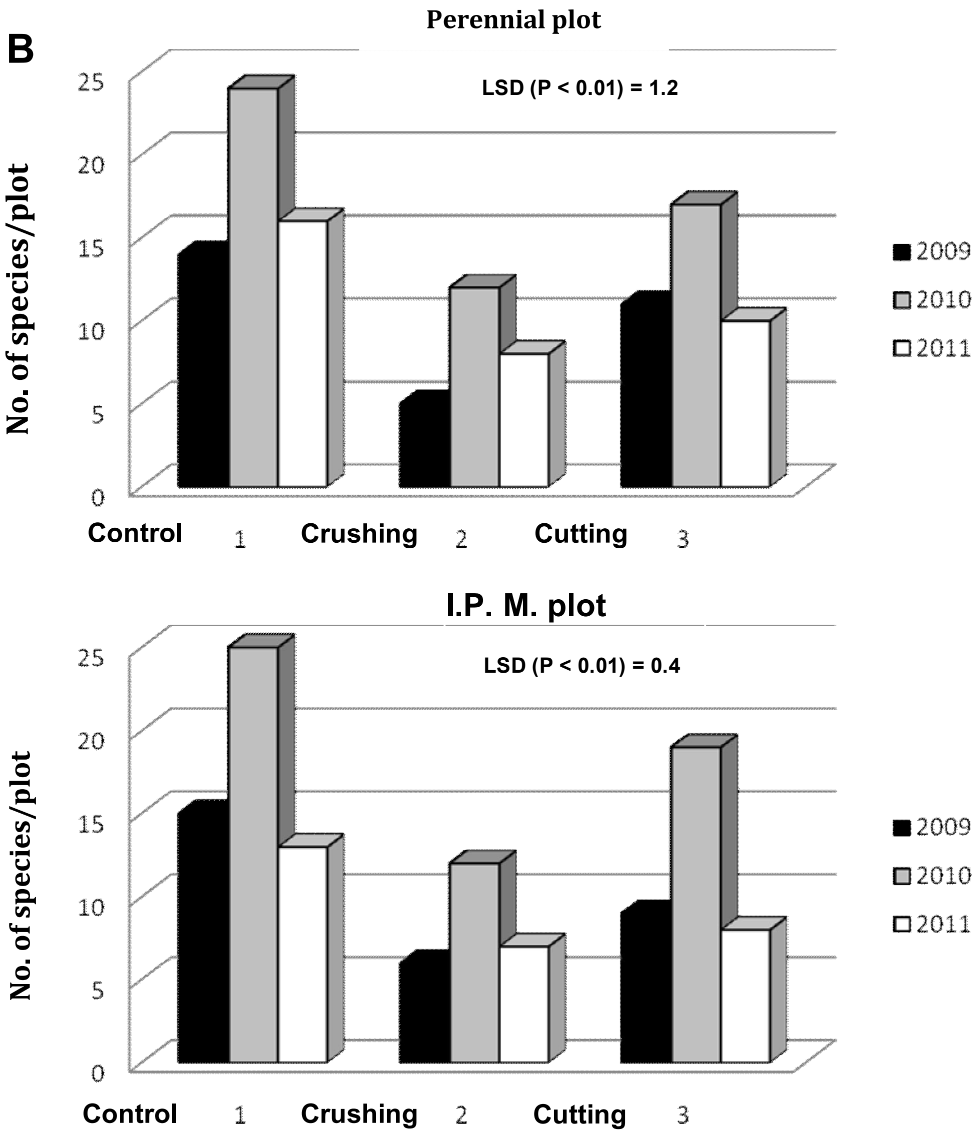


Fig. 4. Plant density (A) and species richness (B) of annual plant communities in two plot types in controls and with crushing and cutting (10 pairs of plots each). Mean values labeled with distinct letters are significantly different ($P < 0.05$; $n = 10$).

In the experiment at Site B, similar results were found (Fig. 4), except the rise in plant density during the last, dry post-drought year. It appears that the patterns of plant density and species richness both simply tracked rainfall, unlike the situation in the survey described above. However, examining the behavior of the individual species revealed that, as in the survey, the increase in species number and plant density from 2010 to 2011 was not due to recovery of dominant and common species, but of relatively rare species. Especially the most common species, *Stipa capensis*, *Malva aegyptia*, and *Plantago notata* decreased greatly in abundance. *S. capensis* was also most affected by crushing and cutting.

DISCUSSION

We expected that the rare species decrease more during a drought year and recover slower than common species. This is because rare species are strongly limited by site availability, especially during drought. Thus, populations of rare species become sparser or extinct. Seed production will be severely reduced, and thus recovery of the less common species was expected to be slow. Common or dominant species, on the other hand, are generalists, able to grow in a variety of conditions. During rainy years (as 2009) their populations are very dense, and less likely to go extinct. Our results indicated the opposite, since species number recovered rapidly but plant density kept declining in the post-drought year, also with low rainfall. Drought affected germination, growth and seed production of both common and rare species negatively. In rare species non-germinated seeds stay dormant, while common species rely predominantly on recent seed production. No seed reserves of common species were present after the drought in contrast to the rare species, which could respond rapidly to ameliorating environmental conditions. In addition, increasing species richness, and sometimes of plant density of rare species may be due to the absence of suppression or site pre-emption of weaker competitors by dominants, which suffered from the drought period.

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