Effects of grazing on seed germination in the inland desert of Dubai (UAE)

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Abstract

The effects of grazing on seedling emergence was studied in a conservation reserve containing two enclosures, one with camels at high stocking rates (DDCR), and an enclosure of five years with gazelles and oryx at lower stocking rates (Al Maha). Post-rainfall seed germination was measured within the two enclosures by counting and identifying all seedlings within 1 m^2 plots. Germination varied enormously from place to place. The gravel substratum contained a very different mix of species than the surrounding dunes. Al Maha plots contained more species than DDCR plots, but the difference was mainly in seedlings of perennial rather than annual species. A greater density of annual species sprouted near established small shrubs, but it is unclear if this is due to local seed dispersal or soil conditions that favored both shrubs and seedlings. No germination was observed to be associated with feces of camels, oryx, gazelle or dhub (*Uromastyx aegyptia microlepis*) lizards. Plants reached reproductive maturity at a height of 10 cm or less, reflecting the extreme aridity of the location. The observed differences among enclosures were probably due to a combination of livestock grazing and granivore effects on the seed bank, and microhabitat differences associated with the vegetation.

Objectives

1. To determine differences in post rainfall seed germination in Dubai inland desert with different species of herbivores; camels and gazelles/ oryx .
2. To determine how patterns of post rainfall seed germination in the UAE compare with other seed germination patterns in other deserts.

Introduction

Several factors have been shown to be important cues for seed germination, but most important is the amount and timing of rainfall (Shreve, 1942, Halwagy, 1962, Freas and Kemp, 1983, Gutierrez and Whitford, 1987, Baskin et al., 1993, Brown, 2003). Seedling density and growth rate vary immensely among seasons. Spatial variation of emergence is typically high within a season, such that germination appears patchy. Seasonal species composition is also determined mainly by the amount and timing of rainfall events (Guo et al., 2000, Brown, 2003).

The effect of herbivory on annual plant species composition can be more pronounced in arid environments due to the limited plant cover (Osem et al., 2002). Excessive grazing by camels has been recognized as the single greatest threat to the inland desert ecology of the UAE (Hellyer et al., 2001), due to a rapid increase in their numbers since unification of the Emirates. The national camel herd increased from a low of 39 500 in 1976 to approximately 250 000 in 2004 (FAOSTAT, 2004). Camels are allowed to wander freely throughout the desert to graze. The recently established Dubai Desert Conservation Reserve (DDCR) offers a unique opportunity to study the seed germination in a large area of Dubai inland desert with different species of herbivores; camels and gazelles/ oryx .

Methodology

The Al Maha enclosure within the DDCR is approximately 70 km southeast of Dubai (24.82°N, 55.66°E) in the inland desert. The Al Maha fence was completed July of 1999. The enclosure surrounds 27.09 km^2 of desert within the DDCR, containing one gravel plain through the center, but mostly containing dune habitat. Grazing pressure within the enclosure is lower for oryx than gazelles. Externally sourced feed is provided for oryx, which supplies probably about half of the their dietary requirement. The gazelles rarely make use of this feed, instead relying almost entirely on desert plants. The DDCR fence, completed July 2003, surrounds 225 km^2 of dune and gravel plain. The area contains 14 active farms with a combined herd of approximately 960 camels (0.043 camels ha^{-1}) and 4000 goats (contained within pens at all times).

Rainfall in the UAE was very low from before the Al Maha fence was completed, until the 2004/5 winter, which was very wet. The Dubai airport recorded 10 rainfall events of one millimeter or more, and a total rainfall 85 mm from November through February 2005. Dubai International Airport indicates an average annual rainfall of 93.8 mm (World Meteorological Organization, 2005).

Eight plots (four inside and four outside) were sampled at the midpoints of the six main straight lengths of fence separating Al Maha from the DDCR to assess post rainfall seedling emergence in dune environments. Plots were chosen visually to include the greatest localized seedling emergence, to exclude established perennial plants, and to avoid any fence line effect on vegetation. In addition, eight plots were sampled on each side of the fence on the gravel plain. Plots of one-meter square were sampled destructively by counting and identifying each seedling. To assess the importance of proximity to perennial vegetation, each plot was categorized as having either low or high established cover, defined as having three or more perennial shrubs greater than 0.5 m in diameter within 10 m. Throughout the study period, middens from camels, oryx, gazelles and dhub lizards (*Uromastyx aegyptia microlepis*) were examined for seed germination.

Statistical analysis was performed using SPSS 12.0.1 for Windows. Box plots were used to assess distribution. Biodiversity was assessed using the inverted Simpson's Index (Brower et al., 1997). Data for total plot plant number and for biodiversity both exhibited a lognormal distribution and were transformed. Analysis of variance was performed to test the effect of enclosure (Al Maha, DDCR), location and the effects of vegetation cover.

Picture: Sprouting at the base of dunes in response to rainfall.

Table 1. Summary of the total number of individuals of a species found in the Al Maha enclosure as compared to the Dubai Desert Conservation Reserve (DDCR) in sand and gravel habitats. Total numbers for a species represent the sum all plants found in 24, 1-m square plots in each area for sand habitats and 8, 1-m square plots in each area for gravel habitats. Annuals =*.

Plant species	Sand habitats in Al Maha	Sand habitats in the DDCR	Gravel habitats in Al Maha	Gravel habitats in the DDCR
Eremobium aegyptiacum *	217	250	11	18
Arnebia hispidissima*	200	105	48	88
Indigofera colutea	162	219	5	0
Cyperus conglomeratus	111	196	0	1
Silene villosa*	90	73	0	0
Moltikoliopsis ciliata	56	8	0	0
Dichanthium foveolatum	53	30	19	26
Heliotropium digynum	36	6	9	0
Pennisetum divisum	34	7	3	5
Launaea mucronata	30	25	4	0
Plantago boissieri*	19	50	2	6
Gisekia pharnaceoides*	12	4	0	0
Schweinfurthia papilionacae*	11	0	0	0
Indigofera intricata	7	26	0	0
Launaea capitata*	7	2	0	0
Lotononis platycarpa*	4	25	0	0
Fagonia indica	3	15	9	0
Cenchurs sp.	2	5	0	0
Monsonia nivea	2	1	42	73
Neurada procumbens*	2	1	14	26
Haloxylon salicornicum	1	0	0	1
Heliotropium kotschyi	0	0	4	0
Total number of plants	1059	1048	170	244
Average number of plants per plot	44.1	43.6	21.2	30.5
Total number of species	21	19	12	9
Average number of species per plot	7	5	6	5
Average Inverse Simpsons Index	3.33	2.81	4.4	3.34

Results & Discussion

Seedlings of 13 perennial and 9 annual or biannual species were observed during the study (Table 1). Germination density did not appear to conform to any pattern, except where it was densest and sparsest. These observations support previous findings (Guo et al., 2000, Brown, 2003, Robinson, 2004) and indicate that germination is heavily influenced by spatial variation in the seed bank and micro-environments. There was a large variation among locations for most variables, including number of plants per plot ($P = 0.013$), number of species per plot ($P < 0.001$), and the inverted Simpson's Index ($P = 0.003$). Plots with a high seedling density contained a higher species richness ($P < 0.001$), but biodiversity was unaffected ($P = 0.381$). The highest germination densities were consistently observed at the base of the wayward wind side of steep dunes. Moisture penetrated deeper into the sand in these areas, and the sand retained the moisture for longer than other areas.

Four species were almost entirely limited to the gravel plain. *Fagonia indica*, *Heliotropium kotschyi* and *Monsonia nivea* were seedlings of perennials with established plants on the plain, while *Neurada procumbens* is an annual / biannual species. Only two species, *Dichanthium foveolatum* and *Arnebia hispidissima*, appeared to germinate frequently in both dune and gravel plain habitats.

Grazing impacts on germination patterns can be inferred from differences between enclosures (Al Maha, containing oryx, gazelles and dhub lizards, and the DDCR containing camels). Al Maha plots contained an average of 1.7 (36%) more species than DDCR plots ($P = 0.007$), even though they contained an equal number of seedlings ($P = 0.741$). This was due to an increase in the number of perennial species ($P < 0.001$) rather than annuals ($P = 0.077$), particularly with *Heliotropium digynum* and *Indigofera colutea*. There was no biodiversity difference between enclosures ($P = 0.076$). Plots in both enclosures tended to be dominated by one to three species, so the presence of a few individuals of another species had little effect on biodiversity.

Close proximity to established small shrubs resulted in twice the number of plants ($P = 0.014$) and species ($P < 0.001$), and a much higher biodiversity ($P = 0.008$). Perennial species were not affected ($P = 0.490$), but there was an average of 3.7 more annual species per plot ($P < 0.001$). Other studies have indicated that seeds of most desert species have cues that favor germination in open areas rather than under trees and small shrubs (Boeken et al., 2004, Robinson, 2004).

Our observation that species richness is higher with lower grazing pressure supports the results of Osem et al. (2002) for low productivity sites. Our study also supports their conclusion that lower grazing pressure increases the occurrence of rare species. Our study does not support the findings of Halwagy (1962), that grazing reduces the occurrence of annuals and grasses, though this might be because grazing still occurred in the Al Maha enclosure at a lower intensity than the DDCR.

We visually observed the feces of camels, oryx, gazelles and dhub lizards, but found no germinated seeds or seedlings. This result was surprising because studies have shown that substrates with more organic material germinate more desert plants (Boeken et al., 2004).

Annual plants generally reached reproductive maturity at a height of 10 cm or less. This is a small size when compared to most plants in North American deserts (Guo et al., 2000, Brown, 2003) and likely reflects the greater aridity of the UAE.

Conclusions

- There was great spatial variation in both numbers and species sprouting in response to rainfall.
- The greatest germination densities were at the base of the wayward side of dunes.
- Grazing by camels reduced the number of species sprouting, but not the density of sprouts when compared to Oryx/ Gazelle grazed areas.
- Animal feces appear to inhibit germination of seeds.
- Close proximity to established small shrubs doubled both the number of species and density of plants germinating.

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