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Research Letter

The Contribution of Endozoochory to the Colonization and Vegetation Composition of Recently Formed Sand Coastal Dunes

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The objective of this study was to determine whether endozoochory contributes to the dispersal and colonization of plant species in recently formed coastal dunes. At least 5.7% of species present in the study area are being dispersed by wild rabbits (*Oryctolagus cuniculus* L.). Most dispersed species are perennial herbs with small seeds size. The continuous input of seeds through rabbit feces into newly created areas would ensure the constant arrival of seeds and would facilitate colonization. Therefore, endozoochorous dispersal may play a relevant role for the structure and composition of dune plant communities.

1. INTRODUCTION

In coastal dune ecosystems, dispersal and colonization take place mainly through wind and water [1], and endozoochory has not been considered an important dispersal mechanism in terms of its contribution to the structure and composition of plant communities [2–5].

In young dunes, vegetation presence is limited by the availability of propagules, stressful environmental conditions, and sand movement [6–8]. In these dunes, the seeds arrival and species colonization are important to the early stabilization of freshly deposited sediments [9, 10]. Endozoochory could significantly contribute to seed rain and play a leading role in primary succession because one of the main constraints on colononization is the seed inputs [11]. The objective of this study was to determine whether endozoochory contributes to the dispersal and colonization of plant species in recently formed coastal dunes.

2. STUDY AREA AND METHODOLOGY

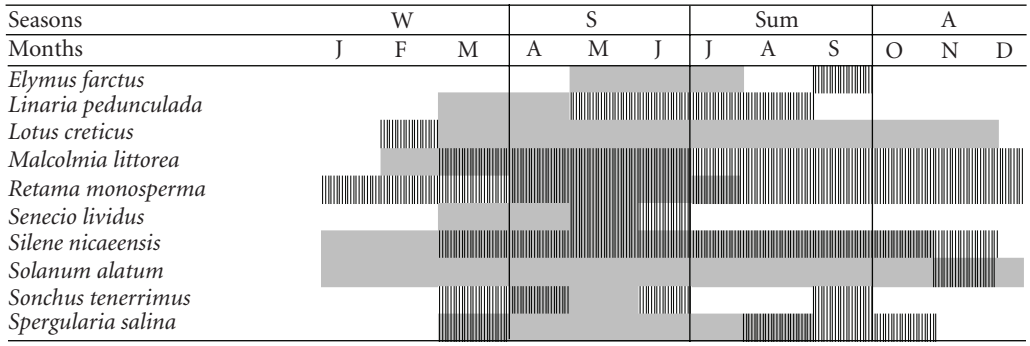
This study was carried out in the twelve young dunes situated on the distance end of "El Rompido spit". This prograding spit is located in the Rio Piedras estuary, Huelva Province, South-Western Spain. Dunes have been formed in the last 47 years, increasing the total spit area by approximately 1.5 ha per year [13]. The climate is mediterranean, with moist winters and dry summers. Mean annual temperature is 18.2°C, and mean annual precipitation is 620 mm. From previous studies conducted in the spit, we can assess that the rabbits (*Oryctolagus cuniculus* L.), medium size mammalian herbivore, have a high population number and are the main disperser of plant dune species [14].

The endozoochorous dispersal activity of rabbits was studied through fecal pellet counts. One permanent line transect was laid at each dune (12 in total), being 1 m wide and with variable length depending on dune size. Line transects were cleared of all rabbit feces in December 2003, and pellets were subsequently collected monthly in 1 m^2 plots over the line transect from January to December 2004. Collected feces were dried in the laboratory and germinated on sterile sand in a greenhouse. They were watered daily and seedling emergence was also monitored daily for eight months. When seedlings could not be identified, they were transplanted into small pots where they were allowed to grow until identification was possible. At each dune ridge, total vegetation cover and individual species cover were estimated by [15] method during spring and autumn, aiming to obtain an accurate list of all species present (annuals and perennials).

Table 1: Biological characteristics [12] of species dispersed by rabbits. H: herbaceous, S: shrubs, P: perennial, A: annual, B: biennial. X indicates species present in feces but not during vegetation surveys.

Species	Life form	Annual/perennial	Seed mean size (mm)	Colonization
Elymus farctus	H	P	0,5	
Linaria pedunculada	H	A	0,6	
Lotus creticus	H	P	0,2	
Malcolmia littorea	H	P	0,95 × 2,55	X
Retama monosperma	S	P	6,1 × 4,8	X
Senecio lividus	H	A	3,45	
Silene nicaeensis	H	P	0,65 × 0,8	X
Solanum alatum	H	A	2,25 × 1,75	
		(P)		
Sonchus tenerrimus	H	S, B o P	3 × 0,75	X
Spergularia salina	H	S, B o P	0,75	X

Table 2: Flowering/fruiting months of species dispersed by rabbits and time of dispersal. Shaded cells indicate flowering/fruiting months. Cells with vertical lines indicate the months during which species were dispersed by rabbits. W: winter, S: spring, Sum: summer, A: autumn.



3. RESULTS

Fifty-two species were recorded in the vegetation surveys and 10 of them were present in rabbit feces (Table 1).

Most seeds dispersed by rabbits belong to perennial herbaceous species with small seeds size (0.2 to 4.4 mm) (Table 1). The largest seeds were those from *Solanum alatum* and *Retama monosperma*, the latter being the only shrub species present in rabbit feces (Table 1).

The seed rain was observed throughout the year (1,89 ± 0,24, 0,32 ± 0,04, 0,29 ± 0,06, and 0,60 ± 0,13 seed by square meter in summer, winter, spring, and autumn, resp.) (Table 2) but considering the flowering/fruiting months of species present in rabbit feces, seeds were consumed and dispersed mainly in spring and summer, that is, when they are available (Table 2). *R. monosperma* was dispersed throughout the year because its fruits fall and persist on the ground for a long time (Table 2).

Seeds from *Malcolmia littorea, Senecio lividus, Silene nicaeensis, Sonchus tenerrimus, Spergularia salina,* and *Retama monosperma* were recorded in dunes where these species were not present during vegetation surveys (Table 1).

4. DISCUSSION

In the young dunes of the study area, at least 10 plant species were dispersed by rabbits through endozoochory, which represents 5.7% of the total species pool of the El Rompido spit [13] and 19% of species recorder during vegetation surveys.

Most species present in rabbit feces have widespread dispersal mechanisms (wind) and are mainly herbaceous species with small seeds size. These results support Janzen's "foliage is the fruit" hypothesis [16] who suggested that endozoochory is an important dispersal mechanism for small-seeded species because they are consumed as the same time as the foliage.

The largest seeds found in rabbit feces belong to species such as *R. monosperma* and *S. alatum* which have no apparent means of dispersal so endozoochory would be an important mechanism for dispersion and colonization.

The seed rain to recently formed dunes was monitored throughout the year, and although seed input was greater during summer, the time of year when most fruits are available, we observed that rabbits operate as a permanent dispersion agent in the study area.

In recently formed dunes, which are under continuous erosion and sand accumulation processes, seeds dispersed through feces can germinate, become part of the soil seed bank, or be buried and lost. The continuous input of seeds through endozoochory would ensure that, once the necessary conditions for germination and establishment are reached, dispersed species may prosper and colonize new areas.

In young dunes, the endozoochory allowed the arrival of species such as *M. littorea, S. lividus, S. nicaeensis, S. tenerrimus, S. salina,* and *R. monosperma* to new areas open for colonization. Except *S. salina,* that is characteristic of salt marshes, all species dispersed will be able to grow in sand dunes and their establishment will contribute to stabilization of freshly deposited sand. *R. monosperma* recruitment will mean an important change in the dynamics dunes because this species reduces stressful environmental conditions and it increases the organic matter of the soil and this will facilitate the entrance of numerous herbaceous plants [17].

Endozoochory implies apermanent seed influx, the dispersion of some species without evident dispersal mechanisms, and the exclusive dispersal of certain species. Furthermore, in some cases, the germination rate is increased, enhanced by the passage through rabbit guts (6). This suggests that endozoochory is an important mechanism shaping the structure and composition of plant communities in young mobile dunes. Endozoochory contributes not only to the species colonization but the richness and density of dune plant communities.

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