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An assessment of the ruderal strategy in herbs: the case of *Plantago hispidula*

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SUMMARY

The hypothesis that *Plantago hispidula* has a ruderal strategy is tested in two habitat patches subjected to different degrees of disturbance by grazing. *Plantago hispidula* appears more successful in disturbed areas as measures of density and total biomass are greater there than in undisturbed areas. This differential success affects the diversity and evenness of the plant communities in which *P. hispidula* occurs.

KEY-WORDS: Plantago - *Disturbance* - *Ruderal strategy.*

RÉSUMÉ

On a testé, sur deux emplacements soumis à différents degrés de perturbation par broutage, l'hypothèse selon laquelle *Plantago hispidula* a une stratégie rudérale. *Plantago hispidula* semble mieux réussir dans les zones perturbées, puisque les mesures de densité et de biomasse totale sont plus élevées que dans les zones non perturbées. Ce succès différentiel affecte la diversité et l'équitabilité des communautés de plantes dans lesquelles on trouve *Plantago hispidula.*

MOTS-CLÉS : Plantago - *Perturbation* - *Stratégie rudérale.*

INTRODUCTION

Plantago hispidula R. et Pav. is a small pterophyte whose vegetative growth starts with the first winter rains, producing seeds by late spring (NAVAS, 1979; WALKOWIAK, 1980). Physiognomically, this herb is an important component of the herbaceous layer in the coastal sand-dune communities in central Chile (see SEREY, 1978). It has been shown experimentally that *P. hispidula* allocates a high proportion of its biomass to reproductive structures and shows a high relative growth rate (R max) (WALKOWIAK, 1980). Given these biological properties it could be expected that *P. hispidula* is more successful in disturbed than in undisturbed areas, thus conforming to GRIME'S (1974, 1977) definition of the ruderal strategy.

Our aim is to verify if *P. hispidula* behaves as a ruderal strategist by testing its ecological success in areas subjected to different degrees of disturbance, as well as the effect that its differential success has upon the diversity of the communities in wich *P. hispidula* occurs.

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MATERIALS AND METHODS

We worked in two adjacent areas in the sand-dunes of Quintero (32°48′ S; 72°30′ W). In the first one, native shrubs were eliminated by man at least 20 years ago (SEREY, personal communication); the only shrubs present in the area are sparcely distributed individuals of the toxic *Cestrum palqui*. This area supports a stock of goats *(Capra hircus)* throughout late spring and summer. We considered this area to be our "disturbed" study site.

The second area is located 1 km apart from the disturbed one; presents a more diverse cover of shrubs, and goats have only rarely been observed. We considered this area as "undisturbed".

In order to evaluate disturbance, we assessed the level of activity of the two commonest introduced herbivores in the area: goats *(C. hircus)* and hares *(Lepus timidus)*. Following JAKSIĆ *et al.* (1979) we counted the number of faecal pellets in plots of 2.5 m^2 randomly set in the field. As a measure of success of *P. hispidula* in the two study areas, we calculated the density and biomass of individuals (dry weight; 36 hours at 70° C) in randomly chosen plots of 0.625 m^2. Special care was taken to collect the herbs without loss of senescent leaves, seeds, or small roots.

We calculated the species diversity using Shannon's H' and the evenness with the parameter J' (see PIELOU, 1974).

RESULTS

The activity levels of *C. hircus* and *L. timidus* (our estimates of disturbance) differ significantly between the two areas: density of faecal pellets is greater in the disturbed area for both *C. hircus* and *L. timidus* ($P < 0.001$; Student's t-test for means with unequal variances. See table I).

TABLE I

Degree of disturbance (as estimated by the activity of goats and hares) and response of P. hispidula *in two adjacent areas of the sand-dunes of Quintero. Figures are mean ± standard error; n = sample size. Activity = N° faeces/2.5 m^2; density = individuals/0.625 m^2; biomass in g.*

	Activity				*Plantago hispidula*					
							Biomass			
	L. timidus	*n*	*C. hircus*	*n*	Density	*n*	Individual	*n*	Total	*n*
Undisturbed	3.3 ± 0.9	30	2.5 ± 1.1	30	33.5 ± 7.5	20	0.033 ± 0.002	50	2.4 ± 0.37	5
Disturbed	9.2 ± 2.1	30	10.7 ± 1.9	30	399.5 ± 17.4	10	0.029 ± 0.001	50	12.5 ± 1.18	5

The density and total biomass of *P. hispidula* are significantly greater in the disturbed than in the undisturbed area (table I; $P < 0.001$ for both density and biomass). Notwithstanding, individual biomass does not show significant differences between the two areas ($P = 0.17$; table I).

Diversity is greater in the undisturbed than in the disturbed area ($H' = 2.12$ versus 0.59 respectively; the values are significantly different at the level $\alpha = 0.001$, using Hutcheson's [1970] test). The same holds for evenness ($J' = 0.78$ versus 0.28) and the number of species present (15 versus 8), indicating that not only there are more

species in the undisturbed area, but they are more homogeneously distributed (see PIELOU, 1974).

The low evenness observed in the disturbed area is mainly determined by the great cover attained by *P. hispidula* (85.2 % of linear cover versus 22.5 % in the disturbed and undisturbed areas respectively).

DISCUSSION

In terms of density and total biomass, our results demonstrate that *P. hispidula* is more successful in the disturbed area, which is in agreement with our hypothesis. In undisturbed areas, the species diversity has been proposed to be limited by competitive exclusion and/or environmental stress (WHITTAKER, 1972; GRIME, 1973). According to GRIME'S (1973) arguments *P. hispidula* has a very low competitive ability (WALKOWIAK, 1980) which would determine its lower representation in the undisturbed areas, presumably a more competitive environment.

With intense disturbance, species with high competitive ability are suppressed and only species with opportunistic response are able to persist (GRIME, 1973). Therefore, in an overgrazed habitat (our disturbed area), *P. hispidula* showed to have the expected selective advantage since it has a high growth rate and high seed production as compared with other sand-dune plants (see WALKOWIAK, 1980). Consequently, the species diversity should decrease (HARPER, 1969).

Another feature that confers advantage to *P. hispidula* in comparison to syntopic herbs in the disturbed area is that when goats arrive in late spring, *P. hispidula* has already produced seeds, but not other pterophytes. Grazing pressure applied on the other herbs before their reproduction consequently lowers their reproductive success thus decreasing their potential for renewal in the next phenological cycle (see JAKSIĆ & MONTENEGRO, 1979; JAKSIĆ & FUENTES, 1980).

Nevertheless, it could be argued that the differences in density observed between the two areas are due to differential soil fertility. It has been shown that in fertile soils, population density of herbs is lower but the individual mean biomass is higher than in soils with low fertility (YODA *et al.*, 1963). This alternative hypothesis can be rejected on two grounds. On the one hand, the edaphic characteristics and chemical composition of the soil do not differ between the two study areas. In both, the soil has the same pH, permeability, and amount of micro and macronutrients (SEREY, 1978; WALKOWIAK, 1980). On the other hand, individual mean biomass does not differ significantly between disturbed and undisturbed areas (table 1).

In conclusion, we propose that the disturbance produced by grazing of *C. hircus* and *L. timidus* in the sand-dunes of Quintero tends to select species with adaptations which facilitate exploitation of temporally favorable conditions (*i. e.* rapid germination, high *R* max, high seed production). These biological properties are exhibited by *P. hispidula* and determine its success in disturbed areas. It would appear therefore that the species is a genuine ruderal strategist.

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