ACTA OECOLOGICA □□ (2006) □□□

available at www.sciencedirect.com

journal homepage: www.elsevier.com/locate/actoec

Original article

The effect of grazing on granivory patterns in the temperate Monte Desert, Argentina

Paola L. Sassi [*], *Paula A. Taraborelli*, *Carlos E. Borghi*, *Ricardo A. Ojeda*

Biodiversity Research Group (GIB), Argentine Institute for Arid Zone Research (IADIZA), Regional Center for Scientific and Technological Research (CRICYT), CONICET, CC 507, 5500 Mendoza, Argentina

ARTICLE INFO

Article history:
Received 24 October 2005
Accepted 21 November 2005

Keywords:
Assemblage
Desert
Disturbance
Ecological process
Granivory
Spatial heterogeneity

ABSTRACT

Structural variations result in a marked heterogeneity of processes in arid environments. Disturbances have noticeable impacts on ecosystems, and a solid way of assessing their effect is to analyze how ecological processes operate. In deserts, granivory has been considered as a keystone process. The objective of our study was to determine the effect of domestic grazing on seed removal rates by birds, ants and rodents as an indirect measure of the process of granivory. This study was carried out in grazed and ungrazed habitats in the central Monte desert ecoregion in Argentina, during February and July 2002. We analyzed three major habitats: mesquite forest, creosotebush shrubland, and sand dunes under two different treatments (grazed, ungrazed). We found significant effects of grazing and non-grazing treatments on total seed removal rates, among granivorous taxa, as well as interactions with season and habitats. Ants and birds were the taxa that differed most under grazing pressure whereas seed removal by rodents showed no significant responses towards grazing. In conclusion, grazing affects plant structure and the assemblage of granivorous taxa, which in turn translates to the granivory process, adding another source of variation to the seed removal patterns reported for the temperate Monte desert.

Seeds are an important and stable food resource in arid ecosystems (Parmenter et al., 1984; Kerley, 1991). The interacting process between plants and animals that feed on seeds has been described under the name of granivory (Hulme and Benkman, 2002). Seed removal rate has been used as an indirect way to measure and compare the intensity of granivory by different granivorous taxa in desert areas of the world (Mares and Rosenzweig 1978; Morton, 1985; Kerley, 1991; Vásquez et al., 1995; López de Casenave et al., 1998). Numerous studies have evaluated seed removal by ants, birds and rodents as a surrogate of granivory, based on their importance in desert ecosystem dynamics and as a measurable attribute indicative of desert convergence (Mares and Rosenzweig, 1978; Brown and Ojeda, 1987; Kelt et al., 1996). Recent studies have shown higher rates of seed removal for some of the South American aridland biomes, and in certain plant communities of the temperate Monte Desert (Kelt et al., 2004; Sassi et al., 2004). Differential patterns of granivory in North American deserts were suggested as being the result of vegetation changes due to the desertification process occurred over the past 150 years (Wada et al., 1995; Kerley and Whitford, 2000). Since grazing pressures affect vegetation structure and composition, granivory is an interesting process to assess the effect of grazing by domestic herbivores on ecosystem functioning. The objective of our study was to test for the effect of cattle grazing on seed removal rates, as an indirect measure of disturbance on a keystone process in arid lands (Brown and Heske 1990).

[*] Corresponding author. Fax: +54 261 428 7370.
E-mail address: psassi@lab.cricyt.edu.ar (P.L. Sassi).

1146-609X/$ - see front matter © 2006 Elsevier SAS. All rights reserved.
doi:10.1016/j.actao.2005.11.009

This study was carried out in the Man and Biosphere (MaB) Reserve of Ñacuñán (34°0.2′S, 67°58′W), and adjacent rangelands of the Monte Desert biome, Mendoza province, Argentina. The region is a heterogeneous mosaic of plant communities with a mean annual rainfall of 326 mm, and mean temperatures of approximately 10 °C and 22 °C in winter and summer, respectively (Roig, 1971; Ojeda et al., 1998). We analyzed seed removal rates by birds, ants, and rodents in the three most conspicuous vegetation patches of the Monte Desert: mesquite forest, characterized by *Prosopis flexuosa*; creosotebush shrublands, dominated by *Larrea divaricata*; and sand dunes, with shrubs, herbs and scattered trees. These vegetation patches occur in both "treatments": grazed lands and the Reserve. Cattle have been excluded from the Reserve for 40 years.

The sampling design followed Giannoni et al. (2001), Taraborelli et al. (2003) and Sassi et al. (2004). Samples were taken in February and July 2002 (humid and dry season, respectively). At each community we established two experimental treatments: grazed by cattle (outside the Reserve) vs. ungrazed (inside the Reserve). On every site we placed three seed trays every 10 m, along two 100-m transects 500 m apart, i.e. 30 seed trays per transect and 60 seed trays per site. Within each set of three trays, one was accessible to birds and rodents (Tray 1), another one only to ants (Tray 2), and the third tray could be accessed by murid rodents only (Tray 3). Trays consisted of plastic dishes 15 cm in diameter and 3 cm deep, filled with 50 g of commercial sunflower (*Helianthus annuus*) and millet (*Panicum miliaceum*) seeds. Tray 1 was placed, unprotected, with edges 3 cm above the ground surface to prevent access by ants. Tray 2 was half buried (i.e. with edges at ground level) so as to allow access by ants, and protected with a wire screen (4 0 × 4 0 × 7 cm^3) to prevent access by birds and rodents. Tray 3 was placed 3 cm above the ground surface, protected with a wire screen (4 0 × 4 0 × 7 cm^3), with two 5-cm openings on each of the four sides that allowed only murid rodents to enter. Sampling was conducted simultaneously in the Reserve and the grazed field over a 48-hour period, after which the remaining seeds were retrieved in labeled bags. In the lab they were weighed to estimate removal by birds, rodents and ants. We performed a multivariate analysis of variance (MANOVA) to test for effects of season (humid/dry), community (mesquite/creosote/sand), and treatment (grazed/ungrazed) on granivory patterns, with removal rates by rodents, ants, and birds as dependent variables. In addition, we performed an analysis of variance (ANOVA) with total seed removal rate as dependent variable. In order to meet assumptions of parametric analysis, data were log-transformed. We used Statistica Software Inc. 6.0 (1997).

We found significant effects for all main factors using each taxon's seed removal rate as dependent variables (Table 1). We used total seed removal rate as dependent variable, in order to determine taxonomic differences among seed removal rates as well as interactions between groups of granivores and environmental factors (season, habitat and treatment). Seed removal rate was higher in the humid season (Mean = 2.61 g/48 h; standard error = 0.148) than in the dry season (M = 1.93 g/48 h; S.E. = 0.149), although these differences were not significant. Seed removal rates for each habitat were: creosotebush: M = 2.70 g/48 h, S.E. = 0.185; sand dunes: M = 2.49 g/48 h, S.E. = 0.182; and mesquite forest: M = 1.63 g/48 h, S.E. = 0.18; the latter was significantly different from the others. Seed removal rates were higher in the grazed field (M = 2.41 g/48 h; S.E. = 0.15) than in the Reserve (M = 2.14 g/48 h; S.E. = 0.148).

Comparison of granivory patterns between grazed and ungrazed treatments in each habitat are shown in Fig. 1. In creosotebush shrublands and sand dune habitats rankings differed between grazed and ungrazed conditions, whereas the mesquite forest showed the same pattern for both treatments. Ants and birds were the taxa that differed most under grazing pressure whereas seed removal by rodents showed no significant responses towards grazing. Seed removal by ants was greater in creosotebush shrublands, while in the mesquite forest seed removal by ants and birds was higher in the grazed field than in the Reserve. Seed removal by rodents showed no significant changes under grazing pressure in different habitats. We found a remarkable similarity in seed removal by different taxa between mesquite forest and previous research performed at the Reserve (ungrazed treatment; Sassi et al., 2004).

In analyzing interactions, the effect of each source of variation behaved in particular ways. The effect of season was evident when considering taxa individually: each one responded differently to the marked seasonality (temperature, trophic resources availability, population density, etc.). Ants seem to respond to temperature, substrate differences, and plant cover, which are in turn affected by cattle (Waser and Price, 1981; Valone and Kelt, 1999; Folgarait and Sala, 2002). Bird and mammal responses seem to be related to predation risk, nutritional requirements, body size and dispersal capacity.

The different sources of variation in seed removal studies, coupled with spatial and temporal variation in desert ecosystems, pose serious methodological problems when looking for patterns of granivory in non-controled experiments versus those of Brown and colleagues (Heske et al., 1993; Hopf et al., 1993; Brown et al., 2001). Rates of seed removal in desert ecosystems vary among taxa, seed type, and temporal (seasons) and spatial scales (from microhabitats to ecosystems) (Vásquez et al., 1995; López de Casenave et al., 1998; Kerley and Whitford, 2000; Folgarait and Sala, 2002; Saba and Toyos, 2003; Taraborelli et al., 2003; Kelt et al., 2004; Sassi et al., 2004). Cattle grazing practices affect plant composition as well as diversity of bird and mammal assemblages in most Monte Desert habitats (Tabeni and Ojeda, 2005; Gonnet, 2001; Ojeda, unpublished data; Sassi et al., submitted). As granivory is an interacting ecological process between plants and animals, we suggest that differential patterns in seed removal dynamics are the result of changes in the structure and composition of plant and granivorous assemblages. Our results show how a single disturbance factor (e.g. grazing) may produce contrasting responses in different components (i.e. patches of habitats) of the desert ecosystem. In conclusion, grazing pressure by domestic herbivores not only affects the process of granivory (e.g. rates of seed removal), but also adds another source of heterogeneity to the previously reported dynamics of granivory for the temperate Monte Desert.

Table 1 – Results of a MANOVA test, with seed removal rate of each taxon as response variables, showing interactions among experimental factors ($P < 0.05$)

	Wilks value	F	df effect	df error	P-level
Season	0.902	15.72	3	437	0.00000*
Habitat	0.923	5.91	6	874	0.00000*
Treatment	0.962	5.64	3	437	0.00084*
Season × Habitat	0.939	4.59	6	874	0.00013*
Season × Treatment	0.973	3.88	3	437	0.00918*
Habitat × Treatment	0.967	2.43	6	874	0.02417*
Season × Habitat × Treatment	0.941	4.44	6	874	0.000193

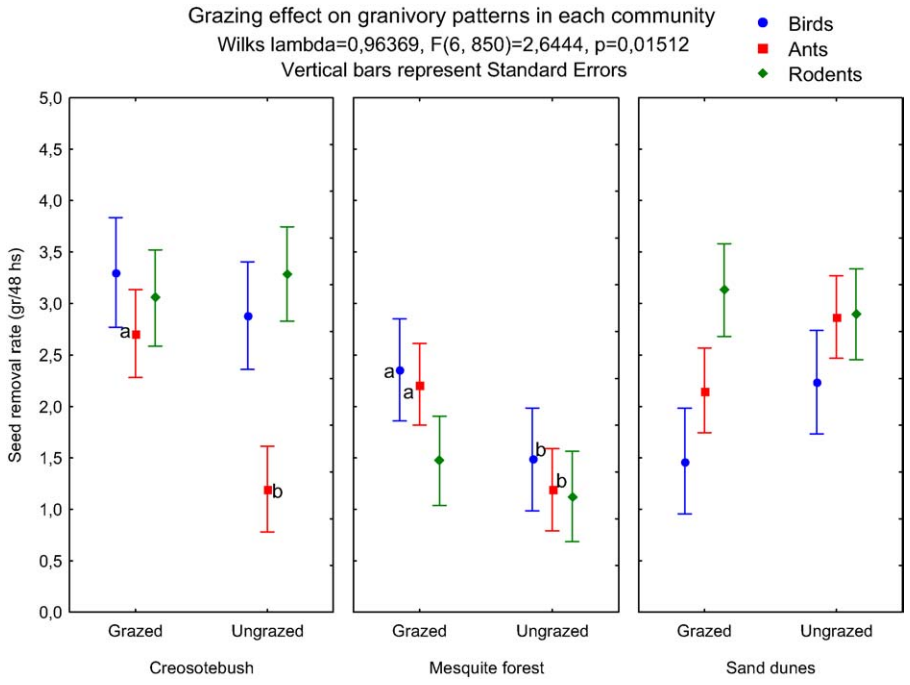

Fig. 1 – Seed removal rates (g/48 h) for each taxon, giving patterns of granivory for each habitat under grazed and ungrazed treatments. When statistically different, letters "a" and "b" indicate within-habitat differences for each taxon's removal rate.

Acknowledgements

We appreciate the comments of Douglas Kelt and two anonymous reviewers on an earlier version of our manuscript. Ana Srur helped us with our fieldwork, and Nelly Horak kindly improved the English version of our text. This research was partially funded by CONICET and SECYT, Agencia Nacional de Promoción Científica y Tecnológica, Argentina (through grants PIP 2884/01 and PICT 03281 to R. Ojeda).

REFERENCES

Brown, J.H., Heske, E.J., 1990. Control of Desert–Grassland transition by a keystone rodent guild. Science 250, 1705–1707.

Brown, J.H., Ojeda, R.A., 1987. Granivory: patterns, processes, and consequences of seed consumption on two continents. Rev. Chil. Hist. Nat. 60, 337–349.

Brown, J.H., Whitham, T.G., Ernest, S.K.M., Gehring, C.A., 2001. Complex species interactions and the dynamics of ecological systems: long-term experiments. Science 293, 643–650.

Folgarait, P.J., Sala, O.E., 2002. Granivory rates by rodents, insects, and birds at different microsites in the Patagonian steppe. Ecography. 25, 417–427.

Giannoni, S.M., Dacar, M., Taraborelli, P.A., Borghi, C.E., 2001. Seed hoarding by rodents of the Monte desert, Argentina. Austral Ecol. 26, 259–263.

Gonnet, J.M., 2001. Influence of cattle grazing on population density and species richness of granivorous birds (Emberizidae) in the arid plain of the Monte, Argentina. J. Arid Environ. 48, 569–579.

Heske, E.J., Brown, J.H., Kumar, S., Guo, Q., 1993. Effects of kangaroo rat exclusion on vegetation structure and plant species diversity in the Chihuahuan Desert. Oecologia 95, 520–524.

Hopf, F.A., Valone, T.J., Brown, J.H., 1993. Competition theory and the structure of ecological communities. Evolutionary Ecology 7, 142–154.

Hulme, P.E., Benkman, C.W., 2002. Granivory. In: Herrera, C. M., Pellmyr, O. (Eds.), Plant-Animal Interactions. Blackwells, Oxford, pp. 132–154.

Kelt, D.A., Brown, J.H., Heske, E.J., Market, P.A., Morton, S.R., Reid, J.R., Rogovin, K., Shenbrot, G., 1996. Community structure of desert small mammals: comparisons across four continents. Ecology 77, 746–767.

Kelt, D.A., Meserve, P.L., Forister, M.L., Nabors, L.K., Gutiérrez, J.R., 2004. Seed predation by birds and small mammals in semiarid Chile. Oikos 104, 133–141.

Kerley, G.I.H., 1991. Seed removal by rodents, birds and ants in the semi-arid Karoo, South Africa. J. Arid Environ. 20, 63–69.

Kerley, G.I.H., Whitford, W.G., 2000. Impact of grazing and desertification in the Chihuahuan desert: plant communities, granivores and granivory. The Am. Midl. Nat. 144, 78–91.

López de Casenave, J., Cueto, V.R., Marone, L., 1998. Granivory in the Monte desert, Argentina: is it less intense than in other arid zones of the world? Global Ecol. Biogeogr. 7, 197–204.

Mares, M.A., Rosenzweig, M.L., 1978. Granivory in North and South American deserts: rodents, birds, and ants. Ecology 59, 235–241.

Morton, S.R., 1985. Granivory in arid regions: comparison of Australia with North America and South America. Ecology 66, 1859–1866.

Ojeda, R.A., Campos, C.M., Gonnet, J.M., Borghi, C.E., Roig, V. G., 1998. The MAB Reserve of Ñacuñán, Argentina: its role in understanding the Monte Desert Biome. J. Arid Environ. 39, 299–313.

Parmenter, R.R., MacMahon, J.A., Vander Wall, S.B., 1984. The measurement of granivory by desert rodents, birds and ants: a comparison of an energetics approach and a seed-dish technique. J. Arid Environ. 7, 75–92.

Roig, F.A., 1971. Flora y vegetación de la Reserva Forestal de Ñacuñán. Deserta (Argentina) 1, 225–232.

Saba, S.L., Toyos, A., 2003. Seed removal by birds, rodents and ants in the Austral portion of the Monte Desert, Argentina. J. Arid Environ. 53, 115–124.

Sassi, P.L., Tort, J., Borghi, C.E., 2004. Effect of spatial and temporal heterogeneity on granivory in the Monte Desert, Argentina. Austral Ecol. 29, 661–666.

Statistica Software Inc. 6.0, 1997. Electronic Statistics Textbook. Tulsa, OK: StatSoft. WEB: http://www.statsoft.com/textbook/stathome.html.

Tabeni, M.S., Ojeda, R.A., 2005. Ecology of the Monte Desert small mammals in disturbed and undisturbed habitats. J. Arid Environ. 63, 244–255.

Taraborelli, P.A., Dacar, M., Giannoni, S.M., 2003. Effect of plant cover on seed removal by rodents in the Monte Desert (Mendoza, Argentina). Austral Ecol. 28, 651–657.

Valone, T.J., Kelt, D.A., 1999. Fire and grazing in a shrub-invaded arid grassland community: independent or interactive ecological effects? J. Arid Environ. 42, 15–28.

Vásquez, R.A., Bustamante, R.O., Simonetti, J.A., 1995. Granivory in the Chilean matorral: extending the information on arid zones of South America. Ecography 18, 403–409.

Wada, N., Narita, K., Kumar, S., Furukawa, A., 1995. Impact of overgrazing on seed predation by rodents in the Thar Desert, northwestern India. Ecol. Res. 10, 217–221.

Waser, N.M., Price, M.V., 1981. Effects of grazing on diversity of annual plants in the Sonoran desert. Oecologia 50, 407–411.