

Research Report

SEEDLING – ADULT PLANT ASSOCIATION AS INDICATOR OF THE INCIDENCE OF FACILITATION AT DIFFERENT SPATIAL SCALES IN THE PREPUNA BIOGEOGRAPHICAL REGION OF SOUTH AMERICA

INTRODUCTION

Harsh conditions prevail in open spaces of deserts and semi-deserts, especially in what relates to plant water balance. In many arid environments, it has been shown that the shade cast by shrubs or trees (nurses) canopies provides a favourable microhabitat for many seedlings (beneficiaries) trying to get established in the community. This process is known as facilitation or the nurse syndrome. Most of the studies have been confined to two or a few species. It is known that some species are entirely dependent on nurse plants to recruit into the community and others can establish and grow in open ground. In some extreme cases, only one or very few species are able to grow without the benefits of shade, and become key species since establishment of other species and, hence, the structure and diversity of the communities where they grow is dependent on their presence.

Very little is known about the incidence of facilitation in the arid Andes of Bolivia. Yet, knowledge of how many species are involved in this interaction may be crucial for conservation and management of populations, especially in the case of threatened taxa, or for habitat restoration, considering that erosion is a major problem in parts of the Prepuna. Species re-introductions or attempts to increase numbers of a given species may depend on knowledge of its role as nurse or beneficiary. For example, to increase numbers of a given species catalogued as beneficiary will involve providing shade to its seedlings. Detection of one or a few species able to recruit in open spaces would mean that these should be protected in order to maintain community structure, function and diversity, since establishment of other taxa would depend on the shade provided by these heliophilous species. Several species (especially woodies and Cactaceae) in the Prepuna are considered as threatened. The Prepuna is one of the most diverse Bolivian biogeographical regions in Cactaceae, a CITES family. The findings of this study will allow the generation of hypothesis which could be tested by experimentation and further, more specific observations, thus providing greater insight into the functioning of these ecosystems.

Objective

The objective of this study was to characterize the spatial relationship of seedlings/saplings of shrubs and cacti with adult plants in the biogeographical region known as the Prepuna. This was done in order to have preliminary information on the possible incidence of facilitation in this Andean semi-desert. The importance of this study was that it not only involved one or a few species, but several and in a whole biogeographic region.

STUDY AREA

The study was carried out in the Prepuna, a biogeographical region of subtropical South America located in the Andes of southern Bolivia and northern Argentina (latitude 20-27 °, approximately, 2000-3200 meters above sea level). Field work was carried out from March 31 to April 15, 2006.

METHODS

The study began with the search of dominant zonal vegetation types of Prepuna that were little disturbed. We travelled almost 3 700 km seeking sampling sites. Twenty-two localities were chosen, 12 in Bolivia and 10 Argentina, between 2400 and 3150 m (Table 1). In each locality, we recorded the presence of all seedlings and saplings (henceforth, juveniles) of shrub species. Here were included all individuals < 20 cm height. The older individuals had basal diameters of up to 1.5 cm, approximately. In the case of two dwarf shrubs and globose and opuntoid cacti, adults were considered since almost no juveniles were found. For each juvenile, we recorded its identity and the microhabitat where it was established: open ground or below a shrub's canopy. In the latter case, shrub identity was also registered. The individuals of one species present in one locality were considered a population. This procedure was followed until a large sample was obtained (ideally, at least 30 individuals per species). However, frequently the low number of juveniles prevented me from attaining such large samples.

In each locality studied, plant cover was measured with the line interception method. Line lengths varied from 100 to 500 m in each locality (*ca.* 3000 m for the whole region), depending on horizontal plant structure. Usually, larger lines were laid out where there was less plant cover. Photographs of the localities and of some plants (especially cacti) were taken. We made botanical collections too.

Table 1. Prepuna localities in which seedling/sapling spatial distribution was recorded.

Station	Coordinates	Altitude (meters)
Humahuaca	S23°08.352' W65°23.632'	3150
Humahuaca I	S23°06.373' W65°22.553'	3200
Maymara	S23°39.087' W65°25.765'	2400
Los Cardones	S25°07.617' W65°59.222'	3000
Los Cardones I	S25°11.039' W65°58.860'	2900
Payogasta	S25°03.850' W66°03.894'	2600
Molinos	S25°25.923' W66°16.114'	2050
Amaicha	S26°37.385' W65°50.392'	2450
Purmamarca	S23°42.692' W65°31.610'	2600
Uquía	S23°21.729' W65°20.737'	2800
Tojo Alto	S21°54.280' W65°26.592'	3150
Tomayapo I	S21°21.119' W65°03.268'	3000
Tomayapo	S21°17.061' W65°02.670'	2850
Impora I	S21°15.529' W65°13.960'	2500
Impora Alto	S21°23.239' W65°17.993'	3150
Torata	S21°22.194' W65°17.313'	2850
Impora	S21°17.147' W65°14.638'	2550
Cruz Huasa	S20°46.878' W65°13.860'	2400
Culpina	S20°44.017' W65°12.266'	2700
Parinolqui I	S20°41.813' W65°29.333'	3000
Parinolqui	S20°43.645' W65°34.146'	3100
Escara	S20°35.908' W65°39.595'	3000

RESULTS

The spatial distribution of *ca.* 2200 juveniles belonging to 51 populations of 16 shrub and 12 cacti species was recorded (Table 2). Twenty-eight (out of 36) shrub species populations were established indifferently both in open ground and in vegetation (the proportion of their individuals was related to the proportion of each microhabitat, i.e.,

below shrubs or in the open), five preferred the open and only three were preferentially associated to the undercanopies of shrubs. Nine of the cacti populations were established below shrubs and six were indifferent to microhabitat.

Table 2. Species populations for which seedling/sapling (adults for cacti) spatial distribution was recorded in the Prepuna region. n = sample size (number of juveniles recorded). In preferred microhabitat, blank cells indicate that both microhabitats are used indifferently.

Species	n	Locality	Country	Preferred microhabitat
Cercidium andicola (Mimosaceae)	31	Tomayapo I	Bolivia	
Cercidium andicola	25	Impora I	Bolivia	
Cercidium andicola	18	Torata	Bolivia	
Cercidium andicola	45	Impora	Bolivia	vegetation
Cercidium andicola	49	Cruzhuasa	Bolivia	
Cercidium andicola	12	Culpina	Bolivia	
Cercidium andicola	32	Escara	Bolivia	
Cercidium andicola	27	Parinolqui I	Bolivia	
Cercidium andicola	20	Maimara	Argentina	
Prosopis ferox (Mimosaceae)	38	Tomayapo I	Bolivia	
Prosopis ferox	45	Escara	Bolivia	open
Prosopis ferox	170	Parinolqui	Bolivia	vegetation
Prosopis ferox	41	Humahuaca	Argentina	
Prosopis ferox	13	Uquía	Argentina	
Acacia feddeana (Mimosaceae)	13	Tomayapo	Bolivia	
Acacia feddeana	24	Torata	Bolivia	
Acacia feddeana	20	Parinolqui I	Bolivia	
Acacia feddeana	18	Escara	Bolivia	
Caesalpinita trichocarpa (Caesalpiniaceae)	39	Tojo	Bolivia	
Caesalpinita trichocarpa	14	Alto Impora	Bolivia	
Caesalpinita trichocarpa	62	Uquía	Argentina	
Parodia cf. maassii (Cactaceae)	23	Tojo	Bolivia	vegetation
Parodia maassii	45	Uquía	Argentina	
Parodia maassii	16	Humahuaca	Argentina	vegetation
Larrea divaricata (Zygophyllaceae)	21	Impora	Bolivia	
Larrea divaricata	15	Los Cardones	Argentina	
Coursetia brachyrhachis (Papilionaceae)	77	Cruzhuasa	Bolivia	vegetation
Coursetia brachyrhachis	42	Culpina	Bolivia	
Echinopsis sp. (Cactaceae)	31	Cruzhuasa	Bolivia	vegetation
Echinopsis sp.	29	Culpina	Bolivia	
Senna crassiramea (Caesalpiniaceae)	21	Maimara	Argentina	
Senna crassiramea	29	Uquía	Argentina	
Baccharis boliviensis (Compositae)	45	Humahuaca	Argentina	open
Opuntia sulphurea (Cactaceae)	24	Los Cardones	Argentina	vegetation
Croton sp. (Euphorbiaceae)	56	Tomayapo	Bolivia	
Bulnesia rivas-martinezii (Zygophyllaceae)	25	Alto Impora	Bolivia	open
Parodia cf. maxima (Cactaceae)	46	Parinolqui I	Bolivia	vegetation
Gochnatia cardenasii (Compositae)	95	Alto Impora	Bolivia	open
Lippia sp. (Verbenaceae)	22	Alto Impora	Bolivia	open
Weingartia cf. (Cactaceae)	14	Alto Impora	Bolivia	
Weingartia cf. leucorensis (Cactaceae)	41	Impora I	Bolivia	
Bulnesia schickendantzii (Zygophyllaceae)	50	Los Cardones	Argentina	

Tunilla cf. soherensi (Cactaceae)	68	Humahuaca	Argentina	
		Los		
Tunilla cf. tilcarensis (Cactaceae)	39	Cardones	Argentina	vegetation
Zuccagnia punctata (Caesalpiniaceae)	33	Molinos	Argentina	
Parodia sp. (Cactaceae)	21	Maimara	Argentina	
Tephrocactus molinensis (Cactaceae)	42	Molinos	Argentina	vegetation
Lophopappus foliosus (Compositae)	13	Uquía	Argentina	
Solanum cf. fiebrigii (Solanaceae)	15	Purmamarca	Argentina	
Gumnocalycium spegazzini (Cactaceae)	15	Amaicha	Argentina	vegetation
Acanthocalycium thionanthum (Cactaceae)	14	Payogasta	Argentina	vegetation

Of those populations established preferentially below shrubs, some species-specific associations were found (Table 3). Most of these potential nurse plants (i.e., the adult shrubs) belonged to plants that are usually dominant in their communities (*Cercidium andicola*, *C. praecox*, *Bulnesia schickendantzii*, *Plectrocarpa rougesii*, *Baccharis boliviensis* and, to a lesser degree, *Prosopis ferox*).

Table 3. Species-specific associations found in different localities of the Prepuna region

Seedling species	Potential nurse
<i>Parodia</i> cf. <i>maassii</i>	<i>Baccharis boliviensis</i>
<i>Parodia</i> cf. <i>maassii</i>	<i>Caesalpinia trichocarpa</i>
<i>Parodia</i> <i>maassii</i>	<i>Prosopis ferox</i>
<i>Parodia</i> <i>maassii</i>	<i>Baccharis boliviensis</i>
<i>Coursetia brachyrhachis</i>	<i>Cercidium andicola</i>
<i>Echinopsis</i> sp.	<i>Cercidium andicola</i>
<i>Echinopsis</i> sp.	<i>Acacia feddeana</i>
<i>Opuntia sulphurea</i>	<i>Bulnesia schickendantzii</i>
<i>Opuntia sulphurea</i>	<i>Plectrocarpa rougesii</i>
<i>Tunilla</i> cf. <i>tilcarensis</i>	<i>Bulnesia schickendantzii</i>
<i>Tunilla</i> cf. <i>tilcarensis</i>	<i>Plectrocarpa rougesii</i>
<i>Parodia</i> cf. <i>maxima</i>	<i>Cercidium andicola</i>
<i>Tephrocactus molinensis</i>	<i>Cercidium praecox</i>
<i>Tephrocactus molinensis</i>	<i>Bulnesia schickendantzii</i>
<i>Gumnocalycium spegazzini</i>	<i>Baccharis</i> sp.
<i>Acanthocalycium thionanthum</i>	<i>Bulnesia schickendantzii</i>
<i>Acanthocalycium thionanthum</i>	<i>Prosopis ferox</i>
<i>Cercidium andicola</i>	<i>Cercidium andicola</i>

A manuscript was prepared with the observations and was submitted to an international scientific journal.

CONCLUSIONS

The results obtained show a predominant pattern among shrub species: they are apparently indifferent to cover type. This in turn shows us that all of them are capable of recruiting in open ground. This is outstanding, because in other similar biomes, several species grow preferentially or exclusively below the canopies of shrubs, where more benign conditions prevail. One reason for the pattern found in the present study could be the lower soil temperatures present in this high altitude environment as compared to

other semi-deserts. There is the need to undertake studies of shrub seed banks and abiotic requirements of Prepuna species to be able to interpret these results.

Cacti, on the contrary, are more inclined to grow below shrubs. This is similar to what has been found elsewhere, which shows that many cacti species are associated to vegetation cover, but in different degrees. For example, some life forms (columnar cacti) are more vulnerable to open conditions, and within a similar growth form, different responses are found relative to microhabitat.

In synthesis, these results strongly suggest that nurses are not indispensable for Prepuna shrubs. However, they do not rule out facilitation as a still important interaction here. I saw many healthy sub-adult and young individuals (older than the sapling seedling/stage considered here) of different species growing beneath potential nurses. This indicates that light conditions are quite good below canopies and that competition may not be very intense there. Additionally, there are proportionally a little bit more saplings associated to shrubs than seedlings, which suggest slightly greater survival probabilities below shrubs. Nonetheless, the ability of shrubs to establish in open spaces indicates that nurses may not be as important in the Prepuna as in other arid regions.

BUDGET

BUDGET (US dollars)

subsistence payment (28 dollars/5 people/ 16 days/)	2240
Car rental	1800
fuel	259.1
Herbarium material and equipment (presses, mounting paper, trowels, tapes)	150
Food (for days of camping)	70.1
Stationery (paper, cartridges, clipboard, pens)	53.2
Battery recharger + battery	23.8
Photographs	20
Some material for the trip (cooler + water containers)	13.3
Road tolls	10.2
TOTAL	4639.7