

Monitoring fog-vegetation communities at a fog-site in Alto Patache, South of Iquique, Northern Chile, during "El Niño" and "La Niña" events (1997-2000)

Raquel Pinto, Equipo de Estudios de Ecosistemas de Niebla, Iquique; Dr. H. Larrain, Universidad Arturo Prat & Iecta, Iquique; P. Cereceda, Pontificia Universidad Católica de Chile; P. Lázaro, Gobierno Regional, Iquique; P. Osses, Pontificia Universidad Católica de Chile. R. S. Schemenauer, Atmospheric Environmental Service, Canada

Abstract: The Flora observations registered in weekly visits performed during more than three years (1997-2001) to the Fog oasis at Alto Patache (20° 49' S, 70° 09' W) are here presented. We analyse the differences in terms of Plant presence-absence between "El Niño" (1997-1998) and "La Niña" (1998-2001) periods. Our informations register a total plant amount of 45 species during "El Niño", and only 24 species during the dry period of "La Niña". Moreover, the field observations prove a strong Desiccation Process, now in action, still visible through the presence of some species surviving in very short numbers of exemplars, whereas other have been dying in the past 4-5 decades, as reflected in today presence of hundreds of dead or decaying Shrubs and Cacti.

1. INTRODUCTION

The presence of Flora at the Peruvian and Chilean Coastal Deserts, particularly in the so called "Lomas" formations, has been recently studied by different authors. Special mention deserves Péfour (1978, 1982), Masuzawa (1986), and recently Jiménez et al., (1998). Among the authors having studied the Chilean Arid North we should mention Rundel, and Mahu (1976); Dillon and Rundel, (1990); Rundel et al., (1991, 1997) and Sielfeld et al., (1995). Our observations in the area South of Iquique date from 1982 when the effects of local rain and their resulting vegetation cover were detected at several coastal places. The same, phenomenon was observed by us in the following years, namely 1987, 1992, 1997, corresponding to the presence of "El Niño". From July 1997 to February 2001, we have carefully followed the local development of all Fanerogama species present in the area of Alto Patache (20° 49' S and 70° 09' W). The site is one of the four main Fog-Oasis present in the coastal area, between Iquique and the Loa River. The weekly checking of Fog water catching devices (Cereceda et al, 1998, 1999), gave us an excellent opportunity to thoroughly study plant growth and their spatial distribution within the oasis. The relationship between rainfall and fog-moisture produced by oceanic "camanchaca", is not yet fully understood. Fog moisture input is much stronger during Winter and Spring months, and lighter in other months. From middle January until late June, Fog-moisture diminishes, but never ceases. Plants, therefore, receive all the year around sufficient moisture to grow. Our observations conclude that

each one of the three years studied has been different, in terms of species present and relative growth or vigor. 1997 was a unusual year in the area of Alto Patache. Rains were here detected in August 1997, assuring a high provision of water, which produced an incredible expansion of Plant cover, and the appearance of species never seen before. In our research, it has been possible to pinpoint exactly the time of appearance, growth, flowering and decay stages. The study analyses the presence and fenology of all species observed in the upper section of the coastal cliff. Within this area, we have distinguished four geomorphologic segments, and detected Plant preferences for them. At the same time, observations have been made in relation to the hypothesis of a gradual but constant Dessication Process in the area, during the last 100 years, by comparing meteorological registers and frequent personal field observations. This severe climatic change, specially acute in the past 50 years, with catastrophic results in terms of Individual reduction or Species extinction. Alto Patache may become one day an excellent laboratory where to check, in the next decades, the progressing Dessication Process of our Coastal Ecosystems.

2. METHODS

We visited, every week and made detailed field annotations concerning Presence and Vigor of Plants along the cliff area (750-800 m high) where normally the great diversity of Species grew during in "El Niño" period, when the huge expansion of vegetation

cover took place. Special attention was given to flowering and seeding Species, since some of the Plants parch before flowering, as in the case of Liliaceae and Amaryllidaceae as observed by us in Spring 2000 (“La Niña” Period).

3. RESULTS

Figure 1 shows the geographical expansion of Plant cover at the Fog site of Alto Patache in the two climatic Events.: the maximal extension due to “El Niño”, and the minimal, to “La Niña”. Table 1 was prepared on the basis of the studies undertaken by Pinto, R, 1999 and Muñoz et al (in press). It shows the appearance and growth of the different Species found at Alto Patache Fog Oasis, along the two climatic periods. “El Niño” Period brought about the growth of 45 Species, belonging to 28 Families and 38 different Genera. Some of them appeared in very

short numbers at the dry period (bulbs and perennial herbs). Cacti, Shrubs and Subshrubs show themselves alive in both periods, but showing a with very different vigorosity. Annual herbs were almost totally absent during “La Niña” period.

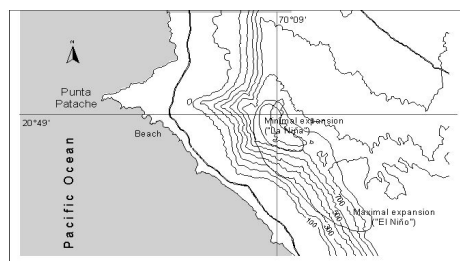


Figura 1 Maximal and minimal extension of plant cover at the Fog-Oasis of Alto Patache

Table 1

Presence vs. absence of vascular Plants registered during “El Niño” and “La Niña” at Alto Patache Fog Oasis.

Species	El Niño	La Niña	GT	Species	El Niño	La Niña	GT
Pteridophyta - Adiantaceae				Nolanaceae			
Cheilanthes mollis	(-)	(-)	ph	Nolana aplocaryorides	+ F	-	ah
Gymnospermae - Ephedraceae				Nolana intonsa	+ F	-	ah
Ephedra breana	++ F	+ F	sh	Nolana jaffuelii	+++ F	-	ah
Fanerogamas - Angiospermae				Nolana sedifolia	++ F	+	sbsh
Dicotyledoneae				Nyctaginaceae			
Aizoaceae				Miriabilis elegans	(-)	-	hp
Tetragonia ovata	++ F	-	ah	Oxalidaceae			
Asteraceae				Oxalis thyrsioidea	+ F	(-) F	ph
Ophryosporus floribundus	+	+ F	sh	Polemoniaceae			
Perytyle emory	+ F	-	ph	Gilia glutinosa	+ F	-	ah
Polyachyrus annuus	++ F	-	ah	Portulacaceae			
Polyachyrus sphaerocephalus	+ F	(-)	sbsh	Calandrinia litoralis	+ F	-	ah
Sonchus tenerrinus	+F	-	ah	Cistanthe amarantoidea	+ F	-	ah
Bignoniaceae				Cistanthe grandiflora	+ F	-	ah
Argylia radiata	+ F	-	ph	Santalaceae			
Cactaceae				Quinchamalium chilense	+ F	(-) F	ah
Eulychnia iquiquensis	+ F	+ F	t	Solanaceae			
Opuntia berteri	+ F	(-) F	ph	Lycium leiostemum	+ F	+	sh
Phyllocactus saxifragus	(-) F	(-)	ph	Lycopersicon chilense	(-) F	-	ph
Caesalpinaceae				Solanum brachyantherum	+ F	(-) F	ph
Hoffmannseggia prostrata	+ F	-	ph	Solanum montanum	(-)	-	ph
Capparaceae				Umbelliferae			
Cleome chilensis	(-) F	-	ah	Apium laciniatum	(-)	-	hp
Caryophyllaceae				Urticaceae			
Spergularia stenocarpa	(-) F	(-) F	ph	Parietaria debilis	(-)	-	ah
Chenopodiaceae				Monocotyledoneae			
Atriplex atacamensis	+ F	+	sh	Amaryllidaceae			
Chenopodium petiolare	(-) F	(-) F	ah	Alstroemeria sp new sp	++ F	+ F	ph
Suaeda foliosa	+ F	+ F	sh	Gramineae			
Frankeniaceae				Stipa vaginata	(-) F	(-) F	ph
Frankenia chilensis	++ F	++ F	sbsh	Liliaceae			
Loasaceae				Fortunatia biflora	+ F	(-)	ph
Loasa nitida	(-) F	-	ah	Leucocoryne appendiculata	+++ F	(-)	ph
Malesherbiaceae				Tecophilaceae			
Maleherbia multiflora	(-) F	-	ah	Zephyra elegans	++ F	(-)	ph
Malvaceae							
Cristaria molinae	++ F	-	ph				
				Total species	45	24	

GT = growth type, t = tree, sh = shrub, sbsh = subshrub, ph = perennial herb, ah = annual herb, F = flowering
+++ very abundant, ++ abundant, + scarce, (-) rare, - absent

Table 2

Number of Plants Species, according to the growth type, present during “El Niño” and “La Niña” at Alto Patache Fog- Site.

Growth type	El Niño	La Niña	% species	La Niña	% species
Trees, Shrubs, Subshrubs	9	9	100	9	100
perennial Herbs	19	11*	57.9	1	5.3
Total perennial Plants	28	20	71.4	10	35.7
Total annual Herbs	17	4**	23.5	0	0
Total species	45	24	53.3	10	22.2

* Weak growth of perennials bulbs; no more than one or two individuals by Species, except among **Alstroemeria**

** Very weak growth of annual Herbs; no more than one or two individuals by Species were present.

4. COMMENTS AND SUGGESTIONS

4.1. Authors having recently written on Coastal Desert Flora of Peru and northern Chile, usually have ignored or not considered the existence of a significant vegetal cover at the Northern Chilean Fog-oasis, and refer consequently to the complete absence of vegetation, been observed between Tocopilla in northern Chile, and South Peruvian Coast. As an example, Rundel and Dillon, (1998) explicitly affirm in their last Paper on the topic: “no Lomas formation rich in species is present in the hyperarid coast near Iquique”. This drastic assertion is no longer sustainable after our findings near and south of Iquique, on the occasion of rainy “El Niño” Events observed by us in 1992 and 1997, as has been explained in Pinto 1999, and recently, in Muñoz et al (in press). The great number of Species, Genera and Families detected by us in the area of Alto Patache, fully justifies our pretention on the necessity of studying this peculiar type of Coastal Flora, present in very isolated and ignored spots, South of Iquique. The more isolated and area restricted, , the more interesting from a botanical and ecological point of view.

4.2. Careful observation on Plant behaviour at Alto Patache Fog-Oasis, along the last three years, have confirmed us on the evident Plant preferences for determinate geomorphological habitats. So far, we can distinguish at least four :

a) The sandy slopes, from 300-700 m high, with dominance of certain Herbs such as Nolanaceae and Liliaceae (**Nolana jaffuelli** and **Leucocoryne** respectively).

b) The Upper section of the rocky Cliff, between 700 and 800 m high, provided with an abundant community of Lichens, presence of Shrubs and Cacti (**Lycium, Ephedra, Frankenia Opuntia, Eulychnia**, respectively), presence of perennial Herbs like **Alstroemeria**, and exceptionally, a few stocks of Adiantaceae and Gramineae. Here the presence of a strong effusion of granite like rock promontories

descending down the slopes, seems to be definitory.

c) A level plain (pampa), covering several hectars of sand at about 800 m high, East of the cliff ridge, where **Nolana, Cristaria, Hoffmannseggia, Fortunatia** and **Leucocoryne** prosper in rainy years.

d) Higher hillock elevations up to the 900 m where only scattered herbs (like **Nolana** species) are to be seen. Behind this hilly section, total desert begins, extending to the East.

4.3. In the course of three and a half years studying the Fog area at Alto Patache, we have detected a slow but increasing dying process of some Plant species, still growing at the upper section of the mountain cliff. The following are our observations:

a) Out of the many hundreds Individuals of **Lycium leiostemum**, present in the area, very few of them are still alive. Most of them (over 90%) are already dead since decades, and therefore, completely covered by different Species of Lichens. The very few still surviving exemplars, are those exceptionally located at the best irrigated spots, among the rock’s crevices, where they still get some moisture from Fog.

b) Very few stands of *Stipa* (Gramineae), are to be found still, and only at a tiny section of the upper cliff, in Northern Promontory, directly affected by Fog.

c) A few Plants of the fern **Cheilanthes mollis** (Pteridophytae), survive still at the same place, grasping to the rock crevices facing South. They have been only observed at this spot.

d) A few Cacti of the species **Eulychnia iquiquensis** are alive; many other around, in descending slopes, appear to be completely dead. Among them, only one exemplar has been observed flowering and seeding in 1997 and 2000.

e) These facts, collected in our field studies, come to prove, in our opinion, the hypothesis that the growing Dissection Process in the area, no only increases, year after year, but will certainly carry several Plant Species to total extinction in this Fog

Oasis, in a very near future, unless a violent change in local Climate conditions appear.

5. CONCLUSIONS

5.1. The presence of a huge Plant cover, extending many hectares of coastal cliffs and slopes, during “El Niño” Event of 1997, justifies the importance of this Fog-Oasis from a botanical point of view, and proves that An important number of Plants (45 Species) have been recorded for the area of Alto Patache, South of Iquique, increasing our scientific knowledge of the area,

5.2.1. Important sections of Northern Coastal Chile have not yet been sufficiently studied by botanists. Assertions made by recent authors concerning the non existence of “Lomas” formations in this part of Northern Chile, have to be reviewed.

5.2.2. Strong proofs of an increasing Dissection Process affecting the area, have been here afforded, confirming the hypothesis that the Fog- Oasis of Northern Chile constitute botanical and biological relictual areas, meriting our protection and thorough ecological studies in the future.

6. REFERENCES

- Cereceda, P., et al, 1999: El factor clima y la floración del desierto en los años El Niño 1991 y 1997. *XX Congreso Nacional de Geografía Chillán*, octubre de 1999
- Cereceda, P., et al, 1998: Colecta de agua en Alto Patache-Iquique y su potencial de aprovechamiento. *XIX Congreso Nacional de Geografía Valparaíso*, Octubre de 1998
- Cereceda, P., et al, 1998: Evaluation of the use of fog water for regeneration of arid ecosystems. *First International Conference on Fog and Fog Collection*, Vancouver, July 1998
- Dillon, M. and P. Rundel, 1990: The botanical response of the atacama and peruvian desert floras to the 1982-83 El Niño event. *Global Ecological*

Consequences of the 1982-83 El Niño-Southern Oscillation. Elsevier Oceanography Series, Edited by P.W. Glynn, 487-504.

Jiménez P., et al, 1998: Southern Peru Loma's Flora. *First Conference on Fog and Fog Collection*, Vancouver, Canada, 481-484.

Masuzawa T., 1986: In Ono, M., (Ed): Taxonomic and ecological studies on the Lomas vegetation in the Pacific coast of Peru, pp 79-88. Tokyo: Makino Herbarium, Tokyo Metropolitan University.

Muñoz, M., et al.: “Oasis de niebla “ en los cerros costeros del sur de Iquique (norte de Chile) durante el evento Niño 1997-98: diversidad y relaciones florísticas. *Revista Chilena de Historia Natural* (in press)

Péfour, J.E., 1978: Composition and structure of communities in the Lomas of Southern Peru. PhD. Thesis, Kansas University, 215 p.

Péfour, J., 1982: Dynamics of plants communities in the Lomas southern Peru. *Vegetario* 49:163-171.

Pinto R., 1999. Oasis de niebla El Niño 1997, una expedición botánica a los cerros costeros del sur de Iquique. Imprenta Ograma Ltda. Santiago, 99 pp

Rundel, P. and M. Mahu, 1976: Community Structure and Diversity in a Coastal Fog Desert in Northern Chile. *Flora*, Bd. 165, S. 493-505.

Rundel, P. et al, 1991: The Phytogeography and Ecology of the Coastal Atacama and Peruvian Deserts. *Aliso* 13(1): 1-49.

Rundel. P. et al, 1997: Tillandsia landbeckii in the Coastal Atacama Desert of Northern Chile. *Revista Chilena de Historia Natural*. 70 :341-349.

Rundel, P. and M Dillon, 1998. Ecological patterns in the Bromeliaceae of the lomas formations of coastal Chile and Peru. *Plants Systematics and Evolution*, 212:261-278.

Sielfeld, W. et al., 1995: Información Preliminar sobre los Oasis de Niebla de la Costa de la Primera Región de Tarapacá. Universidad Arturo Prat, *Programa de Recursos Hídricos Naturales Renovables*, Iquique 56 pp