Zeitschrift: Candollea : journal international de botanique systématique = international journal of systematic botany

Herausgeber: Conservatoire et Jardin botaniques de la Ville de Genève

Band: 52 (1997)

Heft: 2

Artikel: The Puna vegetation in the valley of Rio Cazaderos, Catamarca Province, Argentina

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DOI: https://doi.org/10.5169/seals-879451

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The Puna vegetation in the valley of Rio Cazaderos, Catamarca Province, Argentina

EDUARDO MARTINEZ CARRETERO

ABSTRACT

MARTINEZ CARRETERO, E. (1997). The Puna vegetation in the valley of Rio Cazaderos, Catamarca Provine, Argentina. *Candollea* 52: 497-508. In English, English and Spanish abstracts.

The Puna vegetation in the valley of Río Cazaderos, Catamarca, Argentina, between 3600-4300 m s.m., was studied from the phytosociological point of view. Fifty-five floristic relevés following the Braun-Blanquet method were made and arranged in a table. The floristical relevés include xeric and wetland vegetation. Two altitudinal-vegetational zones are proposed: a lower elevation shrub zone, between 3600-3800 m s.m., dominated by the *Acantholippia punensis* community, with *A. punensis, Chuquiraga atacamensis, Lycium chañar*, etc., and a higher elevation zone, between 3800-4100 m s.m., characterized by the *Stipa chrysophylla* community, with *S. chrysophylla, Adesmia subterranea, Fabiana bryoides*, etc. The latter community shows a large spatial distribution from the southern parts of Bolivia to the provinces of Catamarca and, possibly, La Rioja, in Argentina. The maximum floristic diversity occurs in wetlands, where vegetational belts appear, composed of different plant communities, following a soil moisture gradient. The principal plant communities are: the *Carex gayana* community in deep, freshwater saturated soils; the *Oxychloe andina* community, above 4100 m s.m., near open and moving water; and the *Ranunculus mandonianus* community in wetlands with very shallow soils, saturated with fast-moving water. Other communities are present but limited in their distribution to specific edaphic conditions, such as the psammophilous *Lampaya hieronymi* community (3800-3900 m s.m.) in sandy places (sand accumulated by the wind); or the *Distichlis scoparia* community on saline soils where the water table is over 2 m below the surface. From our data we propose the hypothesis that plant dynamism in the wetlands is currently related to the effects of diminishing rainfalls on the hydrical regime. We also suggest existence of new taxonomic units for Argentina, some of which were already suspected. From the *Calamagrostietea vicunarum* Rivas Martinez & Tovar, 1982, the following communities are present in the area: *Lobivio ferocis-Fabianion densae* Ruthsatz, 1993; *Urbanio pappigerae-Stipion frigidae* G. Navarro, 1993; *Puccinellio oresigenae-Oxychloetum andinae* G. Navarro, 1993.

RESUMEN

MARTINEZ CARRETERO, E. (1997). La vegetación puneña en el valle del Río Cazaderos, Catamarca, Argentina. *Candollea* 52: 497-508. En inglés, resúmenes en inglés y español.

Se estudia fitosociológicamente la vegetación puneña del valle del Río Cazaderos, Catamarca, comprendida entre los 3600-4300 m s.m. Cincuenta y cinco relevamientos florísticos fueron efectuados según el método de Braun-Blanquet y ordenados en una tabla de acuerdo al gradiente de xericidad. Dos zonas altitudinales de vegetación se proponen: una zona inferior, arbustiva, entre 3600-3800 m s.m., dominada por la comunidad de *Acantholippia punensis,* con *A. punensis, Chuquiraga atacamensis, Lycium chañar,* etc., y otra zona a mayor elevación, entre 3800-4100 m s.m., caracterizada por la comunidad de *Stipa chrysophylla,* con *S. chrysophylla, Adesmia subterranea, Fabiana bryoides,* etc. Esta última comunidad muestra una extensa distribución espacial desde el sur de Bolivia hasta la provincia de Catamara y, posiblemente, de La Rioja en Argentina. La máxima diversidad florística ocurre en las vegas, donde los cinturones de vegetación, constituyendo diferentes comunidades vegetales, siguen un gradiente de humedad del suelo. Las principales comunidades vegetales son: la comunidad de *Carex gayana* en suelos profundos saturados de agua, la comunidad de *Oxychloe andina,* sobre los 4100 m s.m., en contacto con agua libre en movimiento, y la comunidad de *Ranunculus mandonianus* en vegas con suelos muy superficiales, saturados con agua en rápido movimiento. Otras comunidades están presentes pero limitadas en su distribución por condiciones edáficas específicas, tales como la comunidad de *Lampaya medi-*

CODEN: CNDLAR
52(2) 497 (1997)
ISSN: 0373-2967

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cinalis (3800-3900 m s.m.) en lugares arenosos (arena acumulada por el viento), o la comunidad de *Dystichlis scoparia* en suelos salinos donde el agua freática supera los 2 m de profundidad. A partir de nuestros datos se propone una hipotésis del dinamismo vegetal en vegas, estrechamente relacionado con los efectos de la disminución de las lluvias sobre el régimen híbrico. Se sugiere además la existencia de nuevas unidades sintaxonómicas para la Argentina, algunas de la scuales se sospechaba su presencia. De los *Calamagrostietea vicunarum* Rivas Martinez y Tovar, 1982, las siguientes comunidades están presentes en el area: *Lobivio ferocis-Fabianion densae* Ruthsatz, 1993; *Urbanio pappigerae-Stipion frigidae* G. Navarro, 1993; *Puccinellio oresigenae-Oxychloetum andinae* G. Navarro, 1993.

KEY-WORDS: Puna – Vegetation – Dynamismus.

Introduction

There are only a few studies on the Puna vegetation in the Province of Catamarca. VERVOORST (1951) suggested the following zonation for the Puna vegetation in the area of Salinas de Laguna Verde, south of the Río Cazadero valley: a shrubby steppe between 3500-3800 m s.m. and a grassy steppe between 3800-4300 m s.m. For CABRERA (1957, 1968, 1976) and CABRERA & WILLING (1973), the Puna extends to the south through the mountains of the provinces of Catamarca and La Rioja between 3000-3700 m s.m. HUNZIKER's work (1952) in northern La Rioja describes the distribution of the Puna area on the border of both provinces. Following MARTINEZ CARRETERO (1995) this area would be included in the so called Distrito Jujeño (Jujeño district). From the geological point of view the Puna boundary lies between Antofagasta (Chile) and the Sierra de Quilmes, Las Cuevas and the Cordillera de San Buenaventura, in the Catamarca Province (TURNER & MENDEZ, 1979; ALLMENDIGER, 1986). It is stratigraphically characterized by Cenozoic volcanic units (TURNER & MENDEZ, 1979). The oldest units are mainly silicious volcanics and the youngest are andesitic strata overlying the Quaternary deposits constituted by tuffa and alluvial deposits. The Holocene deposits are mostly composed of sand and clay, generally reworked by floods and presently covered by sand dunes. Using an ESE-NW transect Fiambalá-C° Nacimiento, the following formations could be found: the Formación La Planchada to the west with Palaeozoic volcanic, andesitic rocks, followed by crystalline granitic Precambrian rocks, and finally Tertiary sediments from the upper Pliocene in the east (ALBA, 1979).

The entire area is markedly arid: Fiambalá, 1400 m s.m., receives 137 mm mean annual precipitation and Antofagasta de la Sierra (3400 m s.m.) 105 mm mean annual precipitation (Table 1). Aridity increases to the west, with only 62 mm of rain per year and a mean annual temperature of 6.8°C in Ollagüe (Chile).

Soils above 3900 m s.m. generally show freezing processes such as slope stripes (structural soil), gelifluction lobes, etc. CZAJKA (1951) found evidence of structural soil associated with stripes in Laguna Verde. In winter, frosts occur practically throughout all day, whereas in summer they only occur at dawn, when dew freezes affecting only the soil surface, mainly in wetlands. IGARZABAL (1984) found a daily freeze-thaw depth of 10-15 cm in bogs located above 4000 m s.m., in the Sierra de Sta. Victoria, Salta Province. In these bogs, permafrost can reach 3 m depth.

Materials and Methods

In the area studied between Cazadero Grande, at 3400 m s.m., 27°24' SL-68°10' WL, and the spurs of the Cerros Nacimiento and Aguas Calientes, at 4250 m s.m., 27°16' SL-68°30' WL (Fig. 1), 55 phytosociological surveys were carried out. The results are arranged in Table 2. In bogs along the rivers Nacimiento and Aguas Calientes as well as on the slopes, 1 m^2 squares were cut 2 cm onto the soil, the thickness grazed by the camelid fauna, to determine the nutritional values of those samples (Table 3).

Fig. 1. General location of the study area.

	Tm c	Tm f	Ppm	Ppm c	Ppm f
Fiambalá	21,7	9,1	137	100	5
A. de la Sierra	12,0	4,4	105	75	6

Table 1. – Climatic data (according to DE FINA & al., 1959; 1941-50 Period). **Tm c:** mean temperature of the warmest month; **Tm f:** mean temperature of the coldest month; **Ppm:** mean annual precipitation; **Ppm c:** mean precipitation of the warmest three month period; **Ppm f:** mean precipitation of the coldest three month period.

Results

Plant communities

The analysis of Table 2 permits to establish the following plant communities in the study area:

1. Acantholippia punensis community (3600-3800 m s.m.).

This community reaches approximately 3800 m s.m., from the extensive Cazaderos Grande alluvial cone, to the W. It is a low shrub vegetation, 0.4-0.5 m high, and very open with a 25-30% mean cover. It is widely distributed on sandy, loess soils. Characteristic shrubs are *Lycium*

Permafrost lower boundary (between community 4 and community 5)

Altitudinal zone	1° veg.belt						2° veg.belt							
							Zonal communities							
Relev. n°	1	3	46	48	49	47	7	8	9	11	12	15	14	13
Exp.	NE	N	N	N	S	N	SE	SE	SE	NW	N	E	N	NE
Slope (degrees)	25	45	40	15	15	15	45	19	10	15	10	10	50	30
Height (1=100)	36	36	38	37	37	37	41	41	41	41	41	41	40	40
Community n°	1						2							
Acantholippia punensis	11	21	21	21										
Lycium chanar	21	11				11								
Ephedra chilensis	11	+	+	11	11	21								
Fabiana punensis	21													
Chuquiraga acanthophylla	11	11		+		21								
Maihueniopsis ovata	+2						+2							+
Acantholippia punensis	11	21	21	21										
Cristaria andicola							+2	11	+2	+		+	+	+
Adesmia subterranea		1					+2			11		22		
Stipa af. chrysophylla					+2	11	22	+	22	22		22		
Stipa speciosa var. breviglumis							11	+	11	+	+	+2		
Nardophyllum armatum							+		+2		21			
Hoffmannseggia af. eremophylla							+							
Adesmia nanolignea						+2	+				+			
Ephedra breana							+							
Junellia seriphioides									+					
Mulinum ulicinum														
Nicotiana petunioides										+			11	11
Cistanthe picta														+
Ipomopsis gossypifera														11
Phacelia setigera var. humahuaquensis														
Chenopodium cf. frigidum														+
Pachylaena atriplicifolia													+	
Stipa frigida			+											
Fabiana bryoides														
Adesmia erinacea														
Ephedra rupestris														
Lampaya hieronymii			+		+2									
Adesmia horrida			11								11			
Distichlis scoparia var. erinacea														
Crassulaceae														
Triglochin concinna														
Scirpus nevadensis var. remireoides														

Altitudinal zone	2° veg.belt													
	Zonal communities										Azonal communities			
Relev. n°	19	39	40	38	2	42	43	5	6	10	44	45	23	50
Exp.	S	SW	E	SW	NE	N	N	NE	NE	N	E	E	E	N
Slope (degrees)	40	30	40	15	15	25	25	10	10	30	10	5	10	17
Height (1=100)	42	42	42	41	36	39	39	39	39	40	40	39	40	38
Community n°	3				4						5			
Acantholippia punensis					+2									
Lycium chanar		(+)			+									
Ephedra chilensis					+									
Fabiana punensis		(+)			12									
Chuquiraga acanthophylla														
Maihueniopsis ovata			+3											
Acantholippia punensis					+2									
Cristaria andicola		+		+2	+	+		+			+			
Adesmia subterranea	+2		11	+		1	1							
Stipa af. chrysophylla					+									
Stipa speciosa var. breviglumis	+													
Nardophyllum armatum														
Hoffmannseggia af. eremophylla														
Adesmia nanolignea														
Ephedra breana														
Junellia seriphioides														
Mulinum ulicinum		+2			+									
Nicotiana petunioides							+				+			
Cistanthe picta														
Ipomopsis gossypifera														
Phacelia setigera var. humahuaquensis					+									
Chenopodium cf. frigidum														
Pachylaena atriplicifolia														
Stipa frigida	31	22	22	32		+							+	
Fabiana bryoides		11	11											
Adesmia erinacea		11	+	11										
Ephedra rupestris		13	+											
Lampaya hieronymii					22	22	22	43	12	22				
Adesmia horrida					+	22	11				11			
Distichlis scoparia var. erinacea											32	33	22	12
Crassulaceae												22		
Triglochin concinna												22		11
Scirpus nevadensis var. remireoides											12			

Altitudinal zone	2° veg.belt																										
	Azonal communities																										
Relev. n°	4	16	21	51	31	36	28	24	27	30	25	29	32	26'	26	35'	35	17	33	34	52	37	41	30'	18	20	22
Exp.	N	E	SE	E	E	SW	E	E	E	E	E	E	E	E	E	E	E	E	W	W	SW	SW	SW	E	E	SE	E
Slope (degrees)	15	15	50	15	15	15	15	10	20	15	10	10	20	15	15	20	20	15	10	25	25	30	20	20	15	40	40
Height (1=100)	36	40	43	40	40	40	40	41	41	41	41	41	41	41	41	40	40	41	40	40	41	40	42	41	41	43	43
Community n°	6								7					8				9									
Acantholippia punensis																											
Lycium chanar																											
Ephedra chilensis																											
Fabiana punensis																											
Chuquiraga acanthophylla																											
Maihueniopsis ovata																											
Acantholippia punensis																											
Cristaria andicola																											
Adesmia subterranea																											
Stipa af. chrysophylla																											
Stipa speciosa var. breviglumis																											
Nardophyllum armatum																											
Hoffmannseggia af. eremophylla																											
Adesmia nanolignea																											
Ephedra breana																											
Junellia seriphioides																											
Mulinum ulicinum																											
Nicotiana petunioides																											
Cistanthe picta																											
Ipomopsis gossypifera																											
Phacelia setigera var. humahuaquensis																											
Chenopodium cf. frigidum																											
Pachylaena atriplicifolia																											
Stipa frigida					+																					+	+
Fabiana bryoides																										+	+2
Adesmia erinacea																											+
Ephedra rupestris																											
Lampaya hieronymii																											
Adesmia horrida			+																								
Distichlis scoparia var. erinacea																											
Crassulaceae																											
Triglochin concinna																											
Scirpus nevadensis var. remireoides																											

Festuca af. argentinensis																							55	55																									
Calamagrostis sp.																							44																										
Juncus lesueurii																							45												+2														
Hordeum comosum																								11																									
Calandrinia compacta																								+3																									
Festuca orthophylla												11													22	11	33	44	42	22	+																	+	
Adesmia af. arenicola																									+																								
Poa sp.																														12				+															
Deyeuxia eminens var. fulva																													11																				
Deyeuxia curvula																												32	11	+	+2																		
Carex gayana																													13	33	33	55	22	55	55	22													
Deyeuxia velutina																										+	+		32			11			32	+													
Eleocharis geniculata																																	43	22		22		11				42							
Festuca acanthophylla																											12							22	11														
Oxychloe andina																																			13	55	23	44											
Scirpus atacamensis																													13							12		33											
Deyeuxia chrysophylla																												11	+2									32											
Chara sp.																																					14												
Algae																																					23												
Scirpus deserticola																																					33												
Oxychloe af. simulans																																					13												
Catabrosa werdermannii																																							33	23									
Ranunculus cymbalaria f. exilis																																							+2	+3									
Mimulus glabratus																																								11									
Hypsela reniformis																																							+4										
Lilaeopsis andina var. microcarpa																																							+4										
Lemna af. gibba																																							+3										
Bryophyta																																					11		34										
Ranunculus mandonianus																													+2						+			12			54	43	22	+2					
Deyeuxia eminens																								22			11	32	+2				+	21							43	32	12	22	44				
Puccinellia oresigena																																			+3				+		+	32		33	12				
Hepaticae																																							33		+3	22	+2						
Potamogeton strictus																																					22		12		12								
Scirpus acaulis																																													13				
Potamogeton af. pectinatus																																														22			
Eleocharis dombeyana																																														11			
Myriophyllum brasiliense																																															12		
Senecio santelicis																																																+	+
Phacelia setigera var. setigera																																																+	+
Cajophora coronata																																																	+

Table 2. – Synopsis of plant communities.
Community of: **1**, *Acantholippia punensis;* **2**, *Stipa chrysophylla;* **3**, *Stipa frigida;* **4**, *Lampaya hieronymii;* **5**, *Distichlis scoparia;* **6**, *Festuca orthophylla;* **7**, *Carex gayana;* **8**, *Oxychloe andina;* **9**, *Ranunculus mandonianus.* Values of abundance-dominance are: r: < 5% veg. cob.; +: 5-10%; 1: 10-20%; 2: 20-40%; 3: 40-60%; 4: 60-80%; 5: > 80%.

chañar, Acantholippia punensis, Chuquiraga acanthophylla, among others, and *Stipa chrysophylla* and *Maihueniopsis ovata* characterize the herbaceous layer.

VERVOOST (1951) distinguished this community as one of the altitudinal zones of the Puna shrub steppe. Several taxa such as *Ch. acanthophylla, L. chañar*, etc. are also characteristic of the *Lobivio ferocis-Fabianion densae* alliance Ruthsatz, 1993 (NAVARRO, 1993) which comprises this community. It constitutes a plant community on rocky slopes between 3500-3900 m s.m. that extends from south-western Bolivia through north-western Argentina and appears to reach the La Rioja Province judging from HUNZIKER's floristic lists (1952). It shows a species impoverishment towards the south and the west.

*2. **Stipa chrysophylla*** community (3800-4100 m s.m.).

This gramineae-dominated community, has a mean cover of 20-30% with a scanty dwarf-shrub vegetation (pulvinate chamaephytes) or with Chamaephytes up to 0.4 m high. It constitutes a very extensive community, from the southern Bolivian Altiplano (NAVARRO, 1993) to Catamarca and, possibly, La Rioja provinces, between 4100-3800 m s.m. in the southern reaches of its distribution. Some of the elements of this community are included in the alliance *Urbanio pappigerae-Stipion frigidae* G. Navarro, 1993, characterized by *Stipa chrysophylla, Adesmia subterranea, Fabiana bryoides, Hoffmannseggia eremophylla*, etc. Among others, there are also *Nardophyllum armatum, Stipa speciosa* var. *breviglumis, Mulinum ulicinum* and *Stipa frigida.*

Facies of *Nicotiana petunioides:* this community occupies old alluvial cones at 4000 m s.m. and have a groundwater table at approximately 2-2.5 m in depth. *Adesmia subterranea* is the only woody species present. However, approximately 30% of the *Adesmia* plants are dead. This is perhaps due to the lowering of the groundwater table, possibly related to a dry cycle of 3-4 years with little contribution from snow. In these sectors, there is severe soil removal by burrowing rodents (*Ctenomys* sp.) which produces a plant facies of *Nicotiana petunioides*, accompanied by *Calandrinia picta, Ipomopsis gossypifera, Phacelia setigera* var. *humahuaquensis, Cristaria andicola.*

*3. **Stipa frigida*** community (>4000 m s.m.).

This is a microthermic, psammophyllous, gramineous plant community with a 40-50% cover, dominated by *Stipa frigida*, that extends across SSW exposed slopes, over basaltic soils with rocks of different sizes in a sandy matrix. *Fabiana bryoides, Adesmia erinacea* and *Ephedra rupestris* characterize the community above 4000 m s.m. This community extends through the Chilean Puna at similar elevation and on similar soil types (LAILHACAR, 1992).

Azonal communities

*4. **Lampaya hieronymi*** community (3800-3900 m s.m.).

Lampaya hieronymi and *Adesmia horrida* characterize the base of north-facing slopes where the wind deposits sand, as well as sandy plains. This community is vicariant to the association *Acantholippio salsoloidis-Lampayetum castellanii* G. Navarro, 1993 in Bolivia and probably also in Jujuy (RUTHSATZ, 1977). Between 3800-3900 m s.m. above the Cazadero river, in drier sectors, *L. hieronymi* behaves as a colonizer, maintaining the population through shoots.

*5. **Distichlis scoparia*** saline soils community

This community generally occupies soils close to wetlands and small endorreic basins, in contact with xeric vegetation. The soils are more or less deep, disperse, covered by saline efflo-

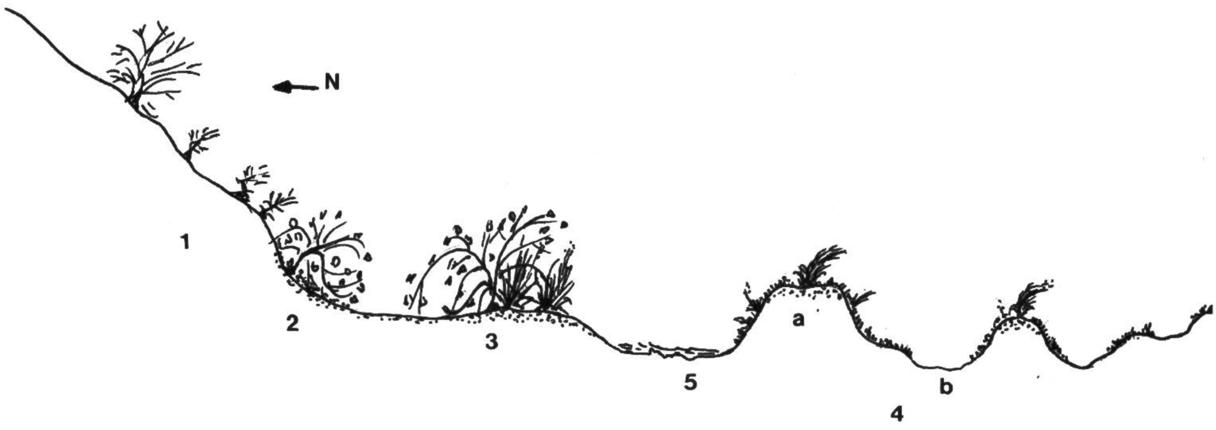

Fig. 2. – Wetland profil and wetland occupied by eolic sands:
1. N exposed slope with *Ephedra americana* and *Acantholippia punensis;* **2.** *Lampaya hieronymi;* **3.** *L. hieronymi* and *Festuca orthophylla;* **4.** wetland with cryogenic small domes (a) and depressions (b); **5.** River.

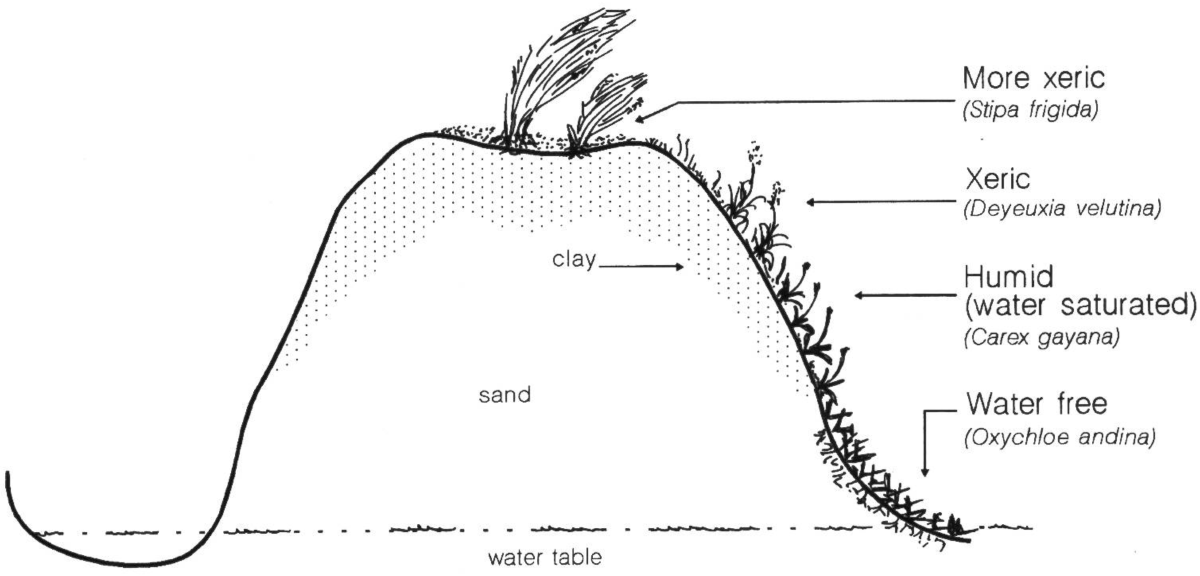

Fig. 3. – Cryogenic dome profil, with different xericity levels.

Community	*C. gayana*	*R.mandonianus*	*S. chrysophylla*
N total	0,81	1,04	0,45
Prot. total	5,07	6,48	3,06
Ashs (%)	24,53	71,80	6,44
Ca (%)	1,55	8,38	0,16
Mg (%)	0,33	0,66	0,06
P (%)	0,07	0,14	1,76
Greases (%)	4,26	1,76	2,46
Fibers (%)	35,19	10,42	39,05

Table 3. – Nutritional value for three Puna communities (mean values of dried matter of 4 repetitions).

rescences where the water table is between 1.2-1.5 m deep. This community is characterized by *Distichlis scoparia* var. *erinacea*, the dominant species, accompanied by *Triglochin concinna, Scirpus nevadensis* var. *remireoides,* etc.

In Catamarca this community is vicariant to the association of *Distichlion humilis-Anthobryetea triandri* G. Navarro, 1993, that reaches its southeastern and southwestern limits in southwestern Bolivia, northeastern Chile and northwestern Argentina (NAVARRO, 1993).

Wetland Communities

These communities have the highest floristic richness. They generally are dominated by grasses on water-saturated soils. The studied wetlands appear to belong to the minerotrophic type (SJÖRZ, 1959; IGARZABAL, 1984). Related to the dynamics of the river, vegetation zones are clearly differentiated according to their response to different degrees of water stress (Fig. 2).

*6. **Festuca orthophylla*** community

This plant community constitutes a vegetation zone on drier soils. Where wind accumulates sand between the *Festuca* tufts, xeric elements of the *Stipa frigida* community appear. This community has a mean cover of 60-70% and a height of 0.6 m.

Deyeuxia curvula and *D. eminens* var. *fulva* are also present in the community.

*7. **Carex gayana*** community

This plant community develops on deep soils (> 1 m), which are alkaline, water-saturated and very rich in organic matter (Table 3). *Carex gayana, Eleocharis geniculata, Deyeuxia velutina* and *Festuca desvauxii* prevail among others.

In this community, the presence of small cryogenic domes up to 0.4 m high is common, where fines textures prevail toward the surface. These formations characterize the drier sectors within the zone of water-saturated soils, where elements of xeric communities penetrate (Fig. 3).

Comparing this community with the *Ranunculus mandonianus* wetland, the lower values of Mg, Ca and P would be due to the differential partitioning of the assimilates between the aboveground and the belowground portion, and would also be due to the aboveground parts being submitted to grazing. The migration of those elements would respond to environmental conditions such as surface freezing, persistent cold winds, and continuous grazing. These environmental conditions would also explain the high fiber and lipid content as a plant response to mechanical pressure because of the freezing of the surface soils. According to RUTHSATZ (1978), the Cyperaceae dominance in these wetlands would partly be caused by the abundant adventitious roots, which allows the plants to reproduce asexually thus increasing the size of the population.

HALLOY (1983), during years of studying the high Andean wetlands in Tucumán, found no evidence of such asexual plant propagation by mechanisms such as cryoturbation. On the other hand, the abundance of roots would facilitate the absorption of the scarce nutrients such as P and N (poorly mineralized), providing a larger surface for gas exchange in a water-satured environment.

This plant community is the most heavily grazed by guanacos (*Lama guanicoe*) and llamas (*Lama glama*). *Festuca desvauxii* also occupies gelifluction lobes on shady slopes, in places where snow accumulates, giving those sectors their uneven appearance.

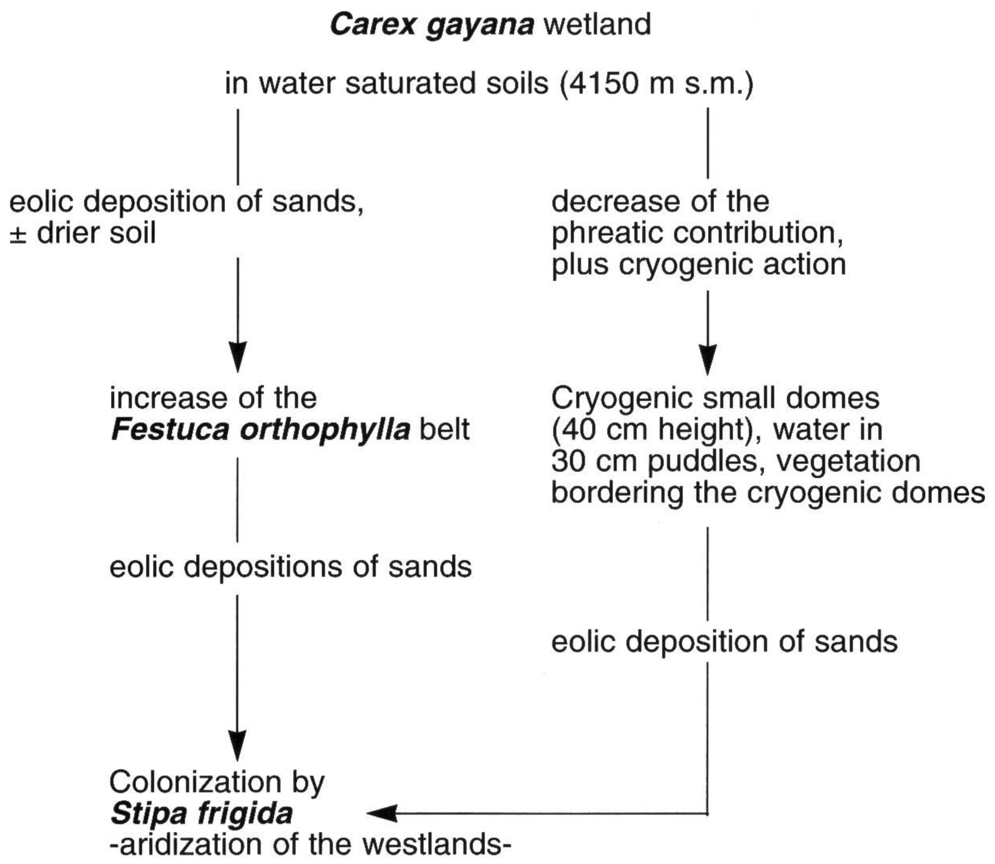

Fig. 4. – Dynamism (xerosere) in *Carex gayana* wetland.

8. Oxychloe andina community

This plant community develops as a thick and spiny dwarf shrub vegetation near running water, above 4000-4100 m s.m. It is dominated by *Oxychloe andina* with a 100% cover, accompanied by *Scirpus atacamensis, Deyeuxia chrysophylla, Scirpus deserticola, Deyeuxia* aff. *simulans* and *Hypsela reniformis*, etc. It also forms a compact, thin belt at the base of the cryogenic domes, and in wetlands of *C. gayana*, near water-filled depressions. For RUTHSATZ (1978), the dwarf shrub growth forms of *O. andina* would respond to physiological drought (caused by low temperatures) and to low nitrogen content.

9. Ranunculus mandonianus community

This community, dominated by *Ranunculus mandonianus* and *Puccinellia oresigena* with a 85-90% cover, occupies the wetlands of the Aguas Calientes creek on consolidated, horizontally bedded sandstone substrates. The roots explore a saline soil no more than 10-15 cm deep, where there is horizontal run-off even under the herbaceous layers.

Because the soil development is very poor and saturated with running water, cryoturbation processes do not occur. This would be the reason for the lower fiber and lipid values of the dominant species. The higher values in calcium and ash content are related to the substrate (calcium consolidated sandstones).

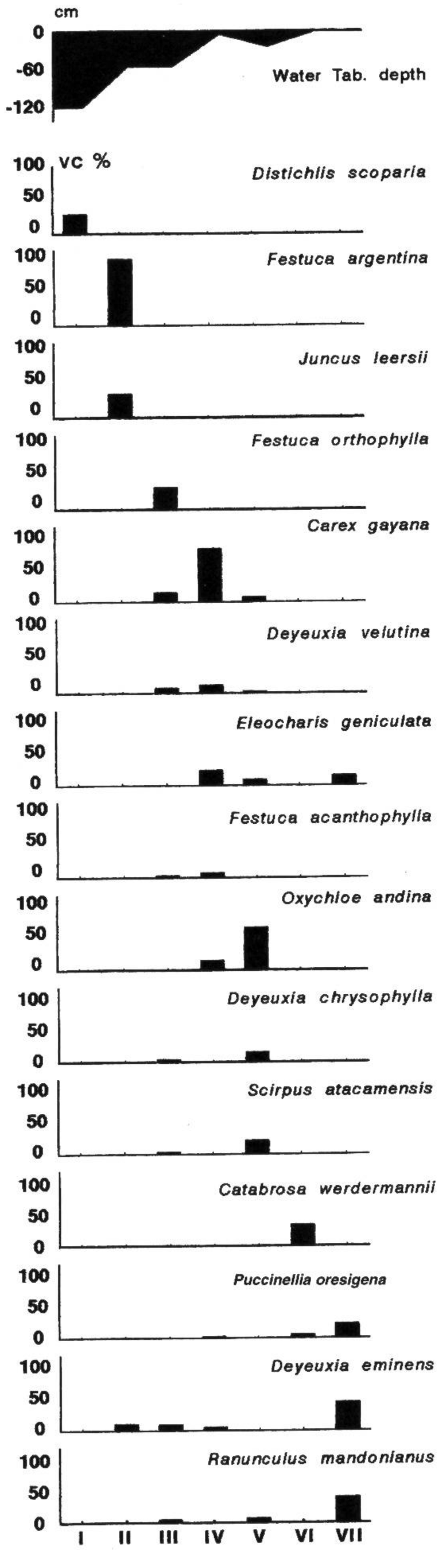

Fig. 5. – Mean percentage cover of most conspicous species from each vegetation unit of the wetland. **I:** *Distichlis scoparia* community; **II:** *Festuca argentina* community; **III:** *Festuca orthophylla* community; **IV:** *Carex gayana* community; **V:** *Oxychloe andina* community; **VI:** *Catabrosa werdermannii* community; **VII:** *Ranunculus mandonianus* community (see Table 2).

Other plant communities

In rivulets, the aquatic plant community of *Potamogeton strictus* can be found, accompanied by *Catabrosa werdermannii, Myriophyllum brasiliense, Lemna* af. *gibba* and *Ranunculus cymbalaria* f. *exilis*.

The last two communities would indicate the presence in our region of *Puccinellio oresigenae-Oxychloetum andinae* G. Navarro, 1993, described for salty lagoons above 4100 m s.m. in Bolivia.

Rock outcrops vegetation

This saxicolous plant community, characterized by *Senecio santelicis, Cajophora coronata* and *Phacelia setigera* var. *setigera*, accompanied by *Stipa frigida*, can be found on rock outcrop fissures, or on soil deposited on rock edges.

Dynamic hypothesis of wetland communities

Some wetland species tend to occupy habitats where eolic sand is deposited, acting as pioneers of subsequent more xeric stages. For example *Festuca orthophylla* installs itself on the drier, upper part of cryogenic domes produced by freezing of the community of *Carex gayana*. When the sand cover thickens, *Stipa frigida* arrives, indicating the encroachment of xeric communities over the wetland communities (Fig. 4). The same occurs with species from environments in contact with open water such as *Ranunculus mandonianus* and *Deyeuxia eminens*, that remain in small depressions where the water table is closer to the surface than in more xeric units. Fig. 5 shows the mean percentage cover of the most conspicuous taxa from each wetland vegetation unit.

Conclusion

The plant communities phytosociologically studied in the area encompassed by Cazaderos Grande valley, Aguas Calientes and Nacimiento hills, show a close floristic relationship with those from northern Salta, Jujuy and part of southern Bolivia.

The floristic data obtained in this study confirm the inclusion of this zone in the Distrito Jujeño, as it has been proposed by the author, based on the distribution of 107 Puna taxa (MARTINEZ CARRETERO, 1995). New syntaxa in Argentina are indicated, some of them were already suspected: from *Calamagrostietea vicunarum* Rivas Martinez & Tovar, 1982:

- *Lovibio ferocis-Fabianion densae* Ruthsatz, 1993,
- *Urbanio pappigerae-Stipion frigidae* G. Navarro, 1993,
- *Puccinellio oresigenae-Oxychloetum andinae* G. Navarro, 1993.

Besides, a dynamic xerosere scheme of the wetlands of the study area is proposed. A close relationship is found between plant communities and cryogenic processes. This is especially pronounced in wetlands with a moisture gradient that shows a remarkable fall from the water-saturated wetland to the cryogenic domes surface, where the species from xeric communities such as *Festuca orthophylla, Stipa frigida*, etc. colonize. It can also be pointed out that, starting from 3900-4000 m s.m., microthermal elements prevail associated with soils that indicate seasonal freezing, such as *Stipa frigida, Deyeuxia antoniana, Ephedra rupestris*, and others.

ACKNOWLEDGEMENTS

To Fidel Roig and Arturo Corte for their comments and discussion of the text, and N. Horak for reviewing the English version.

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