CONSERVATION OF HIGH ANDES FLAMINGO SPECIES (*Phoenicoparrus andinus* and *P. jamesi*): HABITAT USE AND ACTIVITY PATTERNS IN TWO CONTRASTING WETLAND SYSTEMS OF ARGENTINA.

FINAL REPORT
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SUBMITTED TO

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Island of water

Andean wetlands represent patches of water in a middle of desert landscape. We must protect this sites, not only because concentrate an limited resource like water, but their beauty too.

Summary.--- *Flamingos are gregarious birds that aggregate in enormous breeding and feeding flocks. Andean and Puna flamingos coexist in high Andes wetlands, these flamingo species are the rarest in the world and considered "Vulnerable" and "Near Threatened" by IUCN Species Survival Commission. Previous studies have focused on their spatial distribution and population sizes. Flamingo presence is associated to food availability and water quality. Their habitats are threatened by mining and water pumping. High Andean flamingos use alternatively over their life cycle, wetlands placed in Central Andes and lowland in Argentina, Bolivia, Chile and Peru. The objective of this study is to analyse habitat use and activity patterns of these species in these contrasting habitats, to understand their behaviour and ecology, which would allow us to develop actions for their conservation. In this way, two contrasting wetland system have been selected, one at 4,500 m.a.s.l. in North-western Argentina and the other at 84 m.a.s.l. in Central-east Argentina. In each site we estimated the total number of flamingos censing, by point counting on shore line, and took temperature, pH, O2 (mg/l), conductivity (Sm), and diversity and abundance of plankton measures. We recorded the behaviour of Andean flamingos, at least over 100 individuals at random, by choosing an individual within a flock and recording the time spent doing each activity (stand feeding, walk feeding, resting, grooming, walking, flight, alert, aggression, courtship) for 3 minutes, in three periods of time: early morning, noon and dusk. Andean flamingos showed similar total numbers on breeding and non breeding sites (Vilama 4,510 m.a.s.l., Melincué 3,254 m.a.s.l.). Puna flamingo was completely absent at lowland sites, with a maximum of 11,145 birds on February 2008. Activity patterns also differed between Andean and lowland sites. At the high Andean site (Vilama), flamingos used the bigger proportion of time on feeding activities (95%), at the lowland site birds showed a major diversity of activities, with only a 60% of the time used on feeding. In the lowland site, a big proportion of birds showed nuptial displays, with marches of between 32 and 225 individuals almost all the time. Physical and chemical variables differed in their average values too, with lower temperatures, and higher oxygen and conductivity in the lower site. The bigger proportion of time used in feeding activities in the high Andean site could be associated to breeding activities. We think that this courtship behaviour conditions the reproductive success of these species at the breeding colonies in the high plateau of central Andes*

Vilama

Thousands of flamingos at Vilama lake. This wetland is placed over 4,500 m in Central Andes at Northwest Argentina.

Melincué

Emerged vegetation at lake flood plains, this microhabitat is not used by flamingos, but many migrant birds, like shorebirds, use it . We are measuring water variables.

INTRODUCTION

Flamingos (Phoenicopteridae) are gregarious birds that aggregate in enormous breeding and feeding flocks (Allen 1956, Ogilvie and Ogilvie 1986). They are filter organisms, with specialist feeding mechanisms, restricted to salty and hyper salty wetlands (Zweers et al. 1995). Andean and Puna flamingos (*Phoenicoparrus andinus* and *P. jamesi*) live in wetlands at central Andes and lowlands in Argentina, and similar habitats in Bolivia, Chile, and Perú (Fjeldså and Krabbe 1990, Valqui et al. 2000). Both species are the two rarest flamingo species in the world (Rose and Scott 1994), they are considered Vulnerable and Near Threatened respectively by the IUCN Species Survival Commission, and are included in appendix I of Convention of Migratory Species (Groombridge 1994, Johnson 1995, Johnson 1996).

Flamingos are nomadic and inhabit at habitats with high seasonal fluctuation in conditions and resources (Arengo and Baldasarre 1995, Arengo and Baldasarre 1999), with a great physical and chemical heterogeneity and geomorphology (Drago and Quirós 1996, Boyle et al. 2004). Their abundances are associated with variations of water characteristics like conductivity, and density, diversity and availability of potential food items (Derlindati 1998, Arengo and Baldasarre 1999, Caziani and Derlindati 2000). High Andes flamingos use alternatively central Andes and lowland wetlands, over their annual cycle (Caziani et al. 2007), using Andean sites during breeding season (Oct-Mar) and lowland sites during non breeding-season (Apr-Sep) (Caziani et al. 2007).

Like many wetlands, high Andean and lowland sites are threatened by human activities, with a conservation priority at regional scale in South America (Caziani et al. 2001). Andean wetlands are threatened by mining, overgrazing and non regulated tourism (Caziani et al. 2001, Caziani et al. 2007), and lowland sites by agricultural and urban activities (Romano et al. 2006). Flamingos and many water birds depend on these wetlands (Hurlbert 1973 and 1979, Parada 1988a, Rocha 1997, Caziani and Derlindati 2000), understanding their responses to habitat conditions and resources variations, is useful to predict biodiversity losses associated to human activities, and to develop monitoring and management plans.

Observation tower

Structure building at Melincué to observe flamingos activities. Principal researcher at left (E. Derlindati) and an undergraduate student (F. Mohr) at work.

Previous studies in the region have focused on their spatial distribution, population sizes, habitat characteristics and conservation aspects (Carballo 1988, Derlindati 1998, Caziani and Derlindati 2000, Valqui et al. 2000, Caziani et al. 2001, Romano et al. 2002, Boyle et al. 2004, Romano et al. 2006, Caziani et al. 2007); or breeding colonies monitoring (Parada 1988b), but activity patterns and habitat use are less studied, and even less in sites located in geographical extremes of flamingo distribution, and in different periods of their annual cycle.

The main objectives of this project are to identify and analyse microhabitat characteristics associated to behaviour and distribution of two species, and to understand similarities and differences between two wetlands used in different moments of their life cycle.

The main outcomes of the project will be the understanding of the interaction of flamingo species with habitat variables and the testing of survey and monitoring techniques in High Andes and lowland wetlands. These techniques will be implemented in the Conservation and Management Proposal for the Network of High Andes Wetland and Associated Habitats for Flamingos, where our proposed sites (i.e. Vilama and Melincué) are included. The Proposal also comprises a common strategy for the four countries in order to increase the scientific knowledge on High Andes species and their habitats, and it uses standarized monitoring techniques for wetlands.

STUDY SITE AND METHODS

STUDY AREA

Study area comprise two wetlands systems sited in opposite places of high Andes flamingos annual range in Argentina (Fig. 1) and are considered key sites for flamingos conservation (Rose and Scott 1994, Wege and Long 1995, Caziani et al. 2007). Both sites are endorreic basins, hyper salty or salty. Vilama is sited in the extreme northwest of Argentina (S22º36', O66º55'; 4500 m.a.s.l.). Climate is cold and dry, high solar radiation, great daily temperature amplitudes, strong winds and low precipitations (200 to 300 mm) (Bianchi and Yañes 1992, Hong and Seggiaro 2001). Vegetation is dominated by grassing steppe *Festuca orthophylla* (Cabrera and Willink 1973), with a high proportion of uncovered soil (15%). Study site is almost inaccessible and human activities are restricted to native llamas raise associated to wetlands, and mining prospecting. Vilama is a key site for flamingo conservation, concentrating a great proportion of both species populations (Caziani et al. 2006, Caziani et al. 2007, Marconi et al. 2007). It is also considered a key area for threatened birds in the Neotropic, too (Wege and Long 1995). The other site, Melincué, is in Central-east Argentina (S33º25', O61º28'; 84m.a.s.l.). Climate is temperate and wet (Pasotti et al. 1984), annual average temperature is 16ºC, and annual precipitation is 917 mm, concentrated in austral summer-autumn (Biasatti et al. 1999). The site is in the principal agricultural zone of the country, native vegetation is grassland, dominated by *Distichlis spicata* and *Paspalum vaginatum* (Romano et al. 2006).

Both wetlands support a great water bird diversity, with a highly proportion of Neartics and Neotropical migrants (Derlindati 1998, Caziani and Derlindati 2000, Romano et al. 2002, Romano et al. 2006). Both sites are used by flamingos alternatively during their annual cycle, Andean sites during breeding season (December-March), and lowlands during non-breeding season (June - September) (Caziani et al. 2007).

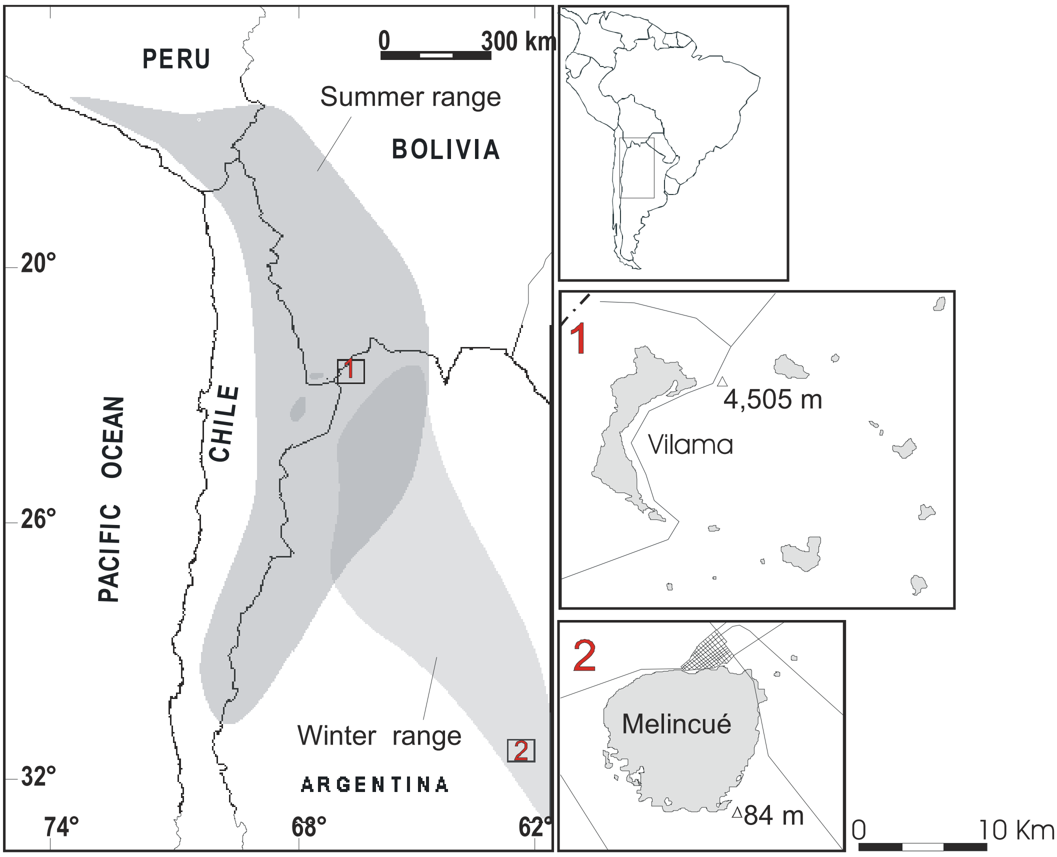


FIGURE 1. Study sites map, (1) Vilama and (2) Melincue, Northwest and Central-east Argentina. The map show seasonal ranges of both species (based on Caziani et al. 2007).

METHODS

To estimate total abundances, during every survey, we counted individuals of both flamingo species. We used the same census points during each subsequent survey. For groups of flamingos of over 4,000 individuals, we counted all individuals of each species; for groups of 4,000, we counted flamingos in blocks estimated to contain 10 or 100 individuals (Bibby et al. 1992). Each count was done by at least two people, and the average was used as the estimated abundance.

We recorded activity patterns of flamingos by choosing an individual within a flock and recording the time spent doing each activity (stand feeding, walk feeding, resting, grooming, walking, flight, alert, aggression) for 3 minutes. We repeated this process with at least 100 individuals at random in three time periods: early morning, noon and dusk (Lehner 1996). Simultaneously we recorded courtship displays, flock size and time spent on display.

In each habitat, we measured several variables: water depth, water temperature, pH, O2 (mg/l) and conductivity (Sm).

DATA ANALYSIS.

We analysed abundances variations graphically through total bird numbers. We analysed behaviour data with a Kruskal-Wallis test, a non-parametric test equivalent to ANOVA (Zar 1999), comparing mean activity patterns between two sites. Activity patterns were grouped in: Alert activities (alarm and alert), Resting activities (sleep, grooming and bath), St-W feed (all feeding activities in stamping and walking birds) and Others (fly, swim, and drink). We also evaluated the association between activity patterns and sites and micro sites grouping activities and variables with a Detrended Correspondence Analysis (DCA) with PC-Ord (McCune and Mefford 1997, Zar 1999). DCA is an eigen analysis ordination technique based on reciprocal averaging. It analyses group activities and micro sites in two dimensional planes, where closed or grouped activities show an association with microhabitat type and microhabitat grouped show similar activity patterns.

RESULTS

We conducted 5 surveys, three during breeding season at Vilama (February and April 2007, and February 2008) and two during non breeding season at Melincué (August and September 2007). Both species showed seasonal variations in abundances (Fig. 2), especially Andean flamingos. Puna flamingos were only present at the Andean site. Andean flamingo showed important numbers at summer and winter sites.

A total of 22 hours were spent observing individuals of Andean and Puna flamingos. Activities were analysed only in Andeans flamingos because this species used both sites. All activity patterns exhibited time differences between sites, feeding activities (Kruskal-Wallis chi-square approximation, $x^2 = 51.69$, df = 1, $P > 0.001$), resting activities ($x^2 = 21.93$, df = 1, $P > 0.001$), alert activities ($x^2 = 7.48$, df = 1, $P = 0.006$) and others ($x^2 = 7.09$, df = 1, $P > 0.001$). Differences of activity patterns were clearly showed by the proportional time used in each activity (Fig. 3). Activity patterns of Puna flamingos were similar to the other species (Fig. 3).

Both species showed courtship displays, Andean flamingos at the lowland site and Puna flamingos at the high Andean site (Table I).

Table II shows principal limnological variables in both sites. Only oxygen [O_2] and conductivity were different between sites.

DCA showed activities clearly associated to Vilama and Melincué microhabitats (Axis 1; Eigenvalue = 0.582). More diverse activities were associated to the microhabitat in Melincué, and walk feeding was almost exclusively associated to Vilama microhabitats.

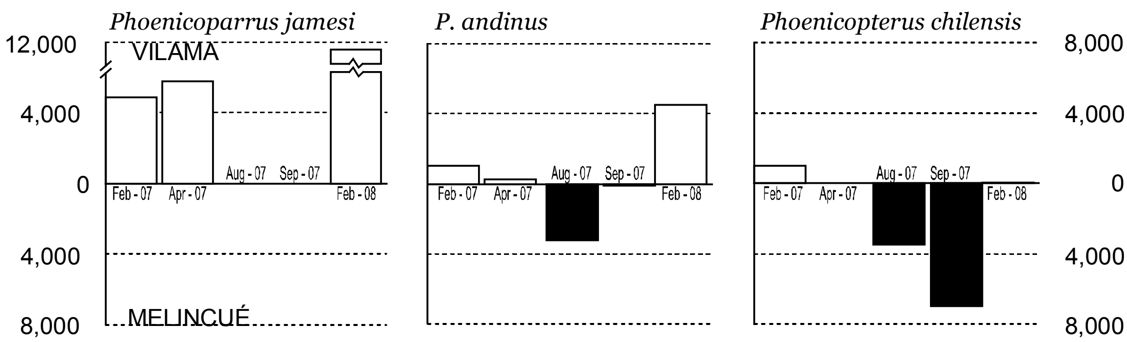


FIGURE 2. Total number of flamingos in Vilama and Melincué counted during different surveys.

TABLE II. Limnological data from Vilama and Melincué.

Site	Microhabitat*	Date	Lat.	Long.	Alt.	Prof.(cm)	TºC	pH	$[O_2]$ mg/l	mS
Melincué	MMw	Mar-07	22º38'59.5"	66º54'33.0	4512	1	15	9	36	60.4
Melincué	MSw	Oct-07	33º40'32.4"	61º24'53.1	84	5	23	9	5.5	5.93
Melincué	MDw1	Oct-07	33º40'32.4"	61º24'53.1	84	30	21	9	5	5.93
Melincué	MDW2	Oct-07	33º42'22.7"	61º24'17.9	84	25	21	9	6.2	3.6
Melincué	MSw	Ago-07	33º43'56.4	61º25'47.2"	84	6	13	10	7.5	7.25
Melincué	MSw	Oct-07	33º44'1.6"	61º30'57"	84	5	23.5	9	5.9	4.06
Melincué	MSw	Ago-07	33º44'43.2"	61º25'46.8"	84	6	15	10	7.2	6.09
Vilama	VSw1	Feb-07	22º32'24.9"	66º54'43.7"	4510	5	20	7	21	84.6
Vilama	VSw2	Feb-07	22º33'29.8"	66º55'9.8"	4500	1	17	9	21	6.08
Vilama	VSw3	Mar-07	22º34'15.2"	66º52'31.3"	4508	5	11	10	18	43.28
Vilama	VDw	Mar-07	22º36'12.8"	66º55'27.6"	4509	10	20	9	16	140.24
Vilama	VDw	Feb-08	22º36'13.7"	66º55'27.6"	4509	10	21.8	8	17	143.52
Vilama	VDw	Mar-07	22º36'14.6'	66º55'27.7"	4506	12.5	22	9	16	157.76
Vilama	VDw	Mar-07	22º36'41.1"	66º43'00.4"	4526	15	14	8	16	58
Vilama	VSw1	Feb-08	22º32'24.9"	66º54'43.7"	4510	7	26	9	8.1	2.7

*See codes in Figure 5.

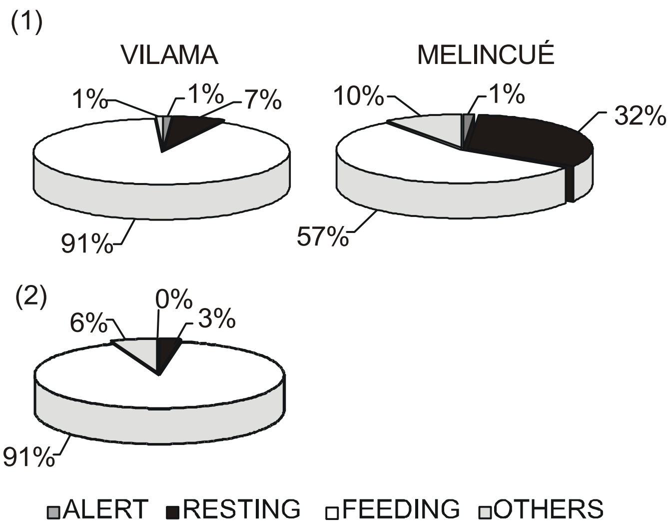


FIGURE 3. Activity patterns of (1) Andean flamingos and (2) Puna flamingos. Proportional use of time in Vilama and Melincué.

TABLE I. Maximum and minimum flock sizes and time spent on courtship displays by Andean[1] and Puna[2] flamingos.

	Time (second)	Flock size Min	Flock size Max
Andean flamingo	780	32	32
	407	80	100
	68	20	30
	1,010	70	80
	1,025	30	50
	1,050	30	40
	1,058	20	30
	600	33	40
	480	40	50
	488	30	40
	400	70	80
	1,440	80	100
	622	70	80
	990	120	130
	265	18	22
	338	200	250
	720	70	80
	336	20	30
	180	56	56
	1,800	36	36
Puna flamingo	620	15	20
	180	20	20
	200	25	30
	310	20	30

[1] Andean Flamingos only showed courtship displays (marching and head-flagging) in Melincué (August 2007).
[2] Puna Flamingos only showed courtship displays (packing) in Vilama (February 2008).

DISCUSSION

Andean and Puna flamingos showed the same seasonal variations in abundances like previous surveys in both sites (Caziani and Derlindati 2000, Romano et al. 2006, Caziani et al. 2007), with highest total abundances in August 2007 and February 2008, in Melincué and Vilama respectively. Feeding activities (i.e. stand feeding, walk feeding) was the dominant activity in both sites, but the proportional time used in each one differs between sites for Andean flamingos. Puna flamingos are only present at the Andean site, the lowland site is included in their non-breeding range (Caziani et al. 2007), but no Puna flamingos was observed in Melincué. A few individuals were seen at a near Central-Argentinean wetland, in Mar Chiquita (Ricardo Torres, com. pers.) on the same season, but main winter range concentration remains unknown (Caziani et al. 2007). Resting activities (i.e. resting, quarrelling, preening, bathing), and displaying behaviours (i.e., marching, grouping, saluting) varied inversely with feeding time. The major proportion of time used in feeding activities in the high Andes site could be associated to breeding activities in colonies near Vilama in Bolivia and Chile (Parada 1998b, Rocha 1994 and 1997, Caziani et al. 2005 and 2007). At the lowland site, energy is available to be used in prenuptial and other social behaviours, these patterns were observed in other flamingo species and waterfowls. We think that this courtship behaviour conditions the reproductive success of these species at the breeding colonies in the high plateau of central Andes, as recorded for other migratory species.

CONSERVATION RECOMMENDATIONS

The activity pool of data from Vilama and Melincué provided an initial description of activity patterns of high Andes flamingos during the breeding and non-breeding season. Habitat types show important differences in activity patterns, especially on feeding, resting and courtship behaviours. Effects of human activities are little known, and their results on flamingos could be extreme, especially at lowland sites where pumping reduces the lake size and water levels (Romano et al. 2006, Romano com. pers.). These human activities appear to decrease feeding habitats, which is important because breeding success depends on feeding intake. Certainly a major management objective should be to maintain current water levels in Melincué, where human threat is more aggressive than in Vilama, in high Andes, which could have a potentially disastrous impact on flamingo food resources. There is a need of research on feeding ecology, food production, reproductive physiology of breeding birds, and a detailed description of the hydrology of both types of wetlands. In order to understand the role of the lowland wetlands in the annual cycle of the Andean flamingo, we must monitor their abundance and record habitat use and activity patterns at this key site during the entire non-breeding period (April-September).

RECOMMENDATIONS

i. For the successful long term management and conservation of the high Andean flamingo wetland, there is a great need to develop monitoring programmes. These monitoring programmes are highly needed at lowland sites, not only in Melincué, also including other key sites like Mar Chiquita and Ambargasta/Salinas Grandes.
ii. There is a great need to include Andean and lowland sites into a network of protected areas.
iii. There is a great need to develop educational programmes to increase valuation of wetlands at different community levels (i.e. school, authorities, etc.).
iv. There is necessary more researches to determine the real relevance of lowland sites on the breeding season and the entire life cycle of flamingos, and to analyse the effect the use of wetland resources and management interventions have on the wetland site, especially those associated to productive activities like wetland drying for mining (Andes) and agricultural/urbanization (lowlands).
v. There is a great need to include local people and governmental authorities in management plans of these basins. These authorities should be responsible for monitoring changes in ecological character of these wetlands.
vi. There is a great need to explore and identify alternative incomes generating activities for farmers and local people, with lower impact on wetlands.
vii. There is a great need to introduce bird watching tours to the wetlands in order to generate more money for the management and conservation of the wetland ecosystem.

OTHER PROJECT RESULTS

Project results are included in study cases in undergraduate programmes of biology career of Salta National University.

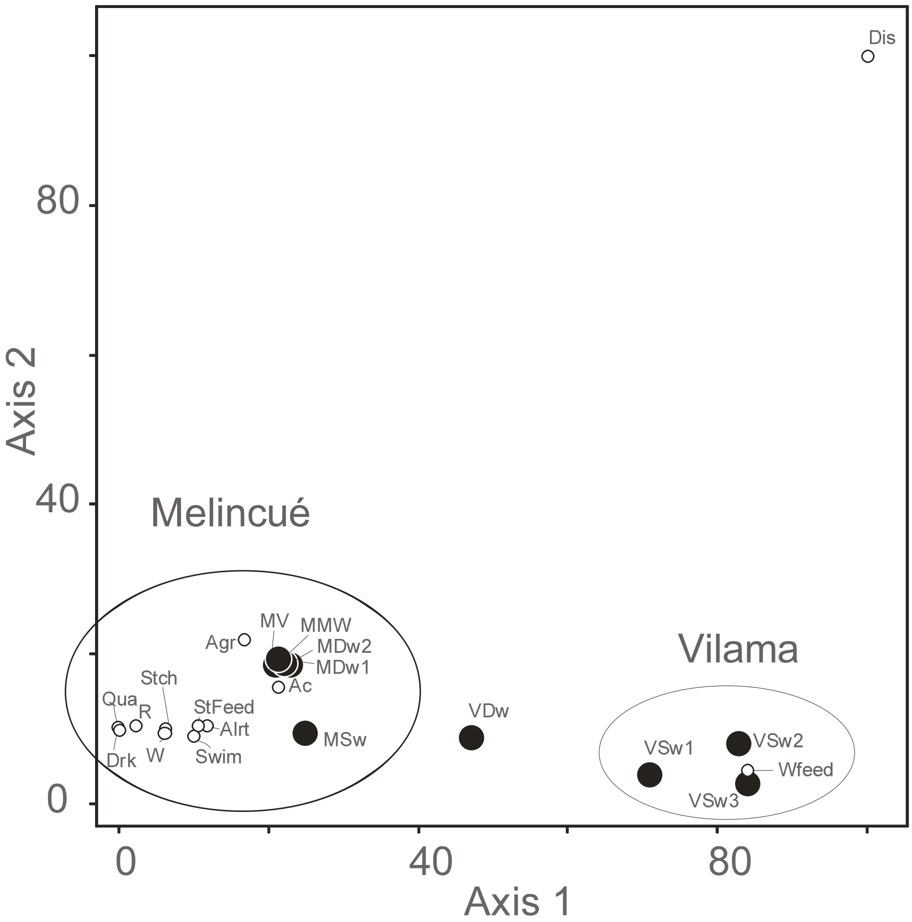
Two students are developing their undergraduate projects in flamingos breeding aspects.

Four undergraduate students receive informal and formal education during different field trips, through their participation in flamingo surveys.

Pink birds

Two mainly characteristic define flamingos: their colour, all species are pink, and their greats flocks. There are almost 34,000 Andean Flamingos and more than 100,000 Puna Flamingos in South America.

FIGURE 5. DCA of activity patterns and microhabitat ordering. Activity patterns, microhabitat and codes. Activity patterns: Agr (aggression), Ac (preening), Dis (displays not marching or grouping), Drk (drinking), Qua (quarrelling), Stch (wing-leg stretching), StFeed (stamp-feeding), Swim (swimming), W (walking) and Wfeed (walk-feeding). Microhabitats: MV (emergent vegetation in Melincué), MMV (Mud with a film of water, Melincué), MDw (deep water, Melincué), MSw (shallow water, Melincué), VDw (deep water in Vilama) and VSw (shallow water, Vilama).



Activities patterns

Some examples of activities in flamingos: A) walking, B) drinking, C) walk-feeding and D) quarrelling. All are Puna flamingos, pictures was taken at Vilama.

Lowland wetlands

During winter, lowland wetlands has characteristics and climatic condition similar to high Andes site. Temperature fall to -7° C during nights and almost 0° C during all day.

Flamingos conservation

There are few breeding colonies, chick survival is low, and winter habitat conditions may affect breeding fitness. Conservation plans must include all this aspect and must comprise entire annual cycle. A network of protected wetlands probably is the best solution.
In this picture we can see the low proportion of chicks (gray bird) compared with adults.

Threatened wetlands

Mainly threats on wetlands are human activities and climate change. Two pictures show same site in Melincué, above winter 2007 (references are my wife and daughter), and bottom effect of water pumping and drying season in summer 2008.

Meet us

Biologist Enrique Derlindati (in yellow at center) and field veterinary Marcelo Romano (in green at left). Here we are moving the observation tower, Melincué is at the background.

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