Flamingo

Bulletin of the IUCN-SSC/Wetlands International
FLAMINGO SPECIALIST GROUP

Special Publication 1

Proceedings of the IVth International Workshop
on the Greater Flamingo in the Mediterranean region
and northwest Africa

Mediterranean and West African Greater Flamingo Network

The Mediterranean and West African Greater Flamingo Network was established in 2002 to allow for more effective information sharing among researchers from France, Spain and Italy. That same year, a common database was developed for the Greater Flamingo ringing programmes and re-sighting data from countries around the Mediterranean.

In 2003, Mauritania and Turkey joined the network, followed by Libya, Tunisia and Algeria. A new website (*www.flamingoatlas.org*) was launched in 2006 to provide a platform for coordinating activities. The goal of the network is to coordinate research aimed at understanding the mechanisms governing the dynamics of the Mediterranean-West African subpopulation of Greater Flamingos in order to develop an effective conservation programme.

Participants in IVth International Workshop, 5-6 November, 2007, Antequera, Spain.

Front row (L-R): Manuel Mañez (Spain), Mike Smart (Tunisia), Francesca Portavia (Italy), Pilar Bayón (Spain), Sergio Nissardi (Italy), Federico Morelli (Italy), Miguel Ángel Rendón (Spain), Manuel Rendón Martos (Spain), Juan Amat (Spain, photographer, not shown).

Back row (L-R): Brooks Childress (UK), Arnaud Béchet (France), José Miguel Ramirez (Spain), Alessia Atzeni (Italy), Boudjema Samraoui (Algeria), Yelli Diawara (Mauritania), Alan Johnson (France), Francesc Vidal i Esquerré (Spain), Christophe Germain (France), Nicola Baccetti (Italy), Rocío Martinez (Spain), Antoni Masip (Spain), Andy Peterson (Spain), Araceli Garrido (Spain).

Cover photograph: Carles Domingo: Flamingos at Punta de la Banya, Ebro Delta, Spain.

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**Proceedings of the IVth International Workshop on the Greater
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**Antequera (Málaga), Spain
5-6 November 2007**

FOREWORD

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The Greater Flamingo is one of the most beautiful and enigmatic birds in the entire African Eurasian region. In the middle of the 20th century, the eastern and western Mediterranean populations were in decline because of sporadic breeding and loss of wetland habitat. Thanks to concerted conservation efforts, first in the Camargue, France, where a new breeding island was built by La Tour du Valat during the winter of 1969-70, and later in other countries, the populations are increasing steadily and the Greater Flamingo is now considered a species of "Least Concern" by the IUCN Red List of Threatened Species.

The first international workshop on the status and conservation of the Greater Flamingos of the western Mediterranean took place in Antequera, Spain in 1989, at a time when only two regular breeding sites remained in the western Mediterranean. Forty-five representatives from 12 countries took part. Following the second workshop at La Tour du Valat in 2002, the Mediterranean and West-African Greater Flamingo Network was formed to encourage more effective information sharing among researchers from France, Spain and Italy.

At the time of this fourth workshop, membership in the network had grown to 14 organisations from seven countries around the eastern and western Mediterranean. Coordinated chick-banding programmes were being conducted whenever possible at 10 breeding sites, hundreds of volunteers had been trained in the re-sighting and reporting of these bands, a coordinated, shared database had been created, and a new website (http://flamingoatlas.org) had been established to enable sharing of data and other information of interest to the members.

The group's fourth workshop, hosted by the Environment Council (Junta de Andalucía), was a resounding success. Presented in these proceedings are reports on the results of the 24-years of Greater Flamingo study and conservation at Fuente de Piedra in Spain (Rendón-Martos *et al.*), using multistate capture-recapture modelling to help understand how colony heterogeneity and individual characteristics interact to shape the breeding dispersal and recruitment of Greater flamingos in the western Mediterranean metapopulation (Balkız *et al.*), and an exploration into whether colony size affects chicks' diet quality (Amat *et al.*).

Also presented are reports on the role of North African wetlands in the growth of the Mediterranean metapopulation (Samraoui *et al.*), the conservation and education projects being undertaken in Algeria (Samraoui *et al.*), the importance of Tunisian wetlands as wintering and kindergarten sites (Smart *et al.*), and how change in a salt company's commercial objectives can cause breeding to be interrupted in managed breeding sites (Béchet *et al.*).

Six papers provide details of the status of the Greater Flamingo and conservation activities in Turkey (Balkız *et al.*), Mauritania (Diawara *et al.*), Ebro Delta, Spain (Curcó *et al.*), Guadalquivir marshes, Spain, (Manuel Máñez *et al.*), Sardinia (Nissardi *et al.*) and mainland Italy (Albanese *et al.*). Rendón *et al.* present proposals for measuring and interpreting results when monitoring breeding colonies, Germain and Béchet elucidate the common database for ring re-sightings, and Baccetti and Morelli report the results of their creative test of the readability of different ring and code colour combinations.

In closing, the network issued a communique calling upon the Tanzania government and Tata Chemicals to reconsider the proposed development of a soda ash extraction facility at Lake Natron, Tanzania, given the potential negative impacts on the Lesser Flamingo.

It has been an honour for me to participate in this workshop and to assist with the editing of the proceedings, and I anticipate even greater future achievements from this dynamic group of flamingo conservationists.

Brooks Childress, Chair
Flamingo Specialist Group, IUCN Species Survival Commission and Wetlands International

Flamingo

Special Publication 1, January 2009

Prodeedings of the IVth International Workshop on the Greater Flamingo in the Mediterrarean region and northwest Africa

REPORTS

Greater Flamingo *Phoenicopterus roseus* monitoring and conservation at Fuente de Piedra Lake

Manuel Rendón-Martos[1], Araceli Garrido[1], Miguel Ángel Rendón[2] and José Miguel Ramírez[1]

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Abstract
In this paper, we present the main results of the long term study and conservation program of the Greater Flamingo *Phoenicopterus roseus* in the Fuente de Piedra Lake from October 1983 to September 2007. The great annual and inter-annual variability of breeding numbers (0-39,593 flamingos) is related to the temporal and unpredictable character of the hydrological cycle of this lake, which in turn determines the establishment or not of a reproductive colony. In wet years this site hosted up to 52% of the breeding birds of the western Mediterranean. The results of the ringing and resighting program, and the conservation actions and social participation are also presented.

Introduction
Greater Flamingos only breed at a few wetlands within its Mediterranean distribution range. Of these, the Camargue (France) and the Lake at Fuente de Piedra are the main breeding sites within the western Mediterranean. However, Fuente de Piedra is the only wetland with an important flamingo colony whose hydrological dynamics remains determined by the annual rainfall typical of temporary Mediterranean wetlands.

Fuente de Piedra Lake unites a series of characteristics which make it one of the most important breeding sites in the Mediterranean. First, the great extension of the lake (1,400 ha.) and the existence of isolated islets provide very suitable nesting areas for flamingos. Furthermore, the location of the colonies at large distances from the shore makes it difficult to arrive for terrestrial predators which may affect adult and chick survival. Finally, the strategic positioning of the Lake in the centre of Andalusia enables flamingos to exploit resources available at different wetlands when raising the chicks.

Wetlands are changing wildlife systems both in time and space, with fluctuations of water availability conditioning salinity levels, sedimentation and the temporal presence of water of variable depth. It is important to emphasise the effect of water levels, both in the Fuente de Piedra Lake itself and in the Marismas (marshes) of the Guadalquivir as the principal alternative sites for feeding. It should also be noticed that in order to maintain the ecological integrity of the wetlands it is necessary to regulate a few human interventions which negatively affect these systems. Further, the importance of the interrelationships between the different wetlands should not be neglected (Amat *et al.* 2005), as it has been demonstrated that the connection between various wetlands coincide with the necessary conditions required to occupy them.

Therefore, the establishment and success of the colony at Fuente de Piedra Lake are affected by conditions within the Lake as well as at other Andalusian wetlands (Rendón-Martos 1996; Rendón-Martos *et al.* 2000). Thus, a wetland can not be treated as an isolated space within its surroundings but as a link in a chain which is connected in time and space. This means that it is important to understand the relationships in the whole area of distribution of this species, both for its own survival and for the conservation and management of the areas it occupies.

It is for these reasons that a long term research program takes place in the flamingo breeding colonies of the western Mediterranean, based on ringing of the chicks hatched each year. These programs fall within the Mediterranean Network for the Study and Conservation of Flamingos. Resightings of ringed flamingos give important information on their movements between the different wetlands within their area of distribution, their activity as breeding adults and their survival. The analysis of the resightings of ringed individuals has permitted the understanding of

several aspects of the species' biology and offers an indispensable tool for the conservation of the species as well as for the management of the wetlands which they use, the majority of these being shallow temporal Lakes which are affected by a large amount of human impact and, on occasions, in serious danger of destruction.

Study Area
Our study has focused on Fuente de Piedra Lake (southern Spain, 37º06'N, 04º44'W), the only seasonal Lake in Western Europe where Greater Flamingos breed regularly. The Lake has a surface area of 1 400ha at an altitude of 400m above sea level, and is at 50 km from the coast. It is a seasonal, saline, endorrheic Lake dependent upon rains for flooding (Rendón-Martos 1996). It is considered to be one of the most distinctive and extensive endorrheic complexes in Spain (Montes and Martino 1987; Linares 1990). Fuente de Piedra still retains its natural hydrological cycle and is protected as a RAMSAR site, a natural reserve and a specially protected area for birds (SPA).

Materials and Methods
Since 1986 a long-term capture and resighting program of Flamingos has been conducted at Fuente de Piedra as part of the flamingo ringing program (programa de anillamiento de flamencos de la Consejería de Medio Ambiente) of the Consejería de Medio Ambiente (Dept. of the Environment). The colony is observed continuously throughout the breeding season from observation towers 200m distant from the breeding areas and from a mobile hide, thus enabling observation of ringed birds at the colony and in the crèche. Observations are conducted systematically on an almost daily basis and the information recorded on the SIAM database of the Greater Flamingo Network. The census of flamingos at Fuente de Piedra was conducted at a frequency of one to seven times per week during the breeding period and once or twice fortnightly during the rest of the year.

Ringing with individually-coded PVC leg-rings, with a specific code for Fuente de Piedra, and metal rings started in 1986 and was interrupted only when there was no nesting. The chicks are captured between June and August, depending on the age of the chicks and the date of the last egg-laying. Capture and ringing is carried out with the help of local volunteers, ornithologists, conservationists and scientists. Every year pre-ringing activities are prepared with the municipality of Fuente de Piedra. The participation of the population to the ringing has made local people feel that this activity is part of the identity of Fuente de Piedra village.

Results

Temporal dynamics of the Greater Flamingo in the Fuente de Piedra Lake
During the twenty-four years of study (October 1983–September 2007) the number of Greater Flamingos in the Lake has varied greatly, both annually and inter-annually, and this variation was mainly related to the water levels of the Lake and the establishment or not of a breeding colony (Figure 1).

The level of water at Fuente de Piedra determines the establishment or not of a breeding colony and can also contribute to the breeding success of the flamingos in two complementary ways: (1) by favouring the isolation of the colony and decreasing the risk of predation, (2) by increasing food availability which reduces the efforts of the adults which then do not have to move to other localities to feed (Rendón-Martos 1996). Since 1986 the onset of breeding has taken place between February and March. The mean depth registered in the Lake in these years differs between years with breeding, when the mean water level is more than 50 cm, and non-breeding years when the level is less than 30 cm (Figure 2).

On the other hand, we have shown that the Marismas of the Guadalquivir constitute the most important feeding area for the flamingos which breed at Fuente de Piedra. This implies that feeding of adults and chicks must be determined in large part by the available resources in the Marismas, because the Lake dries out as the breeding season progresses (Rendón-Martos *et al.* 2000).

During the nineteen years when breeding has taken place, the numerical evolution of the flamingos in the breeding area shows the same profile as the total number of flamingos in the Lake, with the exception of the years 189/90, 1996/97 and 1997/98 (Figure 1). The mean monthly

number of birds in the Lake shows a significant positive relation with the mean monthly number of birds in the breeding colony (Rendón-Martos 1996). These results indicate that the dynamics of the flamingos at Fuente de Piedra is related to the occupation of the breeding area.
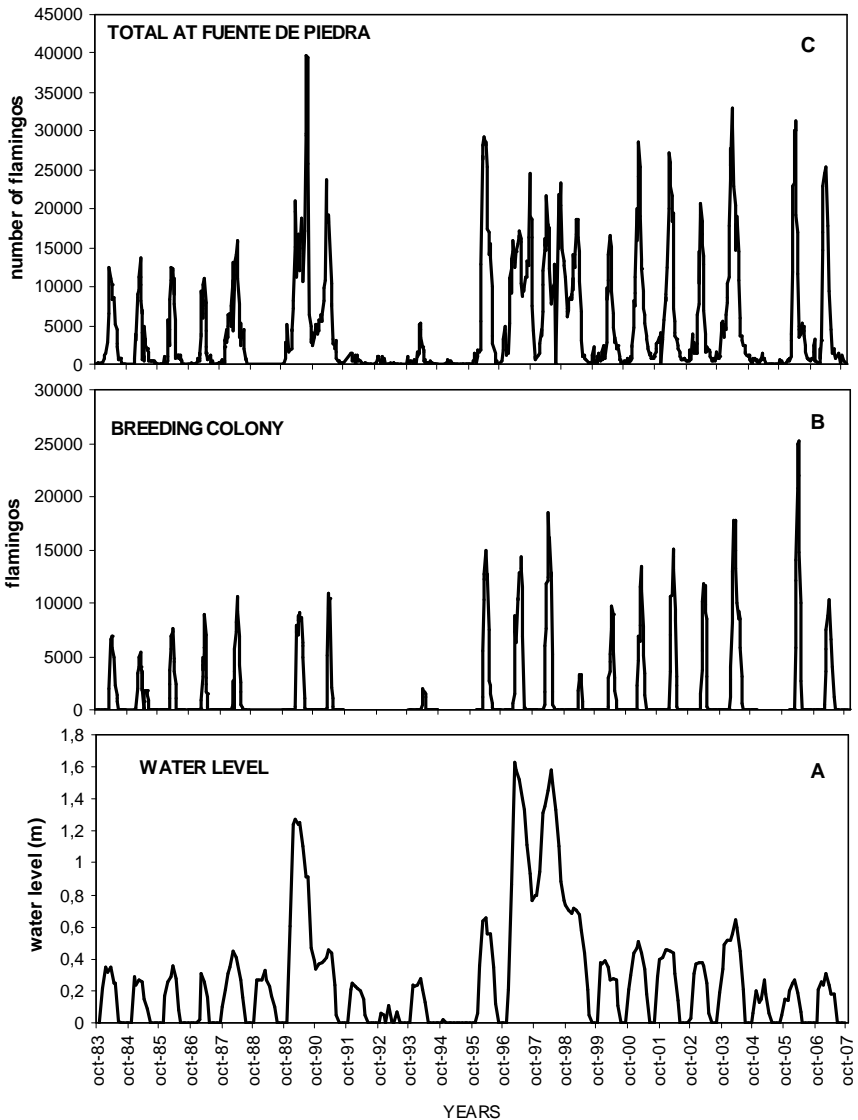
Figure 1. Monthly variation in the number of Greater Flamingos and water levels at Fuente de Piedra Lake from October 1983 to September 2007. (A: flamingos at the lake, B: flamingos at the breeding colony, C: water levels).
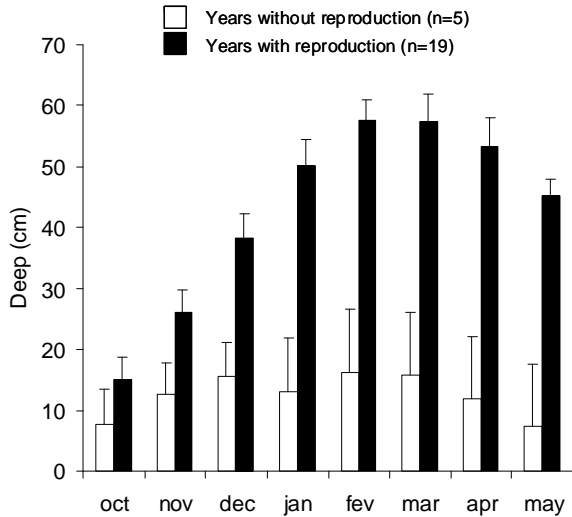
Figure 2. Breeding of flamingos at Fuente de Piedra in relation to water level, 1984-2007.

The mean monthly number of flamingos (Figure 3) has fluctuated between 1,990 birds in October and 28,985 in April. The maximum number for the twenty-four years was of 39,593 birds recorded in August and the minimum for each month was zero, with the exception January, February and March (2,207 and 2 birds respectively). The years 1989-90, 1995-96, 1996-97, 1997-98 and 2003-04, when Fuente de Piedra reached and maintained high water levels, are featured by maximum numbers of flamingos for all months. Between October and January the mean number of flamingos increases slightly, being approximately a thousand or so birds. In this period there have been counts of 19,000 birds in years when the Lake has remained flooded.
From February onwards the mean number of birds in the Lake increases until reaching the maximum in April, falling sharply in May and maintaining a more or less constant number of birds until August. This period presents the greatest variations of the number of flamingos which corresponds to the establishment of the breeding colony when conditions for breeding are favourable. In September the mean number of flamingos is normally much reduced and presents variations similar to those at the beginning of the hydrological year depending upon the water level in the Lake.

The noticeable inter-annual variation in the water level in the Lake and, as a consequence, the number of flamingos that are present, has made necessary a classification of the different types of years, according to hydrological conditions in the Lake and to the existence or not of breeding, in order to be able to explain the dynamics of the species at Fuente de Piedra. The twenty-four years studied may be grouped depending upon the establishment of a breeding colony or not and if the Lake dries or remains flooded until the end of the hydrological year. With this classification, three different year-types can be identified which may be considered representative of the period studied.

The first is composed of years when there was no breeding (1988-89, 1991-92, 1992-93, 1994-95 and 2004-05). The second type is of the years when there was breeding but the Lake dried out for a period of time (1983-84 to 1987-88, 1990-91, 1993-94, 1995-96, 1999-00 to 2003-04 and 2005-06 to 2006/-). The last type is of the years when there was breeding and the Lake remained flooded to the end of the hydrological year (1989-90, 1996-97 and 1997-98; Figure 1).

In the years when the flamingos did not establish breeding colonies (n=5), the Lake maintained a low water level (mean level: 0.19-0.00 m) and the summer drying-out was advanced to May (Figure 4A). These years were characterised by the presence of few birds and by an irregular temporal distribution. There were small nomadic groups of some tens or hundreds of

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birds that, in general, stayed for a few days in the Lake (Figure 4A). Between November and April the mean number of birds was relatively constant, although the maximum number occurred in December. From May onwards the number diminished notably to the point of registering only an occasional presence.
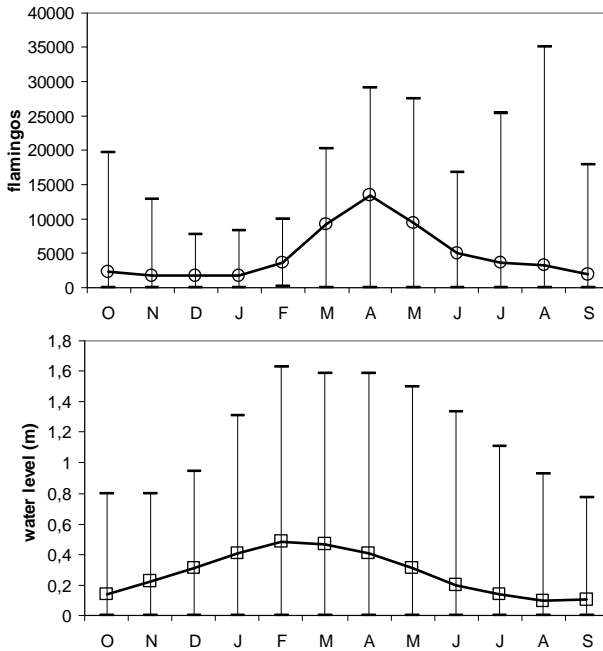
Figure 3. Monthly evolution of the mean number of flamingos, water level and range determined by the maximum and minimum numbers in Fuente de Piedra Lake in the period 1983/84-2006/2007.

In the breeding years when the Lake dries out in summer (n=16), the hydrological cycle starts with either a low water level (0.13 m) or no water at all, with the exception of the years when the Lake still retains water from the previous hydrological cycle, such as it occurred in October 1998 (0.74 m). The maximum level attained was registered in February (0.40 m). From March onwards the water level falls, reaching levels of 0.10 m between June and September, the period where the Lake is normally dry. In these years the mean abundance of flamingos is high. The greatest affluence of birds was registered in February (4,193), with a strong increase in March (11,230) and April (17,360; Figure 4b). From June onwards there is a strong decrease in numbers until September (469), this last being the month where the minimum number of birds has been recorded for the study years.

During the study period, the hydrological years 1989-90, 1996-97 and 1997-98 were characterised by an exceptionally high rainfall (666 mm), so that water levels remained high during the major part of the year (Figure 4c). In October the mean water level is 0.27m, reaching the maximum in April (1.45 m) and maintained 0.64 m until the end of the hydrological year. The monthly evolution of the numbers of flamingos in these years shows two periods: October-April where a pattern similar to that previously described for the rest of the breeding years is maintained, and May-August when the birds that remain in the Lake show a strong increase until reaching 39,593 birds in August (Figure 4C). This increase is because of the establishment of a strong breeding colony in these months. The numbers then decrease in September to a minimum

of 11,564 flamingos. The greatest variations in flamingo numbers occur during the period July to September and in October.
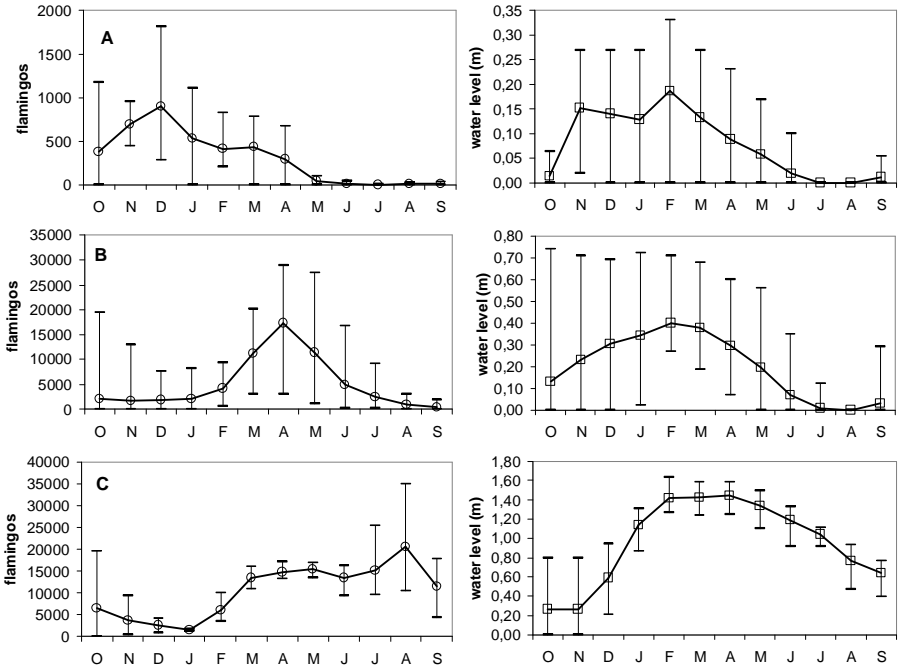

Figure 4. Monthly evolution of the mean number of flamingos, water level and range determined by the maximum and minimum at the Fuente de Piedra lake: (A) for the years when no breeding colony was established, (B) for years when a breeding colony was established with summer drying of the lake, and (C) without drying out.

Breeding colony
The first written evidence of the breeding of flamingos at Fuente de Piedra is from the end of the nineteenth century and first half of the twentieth (Arévalo y Baca 1882, Bernis et Valverde 1954). Nevertheless, the first breeding colony was not found until 1963 (Valverde 1964). The marked seasonality of the Lake and continuous erosion of the islands were the fundamental parameters which conditioned the presence and breeding of the flamingo at Fuente de Piedra until 1981, when the first management work started. However, it was after 1984 when the Lake was declared a Reserva Natural (Natural Reserve) and a regular monitoring of the colony was initiated and in 1985 when an investigation programme was started which permitted the evaluation of the breeding parameters of this breeding colony (Rendón-Martos and Johnson 1996).

For the last twenty-four years the hydrological cycle at the Lake has been the ultimate determinant of the breeding of flamingos at Fuente de Piedra. In the period 1984-2007 breeding has taken place for nineteen years. The annual number of pairs has fluctuated between a maximum of 19,500 in 1998 and a minimum of 2,083 in 1994, while the number of chicks has varied between 15,387 and 478 for the years given above (Figure 5). Over these years, Fuente de Piedra has held a mean of 35.7% of the breeding pairs and 40.4% of the chicks hatched within the Western Mediterranean.

Location of the breeding colonies
During the study period the breeding colonies have been located at different sites on the old retaining walls of the old salt pans, one of them having been remodelled in order to facilitate its

occupation, and in the area Canchones del Suroeste (Rendón-Martos and Johnson 1996) (Figure 6). In all these areas the substrate is a clay type.
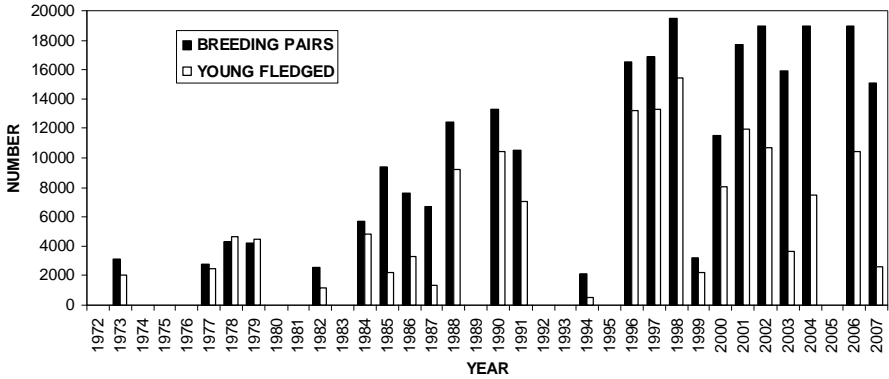
Figure 5. Numbers of breeding pairs and young fledged, 1972-2007
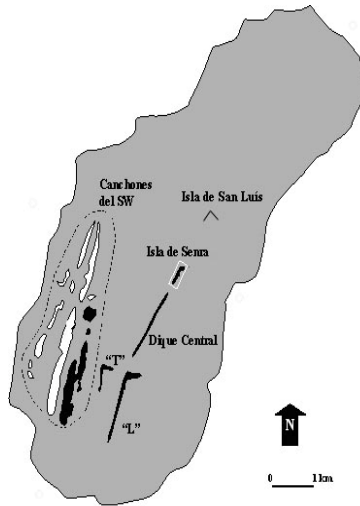
Figure 6. Location of natural islets and artificial dykes occupied (in black) by nesting colonies of Greater Flamingos during 1984-2007 in Fuente de Piedra Lake

All the sites occupied by the flamingos in the nineteen years of breeding are the remains of the salt pans, with the exception of the Canchones del Suroeste, which are natural islets providing sufficient isolation only in years with exceptionally high water levels (1990, 1997 and 1998). Of all these territories, Senra Island has been the main nucleus occupied for breeding by flamingos on sixteen occasions. Because of erosion, this site has been remodelled to maintain its surface area on several occasions (Rendón-Martos and Johnson, 1996). The Dique Central (central dyke) has also maintained breeding pairs as an extension of Senra Island since 1999 and has suffered much erosion in recent years. The Isla de San Luis was occupied by flamingos in 1985 only. In the 'L' and 'T' dykes the flamingos laid in 1990 and 1998, with a third occupation of the 'L' in 2004.

Ringing and ring resighting
In 1986, the Consejería de Medio Ambiente de la Junta de Andalucía (Spain) initiated the ringing program of Greater Flamingo and in the 17 years that the flamingos have bred, a total of 14,221 chicks have been ringed (Table 1), this corresponding to 11.0 % of the chicks hatched in the colony.

Table 1. Greater Flamingos at Fuente de Piedra: breeding, banding and resighting data

Year	Est. no. breeding pairs	Est. no. young fledged	No. young banded	% of young banded	No. of resightings
1986	7,600	3,300	622	18.9	13,102
1987	6,700	1,360	700	51.5	14,282
1988	12,500	9,200	1,000	10.9	9,869
1989	0	0	0	0.0	0
1990	13,300	10,417	968	9.3	11,102
1991	10,500	7,005	700	10.0	8,695
1992	0	0	0	0.0	0
1993	0	0	0	0.0	0
1994	2,083	478	478	100.0	4,857
1995	0	0	0	0.0	0
1996	16,500	13,252	1,302	9.8	10,015
1997	16,900	12,272	1,142	8.6	7,532
1998	19,500	15,387	1,339	8.7	5,086
1999	3,240	2,205	868	39.4	4,151
2000	11,500	8,019	863	10.8	3,218
2001	17.700	11,911	1,000	8.4	3,386
2002	19,000	10,656	800	7.5	1,843
2003	15,900	3,668	612	16.7	1,463
2004	19,500	7,500	600	8.0	985
2005	0	0	0	0.0	0
2006	18,500	10,400	611	3.3	572
2007	15,076	2,658	616	4.1	224
Totals	241,099	129,688	14,221	11.0	100,382

Dispersal of flamingos hatched at Fuente de Piedra
Of the 14,221 flamingo chicks ringed at Fuente de Piedra between 1986 and 2007, there have been 100,382 resightings up to 2008. The percentage of controls carried out in different areas is given in Figure 7 and shows that by far the greatest part of the sightings is located in Spain (76.0%) followed by France (11.2 %), Italy (4.5 %) and Portugal (1.6 %) in the northern sector of the Mediterranean, and in the south from Algeria (3.9%), Tunisia (2.8%) and Morocco (1,1%). The most extreme distances recorded were from eastern Mediterranean (Turkey 0.06 % and Cyprus 0.006 %), and Northwest Africa (0.7%).

The distribution of the resightings among the different countries does not properly reflect the tendencies of juvenile dispersal of flamingos hatched at Fuente de Piedra because local variation of observation effort is not taken into account. In spite of its limitations, it gives an overview of the dispersal of flamingos hatched at Fuente de Piedra, showing that it coincides basically with the area of the Mediterranean and northwest Africa.

Controls of ringed flamingos
The total number of controls carried out at Fuente de Piedra since the start of the program has been 125,027 (Table 2), which represents 39.9% of all ring readings recorded in SIAM. Flamingos born at Fuente de Piedra represent 79.0% of the readings, and birds from the Camargue 19.6%.
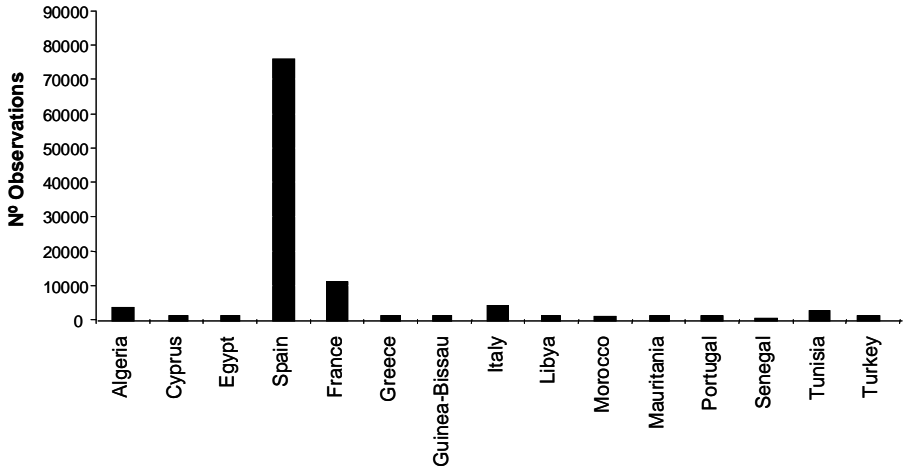
Figure 7: Number of observations, by countries, of flamingos ringed at Fuente de Piedra lake during the period 1986 to 2007.

Birds ringed in Italy are regularly observed in low numbers (0.07%) at the Lake. One Turkish ringed individual has been observed and to date no birds from Algeria have been seen. The life history of ringed individuals has shown that Fuente de Piedra is the area of greatest quality in Andalusia for breeding flamingos. The breeding colonies in the Marismas of the Guadalquivir are often made up of unexperienced, often young, birds which try to breed at this site when the colonies at Fuente de Piedra are saturated. These differences between colonies suggest that the colony at Fuente de Piedra provides a safe breeding area dominated by experienced breeders, while younger birds are displaced to the less safe colonies of the Marismas of the Guadalquivir where breeding success is almost nil (Rendón *et al.* 2001).

During the chick rearing period, tracking individually ringed birds has allowed to show that the birds breeding at Fuente de Piedra feed at wetlands within a radius of 200km of the colony. Amongst these areas there are the salt pans at Cabo de Gata, the Marismas de Odiel and especially the Marismas of the Guadalquivir (Rendón-Martos *et al.* 2000). These results show that breeding of flamingos does not depend solely on conditions at Fuente de Piedra but includes the greater part of the Andalusian wetlands which must be managed for this species.

Colony management
Management of the natural Reserve of Fuente de Piedra has as its principal objective the conservation and restoration of the processes which determine the natural functioning of this temporary Lake characterised by seasonal and annual cycles of flooding and drought which, in the final instance, determine the presence of breeding of the flamingos.

The processes which determine and influence the biological cycle of this species are subject to an important inter- and intra-annual variability. Some of these processes are predictable and other no, because of their catastrophic nature. Because of this, the management of this colony of flamingos is directed at reducing this second group of factors in the following ways: (a) maintenance of the breeding area of the colony on Senra Island with the aim of avoiding its disappearance and improving its shape in order to attract nesting pairs; (b) maintaining adequate water levels once chicks have hatched if the Lake is drying out around Senra Island until the chicks fledge; (c) vigilance at the Lake to avoid problems of human origin (Rendón-Martos and Johnson 1996); monitoring the breeding colony in order to know the factors which affect its development and its relationship with the rest of the population.

Table 2. Number of ring readings during the period 1986-2007 at R.N. Laguna de Fuente de Piedra of birds ringed in different colonies.

Country	Natal colony	No. ring readings 1986-2007 at Fuente de Piedra
Spain	Fuente de Piedra	98,788
	Doñana	1,589
	Delta del Ebro	5
France	Camargue	24,534
Italy	Molentargius	62
	Macchiareddu	19
	Santa Gilla	14
	Orbetello	11
	Comacchio	4
Turkey	Camalti	1
Algeria	Ezzemoul	0

Social participation

All around the Mediterranean, many wetlands used by flamingos are close to human populations which have traditionally been exploiting them as a resource. This is also the case for both Fuente de Piedra village and Lake. Since remote times man has taken advantage of its natural resources (salt, hunting, grazing, halophytic vegetation, baths, etc.) until the site was declared a Natural Reserve (Reserva Natural) in 1984. After this date the only authorised use were those aimed at conservation and research. This caused the opposition of the local stakeholders to the management of the Lake as a protected site. This opposition has now decreased since the Consejería de Medio Ambiente has encouraged the participation of local people in activities related to the Lake and has involved them in participants in the conservation of their natural heritage. Obviously, for a wetland to be conserved and the breeding colonies to continue throughout the years, it is vital to rely upon the participation and support of the local inhabitants.

The flamingos and in particular the ringing of chicks have permitted the increasin involvement of the community of Fuente de Piedra in activities related to the Lake. They have joined in the activities prior to the ringing which are organised in the village along with the Town Hall and through which the populations feels itself to be participating to the point that it is theirs.

Conclusions

The value of Fuente de Piedra lies in its natural functioning which is determined by the temporal and unpredictable character of its hydrological cycle and its capacity to host the most important breeding colony of Greater Flamingos in the Mediterranean. This is attained without human interference in the maintenance of water levels which are adequate for guaranteeing breeding, as it occurs in the Mediterranean salt pans.

The strategy used by flamingos consists in an irruptive occupation of the Lake when the environmental conditions are favourable for the establishment of a breeding colony, in following a sequential use of the trophic resources and displacement to other localities when there are adverse conditions.

The breeding of the Greater Flamingo at Fuente de Piedra Lake provides an excellent indicator of the environmental conditions at the different Andalusian wetlands as the birds move to these to feed during the breeding season (Rendón-Martos 1996). Thus, monitoring this breeding colony allows an annual evaluation of the state of the temporal wetlands of Andalusia.

Birds ringed at Fuente de Piedra disperse throughout the Mediterranean, from the Iberian Peninsula to Turkey and North-west Africa. This implies to maintain and encourage the exchange of information between the different countries where flamingos breed in order to know the movements and origin of the birds which visit each wetland. In this way, it is necessary to continue

and improve long term investigation programs based upon marking the chicks born each year and the resightings of ringed individuals at each main breeding colony.

The management work carried out in the breeding territory of the colony and the additional water supplied to the chicks during the summer have not modified the biological cycle of the flamingos at Fuente de Piedra, nor has it affected the number of breeding pairs (Rendón-Martos 1996). The management work carried out has served to reduce the loss of the isolation of the natural islets because of the reduction of water supplies from the streams which enter the Lake. The vigilance by the wardens has permitted the detection and correction of negative interference of human origin at Fuente de Piedra.

In order to conserve the wetlands it is necessary to encourage the participation of the people who live around it. The flamingos in general and their ringing in particular provide a strong motivation to encourage social participation programs and activities by environmental volunteers.

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Metapopulation dynamics of the Greater Flamingo *Phoenicopterus roseus* in the Mediterranean: implications for conservation

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Abstract

The factors that influence dispersal in metapopulations are not well known. Using multistate capture-recapture modeling, we studied how colony heterogeneity and individual characteristics interact to shape the breeding dispersal and recruitment of Greater flamingos *Phoenicopterus roseus* in the western Mediterranean metapopulation. Our results indicate that breeding experience is a major determinant of dispersal decision. Experienced flamingos showed higher breeding site fidelity than less experienced ones. A long lasting effect of the natal colony was also apparent among less experienced breeders. Indeed, in the Camargue and Fuente de Piedra locally hatched birds had a greater probability to become regular breeding immigrants. Recruitment was delayed in both the Camargue and Fuente de Piedra with indications of density-dependence effects.

Introduction

Factors influencing dispersal in metapopulations are not well-known. In this paper, we analyse how colony heterogeneity and individual characteristics interact to shape breeding dispersal and recruitment in the Greater flamingo of the western Mediterranean metapopulation. This paper summarizes unpublished results of Ozge Balkız (2006).

Nager *et al.* (1996) showed that flamingo movements differ between colonies depending on colony characteristics (*i.e.* level of environmental variation, disturbance, colony saturation) and individual characteristics (*i.e.* breeding success). However, their analysis is potentially biased by the absence of capture-recapture modeling framework and a limited study area. Here we brought their work a step further by enlarging it to three colonies that account for >85% of the breeding pairs of the western Mediterranean, namely the Camargue (France), Fuente de Piedra (Spain) and Molentargius (Sardinia). We evaluated the effect of breeding experience and natal colony on breeding dispersal by using multistate-capture recapture modeling.

Flamingos are known to postpone reproduction beyond the age at which they attain sexual maturity (Pradel *et al.* 1997). The age at which individuals start to breed may differ among colonies. Indeed, previous findings showed that the age of individuals reproducing for the first time differed among colonies (Nager *et al.* 1996, Rendón *et al.* 2001). In this second analysis we inferred recruitment variations between the Camargue and Fuente de Piedra. We first estimated juvenile and immature survival probabilities. We then assessed the effects of natal colony, temporal and population factors on recruitment at the two colonies using multistate capture-recapture modeling.

Material and methods

Study area

In the Camargue (Southern France, N43°25', E04°38') , Greater flamingos have been breeding regularly on an artificial island within a large commercial salt production complex since 1974 (Johnson and Cézilly 2007). Between 1977 and 2002, breeding occurred in the Camargue every year and colony size varied from 4,200 to 22,200 pairs. The second most important breeding colony of the Greater flamingo in the west of the Mediterranean is a natural saline lake at Fuente de Piedra, southern Spain (Malaga Province, N37°06', W04°45'). While the number of breeding pairs at Fuente de Piedra is often higher than in the Camargue, frequent drought prevents annual reproduction (Rendón-Martos and Johnson 1996, Rendón *et al.* 2001). From 1977 to 2002, breeding occurred in 19 out of 26 years and colony size varied from 2,083 to 19,500 pairs. We considered a third colony located in the coastal lagoons of Molentargius in Sardinia (Italy, N39°13', E09°08'). From 1993 to 2002, the Molentargius lagoon has been occupied every year except in 2001, when there was no breeding in Sardinia and in 1999 flamingos when flamingos bred in the nearby Macchiareddu salt pans. For simplicity, we pooled the observations made at this last site with the one from Molentargius (Nissardi *et al* in this issue). Colony size varied from 825 to 4,500 pairs.

Modeling data set and parameters of interest

Since 1977 in the Camargue and 1986 in Fuente de Piedra, about 10% of the chicks have been ringed with a metal ring and a plastic band bearing a unique alphanumeric code readable from up to 300 meters (Johnson and Cézilly 2007), thus enabling assessment of individual breeding status. An individual is classified as a breeder when observed incubating an egg, attending a young, or observed on the same nest >24 hours (assessed using numbered landmarks). Otherwise the individual is classified as a non-breeder.

Recent developments of multistate capture-recapture models allow proper estimation of breeding dispersal and recruitment parameters using individual resightings (*e.g.* Hestbeck *et al.* 1991, Spendelow *et al.* 1995, Lindberg *et al.* 1998, Lebreton and Pradel 2002, Blums *et al.* 2003, Cam *et al.* 2004). This approach permits testing biological hypotheses by allowing proper estimation of three parameters (following the notation of Lebreton and Pradel 2002):

P_t^s : The probability that an individual is encountered at time t at site s given that it is alive and present at site s at time t (encounter probability).

F_t^s : The probability that an individual alive at site s and time t is still alive at time t+1 (survival probability).

ψ_t^{sz} : The probability, conditional to survival, that an individual moves from site s at time t to site z at time t+1 (transition probability).

We limited our modeling to the Camargue, Fuente de Piedra and Molentargius colonies (Figure 1). To account for temporary emigration outside our study area, we incorporated an unknown breeding site where no observations are done.

For the breeding dispersal analysis, we considered the resightings of 4,900 individuals ringed as chicks in the Camargue and Fuente de Piedra until 1997 and observed breeding in the Camargue, Fuente de Piedra and Molentargius colonies from 1983 to 2002. Resighting histories start with the first observed breeding (coded differently for each colony) at one of the 3 colonies and continues with the subsequent observations. The natal colony effect is modeled by sorting individuals by groups of similar origin.

For the recruitment analysis, we considered a total of 21,630 resightings of flamingos ringed as chicks in the Camargue and Fuente de Piedra until 1997. The resighting period lasted until 2002, consisting of observations made during the breeding season (from March to August). Firstly we estimated survival during the first three years of life (juvenile [0 to 1 year] and immatures [1 to 3 year]) before sexual maturity. This was required to make recruitment parameters identifiable. We then pursued by modeling the recruitment process separately in the Camargue and in Fuente de Piedra.
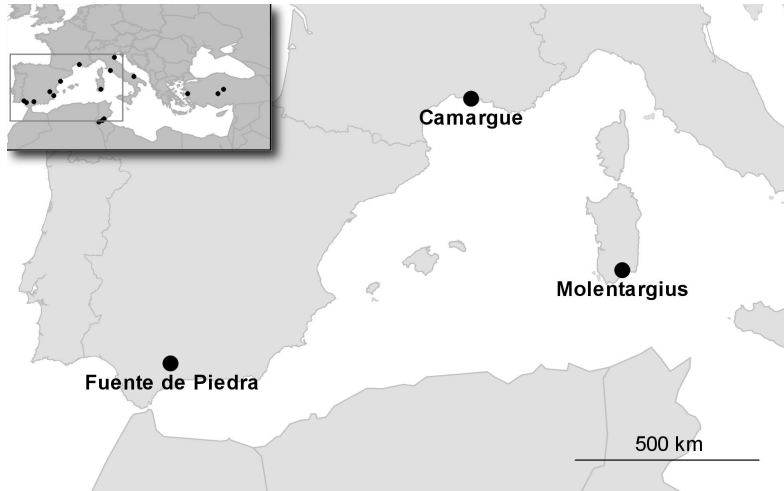
Figure 1. The Greater Flamingo breeding colonies occupied at least once between 1983 and 2002 across the Mediterranean. In detail are the locations of the three main colonies in the western Mediterranean, namely the Camargue (France), Fuente de Piedra (Spain) and Molentargius (Sardinia).

Goodness-of-fit tests and multistate modeling
Using U-CARE (v 2.2.1; Choquet *et al*. 2003), we run goodness-of-fit tests (GOF) to assess the relevance of a model in capturing the variation in the data at hand (Pradel *et al.* 1997). Model fit was achieved by maximizing the likelihood with program M-SURGE (v 1.8; Choquet *et al.* 2004). Model selection relied on the Akaike Information Criterion (AIC) or its modified version (QAIC) when model deviances are scaled using the overdispersion factor, ĉ (Burnham and Anderson 2002).

Results
Long lasting attractiveness of natal colony shapes breeding dispersal in the Greater Flamingo
The probability to become a regular breeder in saturated colonies (namely the Camargue and Fuente de Piedra), was enhanced for locally born birds and higher for experienced breeders. Individuals observed breeding for the first time had a low probability to remain in these colonies, except when it was their colony of birth. This suggests that competition is high in saturated colonies, yet the familiarity with the site where they are born increased the tenacity of less experienced individuals to remain there after their first breeding attempt. Experienced breeders showed higher level of faithfulness to their last breeding colonies. We found a strong connection between Molentargius and the Camargue with movements of flamingos breeding at Molentargius being preferentially oriented towards the Camargue. Finally, we question the nomadic character of the Greater Flamingo given the high levels of site faithfulness and the socially and spatially structured dispersal it exhibits (Balkiz 2006).

Delayed recruitment in a two-site system: contrasting population and individual effects
Survival was the lowest during the first year of life (0. 73 ± 0.01; mean over sexes and types of years - normal years and cold spell year) and increased gradually thereafter (0.88 ± 0.01 and 0.92 ± 0.01 during the second and third year of life, respectively). Flamingos delayed recruitment both at the Camargue and Fuente de Piedra (highest recruitment rate reached at 7 years old). There were indications of density-dependent regulation of recruitment. However, no simple conclusion

could be drawn about the relationship between colony size and recruitment rate at neither of the two colonies. Our study demonstrated that individual factors like the site of birth might be responsible for further variation in recruitment strategies. French flamingos recruited at Fuente de Piedra with a higher probability at younger ages than in the Camargue and than Spanish flamingos in Fuente de Piedra. It appears as if Fuente de Piedra was used by the French birds as an alternative breeding colony easier to access than the Camargue. On the other hand, the reasons for this origin related differences of recruitment strategies at Fuente de Piedra remain unclear (Balkiz 2006).

Discussion

If a breeding site is predictable and of high quality, natal fidelity (philopatry) and breeding fidelity are believed to be advantageous (Greenwood and Harvey 1982, Nager *et al.* 1996, Forero *et al.* 1999). Flamingos fidelity to their breeding colonies were much higher than would have been expected for a so called "nomadic" species. It is possible that the conservation efforts made at the main colonies favors a progressive decrease in their nomadic behavior. as also found for Northern Shovelers *Anas clypeata* and Tufted Ducks *Aythya fuligula*; Blums *et al.* 2003). In the Camargue, the breeding island is located in the middle of a commercial salt pan, where water levels fit flamingo needs. Furthermore, the artificial island, which has been restored several times, facilitates annual reproduction. Fuente de Piedra is a more natural site, yet as a natural reserve, the colony is protected against the risks of human disturbance. Thus, both colonies are more attractive to flamingos than the less predictable, smaller or more disturbed colonies. This might in turn cause the saturation of both colonies by already established breeders, thus preventing new individuals, especially the less experienced ones, to recruit at these colonies. Both the breeding dispersal and recruitment behavior of flamingos supported this view. Individuals observed to breed for the first time had a low probability to remain in the saturated colonies the following year, except when it was their colony of birth. Similarly, recruitment was delayed at both colonies with indications of density dependence. Flamingos born in the Camargue and Fuente de Piedra were thus forced to either delay their recruitment or to move elsewhere.

Since 1993, flamingos have bred in several new colonies in the western Mediterranean. Molentargius is one of them. It has been suggested that these new colonies resulted from the saturation of the Camargue and Fuente de Piedra (Johnson 1997). Our results tend to confirm this hypothesis as Molentargius was joined mainly by young individuals, either recruiting there, or gaining the experience required to enter the saturated colonies afterward. Thus, the colonies of the western Mediterranean metapopulation do not contribute equally to population dynamics. In metapopulations in general, identifying the role of each local population is a prerequisite to evaluating the significance of particular habitat patches for the long-term persistence of the metapopulation (Hanski 1994). In our case, the small colonies may not contribute for an important part to the growth of the metapopulation but may be nonetheless important as training sites for young birds. On the other hand, the two main colonies, Camargue and Fuente de Piedra, likely less prone to extinction, export birds over larger areas. Therefore their protection should also be emphasized (e.g. Trenham *et al.* 2001).

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Foraging ecology of breeding Greater Flamingos in the Mediterranean Basin: preliminary results from a study using stable isotopes

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Abstract
We collected wing cover feathers from Greater Flamingo *Phoenicopterus roseus* chicks at the colonies of Ebro Delta (NE Spain), Fuente de Piedra (S Spain), Garaet Ezzemoul (NE Algeria) and Macchiareddu (Sardinia, Italy) to know whether diet quality (as determined using stable isotopes of N and C) is affected by colony size. Isotopic values of N and C were not related to colony size. This result, however, is not conclusive, as we did not control for some factors that affect colony size (*e.g.* availability of foraging sites of different quality around colonies).

Introduction
Competition for feeding resources, through its effects on food availability, is one of the factors that affect colony size in birds (Ashmole 1963, Furness and Birkhead 1984, Forero *et al.* 2002). High densities of birds around colonies may result in increased intraspecific competition, which may lead to the depletion of feeding resources. As a result of this, foraging adults may provision their chicks with food of lower quality as colony size increases. We tested this prediction on Greater Flamingos that have breeding colonies of different sizes around the Mediterranean Basin. For this, we related colony size to diet quality, which was evaluated using stable-nitrogen isotope (Forero *et al.* 2002). Another prediction derived from the food depletion hypothesis is that as colony size increases, the spatial range of foraging Greater Flamingos should increase. We evaluated this last prediction using stable-carbon isotope.

The stable isotope ratios $^{15}N/^{14}N$ ($\delta^{15}N$) and $^{13}C/^{12}C$ ($\delta^{13}C$) may be used to infer some aspects of the foraging ecology of animals, as these ratios reflect those in their foods. Applications of stable isotope technique to studies of avian foraging were summarized by Hobson and Clark (1992) and Kelly (2000). The stable-nitrogen isotopic composition of consumers is enriched in ^{15}N relative to diet by about 3‰ relative to their prey (Hobson and Clark 1992). Therefore, individuals with higher $\delta^{15}N$ values feed on prey of higher trophic levels. Body tissues are enriched in ^{15}N relative to ^{14}N during digestive processes, and thus prey with higher $\delta^{15}N$ values may be considered of higher nutritional quality (*e.g.* Forero *et al.* 2002). The stable-carbon isotopic composition of consumers is almost identical to that of their prey, and thus provides information on the sources of nutrients (Hobson and Clark 1993). In accordance with predictions from the food depletion hypothesis, we expected that $\delta^{15}N$ values in larger colonies should be lower than in smaller colonies. The opposite was expected for $\delta^{13}C$ values, which would indicate a broader foraging range for flamingos in large than in small colonies.

Methods
In 2006, we collected wing cover feathers from flamingo chicks during ringing at the colonies in Ebro Delta (NE Spain), Fuente de Piedra (S Spain), Garaet Ezzemoul (NE Algeria) and

Macchiareddu (Sardinia, Italy). We sampled 50-100 chicks at each colony. The feathers were washed using detergent and thoroughly rinsed to remove waxes, debris, and residual detergent; they were then oven dried and cut into small pieces using scissors. The samples were analyzed for $\delta^{15}N$ and $\delta^{13}C$ at the Iso-Analytical Ltd. laboratory (Sanbach, UK), using an elemental analyser combustion stable isotope ratio mass spectrometer. Standards were run in duplicate every five measurements.
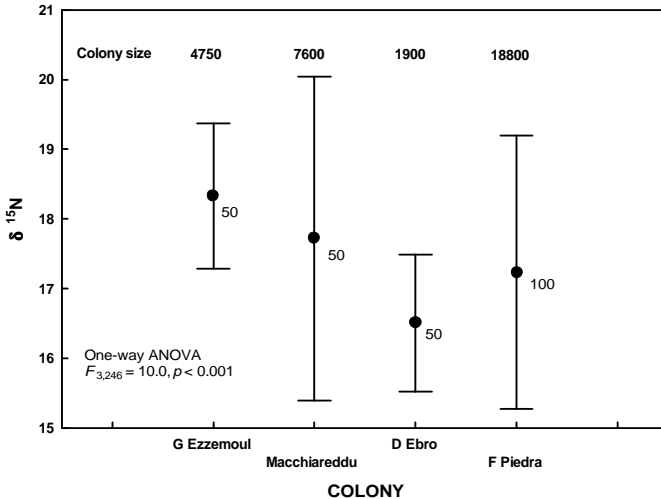
Figure 1. Variations in $\delta^{15}N$ (means ± 1 SD, sample sizes beside points) in wing cover feathers of Greater Flamingo chicks collected in four colonies of the Western Mediterranean, whose sizes are indicated at the top of the graph. Differences between colonies were tested with analysis of variance (ANOVA).

Results and discussion
There were significant inter-colony variations in $\delta^{15}N$, which were not related to colony size (Figure 1). Similarly, although there were significant differences in $\delta^{13}C$ between colonies, these were not related to colony size (Figure 2). For $\delta^{15}N$, the larger colonies show broad SD intervals (Figure 1), suggesting that in the larger the colonies the diversity of food types obtained by flamingos was greater than in the smaller colonies. For $\delta^{13}C$, only the sample from the Garaet Ezzemoul colony has a small SD (Figure 2), suggesting that the spatial range over which Algerian birds obtained food was rather limited in comparison with that of flamingos from other Mediterranean colonies (see Hobson *et al.* 2004).

Our findings do not support the predictions derived from the food depletion hypothesis. However, this does not necessarily argue against this hypothesis, since some of the factors that affect colony size were not controlled for. Thus, if habitat use by Greater Flamingos is governed by some kind of competitive interaction (e. g. despotism, see Fretwell and Lucas 1970), the availability of foraging sites of different quality around colonies should be controlled for. These aspects will be studied as part of an ongoing project.

Acknowledgements

Figure 2. Variations in $\delta^{13}C$ (means ± 1 SD, sample sizes beside points) in wing cover feathers of Greater Flamingo chicks collected in four colonies of the western Mediterranean, whose sizes are indicated at the top of the graph. Differences between colonies were tested with analysis of variance (ANOVA).
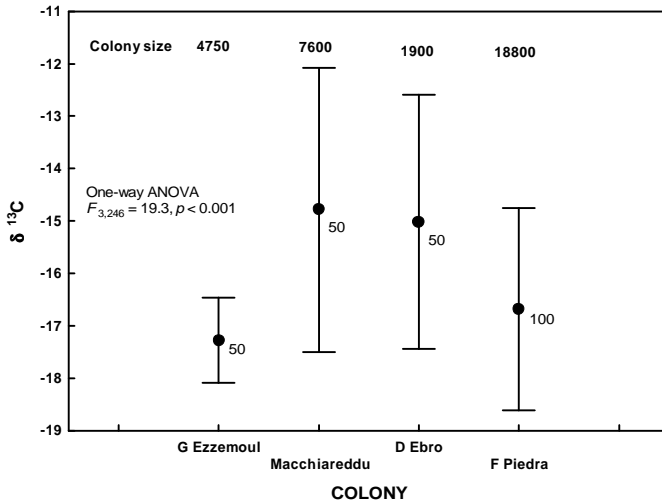
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Current research and conservation of the Greater Flamingo *Phoenicopterus roseus* in Algeria

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Abstract

The role of North African wetlands has been reassessed in the light of the increasing number of wintering Greater Flamingos *Phoenicopterus roseus* and the discovery of an important breeding colony at Garaet Ezzemoul, Algeria where the Greater Flamingo bred successfully in two consecutive years. In the last five years, and before conservation measures were taken, flamingos unsuccessfully attempted to breed at Ezzemoul and three other sites (Bazer Sakra, El Goléa, Chott Hodna). The monitoring of banded flamingos has noticeably increased in North Africa, shedding new light on the dynamics of the Mediterranean metapopulation and revealing an extensive exchange between southern Europe and North Africa, possibly structured as flyways. North African wetlands are under strong anthropogenic pressures and are mainly threatened by hydrological changes provoked by the building of dams and reservoirs. International collaborative efforts are needed to maintain the functions and connectivity of these wetlands which provide important and diverse services.

Résumé

Le rôle des zones humides nord-africaines a été réévalué à la lumière du nombre croissant de Flamant Rose (*Phoenicopterus roseus*) hivernants et de la découverte d'une importante colonie nicheuse à Garaet Ezzemoul, Algérie où le Flamant rose s'est reproduit avec succès deux années successivement. Au cours des cinq dernières années, et avant que des mesures de conservation ne soient prises, les flamants ont tenté sans succès de se reproduire à Ezzemoul et dans trois autres sites (Bazer Sakra, El Goléa et Chott Hodna). Le suivi des flamants roses bagués a permis de mieux cerner la dynamique de la métapopulation méditerranéenne de flamants roses en soulignant les échanges fréquents entre le sud de l'Europe et l'Afrique du nord, structurées probablement en voies de migration. Les zones humides nord-africaines subissent une pression anthropique intense et sont principalement menacées par les changements hydrologiques résultant de la construction de barrages et de retenues colinéaires. Une collaboration internationale est nécessaire pour préserver les fonctions des zones humides et leur connectivité afin de maintenir les services fournis par ces milieux précieux.

Introduction

The Mediterranean population of the Greater Flamingo is considered to be a metapopulation with a relatively few breeding colonies (Balkiz 2006), and is estimated at between 100,000 and 165,000 (Childress 2005). North Africa has traditionally been perceived as a wintering ground or a kind of "crèche" for immature flamingos (Isenmann and Moali 2000). Past breeding, recorded sporadically in Tunisia (Castan 1960, Domergue 1951-52) and Morocco (Robin 1966, 1968, Panouse 1958) has not altered this commonly held perception. Following vigorous conservation efforts in southern Europe (Johnson 1983, 1997, 2000), a marked increase in the number of Greater Flamingos was observed in Algeria. This led us to begin a long-term survey of the wetlands complex of the Hauts Plateaux, which revealed that the region is an important wintering and breeding site for waterbirds (Boulkhssaïm *et al.* 2006a, Samraoui *et al.* 2006b, Samraoui *et al.* in press). Protective measures are needed for the Hauts Plateaux wetlands complex, as these habitats are threatened with hydrological changes and human encroachment. As a flagship species and an icon, the Greater Flamingo may facilitate education programs and help build public support for conservation efforts. In this paper, we review past and current research efforts

to monitor the population of Greater Flamingo, especially breeding colonies, across Algeria in order to devise and implement adequate conservation measures.

Study Area
In 2002, we began a systematic survey of all major wetlands in the northeastern Hauts Plateaux, Algeria (Figure 1). Our search for breeding colonies and foraging sites focused mainly on the salt lakes complex of Oum El Bouaghi, but also included adjacent complexes like that El Eulma, Chott Hodna and in northern Sahara.
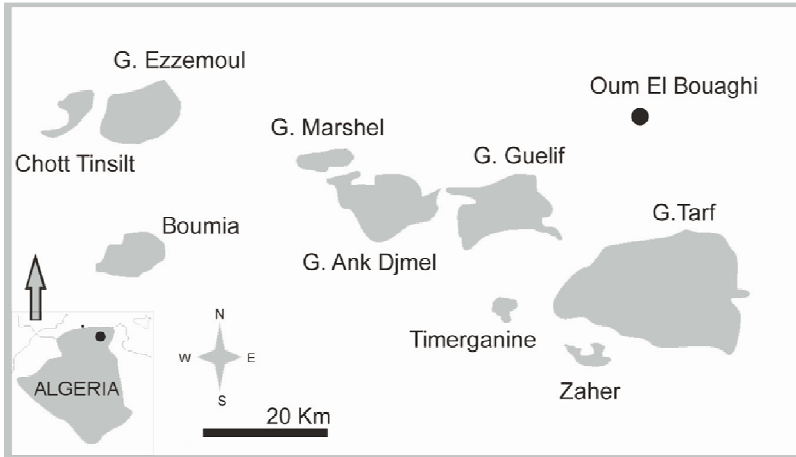
Figure 1. Map of study area

Material & Methods
We first concentrated on evaluating the status of the Greater Flamingo in the eastern part of Algeria, and mapping its spatial and temporal distribution. Diurnal activity budgets and the nature of trophic resources at key sites were investigated in order to determine how these wetlands were used by the Greater Flamingo, and to identify important environmental factors regulating the abundance and distribution of the species. Part of our effort was devoted to searching for breeding colonies. Once found, a colony like that of Ezzemoul had to be physically protected and broader conservation measures (e.g. participative approach with local people, education and exhibitions) had to be initiated. The reproductive ecology of the Greater Flamingo was studied at Ezzemoul in 2005 and 2006, and a banding program was started aimed at collaboratively attempting to study the dynamics of the Greater Flamingo metapopulation in northwest Africa and the Mediterranean Basin. Chicks were ringed with PVC bands, with a specific code for Algeria. Colonies were approached using mobile hides and bands were read using spotting scopes.

Results

Numbers and habitat use
Our censuses revealed that the Algerian population far exceeds the previous estimates of 5,000 birds (Isenmann and Moali 2000). When only the eastern part of Algeria is taken into account, numbers may, under favorable conditions, fluctuate between 30,000 and 50,000 individuals. It was not unusual to count over 30,000 flamingos in some sites (Chott Merouane: 30,000, Garaet Tarf: 40,000 on 15/12/2004; Chott Ank El Djmel: 30 000 on 6/9/2005). Less regular counts in western Algeria exceed 12,000 flamingos. The Greater Flamingo preferentially uses saline habitats and to a lesser extent brackish and saline habitats. Counts of the species rarely exceed 1,000 individuals in coastal wetlands where freshwater habitats are the majority.

Feeding was the dominant diurnal activity at Guelif and Tazougart (Ouldjaoui *et al.* 2004) and the Sahara (Houhamdi *et al.* 2008). Detailed behavioural studies are currently underway. A systematic sampling of the macroinvertebrates of the salt lakes across Algeria has indicated that the carrying capacity of these habitats is high and is mainly based on "pulses" of fairy shrimps: *Artemia salina*, *Branchinella spinosa* and *Branchinectella media*, which can occur at a huge density (Samraoui *et al.* 2006a).

Breeding

A breeding colony of the Greater Flamingo at Garaet Ezzemoul was discovered in March 2004. The colony, known to local people since at least the early part of the twentieth century, was subject to egg pilfering, and breeding failed in 2003 and 2004 (Saheb *et al.* 2006). Three separate breeding attempts were recorded at sites other than Ezzemoul. In each case, nests (Bazer Sakra 2007, El Goléa 2006 or earlier) or egg fragments and witnesses (Chott Hodna 2004 or earlier) confirmed the breeding attempts. Low water levels and human interference were most likely the cause of the reproductive failure. Physical protection (guards) of the Ezzemoul colony led to the first recorded successful breeding in Algeria in 2005 (Samraoui *et al.* 2006b) and 2006 (Samraoui *et al.* in press). Over 8,500 chicks fledged in the two years combined. Of these, 208 were banded in 2006 (Boulkhssaïm *et al.* 2006b), and their dispersal was monitored with the aid of observers around the Mediterranean.

Special efforts have been made to monitor the dispersal of the Greater Flamingo across Algerian wetlands, and in the last few years, an increase in the number of bands read is apparent (Figures 2 and 3). Preliminary results (Figure 4) indicate that banded birds originate mainly from the Camargue (France) and Fuente de Piedra (Spain). The distribution pattern of these birds is possibly structured into flyways but this aspect requires confirmation. Over 50% of the banded chicks at Ezzemoul have so far been observed in several localities in southern Europe (Portugal to Italy) and North Africa (Algeria, Tunisia and Libya) (Figure 5). Four banded chicks have been recorded dead at Ezzemoul, apparently unable to fly to other sites when Ezzemoul dried out in the late summer of 2006.
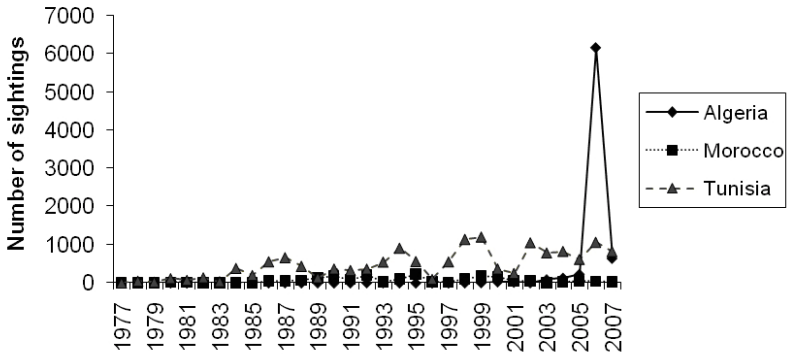
Figure 2: Total number of banded Greater Flamingos sighted in the Maghreb (1977-2007), including duplicate band sightings.

Participation of local people in the protection of the Ezzemoul colony and the banding operation ensured that egg-pilfering is no longer considered the main threat. Special efforts were devoted to education, through exhibitions aimed towards school children, managers and decision makers. Capacity building to enable local universities to undertake wetland management is also considered a priority, and several lectures and courses on conservation as well as field trips have been organized.
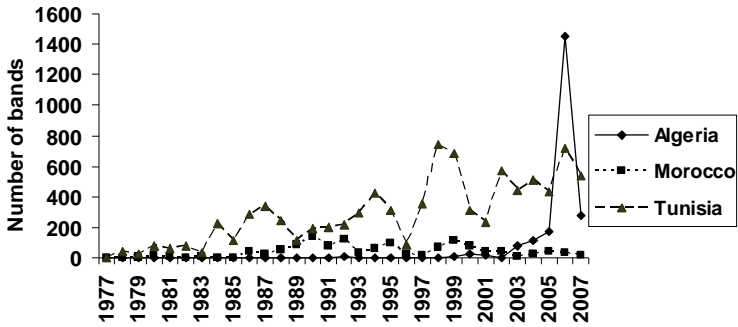
Figure 3: Number of unduplicated Greater Flamingo bands recorded in the Maghreb (1977-2007).

Discussion

Our results have led to a reassessment of the status of the Greater Flamingo in Algeria. The program of reading color bands has led to a substantial revision of our understanding of the role of North African wetlands, which could play a key role in the dynamics of the Mediterranean flamingo metapopulation. Over the past two years, the movements of chicks banded at Ezzemoul were monitored across the region, and they have already revealed extensive exchange between the Ezzemoul, European colonies and other North African regions (Samraoui *et al.* in press). In the near future, we will be able to assess the extent of gene flow of Greater Flamingos across Mediterranean colonies.
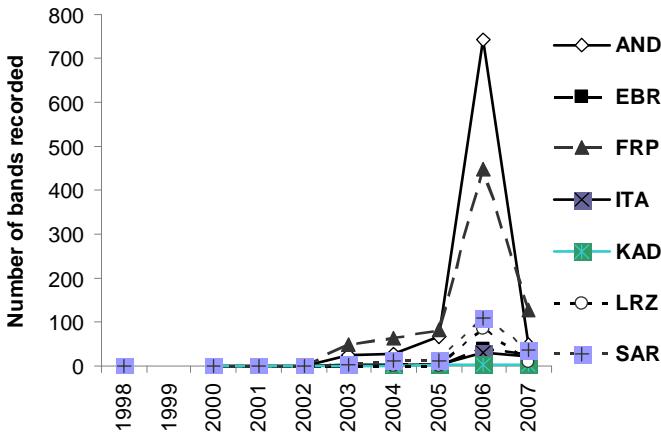
Figure 4: Origin of the bands read in Algeria (1977-2007) with the following abbreviations: AND = Andalusia/Spain, EBR = Ebro Delta/Spain, FRP= France, ITA = Continental Italy, KAD = Turkey, LRZ = Algeria, SAR = Sardinia).

Despite the optimistic trend displayed by the Greater Flamingo population, the future of this species and that of its habitats is far from secure. At Ezzemoul an unmanaged site and where the onset of breeding is relatively late (early May), preliminary data have shown that survival of chicks is tied to the length of the hydroperiod. Damming the wadi that feed the salt lakes is now considered the major threat to the maintenance of these important habitats, but studies in the highly managed Camargue have also shown that breeding of the Greater Flamingo remains

sensitive to large-scale climatic variations (Béchet and Johnson 2008), thus any hydrological changes (climatic or man-induced) could put the future of the Ezzemoul colony in jeopardy. The formal recognition of the Greater Flamingo's breeding and foraging habitats across North Africa as Ramsar Sites or parts of Biosphere Reserves should afford them effective protection, although increases in demography or climate changes, by putting more pressure on scarce water resources, may significantly and negatively affect their survival.
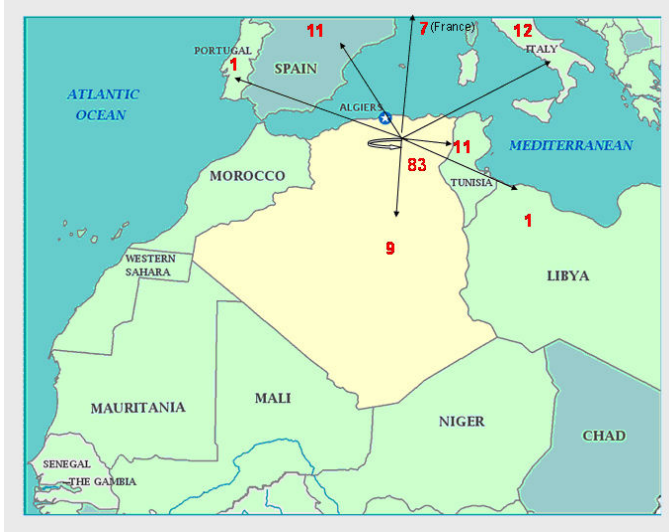
Figure 5: Records of flamingos banded at Ezzemoul (Italy includes continental Italy, Sicily and Sardinia).

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Greater Flamingos stop breeding in the Camargue (southern France) in 2007, for the first time in 38 years; the beginning of a new era?

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Summary
For the first time in 38 years, Greater Flamingos *Phoenicopterus roseus* did not breed in the Camargue in 2007. This was because the salt company decided to drastically reduce salt production, and as a consequence the breeding site at the Etang du Fangassier was not flooded. A brief overview of flamingo breeding in the Camargue reveals how the sudden change of the salt company's commercial objectives caused this interruption. We give details of the 2007 breeding attempts and propose a different management strategy for this species in the future.

Introduction
For the first time in 38 years, Greater Flamingos did not breed in the Camargue in 2007. This was because the Etang du Fangassier, the usual breeding site, was not flooded by the salt company. Since the 1970's, the conservation of this species in France has been closely associated with salt production. Colonies have been established annually and the flamingo population has not only recovered but increased in size. However, we question if this breeding pattern corresponds to the natural dynamics of the main habitats used by flamingos, temporary wetlands, or to the particular life history strategies adopted by this species to tolerate the hydrological unpredictability of these habitats. We thus believe that this event should permit a paradigm shift for the conservation of this species.

In this paper, we first make a brief historical overview of flamingo breeding in the Camargue which enables a better understanding of how the commercial decision by the salt company has had an effect on this species. We then summarise the failure of the different 2007 breeding attempts and propose a different management strategy for this species in the future.

Historical overview
Flamingos have bred in the Camargue since at least the mid 16th Century, and breeding attempts have been monitored annually for almost a century (summarised in Johnson and Cézilly 2007; Figure 1). In the 1950s breeding success was poor, and in 1962 and 1963, flamingos failed to raise any chicks. For the following five years (1964-1968), no breeding was even attempted (Johnson 1966, Johnson 1970). An important conservation programme was then set up by La Tour du Valat in partnership with the salt company on whose property flamingos usually bred. This included culling of the Yellow-legged Gull (*Larus cachinnans*), reduction in aircraft disturbance and the construction of an island upon which flamingos could breed. In 1969, breeding began again naturally in pan 1 of Etang du Fangassier at the salins de Giraud, the largest commercial saltpans in Europe (11,000 ha). This was an encouragement to build the new island over winter 1969-1970 in the shallower pan 2 of the Fangassier. The Flamingos eventually settled on this purpose-built site (6,200 m^2) in 1974, apparently attracted by the artificial nest mounds put down the previous winter (Rendon-Martos and Johnson 1996). Occupied as an annexe site in 1974 and 1975, the island has been fully colonised every year since 1976 with ~10,000-12,000 breeding pairs each year. From 1974 to 2006, >150,000 flamingos fledged from this site. What happened in 2007 for the birds not to have returned home?
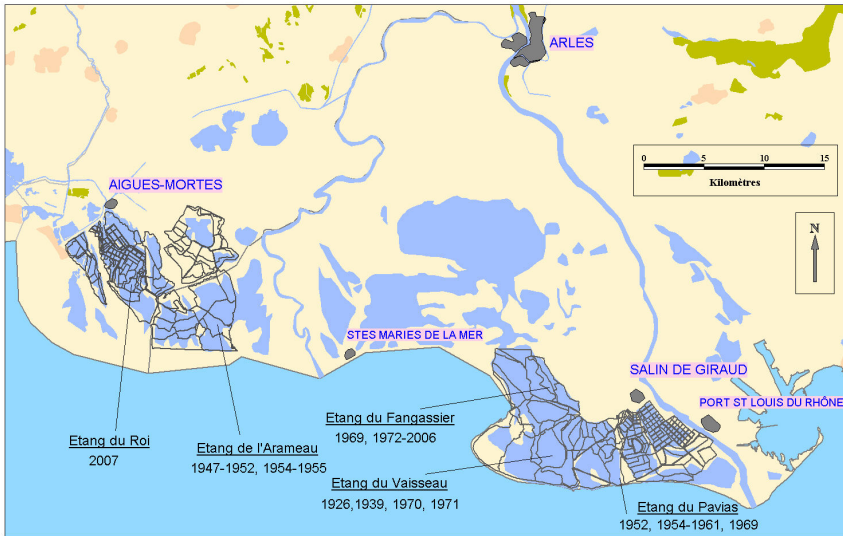
Figure 1. Location of flamingo colonies in the Camargue and Petite Camargue, southern France 1926-2007.

The Etang du Fangassier forms part of a circuit for salt water which is pumped from the sea, usually from mid-March through to the end of summer (Johnson and Barbraud 2004). As the water flows through the system it evaporates and increases in salinity, the brine reaching saturation in the harvesting ponds where production varies from 400,000 to almost 1,400,000 metric tons per year. Most of the salins de Giraud's production is used by industry. During winter, the Fangassier pan 2 is allowed to dry out. The spring flooding of this lagoon by the salt company conditions the establishment of flamingos and determines the date of egg-laying, which occurs on average 20 days later (Béchet and Johnson 2008).

At the beginning of 2007, the salt company decided to decrease production from an average 900,000 to 340,000 metric tons annually. This was accompanied by the announcement of the dismissal of half the personnel. There were negotiations between the workers and the management but the crisis persisted, and as a result no water was pumped into the Fangassier pan 2 that spring.

The 2007 breeding season

In mid-April, a little rain flooded the Fangassier pan 2 just around the flamingo island and some flamingos then occupied about a third of the site. Ten days later, the water had evaporated and the colony was abandoned. Only a few eggs were observed, suggesting that the birds had not started laying eggs en masse.

On April 25, a new colony was discovered in the salins d'Aigues-Mortes where flamingo had bred in the past (Figure 1). The colony was established on several low-lying islets and on a dyke nearby. In the first days of May, heavy rains flooded the island and this colony was abandoned. This same heavy rainfall again flooded the Fangassier pan 2 where flamingos settled for the second time on May 5. However, once more there was rapid evaporation, and by May 20 the island was again abandoned by flamingos. The Fangassier pan 2 was finally flooded by pumped water on August 7, but it was too late to attract flamingos.

Counts in mid-March and mid-May along the Mediterranean coast of France indicate that only about 5% of the 42,795 flamingos present in March may have left France, possibly to attempt

breeding elsewhere. Hence, it seems that most birds decided to wait near their preferred nesting site until conditions improved.

Discussion

Salt production, as it is practiced throughout much of the Mediterranean, can be greatly beneficial to waterbirds and it is most unfortunate that the salt company decided to reduce its production. In the Camargue, saltpans act as a buffer zone reducing the effects of drier years by providing constant water levels during summer (Béchet *et al.* 2009).

The collaboration between La Tour du Valat and Salins has always been excellent (except for the 2002 closure of the site to La Tour du Valat researchers due to a confused political situation in the Camargue Regional Park). In addition to having built the island, Salins also restored it on three occasions, and in recent years, they provided logistical support for the banding operations.

An agreement has now been reached between the staff and the management of Salins, and it has been announced that 2,000 ha of saltpans (including the Fangassier lagoons) will be sold to the Conservatoire du Littoral, a French government agency dedicated to purchasing coastal lands in order to protect them from urban and industrial sprawl. Such a purchase means that wildlife managers will now take part in the management of the site. A new era could thus begin raising some challenging questions.

The conservation status of the Greater Flamingo in the west of the Mediterranean has improved with a) the population having increased recently and now numbering at least 100 000 individuals (with 40,000 throughout the year in France) and b) the number of breeding sites in the Mediterranean having also considerably increased in the last fifteen years (regularly >10 sites produce fledglings). We can thus wonder whether it would not be reasonable to stop artificially maintaining a site systematically suitable for breeding each year.

Since the 1850s the sea wall and the embankments along the Rhone river have prevented natural formation of islands (Chauvelon 1998). Thus, a minimal management remains necessary to maintain the flamingo as a breeding bird in France. However, this management could be inspired by what the demography of the species tells us about its evolutionary adaptations. Several Greater Flamingo life history traits may have evolved in response to the unpredictability of breeding conditions: high survival (Tavecchia *et al.* 2001) and high divorce rates (see Cézilly and Johnson 1995). Greater Flamingos also exhibit significant rates of juvenile and adult dispersal (Balkiz 2006). If faithfulness to a breeding site is advantageous when environmental conditions are stable (Schmidt 2004), dispersal is advantageous for species occupying unpredictable habitats such as those occupied by flamingos. Dispersal enhances the persistence of a species by compensating for the decline of some populations or by allowing re-colonisation of previously occupied sites. Yet, as such, the constant availability of the Camargue breeding site for more than 30 years may select for philopatric strategies. If we wish to conserve flamingos together with their adaptations, habitat management should mimic the hydrological variations of Mediterranean wetlands. For instance, it could be possible to accompany natural variations of winter-spring rainfall, guaranteeing a sufficient water level for breeding only when rainfall is above a certain threshold and discouraging breeding (no pumping of water) in dry years. Nevertheless, such a management practice may be difficult to attain, particularly because of the existence of the neighbouring Salins d'Aigues-Mortes (9,000 ha) where water levels will always remain attractive.

Concomitant with the possible experimentation of this innovative management approach, we hope that we will be able to resume our participation in the Mediterranean-wide band-resighting programme which has suffered somewhat in recent years. This is indispensable as our conservation choices should rely on a constant improvement of our understanding of the flamingo life history strategies.

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An update of the status of the Greater Flamingo *Phoenicopterus roseus* in Turkey

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Abstract

Turkey hosts one of the largest Greater Flamingo *Phoenicopterus roseus* populations of the Mediterranean region. In this paper, we present the results of the 2007 monitoring program at the two main breeding sites. We counted 4,382 chicks in Tuz Lake and 3,000 – 4,000 chicks in the crèches of the Gediz Delta. A total of 36 individuals banded in the western Mediterranean were observed in the Gediz delta. Among them, 12 were confirmed as breeders. We also report the first observation of a flamingo banded as chick in Turkey and confirmed as a breeder in the Gediz delta, a premiere for Turkey. A total of 216 flamingo chicks were banded in 2007 in the Gediz delta. Finally, we report an increase in the threats faced by flamingos in Turkey, with the worrying situation of Tuz Lake, where several hundred chicks died at the end of the breeding season because of water shortage. We call for a continuation of the monitoring project, in order to develop sound conservation plans for this species in Turkey.

Introduction

Turkey hosts one of the largest Greater Flamingo populations of the Mediterranean region with up to 19,000 breeding pairs counted in 2005 at two colonies, the Gediz Delta and Tuz Lake. However, until recently there was no long term monitoring of the flamingo populations in this country. From 2003 and 2006, La Tour du Valat financially supported a detailed research program on the species through a Ph.D. project. The results of this study demonstrated the need to initiate a long term research and monitoring program for this species, which is listed as a threatened species in Turkey because its two breeding sites are under threat.

In 2007, supported by a scientific cooperation grant from the PACA region in France, we monitored the two Turkish breeding colonies. Our objectives were to: (i) monitor flamingo breeding success, (ii) record any banded flamingos present at the Gediz Delta colony and determine their breeding status, and (iii) carry out the fourth banding operation in the Gediz Delta to enable the collection of information about the dispersal strategies of flamingos hatched in Turkey.

Material and Methods

There are two known Greater Flamingo breeding colonies in Turkey. The first is located in an active salt pan within the Gediz Delta (N38°32', E26°52'), and the second is located in Tuz Lake in Central Anatolia (N38°34', E33°29'). The Tuz Lake colony is 17 km from the lake shore and no ground surveys or ring sightings could be made there. Therefore, the Tuz Lake colony was surveyed via an aerial flight on 2 July, 2007. The objective of the three-hour flight was to estimate the number of chicks produced using aerial photographs of the crèche just before fledging.

At the Gediz Delta colony, we conducted three field surveys from May to July 2007, the first two lasting five days and the third one lasting two days. We spent a total of 12 days in the field, and made 89 hours of observation at the breeding colony. We estimated the size of the crèche and recorded banded flamingos using telescopes allowing accurate reading of the band code from up to 300 meters (Johnson 2000). We considered a bird as a breeder if it was observed incubating an egg, tending a chick, or if it was observed on the same nest for more than 24 hours (this was assessed using landscape features to locate the incubating bird from one day to another). The first attempt to count the colony from an aerial photograph was made using a microlight aircraft on 11 August, 2007. However, the photographs taken did not enable us to count the chicks. Therefore, the estimates of the crèche size at this site rely on the ground survey.

At the end of the breeding season, we conducted the fourth banding operation in the Gediz delta. A total of 216 chicks were captured on 29 July, 2007. All chicks were measured and ringed with both a metal ring, and a plastic ring with a unique alphanumeric code (Johnson 1989). A total of 75 volunteers participated to the operation and no flamingo was injured.

Results

Tuz Lake
We counted 4,382 chicks on the aerial photograph of the crèche on Tuz Lake. Following the breeding surveys, a ground survey was conducted on 20 October, 2007 near the Konya channel, located along the southwest shore of the lake where the crèche usually feeds. This survey was based on local news reports of the death of flamingo chicks at site. The survey documented the presence of several hundred (<500) dead chicks at the site (see Figure 1). This is the first time such an observation had been recorded at Tuz Lake. The observations, and the information collected from local people, suggested that terrestrial predators must be responsible for the high number of dead animals found at the site.

Figure 1. The photograph of a dead young flamingo from the Tuz Lake (Photograph credit: Murat Ataol)

Gediz Delta

A crèche of 3,000 to 4,000 flamingo chicks was counted from the ground. We also counted a total of 4,234 nests on 22 July. However, we believe that this number underestimates the real number of pairs that attempted to breed at the site. When we visited the site to prepare for the banding operation, we observed that about 700 m^2 of the island area had eroded. This erosion, which resulted in a decrease in area available for flamingos, has also been observed at the other breeding islands in the salt pan.

A total of 36 banded individuals were recorded at 75 different times. Eighteen of these individuals were from France, seven from Spain, two from continental Italy, one from Sardinia and eight were from Turkey. Among these, 12 individuals were confirmed breeders: five from France, three from Spain, two from Italy, one from Sardinia and one from Turkey. It is the first time that a flamingo banded in Turkey has been confirmed as a breeder in Turkey (also see Balkiz *et al.* 2007).

Post-fledging dispersal of flamingos born in Turkey

Flamingo chicks ringed at the Gediz Delta in 2003, 2004, 2005 and 2007, have been resighted in 12 countries outside Turkey: Greece, Cyprus, Israel, Libya, France, Spain, Italy, Tunisia, Mauritania, Portugal, Slovenia, and Algeria.

Discussion

Tuz Lake and the Gediz Delta in Turkey are among the most important flamingo breeding sites of the Mediterranean. The observations made during the last five years demonstrate that Turkey provides a large proportion of the flamingo chicks hatched in the Mediterranean, South West Asia and West Africa (Figure 2). Furthermore, through monitoring efforts, it has been shown that birds hatched and banded at the western Mediterranean colonies regularly use the Gediz Delta as a breeding site.
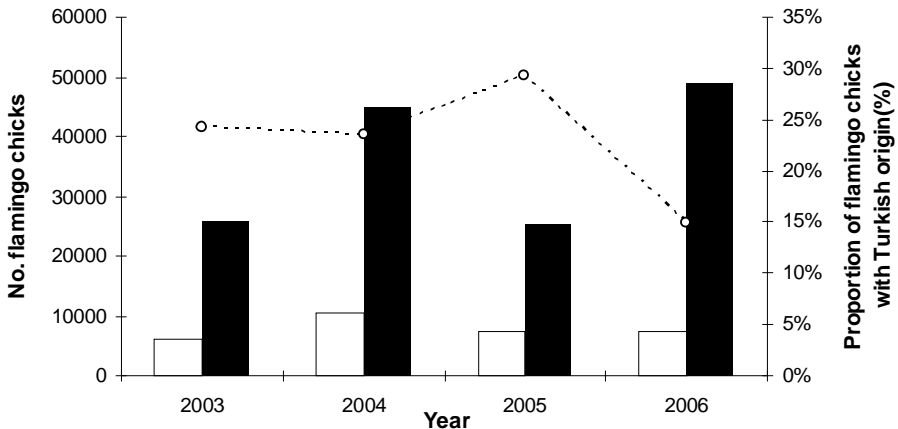
Figure 2. Number of flamingo chicks hatched in Turkey (white bars) versus in the Mediterranean (including Turkey), South West Asia and West Africa (black bars), and the comparison between the two (dotted line) from 2003 to 2006. In 2006, due to logistical constraints, we could not estimate the chicks hatched at Tuz Lake. Therefore the numbers given in 2006 are probably an underestimate of the real number of flamingo chicks hatched in Turkey.

Conservation measures to be taken in Turkey
The massive mortality of flamingo chicks at Tuz Lake probably resulted from the wrong irrigation practices (surface irrigation), developed due to the high water demands for agriculture in Central Anatolia, and the increase in the number of illegal water pumps set up in the last decade. This has resulted in a sharp decrease in the water levels of Tuz Lake and its surrounding satellite lakes. Furthermore, low precipitation in 2007 resulted in a pronounced drought at the lake. The sharp decrease in water levels might have permitted terrestrial mammals, such as foxes, to predate flightless flamingo chicks. Another possibility is a decrease of food availability at the site, also due to the decrease in water levels. This is a remarkable observation, showing the increase in the threats the flamingos are facing in their biggest and most important colony in Turkey.

In the Gediz Delta, the existing breeding islands are seriously eroded, decreasing the area available for flamingos. This demonstrates the necessity of the construction of an artificial breeding island at the site in the near future. Developing sound conservation plans for these sites necessitates the continuation of the flamingo monitoring project, as this would enable the collection of scientific data needed to document and publicize the threats to the breeding colonies.

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Monitoring of the Greater flamingo *Phoenicopterus roseus* in Mauritania

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Abstract

The Greater Flamingo (*Phoenicopterus roseus*) is one of the most abundant waterbirds in Mauritanian coastal wetlands. It is observed year round, from the tidal mudflats of the Banc d'Arguin in the north to the freshwater and salt marshes of the Aftout es Saheli, Chatt Boul and Diawling National Park in the Senegal delta in the south. Breeding has been recorded several times in the Banc d'Arguin, where there has been a recent relocation of the colony from a low-lying island to the high rocky plateau of the Kiaone islands. The number of breeding pairs has varied from 8,200 in 2003 to a maximum of 16,600 in 2005, with breeding success varying from 43% to 83%. Ninety two percent of the flamingo rings resighted in Mauritania have been from birds hatched in Spain, supporting the hypothesis of an heterogeneous dispersal from Mediterranean breeding sites to West Africa, via a western flyway from Andalusia to Mauritania.

Introduction

The Greater Flamingo is one of the most abundant waterbirds in Mauritanian coastal wetlands. It is observed year round, from the tidal mudflats of the Banc d'Arguin in the north to the freshwater and salt marshes of the Aftout es Saheli, Chatt Boul and Diawling National Park in the Senegal delta in the south. Breeding has been recorded several times in the Banc d'Arguin, where there has been a recent relocation of the colony from a low-lying island to the high rocky plateau of the Kiaone islands (Trotignon 1976, Campredon 1987, Cézilly *et al.* 1994, Gowthorpe *et al.* 1996, Diawara *et al.* 2007).

Since the creation of the Diawling National Park (PND) and the Chatt Boul Natural Reserve in the delta of the Senegal River, Greater Flamingos are observed there every winter, including juveniles which are especially abundant from October to March (Hamerlynck 1997). Breeding was only observed there at the end of the 80's, following heavy winter rainfall that broke the sandbank south of Chatt Boul and flooded the Aftout es Saheli (Gowthorpe *et al.* 1996).

Since 1977, a program of banding flamingos with individually-coded PVC bands has been conducted in the Camargue, France (Johnson 2000). This type of program has also been conducted in Spain since 1986 and in Italy since 1994. Greater Flamingos banded in these three countries have been observed regularly in Mauritania, in all seasons, since 1978 (Trotignon and Trotignon 1981, Johnson 1989). These observations have lead to the hypothesis that there were genetic exchanges between the Mediterranean and Mauritanian populations, and this has been confirmed recently by the observation of Mediterranean birds feeding chicks on Kiaones Island (Diawara *et al.* 2007). In this paper, we update the results presented in Diawara *et al.* (2007) and propose some avenues for future investigation.

Study area

The Banc d'Arguin National Park is located near the 20th parallel and extends >180 km along the Mauritanian coast. It includes an area of 12,000 km2, with an equal proportion of coastal and terrestrial habitats (Figure 1). The Banc d'Arguin itself is a very shallow tidal mudflat (*e.g.* only five meters deep 50 km from the coast) crossed by channels and covered with submerged grass beds. This exceptional ecosystem is flooded by upwellings of cold water rich in nutrients. The simultaneous presence of grass beds and upwellings creates high biological productivity, which explains the dense populations of birds, fish, invertebrates and marine mammals.

In the southern region of Mauritania, coastal wetlands are concentrated around the Senegal River delta, between 16°02'N and 16°35'N (Figure 1) . Until recently this delta was alternatively inundated by fresh and marine water, favoring the growth of an extremely rich biodiversity (Hamerlynck 1997). Since 1970, lack of rainfall and the building of several dams in the valley of

the Senegal River have considerably degraded this unique ecosystem. To attenuate the effects of these developments, a conservation plan has been encouraged for the lower delta which has resulted in the creation of the Diawling National Park (PND) in 1991 and the Chatt Boul Natural Reserve, now both included in a Biosphere reserve which additionally includes Aftout es Saheli.

Methods
Aerial surveys of flamingos, using pre-defined transects, were conducted at the Banc d'Arguin National Park and the Senegal Delta between 2003 and 2007. The Banc d'Arguin surveys were conducted between the 9th of April and the 7th of May. The surveys of the Senegal River delta were conducted from the end of November to the beginning of December. In 2006 and 2007, three terrestrial expeditions were also conducted in the Aftout es Saheli.

During the aerial surveys all flamingos were counted, and the breeding colonies were photographed using a 24x36 reflex camera with a 50-70mm zoom. Incubating birds and chicks were counted using a digital pen on the photograph film, enlarged to 75x50 cm, or using MapInfo on digitalised photographs. In years when some chicks had already hatched at the time of the survey, we estimated the number of breeding pairs by adding the number of chicks to the number of incubating birds counted on the photographs.

Terrestrial expeditions to the Grande Kiaone colony in the Banc d'Arguin have been conducted during the first half of June each year since 2003. Observations were made by getting close to the colony with a mobile hide on a sandbank during the 2-3 hours of low tide. Observation periods were chosen to be during high tide periods at the end of the day to coincide with the return of the adults to the colony for feeding their chicks (Cézilly *et al.* 1994). The peak laying date was estimated based on the age of the chicks at the crèche. At Kiaone Island, flamingos breed among other waterbird species, such as *Sterna caspia*, *Ardea cinerea*, *Sterna anaethaetus*, *Gelochelidon nilotica*, *Phalacrocorax africanus* and *Platalea leucorodia balsacï*. We took all necessary precautions to avoid disturbing the birds, and in particular, we did not climb onto the island.

Results

Greater Flamingo breeding at the Banc d'Arguin
From 2003 to 2006, we estimated the peak laying laying date between 1st and 25th of March.

Table 1. Banc d'Arguin aerial and terrestrial survey dates and estimated peak laying dates of Greater Flamingos breeding on Grande Kiaone Island.

Year	Aerial survey	Terrestrial survey	Est. peak laying date
2003	26 April	26-30 May 12-16 August	10-15 March
2004	7 May	2-6 June	1-10 March
2005	9 April 3 June	4-7 June	25 March
2006	10 June	8-12 June	25 March
2007	17 April	12-15 June	1-10 March

Greater flamingos are now regular breeders on Grande Kiaone Island, where they find the lack of disturbance required for successful breeding. The number of breeding pairs varied from 8,200 in 2003 to a maximum of 16,600 in 2005 (Figure 2), with breeding success ranging from 43% to 83%. We suspect that the high number of breeding pairs recorded in 2005 could have resulted from the absence of breeding at Fuente de Piedra, the main Spanish breeding site. In contrast, a similar effect was not found in 2007 when there was no breeding in the Camargue.

From 2003 to 2007 we made a total of 160 resightings of 148 different birds, with 11 of them shown to be breeders, as they were feeding a chick in the crèche on Kiaone Island (Table 2). In 2003, the only banded breeder we saw had been marked as an adult in Spain, so its age and natal origin were unknown. In 2004, the two banded breeders observed were eight and seven years old respectively and had never before been observed breeding. In 2005, we observed a

much higher number of Mediterranean birds than were usual observed, and especially seven Spanish birds feeding chicks.

Table 2. Observation effort, number of bands resighted, origin of the resighted bands (number breeding), and percentage of the resighted birds that had not been sighted previously at Kiaone Island, Mauritania.

Year	Observation effort (hours)	Observation effort (days)	Bands read	Spanish	French	Italian	New bands (% of total read)
2003	25.5	7	16	11 (1)	4	1	16 (100%)
2004	27.5	5	29	20(1)	9(1)		27 (93%)
2005	21,15	5	50	47(7)	3		44 (88%)
2006	16.30	4	24	20(2)	4		17 (71%)
2007	14.30	4	36	33(0)	3		25 (69%)

Surveys of the Aftout es Saheli
A breeding attempt was observed in December 2004, but a terrestrial survey suggested that this breeding attempt failed, probably because of disturbance and/or poaching. The sites where flamingos had previously bred were empty of water at the time of our surveys in following years.

Juvenile dispersal
In 2007, we noted the quasi-absence of juveniles from the previous year in Banc d'Arguin National Park. In contrast, in May 2007, more than 20,000 flamingos were counted in the Aftout es Saheli, most of which were juveniles. However we cannot be certain that these juveniles come from Banc d'Arguin National Park.

Discussion
The large majority (92%) of bands observed at the Grande Kiaone colony were from birds hatched and banded in Spain. This suggests the existence of a Spain-to-Mauritania flyway. Hence the link between the Mediterranean and West African populations of Greater Flamingos is mainly due to Spanish birds, with 11 of them found breeding in the Banc d'Arguin.

The crèche and adults appeared to be less and less disturbed by the observers. In 2007, the crèche was very far down the cliff on Kiaone Island, enabling observers to have more opportunities to read bands, but at the same time making access more difficult.

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Conservation and management of the Greater Flamingo *Phoenicopterus roseus* at the Ebre delta

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Abstract

The Greater Flamingo *Phoenicopterus roseus* has been a regular breeder in the Ebre delta since 1993, foraging in coastal lagoons, bays, salt marshes, rice fields and saltworks. It breeds in the salt pans of the Punta de la Banya, and the colony size has increased from 250 to 1,900 pairs. In this paper, we summarize the main results of the conservation scheme developed by the natural park administration, which consists of four programs: 1) monitoring (bimonthly censuses, breeding colony survey, and banding and band resighting), 2) public environmental awareness (public information and participation, flamingo support scheme and resighting campaigns), 3) mitigation of damage to rice fields, and 4) survey and control in the salt works (wardens, control of saltpan water levels and control of the saltworks' activity). We suggest several future tasks, such as a powerful analysis of resighting data, a more quantified survey of rice crop damage and the relationships between the saltworks' activity and the conservation of the Greater Flamingo.

Introduction

The Greater Flamingo is a resident species in the Ebre delta, but its numbers vary greatly from month to month. Some reports indicate that it was an abundant breeding bird here in the 16th century (Despuig 1981), although there is no data until the 1970's, when the species is reported to have made several breeding attempts (Bigas and Vidal 2004). The species started to reproduce with success in 1993 on a small island of 0.6 ha (Tora dels Conills) within the Trinitat saltworks within the Punta de la Banya.

The Greater Flamingo is an emblematic species of the Ebre Delta Natural Park, and at the regional level it is listed as "Endangered" (EN), since the Ebre delta is the only place where it breeds. For these reasons, conserving the species is one of the main objectives of the park authorities, which implies an accurate monitoring program and a suitable habitat management. In this paper, we detail the monitoring program conducted by the park and the main results obtained up to 2007. We also provide an outline of the habitat management and environmental education programs.

Study area

The Ebre delta (330 km^2) is located on the north-western Mediterranean coast (40º 43' N, 0º 44' E) and constitutes the most important wetland between the Camargue in France and the Guadalquivir marshes further along the coast in Spain. Most of the upland is devoted to rice growing (>60% of the area), while the remaining area consists of natural marshes (coastal lagoons, salt marshes and bays). The Ebre Delta Natural Park covers about 7,300 ha of upland and 470 ha of marine area. The Greater Flamingo uses a wide range of habitats (including rice fields), although it is particularly abundant in the saltworks of the Punta de la Banya. The Punta de la Banya (2,500 ha) is a sandy spit connected to the delta plain by a narrow isthmus. Most of the area is covered by salt marshes and dunes, and includes 780 ha of commercial salt pans. This area has restricted access and was declared "Reserva Natural Parcial" (a protection status almost equivalent to "Integral Reserve").

Monitoring program

Bimonthly censuses

The park staff conducts bimonthly flamingo censuses in the bays of Fangar and Alfacs, the coastal lagoons of Canal Vell, Garxal, Calaixos de Buda, Tancada and Encanyissada, and the saltworks of the Punta de la Banya. These censuses are conducted within a wider waterbird monitoring program.

Annual breeding colony surveys
The number of breeding pairs and the number of chicks are counted just prior to fledging by aerial photography. We estimate breeding success from the quotient of the two counts. We also make regular observations from the ground to monitor breeding phenology.

Banding and band resighting
The capture and banding of fledglings with metal rings and PVC coded leg-bands began in 2004. The procedure is identical to those carried out in the Camargue and Fuente de Piedra (Johnson and Cézilly 2007). During the marking operation, measurements of mass, total tarsus length, wing length and bill length are taken, an estimation of the crop volume is made, and blood samples are collected for other studies (Avian Influenza, genetic research, etc). Finally, we conduct resighting sessions in different sectors of the park. All this information is recorded in the SIAM database of the Greater Flamingo Network.

Public Awareness and environmental education

Public information and participation
The banding operation is performed with the help of local volunteers, which provides the opportunity to combine scientific and public awareness dimensions. During the preparatory meeting, we emphasize the importance of conserving the flamingos and the Punta de la Banya reserve, along with the conservation and management actions conducted by the park.

The flamingo support scheme
Using the La Tour du Valat program as a model, in 2005, the Ebre Delta Natural Park started promoting the adoption of flamingo chicks hatched in the Ebre delta. In exchange for an annual donation, the park sends the sponsor an up-to-date life history of its flamingo each year. These funds are used to buy optical material for NGO's with few resources, in order to increase resightings in other Mediterranean wetlands.

Resighting outings
The Ebre Delta Natural Park also organizes resighting outings with volunteers and collaborators. These activities, stimulated by the sending of life-histories of the flamingos observed at the end of the session, improve the sensitization and promote resightings activities among volunteers.

Mitigation of damage to rice fields
During the first phases of rice growth (April-June), Greater Flamingos can cause damage to the rice fields, sometimes causing losses of production or additional costs of re-sowing or replanting. To discourage nighttime visits by flamingos, thus mitigating the conflict between farmers and conservation objectives, the park organizes spring scaring campaigns using flashing lights, hand-held halogen floodlights, and flares in the affected areas. When the scaring operation is not effective enough, technicians evaluate the loss of production and/or the additional costs, and the regional government pays for the damage.

Survey and control in the salt industry
Wardens
Many breeding birds of the Punta de la Banya are very sensitive to human disturbance. For this reason, public access is highly restricted and only activities related to research and the saltworks are allowed. The park has assigned a warden at the reserve almost all year, and especially during the breeding period.

Control of saltpans water levels
The warden periodically controls water levels in order to prevent terrestrial predators (e.g. Eurasian Badger *Meles meles* and Red Fox *Vulpes vulpes*) from accessing the colony.

Control of the saltworks activity
The salt industry in the Punta de la Banya has a temporary administrative concession, since it occupies a coastal area property of the Spanish state. This activity is conditioned by the rules and

regulations of the Ebre Delto Natural Park, thus making any modification or the creation of new infrastructures conditional to environmental authorizations.

Results
Monitoring programme
The bimonthly and wintering censuses show that the number of flamingos has steadily increased in the last 30 years (Figures 1 and 2). The wintering population, which ranged between 25 and 200 in the 1970s, has ranged between 5,800 and 8,300 birds since 2000. However, numbers can fluctuate greatly from month to month. They are at a minimum in June and July (2,800-2,900 birds from 1996 to 2006), and at a maximum from November to March (5,200-5,700 birds from 1996 to 2006). The population rise in this period is possibly related to the creation of the natural park (1983) and the recent colonization of the Ebre delta as a breeding site (1992-93).

Until 2007, the Greater Flamingo had bred successfully 13 times, and the number of breeding pairs had increased from 250 to 1,900 (Table 1). The number of chicks produced has varied from 38 to 1,294 (2001 and 1995, respectively). Breeding success has also fluctuated greatly, ranging from 0.15 to 0.82 chicks fledged per pair (2001 and 1995, respectively). Complete breeding failures occurred in 1992 (disturbed by a low-flying aircraft), in 1999 (disturbances for saltworks management/Red Fox impacts), and in 2005 (adverse weather conditions).
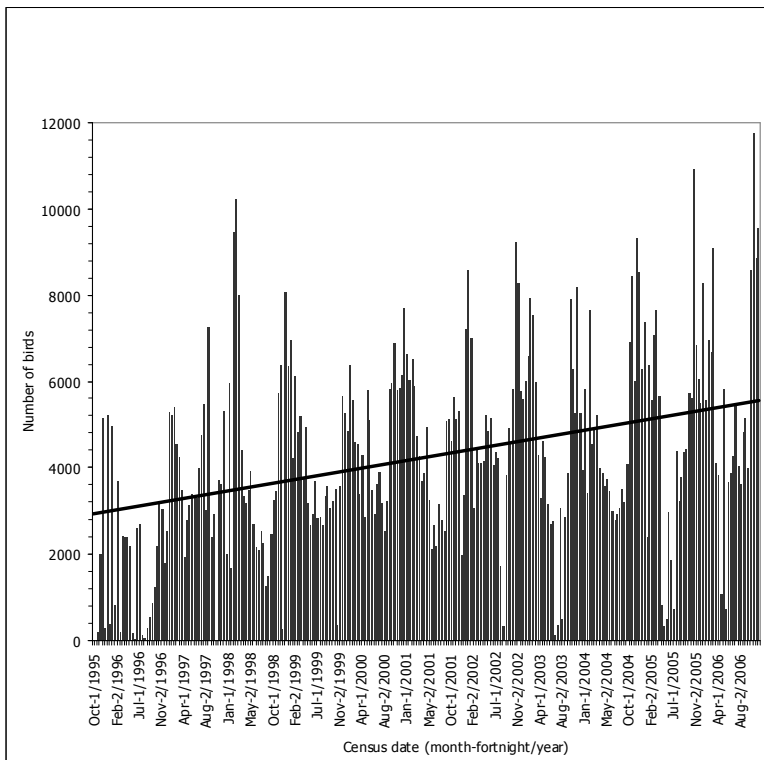
Figure 1. Bimonthly counts of Greater Flamingos at the Ebre delta from 1995 to 2006.

Since 2004, 1,200 chicks have been ringed and banded (about 400 chicks per year), representing 43.5% of the total chicks produced. By the end of 2007, 2,594 observations of these flamingos had been recorded (representing 886 different individual birds, or 73.8% of the total birds banded). The average of the number of resightings per individual bird has been 2.9,

although the range varies between 1 and 51 resightings. Observations of Greater Flamingos hatched in the Ebre delta have been distributed throughout 12 countries, although 86.7% of resightings are located in just four countries: Italy, especially along the Adriatic coast (29.3%), France, especially in the Aude coast and the Camargue (26.6%), Spain, especially in the Ebre delta (19.6%), and Tunisia, especially in Sfax (11.2%). Sorted by number of observations, the rest of countries are Algeria (238), Portugal (62), Morocco (18), Greece (13), Libya (5), Mauritania (4), Serbia and Montenegro (3), and Turkey (2).

From 1978 to 2007, a total of 10,346 resightings of 2,998 individual birds were made in the Ebre delta (about 345 readings per year). Most of the resightings (67.7%) have occurred between 2004 and 2007, with an annual average of 1,751 resightings (Table 1). Considering only the flamingos banded as chicks (n = 2,965), 52.3% of the birds come from the Camargue, 32% from Fuente de Piedra and 5.9% from the Ebre delta. A very small number of Greater Flamingos hatched in the marshes of the SW Iberian peninsula, Algeria, Sardinia, Italy and Turkey have also been observed.

Public awareness of the environment
About 600 people have participated to the flamingo banding operations organised during the past three years. We have made special efforts to involve participants from the different socioeconomic sectors of the Ebre delta (*e.g.* local associations of farmers, hunters and fishermen, local governments, NGOs, etc.). The event has been highly publicised in the local and regional media. The flamingo adoption scheme has resulted in the "adoption" of 72 flamingos and the purchase of a telescope that was given to the Gabès regional section of "Association les Amis des Oiseaux" of Tunisia (April 2006).
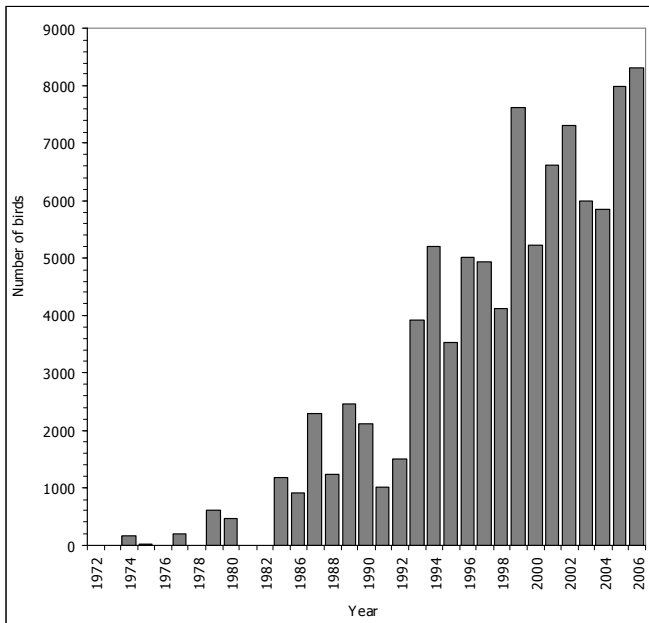
Figure 2. Winter counts of Greater Flamingo at Ebre delta from 1972 to 2006.

Effects on the rice fields
Campaigns of crop damage prevention have been conducted every year since 1993. The flamingos tend to affect primarily certain types of rice paddies (e.g. large plots, distant from wooded hedges, etc.) and the same fields can be visited in consecutive years (Jiménez and Soler
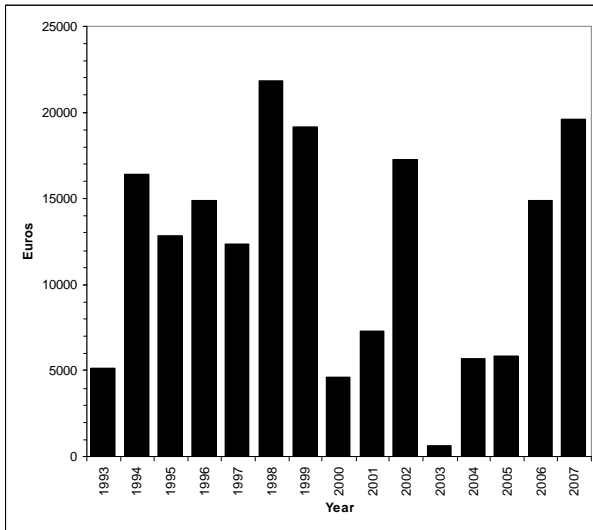
1996). During this period (April-July), farmers inform the park authorities of the presence of flamingos in the rice paddies. After checking that the damage has not been produced by other species (*e.g.* Mallard *Anas platyrhynchos*), 2-4 groups, each consisting of two people, install flashing lights in the affected plots and, if necessary, they can use hand-held halogen floodlights and flares. This is done every night (from before sunset to morning). An average of 11,907 € per year (Figure 3) has been used to compensate farmers when damage could not be avoided, although with large yearly variations (Roig 2006).

Survey and control in the salt industry
Control of the saltworks activity is a priority conservation goal of the Ebre Delta Natural Park, not only for the Greater Flamingo, but also for many threatened species (Slender-billed Gull *Larus gene*i, Common Shelduck *Tadorna tadorna*, etc.). The saltworks are located in a highly dynamic coastal area, with a strong weather environment. This requires regular maintenance of the dykes. Since 1999, the salt industry company has constructed several new dykes, some of them near the saltpan where the Greater Flamingo breeding colony is located, with the goal of mitigating the sudden changes in water level produced by strong NW winds. On the other hand, regressive coastal dynamics has promoted the inland reconstruction of the southern dyke. More recently, the saltworks company has proposed increasing the compartments of the saltpan occupied by the Greater Flamingo colony. All these actions are evaluated previously by the technicians of the park, generally with the advice of the Flamingo Specialist Group.

Table 1. Breeding parameters, and banding and resighting data at Ebre delta. No. of breeding pairs was estimated from ground counts. (1) Number of chicks fledged/number of breeding pairs

Year	Number of breeding pairs	Number of chicks fledged	Breeding success (1)	Number of chicks banded	Number of resightings of flamingos hatched in the Ebre delta	Number of resightings in the Ebre delta
1992	251	0	0			17
1993	503	313	0.62			93
1994	600	306	0.51			70
1995	1,500	1,294	0.86			286
1996	1,500	945	0.63			41
1997	1,273	788	0.62			149
1998	1,461	476	0.33			457
1999	0	0	0			209
2000	1,600	1,041	0.65			157
2001	251	38	0.15			34
2002	1,677	572	0.34			687
2003	1,355	406	0.30			807
2004	1,600	907	0.57	399	307	1,539
2005	0	0	0	0	341	1,809
2006	1,907	960	0.50	400	849	1,825
2007	1,800-2	891	0.45-0.50	401	993	1,761
Mean	1,233	640	0.42			

Figure 3. Yearly amount expended due to rice fields damage caused by the Greater Flamingo in the Ebre delta (1993-2007).

Conclusions
After a steady population increase since the 1970s, the Greater Flamingo has bred in the Ebre delta almost continuously since 1993, and now constitutes one of the stable colonies of the Mediterranean basin (Johnson and Cézilly 2007). Among other factors, the current situation is due to environmental improvement related to the creation of effective protected areas (1983), mainly under the guidance of the Ebre Delta Natural Park and Natural Reserve (Rendón-Martos 2004). The monitoring program conducted by the park brings very valuable conservation information at local and global scales.

Conservation actions have not been limited to the breeding colony, because of the strong interactions between some economic activities (rice crop and salt industry) and the Greater Flamingo. For these reasons, the park also helps mitigate the conflicts (scaring campaigns in the paddies, surveillance in the saltworks), as well as different actions (ringing campaigns, partnership, etc) to raise public awareness on the importance of the Greater Flamingo conservation.

In the future we aim to consolidate the tasks accomplished to-date: monitoring, management and environmental education. However, some goals deserve greater emphasis, like a powerful analysis of resighting data, a more quantified survey of rice crop damage, and the relationships between the saltworks activity (creation of new dykes, hydrological management) and the conservation of the Greater Flamingo.

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The breeding of Greater Flamingos *Phoenicopterus roseus* in the Guadalquivir marshes from 1989 to 2007

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Abstract

We summarize the breeding events of Greater Flamingos in the Guadalquivir marshes, southwestern Spain, from 1989-2007. During this period the flamingos established colonies, in which they started incubation, in 8 years. There were also breeding attempts in other 3 years, in which incubation was not started. There were considerable interannual variations in breeding pairs, which ranged 120-13,200. In most years there was some management to facilitate fledging success. In spite of this, breeding success was very low, ranging 0-26.5%. The colonies suffered heavy predation by Wild Boars and gulls.

Introduction

In a previous paper (Máñez 1991) we summarized the breeding events of Greater Flamingos *Phoenicopterus roseus* in the Guadalquivir marshes until 1988, presenting data on colony sizes, laying dates and breeding success. In the present paper we summarize the breeding cases from 1989 until 2007.

Study area

Our observations were conducted at the Guadalquivir marshes in southwestern Spain. These marshes are a wetland complex (natural marshes, ricefields, fish farms, saltworks) in which water levels mainly depend on rainfall. In a typical year, the marshes flood in autumn/winter and dry out in June/July (see Valverde 1958).

Material and methods

Once the settlement of adults was observed at breeding sites, we paid regular visits to those sites to estimate laying dates. Laying date was considered as that in which the first egg was observed, or by backdating from hatching dates. We estimated colony sizes from an airplane or from land. Once breeding had finished and there were no adults around the colonies, we estimated the number of nests and counted the number of both unhatched and depredated eggs, as well as the number of dead chicks. The number of chicks alive was also estimated, or counted directly when chicks were reared in captivity (see below). The difference between the number of nesting pairs and fledging chicks served to estimate breeding success. Meteorological data were obtained from the station at Palacio de Doñana, and are referred to the period September-April.

Results

After the breeding season of 1988 (Máñez 1991), Greater Flamingos did not attempt breeding again until 1996, likely because of a dry period, in which yearly rainfall was always < 480 mm, except 1989-1990 when rainfall was 953 mm.

The main breeding parameters of the breeding attempts during 1996-2007 are summarized in Table 1. From 1996 onwards, Greater Flamingos no longer bred at the site used during 1977-1988 (Veta de las Vaquiruelas in Doñana National Park, Máñez 1991). Breeding success in the Guadalquivir marshes during 1996-2007 was very low (0-26.5%, Table 1).

In 1996 the colony was established in late May at Vetones del Burro (Marisma de Hinojos, Doñana National Park), and deserted in late June because of heavy nest predation by Wild Boars *Sus scrofa*. In 1997 the colony site was occupied in late April. Only 600 adults remained after a heavy hailstorm on 30th May, some of which have their belly feathers tinged with eggs' yolk, suggesting that many birds deserted the colony because of hail. On that date we counted 98 chicks. The large number of deserted eggs attracted Black Kites *Milvus migrans* and Lesser Black-backed Gulls *Larus fuscus*, as well as Wild Boars. On 19th June there were no adults nor

chicks at the colony site, and only 19 were found in nearby sites. Such chicks were captured and reared in captivity, being released when able of flying.

Table 1. Location of breeding sites of Greater Flamingos, breeding parameters, and rainfall (September-April) in the marshes of the Guadalquivir, SW Spain, during 1996-2007. All sites, except Veta la Palma (a fishfarm) and the saltworks of Sanlúcar de Barrameda, are in Doñana National Park. (Colony size= number of nests or number of pairs).

Year	Site	Colony size	Nesting pairs	Chicks hatched	Fledging	Rainfall* (mm)
1996	Vetones del Burro	1250	≥ 205	0	0	897.0
1997	Vetones del Burro	700	≥ 220	98	19	
	Veta la Palma	30	0	0	0	782.8
1998	Vetones del Burro	1000	≤ 1000	155	138	672.71
2000	Madre Marismas	7	0	0	0	
	Veta la Palma	80	0	0	0	399.1
	Salinas de Sanlúcar	70	0	0	0	
2001	Veta Castellana	30-40	0	0	0	
	Vetones del Burro	2539	≥ 1781	956	281-311	651.3
2002	Vetones del Burro	3.020	≤ 3020	0	0	560.2
2003	Vetones del Burro	15226	≥ 5186	2285	963	
	Veta del Hierro	1000	≥ 120	0	0	549.1
2004	Vetones del Burro and other 6 sites	13507	≥ 13187	5331	3500	710.0
2005	Veta la Palma	80	0	0	0	167.0
2006	Veta Reguera	50	0	0	0	434.6
2007	Veta Reguera	500	≤ 500	90-95	52	
	Veta Ansares	1200	1200	0	0	633.2
	Veta del Hierro	300	≤ 300	0	0	

*Referred to September-April

The breeding site was occupied in 1998 in late April by about 1000 pairs. On 19th June, when water levels were very low, all chicks were captured and reared in captivity until they were able of flying, being then released.

Water levels in the marshes were very low in 1999 (rainfall = 240 mm), and there was no breeding, though there were two breeding attempts (nests constructed). One of them was in a fishfarm (Veta la Palma), where the flamingos had also attempted breeding in 1997 and 1998. The other attempted case of breeding in 1999 was at the saltworks of Sanlúcar de Barrameda.

Water levels in the marshes in 2000 were also very low, and in spite of that, Greater Flamingos attempted breeding, laying four eggs that were abandoned before incubation. There were also two additional breeding attempts, but the sites were abandoned before laying.

In mid-April 2001 Greater Flamingos attempted breeding at Veta Castellana in Doñana National Park, but the site was soon entered by Wild Boars, and the flamingos deserted. Almost simultaneously, the flamingos started laying at the Vetones del Burro. On 19th June we captured all chicks (956), which were transported by vehicles to a flooded fenced area (4 ha) located 8.2 km north of the breeding site. In the afternoon of the same day in which the chicks were moved to the flooded area, we observed adults feeding their chicks. However, in this site there was an episode of intoxication by cyanobacteria (Alonso-Adicoberry *et al.* 2002), and only about 30% of chicks survived (the exact number is difficult to estimate, because these site was used by fledgings dispersing from the Fuente de Piedra colony).

In 2002 the Vetones del Burro were occupied in mid-April, but the site was deserted on 25th April, after Wild Boars entered the colony. There were also two failed breeding attempts, one of them in Veta la Palma fishfarm, and another in Sanlúcar de Barrameda saltworks.

In 2003 the flamingos occupied first the Vetones del Burro, and there was also one late breeding attempt in Veta del Hierro (Marisma de Hinojos, Doñana National Park). On 15th June there were no adults incubating, and all chicks were in a compact crèche. Because the marshes started to dry out, a corridor (450 m) was made by mowing emergent vegetation, connecting the breeding site with areas in which water levels were deeper. On 9th July the chicks were guided to these zones of deeper water by men on horseback. However, most chicks were not able to fly before these zones dry out, so that on 25th July all remaining 1209 chicks were captured and transported by vehicles to the same flooded fenced area to where chicks were moved in 2001. We estimate that about 80 % of chicks survived.

Water levels in 2004 were high and breeding success was the highest for the studied period. In this year, human intervention was minimal. The flamingos settle first in the Vetones del Burro in late March, but during April other three colonies were established, located at Veta del Hierro, Veta Reguera and Veta de los Ánsares. All these colonies produced chicks. Furthermore, in May, the flamingos settled at Veta Quemada, Veta Tres Puntas, and Pacil de Veta la Arena, where some chicks hatched in the first two sites. On 12th July the chicks were guided by men on horseback to flooded areas through a system of corridors in which emergent had been mowed.

2005 was the driest year of the studied period, and the flamingos did not attempt breeding in Doñana National Park, though in mid June we observed 80 nests in Veta la Palma fishfarm, where no eggs were laid.

About 6000 flamingos settled in early April 2006 in Veta Reguera. We counted 50 nests on 11th April, but the site was deserted in late April. No laying was detected.

Finally, in 2007 the flamingos settled in three sites located at Veta de los Ánsares, Veta del Hierro and Veta Reguera, though chicks hatched only in the last one. Most nests at these sites were preyed upon by Wild Boars and Yellow-legged Gull *Larus michahellis*. We recorded a few cases of chick predation by Black Kites and Red Kite *Milvus milvus*.

Discussion

Despite that flamingos bred in rainy years, when water levels were higher, some management was necessary because wetlands in the marshes usually dried out before the chicks could fly (see also Valverde 1960, Rodríguez 1983, Máñez 1991). However during years in which water levels were very high, such as 1990, the flamingos did not attempt breeding, likely because the nesting sites were flooded. In years of low water levels, when rainfall during September-April was < 480 mm, there were some breeding attempts, mostly in saltworks or fishfarms, but the flamingos did not laid eggs.

There was no correlation between rainfall, indicative of water levels, and colony sizes or fledging successes in the Guadalquivir marshes (see Table 1). Colony size in these marshes may be related to breeding conditions in Fuente de Piedra lake, which seems to be preferred as breeding sites by Greater Flamingos (Rendón *et al.* 2001). In spite of management actions, breeding success in the Guadalquivir marshes was very low in most years, as predators usually entered colony sites and this caused the desertion of nesting sites by adult flamingos.

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Greater Flamingo *Phoenicopterus roseus* breeding in Sardinia: numbers and management issues

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Abstract
The Greater Flamingo *Phoenicopterus roseus* was possibly a breeding species in Sardinia in the 19th and early 20th centuries. After several breeding attempts in the 1970s, breeding colonies were recorded continuously in the immediate surroundings of Cagliari city beginning in 1993. They were sited initially on the Stagno di Molentargius, and then also at Saline di Macchiareddu. Breeding success was affected by several limiting factors, usually connected with the high level of human activities in this area. Nevertheless, except for a few instances of total colony failure due to disturbance by stray dogs and unauthorized people, breeding success has been relatively high, between 61% and 94%. Colour leg band marking of chicks began in 1997 and showed a widespread juvenile dispersion to North Africa, France and Spain. Based on ring readings, the Cagliari breeders rely on many wetlands within a radius of 100 km for feeding.

Introduction
Sardinian wetlands have long been known as stop-over and wintering grounds for the Greater Flamingo. Some historical, unconfirmed information about breeding was reported in the 19th century and early 20th century (Cara 1842, Giglioli 1886, Bittanti 1911). There were no further reports of breeding until a few failed attempts were recorded in Stagno di Molentargius in 1975, 1980 and 1992 (Schenk 1976, Mocci Demartis and Pinna 1980, S. Nissardi, unpubl. data) and in Saline di Macchiareddu in 1979, 1981 and 1982 (Brichetti *et al.*1992).

Regular breeding began at Stagno di Molentargius in 1993 (Schenk *et al.* 1995, Johnson and Cézilly 2007 and references therein). Since then a considerable increase of the number of breeding pairs has been recorded. The colonies were located initially at Molentargius and later in nearby Saline di Macchiareddu. Several recent breeding attempts outside the Cagliari wetlands were recorded also, but these always failed, probably because of disturbance by people, dogs or foxes. In 1997, we joined the Greater Flamingo banding program, and continued the effort sporadically afterwards due to lack of funds.

In this paper we present estimated breeding colony sizes and success, and an analysis of the dispersion of flamingos banded at the Sardinian colonies during a 15-year period.

Methods
The estimates of the number of breeding pairs were based either on distance counts of the brooding birds and/or nest counts after the breeding season. The numbers of fledglings have been estimated by distance counts of the crèche, but in two cases counts were made using pictures taken from a helicopter. Breeding success has been estimated by number of fledglings / number of pairs (minimum values). In Macchiareddu, estimated breeding success from 2004 to 2007 was improved by the additional count of dead chicks and of the lost/abandoned eggs near the breeding colony. For the analysis of the dispersal of Sardinian-ringed birds, we only considered the first resighting of a bird in each country/region.

Results
Until 1998, only Stagno di Molentargius was occupied by flamingos, with a fluctuating number of breeding pairs (Table 1). Since 1999, Saline di Macchiareddu has been colonized, and from 2004 onwards, this latter site has become the most important, with increasing numbers of the breeding pairs. Breeding success has always been high, between 61% and 94%, except in two years of total abandonment of the colony.

Table 1. Numbers of Greater Flamingos breeding in Stagno di Molentargius and Saline di Macchiareddu, 1993-2007

	Stagno di Molentargius			Saline di Macchiareddu		
Year	Pairs	Fledglings	Breeding success	Pairs	Fledglings	Breeding success
1993	1300	940	72%			
1994	860	710	83%			
1995	750	635	85%			
1996	950	850	89%			
1997	2400	1800	75%			
1998	4400	4120	94%			
1999	700	0	0%	800	600	75%
2000	2700	2500	93%	700	0	0%
2001	2392	0	0%			
2002	3100	2840	92%			
2003	4600	4000	87%	1400	850	61%
2004	1500	1200	80%	6500	5600	86%
2005				7600	6900	91%
2006				7400	5800	78%
2007				14000	12000	86%

Several failed breeding attempts have been recorded in the following localities and years: Sulcis wetlands (SW Sardinia) in 2000 and 2001 (Grussu, 2000; 2001); Stagno di Cabras (north of Oristano) in 2001; Stagno di S'Ena Arrubia (south of Oristano) in 2001 and 2003 (Nissardi and Zucca, unpubl.). The two cases of complete abandonment in Stagno di Molentargius resulted from the presence of stray dogs. In 1997, they caused the desertion of the colony during the display phase (the colony then moved to Saline di Macchiareddu), and in 2001 they caused the total abandonment of the eggs at the end of the incubation period, without any other successful breeding attempt in the same season. The total desertion of the Saline di Macchiareddu colony in 2000 was caused by human disturbance.

Further causes, due especially to the high level of human disturbances in the area, have limited the breeding success though generally with a modest impact:

1) In 1993, in Stagno di Molentargius, the high media interest in the first breeding episode attracted a lot of photographers and filmmakers. They caused great disturbance during the occupation phase of the colony and the abandonment of the nests closest to their hide. Some disturbance by photographers has been recorded more recently in Saline di Macchiareddu.

2) In some cases, hydraulic works occurred in the vicinity of the breeding site. As a consequence, sometimes the flamingos delayed their occupation or moved to other breeding sites.

3) The presence of power lines (now removed from Stagno di Molentargius but still present in Saline di Macchiareddu) caused high mortality among both adults and young (in 1997 nearly 8% of the locally-banded chicks struck power lines right after fledging).

Predation by the Yellow-legged Gull *Larus cachinnans* is low in Stagno di Molentargius, where less than 10 gull pairs breed, and higher in Saline di Macchiareddu, where this is probably the main cause of egg/chick losses which amounting to 1,600-2,000 in 2007.
A further problem, verified in Stagno di Molentargius when this was the only site occupied by flamingos, was dyke erosion as they are not maintained due to the interruption of salt production. This led to a scarcity of dykes and islets causing strong competition for breeding sites that affected mainly other waterbird colonies, especially Slender billed Gull *Larus genei*, and forced them to select sub-optimal sites.

From 1997 to 2007, in eight ringing operations, 3,135 chicks were banded. As many as 7,278 resightings, corresponding to 1,837 individuals, have been made on 2,717 chicks banded up to 2006 (Table 2).

Table 2. Numbers of banded chicks, individual bands read and total sightings

Year	Locality	Banded	Individuals resighted	Total resightings
1997	Molentargius	404	315	1,482
1999	Saline Macchiareddu	200	134	738
2000	Molentargius	383	169	835
2003	Saline Macchiareddu	312	250	1,068
2004	Saline Macchiareddu	499	353	1,402
2005	Saline Macchiareddu	426	302	939
2006	Saline Macchiareddu	493	314	814
Total		**2,717**	**1,837**	**7,278**

Most chicks leave the breeding site just after fledging. Apart from the 1,076 Sardinian re-sightings (data strongly influenced by re-sightings sessions made in the nursery soon after banding), most re-sightings came from France, Tunisia, Spain, the Adriatic, Algeria and the Tyrrhenian coast of Italy (Figure 1). Probably, the main dispersion areas of young Sardinian flamingos is North Africa, as suggested by the relatively high number of re-sightings from Tunisia and Algeria, where the reading effort is presumably lower than in France, Spain and Italy.
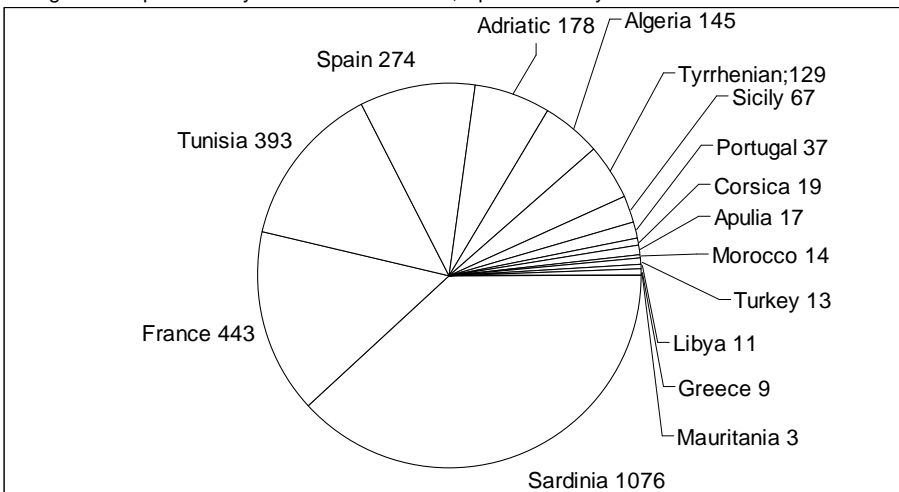
Figure 1. Number of individuals banded in Sardinia up to 2006, and re-sighted in different countries or regions

Discussion

Conservation of the Sardinian breeding population depends mainly on the management plans of the two breeding sites: the active salt-pans of Saline di Macchiareddu and the disused salt-pans of Stagno di Molentargius, which are presently a Regional Park, the management of which is actually under discussions.

However, band re-sightings during the breeding period suggest that survival of the breeding population also strongly depends on the management of many other Sardinian wetlands within a radius of 100 km from Cagliari that the birds use for feeding. The availability of abundant food

resources and the low incidence of limiting factors help explain the high productivity recorded to-date at the Sardinian colonies. An increase of re-sighting effort at the feeding wetlands during the breeding period is one of the monitoring priorities of flamingo project in Sardinia.

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The Flamingo Project in mainland Italy: an update of the situation at the end of 2007

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Abstract
This paper provides a summary of the colony sizes, breeding success and ringing totals at the two Greater Flamingo *Phoenicopterus roseus* breeding colonies of mainland Italy (Margherita di Savoia and Comacchio), from their initial colonisation through 2007. Both colonies are located along the Adriatic coast. They exhibited marked growth only during the first few years following their initial settlement. Chicks have been ringed every year only at the Comacchio colony. The distribution of resightings spans the entire Mediterranean, although in NW Africa, there have been fewer resightings of Italian-ringed birds than of birds ringed at more western colonies. Ring monitoring at the Adriatic colonies has revealed that the origin of the breeding birds at both sites is similar. Locally ringed birds are now well represented among Comacchio breeders.

Introduction
In the past decade, Greater Flamingos have regularly bred on the Adriatic coast of the Italian peninsula: at Margherita di Savoia in the south (since 1996, Figure 1) and at Comacchio in the north (since 2000, Figure 2). Both colonies are in salinas, although industrial salt extraction ceased at Comacchio in 1985, and water levels are now kept relatively constant year-round. The Comacchio saltpans, c. 400 ha, occupy just a small corner of a larger natural wetland (Valli di Comacchio, 12,500 ha) that is connected to the sea by canals and characterised by a relatively high tidal regime for Mediterranean standards. At Margherita di Savoia, the salina is nearly 10 times larger and entirely covers what, in ancient times, was a coastal lake. Salt production still goes on and has recently been privatised. As there is no specific management of the flamingo breeding sites in either location, breeding success is quite variable. In this report, we provide data on breeding colony sizes, breeding success and ringing totals at both sites, since their initial colonisation to 2007. We also discuss some preliminary results obtained by ring resightings at these sites.

Materials and methods
The two sites were monitored with a very different intensity, temporal coverage at Margherita di Savoia being usually less complete (especially in recent years). Colony size was usually determined by counting nest mounds in all colony sectors where there had been incubating adults. Breeding success was estimated at Comacchio by counting all trapped and escaped/released chicks during the ringing operation. At Margherita di Savoia, breeding success was estimated by censusing the nursery as late in the season as possible, before any juveniles fledged. The Comacchio ringing operations were performed by teams of up to 100 participants, usually in early July, following the La Tour du Valat methodology.

Figure 1. One of the three colonies that were simultaneously present at Margherita di Savoia in June 2005 (photo G. Albanese). This peripheral dyke (originally 6 km long, now fragmented into several sections) has hosted all the successful colonies recorded since the year 2000, (*i.e.* since erosion has made all the central dykes unsuitable).


Figure 2. The Comacchio colony in May 2008 (photo G. Arveda). Here flamingos have always bred in the same part of the salina, on man-modified islands within a large semi-natural pan ('Valle Lamenterio') once used in the pre-evaporation stage.

Results and discussion

Colony size, breeding success and ringing totals
Figures 3 and 4 offer an overview of the colony size, number of fledged juveniles (as an indication of breeding success), and ringing totals in the two colonies up to the year 2007. The phenomenon of autumn breeding, observed in the early Margherita years (cf Johnson & Cézilly 2007), was never recorded more recently. Breeding success is usually quite low especially at Margherita, where water levels are regulated according to industrial criteria, with sudden floods and similar problems. A proportion of chicks usually greater than 50% was ringed every year at Comacchio only (N ringed = 2322 from 2000-2007).
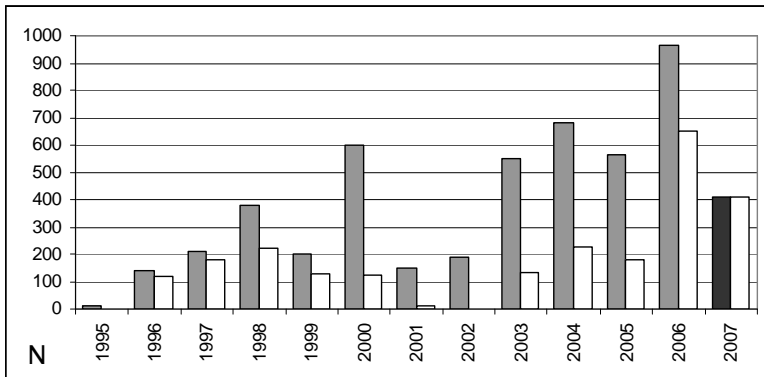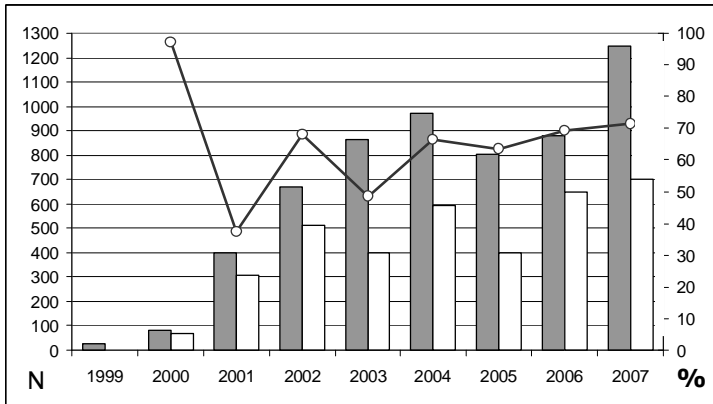

Figure 3. Colony size data from Margherita di Savoia. Grey bars: number of breeding pairs (from empty nest counts); white bars: number of fledged chicks. Nests were not counted in 2007 (black bar: minimum estimate, equalling number of chicks).

Ring monitoring in Italy and elsewhere
The start of Italian ring sightings has been impressive, with nearly all the birds of the first cohort being resighted within one year after fledging (Baccetti and Dall'Antonia 2002). However, it was not an ephemeral performance. There were 991 resightings of the 2005 cohort from banding to their second year of life (July 2007), corresponding to the observation of 248 individuals out of 255 ringed. Overall, through 2007, the blue Comacchio rings had been resighted 19,954 times on 2,122 individual birds.

Figure 4 shows the localities where at least one Comacchio-ringed bird has been recorded. The southwestern part of the range (*e.g.* Morocco) turns out to be unusually poor of dots, being probably seldom visited in comparison to what appears from dispersal maps of birds of a more western origin (*e.g.* see Tab. 9 in Johnson and Cézilly 2007). In the souteast, by comparison, there is possibly a gap in coverage. A recent (post-2007, thus not shown) bird shot in Syria and two observations in eastern Libya, however, represent a significant extension in this sector. Within Italy, but outside the breeding colonies, many wetlands have now a local team of regular ring-readers and a sort of 'competition' among them is organized every year on a fixed date, in order to further spread this activity among bird-watchers and improve the site coverage.

Figure 4. Colony size data and ringing performances at Comacchio. Grey bars: number of breeding pairs (from empty nest counts); white bars: number of fledged chicks; line (referred to the second y-axis): proportion of chicks that were caught and ringed.
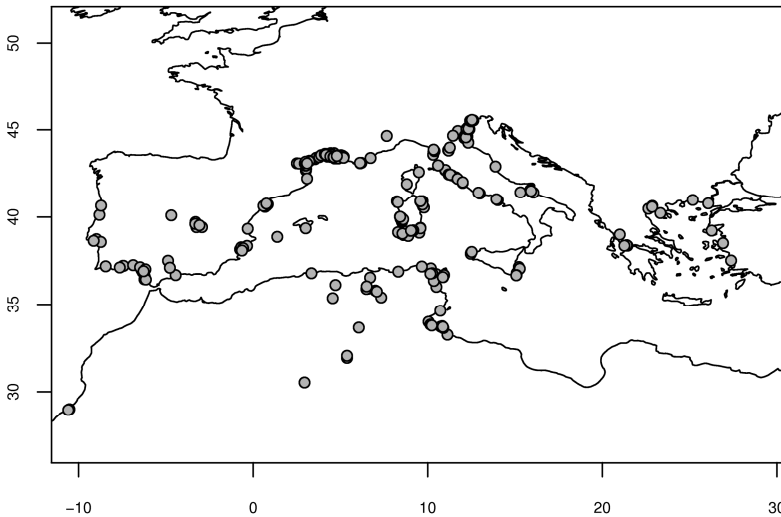
Figure 5. Sites of observations of all the Comacchio-ringed flamingos, based on nearly 20,000 ring readings

Ring monitoring at the two colonies
Ring-monitoring is conducted every year at the Comacchio colony, whereas monitoring at Margherita di Savoia occurs quite irregularly (no ring readings of breeding birds in 1997, 2000, 2001, 2005, 2006; max. 60 rings read in 2003). Nevertheless, the origins of the ringed breeders appears to be remarkably similar in the two colonies (Figure 6), except that at Comacchio, birds of local origin are obviously over-represented when compared to the Comacchio origin at Margherita, whereas at Margherita no category exists for locally ringed birds.
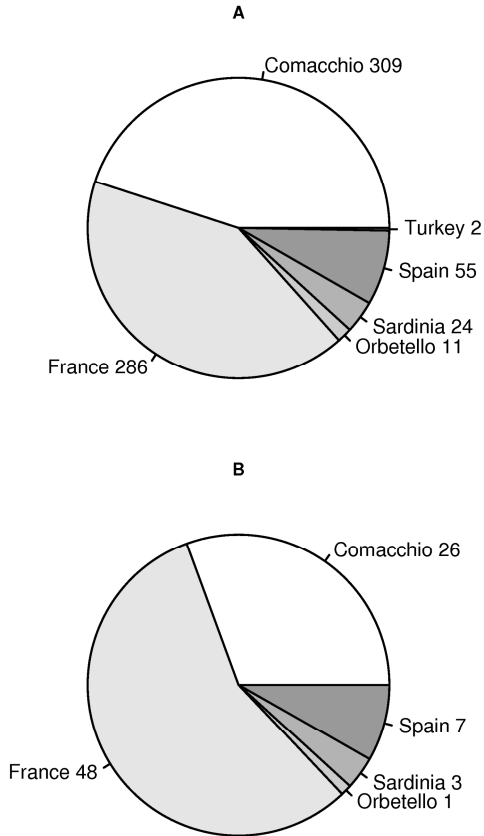
Figure 6. The natal origin of marked birds recorded breeding at Comacchio (A) and Margherita di Savoia (B). Periods of reference are: for A, all years 2000-2007 (min: 22 individuals in 2000, max: 267 individuals in 2007); for B, eight years from 1995 to 2007 (blank years listed in text). Andalucia and the Ebro delta were lumped in the 'Spain' category. Small sample size in B (85 inds./year vs. 687 in A) did not allow recording the rarest origin (Turkey). At Comacchio (A), single Turkish birds were recorded as breeders in 2004 and 2007, Comacchio-hatched birds were recorded every year since 2002, and all the other origin categories were represented every year.

In the Comacchio colony, Comacchio-hatched birds were recorded every year from 2002, when they first appeared as apparent recruits (Figure 7). After the age of 2-3 years, no cohorts seem to be represented by increasing numbers of birds. Some cohorts (*e.g.* 2002) are over-represented compared to the others, due to an originally higher number of ringed birds. However, this does not bias a comparison made along the rows of Figure 7 (*i.e.* looking at the importance in time of each particular year of birth), because in these graphs, the same individuals were counted anew for each year of monitoring, and there is probably a strong effect of site fidelity. A hypothesis that we may be able to test statistically, once the sexually mature cohorts are more numerous is: A small colony, such as the Comacchio colony, which shows no real signs of increase, but provides very constant habitat conditions, may be a settling option for a given number of local birds just when

they are at the age of their first breeding attempts. The rest of the birds of the cohort would then start queuing at any of the 'big' colonies (Fuente de Piedra, Fangassier, Macchiareddu), or attempt colonizing new sites. The group of birds that succeeded in settling at Comacchio would appear again one year later with a similar individual composition (due to philopatry), and thus with the same number of birds. This pattern would repeat in time, leaving perhaps progressively less space for the younger cohorts, but each one of them being constantly represented in time. It would be interesting to carry on monitoring this and other 'small' colonies, beside the big ones, in order to confirm this hypothesis.
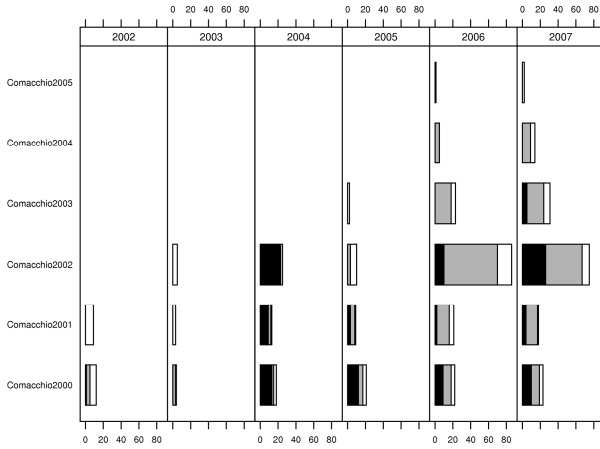
Figure 7. Presence in the Comacchio colony of locally-marked breeding birds in every year (columns) since they first appeared as apparent recruits in 2002: white, "at the colony" (juvenile birds excluded); grey, probably breeding (dirty plumage, paired, displaying near colony); black, confirmed breeders. Number of birds in the x-axes.

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Analysis of the mass of raw data on Greater Flamingos *Phoenicopterus roseus* on their wintering grounds, particularly in North Africa

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Abstract
Over the last forty years a great deal of data has been collected on the Greater Flamingo *Phoenicopterus roseus* in Tunisia, including winter and summer counts, and the resightings of >10,000 ringed birds. Sadly, these data have never been systematically analysed. This paper presents an outline of the situation in Tunisia, emphasising the need for analysis of the data in order to fill what we consider as a major gap in our understanding of the Greater Flamingo population dynamics and migratory strategy.

Introduction
A great deal of data has been collected on flamingos in Tunisia. This includes counts, with information on numbers at a variety of sites going back over forty years. For some years there are near-complete censuses of all major sites, mainly in the winter period but also in summer. In addition, a vast number of readings of Darvic rings (c. 10,000 readings) have been made since the ringing programme in the Camargue began in 1977. In recent years, there have been readings of rings from the Ebro and Andalusian colonies in Spain, from Sardinia, Orbetello and Comacchio in Italy, from Algeria, and from Turkey.

Sadly, these data have never been collected or systematically analysed, so the information and views presented here are based on field experience and impressions over many years, rather than on systematic analysis. In general, detailed studies of flamingos have in the past concentrated on the breeding grounds, where the major research stations and the biggest concentrations of scientists are found. However, since the flamingos spend more than half the year away from the breeding colonies, this period of their life also needs to be fully analysed and understood. In this paper we present only an outline of the situation in Tunisia, but we suspect that the same is true of Algeria and Morocco.

The Importance of Tunisia for Greater Flamingo
Tunisia is generally considered to be important as a wintering ground for Greater Flamingos. In fact, the country is also important at other times of the birds' life-cycle, for breeding and summering, and for the generally overlooked function as a 'kindergarten' for immature flamingos.

The Tunisian Government designated 19 new Ramsar sites on 7 November 2007, including several major flamingo sites such as Korba, Sejoumi, Kelbia, Thyna Saltpans, Kneiss Islands, three sites round Djerba and Bahiret el Bibane. Basic site conservation measures are in place.

Importance for breeding flamingos
Traditionally, breeding occurs in Tunisia only occasionally, after unusually wet winters, and normally in large natural saline basins in central and southern Tunisia. Major historical breeding events were in 1970, with a massive breeding colony at Chott Jerid/Fejaj, in 1974 at Sidi el Hani with 10,000 pairs, and in 1991 at Sidi Mansour with 4,000 pairs (Figure 1; Johnson and Cézilly 2007). There has been no major breeding colony in Tunisia since 1991. We are due for a wet winter in southern Tunisia fairly soon, as suggested by previous gap durations among the breeding episodes. This event, when it finally comes, should meet a favourable situation in terms of teams of wardens, observers and ringers.

In addition to traditional breeding at huge colonies in southern Tunisia, occasional breeding attempts are made by small numbers of birds, probably only just sexually mature. In Thyna saltpans, small breeding attempts are recorded almost every year, with finally 17 young raised in

2007, probably the first time in recent years that young have actually fledged (Azafzaf *et al.* 2007). Breeding has also occurred at least once in the last 20 years, probably unsuccessfully, at Ariana, Sejoumi, Lake of Tunis and Ichkeul. It would be possible (and not too difficult?) to create a man-made breeding site in Tunisia like those in southern Europe (*e.g.* at Thyna saltpans), but the question remains if we want to encourage such measures.
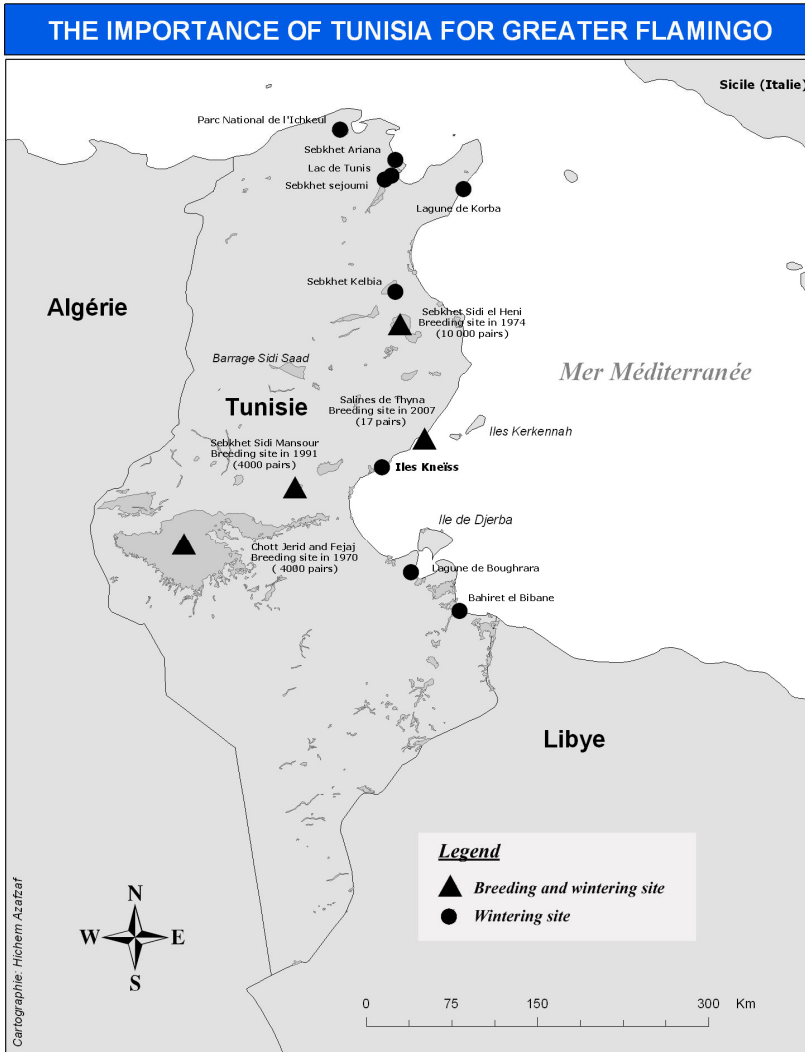
Figure 1. The main breeding and wintering sites of Greater flamingos in Tunisia. Source: Johnson and Cezilly 2007.

59

Importance for summering flamingos

Not all sexually mature adults return to breeding colonies in Europe. Many which winter in the vast saline depressions of southern Tunisia are obliged to move north in summer because southern sites dry out. Are these birds waiting for a wet year when they can breed in the south? Or, are the adults seen in Tunisia in summer failed breeders returning early from the colonies? Do some birds never return to European colonies? Ring resightings indicate that some adults (especially Spanish birds) arrive in Tunisia as juveniles and seem to stay for a very long time, without ever returning to their natal area.

Some summering sites (*e.g.* Sejoumi) have much higher proportions of adult birds while others (*e.g.* Korba) attract more 2-3 year old birds (Figure 1). It is possible that there are different summering areas for different age cohorts. Other sites where water is not too saline (*e.g.* Ichkeul National Park – IBA n° 002 since the restoration of fresh water conditions in winter 2002-03) attract large numbers of birds in July-August, probably coinciding with hatching of invertebrates. How important is this for flamingo survival? The analysis of ring readings would help provide answers to the above questions.

Importance for wintering flamingos

Large numbers of Greater Flamingos winter in Tunisia, with probably up to 40,000 individuals coming (as shown from ring readings) from all breeding colonies of the Mediterranean metapopulation. The importance of wintering grounds for annual survival remains poorly understood. Wintering adults seem more likely to winter in Tunisia if they spend their first three years there. The arrival of juveniles, in turn, occurs in different proportions every year, also according to climatic conditions (*e.g.* wind direction; Green *et al.* (1989)) at the moment of leaving Europe. Some wintering sites seem to be occupied preferentially by adults, others (*e.g.* probably Bou Ghrara - IBA N° 038 - in the far south; Figure 1) by very young birds (cf also Vand der Have *et al.* 1997). If young birds are forced to use suboptimal sites, what is the effect on survival?

Importance as a kindergarten

There is clearly huge pressure on recently fledged birds from European colonies to seek food resources elsewhere. They arrive in Tunisia in large numbers very early (some by early August, only three weeks after fledging and ringing). Once arrived, most stay in Tunisia for at least three years before returning to colonies. Tunisia thus plays a vital role as a "kindergarten" for all European colonies.

This kindergarten period is clearly crucial in a flamingo's life history, and raises a number of unanswered questions. What are mortality rates in these first three years? What factors cause mortality? Are there particular sites where immatures congregate in the first three years? What causes them to return to the colonies? How many flamingos which have spent their kindergarten years in Tunisia return to winter in Tunisia, and how many go to other wintering areas?

The need for analysis

A large number of juvenile flamingos spend the whole of their first three years (at least!) in Tunisia. Many breeding adults spend more than half the year in Tunisia with some adults spending all their life in Tunisia, apparently waiting for a wet year. Tunisian wetlands are therefore essential for the survival of a large fraction of the meta-population. Analysis is therefore needed to define and understand the importance of these sites.

A network of flamingo observers has now developed in Tunisia. Its members need to receive feedback on the importance of their observations, to provide encouragement for future work. They also need guidance on which topics are of greatest interest in future.

The task ahead for analysis

The census data should be collected and analysed, to improve definition of how many birds occur in different seasons, to pinpoint the key sites for different age groups, and to identify any changes over the period of the data. The ring readings should be analysed in much finer detail, among other things to define common patterns of movement, and preference of different age groups for different sites.

It is assumed that the colour-ringing centres are willing to make all ring readings available to bone fide analysts. It would seem most sensible for the analysis to be carried out in Tunisia, partly

because scientists attached to the breeding colonies are already over-stretched, and partly because it would be desirable to train Tunisian experts. The AAO (Association des Amis des Oiseaux – the national BirdLife partner) and the Tunisian universities are the obvious bodies to carry out this work. Indeed many graduate and postgraduate theses are already being prepared on ornithological topics and they would benefit from advice and contacts with existing flamingo specialists.

In the long run, it would be desirable (in Tunisia as in many other Mediterranean countries) to establish national ornithological centres, staffed by a small number of professionals who would coordinate the fieldwork of voluntary observers.

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Monitoring of Greater Flamingo colonies: some proposals for measuring and interpreting results

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Abstract
Monitoring programs for the Greater Flamingo *Phoenicopterus roseus* have been implemented in several colonies of the Mediterranean basin and northwest Africa. Methodologies used to obtain estimates of population sizes, breeding success, and demographic parameters may substantially differ among localities. It is important to attain a consensus on methodology in order to make the results obtained from different colonies comparable. In this paper we review the methods used to estimate the size of the breeding colonies, the behaviour of banded individuals, and the body condition of adults and chicks, based on the experience obtained from studies conducted in the Fuente de Piedra colony (southern Spain). The main results of this paper are: (1) the size of Greater Flamingo breeding colonies was systematically underestimated when reoccupations were not taken into account, (2) ring readings must be accurately applied, and field data must be filtered to obtain unbiased demographic parameters, and (3) accurate estimates of body condition for both adults and chicks should consider recent feeding and provisioning patterns.

Introduction
Population monitoring programs involve regular recording of parameters in order to understand the processes that operate at the individual and population level, thereby providing valuable information for scientific and management purposes (Yoccoz *et al.* 2001). The Mediterranean population of Greater Flamingos has been studied since the 1960s (Johnson 1997), and since then a number of monitoring programs have been implemented in the Mediterranean and northwest Africa (Johnson and Cézilly 2007). Information gathered from these programs has enabled inferences to be made relative to the processes acting upon the metapopulation dynamics of the Greater Flamingo across its Mediterranean distribution range (Nager *et al.* 1996, Barbraud *et al.* 2003, Amat *et al.* 2005).

Among the variables monitored in Greater Flamingo breeding colonies are counts (Rendón-Martos 1996, Béchet and Johnson 2008), measures of productivity and breeding success (Cézilly *et al.* 1995, Rendón *et al.* 2001), indices of chick body condition (Cézilly *et al.* 1995, Amat *et al.* 2007, Béchet and Johnson 2008), biochemical and haematological parameters (Amat *et al.* 2007, in press), and demographic estimates through mark-recapture studies (Lebreton *et al.* 1992, Barbraud *et al* 2003). Other variables are difficult to obtain in this species, despite their potential importance (*e.g.* body condition of adults).

Several approaches that differ in accuracy and meaning have been applied to obtain estimates of the variables monitored in breeding colonies. Counts are made from the air (Béchet and Johnson 2008) or ground (Rendón-Martos 1996), depending on the colonies, and peak counts or continuous censuses have been applied to estimate breeding population size. However, the accuracy of counts varies greatly if the objective of the study is to evaluate wintering or breeding populations (Green and Hirons 1988, Johnson and Cézilly 2007). Estimates of breeding success and body condition of chicks have been obtained with standard methodologies, as applied to other bird species. Breeding success is calculated as the percentage of pairs that fledged young (Cézilly *et al.* 1995, Rendón-Martos 1996), so accurate estimates of number of breeding pairs which actually laid an egg is essential to assess this parameter. In relation to the body condition of chicks, two methods have been applied: the slopes (Cézilly *et al.* 1995) and the residuals (Barbraud *et al.* 2003, Amat *et al.* 2007, Béchet and Johnson 2008) of the tarsus length-body mass relationship. Beside the suitability of either method, systematic deviance from the true chick mass may occur because the chicks store meals in the crop, but rarely this aspect is taken into account (but see Amat *et al.* 2007).

With regard to the resighting of marked individuals, codes have been established to categorize the status of individuals during the breeding season (Johnson 1983, Rendón-Martos 1996). However, lack of skill or rigor in the allocation of the codes (or perhaps just different interpretations of the code meanings) can cause loss of valuable information on the breeding status of birds, which prevents reliable monitoring of reproductive events in the colony. Such methodological differences can make it difficult to compare results from monitoring programs conducted in different colonies. Therefore, it seems necessary to attain a consensus on the methods used to record breeding parameters in Greater Flamingo colonies, as well as on their interpretations.

The aim of this paper is to discuss several aspects of the monitoring in Greater Flamingo breeding colonies, based on the experience obtained at Fuente de Piedra Lake (hereafter referred to as FP). The monitoring of the colony in this Natural Reserve began in 1984 (Rendón-Martos 1996), and since then the Consejería de Medio Ambiente (Department of Environment) of the Junta de Andalucía (Regional Government) has developed intensive surveys in this breeding colony. When possible, we will compare the differences between the parameters obtained using the methodologies applied in FP with regard to those applied in other breeding colonies. We are aware that several methodologies applied in FP would not be feasible elsewhere, because of the unique characteristics of each colony. However, despite this fact, we stress the need for obtaining comparable parameters from different monitoring programs in order to understand the mechanisms that operate in the Mediterranean metapopulation of Greater Flamingos.

Breeding pairs estimates

The number of simultaneously breeding subcolonies at FP varied each year from zero to eleven depending on the number of breeding pairs that attempted to settle, and the availability of suitable nesting sites (Rendón-Martos 1996). The substrates for the settlement of the colonies were usually artificial dikes of former salt pans (Figure 1), but in wetter years these dikes flooded and the colonies are established on natural islets.

The main colonies established between 1984-2006 at FP, both on artificial dikes and natural islets, were gridded into quadrats of 10x10 m (Figure 1), and the central dike was marked with canes every 10 m.
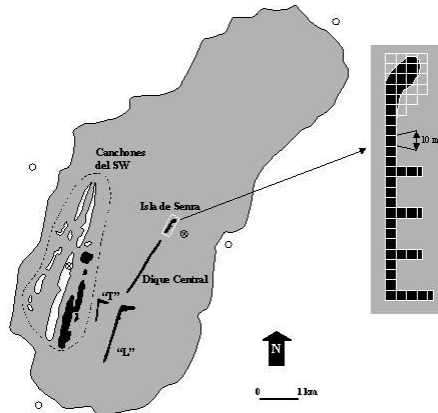

Figure 1. Location of natural islets and artificial dykes occupied (in black) by nesting colonies of Greater Flamingos during 1984-2007 in Fuente de Piedra Lake. The distribution of quadrats on the main nesting site (Isla de Senra) is shown. (⊗: locations of hides; ○: census points).

Counts of incubating birds by quadrat were made using a spotting scope, both from hides located about 250 m from the nesting sites and from elevated locations around the lake (Figure 1). In the colonies where there were no reference marks, location of settlements were recorded by

visual references on the ground or by covering the colonies using a fixed field of vision with a spotting scope. Individuals counted incubating in each sector were recorded as breeders. In the absence of disturbances by predators, if a quadrat was occupied for more than 45 days, it was considered that there was reoccupation of the sector, and newly counted individuals were added as new breeders.

In addition to the counts, the colonies were mapped at least once a week, and the surface occupied and the behaviour of breeders per quadrat was recorded. When the breeding season finished, nests built in every quadrat were also counted (Rendón *et al.* 2001). The numbers of nests were equated to breeding pairs. The maps of nests occupied and the distribution of incubating birds throughout the breeding season were compared. As with the counts, it was considered that a quadrat was reoccupied if settlements lasted more than 45 days. Results of this double surveying were averaged in order to obtain annually the number of breeding pairs.

In order to compare the estimates of the number of breeding pairs at FP colony that we obtained by census methods (hereafter "breeding pairs") with those obtained through counts when peak numbers are incubating, we used both the mean counts of birds on the colony in the month of highest density and the number of nests recorded once the breeding season finished. Data correspond to the 1984-2006 period, but for 1996, 1999, 2000, and 2004, nest numbers were not available.
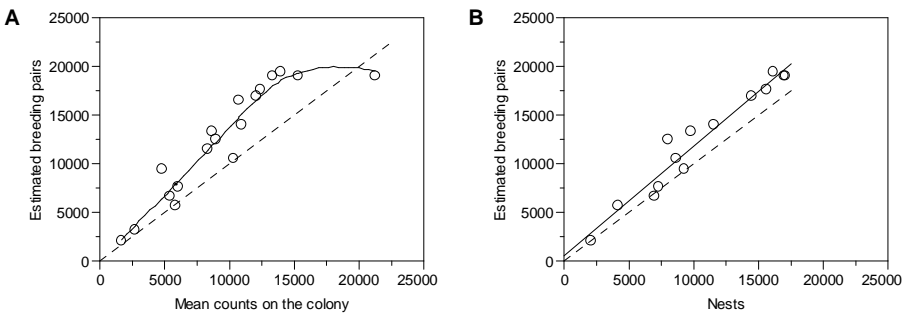

Figure 2. Scatter plot of annual breeding pairs *vs*. mean counts of adults in the month with peak number of birds (A), and the number of nests (B) at the FP colony during 1984-2006. Solid lines represent (A) smoothed curve (smoothing spline λ=3e+10, r^2=0.93) and (B) linear model (r^2=0.95, p<0.001). Dashed lines are the lines of equality.

Comparisons between breeding pairs and both peak counts and nest numbers showed that the two last methods underestimated the breeding population (Figure 2). The mean difference between breeding pairs and peak counts was 2,852 ±567 (t_{14}=5.03, p<0.001), which represents an average error of 22% ±3. Absolute differences between peak counts and breeding pairs increased when peak counts were higher (slope of the linear range: 1.35, C.I. 95%: 1.12-1.57). Furthermore, as peak counts increased, the number of breeding pairs tended to become asymptotic. This relationship suggests that there were a number of transient individuals potentially prospecting for nest sites at the colony, but that they did not attempt breeding. In this case, peak counts overestimated the number of breeding pairs when the carrying capacity of the colony was reached. With regard to the relationship between nest counts and breeding pairs, the mean difference was smaller and less variable than those obtained from peak counts (1,844 ±377, t_{13}=-4.89, p<0.001; average error of 16% ± 4). Differences with breeding pairs also increased with the number of nests but to a lesser extent (slope: 1.26, C.I. 95%: 0.96-1.29), and no asymptotic relationship was observed.

The estimation methods of breeding pairs not only affected the colony size estimates, but also the relationship of breeding pairs with environmental variables. Precipitation is known to affect Greater Flamingo breeding colonies (Cézilly *et al.* 1995, Rendón-Martos 1996, Béchet and Johnson 2008). Rendón-Martos (1996) stated that accumulated precipitation between October-April in Doñana marshes affected the breeding population of flamingos at FP colony during 1984-

1994. These marshes are located about 150 km west of FP, and are the main foraging grounds of adult Greater Flamingos during the chick rearing period (Rendón-Martos 1996, Amat *et al.* 2005). Using the same data set, we compared the fit of a logarithmic model using breeding pairs, nest numbers, and peak census as dependent variables and accumulated precipitation as an explicative factor (Figure 3). The best fit was obtained from the estimated breeding pairs (r^2=0.79), followed by nest number (r^2=0.52), both models being significant at the 0.05 level. On the contrary, annual variation of peak counts was not significantly related to the accumulated precipitation (*p*=0.083).
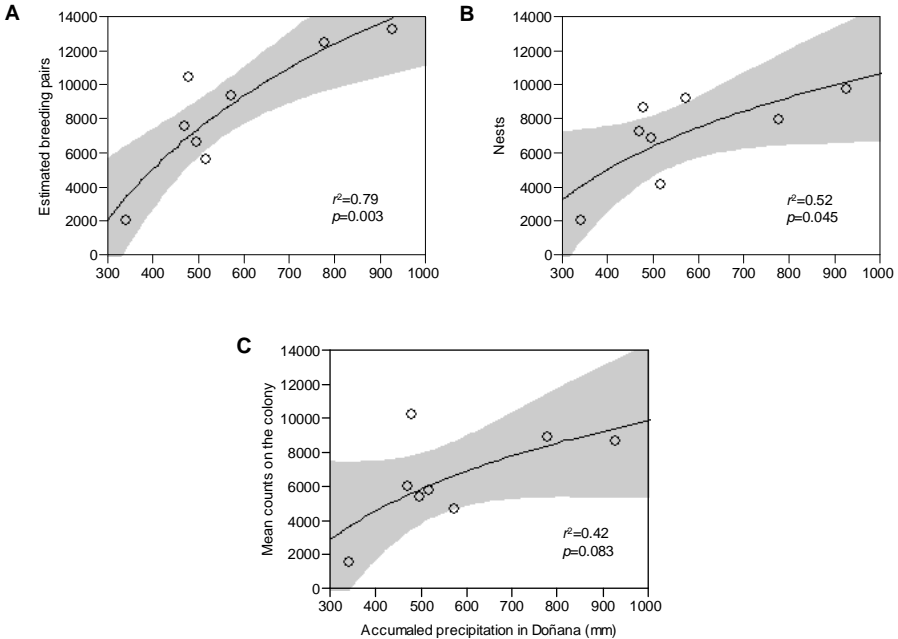

Figure 3. Logarithmic relationship between accumulated precipitation (October-April) in Doñana and (A) breeding pairs, (B) nest numbers, and (C) peak counts of birds on the colony in FP during 1984-1994. Shaded areas are 95% confidence fits. Coefficient of determination and significance of the models are shown.

Ring readings

The methodology applied to assign behaviour codes to individuals in breeding colonies was developed by Alan Johnson in the Camargue (Johnson 1983). Status codes assigned to individuals standardize a wide range of behaviours, from presence in the lake (*e.g.*, code 00, healthy bird) to specific breeding activities (Appendix I). The number of ring readings and the behaviours recorded in the colonies of the Mediterranean region and northwest Africa differed among localities. As an example, Figure 4 shows the frequency distribution of ring readings in 2006. It is evident that the number of records of banded birds did not match with the breeding populations at different areas due to differences in sampling effort. On the other hand, resightings focused on different behaviours (*e.g.*, birds near the colony *vs.* specific breeding activities) and breeding phases (*e.g.*, incubation *vs.* chick attendance) in each colony. Thus, while for most localities, resighting records were concerned with individuals close to the colony or crèche (code 20), in Algeria and Comacchio records were registered more frequently for individuals classified as probable breeder (code 29), and in Delta del Ebro the records show a high proportion of adults attending chicks outside the colony (code 45). This lack of homogeneity in resightings may

prevent a representative sample of marked individuals across the breeding season that enables the comparison of demographic rates among colonies.
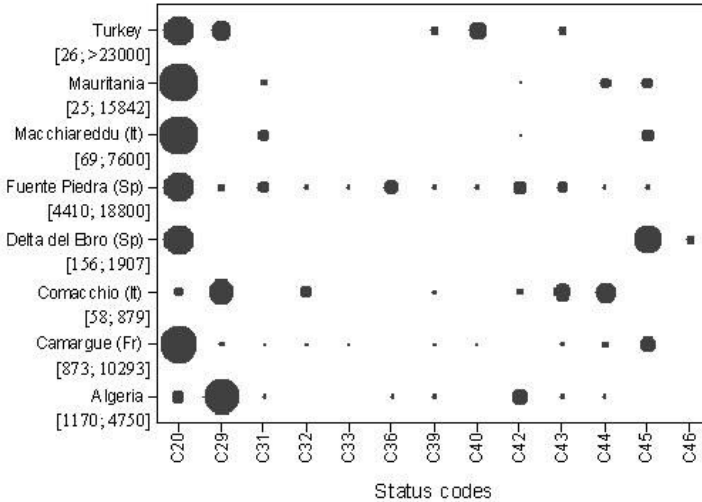

Figure 4. Proportion of status codes (code ≥20) recorded from ring readings in different colonies of Greater Flamingos in the western Mediterranean and northwest Africa during 2006. Dot sizes are related to the fraction of records in each colony. When colony name was specified, country abbreviation was provided in parentheses (Fr: France, It: Italy, Sp: Spain). Sample sizes of ring readings and breeding pairs are in brackets. Data obtained from SIAM (Suivi Individuel d'Animaux, C. Germain, La Tour du Valat) and Béchet (2006).

Accuracy in allocating status codes is essential to consider individuals as breeders. Individuals on a breeding colony can be classified as probable breeders (code 29). However, allocation of this status without confirming reproductive behaviour can lead to mistakes. Even when an individual can be located on a nest, this behaviour is not a guarantee of incubation, because individuals could be transients. In order to prevent this uncertainty, an adult observed as a probable breeder must only be considered as an accepted breeder if it stays in the same nest ≥3 days (code 39), and the following observations of the same bird on the nest will be classified as a known breeder (code 40), unless an egg or chick are visible (codes 42-63). The generalized use of these criteria will guarantee a reasonable degree of reliability on the breeding status of individuals. However, this categorization entails the filtering of the ring readings before their inclusion in any common database (*i.e.*, change from code 29 to 39, and 39 to 40 when appropriate), otherwise codes may lose their meaning. For instance, if an individual recorded more than three times as code 29 is not considered as code 39, any user of the data can interpret that bird as having changed its nest site.

The codes that identify behaviours other than those related to reproduction (*e.g.*, codes 21, 31, 32, 33, 36), are less represented and are more likely to be recorded when sampling effort increases (Figure 4). Despite that the probability of sighting marked individuals displaying, some of these behaviours may be limited, and the aim of the monitoring in most of the breeding sites is to confirm and identify the presence of breeders, we encourage checking for the occurrence of these other behaviours because it will enable the study of processes acting on successive phases of the breeding period (*i.e.* display, pairing, copulation, and nest building).

Finally, we advise against the use of uninformative codes (*e.g.* code 22, which corresponds to a single individual observed alone before colony settlement). Codes must be mutually exclusive and stated according to the presence of an identifiable characteristic and not to the absence of

attributes (Legendre and Legendre 1998). The characteristic defining code 22 is the absence of a pair, which actually is unknown from such observation because there is no definitive evidence that an individual without pairing behaviour is not paired. Therefore, code 22 should be deleted, and individuals exhibiting that behaviour included into the code 00 (behaviour unknown).
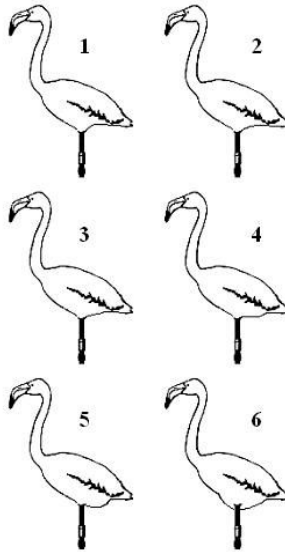
Figure 5. Categories of API used for adult Greater Flamingos (1: concave, 2: slightly concave, 3: plain, 4: slightly convex, 5: convex, and 6: hanging). Modified from C. Barbraud and A. R. Johnson (pers.com.)

Body condition of adults

Adult body condition is a relevant parameter because it is a determinant of migration (Drent *et al.* 2003) and breeding decisions in birds (Weimerskirch *et al.* 2001). Body condition has been associated with stored fat mass, which is the main form of stored energy in birds (Griminger 1986). One of the most accurate techniques for measuring body condition involves the capture of individuals. However, in the case of Greater Flamingos, the capture of adults may be very difficult and stressing for the birds. Furthermore, recaptures of the same individual are highly unlikely.

As an alternative to the capture of birds, semi-quantitative indexes of roundness of the abdominal region (abdominal profile index, API) have been applied to estimate the stored energy in birds (Owen 1981). A positive relationship has been established between API and body mass (Moriguchi *et al.* 2006), and it has been used to measure body condition in several species (*e.g.* Wiersma and Piersma 1995, Ferns and Lang 2003, Madsen and Klaassen 2006).

API categories for Greater Flamingos were adapted by Barbraud and Johnson (pers. com.) from those of other species, and were described in six ordinal scores, from concave (1) to hanging profiles (6) (Figure 5). As far as we know, there are no published studies that corroborate the relationship between body condition and API in flamingos, or whether structural size must be taken into account in order to make API a useful body condition index (Moriguchi *et al.* 2006). Preliminary results of breeding flamingos at FP indicated that there were temporal variations in API for both males and females (Figure 6). From the seasonal variation of API emerged a decreasing pattern of abdominal roundness. API was higher in incubating birds and decreased during incubation and while adults attended chicks. However, this pattern differed between sexes in such a way that while, for males, the decreasing in API occurred progressively throughout the breeding season, females only decreased their API from incubation to the chick-at-nest period, and maintained similar values during incubation and chick rearing.

In order to use API as a useful body condition index in field studies, it is necessary to account for several factors affecting short-term changes in this index. The variation of API in 19 individuals observed by the same observer at FP indicated that birds with API scores 2-3 in the morning changed significantly to score 4 in the evening and *vice versa* (Figure 7). This observation is in accord with other field observations that showed that individuals increased API during feeding and drinking. Furthermore, if feeding behaviour affects short-term changes of API, feeding conditions or proximate factors (*e.g.* water level) must also be accounted for. Regarding the example from Figure 6, a significant negative temporal trend in API was detected for both males and females, suggesting that the summer dry-out of the lake affected the abdominal roundness. Though other interpretations of this result are possible, with these examples we want to stress that the inclusion of the behaviour of birds and feeding conditions in statistical models can account for confounding factors that affect short-term variation of API.
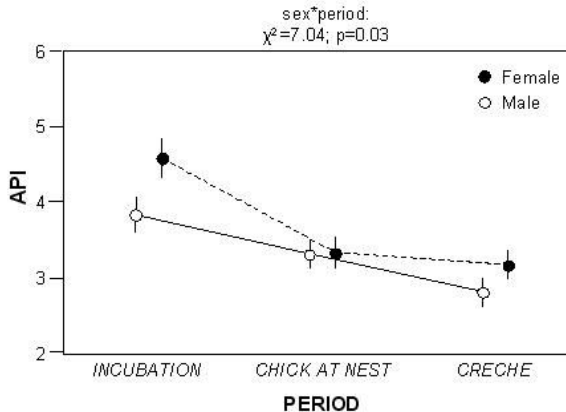

Figure 6. Mean values (±SE) of API for males and females over the breeding season at FP colony in 2001. Interaction sex*period was significant in a generalized linear model, which also included as effects: sex, period, time, sex*time, and period*time.

Body condition of chicks
The body condition of chicks has long-term consequences on individual fitness (Cam *et al.* 2003). Measuring body condition index (BCI) involves determining energy reserves, after accounting for structural body size. The more common method to estimate BCI is using the residual from a regression model of mass on body size, although there is disagreement on which statistical methods must be applied (Green 2001, Schulte-Hostedde *et al.* 2005). BCI has been estimated for Greater Flamingo chicks from the linear relationship between log mass and log tarsus, using both annual slopes (Cézilly *at al.* 1995), and individual residuals (Barbraub *et al.* 2003, Amat *et al.* 2007, Béchet & Johnson 2008). Furthermore, blood parameters also have been useful in documenting changes in body condition (Amat *et al.* 2007). Nevertheless, because a flamingo feeds its chick with secretions (Johnson and Cézilly 2007) that the chick stores in its crop for more than 13 hours (M. A. Rendón *et al.*, unpubl.), the accuracy of BCI could be biased. The mean daily weight of meals ingested by four-seven week old chicks raised in captivity was *c.* 340 g. (Batty *et al.* 2006), and for free-living individuals the mean mass of food received by chicks was estimated as 336 g (Amat *et al.* 2007). This extra mass can jeopardize the accuracy of BCI estimates and make them unreliable because of short-term provisioning patterns.

Since 1998, crop profile indices (CPI) have been recorded during the ringing of chicks at FP, assigning each crop size to one of four pre-established categories, from concave (0) to turgid crop (3) (Figure 8). In order to show the effects of CPI on the estimates of BCI, linear models were applied for three selected years with different rainfall patterns in the Doñana marshes (dry, normal and wet), which conditioned low, mean and high breeding populations at the FP colony (table 1) (see above). The first model included total tarsus length, year, and their interaction as explicative

factors of chick body mass. In addition, the second model included the CPI scores and CPI*year interaction to test both the effects of food stored on the body mass, and if such effect was consistent across years. Finally, a third model integrated all the factors included in the second model with the identity of the observers estimating the crop sizes as a random effect, because observers changed between surveys.
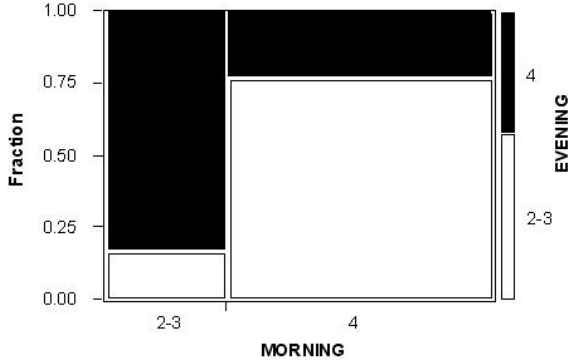
Figure 7. Values of abdominal profile index (API) for 19 individuals recorded by the same observer in the morning and the evening in FP. API scores changed across the day (Fisher's exact test: n=19; p<0.05).
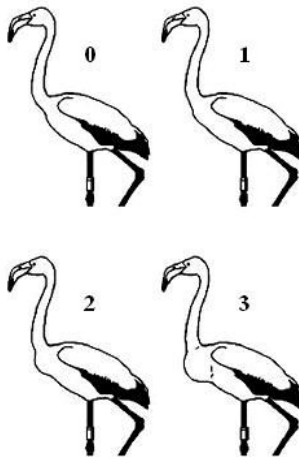
Figure 8. Categories to which the crop profile of Greater Flamingo chicks was allocated (0: concave, 1: slightly convex, 2: convex, and 3: turgid)

The results of the first model showed that the tarsus*year interaction on the chick body mass was significant, and the explanatory power of the model was high (R^2=0.68). According to Béchet and Johnson (2007), the body condition of chicks was lower in years with the higher colony density. The second model showed a significant effect of CPI on body mass (R^2=0.72). Thus, it was evident that body condition was systematically overestimated when CPI was ignored (Figure 9). Furthermore, tarsus-mass slopes also varied, depending on whether CPI was or was not included in the models. In the wettest year, when the body mass was lower, the tarsus-mass slope was steeper in the model that did not include CPI (Figure 9, line C), and no differences

between slopes were appreciable in the driest year, when mean body mass was higher (Figure 9, line A).

Table 1. Regression models of factors affecting the mass (log-transformed) of chicks banded at FP colony in three years, with both different hydrological conditions in Doñana marshes and breeding populations. The first model included log tarsus, year as a categorical variable. and their interaction. The second model also included the individual crop profile index (CPI) as a categorical variable, and the interaction year*CPI. The third model was a mixed model including the variables applied in the second model as fixed effects and observer identity as a random effect. Components of the variance of the mixed model are specified for both observer and error. Sample size comprised 2,685 chicks.

Model 1: R^2=0.68

Source	d.f.	F	p
log tarsus	1	3136.346	<0.001
Year	2	786.110	<0.001
log tarsus*year	2	33.273	<0.001

Model 2: R^2=0.72

Source	d.f.	F	p
log tarsus	1	3410.796	<0.001
Year	2	732.6909	<0.001
CPI	3	129.3904	<0.001
log tarsus*year	2	27.2353	<0.001
CPI*year	6	2.1466	0.045

Model 3: R^2=0.78

Source	d.f.	F	p
log tarsus	1	4938.754	<0.001
Year	2	605.879	<0.001
log tarsus*year	2	47.937	<0.001
CPI	3	156.396	<0.001
CPI*year	6	1.285	0.260

Random effect	Variance component	S.E.	% of total
Observer	0.0059	0.0032	37.5
Residual	0.0098	0.0003	62.5
Total	0.0157		100

Therefore, the inclusion of CPI in the models determined differences both in the annual mean body mass estimates and in the tarsus-mass slopes, due to the absolute proportion of chicks fed each year and the relative distribution of chicks fed with regard to their tarsus length (*i.e.* age), respectively. The second model also showed a significant effect of CPI*year interaction on body mass, indicating that a same category of CPI indicated different values of mass in different years. When observer identity was included as a random effect, the regression model improved the variation explained (R^2=0.78), and approximately 38% of the unexplained variance was accounted for by observer identity. Mixed model also resulted in a non-significant effect of CPI*year interaction, suggesting that the inclusion of observer identity in the model accounted for variations due to differences in the abilities to perceive CPI categories.

Food stored by chicks not only affected the estimates of body condition obtained from body mass-tarsus length relationship, but also affects the blood parameters. Thus, Amat *et al.* (2007) showed that recently fed chicks, as indicated by CPI, had higher levels of plasma metabolites such as proteins, uric acid, tryglicerids, and glucose, which are frequently used in other species to asses the body condition of individuals (Figure 10). This result stresses the importance of accounting for crop content when relating body mass variations to blood parameters. In the case of Greater Flamingo, once the effect of crop content on blood parameters and body mass was controlled for, Amat *et al.* (2007) determined that cholesterol levels were related to body condition of chicks. Annual variation of cholesterol levels and CPI were associated (mean cholesterol concentration *vs.* percentage of CPI 3: r_S=-1, n=4, p=0.083, significance determined by permutation), which suggested that frequencies of crop sizes also could be a useful index of feeding frequency (Figure 10).
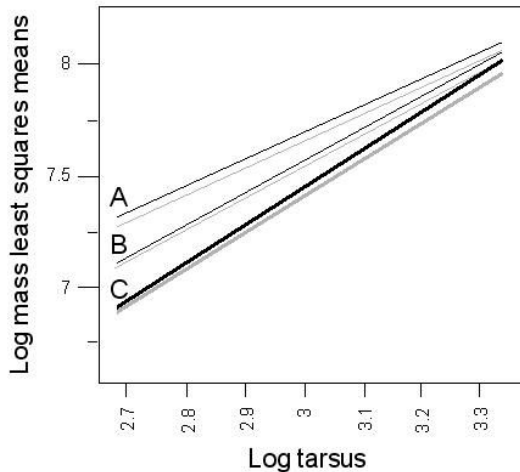
Figure 9. Relationship between chick mass and tarsus length at Fuente de Piedra during dry (A), normal (B), and wet (C) years in Doñana marshes. Black lines correspond to a model including log tarsus, year, and log tarsus*year as independent variables. Grey lines are the predictions for individuals with empty crop corresponding to a model that also included crop categories as a predictor.

Conclusions

We have attempted to outline some aspects of the methodology used in the monitoring of Greater Flamingo colonies that we next summarize.

1- Regarding estimates of numbers of breeding pairs, reoccupations of nests must be taken into account or otherwise population could be underestimated. When continuous monitoring is not feasible, nest counts seem to provide more reliable annual indices of breeding populations than peak counts.
2- Ring reading effort must be increased in several areas (*i.e.* Turkey and Mauritania) in order to obtain accurate estimates of the demographic parameters of the Greater Flamingo metapopulation. Ring readings should be gathered during the whole breeding season. Late observation could prevent the detection of breeding individuals leaving the colony in early breeding stages. Status codes must be rigorously applied and field data accurately filtered before they are added into databases to prevent mistakes. Furthermore, sampling effort devoted in each area should be reported in order to perform accurate capture-recapture models.

3- Body condition index for adults can be easily recorded using API scores. Nevertheless, the analysis of this index must take into account that recent feeding and drinking, as well as food availability can modify API estimations in the short-term.

4- Crop profile is a useful index of the food stored by chicks, and its effects must be taken into account when body condition indexes are estimated from tarsus-mass relationships or blood parameters. Furthermore, annual records of CPI seemed to be related to the feeding frequencies of chicks.

5- Because both API and BCI are ordinal measurements rated subjectively by different observers, models fitted must use observer identity as a random effect.
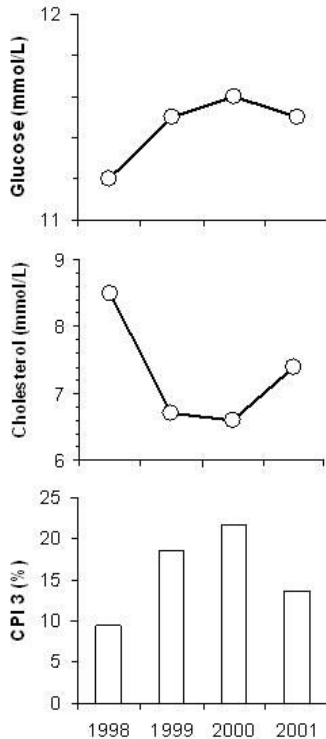
Figure 10. Annual variations of the percentage of chicks with turgid crops (CPI 3), and blood concentrations of glucose and cholesterol in chicks banded at Fuente de Piedra colony. Mean values of blood parameters were taken from Amat *et al.* (2007)

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Appendix I. Status codes allocated to resightings of Greater Flamingos banded with Darvic rings. Modified from SIAM system (Suivi Individuel d'Animaux Marqués, C. Germain, La Tour du Valat).

Behaviour		Code	Definition
Unspecific		00	Pairing/breeding status and behaviour unknown
		01	Only ring found
		02	Dead
		03	Injured or ill
		04	Injured or ill, released
		05	Injured or ill, kept in captivity
		06	Trapped and released
		07	Trapped, kept in captivity
		08	Released
		99	Darvic ring lost, metal ring read
Breeding	Possible breeder	20	Close to breeding flamingos or to the crèche
		21	Brief bout of display
		22	Single (observed alone before colony settlement)
	Probable breeder	29	Believed breeding
		31	Intensive display
		32	Paired
		33	Copulates
		34	Copulates with ringed bird
		36	Bird having built a nest
		37	Paired with ringed bird
	Accepted as a breeder	39	Accepted breeding (≥3 days on the same nest - egg/chick not visible)
		40	Known breeders (but egg/chick not visible)
		42	Incubating, egg seen
		43	Attending chick on nest
		44	Feeds/attends check in creche still on island
		45	Feeds/attends check in creche having left island (ring not visible)
		46	Feeds ringed chick
		47	Feeds chick not ringed
Chick provisioning		60	Chick fed by ringed adult
		61	Chick fed by unringed adult male
		62	Chick fed by unringed adult female
		63	Chick fed by unringed adult

A common database for the ring resightings of the Greater flamingo *Phoenicopterus roseus* in the Mediterranean

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Introduction

At the heart of the study of the population dynamics of the Greater Flamingo in the Mediterranean and West Africa is a ring resighting methodology. In order to manage the data gathered by this approach a good database program must have several properties. It must be fast, user-friendly and allow for the rapid producing the birds' life histories for volunteers who sent their observations. The metapopulation project launched in 2002 ambitioned to rely on the integration the data from several banding sites in order to facilitate estimation of dispersal. This set an additional challenge: the database should allow efficient synchronisation among data from several local data managers who would keep the responsibility to code the resightings of the birds they banded. In this paper, we present the multi-site database we implemented and discuss its uploading to the internet.

Methods

A database system, called SIAM (for Suivi Individuel d'Animaux Marqués in French), has been developed in Microsoft® Access so that it can run on most local computers. The user interfaces are available in French, Italian, Spanish and English (other languages could easily be added).

A module allowing the synchronisation of new, modified or deleted data among the different databases has been implemented. This synchronisation is coordinated by a database manager leader. Approximately once per month, the database managers send the new data managed since the last synchronisation to the leader. Then the leader checks for possible duplicates of observers or localities possibly entered by the different managers during the period. He then generates a final file which is sent back to the others. The update of their own database is then made with a single click.

There are possibilities to enter the ringing and re-sighting data manually or by importing excel files. A tool is also included to extract raw data into excel or text format according to all the possible ringing and/or re-sighting criterions.

The accompanying letters, the bird life histories and dispersal graphics are produced in the observer's language (the same 4 languages plus Turkish added in 2003) and can be automatically output in pdf format or on paper. SIAM can also generate on demand single individual dynamic maps using MapInfo or static maps as images for several individuals.

Finally, SIAM contains a module which permits to manage the Flamingo supporting scheme with automatic outputs when new observations of a supported bird are registered. More recently we have developed a bridge between SIAM and the Flamingo Atlas web site (www.flamingoatlas.org). It allows the supporter to immediately view on a dynamic map, the travels made by "its" birds.

Result and discussion

At the end of 2001, the new database was presented at Estacion Biologica de Doñana and Fuente de Piedra to gather remarks and adjust the development to the demand of database managers. During the 2nd Greater Flamingo workshop in the Camargue in March 2002, the Spanish and Italian database managers agreed to use this tool henceforth. Spanish and Italian data were then transmitted to La Tour du Valat, where they were formatted and pooled with the French ones. The common database was completed in April 2002 and then sent to Italy and Spain where it has been used immediately.

Progressively, after the new ringing operations initiated in Turkey in 2003, in the Ebro Delta in 2004 and in Algeria in 2006, the new data were integrated into this common database. To date, it contains nearly 45,000 different ringed birds and more than 520,000 resightings.

During the 4th Greater Flamingo workshop we have presented what could become this database by showing the first functionalities of the web ring resighting database of the Audouin's Gulls (www.audouinii.org). This project developed by La Tour du Valat for the Ebro Delta Natural

Park should be finished by 2009. It will allow observers to enter their resightings directly on a website. Location of the resighting will be possible either by using an interactive map, by choosing a locality from a list or by entering GPS coordinates. All functionalities of SIAM, will be included like the exportation of raw data, reserved to the banding project leaders.

When the data are validated by the database managers of each project, the band readers will be able to see the life histories of the birds they observed immediately on the site. An important plus of this new database will be that these life histories will remain available to the observers so that they will be able to track the consecutive observations of a bird they have already observed.

Such a database will present the advantage of reducing the time dedicated to data treatments and to the observer replies, which is far from negligible. Furthermore we believe that it can improve the involvement of volunteers in resighting birds.

Which ring colour looks best: results of the Antequera 'ophtalmic' tests

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Abstract

Accurate reading of ring codes is a critical assumption of capture-mark-resighting studies. However, the effects of the different ring characteristics on reading accuracy in the field have not received the attention they deserve. Here we present the results of a very preliminary field test on the performance of a panel of flamingo experts in correctly recording varied sets of colour rings placed at increasing distances on the mudflats of the Fuente de Piedra lagoon. Mistakes occurred most often on dark rings, yellow ones performing best.

Introduction

The correct recording of individual codes that are engraved on colour-rings is of crucial importance in the study of flamingos and marked birds in general. 'Un-recording' colour-marked birds, because of the loss of their marks is frequently acknowledged as a source of bias in studies of bird demography (e.g. Pistorius *et al.* 2007). Mark loss, however, is the very final stage of a process of mark ageing, during which fading and partial breaking are likely to increasingly cause wrong records that seem even more dangerous, as each incorrect record affects two individuals, instead of only one (i.e. one bird that is locally present, whose code is missed, and one that is probably absent, whose code is recorded by mistake).

Plastic quality, strictly related to mark durability, is one of the causes of possible misidentification as a colour ring ages. A number of other variables, however, affect the recording performance even when a ring is new (*e.g.* colour, size and type of code, and many more subtle differences). The effects of ring characteristics on reading accuracy in the field have not received the attention they deserve (see Mitchell and Trinder 2008, and references therein). When starting a new colour ringing project, the ring characteristics are usually selected in terms of common sense, what might well work properly until ringers are few and available combinations many. 'Project overcrowding' of some species (see www.cr-birding.be) or very long-running projects may now strongly constrain the choice and lead to sub-optimal solutions.

The gathering of many experienced 'flamingo-readers' at this workshop in Antequera, Spain was an opportunity to attempt a preliminary field test on their performances in correctly recording varied sets of colour rings at increasing distances on the mudflats of Fuente de Piedra lagoon.

(Human) material and methods

The rings used were the usual size for Greater Flamingos Phoenicopterus roseus (55 mm long with 19 mm inner diameter). They had been purposely produced by ProTouch (Canada) in five different colours with 4-letter codes engraved three times (black codes on white and yellow rings, white codes on blue, green and black rings). The same 15 letters (A B C D F H J K L N P S T V Z) that are used In Italy on wild Greater Flamingos *Phoenicopterus roseus* were randomly present in the codes, each letter being c. 19 mm high and engraved by a 3 mm point. The red colour was not tested, as it was judged to offer not enough contrast with adult flamingos' legs.

Experimental design

Five sticks holding 10 rings (two each of the five colours) were fixed in the solid mud at 50 m intervals, 200 m to 400 m from the observers' position. Only 14 participants could be tested, due to failing light conditions, and not all of them had time to check all sticks. Each observer dictated the colour and code combinations to another person who recorded them on a standard form. Our aim was to test only: i) the accuracy of colour identification and ii) the accuracy of code reading by ring colour. On checking the forms, cases of wrongly identified colours were considered as individual mistakes for the first test, while partial readings and wrong readings (e.g. containing at least one incorrect letter) were both counted as individual mistakes and summed up according to the respective ring colour (second test).

Results
Identification of colours

Most ring colours were correctly identified (Table 1). Very few mistakes were recorded in the case of green, white, black and yellow, while several blue rings were noted as black (but not the reverse).

Table 1. Number of times a given ring was said to be of a given a colour depending on its real colour

Real colour	Number of detection as				
	green	blue	white	black	yellow
green	102	1	0	1	0
blue	1	92	0	1	0
white	1	0	114	0	2
black	1	21	0	115	0
yellow	0	0	0	0	115

Accuracy of code reading according to ring colour

Table 2 shows first, the percentage of codes that were read correctly (for each colour), and then the sample size (how many rings of each colours were examined by the participants). Mistakes occurred most often on black rings, yellow ones performing best.

Table 2. Percentage of correct reading of ring code by ring colour

Colour	% correct	N
Yellow	91.1	123
White	89.3	121
Green	75.4	129
Blue	75.2	126
Black	69.8	129

Discussion

No statistical analysis was done of these results, because the sample size was small and the test itself very preliminary. Nevertheless, some useful indications are apparent and usually confirm Mitchell and Trinder's (2008) findings, with a few differences: blue being correctly identified as often as the other colours in their case, but being at the same time the colour that accounted for most misread codes, instead of black. The reason for these differences might be either in the shade/brightness of each ring colour used in the two experiments, or to fading light conditions during the Antequera test, or in ambiguous notations on some field sheets (BL abbreviation used for black or blue), all these being possible sources of variability that were not controlled.

There are many other aspects that could be analysed in this way (*e.g.* the effects of distance, and the legibility of the 15 letters). We plan to organize a similar test on the Italian observers' network, taking full advantage from the Antequera trial.

Acknowledgments

References

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WORKSHOP COMMUNIQUE

Proposed soda ash development at Lake Natron, Tanzania, threatens the Lesser Flamingo

The Mediterranean and West African Flamingo Network at its fourth international meeting at Antequera (Malaga) Spain on 5-6 November 2007, calls upon the Tanzania government and TATA Chemicals to reconsider the proposed development of the soda ash extraction facility at Lake Natron, Tanzania, given the potential negative inpacts on the Lesser Flamingo.

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CONCLUSION

This IVth Workshop on the Greater Flamingo in the Mediterranean region and northwest Africa was an intense and memorable event. Beyond being a meeting of flamingo experts, it has become the regular meeting of the Greater Flamingo Network where is elaborated a shared knowledge on the biology and conservation of this species.

At the origin of the network are scientists regularly participating to ringing operations at each others breeding sites. The strength of the network comes from an original data infrastructure, a common ring-resighting database linking each partner to the others. This database is to be completed soon by an additional layer, a common monitoring scheme for flamingo counts: the flamingo atlas website. The additional value of this collaborative infrastructure was exemplified by the empowerment brought by multi-site studies such as those of Balkiz *et al* or Amat *et al*. They demonstrate the importance of the flyway approach for a proper understanding of the processes driving Greater Flamingo population dynamics.

Despite these promising results, the point was raised that further standardization of data collection could facilitate such meta-analyses. The next workshop should thus reserve a period of time to reach consensual "monitoring guidelines" that would be endorsed by all network members.

Finally, while the network for developing scientific studies on the Greater Flamingos is now working efficiently, breeding sites remain managed locally. Further effort should be put in developing a network of site managers where to discuss and implement large scale management and conservation plans for the Greater flamingo. In particular, salt pans abandonment in the North of the Mediterranean region and climate warming in the South are major forthcoming challenges which will have to be addressed collectively if we want to maintain this population at its current level in the future.

Arnaud Béchet, Eastern Hemisphere Chair

El IVème Taller sobre el Flamenco Común en el Mediterráneo y en el noroeste de África fue un intenso y memorable evento. Más allá de ser una reunión de expertos en flamencos, es ahora la reunión de referencia de la red de estudio del Flamenco común. Por lo tanto, es el lugar donde se desarrolla un intercambio de conocimientos sobre la biología y la conservación de esta especie.

En el origen de la red están los científicos que participan regularmente en operaciones de anillamiento en cada uno de los lugares de cría. La fuerza de la red proviene de una infraestructura de datos original, una base de datos común de anillamiento-lecturas que vincula cada uno de los socios. Esta base de datos se completará en breve por una capa adicional, un sistema común de seguimiento de flamenco, que será gestionada a través de la página web flamingoatlas. El valor adicional de esta infraestructura de colaboración esta aquí demostrado por el refuerzo de por los estudios multi-sitio, tales como los de Balkiz *et al.* o Amat *et al.* Ellos demuestran la importancia de tomar en cuenta el área de repartición del flamenco para una correcta comprensión de los procesos que gobiernan la dinámica de su población.

A pesar de estos resultados prometedores, se ha demostrado que una mayor normalización de la recopilación de datos (Rendón *et al.*) podría facilitar este tipo de meta-análisis. El próximo taller de flamencos debería reservar un período de tiempo para elaborar "monitoring guidelines", que serían aprobados por los miembros de la red.

Por último, aunque la red para el desarrollo de estudios científicos sobre el Flamenco común está trabajando de manera eficiente, los sitios de reproducción siguen siendo gestionados a nivel local. Se debe poner un mayor esfuerzo en el desarrollo de una red de administradores de los sitios donde se pueda debatir y poner en práctica modelos de gestión y planes de conservación para el Flamenco común. En particular, abandono de salinas en el norte de la región del Mediterráneo y el calentamiento del clima en los países del Sur son los principales futuros desafíos que tendrán que abordarse en su conjunto si queremos mantener esta población en su nivel actual en el futuro.

Arnaud Béchet, Eastern Hemisphere Chair

FLAMINGO SPECIALIST GROUP

The Flamingo Specialist Group (FSG) was established in 1978 at La Tour du Valat in France, under the leadership of Dr. Alan Johnson, who coordinated the group until 2004. Currently, the group is coordinated from the Wildfowl & Wetlands Trust at Slimbridge, UK, as part of the IUCN-SSC/Wetlands International Waterbird Network.

The FSG is a global network of flamingo specialists (both scientists and non-scientists) concerned with the study, monitoring, management and conservation of the world's six flamingo species populations. Its role is to actively promote flamingo research, conservation and education worldwide by encouraging information exchange and cooperation among these specialists, and with other relevant organisations, particularly the IUCN Species Survival Commission (SSC), Wetlands International, the Ramsar Convention on Wetlands, the Convention on Conservation of Migratory Species (CMS), the African-Eurasian Migratory Waterbird Agreement (AEWA), and BirdLife International. The group is coordinated from the Wildfowl & Wetlands Trust, Slimbridge, UK, as part of the IUCN-SSC/Wetlands International Waterbird Network.

FSG members include experts in both *in-situ* (wild) and *ex-situ* (captive) flamingo conservation and education, as well as in fields ranging from research surveys to breeding biology, infectious diseases, toxicology, movement tracking and data management. There are currently 270 members representing 185 organisations in 56 countries around the world, from India to Chile, and from France to South Africa. Further information about the FSG, its membership, the membership list serve, or this bulletin can be obtained from Brooks Childress at the address below.

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Mediterranean and West-African Greater Flamingo Network

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