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A breeding colony of the Near Threatened Lesser Flamingo *Phoeniconaias minor* in western Africa: a conservation story of threats and land management

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Summary

The 2011 breeding results of the Lesser Flamingo *Phoeniconaias minor* at its only West African colony, in Aftout es Saheli, south-west Mauritania, are presented. Several breeding attempts have been documented since the second half of the 19th century although no successful breeding, in terms of fledged juveniles, was recorded until 2010. Adverse hydrological dynamics, easy access to the colony by predators, and disturbance and direct mortality caused by poachers led to the failure of all previous breeding attempts. In 2011 the breeding colony was monitored and a number of major threats were identified and averted. Management interventions consisted of deterring and trapping predators (jackals *Canis adustus* and *C. aureus* and warthog *Phacochoerus africanus*) around the colony and preventing the killing of flamingos by poachers. As a result, 4,800 Lesser Flamingos and 10,200 Greater Flamingos *Phoenicopterus roseus* incubating individuals, as well as about 14,000 chicks of both species, were recorded. It was not possible to prevent the death by predation or other natural causes of 4,672 juveniles of both species after the wetland dried up, so the final estimated number of fledged juveniles was 10,000. The field work allowed us to collect information on hydrological dynamics and to propose conservation measures matching Lesser Flamingo ecological requirements. Similarly, we identified the most sustainable measures for deterring predators, with the aim of including them in the management of the wetland.

Introduction

The distribution of the Lesser Flamingo *Phoeniconaias minor* includes Asian and African regions (Del Hoyo *et al.* 1992) with an estimated total non-breeding population of more than 2.6 million individuals (Childress *et al.* 2008). Lesser Flamingo populations show a globally decreasing trend and are thus considered "Near Threatened" (BirdLife International 2009). The species breeds regularly at only five colonies in India, Namibia, Botswana and Tanzania, while other locations host only occasional or suspected breeding attempts, such as Mauritania (Childress *et al.* 2008). Despite the large population, the fact that more than 75% of breeding individuals are concentrated at only one site (Lake Natron, Tanzania), with threats to this wetland including salt exploitation and the building of infrastructures (Köenig 2006), make the species very sensitive to habitat alteration (Childress *et al.* 2008). Therefore, the Lesser Flamingo is the subject of an International Action Plan under the AEWA-UNEP programme of the Convention on Migratory Species, which sets out the priorities for conservation action in a global context (Childress *et al.* 2008).

The presence of Lesser Flamingo in the Senegal River delta (West Africa) was first documented in the 19th century, where it was considered a common species (Tremau de Rochebrune 1884).

In 1965, breeding was confirmed in flooded areas of Aftout es Saheli, in the Toumbos Lagoon, south-west Mauritania, with about 800 individuals observed incubating, but confirmation of fledging was not possible (Naurois 1965). Between 1986 and 1988, Lesser Flamingo and Greater Flamingo *Phoenicopterus roseus* settled in a breeding colony at Aftout es Saheli, with a maximum of 9,000 Greater Flamingos and 200 Lesser Flamingos incubating, but the attempt failed (Lamarche 1988). Breeding of Lesser Flamingo was suspected in 1998 (Hamerlynck and Ould Messaoud 2000) and breeding of Greater Flamingo was observed in 2004 (Hamerlynck 2005) and in 2008 when 800 juveniles fledged (Diawara *et al.* 2007, 2008). In 2010 a mixed colony of Greater and Lesser Flamingos succeeded, producing 1,500 chicks of both species, of which at least 178 were juvenile Lesser Flamingos (Ould Sidaty and Ould Daf 2010). The reasons for the increase in the number of incubating flamingos in 2008–2010 are unknown, but a better knowledge of the area and increased monitoring effort and high levels of annual rainfall could have contributed to this positive trend (Diawara *et al.* 2008, Ould Sidaty and Ould Daf 2010).

The breeding success of flamingos at Aftout es Saheli was ultimately very low in all cases, given the pressure of poachers, who traditionally exploit flamingos as a food resource, and abandonment of the colony due to predation by jackals *Canis* spp. and warthogs *Phacochoerus africanus* (Ould Sidaty and Ould Daf 2010, Parc National du Diawling 2010), as the primary threats. Since the stable reproduction of the Lesser Flamingo in its only Western African locality is of great importance for the conservation of the species (Childress *et al.* 2008), several management actions were taken in 2011 to reduce the effects of both threatening factors. The results are reported in this paper.

Methods

Study area

The area where Greater and Lesser Flamingos bred in 2011 and where monitoring and conservation measures were applied was the lagoon of Aftout es Saheli in the Senegal River Transboundary Biosphere Reserve, south-west Mauritania (Figure 1). It consists of a saltmarsh about 100 km² in area, 45 km north of the Senegal River mouth, separated from the sea by a coastal dune bar. It is part of the vast coastal depression and floodplains of the Senegal delta (Duvail 2001). Aftout es Saheli is connected through various channels to the Aftout dam on the Senegal River that, together with the contribution of groundwater, allows the seasonal inflow of water to the lagoon (Duvail 2001, Hamerlynck and Duvail 2003). Four different islands, with a maximum surface area of about 1,600 m², 1,400 m², 4,000 m² and 3,600 m² respectively, emerge after the flooding of the wetland and subsequent progressive drying. These islands, situated in the north-east of the lagoon, form the flamingo colony, while other islands and trees are breeding sites of cormorants *Phalacrocorax lucidus* and *P. africanus*, terns *Sterna caspia* and *S. maxima* and Great White Pelicans *Pelecanus onocrotalus* (Isenmann *et al.* 2010). The study area is located in the Sahel region, a transitional pastoral semi-desert area with an annual rainfall of around 250 mm (Zwarts *et al.* 2009). The habitats surrounding the breeding colony are characterised by sand dunes, seasonal herbaceous vegetation, a wide extent of *Salicornia* communities and small patches of savanna with *Tamarix* sp. and *Acacia* sp. (Hamerlynck and Duvail 2003).

Field work

Monitoring breeding

With the aim of understanding the breeding cycle of flamingos, weekly counts were conducted to record: 1) number of incubating individuals of both species, 2) total number of chicks and identification of the species when possible, 3) number of abandoned eggs, 4) number of individuals (chicks and adults) predated and 5) date of emergence of different nesting islands.

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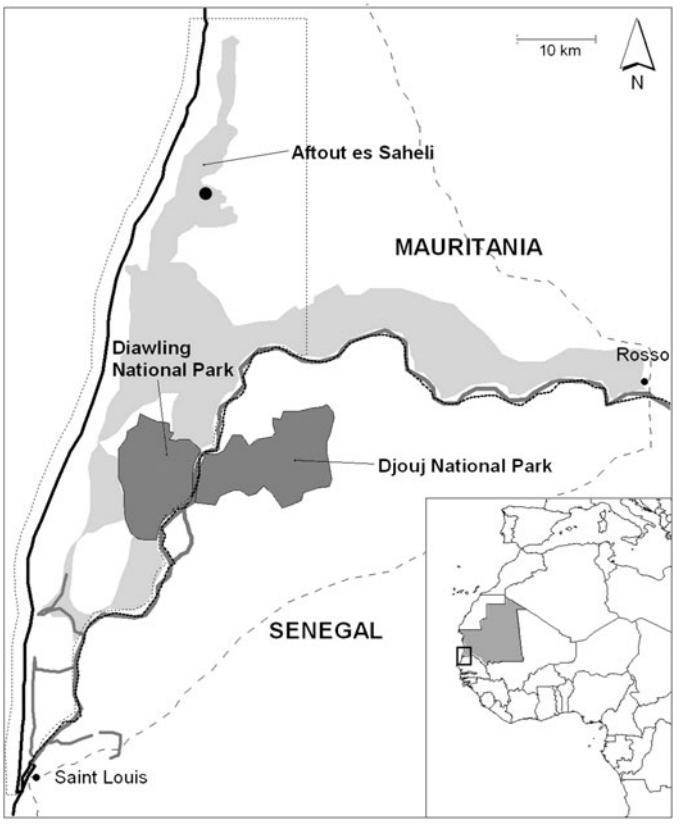

Figure 1. Location of the Greater Flamingo *Phoenicopterus roseus* and Lesser Flamingo *Phoeniconaias minor* breeding colony in Aftout es Saheli lagoon (SW Mauritania, black dot), within the Transboundary Biosphere Reserve of the Senegal River in Mauritania (dotted line). The map also shows the Senegal river (dark grey), the flooded areas of the Senegal delta in Mauritania (light grey) and national parks of Diawling and Djouj.

Monitoring and deterring predation

A team of six people, permanently established around the wetland, monitored the breeding colony from 27 January to 31 May. Daily tours around the closest shores to the colony were carried out to detect the presence of people and to identify potential predator species through indirect evidence, camera traps and tracks (Silveira *et al.* 2003, Long *et al.* 2008). Moreover, the following predator deterrent and trapping devices were set up (Neuman *et al.* 2004, Muñoz-Igualada *et al.* 2010):

– Electric fences. Electrified net 90 cm high, 300 m long, composed of orange braided polyethylene mesh, plastic posts and Solar Electrifier Viper S250 and a recharging battery (Smith *et al.* 2010a; Figure 2).
– Scent stations. Pieces of cotton fabric periodically provided with commercial perfumes.
– Fladry line. A line of about 2,000 m was installed along the shore of the lagoon near the breeding colony; this consisted of a tensioned wire fixed to a post, from which 50 cm plastic strips were suspended every 2–3 m to indicate the presence of a barrier visually and aurally (Shivik *et al.* 2003; Figure 2).

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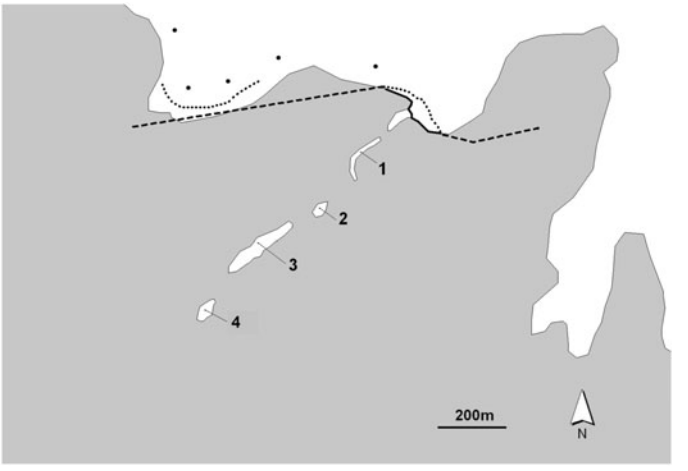

Figure 2. The four islets on which the breeding colony of Lesser Flamingos *Phoeniconaias minor* and Greater Flamingos *Phoenicopterus roseus* in Aftout es Saheli, south-west Mauritania, is situated (water in grey and inland in white). Location of the different predator deterrent and trapping devices: electric fence (solid line), fladry line (dashed line), lines of snares (dotted line) and Belisle traps (dots).

The devices used to trap potential mammal predators were selected for their efficacy, selectivity and absence of risk to the welfare of captured animals (Muñoz-Igualada *et al.* 2010):

> – Line of snares. A barrier consisting of branches of *Prosopis* sp. was erected to prevent entry by animals. Every 10 m, a 50-cm wide gap was left open to allow the passage of animals. At each gap a top-locked snare was installed (Wisconsin DNR 2004, Muñoz-Igualada *et al.* 2010), to live-trap medium-sized carnivores by their necks. The length of the barrier was expanded sequentially along the shore of the lake in accordance with water level dynamics. The barrier reached 300 m in length (Figure 2).
> – Walkway snares. After a new access point to the breeding colony was detected, 25 top-locked snares were installed (Wisconsin DNR 2004, Muñoz-Igualada *et al.* 2010) among the vegetation around the pond in order to live-trap medium-sized carnivores by their necks (Figure 2).
> – Belisle traps. Five Belisle leg-hold traps with scented bait (Les Entreprises Belisle 2011) - were set in the surroundings of the lagoon along target-predator paths (Figure 2).

Trapped animals were released 15 km away from the lagoon. The intention was that trapped predators would experience their attempt to access the breeding colony as traumatic but also remain in their territories, to avoid attracting other individuals of the same species (Pitt *et al.* 2003). However, we realised that jackals were not exclusively territorial (McDonald 1979, Loveridge and MacDonald 2001) and that the number of jackals attracted to the colony increased with the increased breeding activity of the flamingos. For this reason, after 1 April it was decided that trapped individuals would be culled, to reduce predation pressure.

Statistical analyses

To establish the relationship between the number of both species of flamingos hatching and the emergence of the different islands on which the breeding colony was situated as water levels

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decreased, we performed an ANOVA (Sokal and Rohlf 1995). We considered as a response variable the number of incubating birds on each census date and as a grouping factor the following options: 1) no appearance of a new breeding islet with respect to the preceding census date, 2) appearance of the first breeding islet, 3) appearance of the second islet, 4) appearance of the third islet, and 5) appearance of the fourth islet. Moreover, to assess whether the number of hatching Lesser Flamingos was positively linked to those of Greater Flamingos, we carried out a simple regression analysis (Sokal and Rohlf 1995).

In addition, to evaluate the moment at which chick predation rates were higher, we also applied an ANOVA (Sokal and Rohlf 1995), considering as a response variable the number of observed dead chicks and as independent qualitative factor 1) the existence of water at the lagoon or 2) the lack of water around the breeding islets.

Results

Breeding

The first incubating Greater Flamingos were detected on 15 February on the first islet that emerged (Figure 3). Their number increased significantly at the beginning of March, coinciding with the appearance of the third islet ($F_{3,6} = 35.937$; $P = 0.0031$; Figure 3), until they reached the maximum of 10,000 incubating individuals. Lesser Flamingos did not overlap the sequence of incubation with the Greater Flamingo ($F_{1,8} = 0.001$; $P = 0.9699$). Once the fourth islet emerged during late March, the number of hatching Lesser Flamingo reached a maximum (4,800 individuals; $F_{3,6} = 18.246$; $P = 0.0028$; Figure 3).

The first chicks were observed in early March and their numbers gradually increased to about 11,000 on 26 April (Figure 4). At that time the water level decreased, many breeding areas remained accessible by land and, therefore, the number of predated flamingos increased significantly ($F_{1,11} = 3{,}787.3$; $P < 0.0001$). Thus, on 5 May more than 4,000 corpses of chicks of both flamingo species were registered. Adding that number to 10,000 live juvenile flamingos yields an approximate total of 14,000 hatched chicks. In late June, after the wetland dried up completely,

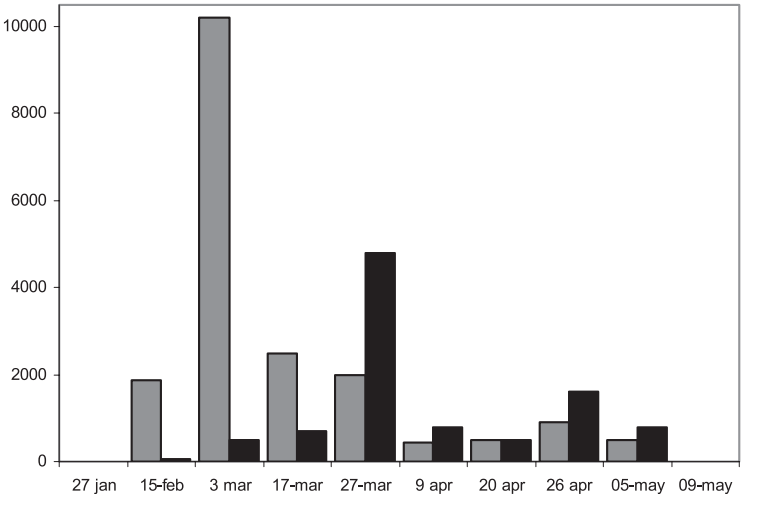

Figure 3. Number of Greater Flamingos *Phoenicopterus roseus* (grey) and Lesser Flamingos *Phoeniconaias minor* (black) incubating at Aftout es Saheli in 2011.

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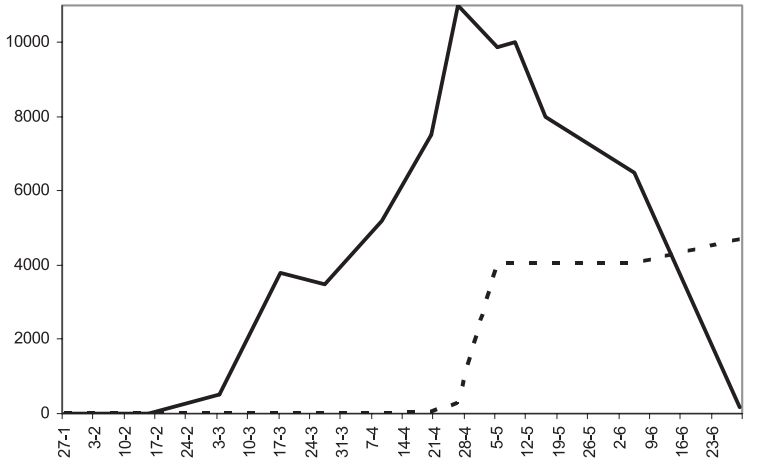

Figure 4. Number of alive chicks of Greater Flamingo *Phoenicopterus roseus* and Lesser Flamingo *Phoeniconaias minor* (solid line) and the number of dead/predated chicks (dashed line) at Aftout es Saheli in 2011.

4,672 corpses of juveniles were found (482 Lesser Flamingos, 1,720 Greater Flamingos and 2,470 unknown), as well as 147 adult casualties (28 Greater Flamingo, 17 Lesser Flamingo and 102 unknown).

The 2011 season was the most successful in terms of number of birds hatching and fledged juveniles, in relation to all previous breeding attempts (Figure 5).

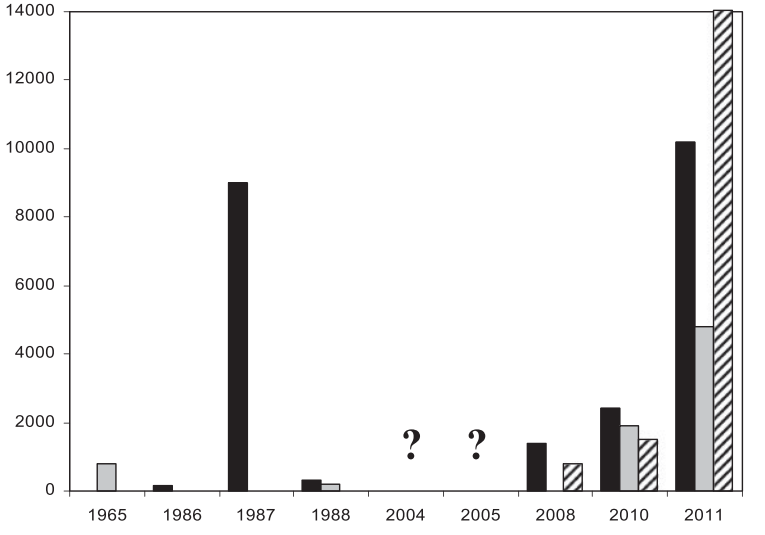

Figure 5. Maximum number of Greater Flamingo *Phoenicopterus roseus* (black) and Lesser Flamingo *Phoeniconaias minor* (grey) incubating at Aftout es Saheli and maximum number of chicks recorded of both species (barred). Breeding was confirmed in 2004 and 2005 but no hatching numbers were released. In 2008, only Greater Flamingo juveniles fledged.

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Protection against predators and disturbance

Around the colony, golden jackal *Canis aureus*, side-striped jackal *Canis adustus*, pale fox *Vulpes pallida*, striped hyena *Hyaena hyaena*, honey badger *Mellivora capensis*, unidentified mongoose species and warthogs were detected. The entry of these species into the colony was prevented by the deterrent and protection systems installed, except on seven occasions, 21 February, 15 March, 19 March, 30 March, 3 April, 4 April and 1 May. All instances, except for 4 April, involved 1–3 jackals. The entry of predators into the colony caused the abandonment of about 1,500 eggs.

Eleven potential predators were trapped (Table 1). Of these, three freed themselves from the traps, six were released by the monitoring team in areas far from the breeding colony and two were culled (a golden jackal and a warthog). No poaching attempts or access by people to the environs of the colony were detected.

Discussion

Breeding

The nesting of flamingos in mixed colonies has interesting ecological aspects that influence development of the reproduction cycle (Kear and Duplaix-Hall 1975, Newton 1992). In the study colony, asynchrony of about 15 days in the maximum numbers of incubating individuals of the two flamingo species was observed, probably caused by limited site availability in the breeding colony (McPeek *et al.* 2001). This limiting factor could determine the maximum number of incubating Lesser Flamingos, as occurs in other flamingo species (Nager *et al.* 1996). Specifically, we observed the occupation of the central areas of the colony by Greater Flamingos, possibly indicating an inferior competitive ability of the Lesser Flamingo since they established nests at the periphery of the colony (Newton 1992). This could delay laying and hatching dates and make Lesser Flamingo chicks more vulnerable to predation when the lake dried up completely during the first half of May.

Habitat management

The hydrological dynamics of wetlands are a key factor in the reproduction of colonial waterbirds (Cezilly *et al.* 1997, Bechet *et al.* 2009). In the case of Aftout es Saheli, the most important variables involved are annual rainfall, the management of the Senegal River dams in supplying the delta and associated farmlands (i.e. opening time, water volume transferred) and the evaporation rate (Hamerlynck and Duvail 2003, Hamerlynck 2005). Such factors could determine the water level, the flooding period and the approximate dates of total drying out of the lagoon (Hamerlynck and Duvail 2003) and also therefore: 1) breeding population size (Cezilly *et al.* 1997, Bechet and Johnson 2008), 2) breeding phenology (Bechet and Johnson 2008), and 3) the likelihood of access by predators (Rendón *et al.* 2001).

Table 1. Number of individual predator species trapped around the flamingo breeding colony of Aftout es Saheli in 2011.

Species	Captures
Phacochoerus africanus	2
Canis aureus	2
Canis adustus	3
Canis sp.	3
Unidentified species	1

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Furthermore, the annual variability in factors influencing hydrological dynamics affects the start and end dates of breeding, the nesting of other bird species and the entry of other species into the colonies, such as Great White Pelican (authors' unpubl. data). Thus, it is necessary to determine an accurate approach to water level management. As an alternative, to ensure the sustainability of flamingo reproduction in the area, managing the size and height of the nesting islands could provide very positive results, as demonstrated in other breeding colonies (Rendón and Johnson 1996, Johnson 1997). So, appropriate management of water levels in Aftout es Saheli to ensure the islands remain isolated for an adequate period of time is a crucial issue and should be considered when updating the management policy for the Senegal delta, especially in years with low rainfall. The next official approval of the enlargement of Diawling National Park should integrate a modified management regime for the river dams according to ecological requirements, including appropriate water timing, levels and dynamics that allow flamingos to breed successfully in Aftout es Saheli, in a compatible way with agriculture, fishing and livestock raising by the local people (Baldó in press).

On the other hand, construction of infrastructure such as paved roads in areas surrounding the breeding colony or even within the whole Senegal River delta may increase human accessibility to the breeding flamingos and thus increase the number of threats from disturbance or poaching (Martínez-Abrain *et al.* 2010, Torres *et al.* 2011). For this reason, a suitable management plan should be developed that considers all the potential threats to this and other protected species (Hamerlynck and Duvail 2003, Hamerlynck 2005, Baldó in press).

Predation and poaching

Monitoring of breeding areas most probably contributed to the reduction in poaching pressure, while predation was revealed to be the main threat to both adults and juveniles. Predation was positively related to greater opportunities for access to nesting islands (Rendón *et al.* 2001) so water level control is one of the best management options for reducing accessibility (Rendon and Johnson 1996, Johnson 1997). Water levels could not be controlled in 2011 so predator access to the colony was prevented as described above and, as a consequence, widespread desertion of the colony was avoided (Johnson and Cezilly 2007) such that only a few eggs were abandoned (Smith *et al.* 2010b).

Implications for conservation

A permanent breeding colony of Lesser Flamingo in West Africa would improve the conservation status of the species by increasing the number of existing colonies, expanding the distribution range, attenuating threats in the few breeding locations and reducing demographic isolation (Childress *et al.* 2008). Thus, although interchange rates among the four main hotspots for the species (eastern, southern, western Africa and the Indian subcontinent; Childress and Hughes 2007, Zaccara *et al.* 2008) are not known, accurately the establishment of new breeding colonies would be a step towards more effective wetland conservation policies and improve the connectivity of the species (Bechet *et al.* 2007, Childress *et al.* 2007).

The experience gained during 2011 led to preliminary recommendations on optimising the sustainability of Lesser Flamingo reproduction in the area: 1) the hydrological dynamics of the Aftout es Saheli wetland should be investigated in detail and properly managed; 2) constant monitoring efforts would allow a better understanding of flamingo population dynamics at the colony; 3) suitability of the structure of the nesting islands should be assessed to increase the synchrony and availability of space for a greater number of breeding Lesser Flamingo; 4) predation might be managed in an advanced and optimised way using the best known practices; 5) technical training for surveillance, monitoring of the breeding colony and deterrence of predation should be continued; and 6) infrastructure such as paved roads or coastal developments should be avoided in the surroundings of Aftout es Saheli and the whole Senegal River delta.

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References

Baldó, J. M. (in press) *Plan d'aménagement et de gestion* 2012-2016 *du Parc National du Diawling*. Nouackchott: Diawling National Park-AECID-GTZ.

Bechet, A., Germain, C., Amat, J. A., Canas, C., Rendon-Martos, M., Garrido, A., Baccetti, N., Dall'Antonia, P., Balkyz, O., Diawara, Y. and Johnson, A. (2007) Metapopulation networks as tools for research and conservation: the case of the Greater Flamingo in the Mediterranean and West Africa. *Ostrich* 78: 506–517.

Bechet, A. and Johnson, A. R. (2008) Anthropogenic and environmental determinants of Greater Flamingo *Phoenicopterus roseus* breeding numbers and productivity in the Camargue (Rhone delta, southern France). *Ibis* 150: 69–79.

Bechet, A., Germain, C., Sandoz, A., Hirons, G. J. M., Green, R. E., Walmsley, J. G. and Johnson, A. R. (2009) Assessment of the impacts of hydrological fluctuations and salt pans abandonment on Greater Flamingos in the Camargue, South of France. *Biodiv. Conserv.* 18: 1575–1588.

BirdLife International (2009) Phoeniconaias minor. In: IUCN 2011. *IUCN Red List of threatened species*. Version 2011.1. <www.iucnredlist.org>. Downloaded on 11 July 2011.

Cezilly, F., Boy, V., Green, R. E., Hirons, G. H. M. and Johnson, A. R. (1995) Interannual variation in Greater Flamingo breeding success in relation to water levels. *Ecology* 76: 20–26.

Childress, B. and Hughes, B. (2007) Evidence of interchange between African Lesser Flamingo populations. *Ostrich* 78: 507–507.

Childress, B, Hughes, B, Harper, D, and van den Bossche, W. (2007) East African flyway and key site network of the Lesser Flamingo (*Phoenicopterus minor*) documented through satellite tracking. *Ostrich* 78: 463–468.

Childress, B., Nagy, S. and Hughes, B. (Compilers) (2008) *International single species action plan for the conservation of the Lesser Flamingo Phoeniconaias minor*. Bonn: AEWA Technical Series.

Del Hoyo, J., Elliot, A. and Sargatal, J. (1992) *Handbook of the birds of the world*. Vol. 1. Barcelona: Lynx Edicions.

Diawara, Y., Arnaud, A., Araujo, A. and Béchet, A. (2007) Nouvelles données sur la réproduction et l'hivernage des Flamants roses *Phoenicopterus rouseus* en Mauritanie et confirmation d'échanges avec les colonies méditerranéennes. *Malimbus* 29: 31–41.

Diawara, Y., Siddaty, Z. and Béchet, A. (2008) Découverte de deux colonies de Flamants roses dans l'Aftout es Saheli, Mauritanie, le 29 février 2008. *Flamingo* 16: 28.

Duvail, S. (2001) *Scenarios hydrologiques et modèles de developpement en aval d'un grand barrage*. PhD Thesis. Strasbourg: University Louis Pasteur.

Hamerlynck, O. (2005) *Mission d'appui à la révision du plan de gestion du Parc National du Diawling et de sa zone périphérique,*

Mauritanie, 30 novembre - 17 décembre, 2004. IUCN. (Unpublished report).

Hamerlynck, O. and Duvail, S. (2003) *The rehabilitation of the delta of the Senegal river in Mauritania*. Gland, Switzerland and Cambridge, UK: IUCN.

Hamerlynck, O. and Ould Messaoud, B. (2000) Suspected breeding of Lesser Flamingo *Phoeniconaias minor* in Mauritania. *African Bird Club Bull.* 7: 109–110.

Isenmann, P., Benmergui, M., Browne, P., Diam Ba, A., Hamallah, C., Diawara, Y. and Ould Sidaty, Z. E. (2010) *Birds of Mauritania*. Paris: Societé d'Études Ornitologiques de France.

Johnson, A. R. (1997) Long-term studies and conservation of Greater Flamingos in the Camargue and Mediterranean. *Colonial Waterbirds* 20: 306–315.

Johnson, A. R. and Cezilly, F. (2007) *The Greater Flamingo*. London: T & AD Poyser.

Kear, J. and Duplaix-Hall, N. (1975) *Flamingos*. London: T & AD Poyser.

Köenig, R. (2006) The pink death: Die-offs of the Lesser Flamingo raise concern. *Science* 313: 1724–1725.

Lamarche, B. (1988) *Etudes Sahariennes et Ouest-Africaines. Tome I, num. 4*. Nouackchott-Paris: Association des Naturalistes Sahariens et Ouest-Africains.

Les Enterprises Belisle (2011) Belisle foot snare. http://belisletrap.com/en/foothold-traps.php

Long, R. A., MacKay, P., Zielinski, W. J. and Ray, J. C., eds. (2008) *Noninvasive survey methods for carnivores*. London: Island Press.

Loveridge, A. J. and MacDonald, D. W. (2001) Seasonality in spatial organization and dispersal of sympatric jackals (*Canis mesomelas* and *C. adustus*): implications for rabies management. *J. Zool.* 253: 101–111.

Martínez-Abrain, A., Oro, D., Jiménez, J., Stewart, G. and Pullin, A. (2010) A systematic review of the effects of recreational activities on nesting birds of prey. *Basic and Applied Ecol.* 11: 312–319.

McDonald, D. W. (1979) The flexible social system of the golden jackal, *Canis aureus*. *Behav. Ecol. Sociobiol.* 5: 17–38

McPeek, M. A., Rodenhouse, N. L., Holmes, R. T. and Sherry, T. W. (2001) A general model of site-dependent population regulation: population-level regulation without individual-level interactions. *Oikos* 94: 417–424.

Muñoz-Igualada, J., Shivik, J., Domínguez, F. G., González, L. M., Aranda, A., Fernández-Olalla, M. and Alves, C. (2010) Traditional and new cable restraint systems to capture fox in Central Spain. *J. Wildl. Manage.* 74: 181–187

Naurois de, R. (1965) Une colonie reproductrice du petit flamant rose *Phoeniconaias minor* dans l'Aftout es Sahel (Sud-Ouest Mauritanien). *Alauda* 33: 166–176.

Nager, R. G., Johnson, A. R., Boy, V., Rendon-Martos, M., Calderon, J. and Cézilly, F. (1996) Temporal and spatial variation in dispersal in the Greater Flamingo (*Phoenicopterus ruber roseus*). *Oecologia* 107: 204–211

Neuman, K., Page, G. W., Stenzel, L. E., Warriner, J. C. and Warriner, J. S. (2004) Effect of mammalian predator management on Snowy Plover breeding success. *Waterbirds* 27: 257–263.

Newton, I. (1992) Experiments on the limitation of bird numbers by territorial behaviour. *Biol. Reviews* 67: 129–173.

Ould Sidaty, Z. E. and Ould Daf, D. (2010) *Nidification du Flamant nain dans l'Aftout es saheli, Réserve de Biosphére Transfrontière (Partie Mauritanie)*. Note d'information du Parc National du Diawling. Unpublished report.

Parc National du Diawling (2010) *Etat de lieu de l'avifaune. Le flamante rose et nain dans le bas Delta du fleuve Sénégal (rive droite)*. Unpublished report.

Pitt, W. C, Box, P. W. and Frederick. F. Knowlton, F. F. (2003) An individual-based model of canid populations: modelling territoriality and social structure. *Ecol. Modelling* 166: 109–121.

Rendon, M. and Johnson, A. R. (1996) Management of nesting sites for Greater Flamingos. *Colonial Waterbirds* 19: 167–183.

Rendón, M. A., Garrido, A., Ramirez, J. M., Rendon-Martos, M. and Amat, J. A. (2001) Despotic establishment of breeding colonies of Greater Flamingos, *Phoenicopterus ruber*, in southern Spain. *Behav. Ecol. Sociobiol.* 50: 55–60.

Shivik, J. A., Treves, A. and Callahan, P. (2003) Nonlethal techniques for managing

predation: primary and secondary repellents. *Conserv. Biol.* 17: 1531–1537.
Silveira, L. Jácomo, A. T. A. and Diniz-Filho, J. A. F. (2003) Camera trap, line transect census and track surveys: a comparative evaluation. *Biol. Conserv.* 114: 351–355.
Smith, R. K., Pullin, A. S., Stewart, G. B. and Sutherland, W. J. (2010a) Is nest predator exclusion an effective strategy for enhancing bird populations? *Biol. Conserv.* 144: 1–10.
Smith, R. K., Pullin, A. S., Stewart, G. B. and Sutherland, W. J. (2010b) Effectiveness of predator removal for enhancing bird populations. *Conserv. Biol.* DOI: 10.1111/j.1523–1739.2009.01421.x.
Sokal, R. R. and Rohlf, F. J. (1995) *Biometry: the principles and practice of statistics in biological research*. 3rd edition. New York: W. H. Freeman and Co.
Torres, A., Palacín, C., Seoane, J. and Alonso, J. C. (2011) Assessing the effects of a highway on a threatened species using Before-During-After and Before-During-After-Control-Impact designs. *Biol. Conserv.* 144: 2223–2232.
Tremeau de Rochebrune, A. (1884) *Faune de la Senegambie. Vol. I.* Paris: O. Doin.
Wisconsin Department of Natural Resources (2004) *Wisconsin cable restraint and snare regulations. Supplement to the 2003 Wisconsin trapping regulations*. www.dnr.state.wi.us/org/land/wildlife/trap/cablerestraint.pdf
Zaccara, S., Crosa, G., Childress, B., McCulloch, G. and Harper, D. M. (2008) Lesser Flamingo *Phoenicopterus minor* populations in eastern and southern Africa are not genetically isolated. *Ostrich* 79: 165–170.
Zwarts, L., Biljsma, R. G., van der Kamp, J. and Wymenga, E. (2009) *Living on the edge: wetlands and birds in a changing Sahel*. Zeist, The Netherlands: KNNV Publishing.

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