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Behavioural flexibility and numerous potential sources of introduction for the sacred ibis: causes of concern in western Europe?

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Abstract

In order to examine the dynamics and potential impact of the recently introduced sacred ibis *Threskiornis aethiopicus*, we review the published and unpublished data and report new information on its distribution in West European countries and particularly in France. This species, which escaped from zoos during the 1990s, is well established and has spread on the Atlantic coast and in Mediterranean region of France, with a mid-winter population reaching ca. 3200 individuals in winter 2004–2005 and ca. 1100 breeding pairs in spring 2005. The species has also escaped from zoological parks in Belgium, Germany, Spain, Italy and Portugal, and feral populations are established in Piedmont (Italy) and in the Canary Islands (Spain). The species dispersing ability has led to observations over hundreds of kilometres from the established colonies. We identify that in temperate habitats the sacred ibis shows a behavioural flexibility similar to that known in its tropical native range, including a large diet spectrum (insects, molluscs, refuse, bird eggs, etc.) and an ability to use various habitats (meadows, rubbish dumps, marshes, reedbeds, seashore, ploughed fields, etc.). This plasticity, the fact that predation by ibises is observed on nests of threatened bird species, and the number of potential sources of ibis in Europe (zoos) are causes of concern suggesting that precautionary measures should be taken to prevent the spread of this new alien species.

Introduction

Species introduction and invasion, including that of vertebrates, continue to occur at a steadily increasing rate in most countries (e.g. in France: Pascal and Lorvelec 2005). One of the commonest ways of vertebrate introduction is when animals, reared for either production or leisure purposes, escape from captivity (Williamson 1996). Escaped problem species in western Europe mostly originate either from fur farming (e.g. American mink *Mustela vison*) or from pets released in the wild (e.g. Red-eared Slider *Trachemys scripta*). Zoological parks, or zoological gardens, now seem to be an increasingly frequent origin for accidentally released animals, particularly when large reproductive groups shown to the public are not confined and are even allowed to move freely. In particular, various exotic bird species are now commonly left free to fly in zoological parks, from which they can escape and thereafter sometimes settle in the wild. The report of case studies involving such invaders informs on their potential impact and may help to understand why some species are so successfully invading new regions.

The African sacred ibis (*Threskiornis aethiopicus*) is a bird species commonly present in zoological parks around the world; in several cases, birds are allowed to fly freely and can move out of the zoo limits. Sacred ibises have been reared since 1975 in such conditions in western France, where a small population rapidly produced young birds that went to forage in wetlands up to 10 km away from the zoo (Frémont 1995). Although several scientists alerted the local government agencies about the potential risk linked to this phenomenon, other scientists considered this alien species as a welcome addition to the local fauna (Marion and Marion 1994). Neither of these opinions were discussed at the time and no management process was undertaken. Breeding colonies settled in wetlands and the introduced ibis population increased in range and number along the Atlantic coast.

Between 2000 and 2004, predation by sacred ibis on threatened tern colonies was observed and managers of protected areas voiced their concern (Kayser et al. 2005; Vaslin 2005). Although a fair knowledge of the species dynamics is needed for a management strategy to be developed so as to protect the fragile bird populations which are predated upon by ibises in western France, and to prevent the spreading capacity of sacred ibis in other European areas, little information was available on the size and distribution of either this particular population or of other feral groups of sacred ibis in Europe. A case study was thus ordered at the end of 2004 by the French ministry for the environment. We review the published and unpublished data collected during this case study (Clergeau et al. 2005) and consecutive surveys, and report on new information on the distribution of sacred ibis in France and in other western European countries.

Behavioural flexibility is a common trait among a number of successful species, either in their native range or when introduced in a new area. This behavioural flexibility can be expressed either in terms of habitat tolerance (Case 1996), diet plasticity (Brousseau et al. 1996) or innovation frequency (Sol et al. 2002). It allows the animals to respond more rapidly to changes in the environment and can be an advantage when invading novel habitats (Sol and Lefevre 2000). This species being ecologically flexible in its natural range (Clark and Clark 1979; Brown et al. 1982), we have also focussed on the capacity of sacred ibis to use various habitats (feeding, roosting and breeding habitats) and resources in a temperate region.

Methods

Distribution in France

(1) We reviewed previous reports, either published or not, and have sought unpublished information from nature reserves and other protected areas, and from various research departments and wildlife services (as listed in Clergeau et al. 2005); (2) We activated regional and national networks of birdwatchers, asking for unpublished data; (3) Together with 'Ligue pour la Protection des Oiseaux' (LPO – BirdLife France) we organized a field census of sacred ibis at roosts in western France, and took part in the census work; all roosts were censused on the same day in December 2004 and January and February 2005, in the evening when the ibises come to the roost; and (4) Following this winter survey, we co-ordinated a census of breeding colonies in spring and summer 2005, taking in charge the survey of the main breeding site.

Distribution in other European countries

We conducted a large enquiry between December 2004 and March 2005 via Internet, particularly through the correspondents of Association of European Record and Rarities Committees (AERC). We also contacted a number of European colleagues specialized either in biological invasion or bird ecology.

Habitat use and biology

In addition to our own observations, a questionnaire was dispatched via Internet to birdwatching, hunting, farming and scientific societies during winter 2004–2005, requesting information on feeding habitats, the number of feeding sacred ibises, their association with other species, and the type of diet items when possible. Further data were obtained during the census of roosting

birds and/or provided by managers of protected areas. Published and unpublished notes and reports on the species feeding behaviour in France were also reviewed.

Results

Distribution in Atlantic region of France

At the zoological park of Branféré, Morbihan (2°24′ W 47°35′ N), breeding of 30 sacred ibises imported from Kenya between 1975 and 1987 lead to a population of 350 individuals in 1993. From the mid-1980s, an increasing proportion of these birds regularly flew away from the park and back, and were soon observed up to 300 km away. Breeding in natural habitats was first noted in 1993 at both Golfe du Morbihan, 25 km from the introduction source (Frémont 1995; it is however suspected that breeding began a few years earlier, Yésou 2005) and Lac de Grand Lieu, 70 km away (following a nesting attempt in 1991, Marion and Marion 1994). Since 1997 the species no longer breeds at Branféré zoo, where food is no longer provided specifically to the ibises; tens of birds however continue to visit the site by day and roost at night within the zoo.

By 1998, breeding numbers increased to ca. 130 nests at Grand-Lieu, while colonies also occurred in Briére marshes (ca. 100 nests) and in Golfe du Morbihan (ca. 100 nests), and a few pairs bred at Brouage marshes and near Arcachon (350 km south of Branféré). The various colonies totalized ca. 450 nests in 2001 and ca. 1100 pairs in 2005 including a new colony on an artificial island in the estuary of the Loire river.

The first estimate of the total population size, including non-breeders, was obtained in 2003 when the first census of winter roosts was organized: ca. 2500 sacred ibises were found during the winter season of 2003–2004, reaching ca. 3000 at 18–25 roosts in 2004–2005 (the late J. Pourreau, co-ordinator, personal communication).

The population of sacred ibis in western France shows an exponential increase both in breeding numbers and in its global size as estimated during the non-breeding season (Figure 1).

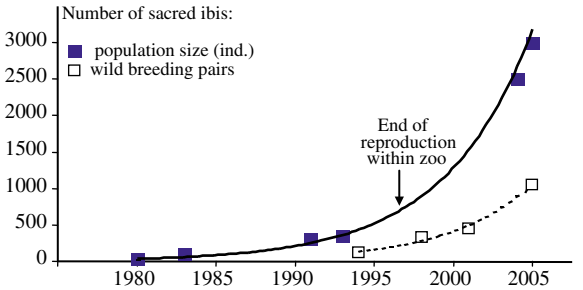

Figure 1. Size of the population of sacred ibis in western France (Atlantic coast) since their introduction at zoological park of Branféré: total population (number of individuals) and number of pairs breeding in the wild. Exponential adjusted curves are presented.

Distribution in Mediterranean region of France

The zoological park of Sigean (2°58′ W 43°02′ N) imported eight individuals in 1982, increasing to 77 sacred ibises in 1992. Allowed to fly, these birds begun to exploit wetlands around the park in 1995, including the lagoons of Bages, Pissevaches and Vendres. Breeding was first noted in 2000 at Bages, where 75 nests were counted in 2004 and 105 in 2005. Breeding may also occur at Vendres and in the Camargue (150 km from Sigean) where the only nest found, in 2001, was not successful (Kayser et al. 2005). No global census was conducted in this region, but from the number of pairs and the count of 192 sacred ibises roosting at Bages, the population size is thought to be at least 250 birds.

Distribution in other regions in France and long-range movements

Although the species dispersal mostly occurred on wetlands along the Atlantic coast, some birds have been observed hundreds of kilometres away, up to the northeastern borders of France, and it seems to suggest that their dispersal mostly followed the Loire river (Figure 2); overall, inland records remain rare (Clergeau et al. 2005).

A notable exception concerns the wetlands of Dombes, north of Lyon, where sacred ibises are reared in a zoological park at Villars-les-Dombes (5°02′ W 46°00′ N). Jarry and Philippot (1994) suggested that the birds observed in the wetlands of Dombes in the 1980s and 1990s came from

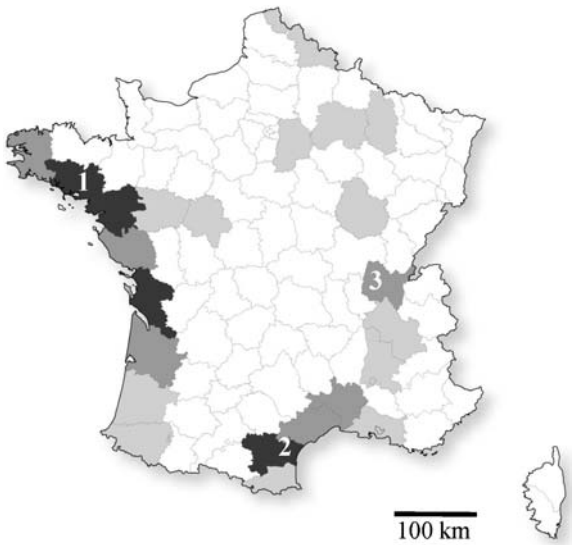

Figure 2. Distribution of sacred ibis in France in 2005. Black: department (administrative division) where the species is breeding. Dark grey: department where ibises are commonly observed. Light grey: department where ibises are occasionally observed (up to March 2005). 1: zoological park of Branféré, 2: zoological park of Sigean, 3: zoological park of Villars-les-Dombes.

this park: about 20 birds stayed for a few years, and it is not clear whether they bred or not, but there were only three remaining in the wild by 2003.

In view of such wide-ranging movements, it has been suggested that most sacred ibises observed in southern Britain in recent years may come from the feral population in France (Blair et al. 2000; but see BOU 2002). Their dispersal capability also suggests that birds from the Bages-Sigean population in southern France might wander to wetlands of the Mediterranean coasts of Spain.

Distribution elsewhere in Europe

Responses to our European investigation were received from ten western and northern European countries where sacred ibises are held in captivity (Table 1). The species is left free to fly in one or more zoological parks in, at least, Belgium, Germany, Spain, Italy and Portugal. In these countries, sacred ibises have been recorded exploiting wetlands and/or rubbish dumps near the zoos where they are reared. Breeding cases have been recorded in the wild since 1974 in Spain (where an urban colony developed in a public garden near the zoo in Barcelona but was controlled and then eradicated in 2001), since 1989 in Italy, and more recently in Canary Islands (1997 onwards), in Portugal (probable breeding in 1998 only) and Belgium (nest construction in 2001). Thus feral populations currently occur in Italy (three breeding sites in Piedmont) and in the Canary Islands.

Roosting and breeding behaviour

In western France during the winter, sacred ibises were spending the night in groups at various roost sites, especially on *Cupressus* and *Pinus* trees. In a minority of cases, roost site and breeding site were the same. Roosts could be either monospecific (up to 700 ibises at one place) or plurispecific, in association with either little egrets *Egretta garzetta* or cattle egrets *Bubulcus ibis*. Most roost sites were in natural environment, but one major mixed roost occurred close to the illuminated car park of a megastore, and another roost was in a large private garden in a suburban area.

In western France, breeding colonies of sacred ibis have occurred in a variety of habitats: on *Cupressus* trees on islets in Golfe du Morbihan; on floating stands of *Salix* trees at Lac de Grand-Lieu; on *Salix* trees isolated amidst very large reedbeds in Briére; both on stranded trees and directly on the ground at an artificial sandy island in the Loire estuary. A colony also occurred on *Thuya* trees in a large private garden in a suburban area. The species thus shows an adaptive capability to different landscapes, provided that there is an island-like appearance.

At Grand-Lieu, Reeber (2005) reported that ibises regularly form monospecific small groups within colonies of other tree-breeding colonial species, mostly little egrets, cormorants *Phalacrocorax carbo* and spoonbills *Platalea leucorodia*. They sometimes built large communal platforms holding up to 30 nests. Such aggregates held up to ca. 250 nests at the main breeding site in the Loire estuary (personal observation).

Table 1. Status of feral population of sacred ibis in Europe (from international enquiries in winter 2004–2005).

Country	Breeding in captivity	Ibises free to fly	Records out of zoological parks	Breeding out of zoological park (feral populations)		
				Area	Period	Maximum number
France	Yes	Yes	Yes	Atlantic coast	1993 (1991 ?) →	ca. 1050 pairs
				Mediterranean coast	2000 →	75 pairs
Spain	Yes	Yes	Yes	Catalonia	1974–2001	18 individuals
				Malaga	1997 →	Possibly breeding
				Canary Islands	1997 →	5 pairs
Portugal	Yes	Yes	Yes	Coimbra	1998	Possibly breeding
Italy	Yes	Yes	Yes	Piedmont	1989 →	At least 26 pairs
Belgium	Yes	Yes	Yes	Hainaut	2001	1 pair, attempt only
Germany	Yes	Yes	Yes	No		
UK	Yes	?	Yes	No		
Luxembourg	Yes	No	No	No		
Sweden	?	No	Yes	No		
Finland	?	No	No	No		
Poland	No	No	Yes	No		

? = No information received.

Sacred ibises breeding at Branféré zoological park laid on average 2.85 eggs per nest ($n = 63$) (Flamen 1994). At Grand-Lieu colony, Marion and Marion (1994) obtained a mean of 2.79 eggs per nest ($n = 19$) and 1.36 young produced per pair ($n = 45$), then Reeber (2005) calculated a mean of 2.38 eggs per nest from a much larger sample ($n = 221$). The mean clutch size was similar at the main breeding site in the Loire estuary: 2.41 ($n = 58$), where breeding success was estimated to be at least 1.46 young fledged per breeding pair from a sample of 486 nests in 2005 (personal observation).

Feeding habitat and diet

According to the information received for western France (synthetic reports by S. Reeber, the late J. Pourreau and Y. Kerninon covering 2–4 years from different areas, plus 63 reports from 18 birdwatchers for winter 2004–2005), the various feeding habitats of sacred ibises are of three main types:

1. meadows, usually but not only wet meadows, with or without cattle; groups of up to ca. 100 ibises could be recorded, occasionally forming mixed foraging groups with other birds species, particularly little egret, curlew *Numenius arquata* or herring gull *Larus argentatus*.
2. rubbish dumps, exploited all year round by ibises, together with various birds species and more frequently herring gull; up to 600 sacred ibises have occurred together at one dump.
3. marshes and reedbeds, particularly used in spring and summer, regularly visited by groups of up to over 100 ibises accompanying various wading species including little egret, cattle egret, grey heron *Ardea cinerea* and also dabbling ducks *Anatidae* and coot *Fulica atra*.

We also identified other habitats that are less frequently used in western France and usually by smaller groups, both in wetlands (lagoons, salt marshes, salt pans, sand beaches, mudflats and seashore consisting in stones and muddy sand) and in farmyards (silage, slurry pits).

The information collected in western France shows that the species diet mostly includes small preys such as earthworms and insects. The consumption of other items has also been observed: fish (eel *Anguilla anguilla*, roach *Rutilus rutilus*, carp *Cyprinus carpio* and flat fish *Pleuronectidae*), small rodents (probably *Apodemus*), molluscs, shrimps, introduced American crayfish, crabs, larvae and adults of batrachians, seeds of maize. Marion and Marion (1994) have underlined the importance of larvae of *Eristalia* sp., Dipteridae, in the food provided to young at Grand-Lieu colony, and crayfish appeared in a number of regurgitates at the main breeding site

in Loire estuary in 2005 (personal observation). Vaslin (2005) and Kayser et al. (2005) reported several cases of predation on eggs and young in colonies of terns (*Sterna sandvicensis*, *Sterna hirundo*, *Chlidonias niger* and *Chlidonias hybridus*) and cattle egret. Predation on eggs of shag *Phalacrocorax aristotelis* has also been strongly suspected (A. Le Névé, personal communication) and predation on eggs or young of waders (*Himantopus himantopus*, *Vanellus vanellus*) has been observed (S. Reeber, personal communication).

Discussion

Population and distribution

The settlement of feral populations of sacred ibis in Europe is a very recent event. In all the reported cases, the introduction involved birds escaped from zoological parks where they were allowed to fly. Currently, colonies are established in at least five areas in three countries, but only five colonies (four in France and one in Italy) appear to involve more than 20 breeding pairs. It is in western France that the invasion process is the most marked in term of number and of geographical spread. For the first time, this species can be considered as an invader away from its natural range.

Although it disappeared from Egypt during the 19th century, this ibis is considered to be either common or very common in sub-Saharan Africa, where it is widespread and not threatened (Del Hoyo et al. 1992). In South Africa, the sacred ibis progressed inland up to Zimbabwe during the 20th century (Harrison et al. 1997). A closely related species, the straw-necked ibis *Threskiornis spinicollis*, also became abundant in Australia during the same period and colonized new habitats such as urban areas (Del Hoyo et al. 1992). These species have already proved their capability to take advantage of habitats modified by man and have consequently expanded their range (Hancock et al. 1992).

Breeding parameters calculated in western France showed higher breeding performances rather than published for Africa: 2.4–2.8 egg per nest in France vs. 2.2–2.3 in Africa (Urban 1974; Maclean 1993) and 1.4–1.5 young fledged per pair vs. usually less than one young per pair in Africa (Del Hoyo et al. 1992). Western France thus seems to present optimal conditions for the reproduction of the tropical sacred ibis.

Habitat, diet and predation

The information collected on habitat use and diet agrees with what is known from the species natural range. In Africa, these ibises forage in a diversity of open habitats, both wet and dry: not only natural grassland but also artificial sites such as dams, sewage, sites used for washing pigs, dung heaps, refuse dumps and cultivated lands, as well as coastal lagoons, intertidal areas and coastal islets (Clark and Clark 1979; A.J. Williams, personal communication). Their nest and roost sites also show a high diversity in Africa, from wetlands and coastal island to urban park (review in Brown et al. 1982; Hancock et al. 1992). The sacred ibis ability to settle away from fresh water and to adapt to human activities, especially in its scavenging behaviour, are put forward to explain the species success in South Africa (Kopij 1999; Blair et al. 2000). The same traits are noted in western France.

Although the sacred ibis diet in Africa seems to be mainly based (1) on small preys such as crickets, water beetles, crustaceans, small fish and batrachians, and (2) on animal and vegetable refuse, numerous other items are consumed (Urban 1974; Clark 1979; A.J. Williams, personal communication). The use of refuse dumps is a common place over the species natural range (Clark 1979) and readily became one of the most important food sources in western France. Such highly predictable feeding areas seem to allow feral populations to survive when harsh conditions occur, e.g., either in cold winters or during the dry season when natural preys become scarce or even inaccessible.

In Africa, sacred ibises have been observed eating eggs and young of colonial waterbirds at coastal or inland areas: various species such as white pelican *Pelecanus onocrotalus*, Cape penguin *Spheniscus demersus*, Hartlaub's gull *Larus hartlaubii*, crested tern *Sterna bergii*, Cape cormorant *Phalacrocorax capensis* or Cape gannet *Morus capensis* have been preyed upon (see review in Urban 1974; Harrison et al. 1997). A study of the predation by sacred ibis at Penguin Island in South Africa showed a much higher

predation rate rather than expected from previous anecdotic reports in the literature (V.L. Ward and A.J. Williams, personal communication): predation was mostly the fact of specialist birds and was considered to be a threat to cormorant colonies. In France, this situation strengthen the concern of conservationists faced to the predation of sacred ibises upon sensible species.

Sacred ibis' extreme tolerance of various environmental conditions, as reported in the literature and from our work on the French introduced populations, underlines the behavioural flexibility of this bird. Species with such a capability to occupy a wide niche or to adapt to changing environment are more likely to successfully invade new environments than are specialized species (Williamson 1996). Particularly, the trait of human commensalism, identified here from the use of refuse, farmyards and very modified habitats, is noted in several meta-analyses of biological traits of invading species (Goodwin et al. 1999; Prinzing et al. 2002). Being such an adaptability, it is suggested that the sacred ibis can rather easily establish itself and spread in other regions of Europe.

Management perspective

For more than 10 years, no action was undertaken against the spread of this alien bird species in France, allowing the feral population to increase in both number and range. At the same time, the species became well known by a large part of the human population along the western French coast. Being a large, white, tame and easily recognizable animal, the sacred ibis was favourably perceived by most people, whereas it got a negative perception from most scientists and all those involved in the management of protected areas (Clergeau et al. 2005).

In France, a classical debate presently opposes (1) those arguing that this alien bird can affect the dynamics of sensitive species, particularly terns, who suggest that a limitation or even the eradication of feral sacred ibises should be undertaken rapidly, and (2) those arguing that this pretty bird species has not proven adverse effect on biodiversity, and that life has to be protected.

In such a debate, it should be considered that alien species are a significant threat to global biodiversity through homogenization process, environment modification and species competition (Vitousek et al. 1997; Beard and Pitt 2005). There is however little experience in policy decisions to eradicate a species in western Europe, particularly for birds which gave rise to very few eradication attempts, all of them in the recent years (Clergeau et al. 2004; Smith et al. 2005), while more experience has been accumulated regarding mammals (review in Courchamp et al. 2003; Genovesi 2004). According to Lobos and Jaksic (2005), decision should be taken as soon as possible, not waiting until either the impact of predation is estimated or the species innocuousness is fully proven. Also, the situation presented here shows that free flying groups of birds in zoological parks are a threat to biodiversity which needs to be urgently considered.

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