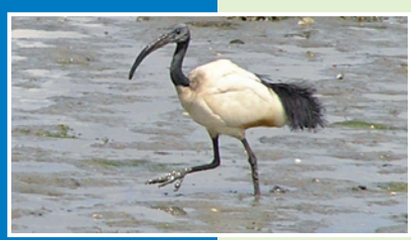
A risk analysis of the sacred ibis in The Netherlands

Including biology and management options of this invasive species



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Preface

During the last decade increasing numbers of the non-native sacred ibis *Threskiornis aethiopicus* have been present in The Netherlands. Since 2002, the species has bred in three areas, including the Natura 2000 site Botshol. To get more of an insight into the probability of establishment of this species in The Netherlands, and any possible ecological, economical and social impacts, the Team Invasieve Exoten of the Ministry of Agriculture, Nature and Food Quality asked Bureau Waardenburg to carry out a risk analysis.

This risk analysis was carried out by ir. R.R. Smits (report), drs. J. van der Winden (project leader and report), Msc M. Collier (review) and drs. P. van Horssen (GIS). Dr. T.M. van der Have, Team Invasieve Exoten, supervised this study.

We want to thank the following experts for their effort and contribution:

- Sacred ibis (France): P. Clergeau, sacred ibis researcher (Professeur du Muséum National d'Histoire Naturelle, France), P. Yésou (ONCFS France).
- Sacred ibis (Italy): M. Fasola (Dipartimento Biologia, Pavia).
- Glossy ibis: A.J. Green (Estación Biológica de Doñana, Spain), J. Figuerola (Estación Biológica de Doñana, Spain).
- Australian white ibis: J.M. Martin (Australia).

Furthermore we want to thank the following people:

- J. Harteman for his information about the number of kept sacred ibises and for some extra information about the species in captivity.
- M. Klemann for his extensive gathered information of sacred ibises before 2005 in Europe.
- H. de Vries (team Waarneming.nl) and D. Verheul (Stichting Natuurinformatie) for providing records of waarneming.nl.
- The observers of the sacred ibis colonies in The Netherlands for their information: S. Strik (colony near Avifauna) and J. van der Woude (Botshol). For the third breeding place, De Banen, J. Nagtegaal provided information.

Furthermore we want to thank the following people for their contribution:

- Observers: W. Beeren, N. van Houtum, M. Renders
- Ring information: F. Lievens (Aviornis Belgium)
- Zoo information: W. Schoo (Burgers' Zoo).

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Nederlandse samenvatting

De heilige ibis *Threskiornis aethiopicus* is in Nederland van oorsprong niet inheems. Sinds enkele decennia heeft de soort zich vanauit gevangenschap in het wild gevestigd in Nederland en neemt in aantal toe. Vanaf 2002 zijn broedgevallen vastgesteld in drie verschillende gebieden waaronder Natura 2000-gebied Botshol. Om meer inzicht te krijgen in de kans dat de heilige ibis zich gaat vestigen in Nederland en de mogelijke ecologische, economische en sociale effecten die daarmee gepaard zouden kunnen gaan, heeft Bureau Waardenburg in opdracht van het Team Invasieve Exoten (Ministerie van LNV) een risico analyse uitgevoerd. Deze rapportage is te beschouwen als een technische wetenschappelijke analyse van de effecten van de heilige ibis op biodiversiteit, economie, veiligheid en de mogelijkheden voor beheer.

De volgende onderdelen zijn onderscheiden:
<u>Risico beoordeling</u>

- waarschijnlijkheid van voorkomen
- waarschijnlijkheid van vestiging
- waarschijnlijkheid van verspreiding
- bedreigde gebieden
- impact
- score risico beoordeling

<u>Risico management</u>

- preventie
- eliminatie
- beheer

Om de bovenstaande onderdelen in te vullen is een uitgebreid literatuuronderzoek uitgevoerd en zijn binnenlandse en buitenlandse experts geconsulteerd.

Het oorspronkelijke verspreidingsgebied van de heilige ibis is Afrika (ten zuiden van de Sahara) en Irak (uitgestorven in Egypte). In Europa heeft de heilige ibis zich gevestigd in Frankrijk, is zich aan het vestigen in Italië en worden in verschillende landen frequent escapes vastgesteld. Zowel de heilige ibis als verwante soorten hebben een hoog dispersie potentieel. Zowel qua habitat als voedselvoorkeur gedraagt de soort zich opportunistisch.

De belangrijkste bevindingen uit de risico analyse zijn:

Risico beoordeling

<u>De waarschijnlijkheid van binnenkomst</u>

- In zowel dierparken als privé collecties worden in Nederland enkele honderden heilige ibissen gehouden. In de toekomst kan dit leiden tot ontsnappingen en dus bijdragen aan kolonisatie of het aanvullen van wilde populaties.

- De belangrijkste wegen van binnenkomst in Nederland zijn escapes afkomstig van vrijvliegende vogels uit dierenparken en privé collecties. Kolonisatie door vrijvliegende vogels uit nabijgelegen landen behoort eveneens tot de mogelijkheden (Belgie, Frankrijk en Duitsland).
- Binnenkomst van vogels die ontsnapt zijn in het buitenland is ook niet uitgesloten sinds Duitse escapes in Nederland zijn vastgesteld.
- De kansen van kolonisatie door vogels afkomstig uit gevestigde buitenlandse populaties zijn laag. Daarentegen bestaat de Franse populatie nog (uitroeiings-campagne wordt gecontinueerd) en zijn geen beheersmaatregelen in Italië gepland.

Het is dus waarschijnlijk dat in de (nabije) toekomst via een van de geschetste wegen heilige ibissen Nederland kunnen binnenkomen.

De waarschijnlijkheid van vestiging

- Zowel voor de heilige ibis geschikt broedbiotoop als foerageergebieden zijn wijd verspreid in Nederland en van goede kwaliteit.
- Vanwege de bovenstaande factoren is het is niet uitgesloten dat de huidige kleine groep broedende en reproducerende Nederlandse vogels zich tot een gevestigde populatie ontwikkelen.
- Recente informatie suggereert een grotere afhankelijkheid van door mensen beïnvloede voedselbronnen, waardoor de waarschijnlijkheid van vestiging kleiner worden. Gegevens over winteroverleving en voedsel zijn essentieel om deze factoren te beoordelen.

De waarschijnlijkheid van verspreiding

- Op basis van de huidige (periode 2000-2009) jaarlijkse gemiddelde groeisnelheid van 12,6%, zal de populatie in 2025 60 paar bedragen en in 2050 1200 paar (berekend over periode tot en met 2009). Echter de laatste twee jaren zijn ibissen actief teruggevangen. Als de jaarlijkse groeisnelheid berekend wordt over de periode tot 2008 (zonder terugvangacties) was de jaarlijkse groeisnelheid 30,1%.
- Indien de populatie in de winter deels afhankelijk is van bijvoeren dan kan de werkelijke groei lager zijn dan onder natuurlijke omstandigheden.
- Het is aannemelijk dat de heilige ibis zich vanuit de huidige broedplaatsen eerst verder gaat verspreiden over het laagveengebied in westelijk Nederland.
- Op de lange termijn is de soort in staat om een groot deel van Nederland te koloniseren, inclusief wetlands verspreid van Zeeland tot aan Groningen, de Waddeneilanden en langs de rivieren.

Bedreigde gebieden

- Het is waarschijnlijk dat de meeste wetlands met Natura 2000 status gekoloniseerd kunnen worden, aangezien habitat naar verwachting niet limiterend is.

- De heilige ibis heeft zich al gevestigd in Natura 2000-gebied Botshol. Gezien de huidige situatie met vogels aanwezig in Lepelaarsplassen, Oostvaardersplassen en het Quackjeswater is het mogelijk dat deze gebieden in de nabije toekomst worden gekoloniseerd.
- Op de lange termijn kan uiteindelijk ieder wetland worden gekoloniseerd (inclusief de Wadden eilanden).

Impact

- Ecologische effecten: mogelijk predatie van kolonievogels (met name nesten van sterns en aalscholvers) en mogelijk nestcompetitie met de lepelaar en reigerachtigen.
- Economische effecten: in Nederland een laag risico.
- Sociale effecten: mogelijk lokaal of minimale effecten.

Score risico beoordeling

- De uitkomst van de Invasive Species Environmental Impact Assessment (ISEIA) methode is 10. Dat betekent dat de soort behoort tot de categorie BL: Watch List. Deze categorie behelst soorten die matige effecten hebben. Buiten het invoeren van regelgeving en restricties op het houden van de soort worden op basis voor deze categorie geen onmiddellijke management acties overwogen.
- De uitkomst van de Bomford methode is een score van 0 voor publieke veiligheid (geen gevaar), 12 voor vestigingsrisico (ernstig) en 11 voor het pest-risico (matig). De combinatie van deze drie items is de Australische VPC (Vertebrate Pest Committee) threat category ernstig. Acties die overwogen dienen te worden bij soorten van deze categorie zijn radicale restricties voor het houden van de soort, uitgebreide beveiligingsmaatregelen en bijhouden van een uitgebreide administratie.

Risico management

Preventie

- Registratie op een centrale plaats van alle in gevangenschap gehouden heilige ibissen. Deze kennis kan helpen bij het inschatten van de omvang van risico populaties en het nemen van maatregelen om ontsnappingen te voorkomen.
- Het risico van toekomstige ontsnappingen of uitzettingen kan voor een belangrijk deel worden weggenomen door voorlichting van alle betrokkenen over de risico's van ontsnapte heilige ibissen en over preventieve maatregelen ter voorkoming van escapes.
- Ook na invoering van de voorgaande maatregelen blijft de kans aanwezig dat vogels ontsnappen of worden uitgezet. Daarnaast blijft het mogelijk dat vogels binnenkomen vanuit buitenlandse dierenparken of buitenlandse populaties.
- Dus het minimaliseren van nieuwe binnenkomst van heilige ibissen is mogelijk, maar het compleet wegnemen van mogelijk wegen van binnenkomst is onmogelijk.

Eliminatie

- De Franse situatie laat zien dat complete uitroeiing moeilijk of onmogelijk is. In de Nederlandse situatie is uitroeiing waarschijnlijk moeilijk vanwege het deels verblijven in moeilijk of niet toegankelijke gebieden.
- Maatregelen, inclusief terugvangen, oliën van eieren, schieten van vogels op geschikte plekken, zullen leiden tot een verwijdering van een groot deel van de populatie. De genoemde maatregelen kunnen leiden tot een acceptabel populatieniveau. Het is onwaarschijnlijk dat ze leiden tot uitroeiing.
- De volgende conflicten kunnen in Nederland voorkomen: sterke lobby van dierenrechten/welzijn groepen, ruiming leidt tot conflicten met beschermde soorten en gebieden. Deze factoren maken een succesvolle eliminatie campagne moeilijk uitvoerbaar.

Mogelijkheden voor beheer

- De verzamelde informatie en de analyse van zowel de waarschijnlijkheid van vestiging als de waarschijnlijkheid van verspreiding ondersteunen sterk dat de heilige ibis zich definitief kan vestigen en verder verspreiden in Nederland indien beheermaatregelen uitblijven.
- In de huidige situatie zijn haalbare management opties voor de Nederlandse populatie heilige ibissen preventieve maatregelen (inclusief registratie van gehouden heilige ibissen) en beheer opties (terugvangen semi-wilde vogels, schieten en mogelijk het oliën van eieren).
- Om de effectiviteit van de genomen management acties op de ontwikkeling van de heilige ibis populatie te evalueren is goede monitoring nodig. Dit betekent populatietellingen over de seizoenen heen, monitoring broedvogels en bijhouden van demografische parameters inclusief broedsucces. Informatie over mortaliteit in de winter en vooral informatie over foerageergebieden kunnen inzicht geven in de noodzaak om terugvangen te continueren.
- Indien populatie management wordt toegepast dan zal naar verwachting de overblijvende kleine populatie afnemen tot slechts een klein aantal individuen, inclusief nieuwe escapes en immigranten. In de toekomst zullen dan kleine aantallen heilige ibissen voorkomen in Nederland.

1 Introduction

During the last decade increasing numbers of the sacred ibis *Threskiornis aethiopicus* have been present in The Netherlands. Since 2002, the species has bred in several areas, including the Natura 2000 site Botshol; at which they are breeding within a spoonbill colony. Native to Africa, the sacred ibis is an exotic species in Europe with established populations in France and Italy (Clergeau & Yésou 2006). To get more insight in the probability of future establishment of the species in The Netherlands, and any possible ecological, economical and social impacts a risk analysis was carried out. The outcome of this analysis is presented in this report. This report can be regarded as a technical scientific analysis of the impact of the sacred ibis on biodiversity, economy and safety and possible management options.

1.2 Goals and terms of reference

The purpose is to accomplish a thorough analysis to the chances of an established population and the probability of the spread of the sacred ibis across The Netherlands. Furthermore, the actual and possible impacts on ecological, economical and social aspects are described.

Conforming to the terms of reference in order to fulfil to above goal the following parts are recognised:

1. Risk-assessment
    - 1a probability of occurrence
    - 1b probability of establishment
    - 1c probability of spread
    - 1d Endangered areas
    - 1e Impact
    - 1f Risk assessment score

2. Risk management
    - 2a Prevention
    - 2b Eradication
    - 2c Management

1.3 Methods

In order to fill in the above-mentioned parts an extensive literature search was carried out. The search was not limited to the ISI Web of Science, Scopus, standard works, but also covered non-peer reviewed published material; the so-called 'grey literature'.

For more in detailed information and to fill in gaps in the knowledge about e.g. the number of captive sacred ibises the following experts were consulted:

- Sacred ibis: P. Clergeau, sacred ibis researcher (Professeur du Muséum National d'Histoire Naturelle, France), P. Yésou (ONCFS France), M. Fasola (Diparti-mento Biologia, Pavia);
- Glossy ibis: A.J. Green (Estación Biológica de Doñana, Spain), J. Figuerola (Estación Biológica de Doñana, Spain);
- Australian white ibis: J.M. Martin (Australia);
- Sacred ibises in captivity (numbers and background): J. Harteman, W. Shoo (Burgers' Zoo);
- Dutch & European records: M. Klemann (pre 2005 records);
- Dutch records: H. de Vries (team Waarneming.nl) and D. Verheul (Stichting Natuurinformatie).

The International Species Information System (ISIS) was used to get insight in the number of sacred ibises kept in zoological parks.

1.4 Structure of the report

In the first chapter, the introduction is given and includes information about the goals, the terms of reference and the methods used. In chapter 2, an extensive overview of the current knowledge of the biology and ecology of the sacred ibis is given. Chapter 3 shows an overview of the naturalised established in Europe, the emphasis being on the situation in The Netherlands and France. By means of the gathered information from chapters 2 and 3 and expert judgement, the goals of this research are answered in chapter 4. Chapter 5 presents the conclusions and recommendations.

2 Biology and ecology of the Sacred Ibis

2.1 Introduction

The sacred ibis *Threskiornis aethiopicus* is a member of the family Threskiornithidae (ibises and spoonbills) and subfamily Threskiornithinae (del Hoyo *et al.* 1992). Formely the species was regarded as conspecific with the Madagascar ibis (see www.worldbirdnames.org). The sacred ibis forms a superspecies with the Madagascar ibis, black-headed ibis and Australian white ibis (del Hoyo *et al.* 1992).

The sacred ibis is the thickest-billed of the four closely related ibis species (del Hoyo *et al.* 1992). The bird is white with black tipped primaries and secondaries, a black head and partly black neck, a black downward-curved bill and black legs (see figure 2.1).

As the species is relatively abundant (250,000-400,000 breeding pairs) and has a large range (17.6 million km^2), it is categorised by Birdlife International as "Least Concern" (Birdlife 2009).

Figure 2.1 Sacred ibises and greylag geese, 29 July 2008, Soerendonks Goor, Soerendonk, Noord-Brabant (picture R. Smits).

2.2 Biology and ecology

2.2.1 Distribution

The current natural distribution of the sacred ibis is shown in figure 2.2. The species is common in Africa, south of the Sahara. Up until the beginning of the 19th century the species was common in Egypt, where it became extinct in 1850 (del Hoyo *et al.* 1992). In ancient Egypt, it was a very common bird that scavenged together with the glossy ibis and the black kite around the streets of Alexandria (Dixon 1989). In 1970, sacred ibises were common in southern Iraq, but it declined due to drainage of wetlands (Snow & Perrins 1998). Recently, after reflooding of the Mesopotamian marshlands, the species was found breeding (Bonn 2005). Populations have become established in several parts of France (Marion & Marion 1994; Clergeau & Yésou 2006; Dubois 2007); in all cases originating from free-flying collections. In The Netherlands, the species has been present for several decades in increasing numbers (van den Berg & Bosman 1999; Hustings *et al.* 2008) and recently the species started to breed. Since 2001, breeding birds have been found at two areas in Zuid-Holland and since 2006 in the border region between Noord-Brabant and Limburg (van Dijk *et al.* 2003; van Dijk *et al.* 2005a; van Dijk *et al.* 2005b; van Dijk *et al.* 2006; van Dijk *et al.* 2007; van Dijk *et al.* 2008; van Dijk *et al.* 2009). For further details of non-native populations see chapter 3.

In large parts of its range the sacred ibis behaves nomadically, especially during the rainy season. In Africa, for example, during the rains, birds south of the equator fly south and birds north of the equator fly north (del Hoyo *et al.* 1992). At the end of the rainy season and the beginning of the dry period birds begin to return. Birds ringed in South Africa have been recaptured in Angola and Zambia. The Iraqi population winters in small numbers in Iran and individuals have been found in Kuwait and Yemen.

Dispersal of birds from the French population has occurred mainly along the Atlantic coast (inland records remain rare), although birds have been recorded up to the north-eastern border of the country (Clergeau & Yésou 2006). New colonies are formed 70 km away from established areas. Clergeau & Yésou suggest that the dispersal of this species has followed the Loire River.
Preliminary results of research on the related Australian white ibis in the Sydney region of Australia, shows that only a small proportion of the adult birds behave as residents (Martin in litt.). Of the birds tagged only a small proportion was found to use the same breeding site the following year with most adults dispersing to other colonies. Dispersal of juveniles of up to several thousand kilometres shortly after fledging has been observed within the natural range.

- **The sacred ibis can adapt quickly to new situations, has a high dispersal probability and a large distribution.**

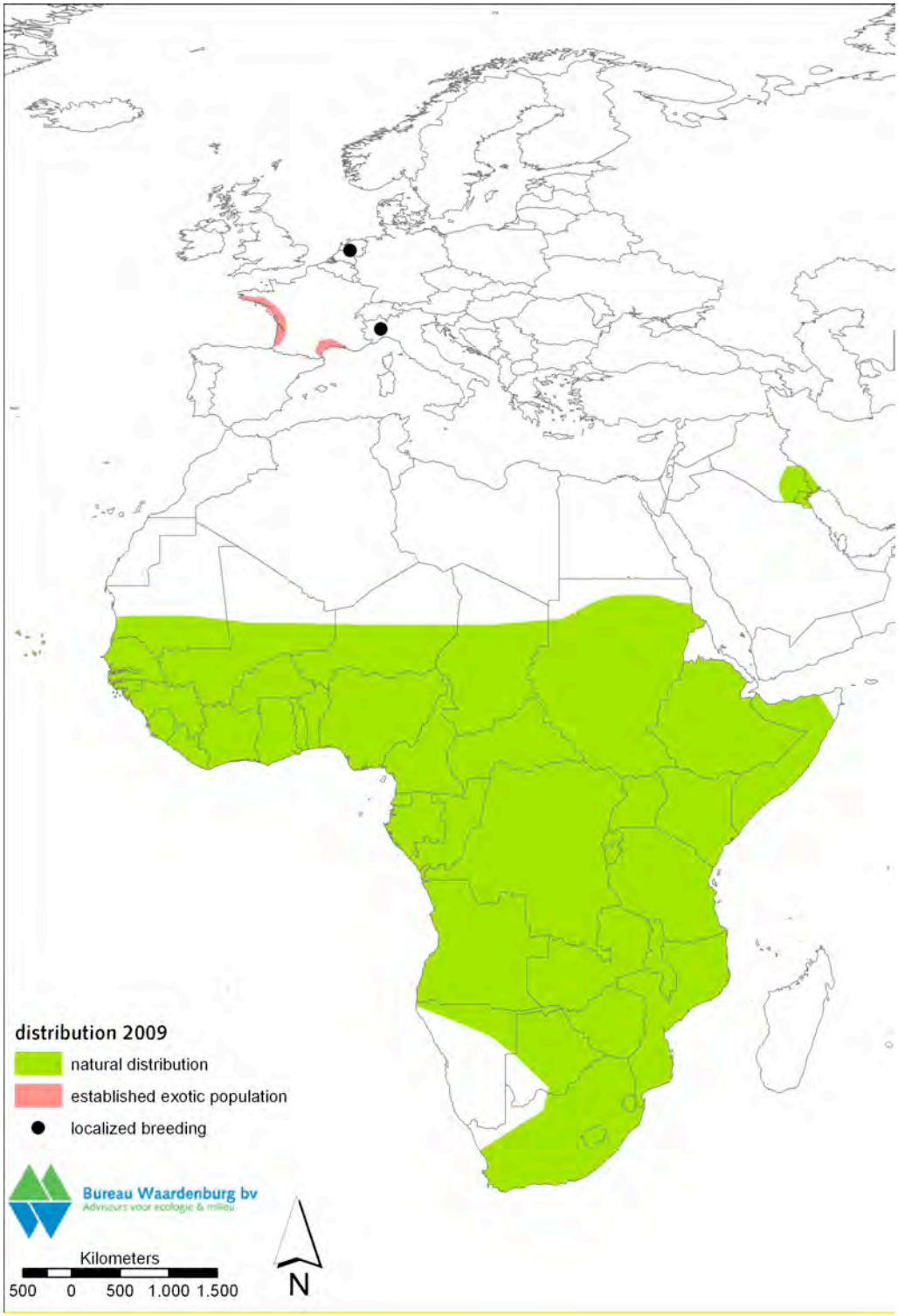

Figure 2.2 Overview of the natural distribution and non-native populations of the sacred ibis. The map does not include non-native populations outside Europe. Sources are Clergeau & Yésou (2006) and del Hoyo et al. (1992).

2.2.2 Breeding Biology

In Africa, breeding takes normally place shortly after wet periods, however, in areas that are normally flooded breeding takes place in the dry period (del Hoyo *et al.* 1992). The sacred ibis breeds in colonies of 50 to 2,000 pairs and commonly in association with other species of herons and ibises (del Hoyo *et al.* 1992; Kopij 1999). Isolated pairs or groups of the closely related Australian white ibis occur in the larger, more concentrated colonies of straw-necked ibis and also among nesting cormorants, spoonbills and herons (Carrick 1962). A colony of 1218 pairs of sacred ibises in Free State, South Africa, was mixed with species like reed cormorants, black-headed herons and little egrets. Often a colony is divided into several sub-colonies (Kopij 1996 en Kopij 1997; both in Kopij 1999).

A normal clutch contains 2-3 eggs and has an incubation period of 28-19 days (del Hoyo *et al.* 1992). Kopij (1999) found that clutches at the start of the incubation season contain more eggs (2.69) than clutches at the end of the incubation (2.40). Kopij (1999) also found that at the end of the incubation period many of the eggs were ejected or dropped from nests. In a colony in South Africa the mean number of hatchlings per nest with eggs was 1.7 and the mean number of hatchlings per nest with hatchlings was 2.3 (Kopij 1999). Hatching success at that colony was 66% and in another colony 88.4%.

At the colony at Wolwekop, South Africa, average fledging success in 1976/1977 was per nest (N=40) with eggs 1.5, per nest with hatchlings 1.9 and per nests with fledglings 2.1 (Kopij 1999). The fledging success in that season was 57.8% and in 1993/1994 51.4%. Birds fledge 35-40 days after hatching. The oldest known ringed bird was 21 years (del Hoyo *et al.* 1992).

In western France the sacred ibises breeding (free-flying) at Branféré zoological park laid on average 2.85 eggs per nest (n=63) (Flamen 1994 in Clergeau & Yésou 2006). In the Grand-Lieu colony a mean of 2.79 eggs (n=19) was found (Marion & Marion 1994) and based on a larger sample (n=221) the clutch size was estimated at 2.38 eggs (Reeber 2005 in Clergeau & Yésou 2006). The breeding success for the Grand-Lieu colony was 1.36 young produced per pair (n=45). Observations by Clergeau & Yésou in the Loire estuary resulted in a mean clutch size of 2.41 eggs (n=58) and in 1.46 young fledged per breeding pair (n=486) (Clergeau & Yésou 2006).

2.2.3 Habitat, diet and feeding behaviour

Breeding habitat

Nests sites are usually selected within trees and thickets, however, birds sometimes build nests on the ground on islands (del Hoyo *et al.* 1992; Kopij 1999). In France, breeding colonies of the species have occurred in trees on islands, on floating stands of willows, isolated willows amidst large reedbeds, in a *Thuya* trees in a suburban area and on the ground of an artificial sandy island (Clergeau & Yésou 2006).

Nests are usually build in trees and thickets, while on (rocky) islands breeding takes place normally on the ground (del Hoyo *et al.* 1992; Kopij 1999). The nests are large, comprising of a platform 27-37 cm in diameter with a height of 10-15 cm. It is constructed of sticks (10-140 cm in length), with a mixture of weed stems, roots and grass clumps (Kopij 1999). In some nests in Free State synthetic materials were used like nylon rope, wire and cable (Kopij 1999). During incubation and in the hatching phase nests are commonly complemented with greenery like grass and willow twigs (Kopij 1999).

Feeding habitat

In the natural range the sacred ibis occurs mainly in the margins of freshwater wetlands, but is found in a wide range of other habitats including sewage works, grasslands, agriculture, coastal lagoons, intertidal areas (figure 2.3) and offshore islands (del Hoyo *et al.* 1992). The species takes advantage of human environments like rubbish dumps, farmyards and abattoirs, and can occur far away from water, often in recent burned areas.

In line with the habitat in the natural distribution the sacred ibis uses a wide range of habitats in their non-native range. In France birds are feeding on meadows, usually wet meadows with or without cattle (Clergeau & Yésou 2006). Furthermore, Clergeau & Yesou mentioned that sacred ibises feed year-round at rubbish dumps, frequently together with herring gulls. Marshes and reedbeds are particularly used in spring and summer.

Less frequently used habitats in western France include lagoons, salt marhes, salt pans, sandy beaches, mudflats (figure 2.3), seashores consisting of stones and muddy sand and farmyards (Clergeau & Yésou 2006).

Feeding behaviour

In France sacred ibises feed in flocks of up to 100 birds and occasionally form mixed groups with other species, particularly little egret, curlew and herring gull (Clergeau & Yésou 2006). In marshes and reedbeds the species regularly forms feeding flocks of more than 100, often with various wading species, including little egret, cattle egret, grey heron, dabbling ducks and coot. Typical foraging behaviour is slowly walking and taking live prey by pecking or probing in mud or soft earth (del Hoyo *et al.* 1992).

Diet

In the natural range the sacred ibis is mainly insectivorous taking grasshoppers, locusts, crickets and aquatic beetles (del Hoyo *et al.* 1992). Crustaceans, worms, molluscs, fish, frogs, lizards and small mammals are also eaten. Sometimes birds feed on eggs of birds and crocodiles, nestlings of birds, carrion, offal and seeds. In some areas rubbish dumps are visited in order to feed on animal and vegetable waste (del Hoyo *et al.* 1992).

In western France the diet of the sacred ibis contains mostly small prey like earthworms and insects (Clergeau & Yésou 2006). Observations shows that the diet includes also fish, small rodents, molluscs, American crayfish, crabs, larvae and adults of batrachians and seeds of corn. The larvae of Eristalia species (Diptera: Syrphidae) are of importance in the food provided to young at the colony of Grand-Lieu (Marion & Marion 1994).

Figuur 2.3. Sacred ibis feeding at coastal mudflats in France, July 2008 (picture J. van der Winden).

Sacred ibises predate eggs and young of colonial waterbirds and have been known to take these from species like white pelican, crested tern and Cape gannet (Urban 1974; Harrison et al. 1997; both in Clergeau & Yésou 2006). In France several cases of predation on eggs and young in the colonies of terns (sandwich tern, common tern, black tern and whiskered tern) and cattle egret have been reported (Kayser *et al.* 2005; Vaslin 2005). Furthermore, the predation of eggs of shag has been suspected (A. Le Névé in Clergeau & Yésou 2006) and predation on eggs and young of black-winged stilt and lapwing has been observed (S. Reeber in Clergeau & Yésou 2006).

A study at Penguin Island in South Africa showed a much higher predation by sacred ibises on cormorants than previous expected. Specialized individuals were mainly responsible for the predation and were found to be a threat to the cormorant colony. The sacred ibis predation, together with the predation by herons, accounted for the third most important cause of mortality among a colony of 4,800 pair Cape cormorants (Williams & Ward 2006). It was observed that the sacred ibises predated 152 cormorant eggs and chicks and 37 heron chicks. Extrapolated across the full season,

this would result in the predation of a total of 960 cormorant eggs and chicks (Williams & Ward 2006). Sacred ibises accounted for 65% of all recorded predations of chicks of Cape cormorants and the loss in annual production was calculated at between 10-15% (Williams & Ward 2006).

- **Both the species feeding habitat en diet are diverse. As a generalist sacred ibis can occur in many different habitat types.**

2.2.4 Predators, diseases and other causes of death

The most important predator of the sacred ibis (not mentioned, but probably mainly nestlings) in Kenya is the African fish eagle (Parson 1977 in Kopij 1999). In Ethiopia and South Africa (Free State) predation was of less importance on reproduction that in Kenya (Kopij 1999). In India, the hatchlings of the closely related black-headed ibis are heavily predated by crows and birds of prey (del Hoyo *et al.* 1992). The turkey vulture sometimes predates the hatchlings of American white ibis (del Hoyo *et al.* 1992).

Sacred ibis can suffer from avian cholera. In 1991 a large scale mortality of Cape cormorants (16% of the breeding population) from avian cholera was reported in western South Africa (Crawford *et al.* 1992). In addition, small numbers of other species, including sacred ibis, were killed. Like all birds, sacred ibises can carry a variety of viruses and bacteria that can cause diseases, like the Australian white ibis that is host to several zoonotic and livestock pathogens (Epstein *et al.* 2006). The actual prevalence of pathogens and parasites in the non-native populations of sacred ibis is unknown.

Relatively high levels of pesticide residuals have been found in sacred ibis eggs in South Africa, this is probably due to its opportunistic diet (scavenging) and the ability to live in close proximity of human developments (Bouwman *et al.* 2008). However, as the sample size of this study was small the authors stated that it should be used with caution.

In The Netherlands, the sacred ibis has once been found as a collision victim of a high tension line near Hazerswoude-Dorp (Prinsen *et al.* 2008).

2.2.5 History as a pest

Pest

There are no indications that the sacred ibis is a pest species within its natural range. However, as the diet includes the seeds of corn (Clergeau & Yésou 2006) and Sabal palm fruit (Herring & Gawlik 2008) it could be a potential pest species for agriculture in specific situations.

In their native range, as stated earlier, the sacred ibis is known to predate the eggs and young of several species, especially colonial birds like terns and cormorants. For several colonies in Africa predation of eggs and nestlings of Cape cormorant is one of the

leading causes of mortality. However, it is unknown whether this predation is a local occurrence or is more widespread. At least five cases of predation of birds, including terns, have been reported in France (Clergeau *et al.* 2005). Furthermore, in southern France the competition for nest sites with cattle egrets and little egrets has been observed (Kayser *et al.* 2005).

Kopij (1999) hypothesized that the increase of sacred ibises in several areas in South Africa are causing the decline of breeding African spoonbill, through competition for nest sites and the use of the same feeding habitat. As ibises and spoonbills are highly dependent on wetlands for feeding, breeding and resting, they are particularly vulnerable to changes or the complete disappearance of these habitats (del Hoyo *et al.* 1992). Such habitat changes often result in food shortages; also one of the causes of decline of the Cape cormorant population (Crawford & Dyer 1995). Overall, without any thorough research and with so many factors to take into account, it seems too easy to attribute the decline of the African spoonbill to the sacred ibis. The available information suggests that the plasticity of the sacred ibis makes the species successful in times that others are declining.

The closely related Australian white ibis, which expanded its range into the urban centres of eastern Australia, is considered to be a pest species. This is because they pose a threat to aircraft safety, scavenge food at waste-management sites, cafes and parks, and compete with other native species for food and habitat (Martin *et al.* 2007).

In Australia, the related straw-necked ibis is known as useful predator of the Australian pest locust and other agricultural pest insects (Carrick 1959)

Other

The closely related Australian white ibis is regularly reported as collision victim with aircrafts (ATSB 2003). Between 1991-2001 39 strikes involving ibises (species not specified) were reported in Australia. Grasslands at airports, especially after mowing or rain, are very attractive as foraging areas for ibises. In Australia, ibises are regarded as the second most important threat to aircraft safety. In Kenya, collisions with sacred ibises are regularly reported. In the period 1991-2001 a total of 224 bird strikes at three Kenyan airports involving Kenya Airways flights were reported and among them were 10 strikes with sacred ibises (Owino *et al.* 2004).

- The sacred ibis is not known as pest species. The closely related Australian white ibis is regarded as urban pest species. Locally the sacred ibis predates on eggs and young of other bird species, however effects at population level are unknown.

3 Established non-native populations

Free flying birds in European zoological parks are reported in at least France, Belgium, Germany, Spain, Italy and Portugal (Clergeau & Yésou 2006). Furthermore, a group of around 30 sacred ibises of Avifauna, Alphen a/d Rijn in The Netherlands has been free flying for several years and are breeding in the wild. Other countries with non-native populations are France and Italy (figure 2.2). Furthermore possible breeding and incidental breeding has been reported from Spain, Canary Islands, Portugal and Belgium (Clergeau & Yésou 2006). Escaped individuals are reported from many European countries including UK, Germany, Sweden and Poland (http://www.michelklemann.nl/ibis/index.htm).

In this chapter the development of the populations in Europe is described.

3.1 France

Atlantic coast

The first breeding of sacred ibises outside the zoological park Branféré, Morbihan, within natural habitat was noted 1993 near Golfe du Morbihan (Frémont 1995 in Clergeau & Yésou 2006) and Lac de Grand Lieu (Marion & Marion 1994). However, it is suspected that breeding started several years earlier. The breeding numbers increased to 130 nests in 1998 at Grand-Lieu, while colonies also occurred in Briére marshes (ca. 100 nests) and near Arcachon about 350 km south of Branféré (Clergeau & Yésou 2006).

The total French breeding population in 2001 was estimated at about 450 pairs and in 2005 at about 1,100 pairs (Clergeau & Yésou 2006). The first censuses to achieve estimates of the total populations were made in 2003. In the winter 2003-2004 2,500 ibises were counted and in the winter 2004-2005 about 3,000 birds were present at 18-25 roosts (Clergeau & Yésou 2006). The number of breeding pairs increased to 1,700 pairs in 2006 and the number of individuals to 5,000 in 2006 (Yésou in Dubois 2007).

Mediterranean coast

At the zoological park of Sigean captive sacred ibises were free flying. The first birds were imported in 1982. In 1992 the total number of birds was 77 and they began to exploit the surrounding wetlands in 1995 (Clergeau & Yésou 2006). First breeding was noted in 2000 at Bages. The number of pairs increased to 75 in 2004 and to 105 in 2005 (Clergeau & Yésou 2006) and the regional population size was estimated at 250 birds.

Between 1994 and 2006, the French population has grown exponentially (figure 3.1). No recent figures for the population sizes have been published. Since 2007 the France government has started an eradication program. At the Atlantic coast about 4,500

birds have been shot, mainly in 2008-2009, and ibises are also shot at the southern coast where about 20-30 birds are left from the original figure of approximately 300 birds (Yésou in litt.).

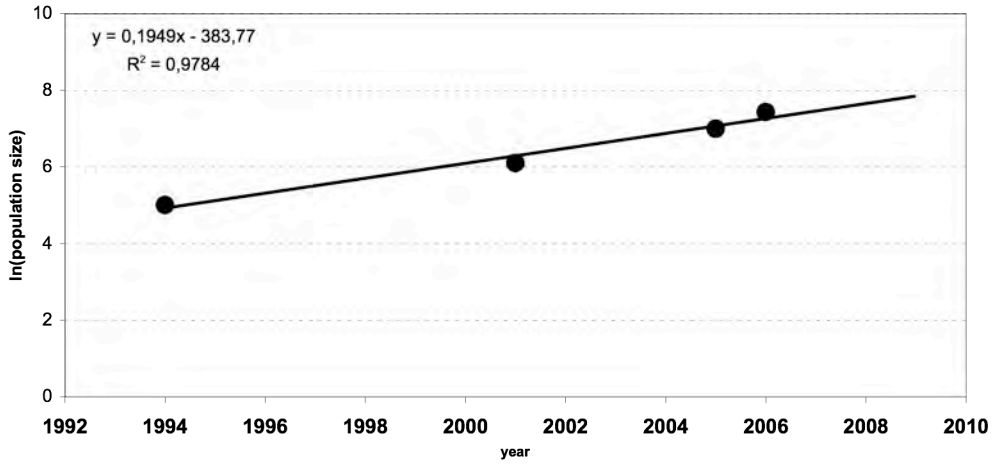

Figure 3.1 Population development (pairs) of the French breeding population of the sacred ibis (average yearly growth of 21.5 %).

France versus native distribution

In France the breeding performance is slightly higher than observed in Africa: 2.4-2.8 eggs per nest in France versus 2.2-2.3 in Africa (Clergeau & Yésou 2006). The number of fledged young is in Africa usually less than one per pair (del Hoyo *et al.* 1992) and in France 1.4-1.5 fledglings per pair (Clergeau & Yésou 2006). It could be that this difference is a result of optimal circumstances in France. On the other hand colonising populations and not yet stabilised increasing populations have higher growth rates than a population that has reached its carrying capacity.

3.2 Netherlands

3.2.1 Breeding

In The Netherlands escaped sacred ibises and (formerly) free flying ibises from zoological park Avifauna in Alphen a/d Rijn, Zuid-Holland resulted in breeding attempts in 2001 and the first successful breeding in 2002. An overview of the development of the breeding population is given below.

2001: 2 pairs

The first territorial birds were present in 2001 in nature reserve Botshol, Noord-Holland, with two pairs in the spoonbill colony (van Dijk *et al.* 2003). Another group of sacred ibises was present during the breeding season in the spoonbill colony in Quackjeswater, Zuid-Holland (website http://www.michelklemann.nl/ibis/index.htm).

2002: 3 pairs
Three pairs bred successfully in Botshol and few individuals were present in de spoonbill colony of the Oostvaardersplassen (van Dijk *et al.* 2003).

2003: 10 pairs
Five pairs bred in Botshol and raised seven young; five pairs were nesting near Avifauna, Alphen a/d Rijn, Zuid-Holland (van Dijk *et al.* 2005a). In Botshol a bird was found dead wearing a ring from zoological park Avifauna (website http://www.michelklemann.nl/ibis/index.htm). The bird was born and ringed in 2001 in Avifauna.

2004: 4 pairs
Four pairs were nesting in Botshol, with one wearing a ring from Avifauna and none were nesting near Avifauna (van Dijk *et al.* 2006).

2005: 7 pairs
Seven pairs were nesting in Botshol and none near Avifauna (van Dijk *et al.* 2007).

2006: 7 pairs
In 2006 again seven pairs were breeding in The Netherlands. None were nesting near Avifauna, six pairs were nesting in Botshol and 1 pair was present for many days in De Banen, Limburg (van Dijk *et al.* 2008).

2007: 15 pairs
In Botshol four nesting pairs and three non-breeding pairs were recorded. Near Avifauna seven pairs were nesting and in De Banen one pair bred unsuccessfully (van Dijk *et al.* 2009).

2008: 6-7 pairs
Near Avifauna, the breeding tree of the sacred ibises was cut and none were recorded nesting in the area afterwards (S. Strik in litt.). In Botshol five pairs were breeding (J. van der Woude in litt.). Sightings of sacred ibises in De Banen suggest again one or more breeding attempts (waarneming.nl).

2009: 4-5 pairs
In 2009 again no sacred ibises were reported breeding near Avifauna (S. Strik in litt). Botshol holds three to four pairs in the spoonbill colony in 2009 (J. van der Woude in litt.). Like in 2008 several pairs were attempting to breed in De Banen (waarneming.nl).

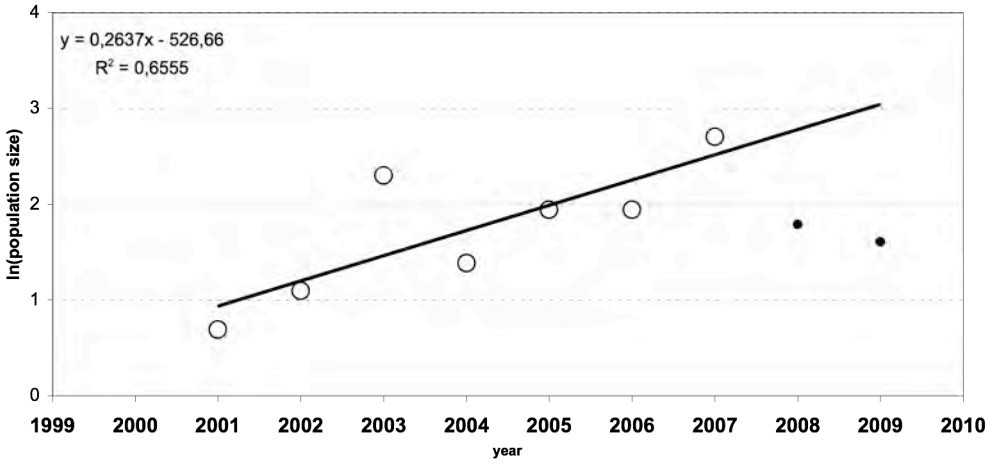

Figure 3.2 Population development of the Dutch breeding population (in pairs) of the sacred ibis. The average yearly growth for the period 2001-2007 (shown) is 30.1% and for the period 2001-2009 12.6% (not shown).

The overall growth rate of the Dutch breeding population of the sacred ibis during the entire period 2001-2009 was 12.6%. However since 2008 population size reduction measurements were taken (see 3.2.2). A severe winter (2008/2009) caused additional mortality contributing to the lower population size. So figure 3.2. shows a population growth with and without (intentional) population reduction. Without reduction a population growth is high. Based on an entire "uncorrected" yearly population growth of 12.6 % the expected number of breeding pairs will be 62 in 2025 and 1200 in 2050.

3.2.2 Origin & population development

Origin

Since the beginning of the nineteen-nineties the sacred ibis started to breed in the zoological park Avifauna. The birds were imported from Africa. Not all young birds were ringed; some flew off before they were ringed. In 2001 about 12 ibises were free flying and regularly fed on the meadows surrounding the zoological park. About 16 pairs were breeding annually in the park. In 2003 at least 30 free flying birds were present (M. Klemann pers. comm.). All birds that bred near Avifauna likely originated from this zoological park. The ibis-nesting tree outside the park near Avifauna was cut down somewhere in 2007-2008 (Strik in litt.). Furthermore, zoological park Avifauna applied containment measures the last few years, including the recapture of 25 free flying sacred ibises (Avifauna in litt.). The administration of Avifauna indicates that a maximum of 41 individuals have escaped since sacred ibises were kept. Since the autumn of 2009 Avifauna is authorised to recapture sacred ibises, including unringed birds. Since then 12 individuals were captured, including three with an Avifauna-ring. The numbers reported to waarneming.nl dropped dramatically with a maximum seen of nine reported near Leidschendam in August 2009 (about 30 birds in 2007 and 16 in 2008). However, Natuurmonumenten reported to Avifauna about 18-28 individuals

during the summer of 2009 in Natura 2000 site Botshol; all birds left the area after the summer months. During the same time that the number of Botshol dropped in 2009, employees of Avifauna recorded an increasing number near Avifauna (> 20 birds). Thus the birds of Avifauna in autumn 2009 are likely the same as the birds reported in Natura 2000 site Botshol. Ring readings from dead and live birds on several occasions in Botshol suggest too that all or a large part of the individuals in this breeding colony originate from zoological park Avifauna (see §3.2.1).

The small flock of 11 birds in Noord-Brabant/Limburg originate from a bird trader in Weert. The birds have been free flying since a tree fell through their cage 10 to 12 years ago. In winter the ibises always return to the cage, but in summer the ibises normally stay away for a while (feeding on e.g. worms in grasslands). The winter of 2008/09 was cold with a period with ice and a (unknown) part of the group died and one bird lost both feet. Since this winter the maximum number of ibises seen in the surrounding of Weert dropped to 4-5 birds (about 9 were presented in autumn 2008). The birds do not have rings (comm. bird trader). However one of the birds present in Soerendonks Goor in 2008 had a small ring (R. Smits obs.). According to the information of the owner of the sacred ibises in Weert a group of free flying birds is present just over 20 km away across the Belgian border in Leopoldsburg. Thus the ringed bird in Soerendonk could be of Belgium origin, however, the zoological park Avifauna or other sources cannot be excluded.

Several birds that have escaped in Germany are present in eastern parts of The Netherlands (data M. Klemann and http://www.cr-birding.be/). This is elaborated further in §4.1.1. Also, it is possible that birds have originated from escaped or free flying groups from Belgium. There is not yet any proof of birds originating from France, but it is not impossible that some individuals do reach The Netherlands. In this respect the reports of birds on migration in the coastal provinces are intriguing.

Population development

In order to get insight in the population development of the Dutch population of sacred ibises data were obtained from waarneming.nl and from M. Klemann (website http://www.michelklemann.nl/ibis/index.htm). For the period before 2005 the set of data from Klemann is the most complete and after 2005 the database of waarneming.nl.

Both datasets are combined to get an overview of the population development. However, as these data are mostly anecdotal and include many double counts, the maximum numbers per 5*5 km/month are used to correct for such factors (figure 3.3). The yearly sum of all maximum numbers per 5*5 km/month is shown, thus not the actual number of birds. The number of records is not corrected for the last months (Nov-Dec) of 2009, as data were yet unavailable. Based on figure 3.3 the number of birds increased until 2007 followed by a decrease or stabilization. The growth rate of the population size is 23% per year (figure 3.4).

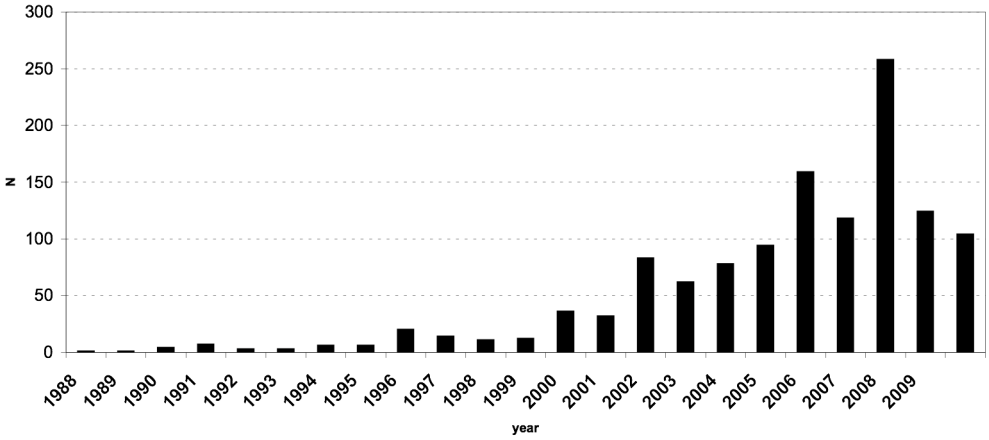

*Figure 3.3 The yearly sum of all maximum numbers of sacred ibis per 5*5 km/month. Based on both the data from waarneming.nl and M. Klemann.*

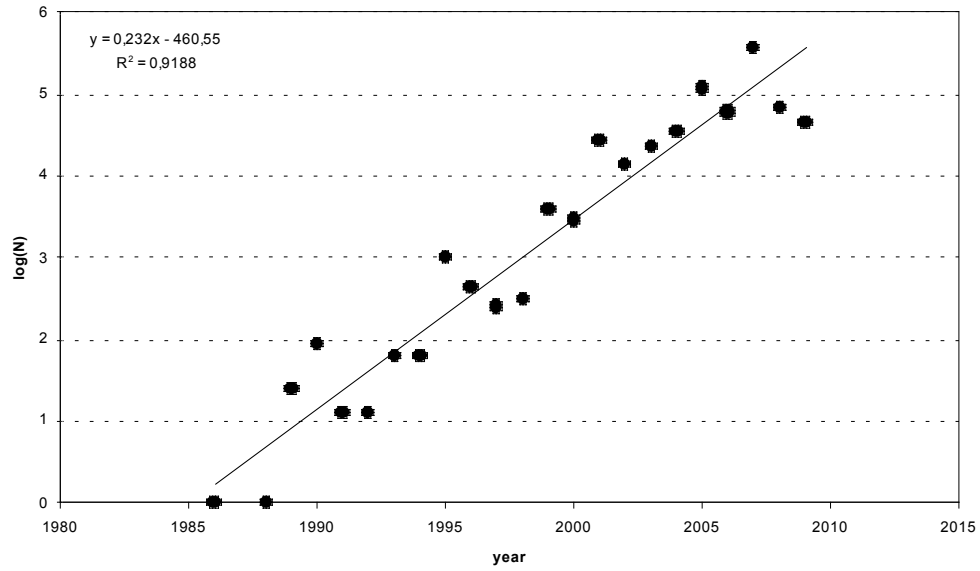

*Figure 3.4 The growth of the Dutch sacred ibis population based on the yearly sum of all maximum numbers per 5*5 km/month (see figure 3.3). The yearly growth rate based on these numbers is 26.1%.*

In order to study the differences in numbers throughout the year, the monthly data were grouped in two periods (< 2000 and 2000) (figure 3.5). For each period the sum of the maximum number of birds per month per 5*5 km is given, shown as a percentage of the highest sum of birds per month/5*5 km. Overall, the numbers are more or less comparable throughout the season, except for Sep-Dec. After the breeding season the reported number increases to a peak in August. Before 2000, the numbers in October and December were the same as in August. In the period after 2000 the peak of recorded birds is in August, followed by a decrease in the reported numbers.

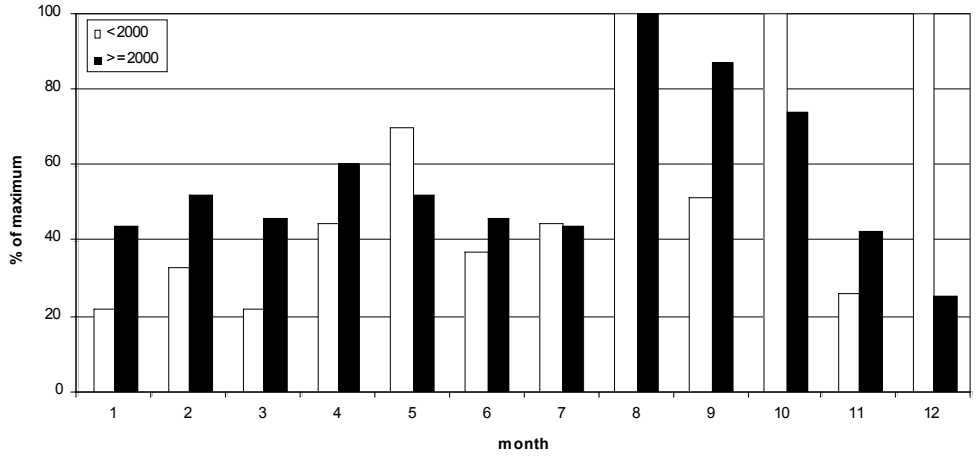

*Figure 3.5 The sum of maximum number of birds per month per area (5*5 km grid) for two different periods (< 2000 and 2000). The 100% is based on the month with the highest sum, which is defined for each period.*

Distribution

The sacred ibis occurs in all Dutch regions (figure 3.6). Before 2000 and after 2000, individuals and groups were recorded in Zeeland, Zuid- and Noord-Holland, Utrecht and Flevoland. After 2000 the number of birds decreased in the northeast and eastern part of the country. During the same time an increase if the numbers in Zuid- and Noord Holland occurred. The same happened near the border with Belgium in the southeastern part of the country.

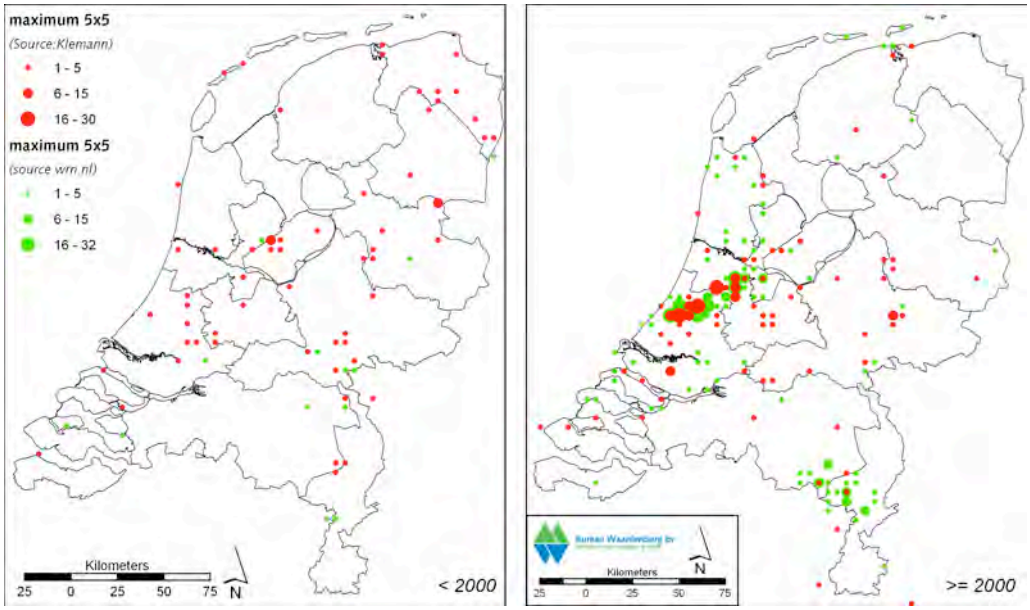

*Figure 3.6 The distribution of the sacred ibis in The Netherlands for the periods before 2000 and after 2000. Presented is the maximum number of birds sighted per 5*5 km (source Klemann and waarneming.nl).*

3.3.3 Discussion

During the years 2001-2007 the development of the Dutch breeding population (30.1%) shows a bit higher growth rate than the French population (figure 3.1 & 3.2). If the years 2008 and 2009 (with reduction measurements) are included the growth rate of the Dutch breeding population (12.6%) is almost half of the French growth rate (21.5%).

An explanation of the higher growth rate of the Dutch breeding population in the period 2001-2007 compared with the French growth rate could be that the Dutch sacred ibis are probably not independent (feeding) and are supplemented with new birds from zoological parks. Direct comparison of the first years of development of both populations is not possible due to lack of data. The drop of the Dutch breeding population after 2007 is discussed in §3.2.2 and is likely the result of containment measures and probably due to increasing winter mortality cause by the cold winter of 2008/09.

3.3 Non-native populations in other countries

Besides the established populations in France and introduced birds in The Netherlands the species occurs in several other countries outside its natural range. In this paragraph the non-native status of the species is described for several countries. Most information originates from M. Klemann and Clergeau & Yésou (2006).

Italy
Since 1989 breeding outside a zoological park is recorded near Piemont. At least 26 pairs were breeding. In 2000 the number of birds reached about 100 and in 2003 breeding occurred at another site in the same area with up to 25-30 pairs, and a few more pairs were found at a third site in 2004 (Yésou & Clergeau 2006). In northeast Italy, near Veneto, individuals are present during the breeding season and attempt to breed (M. Fasola pers. comm.). In central Italy, near Tuscany, breeding attempts have been recorded since 2000.

Spain
In Catalonia, Malaga and the Canary Islands free flying ibises bred or are still breeding. In Malaga birds are possible breeding since 1997 and in the Canary Islands (Tenerife) a maximum of five pairs is breeding since 1997.

Portugal
Since 1998 escaped/free-flying ibises from a zoological park in Coimbra are possibly breeding.

Belgium
In Belgium, in Hainaut, only one breeding attempt occurred in 2001.

Germany

Free flying populations of zoological parks are known. No breeding outside a park has yet been recorded. Twelve colour-ringed birds escaped from the Metelener Heide Bird Sanctuary (www.cr-birding.be) and are probably seen in eastern Netherlands (data from M. Klemann).

Outside Europe

United States of America

Since 2005 sacred ibis is breeding in the Florida Everglades (Herring & Gawlik 2008). Sacred ibises were present in this area since the mid 1990s with occasional breeding confirmed near the Miami Metro Zoo.

United Arab Emirates

Since 1989 a small, introduced population occurs and breeding is regularly recorded in Sir Bani Yas Island (Yésou & Clergeau 2006).

Taiwan

Since 1998 the species is establishing in Taiwan (website http://www.michelklemann.nl/ ibis/index.htm). In 2004 the species was reported to expand its range in Taiwan (Agoramoorthy & Hsu 2007).

4 Risk Analysis

4.1 Risk assessment

4.1.1 Probability of introduction

In this paragraph the different pathways through which the sacred ibis can enter The Netherlands are described.

In The Netherlands the sacred ibis is kept in captivity in a number of private collections (Harteman in litt.). In 2008 an inventory was held among the members of Aviornis Nederland. The estimate of the total number of sacred ibises in captivity among the members was 136 individuals spread over 32 members. However, not all people with a private collection are a member of Aviornis. The actual number of sacred ibises in captivity is, therefore, higher than this figure.

By means of the administration system of ISIS (http://app.isis.org/abstracts/Abs52737.asp) an overview was composed of the number of sacred ibises in zoological parks. It should be noted that the numbers are not always up to date and should be considered as a rough estimate. The estimates for several countries and Europe/the Middle East are: Belgium (15), Germany (55), France (202), The Netherlands (64), Europe and Middle East (817).

In The Netherlands sacred ibises in zoological parks are held in captivity in Avifauna (Alphen a/d Rijn), Artis Zoo (Amsterdam), Safaripark Beekse Bergen (Hilvarenbeek), Ouwehand Zoo (Rhenen) and De Vleut (Best). In Belgium zoological parks with sacred ibises are situated in Brugelette, Olmen-Balen and Mechelen.

Escapes from free flying collections

In The Netherlands there are currently two locations with free flying birds known: zoological park Avifauna in Alphen a/d Rijn and a bird trader in Weert. Since 2008 Avifauna carried out measures in order to keep the ibises in their cages, to recapture former free flying birds and by cutting down the nesting tree near the park where free flying birds were breeding. In Weert about 11 birds are flying around for more than ten years since they escaped, with a few left in 2009 (comm. by owner).

The group of free flying birds around Avifauna contained at most about 40 individuals until the park started with recapturing and closing cages (since 2008). This group of birds started breeding near the zoological park and in Natura 2000-area Botshol. This population showed a higher growth rate between 2001-2007 than the French population. If the years 2008 and 2009 are included the growth rate decreased to roughly a third, probably due to containment measures carried out by Avifauna and the strong winter of 2008-09. This indicates the effectiveness of reduction measurements.

If zoological park Avifauna continues its policy the chances of new escapes are small. This is because the low numbers kept in captivity. Nevertheless, situations can occur again, including from private unregistered collections. Following this it seems that just over the border near Weert, in Leopoldsburg, a free flying group of sacred ibises is present.

Escapes from aviaries

In The Netherlands there is no central system for owners to register escaped birds. Several reported birds are thought to be escaped individuals from private collections. However, no birds with rings from private collections are reported with certainty so far in The Netherlands.

In Belgium there is one record of a bird with colour ring, present in a wide range around Westerlo in the summer of 2008. The ring of the bird read (waarneming.be) and was registered in St. Gillis Waas near Mechelen (Lievens in litt.), although it could have been traded after registering.

In 2000 a group of 11 colour-ringed sacred ibises escaped near Munster (http://www.cr-birding.be/). In September 2000 a sacred ibis with colour ring was seen near Hengelo, The Netherlands (bron: Twentse VWG, via data M. Klemann). Although the colour of the ring combination was not completely correct (fading of the colour?) the birds origin was very probably the zoological park near Munster, Germany.

Foreign established populations

As shown in chapter 3 the French population is well established. Currently an eradication program is being carried out. Due to the ongoing eradication program the likelihood that birds from the French population will spread to The Netherlands is limited, but not zero.

Until now there have been no proven records in The Netherlands of individuals from the French sacred ibis population. There is one record of a bird near the border Belgium along an important migration route for birds. The bird was seen on 11 February 1998 flying to the northeast over bird observatory Breskens in Zeeland (Lilipaly *et al.* 2000).

The chances of colonisation of sacred ibis from the French population seem very low at the moment. However, not all birds are removed and a part of the former population still exists. No measures against the Italian populations have yet been proposed (Fasola in litt.). Thus if eradication succeed in France the sacred ibis still exist in other countries and it could be that it will enter France.

Conclusions

- In both zoological parks and private collections in The Netherlands several 100s of birds are currently present, this might lead to future escapes and contributing to colonisation or support of wild populations.

- The most important pathways of birds entering The Netherlands are free flying birds from as well zoological parks as private collections. Also colonisation of free flying birds from nearby countries (Belgium, France and Germany) is possible.
- Even birds originating from foreign zoological parks cannot be excluded as escapes from German parks have reached the Netherlands.
- Chances of colonisation by foreign established populations are currently low. However, the French population still exists (eradication continues) and no management actions are taken in Italy, which might lead to population growth.

4.1.2. Probability of establishment

The sacred ibis has been breeding and producing offspring since 2002 at 1-2 places in The Netherlands. This small but increasing group of birds might develop to permanent and larger established population. In both the natural and non-native range the species is breeding commonly in association with spoonbills, herons and sometimes cormorants.

To date, successful breeding has taken place in lowland peat marshlands in the western part of The Netherlands. Breeding attempts in peat bogs in the southeastern part of The Netherlands have been, so far, unsuccessful. In several spoonbill colonies, including the Oostvaardersplassen and Quackjeswater, sacred ibises have been seen in spring and could be a sign that breeding will take place in the near future. Other common feeding areas are meadows and intertidal mudflats. All these habitats (and thus feeding and breeding areas) are common and widespread in The Netherlands.

If the current population spreads as suspected it is likely that the optimal areas will be colonised first. These are wetlands like in the lower part of The Netherlands, but also along the rivers and the Delta. In a later phase it is possible that the sacred ibis will spread further over peat bogs, city parks and the Wadden Islands (figure 4.2).

The growth of the population in recent years indicates the possibility of a future larger population. On the other hand recent recapture measurements at zoos and winter mortality in the severe winter of 2008/09 indicates the population is depending on human resources. As "wild birds" were feeding in winter near zoos it might not be as independent as expected based on the observed population growth. More information about its winter survival in normal and sever winters is needed to assess its sustainability in circumstances without feeding at zoos as it might give another view on "natural" population growth.

Conclusions

- Both breeding places and feeding habitat for Sacred Ibis are widespread and of good quality in The Netherlands;
- It cannot be excluded that the small breeding and reproducing Dutch population will establish a population, due to the factors mentioned above.
- However recent information suggests a higher dependence on human influenced food resources. This might decrease the probability of future establishment. Information on winter survival and food is needed to assess this.

4.1.3 Probability of spread

In France new colonies of sacred ibis have established up to 70 km away from the original site. Furthermore, dispersal of up to several hundreds of km is recorded. In this paragraph the probability of spread, without any kind of management, is described.

Based on a growth rate of 12.6% the Dutch population might increase to a predicted number of 60 pairs in 2025 and 1200 in 2050. If the years 2008 and 2009 are excluded the Dutch growth rate is 30.1% (containment measures are carried out since 2008). Without information about breeding success and annual survival it is difficult to predict the future development. The increase in the number of birds and the number of breeding pairs can actually be due to 'new' escaped birds and winter-feeding.

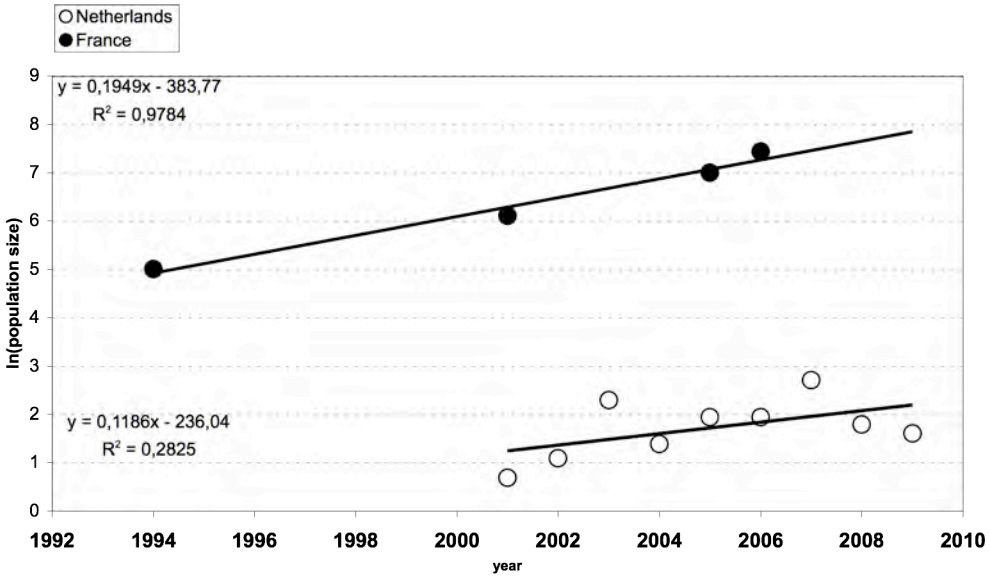

Figure 4.1 The population development of both the French and Dutch number of pairs. The growth rate of the French population is 21.5% and the Dutch population 12.6% (excluding 2008 and 2009 the Dutch growth rate is 30.1%).

As stated earlier both breeding areas and feeding habitats are widespread and are thus not limiting the spread.

Without any prevention measures it is possible that the population will establish in the low peat in the western part of The Netherlands. The distribution of the species now is more or less southwest-northeast, including records in the spoonbill colonies of both the Oostvaardersplassen and Quackjeswater. Given the actual distribution and the species' habitat preference it is possible that the sacred ibis will colonize these or comparable areas. Further spread into other wetlands from Zeeland to Groningen and along the rivers inland can be expected, because both breeding and feeding habitats are availably (figure 4.2). As the sacred ibis is not limited to freshwater habitats even the Wadden Islands could be colonised.

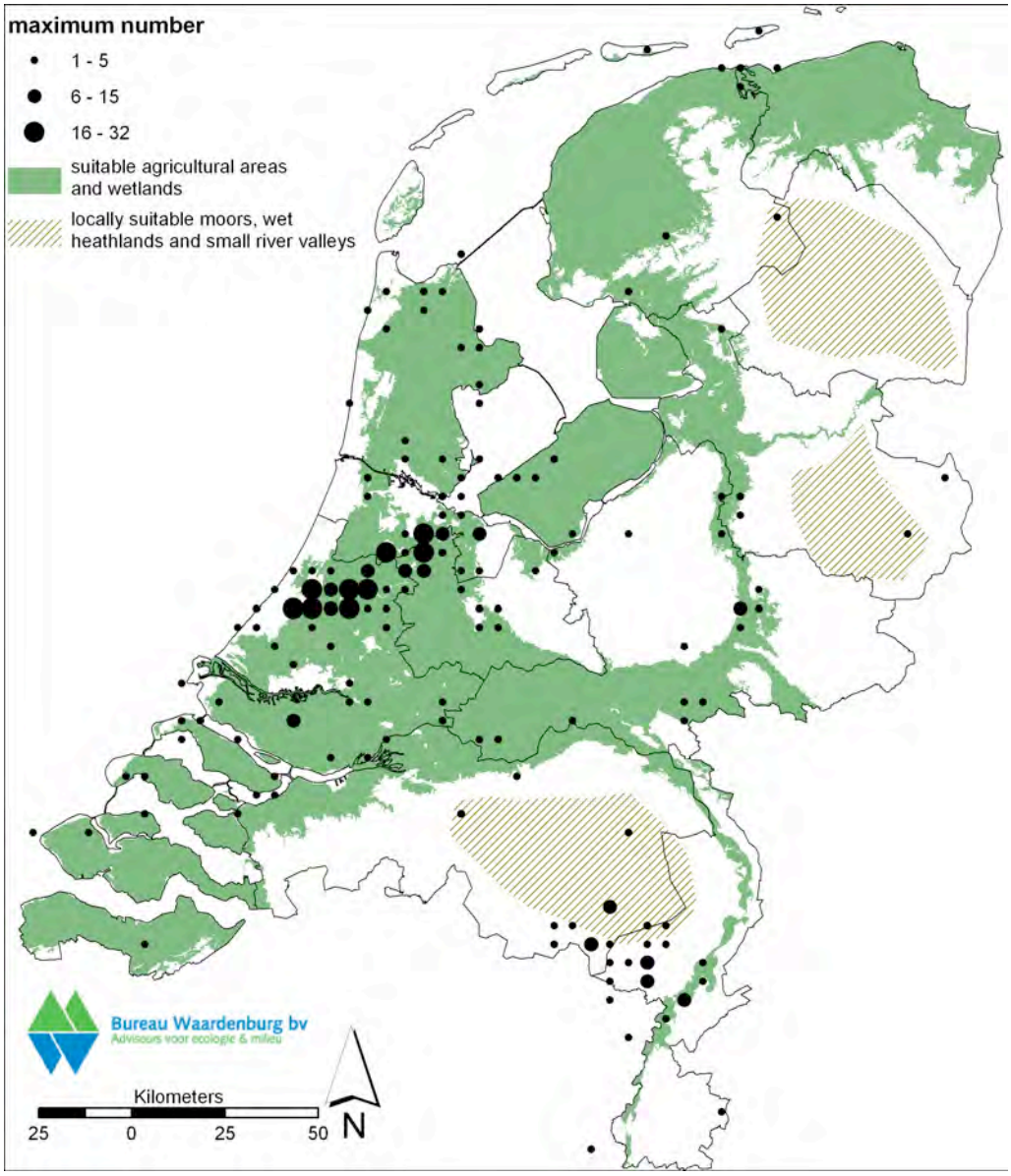

*Figure 4.2 Possible future colonisation range of the sacred ibis in The Netherlands. Locations with recent sightings (maximum number per 5*5 km square after the year 2000) of individuals are included (source Klemann unpubl, www.waarneming.nl).*

If the sacred ibis starts with successful breeding in peat bogs in Limburg/Noord-Brabant it opens the door for further spread along this habitat type in this part of The Netherlands and Belgium. Furthermore, via this way the species can spread along the river Maas.

The spread of the species might be strengthened by the accidental input of new released or escaped birds. Some areas, like very large forests such as the Veluwe, are likely to be unsuitable. But see discussion in section 4.1.2.

Conclusions

- With the current growth rate of 12.6% the population is predicted to be 60 pairs in 2025 and 1200 pairs in 2050. Excluding the years with containment measures (2008-2009) the growth rate is 30.1%. The actual growth is not known due to the lack of knowledge of breeding success and survival. The high growth rate before 2008 can be due to new escapes.
- If the population depends partly on winter-feeding, the growth rate might be lower under natural conditions.
- It is likely that an established population will first spread over the marshlands in the low peat of the western part of The Netherlands.
- On the longer term the species can spread over a large part of The Netherlands, including wetlands ranging from Zeeland to Groningen, the Wadden Islands and along the rivers.

4.1.4 Endangered areas

Many of the protected areas (Natura 2000-sites) in The Netherlands are marine, brackish or freshwater wetlands. On the long term all such areas can be colonised by the sacred ibis. The areas that are possibly to be colonized in the near future are the wetlands ranging from Quackjeswater in the southwest to the Oostvaardersplassen in Flevoland (current range of roaming birds). However, it is possible that due to the high dispersal of the species, individuals will find the way to areas further away like the Lauwersmeer (birds are already recorded here). After 2025, with a continuing growth rate, the population might increase to 1200 pairs in 2050. Eventually, almost every wetland, including the Wadden islands can be colonised. Many of them are Natura 2000-sites.

In the near future, up to 2025, the number of breeding birds could be 60 pairs if the same growth rate continues. It could be that all of these birds remain in Natura 2000-site Botshol. If the species spreads then it is most likely to be to areas where they have been already seen in spring in colonies of herons and spoonbills. These areas are Lepelaarplassen, Oostvaarderplassen and Quackjeswater. All these areas are Natura 2000-sites. Near Botshol individuals are sometimes present in the Geerplas near Langeraar in a mixed heron-cormorant colony (Strik in litt.).

Conclusions

- Most wetlands with a Natura 2000 status are prone to be colonised as habitat is expected to be not limitative;
- Sacred Ibis has settled already in the Natura 2000-site Botshol. With birds present in the breeding season in, Lepelaarsplassen, Oostvaardersplassen and Quackjeswater near future colonisation of these areas is possible;
- Eventually, on the longer term, almost every wetland might be colonised (including the Wadden Islands).

4.1.5 Impact

In this paragraph the impacts of the species on ecological, economic and social aspects are discussed.

Ecological impact

In the natural range the recorded ecological impact is predation on several colonial bird species. The extent of sacred ibis predation in South African cormorant colonies can be high, with up to 10-15% of the young of a cormorant colony eaten in a season (Williams & Ward 2006). In the introduced populations in France predation on eggs and young of several bird species have been recorded on five occasions (Yésou 2005). The predation in France included the predation of eggs and young of several species of terns, cattle egret, black-winged stilt and lapwing (Clergeau & Yésou 2006). In one occasion all nests of a small colony of terns were lost due to predation by sacred ibises. In one case nest competition with cattle and little egret was reported in France (Kayser *et al.* 2005). Many pairs of cattle egret and little egret were forced to leave their colony.

Questions not yet solved include whether or not competition of food with other species occur. Furthermore, it is unknown what the impact of predation and nest competition is on population level of the species involved.

Future ecological impacts that might possibly occur in The Netherlands are competition for nest sites (spoonbill, heron species) and predation of young colonial birds (especially terns and cormorants) often within Natura 2000-sites. With the current information no estimates of the extent of the ecological impact can be made with any certainty.

Economic impact

In §2.2.5 the sacred ibis is described as a possible hazard to aircraft. In The Netherlands this is not a great risk as larger wetlands are not close to airports, but occasional risk situations might occur. Grassland habitats used as feeding habitat do occur commonly around airstrips.

Social impact

The Australian white ibis along the east coast of Australia is considered an urban pest species, because the species is 'dirty', 'unattractive' and scavenges from bins (Shaw

1999, Ross 2004; both in Martin *et al.* 2007). The classifications 'dirty' or 'unattractive' are not objective and it is unlikely to be a factor in its identification as pest species.

Scavenging birds can be annoying, although refuse bins are small in The Netherlands and most rubbish dumps are closed. It is possible that colonies establish near urban areas and that ibises start feeding around fast food stores (like feral pigeons or crows).

Conclusions

- Ecological impacts: possible predation of colonial birds (especially terns and cormorants) and possible competition for nests with spoonbill and species of heron;
- Economic impacts: a low risk in The Netherlands;
- Social impacts: possible local or minimum impacts.

4.2 Bomford and ISEIA method for Risk assessment

For the Sacred Ibis risk analysis two methods have been used: Bomford (Bomford 2003, 2006, 2008) and the Invasive Species Environmental Impact Assessment (ISEIA). The first method is strong in detail and in assessing risk of entries (establishment risk score, category B). The second method is strong in assessing risks of ecological effects, but refers only to species with established populations. The Bomford (2003) method includes an assessment of social and economic impact, which the ISEIA-method lacks.

In a continental situation as in The Netherlands the risks of establishment are always relatively high. This implies that the overall establishment risk score in the Bomford method will inevitably give a high risk score.

It would be better to update the detailed Bomford method into a "continental" classification with a focus on "Pest risk score". In fact the risk categories match to areas with susceptible native species or communities (C6), Primary production pest status (C7), Spread disease (C9) have to be upgraded with subsequent categories from the ISEIA method: Impact to native species, competition, hybridisation, impact on ecosystems, predation and disturbance of food web. This procedure needs gauging into the score system and two or three test species (e.g. invertebrate, bird, mammal) as a pilot. A combination as such would strengthen both methods.

For the time being, the Bomford and ISEIA method have not been adjusted and used in their original set up. Only Category C4 is generalised into "competition with native fauna for nesting space" instead of competition for nest holes as it limits the species list by definition.

4.2.1 Method of Bomford

The method developed by Bomford (2003, 2006, 2008) is more comprehensive than the method of the ISEIA. Due to the extensive character of the analysis the outcome is placed in appendix 2. In table 4.1 an overview of the outcome is presented and the VPC-threat category was "serious". This outcome implies that management actions should be considered, including radical restrictions of keeping the species, extensive security measures and extensive administration (VPC 2004).

Table 4.1 Overview outcome risk assessment conform the Bomford method (2003,2006,2008).

Category	Score		Outcome
A. Public safety Risk Score	0	0 = not dangerous 1 = moderately dangerous 2 = highly dangerous	not dangerous
B. Establishment Risk Score	12	≤6 = low 7-11 = moderate 12-13 = serious ≥14 = extreme	serious risk
C. Pest Risk Score	11	<9 = low 9-14 = moderate 15-19 serious >19 extreme	moderate
VPC threat category	A+B+C		serious

The Vertebrate Pest Committee (VPC) threat category is determined from a combination of the three risk score. For an overview of the various combinations see appendix 2.

4.2.2 ISEIA

In table 4.2 the method of ISEIA is elaborated. The outcome of this method is a score of 10 that means the species falls into category B: Watch list. The watch list contain species with a moderate impact. In Appendix 1 an overview of the method is given and the final score is 10 which implies that the sacred ibis should be placed at the "watch list" B. This result suggests that no immediate management actions are necessary. Actions that imply the watch list are legislation and restrictions for keeping the species.

4.2.3 Comparison of both RA methods

As predicted (4.2 introduction) the Bomford method leads to a serious risk score due to the high risk of establishment of the population in The Netherlands. As more pathways are present, with several that cannot be influenced by Dutch authorities, future

establishment cannot be prevented easy. On the other hand there are strong indications the population is growing but manageable. And effects on ecology, economy and society are never serious. This is more in conjunction with the ISEIA result: "moderate impact". The ISEIA method is more specific in categorising possible impacts with predation in other bird species (nests) as the highest risk. As most categories score low in this ISEIA method the final results is low neglecting colonisation possibilities and speed of colonisation. This might lead to management necessity as such. These categories are strong elements in the Bomford method.

Table 4.2 ISEIA of the sacred ibis. L=low, M=moderate, H= high (score 1-3).

	Category	estimate	score
5.1	Dispersal potential	H	3
5.2	Colonization of natural habitat	H	3
5.3	Impact on native species		3
	Predation	M	
	Competition	H	
	Spread of disease	L	
	Hybridization	L	
5.4	Impact on ecosystems		1
	Nutrient circle	L	
	Physical alterations	L	
	Natural successions	L	
	Food webs	L	
	Total score	10	
	List	B	
	List B = Watch list		

4.2.3 Conclusions

- The outcome of the ISEIA method is a score of 10. That means that the species should be included into category BL Watch list. The watch list contain species that have a moderate impact. Beside introduction of legislation and restrictions for keeping the species no immediate management actions are considered.
- The outcome of the Bomford method is a score of 0 for public safety risk (not dangerous), 12 for establishment risk (serious) and 11 for pest risk (moderate). The combination of these three items is the Australian VPC (Vertebrate Pest Committee) threat category serious. Management actions should be considered, including radical restrictions of keeping the species, extensive security measures and extensive administration.

4.3 Risk management

4.3.1 Prevention

This paragraph describes possible management actions that can prevent further establishment of sacred ibises in The Netherlands. There are three pathways along which sacred ibises can enter the country:
1. Free flying populations from zoological parks
2. Escapes from aviaries
3. Dispersal from neighbouring countries

Bomford (2003) listed the factors that affect the possible escape or release of a species. Below the factors are listed.
1. Security of premises:
    - Cage or enclosure security;
    - Keeper numbers, skills, experience and work-load;
    - Frequency and thoroughness of cages and enclosures inspections;
    - Frequency and thoroughness of inspections of animals;
    - Reporting requirements;
    - Financial viability of owners;
    - Adequacy of escapes contingency plans.

2. Keeping restrictions
    - limits the number of locations at which a species is kept;
    - limits the number of animals which are kept together;
    - single sex collection;
    - sterilisation;
    - pinioning or other techniques to restrict movement.

3. Community and keeper attitude
    - value of a species;
    - desire by hunters or others to establish a wild population;
    - low perceived risk of illegal removal or release of animals from approved premises being detected or prosecuted;
    - low penalties imposed for loss or release;
    - low awareness of a species potential pest status;

Thus to keep the possibilities of a new release or new escapes low it is necessary that the security (1) is performed, the restrictions (2) are performed and the community attitude (3) is adapted. Overall the cost of keeping and controlling all the aspects above will be high, probably to high too carry out. In the Dutch situation prevention measures can include (1) legislation (prohibiting free-flying) and registry system for cage birds, (2) pinioning and (3) campaign to inform the stakeholders about the risks of escaped birds and measures to prevent new escapes. Even with all thes e measures it is

impossible to prevent future escapes or colonisation as some pathways are beyond the responsibility of the Dutch authorities.

In the Netherlands legislation and awareness of zoo keepers can be strengthened to limit the numbers of future new releases or escapes. At this very moment it is imperfectly known where sacred ibis is kept in captivity and Zoo keepers are not always aware of risks of escapes of their stock. A campaign to set up registration of captive sacred ibis and raising awareness among stakeholders is to be suspected to be of significant importance to make a step forward in prevention of future new escapes of releases.

Conclusions

- Registration of all captive individuals of the sacred ibis at a central place can facilitate the knowledge on the size of risk populations and measurements to prevent escapes.
- The risk for future escapes or new releases can be significantly limited by informing all stakeholders about the risks of escaped birds and measures to prevent new escapes.
- Nonetheless, the chance of new escapes and new releases are still possible if above measures are applied. Furthermore entering of sacred ibis from foreign zoos or foreign established populations remains possible.
- Minimising new entries is possible but complete prevention of birds entering The Netherlands is impossible.

4.3.2 Eradication

Eradication is the complete and permanent removal of all wild populations from a defined area by a time-limited campaign (Bomford & O'Brien 1995). If an eradication campaign lacks a specified end point it is continuing control like harvesting a certain amount of the population. For eradication three criteria which must be met and three criteria that should be met for a successful eradication campaign are described in 1995 (Bomford & O'Brien 1995). The authors describe that despite the fact that eradication is a popular measure no eradication campaign against any well established introduced vertebrate was successful on any continent. A few, small-scale, successful campaigns in Europe were presented in 2005 in a review (Genovesi 2005) The criteria below are based on Bomford & O'Brien 1995.

Criteria for achieving eradication:
1. Rate of removal exceeds rate of increase at all population densities
2. Immigration prevented
3. All reproductive animals must be at risk

Criteria that are desirable and that determine whether eradication is preferred over continuing control:
4. Animals can be detected at low densities

5. Discounted benefit-cost analysis favours eradication over control
6. Suitable socio-political environment

Can the eradication criteria be met in The Netherlands?

1. Rate of removal exceeds rate of increase at all population densities

To achieve this criterion the measures mentioned by Yésou (see below in example of eradication) could be carried out, including the shooting of birds at feeding grounds (meadows). Furthermore, the recapture of free flying individuals can be done at sites where birds still return to cribs at zoological parks and private collections. Within nature reserves, where shooting cannot be carried out, the oiling of eggs is possible. Sterilization of eggs can also achieved by oiling the eggs by spraying 5 mL of canola oil upon each egg (Martin *et al.* 2007). A method was proved to be effective to suppress hatching. In a laboratory trial the effectiveness was 100% and in the field it was 98%. No differences were found between the different applications: spraying once a week, early (<7 days), mid (14 days) or late (>18 days) incubation (Martin *et al.* 2007). Thus the three measures that can be carried out are recapturing, shooting and oiling eggs.

Theoretically, at the current stage, performing these three measures will likely lead to a removal rate that exceeds the increase. Practically, it will be very difficult to achieve this criterion completely (further elaborated in point 2-6).

2. Immigration prevented

Eradication will be unachievable if birds can immigrate into the eradicated area or are released from captivity. Preventing free flying population will limit the chance of escapes. The eradication campaign in France resulted in a removal of a large number of birds, but the species is breeding within several protected areas. The chance of immigration from foreign populations is small but still present and out of control of Dutch authorities. Thus currently this criterion cannot be met completely.

3. All reproductive animals must be at risk

All reproductive animals of the population must be removed to make the eradication feasible. Thus, if the campaign results in a situation where birds retreat to areas where no eradication can take place, a subset of the population is not at risk and will not be eradicated. It is questionable whether or not this criterion can be met. Birds within protected areas might be temporarily out of reach (like breeding colonies in Natura 2000-sites). In the Dutch situation sacred ibises are commonly feeding at meadows and can probably be taken out easily in this landscape. In France professional hunters are carrying out this task. To avoid too much disturbance and to avoid shooting the wrong species professional hunters are preferred. Furthermore, a part of the birds can be recaptured (see above 2). Although we assume it is impossible to take out all birds by recapturing and shooting a large part of the Dutch population can probably be removed with both measures.

4. Animals can be detected at low densities

If animals cannot be detected at low densities, there is no way to measure whether eradication efforts are still effective and no way to determine if eradication has been achieved (Bomford & O'Brien 1995). This overlaps slightly with criterion 3. If birds are dwelling in areas that are large and difficult to overlook individuals and small groups can easily missed. The latter is something that is plausible in The Netherlands, because the species is breeding and partly feeding within protected areas that are difficult or not easily monitored.

5. Discounted benefit-cost analysis favours eradication over control

Eradication efforts should be based on accurate cost-benefit analysis, and data needed for these calculations are often not available (Bomford & O'Brien 1995). Bomford & O'Brien (1995) stated that if eradication is more cost effective than no control; the benefits of eradication still must be weighted against alternatives. The chance of a failing eradication campaign should be considered. A failed eradication attempt will waste a lot of money. Both arguments should be taken into account with making the decision between control and eradication. The information gathered in this report is not enough to give answesr whether or not this criterion will be met. As described above the measures removal and prevention have high chances to succeed. As stated earlier the complete eradication of a species has considerable risk and it is expensive. The former factors hint at control measures instead of eradication. Management actions might lead to eradication on the long term or lead to a population size of acceptable level.

6. Suitable socio-political environment

Conflicting community or governmental goals or legal barriers can frustrate eradication attempts (Bomford & O'Brien 1995). When looking at this criterion several problems may arise: negative public opinion and legal barriers. An eradication campaign without strong support from the public will probably meet resistance of certain groups. The following conflict situations can develop in The Netherlands: a lobby by animal welfare groups, sacred ibis might be a species which the public likes (culling leads to resistance), culling will conflict with the protection of this species and areas.

Eradication campaign in France

In France in 2007 an eradication campaign was started which is still ongoing. The information below is provided by Pierre Yésou (ONCFS).

Measures taken to limit the development of the feral population of Sacred Ibis in France are carried out under administrative guidance and are of three kinds:

1. Re-trapping (with alpha-chloraline baits) at the zoo from where these escaped in southern France and where part of the feral population continued to come at feeders. They succeeded in capturing about one third of the c300 individuals in the wild in this part of France.
2. Sterilization of eggs, carried out since 2009 at one site, a nature reserve where disturbance must be kept very low (many sensible species breeding in the same area as

the ibises) thus shooting (see point 3 below) cannot be carried out. Sterilization by picking the eggs, may not be the most efficient method but seems the only practical one given the local conditions. Only c 150 nests out of c 800 have been sterilized last spring, as most eggs had already hatched at the time the action was undertaken.

3. Shooting of birds able to fly. This is carried out only by official people from "Office National de la Chasse et de la Faune Sauvage, ONCFS", who are acting as "environmental policemen" under the ministry in charge for it. Shooting occurs at rubbish dumps and at other places where the birds congregate outside the colonies; simple forms of ibises (hand made from polystyrene foam) are very attractive and this helps a lot. Shooting is also carried out near breeding sites (mostly aiming at flying birds moving to and from the colony), only when this is considered safe for sensible species (e.g. no such shooting near mixed colonies with herons or spoonbills, but shooting possible when only large gulls are to be disturbed). Shooting is the most employed method and proved to be efficient. Hence, only 20-30 birds are still alive in the wild in S France (from c300), and over 4500 birds have been shot in W France since 2007 (mostly in 2008, 3000 birds shot, and 2009, since 2007 was a trial year). Efficiency is decreasing, however, and as expected it is more difficult to reach the very last birds (situation in S France). Shooting at colonies led the ibises to concentrate on protected sites where shooting cannot be carried out (in 2009, c800 from a regional population of c900 pairs in W France concentrated in a single colony in a nature reserve, see point 2 above, where they produce nearly as many young as the number of bird shot since the beginning of the year). Lastly, the rubbish dumps are closing one after the other, leaving few opportunities for "easy" shooting operations. The closure of rubbish dumps seems to have had no effect on the winter survival of the species.

Conclusions

- Complete eradication proved to be difficult in France. In the Dutch situation eradication might be difficult too due to the temporarily occurrence of sacred ibises in difficult or inaccessible areas and future new entries.
- Control measures, including recapturing, oiling eggs, shooting birds at easy place, will result in a removal of a large part of the population. Control measures might lead to a population size of acceptable level but unlikely to eradication.
- The following conflicts can turn up in The Netherlands: strong animal rights/welfare groups lobby, sacred ibis is a species the public likes (culling leads to resistance), culling will conflict with the protection of species and areas. These factors make an eradication campaign less feasible.

4.3.3. Management

The gathered information and the analysis of both probability of establishment and spread strongly supports that the sacred ibis will establish and spread through The Netherlands if management actions are not applied.

The population development in The Netherlands has almost the same growth rate as the French population at least up to 2007 indicating a possible future colonisation of most of the country. However currently the population is still fairly small and recent recaptures at zoos and winter mortality indications at least partial dependence on human recourses might facilitate management and hinder natural growth. If measures are continued on the short term the population can probably be managed and prevented to grow exponential. Population development of the sacred ibis should be monitored properly to evaluate the effectiveness of management actions. This means population counts in the different seasons, counting the number of breeding pairs, monitoring demographic parameters including nesting success. Information on winter mortality and especially on feeding sites might give an indication of the necessity to continue recaptures. If sacred ibis indeed depends partly on food collected nears zoos control mechanisms increase.

Table 4.3 Overview management tools and feasibility in The Netherlands. Effect: L=low, M=moderate; R=reasonable, H=high, U=unknown.

options	measure	where/how	feasibility/effect
prevention	legislation	government	feasible/M
	registry	government	feasible/M
	campaign	government	feasible/M
	pinioning birds outside cage	zoo's/private collections	feasible/R
control	recapture semi-captive birds	Weert/Avifauna	feasible/H
	shooting at easy places	feeding areas on meadows	feasible/U
	oiling eggs	breeding colonies	difficult/L
	monitoring/research	colonies/feeding areas	feasible/H
eradication	removal of all individuals	countrywide	questionable/L

The different options of management measures, including control, are all already discussed in the sections 'prevention' and 'eradication'. It could be that oiling of eggs is less feasible when birds are breeding in a protected site like Botshol. With the management actions that are feasible it is possible to minimize the chance of new escapes. The feasible management actions result in a removal of a large part of the population. Several of the possible management tools are in use since 2007 by Avifauna. The drop in the number of birds reported at waarneming.nl and the slight decline in the number of breeding pairs since 2007 are likely a result of the management of Avifauna. In the winter of 2008-09 Avifauna started with recapturing the remaining group of about 20-25 birds. While maintaining the measures that are feasible (table 4.3) we assume that the remaining small population will further decline until only a few individuals remain, including new escapes and immigrants. Thus low numbers will occur in The Netherlands in future.

Conclusions

- The gathered information and the analysis of both probability of establishment and spread strongly supports that the sacred ibis might establish and spread through The Netherlands if management actions are not applied.
- Currently, feasible management options for the Dutch population are prevention (including registry of captive birds) and management (recapturing semi-captive birds, shooting and possible oiling eggs).
- To evaluate the effectiveness of management actions the population development of the sacred ibis should be monitored properly. This means population counts in the different seasons, counting the number of breeding pairs and monitoring demographic parameters including nesting success. Information on winter mortality and especially on feeding sites might give an indication of the necessity to continue recaptures.
- If population management is implemented the remaining small populations will probably decline until only a few individuals remain, including new escapes and immigrants. Thus low numbers will occur in The Netherlands in future.

5 Conclusions, discussion and recommendations

5.1 Risk Assessment

The probability of entry

- In both zoological parks and private collections in The Netherlands several 100s of birds are currently present, this might lead to future escapes and contributing to colonisation or support of wild populations.
- The most important pathways of birds entering The Netherlands are free flying birds from as well zoological parks as private collections. Also colonisation of free flying birds from nearby countries (Belgium, France and Germany) is possible.
- Even birds originating from foreign zoological parks cannot be excluded as escapes from German parks have reached the Netherlands.
- Chances of colonisation by foreign established populations are currently low. However, the French population still exists (eradication continues) and no management actions are taken in Italy, which might lead to population growth.

In the (near) future it is highly likely that Sacred Ibis individuals will enter the Netherlands through any of these pathways.

The probability of establishment

- Both breeding places and feeding habitat for Sacred Ibis are widespread and of good quality in The Netherlands;
- It cannot be excluded that the small breeding and reproducing Dutch population will establish a population, due to the factors mentioned above.
- However recent information suggests a higher dependence on human influenced food resources. This might decrease the probability of future establishment. Information on winter survival and food is needed to assess this.

The probability of spread

- With the current growth rate of 12.6% the population is predicted to be 60 pairs in 2025 and 1200 pairs in 2050. Excluding the years with containment measures (2008-2009) the growth rate is 30.1%. The actual growth is not known due to the lack of knowledge of breeding success and survival. The high growth rate before 2008 can be due to new escapes.
- If the population depends partly on winter-feeding, the growth rate might be lower under natural conditions.
- It is likely that an established population will first spread over the marshlands in the low peat of the western part of The Netherlands.

- On the longer term the species can spread over a large part of The Netherlands, including wetlands ranging from Zeeland to Groningen, the Wadden Islands and along the rivers.

Endangered areas

- Most wetlands with a Natura 2000 status are prone to be colonised as habitat is expected to be not limitative;
- Sacred Ibis has settled already in the Natura 2000-site Botshol. With birds present in the breeding season in, Lepelaarsplassen, Oostvaardersplassen and Quackjeswater near future colonisation of these areas is possible;
- Eventually, on the longer term, almost every wetland might be colonised (including the Wadden Islands).

Impact

- Ecological impacts: possible predation of colonial birds (especially terns and cormorants) and possible competition for nests with spoonbill and species of heron;
- Economic impacts: a low risk in The Netherlands;
- Social impacts: possible local or minimum impacts.

Risk assessment scores

- The outcome of the ISEIA method is a score of 10. That means that the species should be included into category BL Watch list. The watch list contain species that have a moderate impact. Beside introduction of legislation and restrictions for keeping the species no immediate management actions are considered.
- The outcome of the Bomford method is a score of 0 for public safety risk (not dangerous), 12 for establishment risk (serious) and 11 for pest risk (moderate). The combination of these three items is the Australian VPC (Vertebrate Pest Committee) threat category serious. Management actions should be considered, including radical restrictions of keeping the species, extensive security measures and extensive administration.

5.2 Risk management

Prevention

- Registration of all captive individuals of the sacred ibis at a central place can facilitate the knowledge on the size of risk populations and measurements to prevent escapes.
- The risk for future escapes or new releases can be significantly limited by informing all stakeholders about the risks of escaped birds and measures to prevent new escapes.

- Nonetheless, the chance of new escapes and new releases are still possible if above measures are applied. Furthermore entering of sacred ibis from foreign zoos or foreign established populations remains possible.
- Minimising new entries is possible but complete prevention of birds entering The Netherlands is impossible.

Eradication

- Complete eradication proved to be difficult in France. In the Dutch situation eradication might be difficult too due to the temporarily occurrence of sacred ibises in difficult or inaccessible areas and future new entries.
- Control measures, including recapturing, oiling eggs, shooting birds at easy place, will result in a removal of a large part of the population. Control measures might lead to a population size of acceptable level but unlikely to eradication.
- The following conflicts can turn up in The Netherlands: strong animal rights/welfare groups lobby, sacred ibis is a species the public likes (culling leads to resistance), culling will conflict with the protection of species and areas. These factors make an eradication campaign less feasible.

Management options

- The gathered information and the analysis of both probability of establishment and spread strongly supports that the sacred ibis might establish and spread through The Netherlands if management actions are not applied.
- Currently, feasible management options for the Dutch population are prevention (including registry of captive birds) and management (recapturing semi-captive birds, shooting and possible oiling eggs);
- To evaluate the effectiveness of management actions the population development of the sacred ibis should be monitored properly. This means population counts in the different seasons, counting the number of breeding pairs and monitoring demographic parameters including nesting success. Information on winter mortality and especially on feeding sites might give an indication of the necessity to continue recaptures.
- If population management is implemented the remaining small populations will probably decline until only a few individuals remain, including new escapes and immigrants. Thus low numbers will occur in The Netherlands in future.

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APPENDIX 1

Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium.

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Version 2.5 (18/10/2007)

1. Introduction

Harmonia is an information system on non-native invasive species in Belgium, which is developed at the initiative of scientists gathered within the Belgian Forum on Invasive Species (http://ias.biodiversity.be). This system aims at collecting standardised information on exotic species which are assumed to be detrimental to native biodiversity in Belgium. It aims to include a high diversity of taxonomic groups from terrestrial, freshwater and marine environments.

Species included in the system are allocated to different list categories based on a simplified environmental impact assessment protocol (ISEIA), and geographic distribution in Belgium (species invasion stage). Such categorisation offers a scientific background to prioritise actions to prevent introduction and mitigate the impact of invasive species, including the improvement of the legislative framework at the federal and the regional levels. This standard provides detailed instructions about the methodology used for this categorisation.

2. Data source

Information is provided to the system by scientists involved in the Belgian Forum on Invasive Species. As much as possible, data entered in the database refers to the available published literature, which include peer-reviewed journals, books, grey sources (reports, etc.) and on-line databases dedicated to invasive species in Europe. Data from field surveys are also used as they provide important information about the naturalisation of new exotic species in Belgium and their habitat preferences.

Scientific nomenclature refers either to national (e.g. Flora of Belgium and neighbour areas) or international standards (e.g. Fishbase).

3. Species classification in the BFIS list system

A list system designed as a two dimensional ordination (environmental impact x invasion stage) is used to categorise non-native alien species found in Belgium and in neighbour areas, based on the guidelines proposed by the CBD decision VI/7 and the European strategy on Invasive Alien Species (figure 1).

Environmental impact and invasion stage are assessed for each species by different scientists, based on the methodology described hereafter. Results are discussed afterwards within the group to find a consensus before being published on the internet.

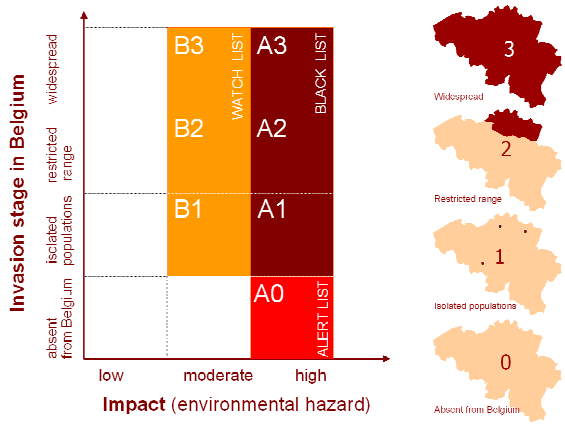

Figure 1 - List system proposed by the Belgian Forum on Invasive Species to identify organisms of most concern for preventive and mitigation actions.

4. Species screening

Not all non-native species are considered to be integrated in the *Harmonia* information system. Only organisms that are already established in Belgium or in neighbour areas characterised by similar eco-climatic conditions (Germany, Ireland, Luxembourg, Netherlands, Northern France, Switzerland and UK; hereafter Western Europe) are taken in consideration[1]. A species is considered as established or naturalised as soon as it is able to reproduce consistently in the wild and sustain populations over several life-cycles through sexual or asexual modes without direct intervention by man (= self-perpetuating populations).

Among the non-native species established in Western Europe, a special attention is given to:

(i) Non-native species that are known to cause adverse impacts on biodiversity and/or ecosystem functioning, including those that already colonised most of their potential habitats;

(ii) Species that recently expanded their geographic range, for which an adverse impact on biodiversity and/or ecosystem functioning is likely.

[1] Non-native species for which there is no evidence of establishment in Western Europe should be evaluated through a specific protocol to assess invasion likelihood. This protocol has to take into account both introduction pathways and potential for establishment in our eco-climatic conditions (see e.g. Baker et al. 2005 and EPPO 2006).

5. Methodology for environmental hazard assessment

A simplified hazard assessment methodology referred to as the Invasive Species Environmental Impact Assessment (ISEIA) was developed to classify non-native species into the BFIS list system and to identify those of most concern for preventive and mitigation actions.

This protocol is intended to allocate non-native species within the different hazard categories of the *Harmonia* information system, as an attempt to minimise the use of subjective opinions and to warrant the transparency and the repeatability of the assessment process (Daehler et al. 2004). The ISEIA protocol consists of four sections matching the last steps of the invasion process, i.e. potential for spread, colonisation of natural habitats and adverse ecological impacts on native species and ecosystems. It has to be noted that this protocol aims to assess environmental risks only and that direct impacts of non-native species on human interests (public health, plant protection, etc.) are not explicitly taken in consideration in the *Harmonia* system, even if adverse ecological impacts frequently induce economic damages in the long term.

Contrary to predictive pest risk assessment protocols mainly based on species' intrinsic attributes for evaluating invasion likelihood (e.g. EPA, EPPO and IPCC standards), the ISEIA approach favours the use of documented invasion histories in previously invaded areas to assess properly their potential to cause adverse ecological effects on the Belgian territory (non native species are likely to cause significant impacts on native species and ecosystems in Belgium if they have already done so in neighbour areas).

The ISEIA protocol allows to allocate species in one of the three following risk categories:

- Category A (black list): includes species with a high environmental risk;
- Category B (watch list): includes species with a moderate environmental risk on the basis of current knowledge;
- Category C: includes other non-native species, that are not considered as a threat for native biodiversity and ecosystems (low environmental risk).

Scoring system

A three point scale is selected for the assessment as it is felt to provide an adequate balance between resolution and simplicity. Providing that information exists and is well documented in the literature (low level of uncertainty), the following scores are used as much as possible for the different parameters,:

- L = low, score = 1
- M = medium, score = 2
- H = high, score = 3

When the parameter is only poorly documented, leading assessment to be based only on expert judgement and field observations, the scoring system is adapted as follows:

- Unlikely, score = 1
- Likely, score = 2

At last, when nothing can be said about the parameter (no information):

- DD = deficient data, no score.

5.1 Dispersion potential or invasiveness

This section addresses the potential of an organism (individuals, seeds, propagules, etc.) to spread in the environment by natural means and/or by human assistance, as a function of dispersal mode, reproduction potential and human commensalism.

The three following situations are recognised:

Low risk. The species doesn't spread in the environment because of poor dispersal capacities and a low reproduction potential. Examples: *Aesculus hippocastanum*, *Zea mays*.

Medium risk. Except when assisted by man, the species doesn't colonise remote places. Natural dispersal rarely exceeds more than 1 km per year. The species can however become locally invasive because of a strong reproduction potential. Examples: *Ameiurus nebulosus, Arion lusitanicus, Robinia pseudacacia, Tamias sibiricus*.

High risk. The species is highly fecund, can easily disperse through active or passive means over distances > 1 km/year and initiate new populations. Are to be considered here plant species that take advantage of anemochory (*Senecio inaequidens*), hydrochory (*Ludwigia grandiflora*) and zoochory (*Prunus serotina*), insects like *Harmonia axyridis* or *Cameraria ohridella* and all the bird species.

5.2 Colonisation of high conservation value habitats

This addresses the potential for an exotic species to colonise habitats with a high conservation value (irrespective of its dispersal capacities), based on habitat preference information from native and invaded areas. This potential is mainly limited by the ability of the new species to establish in habitats with specific abiotic conditions and to outcompete native species that are already present ('biotic resistance').

Habitats with a high conservation value are those where disturbance by man is minimal, thus allowing specific natural communities and threatened native species to occur. Natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers and ponds provided with natural banks and estuaries (see e.g. the list of natural habitats in the Annex 1 of the 92/43/EEC Directive) are considered as habitats with a high conservation value. Parks, orchards, planted forests, fallow lands, road embankments are habitats with an intermediate value. At last, man-made habitats like channels, farmlands or urban areas are classified as sites with a low conservation value.

Scoring system (adapted from the invasive categories of Cronk & Fuller 1995):

Low risk. Populations of the non-native species are restricted to man-made habitats (low conservation value). Examples: *Linepithema humile*, *Setaria verticillata*;

Medium risk. Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonise high conservation value habitats. Examples: *Lepomis gibbosus, Sander lucioperca, Solidago gigantea*;

High risk. The non-native species often colonises high conservation value habitats (i.e. most of the sites of a given habitat are likely to be readily colonised by the species when source populations are present in the vicinity) and makes therefore a potential threat for red-listed species. Examples: *Ludwigia grandiflora*, *Lysichiton americanus*, *Procyon lotor*, *Spartina townsendii*, *Umbra pygmaea*.

5.3 Adverse impacts on native species

This section addresses the potential of exotic species to cause species replacement through different mechanisms. Impacts may include (i) predation/herbivory, (ii) interference and exploitation competition (including competition for plant pollinators), (iii) transmission of diseases to native species (parasites, pest organisms or pathogens) and (iv) genetic effects such as hybridisation or introgression with native species. Such interactions may lead to change in native population abundance or in local extinction. They should be documented from invasion histories within Belgium or other regions characterised by similar eco-climatic conditions.

Exotic species that act as generalist predators or those which have native congeners showing similar eco-morphological traits are especially on target. The different types of interactions are considered separately for each non-native species. Their severity is scored as follows:

Low risk. Data from invasion histories suggest that the negative impact on native populations is negligible;

Medium risk. The non-native species is known to cause local changes (< 80%) in population abundance, growth or distribution of one or several native species, especially among common and ruderal species. This effect is usually considered as reversible. Examples: transmission of sublethal diseases to native species (*Crassostrea gigas, Mustela vison, Sander lucioperca*), predation/herbivory pressure leading to abundance decrease of native species (*Branta canadensis, Nysius huttoni*), moderate competition with native species (*Alopochen aegyptiacus, Pimephales promelas, Senecio inaequidens*);

High risk. The development of the non-native species often cause local severe (> 80%) population declines and the reduction of local species richness[2]. At a regional scale, it and can be considered as a factor precipitating (rare) species decline. Those non-native species form long-standing populations and their impacts on native biodiversity are considered as hardly reversible. Examples: strong interspecific competition in plant communities mediated by allelopathic chemicals (*Fallopia japonica, Prunus serotina, Solidago spp*., etc.), intraguild predation leading to local extinction of native species (*Dikerogammarus spp., Harmonia axyridis, Neogobius melanostomus, Rana catesbeiana*), transmission of new lethal diseases to native species (*Pacifastacus leniusculus, Pseudorasbora parva, Rana catesbeiana, Sciurus carolinensis*).

Species impact score = maximal score recorded for predation/herbivory, competition, disease and genetic interaction sections.

5.4 Alteration of ecosystem functions

This section addresses the potential of an exotic species to alter native ecosystem processes and structures in ways that significantly decrease native species ability to survive and reproduce. Ecosystem impacts may include (i) modifications of nutrient cycling or resources pools (e.g. eutrophication), (ii) physical modifications of the habitat (changes or hydrologic regimes, increase of water turbidity, light interception, alteration of river banks, destruction of fish nursery areas, etc.), (iii) modifications of natural successions and (iv) disruption of food webs, i.e. a modification of lower trophic levels through herbivory or predation (top-down regulation) leading to ecosystem imbalance.

[2] Exotic plants that are known to often form large and dense monospecific stands are considered as a high risk for native plant communities when the potential for species replacement is poorly documented.

Scoring system:

Low risk. The impact on ecosystem processes and structures is considered as negligible.

Medium risk. The impact on ecosystem processes and structures is moderate and considered as easily reversible. Examples: temporary modification of soil or water properties (*Lemna spp*.), decrease or increase of the rate of colonisation of open habitats by shrubs and trees (*Pinus nigra*);

High risk. The impact on ecosystem processes and structures is strong and difficult to reverse. Examples: alteration of physico-chemical properties of water by invasive aquatic plants (*Hydrocotyle randunculoides, Ludwigia spp., Myriophyllum aquaticum*), facilitation of river bank erosion (*Impatiens glandulifera*), prevention of natural regeneration of trees (*Lonicera japonica, Prunus serotina, Rhododendron ponticum*), destruction of river banks, reed beds and/or fish nursery areas (*Eriocheir sinensis, Myocastor coypus, Ondatra zibethicus*), food web disruption (*Crassostrea gigas*, *Lates niloticus*).

Ecosystem impact score = maximal score recorded for nutrient cycling, physical alteration, natural successions and food web sections.

Note: When impact is strongly dependent on the type of ecosystem, one should consider the worst case scenario, with a special focus on vulnerable ecosystems.

5.5 Global environmental risk

Consistent with other risk assessment standards, equal weight is assigned to each of the four sections, i.e. dispersion potential, colonisation of natural habitats, species and ecosystem impacts. The global ISEIA score is the sum of risk rating scores from the four previous sections (global score is between 4 and 12). It is used to allocate species to the different risk categories (see table).

ISEIA score	List category
11-12	A (black list)
9-10	B (watch list)
4-8	C

6. Invasion stage in Belgium

In addition to species classification in risk categories, invasion stage is also taken in consideration in the list system as it provides important information to prioritise actions in the field, especially for invasive species which are highly detrimental.

As illustrated in figure 1, a distinction is made between:

(i) Alert list species: species that are not yet naturalised in Belgium but are invasive in neighbour areas. Note that only species with a high environmental impact among non established species are taken in consideration, e.g. organisms from the list of worst invasive alien species threatening biodiversity in Europe (SEBI 2010) or from the priority list of invasive alien plants to be managed in EPPO member countries. Importation and trade regulation are the adequate tools to avoid intentional introduction of alert list species in our country;

(ii) Species under naturalisation (isolated populations): species that are at the prime stage of the invasion process in Belgium, that only form recent and small isolated populations located in the immediate vicinity of

their introduction points, resulting in a non contagious or random distribution of the observations. These species only colonised few of their potential habitats in the country and can still be eradicated at a national scale at a very low cost corresponding to the damage they can cause in the future if no action is undertaken;

(iii) Naturalised species with a restricted range: species whose populations are in strong expansion in the wild and form new populations far away from their introduction points after an active dispersion phase, but whose distribution is still limited to some biogeographic areas in Belgium. Those species are likely to be contained in some regions of the country providing that active control measures are undertaken;

(iv) Widespread naturalised species: species that are widely distributed in the country and that already colonised most of suitable sites for their establishment.

7. List of contributors

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Appendix – List allocation of some non native species through the ISEIA protocol

	5.1	5.2	5.3 – Impact on native species				5.4 – Impact on ecosystems				ISEIA	LIST
	Spread	Natural habitats	Predation	Competition	Disease transm.	Hybridisation	Nutrient cycling	Physical alter.	Successions	Food webs	SCORE	
Aix galericulata	high	high	low	likely	DD	low	low	low	low	low	**9**	**B**
Cameraria ohridella	high	medium	low	low	low	low	low	low	low	DD	**7**	**C**
Carassius gibelio	high	high	low	high	low	high	medium	high	low	high	**12**	**A**
Crassostrea gigas	high	high	low	high	medium	likely	likely	high	low	high	**12**	**A**
Epilobium ciliatum	high	high	low	unlikely	low	medium	DD	low	low	low	**9**	**B**
Eriocheir sinensis	high	high	high	likely	DD	low	DD	high	low	likely	**12**	**A**
Harmonia axyridis	high	high	high	high	low	low	low	low	low	likely	**11**	**A**
Ludwigia grandiflora	high	high	low	high	low	low	high	high	high	low	**11**	**A**
Ondatra zibethicus	high	high	high	DD	DD	low	medium	high	high	likely	**12**	**A**
Pacifastacus leniusculus	high	high	medium	high	high	low	low	low	low	likely	**11**	**A**
Procyon lotor	high	high	likely	DD	DD	low	low	low	low	low	**9**	**B**
Robinia pseudacacia	medium	medium	low	high	low	low	high	high	high	low	**10**	**B**
Sciurus carolinensis	high	high	medium	high	high	low	low	medium	low	likely	**11**	**A**
Tamias sibiricus	medium	high	medium	likely	DD	low	low	low	low	likely	**9**	**B**
Umbra pygmaea	medium	high	low	medium	DD	low	low	low	low	low	**8**	**C**

APPENDIX 2

	Risk analysis conform method developed by Bomford (2003, 2006, 2009)			
	Factor	**Score**	**Information**	**Conclusion**
	Stage A: Risks posed by captive or released individuals			
A1.	Risk to people from individual escapes (0-2)	0	only relates to aggressive behaviour	Not Dangerous
A2.	Risk to public safety from individual captive animals (0-2)	0	about the irrisponsible use of products obtained from captive individuals of the	n.a.
	A. Public safety Risk Score	**0**		**Not Dangerous**
	Stage B: Porbability escaped or realeased individuals will establish a free-living population			
B1	Climate match score (1-6)	4	The match of the natural geographic region and the region of assessment, based on 16 climate parameters of temperature and rainfall. The climate match score is 1 (low) up to 6 (exteme).	The situation in Europe suggests that climate is not really a restriction. The used habitat in France (e.g. grasland and wetlands) are abundant in the Netherlands. A part of the Dutch population returns in winter to their cages, profits from feeding in winter and summer. Some evidence suggests higher mortality in cold winters. Therefor the climate match score is set to high (4).
B2	Established exotic populations Score (0-4)	4	0 = none, 2 = on island <50.000 square km, 4 = established on large islands or on a continent	Nowadays established in e.g. France, Italia, The Netherlands and Florida.
B3	Taxanomic class score (0-1)	0	0 = bird, 1 = mammal, reptile or amphibian	Mammals, reptiles and amphibians have a larger potention to cause negative effects.
B4	Migratory score (0-1)	1	0 = migratory 1 = non-migratory	Migratory/nomadic due to rains and droughts, up to 1.000-1.500 km in Africa. Dispersal in France up to 400-500 km away from breeding
B5	Diet score (0-1)	1	0 = specialist, 1 = generalist	Mainly invertebrates, but as a generalist also feeding on small animals (including fish, small mammals, eggs, young birds) and on rubbish
B6	Habitat score (0-1)	1	0 = undisturbed habitat, 1 = including human disturbed habitats	Found in undisturbed and human disturbed habitats.
B7	Range size score (0-2)	1	In million km2: 0 = 0-1, 1 = 2-69, 2 = ≥70	Natural distribution is about 17 million km2
	B. Establishment Risk Score	**12**	**Low = ≤6; moderate = 7-11; serious = 12-13; Extreme ≥14**	**Serious risk**
	Stage C: Probability an established exotic mammal or bird will become a pest.			
C1	Taxanomic group (0-4)	0	0 = none, 1 = known to hybridise, 2 = within the group that cause agricultural damage	Bomford (2003, 2006, 2009) mentioned the taxanomic groups belonging to the scores. None is applicable to the sacred ibis.
C2	Range (0-2)	1	in million km2: 0 = <10, 1 = 10-30, 2 = >30 (including range unknown)	Natural distribution is about 17 million km2
C3	Diet and feeding (0-3)	0	0 = not a herbivorous mammal or a mammal, 1 = non strict carnivorous mammal, 2 = carnivorous mammal, 3 = herbivorous or carnivore an arboreal mammal	
C4	Competition with native fauna for nesting space (0-2)	2	0 = no competition, 1 = minor competition, 2 = strong competition (breeding in tree hollows, less abundant breeding space)	The sacred ibis is using space within colonies of other heron, ibis and spoonbill species which are restricted to certain areas.
C5	Pest status (0-3)	1	1 = minor pest, 2 = moderate pest, 3 = major pest (uncluding species with unknown pest status)	Observations in France suggests incidental predation of eggs and young of several species (including terns). Predation in some colonies in South Africa is high. The xtent of predation is not known. Due to the many uncertainties set to 1 (minor pest).
C6	Match to areas with susceptible native species or communities (0-5)	3	Identify any native animal or plant species or communities that could be susceptible to harm by the sacred ibis. Compare the geographic distribution of this susceptible species with the possible distribution of the sacred ibis (0-5). From 0 (no overlap) to 5 (complete overlap with vulnerable species or community).	Overlap with the natural distribution of several scarce birds, including spoonbill and species of tern (possible imoacts are predation and nest competition). Dutch population partly prfits from food supply, some evidence for higher mortality in cold winters. Due to these uncertainties set to 3.
C7	Primary production pest status (0-3)	0	0 = no damage to crops, 1 = minor, 2 = moderate, 3 = major	Is not reported to damage e.g. crops. Related species are reported to eat pest species like
C8	Match with susceptible primary production (0-5)	0	Assess potential commodity impact score for each primary production commodity.	No reports of any damage to primary production.
C9	Spread disease (1-2)	2	1 = amphibians and reptiles, 2 = all birds and mammals	All birds and mammals can play a role as a vector of diseases/parasites and thus can be a risk for livestock or other domestic animals.
C10	Harm to property (0-3)	1	damage to e.d. Buildings, vehicles, fences, road, ornamental gardens. 0 = $0, 1 = $1.000-$10 million, 2 = $11-$50 million, 3 =	Possible airplane strikes.
C11	Harm to people	1	0 = nill risk, 1 = low risk, 2 = injuries (minor), 3 = moderate, 4 = severe/fatal, 5 = extreme risk (many fatalities)	Possible airplane strikes (possible failure of engine).
	C. Pest Risk Score = Som C1-C11 (1-37)	**11**	**< 9 Low, 9-14 Moderate, 15-19 Serious, >19 Extreme**	**Moderate**
	A. 0 = not dangerous, 1 = moderately dangerous, ≥2 = highly	0		Not Dangerous
	B. ≤6 = low, 7-11 = moderate, 12-13 = serious, ≥14 = extreme	12		Serious risk to establishing a wild population
	C. <9 = low, 9-14 moderate, 15-19 = serious, >19 = extreme	11		Moderate risk to become a pest
	VPC threat categorie			**Serious**

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