







Threskiornis aethiopicus is native to Africa and the Middle East and introduced in Europe. © Wolfgang Rabitsch

The management of sacred ibis (*Threskiornis aethiopicus*)

Measures and associated costs

Scientific name(s)	<i>Threskiornis aethiopicus</i> (Latham, 1790)
Common names (in English)	Sacred ibis
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Common names

BG	Свещен ибис
HR	Sveti ibis
CZ	Ibis posvátný
DA	Hellig ibis
NL	Heilige ibis
EN	Sacred ibis
ET	Pühaiibis
FI	Pyhäiibis
FR	Ibis sacré
DE	Heiliger Ibis
EL	Ιερό Ιβίδα
HU	Szent íbisz
IE	–
IT	Ibis sacro
LV	Svētais ibiss
LT	Šventasis ibis
MT	–
PL	Ibis czczony
PT	Íbis-sagrado
RO	–
SK	Ibis posvátný
SL	Sveti ibis
ES	Ibis sagrado
SV	Helig ibis



Summary of the measures, emphasizing the most cost-effective options.

The information here reported on measures and related costs regarding prevention of spread, rapid eradication and management of sacred ibis (SI) comes mainly from France. Since the early 2000s, French ornithologists have widely worked both on the Atlantic coast and on Mediterranean SI populations, which has allowed them to gather data and acquire major experience on measures aimed at SI management and eradication, their effectiveness and costs. Other useful experiences used for this report derive from activities carried out in The Netherlands and Belgium, including risk analyses of the species, and in Spain and Florida (USA). Although the distribution and numbers of the Italian SI population have been growing in the past years, probably currently being the largest among EU Member States (MS), there still have not been direct experiences of eradication in this country. However, evaluation tests of the effectiveness of shooting flying birds have been carried out in a localised area, which is mentioned as a valuable experience.

SI is listed as an invasive alien species of Union concern which, therefore, cannot be intentionally brought into, kept or bred in EU territory, in accordance with Article 7 of the EU IAS Regulation 1143/2014, although as a transitional measure, species can be kept in contained holding until the end of their natural life, provided that reproduction and escape are prevented. In this context, it is important to mention that although populations of SI in the wild only seem to exist in six MS, until recently the species was kept in captivity in a number of private collections, aviaries and in over 100 zoological parks in the whole of the EU territory, with the Zootierliste¹ website reporting its presence in zoos of 20 MS. This is a crucial aspect, because birds escaped or left free from zoological parks have been the main cause of established feral or wild populations in several countries, such as France (Loire, Camargue), Italy, Portugal, Spain and The Netherlands. This indicates that restrictions imposed by the IAS Regulation should be strictly enforced, in order to avoid further escapes from private collections and zoological

parks. Furthermore, at present, it is possible to buy SI from commercial vendors from at least two Italian ornamental suppliers², which means that more efforts are required to stop illegal activities.

The measures discussed below are divided into four main groups: prevention of escapes and reproduction of animals in containment, surveillance measures to support early detection of the species in the wild, rapid eradication, and management. No measures to prevent unintentional introductions or secondary spread of the species were identified. The methods proposed to implement surveillance to support early detection involve establishing cooperation between MS, promoting citizen-science internet data platforms, and collecting data derived from standardised ornithological programs of wild bird populations to monitor SI populations. The recommended measure for rapid eradication of new introductions is by targeted shooting by professional hunters and other operators and, the measures proposed for management are shooting of birds, removal of birds escaped from captivity and showing a synanthropic behaviour by trapping/luring with food bait or by shooting, and finally destroying nests, removing or sterilising eggs, combined with shooting.

The measures indicated in this report have been selected on the basis of compliance with the requirements of maximum selectivity and effectiveness of action, as well as reduced disturbance of wild animals. Furthermore, the local application of each suggested measure must deal with different regulations, as well as with public sensitivities and customs, which can greatly influence their practical application. In what concerns costs, it is noteworthy to mention that some methods described below, such as the implementation of citizen-science platforms for early detection, are applicable not only to SI, but can also be used for management of other invasive alien species (IAS), allowing to increase their cost-effectiveness.

1 <https://www.zootierliste.de/en/?klasse=2andordnung=208andfamilie=20805andart=2050507>

2 <http://www.oasicoperativa.com/shop/ibis-sacro> and <http://amicidibecco.wixsite.com/uccelli-esotici/animali-in-vendita-e-su-ordinazione-1> [both accessed 20/05/19]

Measures for preventing the species being introduced, intentionally and unintentionally.

This section assumes that the species is not currently present in a Member State, or part of a Member State's territory.



A ban on importing (pre-border measure), selling, breeding, growing, and cultivation, as required under Article 7 of the IAS Regulation, targeting intentional introduction of plants and propagules of *T. aethiopicus*.

MEASURE DESCRIPTION

As the species is listed as an invasive alien species of Union concern, the following measures will automatically apply, in accordance with Article 7 of the EU IAS Regulation 1143/2014:

Invasive alien species of Union concern shall not be intentionally:

- (a) brought into the territory of the Union, including transit under customs supervision;
- (b) kept, including in contained holding;
- (c) bred, including in contained holding;
- (d) transported to, from or within the Union, except for the transportation of species to facilities in the context of eradication;
- (e) placed on the market;
- (f) used or exchanged;
- (g) permitted to reproduce, grown or cultivated, including in contained holding; or
- (h) released into the environment.

Also note that, in accordance with Article 15(1) – As of 2 January 2016, Member States should have in place fully functioning structures to carry out the official controls necessary to prevent the intentional introduction into the Union of invasive alien species of Union concern. Those official controls shall apply to the categories of goods falling within the Combined Nomenclature codes to which a reference is made in the Union list, pursuant to Article 4(5).]

Therefore measures for the prevention of intentional introductions do not need to be discussed further in this technical note.

However, species covered by the restrictions set out under Article 7 of the EU IAS Regulation 1143/2014 may still be kept in containment under the condition that escape and reproduction are not possible, according to:

- (1) Articles 8 (Permits) and 9 (Authorisations) which allow for permitted specimens to be kept (reproduction may also be permitted).
- (2) Articles 17 (Rapid eradication) and 19 (Management) which allow for animals to be kept as part of non-lethal eradication/management measures.
- (3) Article 31 (Transitional provisions for non-commercial owners) which allows non-commercial owners to keep their companion animals until the end of the animals' natural life, provided that these were kept before the inclusion on the Union list.
- (4) Article 32 (Transitional provisions for commercial stocks) which allows commercial owners to keep specimens of invasive alien species of Union concern for up to two years after inclusion on the Union list.

Therefore, this note includes information on the appropriate measures to ensure that reproduction or escape from containment are not possible, please see *Prevention of escape into the environment* and *Prevention of reproduction of contained specimens* sections below.



Aviaries and pinioning.

MEASURE DESCRIPTION

From a biological and practical point of view, preventing the escape of every SI kept in captivity in private collections and zoos is a crucial goal in order to reduce the chance of new colonisations or the increase of wild SI populations already established. Subjects held in captivity can be prevented from escaping into the environment by keeping in secure aviaries and by pinioning (surgically removing one pinion joint of a bird's wing to render them flightless) to prevent individuals from flying if they were to escape. The achievement of a no-escape goal requires the cooperation of stakeholders through a communication and information policy, the implementation of controls and the provision of adequate fines. Moreover, it is necessary to provide for the obligation of pinioning, of marking and of denunciation of detection.

Keeping an updated database of aviaries and of individual birds kept in captivity is fundamental to evaluate the size of risk populations and to apply measures that can efficiently prevent escapes. In addition, plans to quickly react to accidental escapes should also be carefully considered and implemented in full. For example, it is believed that the SI found living in the wild in Florida have descended from animals that escaped from the Miami Metro Zoo during or after the widespread destruction caused by Hurricane Andrew in 1992 (Johnson and McGarrity, 2009).

SCALE OF APPLICATION

These prevention measures must be applied to all captive colonies of the species (such as in zoological parks and private collections). Aviaries could also be used for temporal or permanent secure keeping of free ranging SI captured during management operations.

EFFECTIVENESS OF MEASURE

Neutral.

Aviaries and pinioning can be used to prevent the species from escaping, although the possibility of escapes still exists, even if the above measures are applied (Clergeau and Yésou, 2006; Smits *et al.*, 2010; Robert *et al.*, 2013; Charlier, 2016).

EFFORT REQUIRED

The measures would need to be in place permanently. It is worth to point out that the SI is a long living bird that, in captivity, may reach 20-25 years of age or more (Brouwer *et al.*, 1994). Given the high potential fertility of SI and the long average life span of the animals kept in captivity, the definition of a maximum quota of SI that can be held in captivity by each structure can be useful.

RESOURCES REQUIRED

In order to keep the possibilities of new escapes low, it is necessary to secure: 1) a proper maintenance of the aviary; 2) well trained staff and keepers; 3) adequacy of escapes contingency plans; 4) adequate budgets for control and registry procedures; 5) financial viability of owners. Compliance of conditions 1 to 4 is already required under the registry system introduced with the IAS Regulation that allows to continue the keeping of birds already owned until the end of their natural lives.

Access to veterinary skills and facilities are needed to undertake pinioning, which incurs additional costs.

SIDE EFFECTS

Environmental: Neutral or mixed

Social: Neutral or mixed

Economic: Neutral or mixed

Assuring that caged birds remain confined in aviaries has no negative effects and would not conflict either with people visiting the zoological parks, or with people keeping SI as pets. However, as for small zoos and private owners the imposition of keeping SIs secure or of pinioning them could inflict too high costs, this may promote further releases into the wild.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Keeping pinioned birds is generally accepted by private owners, as pinioning is a common practice for a wide range of middle and large sized birds such as waterfowl and flamingos, and it allows to keep birds in semi-natural conditions (such as open ponds and fenced aviaries), reducing the costs of maintaining large closed cages. However, while pinioning is largely practised by zoos and private owners, it may be seen by some animal right organisations as cruel.

ADDITIONAL COST INFORMATION

Inaction would increase the risk that even a few escaped birds can create new populations and establish in the wild, making eradication actions, which are more costly and difficult to implement, necessary.

LEVEL OF CONFIDENCE*

Well established.

The practice of keeping birds in aviaries and incurring pinioning is widespread for preventing the escape of birds.

* See Appendix



Habitat management, nest destruction, egg removal/sterilisation.

MEASURE DESCRIPTION

As in the wild, SI can adapt to nest on a wide variety of substrates including trees, reedbeds and bare ground when present in confined areas. Therefore, removing suitable nesting sites, or destruction of nests if constructed, will limit the opportunity for the species to lay eggs and raise young. In addition, if the species is able to lay eggs, their removal or sterilisation (by piercing them, or spraying them with paraffin or vegetable oil; Christens and Blokpoel, 1991) can be undertaken to prevent successful reproduction. For more details on these techniques, please see the *Management* sections below on 'Destroying nests/eggs, or sterilising eggs, combined with shooting'.

Nicarbazin (NCZ) is a non-vaccine contraceptive that can be used as a bird-specific oral contraceptive. Unfortunately, in order to preserve its efficiency, this drug must be fed continuously before and during egg-laying. In addition, the currently available commercial formulations are unlikely to be suitable for SI, hence a new formulation would need to be developed together with a species-specific delivery system in order for it to be used (IUCN, 2017).

SCALE OF APPLICATION

It should be feasible to carry out these measures for individuals present in contained facilities.

EFFECTIVENESS OF MEASURE

Effective.

If correctly implemented, nest destruction and egg removal/sterilisation will all prevent the species from successfully reproducing.

EFFORT REQUIRED

The measures would need to be in place permanently.

The measures should be applied constantly during the reproductive life of the birds.

RESOURCES REQUIRED

Time for trained staff to undertake the measures and egg sterilisation equipment and paraffin/oil. As the species may rebuild destroyed nests and attempt a replacement brood, operations might have to be repeated during the year, incurring increased costs.

SIDE EFFECTS

Environmental: Neutral or mixed

Social: Neutral or mixed

Economic: Neutral or mixed

None known.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Some stakeholder groups might oppose the measures, particularly egg removal and oiling, based on welfare concerns.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Established but incomplete.

There is little information available on these measures being applied for the species specifically in captivity.

* See Appendix

Measures to prevent the species spreading once they have been introduced.



There are no measures known that have the specific intention of preventing the secondary spread of the species.

MEASURE DESCRIPTION

The authors are treating measures that target preventing the spread of synanthropic populations originating from zoological gardens and private collections (aviaries) as eradication or management (see below).

Measures for early detection of the species and to run an effective surveillance system for an early detection of a new occurrence.



Establish cooperation between European countries.

MEASURE DESCRIPTION

For a highly mobile species such as SI, it is necessary to develop cooperation between countries where the species is present and neighbouring or closely-located countries. The goal of this measure is to promote cooperation and communication between MS, in order to reduce the likelihood that SI specimens cross country borders and establish populations in new MS (Genovesi and Shine 2004, Shine *et al.*, 2009). Several cases of such dispersal have been documented; for instance, ringed individuals from the French Atlantic coast being found at the Belgian border, or in the Netherlands. Similarly, a French specimen was found in a group present at Doñana National Park (Yésou *et al.*, 2017) and ibises seen in Catalonia (Spain) in the early 2000s are also thought to originate from the French Mediterranean coast (de Juana and Garcia, 2015). Moreover, SI recently seen in eastern France are suspected to come from Italy (M. Pavia, Gruppo Piemontese Studi Ornitologici, pers. comm., 2019). Other cases may have occurred, although not having been documented.

Reporting the presence of SI that are located close to a border of a country in which they occur, or that have recently crossed a border, allows the neighbouring state(s) to arrange for rapid intervention on a still small number of specimens, increasing the possibility of undertaking local eradications. An efficient cooperation between MS would require the presence, in each State, of reference structures responsible for the coordination, control and management of the potential introduction into the country of alien species, in general, and SI in particular. These structures ought to dialogue with each other and share concrete objectives (action plans) aiming to prevent SI becoming an established alien species.

SCALE OF APPLICATION

The measure concerns MS where SI is present and neighbouring or closely-located countries. SI have established populations in France, Italy, Portugal, Spain,

the Netherlands, and free flying SI have been reported from other European countries including UK, Ireland, Sweden and Poland (Robert *et al.*, 2013). The extent of the area involved in the measure can vary over time, depending on the dynamics of SI distribution in the MS.

EFFECTIVENESS OF MEASURE

Neutral.

The effectiveness of the measure is potentially high, although it depends on various aspects, such as 1) the existence of an adequate international communication network, 2) the ability of countries to (re)act quickly, and 3) the operational capacity of the individual MS. As an example, this measure has been considered as “absolutely necessary” to stop or reduce the expansion of the racoon dog (*Nyctereutes procyonoides*) in Scandinavia (Dahl and Åhlén, 2017).

Countries with an existing SI population may be encouraged to run effective management programs, if partly funded by neighbouring or closely-located countries that are under threat of invasion, or by supranational authorities.

EFFORT REQUIRED

The measure would have to be applied by MS and their neighbouring or closely located countries as long as there are SI specimens present in their territories.

RESOURCES REQUIRED

International cooperation networks for reporting SI movements across borders should be implemented by the MS reference institutions responsible for the control and management of alien species, in general, which should not incur extra high costs. In fact, the most cost-effective approach would be to monitor the presence of SI through networks used for the surveillance of any IAS of Union concern. This would just require organising a flow for exchanging data and information between existing structures of different MS. However, there are costs involved in implementing

associated measures, such as monitoring SI populations close to borders and further actions targeting rapid intervention and species eradication (see sections below).

SIDE EFFECTS

Environmental: Positive

Social: Neutral or mixed

Economic: Neutral or mixed

The measure may provide the communication and cooperation networks to support similar surveillance for other mobile IAS, especially those of Union concern.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

Establishing an international cooperation network between neighbouring or closely located countries seems acceptable to all stakeholders, unless some countries are not interested in collaborating with specific countries (for example, due to political issues).

ADDITIONAL COST INFORMATION

To be proactive in establishing cooperation with neighbouring or closely-located countries is probably a cost efficient measure, especially for the countries where SI does not occur yet.

LEVEL OF CONFIDENCE*

Established but incomplete.

Several instances of international cooperation aimed to monitor and manage IAS are reported in literature, but little cases, so far, involved SI.



The sacred ibis is a wading bird belonging to the family Threskiornithidae. © Cliff1066. CC BY 2.0

* See Appendix



Citizen-science.

MEASURE DESCRIPTION

Sacred ibises can fly for kilometres from the site of origin, dispersing over large areas and becoming difficult to follow (Smits *et al.*, 2010, Cocchi *et al.*, 2018). However, they are large and unmistakable birds that can be easily detected, even at low densities. Informed people, such as amateur naturalists, birdwatchers, and the general public can act as sentinels to early report on any new SI encountered. Citizens, and in particular key stakeholder groups, should be encouraged to share their own observations of SI through citizen-science platforms.

The data provided by citizen-science platforms would help managers to early detect SI in new territories, monitor their distribution in occupied areas and prepare actions for their eradication and control. The minimum data required for information to be useful must include the geographic coordinates of the observation locality, the date and the number of SI observed, as well as, whenever possible, an original digital picture to secure the correct identification of the species. It is crucial to confirm that the reported animal is a SI, before the observation is included in a database or is used for taking any action. Every single record must be validated by experts using, for example, the same criteria as those used by ornithological internet platforms or bird rarities committees. Once validated, the data will enrich national geodatabases, providing information that is freely available to stakeholders and that can assist MS in their reporting obligations in the scope of the EU IAS Regulation. To be truly effective, data coming from citizen-science platforms need to be promptly delivered to the organisations in charge of rapid eradication and management actions. This requires close coordination and constant exchange of information between Early Detection operators and Rapid Eradication Teams (RET) (see *Rapid eradication* section).

Internet platforms aimed at collecting and sharing data on flora and fauna have already been developed and are widely used in various countries; some of these are specifically aimed at IAS, while others are dedicated to birds or other fauna groups. For example, the European Alien Species Information Network (EASIN³) is a platform developed by the European Commission Joint Research Centre. EASIN builds on collaboration with existing European and global partners to deliver tools and information in support of alien species policies. EASIN has been appointed as the information

exchange mechanism supporting the implementation of European Regulation 1143/2014 on the prevention and management of the introduction and spread of IAS. EASIN has developed a citizen-science smartphone application called “Invasive Alien Species Europe” through which citizens can report sightings of the 49 IAS of Union Concern (of which SI is part). This app aims to use the contribution of citizens to report new introductions and help prevent the spread of IAS in Europe. In Italy, an app developed in the framework of the LIFE project “Alien Species Awareness Program” (LIFE15 GIE/IT/001039, acronym ASAP⁴) also allows citizens to collaborate in the collection of sighted IAS records.

Another example of a platform that can be used to report sightings of SI is Ornitho, an ornithological platform available in several European countries. This platform originated as Ornitho.ch, which was launched in 2003 by a company based in Switzerland. In 2004, it was extended to the entire French part of Switzerland and, since 2007, observations can be entered for the whole of Switzerland. Meanwhile, national or regional Ornitho portals have been created in France, Italy, Austria, Poland, Croatia, Catalonia and the Basque Country. These systems all have the same basic structure, which facilitates the entry of observations in different countries and the aggregation of data. A recent development of the Ornitho platform is the app for mobile devices NaturaList⁵, which allows direct uploading of observation data into the national Ornitho portal (where one exists) or into another dedicated web portal. This allows all reported information collected at a European level to be gathered by and be made available from one single common source.

In order to limit, as much as possible, the dispersion of data on a myriad of different information platforms (which is likely inevitable), it is necessary to identify in advance the platforms that will be the focus of the measure and to direct observers to those. The choice of the platform(s) to be considered must take into account their degree of usability and some knowledge of their potential users.

SCALE OF APPLICATION

The measure should be applied in all MS. This measure is useful to report on early detections of SI in countries where the species is currently absent, being especially relevant to countries that share borders with others where SI is already present. The measure is also useful to follow changes in

³ <https://easin.jrc.ec.europa.eu/easin>

⁴ <https://lifeasap.eu/index.php/en/>

⁵ <https://data.biolovision.net/>

distribution in countries where SI have already established. Given the high adaptability of the species, the speed of colonisation of new areas and the large distances covered by dispersal of the species, a widely extended system of rapid monitoring of new presences of SI is necessary. The use of a platform shared among all MS (and potentially including other IAS) satisfies this requirement and provides an efficient tool to exchange information between neighbouring or closely-located states, allowing for a stricter coordination of eradication programs.

EFFECTIVENESS OF MEASURE

Effective.

The use of internet portals and applications for collecting observations reported by citizens is widespread in several European countries, being a tool that is already in use to monitor the distribution of several IAS, including SI. In many cases, data are entered in the internet platform on the same day of observation or, even more often, "live". As such, a surveillance system based on citizen-science is – de facto – already in place. This surveillance system would work at its best if accompanied by an active media dissemination strategy, aimed at teaching as many people as possible that the sacred ibis is an IAS. Examples of the effectiveness of this measure in assisting early detection of IAS, and enabling rapid responses, have been shown for several species in the UK, such as the oak processionary moth (*Thaumetopoea processionea*) (Pocock *et al.*, 2017), Asian hornet⁶ (*Vespa velutina*) and Oriental chestnut gall wasp⁷ (*Dryocosmus kuriphilus*), but are less frequent or inexistent for bird or mammal species.

EFFORT REQUIRED

This measure needs to be continued indefinitely.

RESOURCES REQUIRED

The cost of creating the ASAP app and portal in Italy, which were built using an existing platform (LifeWatch), was around 15,000 Euro (P. Genovesi, ISPRA, *in litteris*, 2019). It is appropriate that only one citizen-science platform is used within each country, so both the costs for building the platform (software development, hardware, maintenance, etc.) and for paying staff can be reduced. At a national scale, costs for staff are limited to a few employees who need to coordinate data collection, validate the observations (although often this is done

at no cost by ornithologists or expert birdwatchers) and compile and report them to the appropriate authorities.

Although new citizen-science internet platforms or apps specifically for reporting SI sightings can be created, the most cost-effective approach is to use the already existing national or regional platforms (such as those mentioned above) and integrate them into SI eradication programs. For example, costs can be even further reduced, or eliminated, if the EASIN EU app for reporting species of Union concern, including SI, is primarily used, with data then being conveyed to national or local databases of each country.

SIDE EFFECTS

Environmental: Positive

Social: Positive

Economic: Positive

If online surveillance systems for SI are integrated into platforms that also monitor other IAS, this will promote generating more records of other alien species, which can assist in their management and, in the long run, bring about environmental, social and economic positive effects.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

In general, there are no major grounds for this measure to generate conflicts of interest among stakeholders. However, it must be considered that part of the public (such as animal rights movements groups) may be against providing data, or even boycott data collection, on the presence of SI and other IAS, being aware that that information will be used for control and eradication activities.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Well established.

The level of information confidence is estimated high given that many citizen-science projects are already undergoing in Europe and there is an increasing number of people practicing bird watching and other recreational activities related to wildlife. Furthermore, due to the ease of identification of the target species, it is likely that this measure would work well for SI.

6 <http://www.nonnativespecies.org/alerts/index.cfm?id=4>

7 <https://www.observatree.org.uk/no-sting-in-this-tale/>

* See Appendix



Monitor wild populations.

MEASURE DESCRIPTION

While the aim of this surveillance measure is not strictly to support early detection of a new occurrence of SI at a Member State level, it is an important measure that will support management and eradication by mobilising data on SI population status and range within MS, and is therefore discussed here. In addition, the data collated through this measure would feed directly into the recommended early detection measure of cooperation between countries with SI populations and their neighbouring countries (as discussed above).

Monitoring the distribution and number of SI populations is a necessary measure for a surveillance system on early detection and rapid eradication at a site level within MS. Apart from France (Yésou *et al.*, 2017), there are no monitoring programs specifically dedicated to SI populations living in the wild. However, this measure can be implemented by compiling data collected within general ornithological monitoring programs. Data on SI are commonly recorded by a plethora of short and long term programs aimed at surveying bird populations or evaluating the outcomes of conservation projects. As an example, counts of wintering water birds are carried out every mid-January in all European countries (IWC) and, in most countries, census of breeding cormorants, herons, spoonbills and other Pelecaniformes with the same breeding habitat as SI, are carried out on a regular basis. Visits carried out by ornithologists inside SI colonies allow to count their nests and verify breeding success of the species, information that cannot be recorded in any other way. Further data are collected for the implementation of local, regional or national bird atlas projects. Such data are of great value for monitoring changes in distribution and size of SI populations. These data are usually more valuable than the data collected through citizen-science because, as they are collected by professional ornithologists or well trained volunteers, the data is already validated. Data from ornithological monitoring programs can be integrated with data from citizen-science initiatives (see above) in order to achieve a more comprehensive picture of SI distribution, numbers and population dynamics.

For this measure to be successful, it is necessary that the individuals and organisations involved in monitoring birds are encouraged to provide their data to authorities in charge of managing SI. This can be accomplished by keeping individual ornithologists and non-profit ornithological associations informed about SI initiatives, and by implementing a simple system for data sharing.

Knowledge of spatial dynamics and population trends of the species also provides invaluable information for implementing management activities both at a local scale and beyond. Without such data, an effective, sustainable and adaptive management process would not be possible.

SCALE OF APPLICATION

All MS where SI live in the wild.

EFFECTIVENESS OF MEASURE

Effective.

The effectiveness of this measure is assessed in terms of providing data to support the management and eradication of the species within MS where it currently exists, and not as an Early Detection measure at a Member State level. Data from ornithological monitoring programs, especially if integrated with data from citizen-science, can provide a good picture of SI distribution, numbers and population dynamics. In France, censuses of SI nests and wintering individuals have been carried out every year since before the start of the eradication program, which has proven useful for monitoring population response to the management campaign and to support early detections in new areas (Clergeau *et al.*, 2005; Yésou *et al.*, 2017). In Italy, although there is no national monitoring program dedicated to SI, breeders have been recorded every year in the central and western Po Plain during monitoring of heron colonies (Fasola *et al.*, 2011; Fasola, 2017). Post-breeding and wintering birds have been counted at night roost in four districts between Piedmont and Lombardy (NE Italy) (Alessandria, 2017; Gola and Scatassi, 2018), and data on wintering birds are collected in January during the mid-winter water birds counts (Zenatello *et al.*, 2014).

EFFORT REQUIRED

Data collection should be carried out indefinitely, or until there are no more SI populations in the wild.

RESOURCES REQUIRED

Bird population monitoring is generally carried out by park guards, professional and volunteer ornithologists coordinated at a national, and local scale, by wildlife national institutes and regional referents. In most MS, monitoring SI at a national scale would already be possible by involving individuals and organisations (for example, research institutes, ornithological associations) that already contribute to bird monitoring programs, such as the IWC and other initiatives aimed at performing censuses of water birds or single bird species (herons, cormorants, etc.). Resources required are mainly of organisational nature,

because the main need is to gather, compile and structure information already collected by ornithologists and/or non-profit ornithological associations.

At a national scale, further costs would arise from the need to employ a person to administrate and coordinate the SI monitoring system, keeping contact with observers in the field to obtain census data, handling the database, writing reports and providing information to the authorities responsible for managing the species. The same person can be managing data from citizen-science initiatives for SI, or even for all the other IAS of Union concern.

SIDE EFFECTS

Environmental: Positive

Social: Neutral or mixed

Economic: Neutral or mixed

There are no evident negative effects deriving from this measure. Using data collected during non-dedicated monitoring programs will contribute to reducing field work and human disturbance in more sensitive sites, such as protected areas and breeding colonies. Public recognition of the contribution given by individual ornithologists and organisations will increase the interest in providing data voluntarily.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The measure is generally acceptable to all stakeholder groups. However, some ornithologists and non-profit organisations might not be willing to share their data either due to not agreeing with its use for SI control, or because of not being willing to share the data before the end of their research (reporting or publication).

ADDITIONAL COST INFORMATION

Using data from well-established monitoring programs and occasional ornithological projects can be cost-effective, by saving costs required to start a whole new program dedicated to SI monitoring.

LEVEL OF CONFIDENCE*

Unresolved.

Monitoring the distribution of bird populations through ornithological surveys has been done extensively and for many years. However, no or very few ornithological monitoring programs have specifically been used as a surveillance measure for early detection and rapid eradication of IAS. Furthermore, combining data from different sources (ornithological surveys and citizen-science) under a common platform is a rather recent opportunity, and there are no experiences of using these data for an IAS eradication program.

* See Appendix

Threskiornis aethiopicus is especially known for its role in the religion of the Ancient Egyptians, where it was linked to the god Throth.

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Measures to achieve rapid eradication after an early detection of a new occurrence.



Targeted shooting.

MEASURE DESCRIPTION

Rapid eradication (RE) is typically directed towards newly escaped birds or birds arriving in a territory that was not occupied before. RE is mostly feasible and appropriate, from a cost-benefit perspective, when the number of SI is still small, and especially when the targeted SI individuals are isolated from any other SI population.

Studies monitoring the breeding ecology of SI in The Netherlands, Florida (USA) and Taiwan show that effective colonisation of new areas can arise from a very small founder population (Herring and Gawlik 2008; Smits *et al.*, 2010; Charlier, 2016). Moreover, studies on the population dynamics of SI in France and Italy show that numbers can remain low for a long time period, before a sudden and marked population increase occurs (Yésou *et al.*, 2017; Cocchi *et al.*, 2018). In this scenario, a rapid and efficient eradication response is the only way to enable control of such populations.

To successfully and quickly eradicate new introductions of SI, shooting using shot guns or other firearms is probably the most efficient technique to prevent individuals from breeding or dispersing further (Yésou *et al.*, 2017). For this, dedicated professional hunters, sometimes assisted by wildlife guards or trained voluntary hunters, have to be organised in rapid eradication intervention teams (RET) committed to the culling of SI. Plastic decoys have been shown to attract SI, being potentially useful to increase culling efficiency by shot gun in foraging areas (Yésou *et al.*, 2017).

SCALE OF APPLICATION

The scale of application of this measure is typically local, corresponding to the small area recently invaded and usually used by SI for foraging, resting and roosting. Shooting birds at easily accessible places, such as foraging sites, or during flights directed from the roosting place to feeding areas, and vice-versa, provides the best opportunity for eradication.

EFFECTIVENESS OF MEASURE

Effective.

The use of an air rifle to cull birds can be an effective and reliable option with almost no drawbacks. The effectiveness of the measure is especially high if culling is initiated on time and efforts last until local eradication is complete. If this does not occur, the eradication program can fail.

Examples of successful eradication programs have been carried out in southern Florida (USA), where a SI population of about 75 individuals isolated from any other population was eradicated (Johnson and McGarrity, 2009), and in Doñana and Barcelona (Spain), where local SI populations were composed of only 10–20 individuals (Clergeau *et al.*, 2005). Although occasional SI sightings continue to occur in northern Catalonia wetlands, local ornithologists consider these birds to probably come from the French population (Yésou and Clergeau, 2005; Clergeau and Yésou, 2006). Field trials carried out by the Italian Institute for Environmental Protection and Research (ISPRA) in 2018, using a compressed air gun (calibre 0.22, 5.5 mm, 47 Joule), were successful in culling SI inside a mixed heronry (colony mixed with individuals of close species, such as herons or spoonbills) and at a foraging site (rice field), killing almost all the target birds in a distance between 15–35 m (Cocchi *et al.*, 2018).

EFFORT REQUIRED

The measure needs to be carried out until all known SI individuals are removed. Ideally, this would be from one day to some weeks, depending on the number of SI to be culled. It is important that shooting, and any other management actions carried out at the same time, are consistently implemented until the whole local population is eradicated. However, where the invaded local area is subject to immigration from other areas (for example, SI moving between the borders of two countries or other administrative units), prompt eradication might have to be performed indefinitely.

RESOURCES REQUIRED

Costs of employing hunting teams, organisation of the actions and required equipment can vary, depending on the promptness of the action and the number and distribution of SI to be culled. Also, remuneration for staff involved in eradication is likely different among MS. At a very early stage of SI presence, one or few teams of hunters may successfully remove all birds. Conversely, for example in some regions in central and southern Italy, where SI have been recorded but are not yet established, there is likely the need of at least one or two dozens of organised teams. In Mediterranean France, the costs of culling 173 SI individuals have been estimated at about 50,000 Euro (Mouronval, 2013). Based on field trials carried out in Italy (Cocchi *et al.*, 2018), culling using an airgun inside a colony can be estimated in the range of 100–300 Euro per bird. In cases where it is necessary to operate in nature protected areas, the presence of a local specialist ornithologist, expert in census of colonial water birds, is required.

In several EU countries, the use of airguns with power over 7.5 J (such as Italy⁹) or 20 J (such as France¹⁰) is forbidden, or limited, and it may be necessary to obtain a firearms or hunting licence, which incurs additional costs. A further possible limiting factor in the use of compressed airguns, is the restricted availability of this type of weapon in the provision of police officers (for instance in Italy) and, more in general, among staff potentially engaged in eradication activities.

SIDE EFFECTS

Environmental: Neutral or mixed

Social: Neutral or mixed

Economic: Neutral or mixed

Shooting can conflict with the protection of other species and areas, especially when shot guns are used. Trials carried out by ISPRA (Italy) using an air gun both inside a mixed heronry and at a rice field, showed that disturbance was minimal. At the heronry, disturbance due to shooting was not higher than that imposed during a visit for counting nests, and no significant effects on bird behaviour or attendance were registered. At the rice field, the remaining SI continued to forage normally after the shooting session. Nevertheless, air gun shooting SI inside mixed colonies should be seen only as a rapid eradication measure, thus limited to heronries where few (1–5) SI pairs are breeding or attempting to breed (Cocchi *et al.*, 2018). To limit disturbance to species breeding in mixed colonies, birds

have to be shot either on the ground at feeding sites or near colonies, when flying to and from foraging areas. Operations inside colonies should be carried out during the brooding stage to avoid that chicks depending on their parents for food and shelter suffer from starvation. Eventually, operations can be delayed until after young animals have fledged. All these factors need to be carefully considered when planning an eradication campaign, such as been done in the Dutch (Smits *et al.*, 2010) and Belgian SI Risk Assessments (Robert *et al.*, 2013). It could be useful to prepare a document containing guidelines of best practice culling and rapid eradication measures for SI.

Shooting with firearms or airguns also entails security (and disturbance) issues for the general public, which can possibly be overcome by adopting the best code of conduct and choosing the best device according to operative conditions.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

SI is a large, easily recognisable, attractive species that benefits from a positive appreciation from the general public, tourists, birdwatchers and nature photographers. As such, there can be conflicts arising both because of these stakeholders, as well as welfare and animal rights groups, opposing to a shooting campaign for ethical reasons.

In Western France, the proposed eradication of SI populations was postponed following the suggestion that the species could have a positive impact on a closely related species, the Eurasian spoonbill (*Platalea leucorodia*). This hypothesis has not been proven (Clergeau *et al.*, 2010), but the long-time presence of SI populations in this area (over 20 years) has promoted a positive feeling about the species and delayed its eradication by several years (Yésou *et al.*, 2017). In Italy, most of the general public is also of the opinion that SI is a nice and commonly appreciated bird (Cocchi *et al.*, 2018).

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Established but incomplete.

Rapid eradication systems for SI using shooting still do not exist in many countries, so there are not many examples of the use of this measure available in the literature.

9 National law 157/92 art. 13.

10 Décret n° 2013-700 du 30 juillet 2013

* See Appendix

Measures for the species' management.



Shooting.

MEASURE DESCRIPTION

Once populations of SI have become widely spread over a country or large territory, long-term management measures have to be considered to control populations and reduce the risk of further spread. These aim at stabilising populations of SI at the current size, and progressively reducing the number of individuals and the area of occurrence below a level that is considered acceptable for biodiversity conservation goals. As such, using shooting as a management measure aims at decreasing numbers of SI adult individuals and lowering recruitment of immature individuals. The objectives, principles and methodologies of shooting for management are generally similar to those reported above for rapid eradication of new introductions, except that they will be applied over a longer time period and with some small differences reported below. This measure is underpinned by the monitoring of wild populations, discussed above in the surveillance sections.

Shooting at flying SI has been integrated in most management and eradication programs both in Europe (France, Spain, the Netherlands) and elsewhere (Florida, USA). Depending on SI habits and distribution, shooting has been performed at rubbish dumps, feeding spots and other places where birds congregate outside their colonies. Shooting for management of populations has also been carried out towards SI flying from and to breeding colonies, but not inside colonies or near night roosts, where often SI are associated with other colonial water birds (herons, egrets, spoonbills, cormorants) (Yésou *et al.*, 2017). Where possible, interventions should be carried out near, or inside, breeding colonies during the egg laying period, in order to focus on culling adult individuals. Shooting adult SI is more efficient in relation to the objective of the measure because those are the birds ready to reproduce and less subject to natural mortality.

As mentioned before, the use of decoys shaped like SI can be used to attract birds during shooting operations in foraging fields (Yésou *et al.*, 2017).

SCALE OF APPLICATION

The scale of application of this measure should correspond to the whole area of distribution of the managed SI population. This measure is, thus, suitable to be applied, for instance, in areas such as northern Italy, where SI have been established in the wild since the late 1980s, and where a population of

around 10,000 individuals is currently estimated. However, it should be stressed that shooting activities covering only small portions of the species distribution area can also have positive local effects, if aimed at reducing specific threats to local biodiversity (for example, to preserve a rare water bird colony). Nevertheless, in terms of managing well established populations, uncoordinated and irregular local shooting will probably result in a waste of resources, with the risk of promoting further SI dispersion due to increased disturbance.

Shooting alone, but especially if coupled with other management measures (see other measures below), should, at least, include the area of a whole SI metapopulation.

EFFECTIVENESS OF MEASURE

Neutral.

This measure is certainly effective in reducing numbers of SI, especially if coupled with other techniques aimed at reducing SI reproductive output (for example, sterilising eggs, see below). However, to obtain the best results, shooting should be coordinated in the whole area under management and carried out as long as needed. When budget is constrained, it is likely preferable to perform shooting from the end of winter, to cause an additive mortality to the natural mortality due to the cold period. Depending on the local climate, shooting can be performed from the second half of January up to the end of April. Where disturbance of other species is not a critical precondition, the use of calibre 12 shotguns is most effective.

EFFORT REQUIRED

The effort required is very variable, and difficult to estimate, depending on the level of action coordination, territory complexity and area, and size of SI population. Efforts might have to be implemented for many years before significant results are obtained: this is likely the case for complex management situations, such as that of the SI population inhabiting the large Po Plain territory in northern Italy. The ability of SI to move over long distances does not help to achieve management goals quickly, and can increase the effort required.

RESOURCES REQUIRED

Hunting professionals and, whenever possible, appointed hunters, are the main individuals to be considered for undertaking shooting activities. They can be assisted

by other trained people (amateur hunters) acting under the responsibility of authorities in charge of the SI management program. Whatever the size of the territory under management is, shooting activities need to be well coordinated, which implies the employment of dedicated staff.

As already mentioned in the Rapid eradication for new introductions sections, the amount of personnel required to manage shooting actions depends on the number of sites to be targeted, the area of those sites and the general effort required (for example, number of SI, operational difficulties). For this reason, it is difficult to come up with a reliable prediction of the necessary resources, which can also be extremely variable from country to country. As an example, in Mediterranean France, the cost of culling 173 of 395 SI individuals has been estimated at ca. 50,000 Euro (Mouronval, 2013), which would extrapolate to ca. 114,000 Euro for the entire population (assuming cost and effort is equal for removing individuals at low population levels). An appropriate cost estimate of a management program should include: administration and overheads; salary for guards, professional hunters and coordination staff; training for all operators; purchase of shotguns and ammunition; reimbursement of travel and living expenses for amateur hunters (if applicable); management of SI carcasses. As indicated under the Rapid eradication sections, in cases where it is necessary to operate in nature protected areas, the presence of a local specialist ornithologist, expert in census of colonial water birds, is required.

SIDE EFFECTS

Environmental: Neutral or mixed

Social: Neutral or mixed

Economic: Neutral or mixed

Although SI is an unmistakable species, personnel involved in shooting must be carefully trained and supervised to guarantee that non-target species are not killed, or largely disturbed, by control measures. Shooting operations should be planned with due caution and carefully undertaken near or inside mixed colonies and/or protected areas, because a certain degree of disturbance to other species is inevitable. If shooting operations are undertaken close to inhabited areas, or areas used by the general public, there can be

some security risks that will need mitigation, or impacts through disturbance.

Some positive side effects on public health may be expected where birds forage at dumps, or roost close to buildings or public parks, due to the reduction of faeces found on the ground and on trees. Removal of SI may also have positive effects on ornamental trees that are used for nesting and roosting, which face a progressive decay due to the detrimental effects of bird faeces and additional weight due to nest platforms.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Resistance against management of SI populations through shooting actions can arise. In particular, opposition by animal rights/welfare groups, especially in regions where they are well represented, can be expected. As SI is a species commonly appreciated by the general public, culling, in particular of young animals, leads to public resistance due to ethical principles. These factors can compromise management campaigns or, at least, make them less feasible or harder to implement. For example, in France, a shooting program was initially proposed to be undertaken by hunters, but this was considered unacceptable by the *Ligue pour la Protection des Oiseaux* (BirdLife partner in France) and other conservation organisations. The program had to be temporarily postponed until the *Conseil National de la Protection de la Nature* (CNPN) recommended that it be carried out by the *Office Nationale de la Chasse* (ONCFS), the body responsible for the implementation of environmental regulations, including monitoring and policing of hunting (Yésou *et al.*, 2017).

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Established but incomplete.

Shooting programs for managing SI populations have been undertaken in some EU countries, but not many details in the cited literature are available on this.

* See Appendix



Removal of birds escaped from captivity and showing a synanthropic behaviour by trapping/luring with food bait or by shooting.

MEASURE DESCRIPTION

SI used to be allowed to fly freely within zoos and in private collections (and probably still do, even if not permitted), often escaping, settling nearby and establishing feral colonies. Since the late 1970s and until recent years, several cases have been documented worldwide, for example in Brittany and Camargue in France (Clergeau *et al.*, 2005; Kayser *et al.*, 2005), Catalonia and the Canary Islands in Spain (Yésou *et al.*, 2017), The Netherlands (Smits *et al.*, 2010), Italy (Andreotti *et al.*, 2001), Germany (Hennenberg, 2014), Florida, USA (Johnson and McGarrity, 2009) and Taiwan (del Hoyo *et al.*, 1992; Charlier, 2016). Birds from zoos may also disperse up to hundreds of kilometres away from the original site, colonising distant regions, as has happened in western France and the entire Po Plain and Delta region in northern Italy (Andreotti *et al.*, 2001). In the latter case, SI let free outside a zoological park in Valbrembo, near Bergamo (northern Italy), established a breeding colony that expanded to 120 breeding pairs, and is nowadays one of the largest recorded in the country (Castiglioni *et al.*, 2015; Castiglioni, 2017). There, nests are built on tall ornamental trees and protected from predators and human disturbance. The breeding season is longer than in colonies located in natural areas, with brood laid during spring and also in early autumn (Castiglioni *et al.*, 2015). Hence, productivity is higher than that recorded in the native Africa (Urban, 1974) and in wetlands along the Atlantic coast of France (Yésou *et al.*, 2006). At the end of the breeding season and in winter, adults and young disperse over the region, with some birds moving up to 400 km from the natal area, where they can settle and promote further expansion of the population range (Cocchi *et al.*, 2018).

The removal of SI individuals escaped from captivity that have established feral colonies is thus mandatory in the perspective of reducing or stopping further spread. This measure can also be used for rapid eradication, when a single individual or a group of free flying SI are reported as having recently escaped from a zoos or private collection. The measure can be accomplished by trapping or luring SI with food bait (containing, or not, anaesthetic), decoy or other attractant, or by shooting birds. Birds that have been in captivity are usually more prone to enter a trap, especially if artificial food is provided as an attractant. Depending on the number of birds to be captured and on local environmental conditions, several trap models can be considered for use, such as walk in traps, noose traps, whoosh nets and mist-nets (Bub, 1991). Free flying SI have been captured in Piedmont, NE Italy, using traps designed to capture ducks for ringing (Cocchi *et al.*, 2018). Trapping can be effective for capturing breeding adults, as well as

immature individuals that live in, or visit, the breeding colony. SI that are used to being artificially fed can also be caught by using food bait mixed with Alpha-chloralose (AC). AC is a substance that acts as an anaesthetic at the appropriate concentrations and has been extensively tested to immobilise and live-capture nuisance birds (O'Hare *et al.*, 2007). Experimental tests conducted in the USA have shown that a dose of 30 mg of AC per kg of body weight is effective and safe on various species of aquatic birds (Woronecki *et al.*, 1992). With this dose, the first effects of the drug are expected about 30–35 minutes after application. Wild SI weigh, on average, about 1.4 kg (range 1.025–1.775, n= 35) (ISPRA database), thus the advisable dose of AC to sedate fully developed individuals is around 43.5 mg. The administration of AC can be done by mixing it with a vegetable oil with which to impregnate food bait or by being introduced into medicinal capsules to be mixed with food (Belant and Seamans, 1997).

Birds that have been in captivity are also usually much easier to be approached at a short distance, in which case shooting using small calibre airguns can be very effective.

SCALE OF APPLICATION

This measure can be applied everywhere SI are used to the presence of man, mainly inside and near zoological parks or private bird collections where a feral population of SI already exists (management), or where single individuals, or a group of free flying SI, are recorded (rapid eradications). If operations are carried out soon after the birds, or population, have been recorded (especially for rapid eradications), the scale of application is strictly local and the measure easier and more effective to apply.

EFFECTIVENESS OF MEASURE

Effective.

Application of the measure is more feasible and effective if carried out as soon as escaped SI individuals, or populations, are recorded. In the early 1970s, SI escaped from the Barcelona Zoo settled in a nearby public park where, in a few years, they started to breed. Reproduction continued throughout the 1980s and 1990s, after which the colony was controlled, and breeding was last recorded in 2001. At Branféré Zoo, western France, a program of recapture and pinioning of SI started in 1994 and, by the end of 1996, all the free flying ibises around the zoo had been caught. However, by then, many had already dispersed elsewhere (Yésou *et al.*, 2017). Free flying SI that escaped from a zoo in Zuid-Holland (the Netherlands) successfully bred in 2002 and, in 2007, the population counted 15 breeding pairs. Eradication measures began in 2008 and resulted in only

4–5 pairs remaining in 2009. A few birds were later observed in the area, possibly the result of incomplete culling, new escapes or birds arriving from Germany (Smits *et al.*, 2010; Robert *et al.*, 2013; Yésou *et al.*, 2017). In the Mediterranean coast of France, 90 free flying SI that continued to feed at the wildlife park from which they originated, were successfully captured alive using bait treated with AC, and later placed in an aviary (Yésou *et al.*, 2017).

Shooting is also very effective and inflicts reduced disturbance to the colony.

EFFORT REQUIRED

The measure needs to be continued until any escaped SI individual (or population) freely ranging close to zoos or private collections/aviaries is captured. It is essential that trapping or culling are carried out as soon as possible after the escape of the birds, when they are still used to captivity and do not fear humans.

RESOURCES REQUIRED

Resources required depend on the number of birds escaped, time elapsed since the escape and local operative conditions. Depending on the conditions observed, trapping techniques may require specific skills that are common among hunters and bird ringers. Capture using bait with AC may not be easy to undertake for an inexperienced staff, or may require the help of a veterinarian.

Using an air compressed rifle would be an easier choice, in case it is considered acceptable to kill the birds, all security issues have been guaranteed and authorised personnel licensed for the use of an airgun is available.



A flying sacred ibis. © Donald Hobern. CC BY 2.0

SIDE EFFECTS

Environmental: Neutral or mixed

Social: Neutral or mixed

Economic: Neutral or mixed

Retrapping or luring with food bait SI escaped from captivity have no marked negative side effects, apart from non-target species being potentially affected by these activities. Positive and negative side effects of shooting are the same as those mentioned above in the *Shooting* sections.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

Trapping of live SI individuals has the least impact on the environment and should have the highest acceptability among stakeholders, including animal welfare groups. The capture of SI using food with AC should also be well accepted, provided that it is warranted that the drug is carefully dosed and no other non-target species are affected. The few case studies found in the literature (Yésou *et al.*, 2017) did not provide full details about the operations undertaken, but none reported any negative claims from the public opinion.

Conversely, shooting with firearms or airguns involves both safety and ethical issues, as mentioned above in the *Shooting* sections.

ADDITIONAL COST INFORMATION

The cost of inaction will undoubtedly lead to higher future intervention costs and increased problems of acceptability by the general public. The colony established in the early 1990s next to the zoological park of Valbrembo (Bergamo, Italy) is a good example. In five years, this colony grew from 33 (2013) to 123 (2017) nests and produced about 600 fledglings (Castiglioni, 2017). From ringing data, it is known that SI born in this colony dispersed throughout the Po River plain, an area rich in natural and artificial foraging sites (rice fields) hosting the largest number of heronries and populations of herons and egrets in Italy (Fasola *et al.*, 2007). Nowadays, the management or eradication of SI living in Valbrembo would require enormous efforts and costs in order to capture or kill hundreds of birds, manage the tall trees where they nest and secure disposal of the carcasses of adult birds (or eggs and nestlings).

In some cases, SI and other alien species inhabit the same area, so efforts and costs needed to capture both free flying IAS birds may be used very efficiently.

LEVEL OF CONFIDENCE*

Established but incomplete.

Experience gained in southern France increases the level of confidence on the measure described above.

* See Appendix



Destroying nests/eggs, or sterilising eggs, combined with shooting.

MEASURE DESCRIPTION

SI are social birds that move in groups, spend the night in common roosts and breed in colonies formed from a few individuals up to some hundred pairs. In most cases, SI congregate for roosting and nesting with other colonial birds, such as herons and spoonbills, which share roughly the same needs in terms of food and habitat parameters. SI breed almost exclusively in association with protected water birds (Ciconiiformes), in mixed colonies located in secure areas inside nature reserves or in Natura 2000 sites.

To increase the probability of success of any SI management or eradication program, it is necessary to consider halting or significantly reducing the reproductive output of SI breeding in the wild. The measures that can be undertaken to stop or disrupt reproductive activity of SI populations are destroying nests/eggs or sterilising eggs, in combination with shooting breeding adults and immature birds, either at the nest, or during flight in/out of the colony.

Nest destruction, or destruction of its eggs, has been a widespread measure used to reduce colonies and the reproductive output of pest species such as gulls (Lewis and Malecki, 1984) and cormorants (Shonk *et al.*, 2004; Bregnballe *et al.*, 2005). This can be done by mechanically removing each single nest (or communal nest-platform, as is typical for SI), or by cutting down the trees where the nests are built. When nests are easily approachable, it is preferred to sterilise eggs by piercing them, or by spraying them with paraffin or vegetable oil (Christens and Blokpoel, 1991). In this way, adults usually do not abandon the nest immediately and continue to brood the eggs, instead of leaving the area or producing a replacement brood. The reproductive output will be almost null and SI will remain in the colony area, providing more opportunities to eliminate them. Shooting adults at the nest, or in the nesting area, can be performed using an airgun, as discussed above for the previous measures. Used in an appropriate way, and under the supervision of people that work inside a heronry (such as park rangers, ornithologists, bird ringers), disturbance caused by this measure can be rather insignificant, and much lower than that caused by a shotgun fired at the edge of the colony (Cocchi *et al.*, 2018).

The combined implementation of these techniques (reducing reproductive output and shooting of flight-capable birds) is a way to limit the number of birds reproducing in the following season (due to shooting flight-capable birds that are primarily adults) and the number of juveniles replacing the eliminated adults (due to the drop in number of fledglings caused by the egg sterilisation).

SCALE OF APPLICATION

This measure is essential in the process of management or progressive eradication of SI from single MS and in the EU as a whole. The measure requires operations to be undertaken at local scale (for example, single colonies), but actions need to be extended to include all colonies comprising a SI metapopulation.

In France, this is the case of the colonies located along the northern Atlantic coast or in the Camargue, and in Italy the case of the central Po Plain, Po Delta and the Lagoon of Venice, where several hundreds of active heronries are occupied by SI.

EFFECTIVENESS OF MEASURE

Effective.

Experience gained in western France shows that destroying nests, or removing or sterilising eggs, without culling the adult birds is a costly, and mostly inefficient, management measure (Yésou *et al.*, 2017). Breeders can move to another place, or produce new clutches, making the measure almost useless. Egg removal or sterilisation combined with shooting is, however, quite an effective method. Nevertheless, its effectiveness depends on various issues, such as:

- if the colony is monospecific or mixed;
- the number of SI nests;
- the conservation status of other co-breeding species;
- the number of nests of the other co-breeding species;
- if the breeding area is protected or not;
- the type of habitat of the colony (wood, shrubs, reedbeds);
- the accessibility of the nesting area (ground inundated or dry, water level, height of the nests, ...);
- the area covered by the colony (for example, nest density).

All the above elements have to be considered while evaluating the pros/cons and cost-benefit ratio for operations to be carried out inside breeding colonies. To be really effective, the measure must neutralise the annual output of the SI breeding in the colony. Operations carried out only in part of the colony, or only for selected nests, will result in low or null effects on the demography of the local population, and will likely only produce minimal effects on the total SI population, because loss of some nests will likely be offset by compensatory mechanisms.

Treating eggs with an oil solution only requires a common sprayer, but is feasible only when nests are built on the ground and the colony can be easily walked by operators. When nests are on inundated areas, or built on bushes or trees, egg spraying becomes too complicated or impossible, and removing eggs or destroying nests are the only

alternatives. These difficulties have already been reported for an eradication program taking place in western France (Yésou *et al.*, 2017). In fact, much of the experience on this measure has been gained in western France, where a national eradication program started in 2008 (Yésou *et al.*, 2017). Earlier trials were carried out in 2006, when the Ligue pour la Protection des Oiseaux (LPO) organised the collection of eggs from what was then the main French colony, at Banc du Bilho, an island in the Loire estuary. A total of 1,223 eggs were collected from 663 nests, but replacement clutches were laid and, since these were not removed, the overall productivity of the colony remained high (Yésou *et al.*, 2017). Consequently, egg removal was considered inefficient as a single measure to reduce the population significantly. In 2009, the National Association for the Protection of Nature, responsible for managing the Grand-Lieu National Nature Reserve (around 70 km away from the Loire estuary), organised a new eradication program involving egg sterilisation and shooting (Yésou *et al.*, 2017). Egg sterilisation was initially done by piercing the eggs, or by picking the eggs one by one; however, as this was considered too time consuming, eggs were finally simply taken out the nest (P. Yésou, *in litteris* 2018). The work inside the colony was carried out by authorised personnel of the nature reserve, who were extremely knowledgeable concerning the local conditions, which made it possible to limit disturbance and impact upon sensitive species nesting nearby. Egg removal was done twice per nesting season, at the same time as nest counting, which systematically involved tree climbing and, according to the reserve staff, did not lead to more disturbance than the counting of nests. Although shooting of flying birds was not allowed at the Grand-Lieu Reserve, shooting was intensively done at other smaller colonies around the area. Overall, eggs from 3,334 nests were sterilised or removed at the Lac de Grand-Lieu colony in 2009–2016. The combination of egg removal at the Gran-Lieu, plus shooting of smaller colonies in nearby foraging areas, led to a marked decline of both the number of breeding pairs and of individuals counted in winter. The population declined from about 4,800 individuals in January 2007 to only about 300–350 birds at winter roost sites in January 2017. Nevertheless, the Grand-Lieu Reserve is the only breeding site still regularly occupied by SI in western France, after operations at alternative breeding sites have led to their abandonment (Yésou *et al.*, 2017). Non-breeding birds continue to disperse over much of the area occupied before the eradication program began, but in much smaller groups. This, and the fact that the ibises have become less approachable over time, makes completion of the program more difficult.

EFFORT REQUIRED

The measure needs to be applied as long as there still are SI breeding individuals present. Egg removal and adult culling carried out only in one colony may require great efforts and have a positive outcome in the long run (more than ten years), resulting in a significant reduction of the

SI population, although not leading to its eradication, as has happened for the Gran-Lieu colony (Yésou *et al.*, 2017). Conversely, where the numbers of SI nests are still small, eradication of each pair from the area is feasible, as shown by an eradication program carried out in South Florida, USA (Johnson and McGarrit, 2009).

RESOURCES REQUIRED

Costs for egg removal alone are not available and they can largely vary depending on the issues that affect its effectiveness, as listed above, and on the type of personnel employed. Operating in a monospecific colony with easy access and nests built on the ground (such as at Banc du Bilho, in the Loire estuary, or on sandy islets in the Po Delta) can be relatively cheap. However, working in inundated reedbeds, or wood, with SI nests built high on trees, and difficult to be distinguished from those of other Ciconiiformes, would require more work and attention, and thus more resources in terms of staff knowledge and capacity, which would be too costly and inadvisable.

When SI nests are in mixed colonies, personnel in charge of egg removal needs to be trained, or accompanied by an ornithologist, to be able to distinguish SI nests among those of other species. Especially in large colonies, not all egg clutches are synchronous, and laying may span over several weeks (Castiglioni *et al.*, 2015; Yésou *et al.*, 2017). Also, SI may rebuild destroyed nests and attempt a replacement brood, which means that operations aimed at sterilising or removing eggs have to be carried out at least twice in the breeding season, incurring an increase in costs.

In western France, the cost of the cull and egg sterilisation program, together with associated administrative expenses, was estimated at ca. 400,000 Euro over a five-year period (2008–2012). About 8,200 birds were killed and eggs from 2,300 clutches were sterilised or removed (Yésou *et al.*, 2017). Although the number of ibises was significantly reduced, the annual cost of performing such activities is now estimated to rise, as more effort is required to remove the remaining birds in an increasingly small, widely dispersed, and now wary population.

Another example is the culling program carried out on great cormorants (*Phalacrocorax carbo sinensis*) in Denmark, which included egg sterilisation by spraying them with paraffin oil. Costs of oiling carried out in 10 colonies in 2002 were estimated at 4,488 Euro (Bregnballe and Olesen, 2004).

SIDE EFFECTS

Environmental: Negative

Social: Neutral or mixed

Economic: Neutral or mixed

In mixed colonies, operations targeted at SI may cause disturbance to protected bird species, with a negative pros-cons balance. This has been the major criticism to the egg sterilisation program carried out at the Gran Lieu-Nature

Reserve, in France, and is seen as the main critical aspect of eradication programs in several European countries.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

In SI monospecific colonies, criticism may arise for ethical reasons, especially if operations are carried out when nestlings are hatched. Killing adults when rearing nestlings can also be considered immoral, as nestlings will likely be predated or die of starvation. Cutting nesting trees may also find opposition from property owners, or may have effects on the local landscape. Nevertheless, all these interventions can perhaps be accepted by different stakeholders if the reasons for the eradication program are explained. Interventions carried out within mixed colonies are, however, much less accepted. Here, main criticisms are due to the disturbance and possible negative effects caused

on protected nesting bird species. Ironically, the protection of these latter bird species is the main reason for which SI has been considered an IAS of Union concern, for which eradication measures have to be implemented in the EU.

ADDITIONAL COST INFORMATION

Allowing new SI individuals to hatch will result in populations being more numerous and difficult to control at the end of the breeding season. Killing hundreds of birds every year is expensive, and useless, if the culled birds are replaced by newly fledged individuals.

LEVEL OF CONFIDENCE*

Well established.

High, according to the results of the large management campaign carried out in western France (Yésou *et al.*, 2017).

* See Appendix

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Appendix

Level of confidence provides an overall assessment of the confidence that can be applied to the information provided for the measure.

- **Well established:** comprehensive meta-analysis¹ or other synthesis or multiple independent studies that agree.
- **Established but incomplete:** general agreement although only a limited number of studies exist but no comprehensive synthesis and/or the studies that exist imprecisely address the question.
- **Unresolved:** multiple independent studies exist but conclusions do not agree.
- **Inconclusive:** limited evidence, recognising major knowledge gaps.

¹ A statistical method for combining results from different studies which aims to identify patterns among study results, sources of disagreement among those results, or other relationships that may come to light in the context of multiple studies.

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