Natural England Commissioned Report NECR009

Horizon scanning for new invasive non-native animal species in England

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NATURAL ENGLAND

Introduction

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Invasive non-native species (INNS) are recognised as one of the main causes of global biodiversity loss and current evidence demonstrates that this is a problem which is increasing. Consequently there are a large number of agreements, conventions, legislation and strategies pertaining to INNS.

In May 2008 the GB Strategy for invasive non-native species was launched. One of the key areas of work identified was the prevention and rapid action for newly arriving, or newly invasive non-native species.

Recognising which species will become invasive is notoriously difficult. The best predictor is the invasiveness elsewhere. To assist in the prioritisation and targeting of prevention work, Natural England sought a horizon scanning exercise to pick out non-native species that are most likely to become invasive in England in the future.

The aim of the report was to produce a list of potential new invasive non-native animal species in England using existing information on INNS. These might be species which are already here but aren't established or species which are yet to arrive. It is envisaged that such a report will stimulate debate and help inform the targeting of resources.

For the purposes of this report non-native species refers to a species introduced by human action outside its natural past or present distribution. An invasive non-native species is a non-native species whose introduction and or spread threatens biodiversity.

It is important for Natural England:

- To be informed of potential new invasive non-native species.
- To understand the challenges that new invasive non-native species may bring.
- To consider appropriate responses to such species.

The purpose of this report is to help Natural England:

- As the lead delivery body for the England Biodiversity Strategy develop a view on potential new invasive non-native species in England and their impacts to biodiversity.
- Implement its invasive non-native species policy.
- Further contribute towards the implementation of the Invasive Non-native Species Framework Strategy for Great Britain.

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Further information
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HORIZON SCANNING FOR NEW INVASIVE NON-NATIVE ANIMAL SPECIES IN ENGLAND

Natural England
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May 2009

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Horizon scanning for new invasive non-native animal species in England

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1. EXECUTIVE SUMMARY

- This report identifies potential new invasive non-native animal species in England and assesses the relative risk posed by each species. The analysis was carried out to identify new and emerging threats, and so it does not consider non-native species that have already become invasive in England.

- Invasive non-native species constitute one of the leading threats to natural ecosystems and biodiversity, through consumption, resource competition, introduction of diseases, interbreeding and disturbance.

- The guiding principles adopted by the Convention on Biological Diversity (CBD) toward the management of invasive non-native species follows a hierarchical process: prevention, eradication, containment and control and mitigation; with an emphasis on preventive measures. Central to an approach of prevention and rapid, targeted action is the identification of those non-native species that are likely to become newly invasive in England; across all taxonomic groups this constitutes a significant number of species.

- A number of non-native risk assessment schemes are available but which are too detailed and labour-intensive for the rapid evaluation of large numbers of species. In this study, a relatively rapid screening process was used to produce a list of potential new invasive non-native species in England, and to assess their relative risks; covering terrestrial, freshwater and marine environments.

- Potential new non-native species fall into two categories: (i) species already present in England but which are currently either not widely established or not acting invasively in the wild, (ii) species that have not entered the country yet but are reasonably likely to do so. A list of vertebrate and invertebrate species meeting one or other of these criteria was collated from a number of sources that included non-native species databases, reference literature and expert opinion.

- The prioritisation process used to evaluate the environmental risk of these species was adapted from an existing protocol developed by the Belgian Forum on Invasive Species; which assigns species to a list system designed as a two-dimensional ordination - environmental impact x invasion stage. Environmental impact was categorised as high, medium or low; invasion stage was categorised as absent, enclosed, isolated population/s and locally established.

- It should be noted, however, that a more detailed risk assessment can, in the case of some species, lead to a different risk categorisation than the relatively rapid scheme used here.

- The system categorises species into three lists: Black List (high risk species either present in isolated populations or locally established in the wild), Alert List (high risk species either currently absent from the wild or present in England but contained in enclosed environments) and Watch List (medium risk species either present, enclosed or absent).

- A separate Watch or Climate List comprised those high and medium risk species currently physiologically constrained from establishing due to unfavourably

temperate conditions and requiring climate warming before establishment could potentially occur.

- A total of 161 species was evaluated with 35, 49 and 77 categorized as high, medium and low environmental impact risk, respectively. When also considering the invasion stage, this equated to 12 Black List, 19 Alert List, 46 Watch List and 7 Climate List species.

- Amongst terrestrial vertebrates 7 species were allocated to the Black List, 11 to the Alert List, 31 to the Watch List and 6 to the Climate List. The major pathway for terrestrial vertebrates to become established is through escape or deliberate release from captivity, including the 'pet abandonment' pathway.

- None of the mammals evaluated (25 species) were categorised as Black List. The eight Alert List species comprised captive species and species that had previously been established and eradicated. Two species, present in collections and the pet trade, the raccoon (Alert List) and chipmunk (Watch List), have established populations in a number of mainland European countries following escapes.

- Amongst the birds (25 species) there were two Black List (Egyptian goose and eagle owl) and three Alert List species (sacred ibis, Indian house crow and common mynah). The Egyptian goose has established local populations in parts of the country, whilst the eagle owl has established isolated breeding pairs in recent years. The sacred ibis and Indian house crow have increasing breeding populations on mainland Europe, from which dispersal to England is likely. The common mynah is present in the pet trade.

- Three amphibians (from 12 species) were categorised as Black List – marsh frog (locally established), African clawed frog (isolated populations) and North American bullfrog (isolated and managed population) are all highly predatory and competitive species. The greatest risk to native amphibians, however, is the fatal infectious fungal disease Chytritiomycosis that can be carried by a number of species of non-native amphibians.

- Species of reptiles (from 17 species) on the Black List are the red-eared terrapin and snapping turtles. These are present in the wild but are constrained from becoming invasive due to the temperate climate. Being very long-lived, however, they represent a potential future risk due to favourable microclimate conditions and/or global warming. Most reptiles are currently constrained from establishing by the temperate climate, e.g. the common pet python and boa species (Climate List). Watch List species, however, include the more temperate adapted highly popular pet corn and king snakes.

- Species of fish representing a high risk are the Ponto-Caspian gobies (Alert List), with Ictalurid catfishes and Eastern mosquitofish posing medium risks (Watch List). Of these, only the Ictalurid catfishes are present in the wild but are confined to a few isolated locations. Fish species likely to benefit from climate warming are red shiner (currently held in captivity with no confirmed reports in the wild) and the fathead minnow (isolated populations in the wild); although these were evaluated as posing low environmental risk.

- Of thirty-six terrestrial invertebrates, one was placed in the Black list, four in the Alert list and seven on the Watch list. Of these, seven are Coleoptera (beetles) of which four are wood-borers; having the potential to directly or indirectly kill trees. Eight of the thirteen species have been introduced to other continents where they have caused significant damage to the environment, agriculture or forestry. The main pathway of introduction for terrestrial invertebrates is accidental transport with plants or plant material (including timber). One Climate List species, the Argentine Ant, is currently restricted to indoor environments and does not persist in the wild.

- Of the aquatic invertebrates, freshwater species of concern include the spiny-cheeked crayfish, false dark muscle and Chinese mitten crab (Black List), the latter of which is well established in a few river basins and is likely to spread. The one Alert List species, the marbled crayfish, is currently absent from the wild but likely to appear in the UK through illegal keeping and release. On the Watch List are red swamp crayfish, narrow-clawed crayfish and Asian clam; all having isolated populations. Amongst the marine invertebrates, the high risk species are Colonial ascidian (Black List) and the red king crab (Alert List), the former already present in England and the later absent but likely to arrive. Aquatic invertebrate species likely to benefit from climate warming are the freshwater triclad *Dugesia tigrina* (currently held in captivity with no confirmed reports in the wild) and two crustaceans, the red swamp crayfish and the Chinese mitten crap (both present in the wild).

- The prioritisation lists generated in this study have facilitated a number of potential applications: (i) identification of species that should be subject to a more detailed risk assessment (Black, Alert and Watch Lists), (ii) identification of species that should be prioritised for consideration of management action (Black List), (iii) identification of high risk species currently confined to enclosed environments (Alert List), (iv) preparation of contingency plans for high risk species that are presently absent but have a high likelihood of entering in the future (Alert List).

2. BACKGROUND

Invasive non-native species (INNS) are accepted as one of the greatest threats to global biodiversity, along with overexploitation and habitat loss (Atkinson 1996; Diamond 1984; Vitousek *et al.* 1997). The impacts of INNS on native species can be grouped into five categories: consumption through predation or herbivory, resource competition, introduction of diseases, interbreeding, and disturbance of the environment (White & Harris 2002). These impacts in turn lead to a loss of biodiversity through direct loss of species or hybridisation. Along with their impacts on biodiversity, INNS also have major economic, agricultural and health impacts.

Non-native species can enter regions outside of their natural range along a number of different pathways. These invasive species pathways can involve either accidental or deliberate movement of species by human activity (Ruiz & Carlton 2003, Hill *et al*. 2005, Copp *et al.* 2007). As a consequence of continued globalisation, i.e. the increase in trade, tourism, transport and travel, indigenous ecosystems face an increasing threat of invasion and establishment of novel species from a broad range of taxonomic groups.

The guiding principles adopted by the Convention on Biological Diversity (CBD) toward the management of invasive non-native species follows a hierarchical process (e.g. Wittenberg & Cock 2001): prevention, eradication, containment and control and mitigation; with an emphasis on prevention measures. The Invasive Non-native Species Framework Strategy for Great Britain advocates '…preventative measures and more rapid, targeted action now to reduce or avert far larger future pressures and costs from invasive non-native species' prevention and rapid response for newly arriving, or newly invasive non-native species (Anon. 2007).

Central to an approach of prevention and rapid, targeted action is the identification of those non-native species that are likely to become newly invasive in England. This will include those species that are currently absent from England but are likely to enter at some future time, and those species that are already present but have not yet become invasive, due to existing constraints on their establishment that may include targeted measures. Identification and risk categorisation of these species will involve consideration of the fact that species-specific invasiveness is not a constant but will vary over time in response to changes in various factors (Copp *et al*. 2005b), such as climate (Britton *et al*. 2005), global trading patterns and fashions in the pet, aquaculture and horticultural trades (Copp *et al*. 2007). Climate change, especially, has the potential to drive changes in the global range of some non-native species that will enhance their probability of entry into England. A warming climate will also facilitate the establishment of reproductively viable populations of some non-native species that are already present sporadically in the wild in England but are currently constrained by the temperate conditions.

Across all taxonomic groups there is a substantial number of non-native species that could become invasive in England. A detailed risk assessment scheme for non-native species in the UK has been developed (Baker *et al*. 2008) and has recently been revised by a consortium consisting of scientists from Imperial College London, CSL, Cefas-BU, RPS Group PLC and the University of Sheffield. This explores the risk of entry, establishment, spread and impacts with approximately 40 questions that require a five-level response (very low, low, medium, high, very high) and a four-level

uncertainty rating. The outputs provide both a detailed profile of the nature of the risk and an overall summary of the risk that can be expressed in terms of likelihood and magnitude classes in a consistent way across all taxa. These risk assessments are now produced regularly for review by the GB Non-Native Risk Analysis Panel and are then provided to the GB Non-Native Species Programme Board to assist the prioritisation and targeting of resources for prevention, eradication, containment, control and monitoring.

Such an exhaustive risk assessment scheme, however, is too detailed and labour-intensive for the rapid evaluation of large numbers of species. Therefore, a screening process is desirable that will facilitate a relatively rapid assessment that ranks non-native species in terms of their relative risk of invasiveness (e.g. high, medium and low). The categorisation of species according to relative risk will support policy makers by facilitating the prioritisation of future actions, which will include helping to target the commissioning of full non-native risk analyses.

The current project uses such a screening approach to undertake a horizon scanning exercise in order to identify and prioritise a list of potentially new invasive non-native species in England. That is, non-native species that are presently not invasive in England but have the potential to become so in the future.

3. AIMS AND OBJECTIVES

The aim of the contract was to produce a list of potential new invasive non-native animal species in England, and to assess the relative risk posed by each species. The study covered terrestrial, aquatic and marine environments.

Specific objectives were:

(i) Review existing information on INNS,
(ii) Produce a list of potential INNS that could threaten biodiversity in England,
(iii) Categorise species into three levels of priority (e.g. high, medium and low risk),
(iv) Produce datasheets briefly summarising species information, including basic ecology, description, range, trend, pathway and impact,
(v) Collate the information into a report and excel spreadsheet.

4. METHODOLOGY

4.1 REVIEW OF EXISTING INNS INFORMATION – SPECIES LISTS

As the aim of the horizon scanning project was to identify and evaluate potentially 'new' invasive non-native species; known invasives that are currently well established in England (e.g. Japanese knotweed, grey squirrel, common carp and goldfish) were not considered. Those non-native species that did fall under the remit of the project fell into two categories:

(i) species already present in England but not yet widely established,
(ii) species that have not entered the country yet but are reasonably likely to do so.

The first group of species include those that are kept in 'enclosed' environments but may also be present in the wild, albeit in relatively low numbers and/or restricted in their distribution. This will include species present in the pet, zoo and aquaculture trades. It will also include species that have isolated or local populations but are not yet invasive in the sense that they are spreading and threatening biodiversity.

The second group of species will include those that have proven their invasiveness in other countries that are similar to England, either in their global position (i.e. North West European countries) or climatically (e.g. New Zealand). With respect to climate, future global warming has the potential to render England more amenable to some species that are not suited to the present day climate.

A variety of databases on INNS were examined for information on species that met the criteria of the two groups. Sources used were: ALARM (Assessing Large scale Risks for biodiversity with tested Methods), DAISIE (Delivering Alien Invasive Species Information for Europe), Audit of Non-native Species in England, GISP (Global Invasive Species Project), ISSG (Invasive Species Specialist Group), EPPO (European and Mediterranean Plant Protection Organisation) alert lists (EPPO 2008) and Invasive Species Ireland.

Some of the databases were not designed to be interrogated in the manner required, e.g. the English Audit of Non-native Species, and required significant manipulation. The English Audit data set represents non-native species that are already present in England but was used here to identify species within that list that had characteristics of high impact but are either not, or not well, established in the wild (i.e. equivalent to 0, 0.5 and 1 species as in Table 3 and Fig. 1). As the dataset was not designed specifically for this purpose, approximations were made on the basis of appropriate existing data fields. The impact was estimated as a combination of the values for "Current trend" of spread, "Future trend" of spread and estimated "Economic impact". A classification of "A" for impact would be achieved by species with the highest category in all three fields; the highest in one field and the second highest in two; or the highest in two fields and the third highest in the other field. The "0" category for presence was only found in the English Audit data for species known to have been introduced but not reported in the wild in any English region. No species met the A_0 criteria, but two met the A_1 criteria (highest level of impact, but present in only one English Region). Thirteen species met B_0 criteria (medium impact but not found in the wild after introduction). Of the B_0 category, four species may be considered to be $B_{0.5}$, depending on the interpretation of the data on presence in English regions, as they do not appear to be classified as present fully in the wild. Finally, expert opinion was used to decide on the inclusion of these species in the overall evaluation process.

The DAISIE database was interrogated for potentially invasive non-native species that are present in neighbouring NW European regions.

Additional sources of information were reference literature on individual taxonomic groups, and specialist websites relating to the ownership and trade of non-native species, and to recent records of non-native species in the wild. In the case of birds, for example, this included websites associated with the pet trade and with information on bird sightings.

Information gathering and/or consultation was also undertaken with organisations and experts working in the field of wildlife ecology, INNS and those dealing with the reporting and movements and sale of non-native species. Examples included the RSPB, BTO, RSPCA and pet trade industry for opinions on potential future risk species and information on changing patterns in the ownership of exotic pet species.

4.2 Assessment of species risk priority

The assessment scheme for prioritising non-native species was required to provide a list of species, categorised into three levels of priority, e.g. high, medium and low risk.

A number of INNS risk assessment schemes already exist and the intuitively most appropriate ones were examined for their suitability to the horizon scanning exercise. Most of these schemes, however, are too detailed (e.g. UK Non-Native Risk Assessment Scheme) and labour-intensive, or have been designed for specific taxonomic groups (e.g. EPPO scheme for invasive alien plants in Europe).

Prioritisation process

The prioritisation process selected was adapted from an existing protocol developed by the Belgian Forum on Invasive Species (http://ias.biodiversity.be). The scheme allocates species to different list categories based on a simplified environmental impact assessment referred to as the Invasive Species Environmental Impact Assessment (ISEIA). The ISEIA satisfied the major criteria desired in the present horizon scanning study, in that the protocol assesses environmental risk only (not economic) and is relatively straightforward and time-efficient, requiring responses to ten questions in four categories or parameters (Table 1). The approach uses documented evidence from invasion histories in other areas to assess the potential for imposing adverse environmental effects in England. Non-native species that have impacted detrimentally on native species and ecosystems elsewhere are also likely to impose such effects in England.

The four variables that are evaluated are: the potential for spread, colonisation of natural habitats, adverse impacts on native species and adverse impacts on ecosystems. Species are assessed against the four parameters on a three-point scale: 1, 2 or 3 corresponding to low, medium and high. Variables for which data are limited cannot be scored in this way and thus are assessed as ‘unlikely’ (=1) or likely (=2), using expert opinion. If a species was completely data deficient for a variable, it is scored as DD (=0).

The total risk score for a species is the sum of the risk rating scores from the four parameters. The total risk score range is 4–12, and is used to allocate species into three risk categories (Table 2). It should be noted that as the total risk score is derived from the cumulative scores of a suite of parameters a high impact score in one category of impact (e.g. predation/herbivory) would not automatically elevate that species into an overall high risk category. Individual scores for impacts on native species and ecosystems, however, are presented in Annex I to the report (which is available as an electronic spreadsheet).

In addition to the allocation of species to environmental risk (or impact) categories, species were also categorised according to one of four invasion stages (Table 3): (i) absent, (ii) absent from the wild but restrained in enclosed environments (e.g. zoological collections), (iii) scarcely established (isolated populations), and (iv) established and frequent locally (locally established).

The protocol, therefore, assigns species to a list system designed as a two-dimensional ordination (environmental impact x invasion stage) (Fig. 1). High risk species that are already present in England (A_2 and A_1 species) pose the greatest threat and comprise a Black List; high risk species that are absent or confined to enclosed environments ($A_{0.5}$ and A_0 species) represent an Alert List; and medium risk species (B_2, B_1, $B_{0.5}$, B_0) form a Watch List.

The prioritisation process also considered the potential effect of climate change in assessing potential new invasive species. A number of the species evaluated are currently physiologically constrained from establishing in England due to the temperate conditions and would require climate warming (in some cases significant warming) before establishment would become possible. Species posing a high or medium environmental risk but which are currently physiologically restrained by climate are listed under a separate Climate List.

Table 1. Scoring system

Score	Dispersal potential	Colonization of high-value habitats	Species Impact Score (predation/herbivory, competition, disease and genetic pollution)	Ecosystem Impact Score (nutrients, hydrology, destruction of nursery areas, modification of succession or food webs)
1	Not spreading in the environment, with either or both poor dispersal or low reproduction	Restricted to man-made habitats	Data from invasion histories suggest that the negative impact on native populations is negligible	Impact is considered negligible
2	Not spreading by more than 1 km per generation unless spread by humans; may become locally abundant because reproducing strongly in situ	Usually confined to habitats with low or medium conservation value, but may occasionally colonize high-value habitats	Non-native species is known to cause local changes (< 80%) in population abundance, growth or distribution of one or several native species	Impact is moderate and easily reversible
3	Fecund and readily spreading by more than 1 km per generation	Often colonizes high-value habitats; at least one type of high-value habitat is readily colonized when a source population is in the vicinity	Non-native species often causes local severe (>80%) population declines in native species (includes exotic plants forming dense mono-specific stands, even where potential for replacement is poorly documented)	Impact is strong and difficult to reverse

Scoring of adverse impacts on native species and ecosystems involves scoring in each of four sub-categories:
Adverse impact on native species: (i) predation/herbivory, (ii) interference and exploitation competition, (iii) transmission of diseases to native species, (iv) genetic effects such as hybridisation or introgression with native species.
Adverse impact on ecosystem function: (i) modifications of nutrient cycling or resource pools, (ii) physical modifications of the habitat, (iii) modification of natural successions, (iv) disruption of food webs.
Species Impact score = maximal score recorded for predation/herbivory, competition, disease and genetic effects.
Ecosystem Impact score = maximal score recorded for nutrient cycling, physical modifications, natural successions and food webs.

Table 2. Total risk score and list category.

Total risk score	List category	Environmental risk
11–12	A	High
9–10	B	Medium
4–8	C	Low

Table 3. Invasion stage.

Score	Category	Mnemonic
0	Not present in England	Absent
0.5	Absent from the wild but restrained in enclosed environments, e.g. zoological collections, or kept as domestic pets.	Enclosed
1	Present in England and either not established or with isolated populations that have not spread more than 10 km from their source	Isolated Populations
2	Local populations present in less than 10% of England, with some having arrived from further than 10 km from their source; or if more widespread then populations scattered and sparse	Locally Established

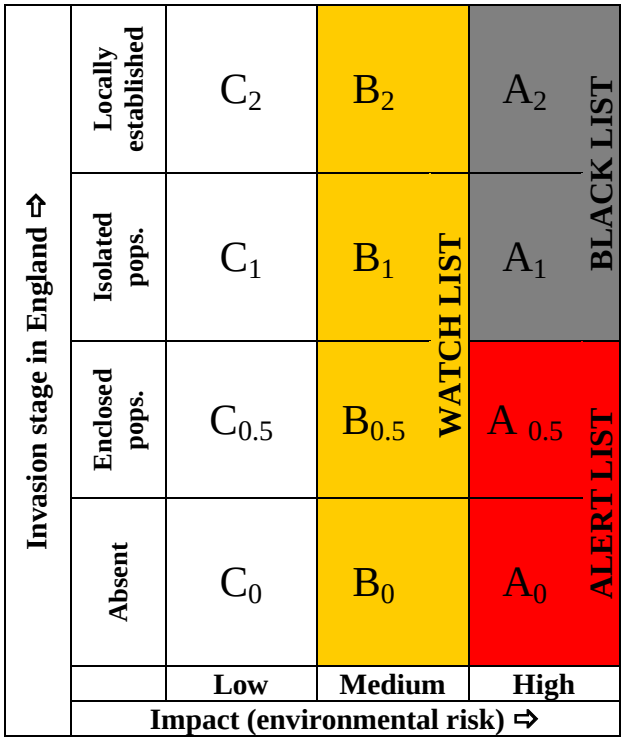

Figure 1. List system categorising potential 'new' non-native species by environmental risk and invasion stage in England. Figure reproduced from the Invasive Species Environmental Impact Assessment (ISEIA) (http://ias.biodiversity.be). High and Medium risk species that currently would require climate warming before establishment would be possible are allocated to a separate Climate List.

4.3 SPECIES INFORMATION SHEETS

Species information sheets were produced, using a common template (Table 4). These sheets presented summary information in five main areas: identity, geographical distribution, biology/ecology, risk status and risk category. Due to the overall number of species considered, the preparation of information sheets focussed on those species categorised as high risk (Black and Alert Lists) and medium risk (Watch List) with fewer examples of low risk species. Species summary sheets are presented in Appendix I.

Table 4. Layout of species information summary sheet with descriptions of the fields.

Common name *Latin name* ***LIST CATEGORY***

Alternative common names

IDENTITY

Taxonomy: Class, Order, Family

Quarantine Status: Legal restrictions limiting movement or trade.

Description: Brief description of the species physical attributes.

Signs & Symptoms: Brief description to enable identification of the presence of a parasitic species within its host/s (if applicable).

GEOGRAPHICAL DISTRIBUTION

Native Range: Geographic area where species is found naturally.

Introduced Range: Geographic area into which the species has been, accidently or deliberately, transported and released by humans.

England: Records of occurrence in England, e.g. frequency and/or locality.

BIOLOGY/ECOLOGY

General: Brief description of the general biology or ecology of the species.

Movement and dispersal: Means by which the species moves or is transported to new sites.

RISK STATUS

Environmental Impact: Detrimental impacts on native biodiversity or ecosystems.

Invasion Stage (England): Description of the extent of establishment in England.

Introduction pathways: Means/routes by which the species is transferred into areas outside its native range.

Control: Actual or potential methods used to remove or confine the species.

RISK CATEGORY

Code for the impact risk (A, B, C) and invasion stage (0, 0.5, 1, 2).

References

4.4 RISK ASSESSMENT SUMMARY SPREADSHEET

Information on the full list of species evaluated was collated into an Excel workbook. To maintain consistency with previous studies the design of the spreadsheet was modelled on that produced for the Audit of Non-Native Species in England (Hill *et al*. 2003). A worksheet was produced for each taxonomic group individually and one for all species from each taxonomic group collectively. The spreadsheets are presented in Appendix II and also as an electronic copy supplied as an annex to the report.

Data columns in the spreadsheet were included for:

Column	Information
Major group	Taxonomic group, e.g. mammal, bird, reptile, etc
Scientific name	Scientific name following standard check list
Common name	Common name following standard check list
Risk category	Score from risk assessment: A = high; B = medium; C = low
Invasion Stage (in England)	0 = absent; 0.5 = enclosed environment; 1 = localised population.
Current trend in records or population in England	0 = absent; Dec = decreasing; Stab = stable; Inc = increasing
Mode of dispersal	Nat = natural; Trans = transported
Species Impact - predation/herbivory	Score from risk assessment
Species Impact - competition	Score from risk assessment
Species Impact - disease	Score from risk assessment
Species Impact - introgression	Score from risk assessment
Ecosystem Impact - nutrient cycling	Score from risk assessment
Ecosystem Impact - physical alteration	Score from risk assessment
Ecosystem Impact - succession	Score from risk assessment
Ecosystem Impact - foodwebs	Score from risk assessment
Introduction Pathway	R = release; E = escape; T = transported; D = dispersed from other introduced population; H = hybrid (spontaneous)
Pathway details	Brief description: e.g. escape/release from collections; ship-assisted transfer.
Control Methods	D = direct (trapping, shooting, weeding, fishing etc.); C = chemical; B = biological; E = environmental; 0 = no control attempted
Comments	Brief relevant comment
References	Short key references

Figure 3. Layout of Excel spreadsheet summary of species information. The electronic versions contain the full complement of data columns; the hard copies in Appendix II are abridged versions.

5. RESULTS AND DISCUSSION

5.1 SPECIES RISK CATEGORISATION

A total of 161 species were evaluated. The distribution of different risk categories amongst the taxonomic groups are summarised in Table 4.

Table 4. Distribution of species between risk categories and lists.

Environment	Group	No. species	Risk Category			List			
			A	B	C	Black	Alert	Watch	Climate
Terrestrial	Mammals	25	8	9	8	0	8	8	1
	Birds	25	5	13	7	2	3	13	0
	Amphibians	12	4	6	2	3	0	4	3
	Reptiles	17	4	6	7	2	0	6	2
	Invertebrates	36	6	7	23	1	4	7	1
Freshwater	Fish	12	2	2	8	0	2	2	0
	Invertebrates	28	4	3	21	3	1	3	0
Marine	Invertebrates	6	2	3	1	1	1	3	0
Total		161	35	49	77	12	19	46	7

Climate High and Medium Risk species requiring climate warming before establishment possible

5.2 MAMMALS

In the UK, exotic mammal species that have established feral breeding populations, at one time or another, were introduced for the purposes of activities such as fur farming (American mink *Mustela vison*, coypu *Myocastor coypus* and muskrat *Ondatra zibethicus*) or for public or private zoological collections (e.g. red-necked wallaby *Macropus rufogriseus*, prairie dog *Cynomys* spp, short-clawed otter *Aonyx cinerea* and Himalayan porcupine *Hystrix brachyura*).

More recently, for mammals (and other vertebrates) one of the most common methods of introduction has been via the pet trade and the 'pet abandonment' pathway (Froglife 1997; Inskipp 2003; Reaser 2007). Owing to a continued increase in the number of households owning an increasingly wide array of exotic species, the potential establishment of self-sustaining feral populations through escapes or deliberate release through 'pet abandonment' is a risk that is increasing. In the UK, the RSPCA reports that the most recent trend in keeping 'unusual' animals appears to be species of mammal (RSPCA 2004). Invasive mammals pose a number of potential risks, most notably predation and disease.

In the present horizon scanning study all mammal species (except for edible dormouse and Chinese water deer) that were evaluated, are species that are confined to enclosed environments (i.e. zoological collections and pets); with only occasional incidences of escaped or released individuals occurring in the wild. The number of different species held in captivity is vast, therefore the species included in the evaluation was restricted to those that have historically shown the highest relative frequency of occurrence in the wild, through escapes; some species even having established past transient populations. Two species (edible dormouse *Glis glis* and Chinese water deer *Hydropotes inermis*) have existing locally established feral populations, which although presently not invasive could become so with expansion of their populations.

The present assessment identified a number of high risk mammal species – Arctic fox *Alopex lagopus*, American beaver *Castor canadensis*, leopard cat *Felis bengalensis*, capybara *Hydrochoerus hydrochoaeris*, raccoon dog *Nyctereutes procyonoides* and raccoon *Procyon lotor*. Two other high risk species, muskrat *Ondatra zibethicus* and copypu *Myocastor coypus*, are already known to pose a significant environmental risk from past population establishments and eradications. All of these species are absent from the wild but present in enclosed environments so are allocated to the Alert List rather than the Black List.

Of these Alert List species, the raccoon is available via the pet trade; whilst the raccoon dog is mentioned on the internet as a privately owned species. Baker (1990) considered the raccoon to be a species that might have been expected to establish a population in Britain. Raccoons are adapted to a temperate environment and survive well out of captivity and are one of the more frequent escapees amongst captive mammals. In other western European countries, raccoon populations successfully established in Germany and expanded into Holland and France, following escapes in Germany (Lever 1985). In England, escapes of raccoons have almost invariably involved single individuals; this stochastic factor is likely to have constrained the establishment of a raccoon population to date. A recent factor, however, that may increase the risk of introductions of the raccoon into the wild is the removal (2007) of this species from the Dangerous Wild Animals Act. Under The Act, private owners of all animals that are legally deemed to be dangerous are required to annually buy a licence from their local authority. The Act was intended to regulate the keeping of certain kinds of dangerous wild animals in order to protect the public. Although no longer considered to present a threat as dangerous wild animals, removal from The Act does not imply that these species do not pose a continued risk as invasive species. A number of animal welfare organisations (e.g. RSPCA) have voiced concerns over the recent amendment to the Act's species list. Removal of the requirement for prospective owners of these species to purchase a license is considered likely to increase the numbers of these species that are kept as pets. In such an event, the likelihood of escape and abandonment of individuals would also increase.

The other four Alert List species (Arctic fox, American beaver, leopard cat and capybara) are confined to zoological collections. Of these the Arctic fox (a predator of ground-nesting birds) is probably unlikely to establish long-term in the wild, following escapes from captivity due to competition from the larger, native red fox. The capybara has the potential to impose similar environmental damage as that imposed by the previously established and eradicated coypu. The leopard cat, as a top predator, has the potential to impose impacts in the form of predation and competition to native species; this is also the case for all species of captive exotic cats. The American beaver can modify habitats though foraging and dam building.

Five of the nine mammal species evaluated as medium risk (Watch List) are traded as pets – coatimundi *Nasua nasua*, Siberian chipmunk *Tamias sibiricus*, Eastern chipmunk *Tamias striatus*, African pygmy hedgehog *Atelerix albiventris* and striped skunk *Mephitis mephitis*. A preliminary assessment of the range and abundance of species available in the pet trade showed that coatimundi and skunk were relatively infrequent compared to the chipmunk and African pygmy hedgehog (Parrott *et al*. 2008). Based on propagule pressure the most likely of these species to establish a population in the wild in England is the chipmunk. Escapes from captivity have

resulted in the establishment of populations of this species in a number of countries, including many in western Europe. In the UK, a number of escapes have occurred including incidences involving multiple individuals; rescues by the RSPCA are also common (e.g. 670 chipmunks rescued during 2000-03 [RSPCA 2004)]). Multiple escapes have tended to occur from collections in wildlife parks/reserves, rather than from private pet owners. In addition, where privately owned, chipmunks may be kept in small mixed sex groups. RSPCA advice on pet care suggests that opposite sex pairs or groups consisting of a single male with up to three females can work well (www.rspca.org.uk). Over recent years, chipmunks have gained in popularity as pets, with some owners housing small colonies in outside enclosures (www.chipmunkery.co.uk/). Kept in such groups, the risk of chipmunks establishing in the wild, following an escape, is heightened. Of the five species traded as pets, the African pygmy hedgehog currently appears to be the most popular. However, as it requires a warmer climate than at present in the UK, establishment would not occur without climate warming. The coatimundi, along with raccoon was recently removed from the Dangerous Wild Animals Act. Therefore, along with the raccoon, there is a risk of increased ownership and associated escapes.

5.3 BIRDS

The potential new invasive bird species that were evaluated comprised three categories: (i) water birds, (ii) passerines (including one corvid), and (iii) psittacines. For all but two of these species (sacred ibis and Indian house crow) the pathway of introduction is via escape or release from public collections or private aviaries.

Five avian species were evaluated as high risk – Egyptian goose *Alopochen aegyptiacus*, eagle owl *Bubo bubo*, sacred ibis *Threskionis aethiopicus*, Indian house crow *Corvus splendens* and common mynah *Acridotheres tristis*. Of these, the former two species are breeding in England (Black List), whilst the latter three species are absent from the wild (Alert List).

The Egyptian goose has established local breeding populations with at least 2500-3000 individuals and 78-130 breeding pairs in the UK (Banks *et al*. 2008). To date, however, the species has not exhibited invasiveness. However, with an increasing population this situation may change. The species is characterised by imposing highly aggressive competition toward native waterfowl and other birds; there is anecdotal evidence of usurping the tree nesting cavities of barn owls.

All of the other waterbird species (except sacred ibis) are present in the wild in England to some extent, ranging from occasional individuals to localised populations (Blair 2000, Banks *et al*. 2008). Like the Egyptian goose, however, none of the species is exhibiting invasiveness. The majority of these species were evaluated as medium risk (Watch List) and were characterised as colonising high value habitat and presenting some competition toward native species.

The recent establishment of breeding by eagle owls in England has been a cause of controversy over whether their presence represents an introduced non-native species, or a natural re-establishment of a formerly native species (e.g. Warburton 2006a, 2006b, 2007). Irrespective of the provenance of eagle owls, a concern over their presence in Britain is their potential detrimental impact on the conservation status of a range of native species, through competition or predation. Although, eagle owls can

predate, for example, other raptor species, their diet appears to be dominated by mammals, which in European studies ranged from 62% to 94% (studies cited in Martinez *et al*. 1992). In the UK, however, as feral birds and breeding has only recently been established, little is known about what eagle owls eat in this environment.

The sacred ibis is currently absent from England but has well established breeding colonies on the French Atlantic coast, which resulted from introduced birds escaping from captivity. Birds are dispersing to northern Brittany and Normandy with increasing frequency; a few also move into eastern France. In some areas, the sacred ibis is a serious predator of other bird species (some of conservation concern) (Yesou & Clergeau 2006). In France, predation of eggs has been observed at a number of colonies of different species of terns.

The Indian house crow has established breeding colonies in *c*.20 tropical and sub-tropical countries outside its native range (southern Asia), and also in The Netherlands (Ottens & Ryall 2003). It is regarded as a widespread and notorious pest in Asia and Africa (Brook *et al*. 2003), where it is a predator of eggs, chicks and adults of other bird species (Long 1981, Cramp 1994) and causes displacement of indigenous bird species through competition and aggression (Long 1981, Cramp 1994, Brook *et al*. 2003). If this species were to become established in England there is no reason to consider that the impact on native avian species would be any less severe than in the rest of its introduced range.

The common mynah is listed by the IUCN as one of the world's 100 worst invasive species. It is both an environmental and economic pest. In several countries it is reported to predate the eggs, young birds and mammals and to adversely affect the breeding of cavity-nesting birds and mammals through aggressive competition for nest sites. The common mynah has a similar native range to the Indian house crow – southern and south-east Asia (Cramp 1994). However, like the house crow, the mynah has the potential to establish in the temperate regions of northern Europe. Goodwin (1956) reports an escaped individual surviving for about four years in central London, whilst several escapes have been reported in Dunkirk, France since at least 1986, with at least one pair breeding in 1998-99 (Hars 1991 cited in Cramp 1994).

Past bird introductions have been dominated in importance by two pathways: intentional release as game animals and intentional movements via the pet trade. In the present day, the most commonly kept pet birds in the UK are psittacines. Their popularity as pets and the relative frequency of free-flying birds (as a result of escapes/releases) mean that there is a continued risk of future establishments of feral birds and populations.

In the US, a review of establishment patterns of the populations of 27 species of psittacines identified five species with relatively large and widespread populations (Pitt & Runde 2007). A further four species were considered as potentially in the process of establishing naturalised breeding populations (including blue-crowned parakeet *Aratinga acuticaudata*). The study concluded that although numerous species-specific traits have been associated with established psittacine populations, previous work had concluded that, like other birds, the most important factor is

introduction effort. Multiple releases of numerous birds are usually required to create established breeding populations.

Psittacine species that pose the highest risk of establishing feral populations, therefore, are the smaller, less expensive species, such as parakeets, that are more likely to be kept in small flocks, and are more likely to experience simultaneous releases or escapes of multiple individuals. This is supported by successful establishments of feral psittacine populations in England being limited to ring-necked *Psitaclla krameri* and monk parakeets *Myiopsitta monachus*; and also small transient colonies of Alexandrine parakeets *Psittacula eupatria*. Although there is a risk of new populations of psittacines (e.g. Alexandrine and blue-crowned parakeets) establishing, the current evaluation categorises their environmental risk as medium; this is because the detrimental effects imposed by psittacines tend to be associated with economic impacts rather than environmental. It should, however, be noted that studies designed to investigate the environmental impacts of feral psittacines populations in England have not yet been carried out.

Global warming has the potential to increase the risk of establishment of some of the avian species considered. The Indian house crow population in The Netherlands is the species' most northerly established breeding population. As such, it is possible that the reproductive success of the population is lower than in its more southerly range. (as shown for ring-necked parakeet - Schwartz *et al*. 2009). If this is the case, the expansion of the population in The Netherlands may currently be relatively constrained compared to that of past colonisations elsewhere. Climatic changes that relax this potential constraint and facilitate population expansion in The Netherlands will enhance the risk of the species entering England. Similarly, a warmer climate would also benefit the reproductive output of other species native to warmer regions, such as psittacines and mynahs, in the event that they establish breeding in the wild.

5.4 AMPHIBIANS AND REPTILES

In the present study, four species of amphibian were evaluated as high risk: marsh frog *Pelophylax ridibundus*, African clawed toad *Xenopus laevis*, North American bullfrog *Rana catesbeiana* cane toad *Bufo marinus*. The marsh frog and African clawed toad are established locally and have isolated populations in England respectively (Black List); the North American bullfrog has an isolated population (Black List) undergoing management. All three of these species are predators that consume a wide-range of native species and out-compete native amphibians. The Marsh frog also impacts on native frogs in the green frog complex (marsh, green and pool frogs) through hybridogenesis; whereby marsh frog progeny are produced from hybrid matings. Although the scheme evaluated the cane toad (which is present in the pet trade) as a high risk, the species is unlikely to establish in England, even in the advent of moderate global warming, due to its critical temperature requirements (Kearney *et al*. 2008); the species was, however, allocated to the Climate List. Also allocated to the Climate List are the medium risk species Caribbean tree-frog *Eleutherodactylus coqui* and Cuban tree-frog *Osteopilus septentrionalis*, the latter currently present in the pet trade.

Potentially the biggest risk to native amphibians is the infectious fungal disease Chytritiomycosis, caused by *Batrachochytrium dendrobatidis*, which can be carried by exotic species. Chytritiomycosis has been affecting amphibians globally and is a

major cause of alarming population declines or extinctions in many amphibian species (Fisher & Garner 2007). The scale of these declines has been such that amphibian Chytritiomycosis has been described as 'the worst infectious disease ever recorded among vertebrates in terms of the number of species impacted, and its propensity to drive them to extinction' (ACAP 2005). Fisher & Garner (2007) determined that a minimum of 28 species of introduced amphibians are known carriers of *B. dendrobatidis*; the majority asymptomatically infected. Of these, seven are non-native species that have at one time been available through the UK pet trade and have been recorded in the wild - the marsh frog, edible frog *Rana esculenta*, pool frog *Rana lessonae*, North American bullfrog, African clawed toad, alpine newt *Triturus alpestris* and midwife toad *Alytes obstericans*. A population of North American bullfrogs removed from Kent was shown to be infected (Garner *et al*. 2005; Cunningham *et al*. 2005 cited in Fisher & Garner 2007). A second population at another site in southern England was discovered in 2006 and is undergoing management. Climate warming could increase the risk from Chytritiomycosis as the fungus is very responsive to temperature, being most active and harmful between 17ºC and 25ºC (Berger *et al*. 2004 cited in Low 2008).

Amongst reptiles, four species were categorised as high risk: red-eared terrapin *Trachemys scripta*, snapping turtle *Chelydra serpentina* (Black List), Burmese python *Python molurus bivittatus* and common boa *Boa constrictor imperator* (representative of other python and boa species) (Climate List). The red-eared terrapin and snapping turtle can eat large numbers of amphibians and other small animals, including young waterfowl and other small birds. These were once very popular pets but as a result of a demanding care regime and their propensity to grow to a large size quickly, however, many subsequently became unwanted and were abandoned and released into the wild, where many survived. At present, however, the majority of individuals are found in urban areas of limited ecological value. There is the potential for significant detrimental impacts on species and ecosystems should they expand or be released into areas of high ecological value. Both species are currently constrained in efforts to breed successfully in the wild due to the required temperature of egg incubation and the effect of specific temperature on determining the sex of hatchlings. For both species a specific narrow temperature range exists outside of which only offspring of one sex is produced. The current climatic conditions are not conducive to successful breeding. The species, however, are long-lived and local microclimates (e.g. heated water outlets and compost heaps) could allow occasional successful breeding; viable clutches of eggs have been discovered. Global warming could exacerbate this potential for successful breeding.

Pythons and boas and Colubrid snakes are the most commonly owned pet snakes; amongst the Colubridae (a vast family of species) the rat snakes *Elaphe* spp (a genus that includes the very popular corn snake *Elaphe guttata*) and king snakes *Lampropeltis* spp are the most common. A number of species of these genera are native to temperate regions of the USA and therefore are likely to survive in the wild in England. Indeed one member of the *Elaphe* genera, the Aesculapian snake has had a self-sustaining population in North Wales since the 1970s. Unlike corn snakes and kingsnakes, the native range of pythons and boas has much warmer climatic conditions and these species are unlikely to flourish in the wild. However, it cannot be ruled out that individuals may survive in more clement regions of the UK, with

periods of torpor or hibernation during colder periods; a scenario which may become more of a possibility in the event of climate warming.

Although lizards are even more common pets than snakes, they are very unlikely to establish in the wild following escape or release. The most common lizard pets are dragons, geckos, chameleons and iguanas; none of these groups being native to temperate environments. A less hospitable European climate is considered the likely reason for a three-fold lower rate in successful introductions of amphibians and reptiles compared to North America (Kraus 2009).

5.5 TERRESTRIAL INVERTEBRATES

Of the thirty-six species that were assessed, one was placed in the Black List, five in the Alert List and a further seven on the Watch List. Of these thirteen species, seven are Coleoptera (beetles), two are Lepidoptera (moths and butterflies), two are Hymenoptera (wasps, bees and ants), one is a nematode and one a slug. Four of the Coleoptera on the Black and Alert Lists are wood boring species (Cerambycidae or Buprestidae) which have the potential to directly or indirectly kill trees and hence lead to significant environmental damage. Their life-cycles, in which the majority of the year is spent within trees, makes them difficult to detect and control with natural enemies or pesticides. Asia is the native range of six of the thirteen species *Anoplophora chinensis* (citrus longhorn beetle) *Anoplophora glabripennis* (Asian longhorn beetle), *Agrilus planipennis* (emerald ash borer), *Popilla japonica* (Japanese beetle), *Selenochlamys ysbryda* (ghost slug) and *Dryocosmus kuriphilus* (oriental chestnut gall wasp). Two species have distributions from across Europe and Asia *Lymantria dispar* (gypsy moth) and *Ips typographus* (eight-toothed bark beetle). Two species are European *Thaumetopoea processionea* (oak processionary moth) and *Monochamus sartor* (sawyer beetle). Two of the thirteen species are North American, *Bursaphelenchus xylophilus* (pinewood nematode) and *Lirssorhopturs oryzophilus* (American rice weevil) and one is originates from South America, *Linepithema humile* (Argentine ant).

Eight of these thirteen species have already been spread by man to other continents where they have caused significant damage to the environment, agriculture or forestry, and hence there is evidence that they are able to adapt and cause damage in environments outside of their native ranges. The eight species are: *A. chinensis*, *A. glabripennis*, *A. planipennis* (Asian species that have been introduced into North America and Europe) *P. japonica* (Asian species introduced into North America) *B. xylophilus* and *L. oryzophilus* (N. American species introduced into Asia and Europe), *L. dispar* (European / Asian species introduced into North America) and *L. humile* (has spread to all continents from South America).

Smith *et al.* (2007) studied the origin and likely introduction pathway of non-native invertebrate plant pests that established in Great Britain between 1970 and 2004. Of the 164 species that were found to have become established, 114 were thought most likely to be the result of human assisted introductions. Of these 114 human assisted introductions, 39 were from Europe, 22 from North America and 22 from Asia. Unsurprisingly, only one of 50 natural colonists was known to have come from outside Europe. The natural colonists were dominated by Lepidoptera (28 species) and Hemiptera (17 species).

The study by Smith *et al.* (2007) suggests that pests that originate in Europe are the most likely to establish in Great Britain (GB). However, the changing patterns in world trade suggest there are likely to be increasing opportunities for introductions of invasive invertebrates into the UK from Asia. One recent example has been the interception of numerous citrus longhorn beetles *Anoplophora chinensis* in *Acer* sp. trees imported into England from China (for example see Moran 2008). Citrus longhorn beetle is now established in Italy and the original introduction was likely to have been directly from Asia. Numerous longhorn beetles, including *Anoplophora glabripennis* have been intercepted in Europe in association with wooden packaging materials and in some cases furniture imported from Asia.

In addition to direct introductions from non-European countries into GB, there are a number of invasive organisms from Asia and North and South America that have become established in continental Europe and the European populations now threaten the UK such as *Anoplophora chinensis*, *Bursaphelenchus xylophilus*, *Dryocosmus kuriphilus, Anoplophora glabripennis, Linepithema humile* and *Pseudaulacapsis pentagona* (white peach scale). *Bursaphelenchus xylophilus* and *Pseudaulacaspis penatagona* have both been intercepted in the UK on material from Europe.

Many non-native terrestrial invertebrates are pests of crops and forest trees, but very few have damaged the wildlife value of terrestrial ecosystems in Europe. Of the '100 worst' species listed by DAISIE (2009), only the Harlequin Ladybird, citrus longhorn beetle and Argentine Ant appear likely to have a substantial effect on natural and semi-natural ecosystems. The Harlequin ladybird is not on the horizon, being already well established in southern England. However Argentine ant is hardly established outside the Mediterranean region, but it could have a large ecological impact if it extends its range northwards

The great diversity of invertebrates means that only a limited range of species can be assessed for their potential as invasive organisms. There is often great uncertainty concerning the potential of invasive invertebrates to survive and thrive in the UK climate, and this uncertainty has been heightened by climate change. There is also often uncertainty about the host range of invasive species. One important example is *Agrilus planipennis* (emerald ash borer). This species has caused huge damage to ash trees in the USA. There is evidence of *A. planipennis* attacking the ash species native to England, *Fraxinus excelsior*, at an outbreak near Moscow, however, more significant damage has been caused to another ash species, *Fraxinus pennsylvanica*. There can also be uncertainty about the ability of invertebrates to act as vectors, for example the potential for *Monochamus sartor* to vector *Bursaphelenchus xylophilus* (pinewood nematode) is unclear.

The difficulties of locating and identifying invertebrates mean that studies such as Smith *et al.* (2007) are likely to provide an underestimate of the number of invasive invertebrates establishing in GB and they are most likely to have a bias towards larger and more easily identifiable taxa. Brasier (2008) argued that a large part of the environmental threat posed by non-indigenous pathogens is likely to come from currently unknown species and sources. The diversity of invertebrates and their potential routes into the UK along with a changing UK climate means that a similar argument could reasonably be applied to invertebrates.

5.6 FISH

Of the fourteen species of fish assessed, two species of Ponto-Caspian gobies were placed in the Alert List, while Ictalurid catfishes and Eastern mosquitofish were assessed as posing medium risks (Watch List). Of these, only the Ictalurid catfishes are present in the wild but are confined to a few isolated locations.

The importation of fishes for food and ornament has a long history in England, but the regulation of freshwater fishes introductions only began the 1980s. Since then, unauthorised introductions have been dominated by two pathways, the ornamental trade and angling related activities (Copp *et al.* 2007). Releases of pet fish are rarely associated with wholesale or retail outlets (for an exception see Copp *et al.* 1993), but rather are the abandonment of unwanted pets (Copp *et al.* 2005c, Ellis 2006), or are associated with fish movements (either as contaminants or as illegal releases to enhance the attraction of a water to anglers). The reasons for the release of pet fishes vary greatly, ranging from practical (the specimen(s) are diseased or have become too big for the holding facilities) to cultural/religious (the ancient practice, endorsed by the Buddhist faith, of releasing a live fish as a highly approvable act of compassion to accumulate merits for favourable judgement in the afterlife; Crossman & Cudmore 1999). In addition to the risks of disease introduction and dispersal, unauthorised fish introductions can lead to adverse impacts on native species, either through predation on other fish or lower animals or through hybridisation and displacement (due to bioengineering or competition). The common carp *Cyprinus carpio* and the goldfish *Carassius auratus* are good examples of fish introduced long ago but about which the adverse impacts have only been revealed in recent decades. The foraging activity of carp is known to displace other species through habitat modification (suspension of sediments reduces water clarity, leading to a decline in aquatic macrophytes and other organisms that prosper in clear waters). Both goldfish and common carp can hybridise with crucian carp *Carassius carassius*, which is native to southeastern England, leading to the decline in the native species, especially in ponds (Copp *et al.* 2008a). Even greater threats have been introduced more recently, such as the highly invasive topmouth gudgeon *Pseudorasbora parva*, which is not only a facultative parasite (of other fish) but is also the healthy host of a non-native pathogen, the rosette agent, which poses a risk to a wide range of native fish species (Gozlan *et al*. 2005, 2006).

Although the regulatory controls of non-native fishes in England are the most advanced in Europe (Copp *et al.* 2005a), reports of new species in the wild continue (e.g. Britton & Davies 2006a, 2006b, 2007). And some of these species may be able to persist under a wide range of climatic conditions and could eventually establish permanent populations (Britton *et al.* 2005). The risks of invasion by marine fishes are known to have occurred elsewhere in the world (Semmens *et al*. 2004), there are no such cases reported for the UK, perhaps because any released marine aquarium specimens are tropical and therefore quickly succumb to the local cold conditions (e.g. Ellis 2006).

Although there are regular reports of vagrant marine fish in the scientific literature and popular press, these are due to natural occurrences and natural processes (i.e. not facilitated by human activities). Hence, these vagrants do not constitute non-native fauna *per se*. In terms of introduced marine fishes, these have generally been the result of deliberate introductions for commercial fisheries, release of exotic, ornamental fishes, shipping/ballast water and, elsewhere in the world, due to canal

construction (Baltz, 1991). Of these, some species have established viable populations outside their natural range (e.g. Whitfield *et al*. 2002; Kimball *et al*. 2004; Semmens *et al*. 2004). However, none of the fully marine non-native fishes have established populations in UK seas. For example, a dead specimen of porcupine fish *Diodon hystrix* in the southern North Sea, which is presumed to be an aquarium release that died as a result of the unsuitable conditions and washed ashore (Ellis 2006).

Within UK waters, there are some non-native fishes that currently physiologically are capable of persisting in UK estuaries, such as the introduced sportfish, pikeperch (a.k.a. zander) *Stizostedion lucioperca*. However, research on this species in the upper Thames estuary indicates that pikeperch avoid the saline waters and consistently use the freshwater parts of the estuary (S. Stakėnas, G.H. Copp & K.J. Wesley, unpublished data). Both in UK waters and elsewhere in the world, various salmonids have been introduced as sport fish, and such species often have a marine phase in their life cycle.

Shipping and exchange of ballast waters has been linked to the introductions of some fishes, with gobies one of the more frequently reported examples (e.g. Pollard & Hutchings, 1990; Greiner, 2002; Francis *et al.* 2003). The round goby *Neogobius melanostomus* can tolerate brackish waters, as well as fresh and more saline environments. In addition to being tolerant of various environmental conditions, this species has a broad diet, is aggressive and has a high capacity for successful reproduction and is therefore highly invasive (Sapota & Skora, 2005; Kovac, 2007). This species has established populations in lake and river systems in both Europe and North America, and has successfully invaded the Baltic Sea since the early 1990s. Introduced round goby have had a demonstrated adverse impact on the native mottled sculpin *Cottus bairdi* in North America (Janssen & Jude 2001). This sculpin is closely related, both taxonomically and ecologically, to bullhead *Cottus gobio*, which is native to England and is listed in Annex II of the EC *Habitats and Species Directive*. Therefore, the arrival of round goby in England should be accorded the highest concern.

In light of the above, the non-native fishes included in the impact assessment are either entirely freshwater species or salt-tolerance species (i.e. Ponto-Caspian gobies) that do not normally inhabit truly marine ecosystems. Not all of the species assessed in the impact risk exercise are profiled, as some are of such similar character that they are either considered together with the related species or they are ignored due to the low likelihood of them entering English waters. Of the species already present in England, profiles are provided for those present in captivity only as well as those that have escaped or been released illegally into the wild.

Species reported in the wild are sterlet *Acipenser ruthenus*, black bullhead *Ameiurus melas*, bighead carp *Aristichthys nobilis*, white sucker *Catostomus commersoni*, grass carp *Ctenopharyngodon idella*, channel catfish *Ictalurus punctatus*, Asian weatherfish *Misgurnus anguillicaudatus*, European weatherfish *Misgurnus fossilis*, and fathead minnow *Pimephales promelas*. Of these species, only three species are confirmed to have established self-sustaining populations: the fathead minnow (G.H. Copp, personal observation) and the Ictalurid catfishes, black bullhead (G.H. Copp, personal observation) and channel catfish (Wheeler *et al.* 2004). Because of their similar biology and environmental risk, the Ictalurid catfishes are profiled on the same sheet.

The establishment success of the weatherfishes remains unclear. The European weatherfish has been reported to have occurred at least three locations (Wheeler *et al.* 2004), but the only confirmed report of a reproducing population is for the Asian weatherfish. This population, found in a garden pond in southern England, was subsequently eradicated by draining and liming the pond sediments (A. Scott, Cefas-Weymouth, personal communication). As a consequence of this find, the Asian weatherfish was placed on the ILFA list for regulation of keeping and release. However, as the Asian species was available in the pet fish trade for a number of years, it is the most likely to be released into UK waters (Wheeler *et al.* 2004). Similarly unclear is the establishment status of the white sucker. There is some circumstantial evidence that the may be able to reproduce in England (Copp *et al.* 2006a), but this requires further investigation.

Species in captivity only but not yet reported in the wild are red shiner *Cyprinella lutrensis* and silver carp *Hypophthalmichthys molitrix*. A species profile is provided for red shiner, which is sold in the pet fish trade and as such is likely to be released illegally. Whereas, the silver carp is currently present in aquaculture facilities only (to help control phytoplankton levels), and it is similar in biology and environmental risk to the bighead carp, so the species profile for the latter is applicable to both species.

Species not in the UK but with some likelihood of appearing in English waters are the Eastern mosquitofish *Gambusia holbrooki* and the Ponto-Caspian gobies, the round goby *Neogobius melanostomus* and the tubenose goby *Proterorhinus marmoratus*. The mosquitofish has already established itself in northern areas of the continent (Beaudouin *et al.* 2008), and there has recently been a report of a cold-hardy variety of mosquitofish (http://www.fattigfish.com/), which suggests that the species poses a greater threat to northern locations than was previously believed (K. Schmidt, posted on ALIENS-List (aliens-l@indaba.iucn.org) on 4 May 2009). Therefore, establishment in England of mosquitofish is likely if the species is transported and released into England, either intentionally or accidentally (e.g. by aquarists or anglers moving between England and France). However, the likelihood of this occurring is less than the dispersal of the gobies across the channel from the Netherlands. Both round goby and tubenose goby are already present in lower sections of the River Rhine (van Beek 2006, von Landwüst 2006). Once their numbers reach sufficiently high densities, then they are likely to be dispersed to other ports as 'hitch hikers' (hull foulants) of ships, which is the means by which these species have moved through European river systems (Wiesner 2005). Both species are highly salt tolerant, so salinity levels in the English Channel are not likely to offer a barrier to these Ponto-Caspian gobies.

The outcome of the present impact risk assessment exercise raises some interesting issues regarding the risk assessment process. In contrast to many of the other taxonomic groups included in the present report, the fresh and brackish water fishes have already be assessed for their potential invasiveness using FISK (Fish Invasiveness Scoring Kit; Copp *et al.* 2009), which comprises 49 questions that encompass and exceed those included in the adapted ISEIA scheme. Of the calibrated FISK scores for the twelve fish species (Table 5) eight fall within the high risk category (Copp *et al*. 2009). Using the adapted ISEIA scheme, all but four species are classed as low risk. That said, most of the FISK scores range from the middle of the

medium risk category to the lower third of the high risk category; only two species have scores in the middle third of the high risk category of FISK. The likely explanation for the underestimation of risk using the ISEIA scheme is that the number of questions (i.e. the sample size of interrogation about the species) is insufficient. In this development of FISK, which was adapted from the Weed Risk Assessment (WRA) scoring system (Pheloung *et al.* 1999), a reduction in the number of questions down from the 49 in the WRA was considered. But, this was abandoned because of concerns over the potentially adverse impact on the certainty of the assessment process if the sample size of the interrogation were reduced.

Table 5. Comparison of invasiveness risk scores for fresh and brackish water fishes using the ISEIA and the FISK schemes.

Latin name	Common name	ISEIA scheme	FISK invasiveness risk	
			mean score	rank
Acipenser ruthenus	Sterlet	L	16.0	upper M
Ameiurus melas	Black bullhead	M	28.8	middle H
Aristichthys nobilis	Bighead carp	L	24.3	lower H
Catostomus commersoni	White sucker	L	23.0	lower H
Ctenopharyngodon idella	Grass carp	L	24.0	lower H
Cyprinella lutrensis	Red shiner	L	18.0	upper M
Gambusia holbrooki	Eastern mosquitofish	M	21.0	lower H
Hypophthalmichthys molitrix	Silver carp	L	22.8	lower H
Misgurnus fossilis	Weatherfish	L	12.5	middle M
Neogobius melanostomus	Round goby	H	29.5	middle H
Pimephales promelas	Fathead minnow	L	19.0	lower H
Proterorhinus marmoratus	Tubenose goby	H	18.5	upper M

Fish species likely to benefit from climate warming are red shiner (currently held in captivity with no confirmed reports in the wild) and the fathead minnow (isolated populations in the wild).

5.7 FRESHWATER INVERTEBRATES

Of twenty-eight species assessed, three were included on the Black List, the spiny-cheeked crayfish, false dark muscle and Chinese mitten crab, and one Alert List species was identified, the marbled crayfish. On the Watch List are red swamp crayfish, narrow-clawed crayfish and Asian clam, all of which have isolated populations.

Amongst the most well known freshwater invaders are the crayfishes. Of these, the signal crayfish *Pacifastacus leniusculus*, was intentionally imported and promoted by the UK government for aquaculture (e.g. Ackefors 2000), but later was found to have a dual impact on the native white-clawed crayfish *Austropotamobius pallipes*. The signal crayfish is both highly aggressive and the healthy host of the non-native crayfish plague *Aphanomyces astaci*. As a result, other crayfish species have attracted particular attention. Of the crayfish species not yet present in England, the marbled crayfish *Procambarus* sp. (aka *P. marmorkrebs*) (Alert List) is likely to appear through illegal keeping and release by aquarists. The taxonomic status of the marble crayfish remains unclear, and the potential risks of this highly plastic species appear to be contradictory: some reports indicate that the species exhibits no aggression towards conspecifics or fish, whereas other have suggested a high potential for the habitat displacement of native species, both crayfish and possibly fishes.

A species of crayfish already in England is the noble crayfish *Astacus astacus*, which is limited in its English distribution to a few locations in the southwest (Bath, Bristol). Unlike the other non-native crayfishes, the noble crayfish is an IUCN listed species as 'vulnerable', and the risk assessment outcome was 'low' risk of impact. Other species already here are the red swamp crayfish *Procambarus clarkia* and the narrow-clawed crayfish *Astacus leptodactylus*, both of which pose a medium risk (Watch List).

Unlike with freshwater fishes, for which the ISEIA risk classifications were at odds with the risk ranking outcomes of FISK, the ISEIA assessments were in general agreement with those of the Freshwater Invertebrate Invasiveness Scoring Kit (FI-ISK; Tricarico *et al.*, under review). Only one species was classed lower by ISEIA than FI-ISK, the red swamp crayfish (Table 6).

Table 6. Comparison of invasiveness risk scores for freshwater crayfishes using the ISEIA and the FI-ISK schemes.

Latin name	Common name	ISEIA scheme	FI-ISK invasiveness risk	
			mean score	rank
Astacus astacus	Noble crayfish	L	0	L
Astacus leptodactylus	Narrow-clawed crayfish	M	15	upper M
Orchonectes limosus	Spiny cheeked crayfish	H	30	upper H
Procambarus clarkia	Red swamp crayfish	M	39	upper H
Procambarus sp.	Marbled crayfish	M	15	upper M

Aquatic invertebrate species likely to benefit from climate warming are the freshwater triclad *Dugesia tigrina* (currently held in captivity with no confirmed reports in the wild) and two crustaceans, the red swamp crayfish and the Chinese mitten crap (both have isolated populations in the wild).

5.8 MARINE INVERTEBRATES

Amongst the six marine invertebrates assessed, the highest risk species are Colonial ascidian (Black List) and the red king crab (Alert List), the former already present in England and the later absent but likely to arrive. Three further species were added to the Watch List (the bryozoan *Watersipoa subtorquata*, Japanese tiger prawn and the veined rapa whelk).

In addition to non-native species that have been introduced for aquaculture (e.g. Pacific oyster *Crassostrea gigas*, quahog *Mercenaria mercenaria*) a range of marine invertebrate species have been introduced into UK waters, typically by vectors such as ballast water or ships hulls (e.g. the pycnogonid [sea spider] *Ammothea hilgendorfi* and the barnacle *Elminius modestus*), or the fauna associated with the shellfish imports (e.g. bamboo worm *Clymenella torquata*). There have also been several reports of the Asian prawn *Marsupenaeus* (*Penaeus*) *japonicus* caught from the English Channel, after escaping from aquaculture facilities in France, although it is unclear as to whether these have formed a breeding population in this area.

Some non-native species have been particularly invasive and have spread widely around the estuaries and coasts of the UK, whereas some other species have been reported from a few locations, typically ports or estuaries, and may have not spread or formed self-sustaining populations elsewhere. For example *A. hilgendorfi*, in which the males carry the eggs, has a low dispersal rate and tends to be reported from specific sites in Europe (including Southampton), and with little evidence of it

spreading. Indeed, this species was found to pose a low impact risk. Similarly, some crabs such as dwarf crab *Rhithropanopeus harrisii* and the mud crab *Neopanope sayi* have been reported from various docks in South Wales.

In contrast, there are several species that have been successful in colonizing UK coastal waters including *E. modestus*, slipper limpet *Crepidula fornicata*, Chinese mitten crab *Eriocheir sinensis* (also a colonizer of freshwater), and the colonial ascidian *Didemnum vexillum*. Such species have a high capability for spreading, whether through the dispersal of various life-history stages (eggs, larvae, adults) and/or via national shipping transport, and the latter species was found to pose a high impact risk. Some non-native species that have established viable breeding populations in southern England and Wales have spread northwards, but been unable to establish self-sustaining populations in northerly areas, possibly due to water temperature. Although many of the non-native marine species tend to have coastal and/or estuarine distributions, some non-native species, such as the ascidian *Styela clava*, have spread further from shore.

Non-native species can affect native fauna and ecosystems. For example slipper limpet is now very abundant in some estuaries, and may have impacted on native oyster populations by modifying the seabed from its previous condition to one characterized by chains of slipper limpets, and thus displacing oysters. Chinese mitten crab is now common in some rivers and estuaries along the east coast of the United Kingdom (Herborg *et al.*, 2005), and is notorious for damaging river banks. Whereas, the bryozoan *Watersipora subtorquata* has an influence on the food-web of the receiving environment and therefore is of medium impact (Watch List).

In recent years there have been several overviews of the non-native species in UK and adjacent north European waters (see Eno *et al*., 1997; Reise, 1999; Goulletquer *et al*., 2002; Minchin & Eno, 2002; Resie *et al*., 2002). Three of the species likely to reach English coastal waters are the red king crab *Paralithodes camtschaticus* (Alert List), which poses a high risk of impact, the two species that pose a medium risk, the Japanese tiger prawn *Marsupenaeus* (*Penaeus*) *japonicus* and the veined (Asian) rapa whelk *Rapana venosa* (Watch List). Climate change leading to warmer coastal water is likely to favour some species (e.g. Japanese tiger prawn) but discourage others (i.e. the red king crab).

5.9 SPECIES INFORMATION SHEETS

Information sheets for 62 species are presented collectively in Appendix I.

5.10 SUMMARY SPREADSHEETS

Summary spreadsheets are presented in Appendix II and also supplied as an electronic copy supplied as Annex I to the report.

6. CONCLUSIONS

The horizon scanning project has identified and categorised a number of non-native species, across different taxonomic groups and habitats, that have the potential to become invasive in England in the future. The risk assessment procedure used was based on the existing Invasive Species Environmental Impact Assessment (ISEIA), used in Belgium.

Evaluation has placed these potential 'new' invasive species into a list system that ranks groups of species according to a two-dimensional ordination: the level of environmental risk they pose (high, medium, low) and their invasive stage in England (locally established, localised population, enclosed, absent). The placement of species within this ordination provided four categories or lists associated with relative risk of invasiveness: Black List (high risk/present), Alert List (high risk/absent or enclosed), Watch List (medium risk/absent, enclosed or present) and Climate List (high or medium risk/absent or enclosed but physiologically constrained from establishing without climate warming).

Black List species are those with a high environmental risk and are already present in England; this list should have the highest priority in consideration of future actions. Alert List species are those high risk species that are either absent from England or confined to enclosed environments; requiring close monitoring of any changes in their status. Watch List species pose a medium risk and require a relatively lower level of vigilance, as do Climate List species.

A total of 161 species was evaluated with the following numbers allocated to the lists: Black List 12, Alert List 20, Watch List 46 and Climate List 6.

The listing scheme has a number of applications:

- Identification of species that should be subject to a more intensive risk assessment, i.e. via the UK Non-Native Risk Assessment Programme (Black, Alert and Watch Lists).
- Identification of species that should be prioritised for consideration of management action, i.e. species with either locally established or isolated local populations that pose a high environmental risk (Black List).
- Identification of those species in enclosed environments that if they were to escape and establish in the wild would risk imposing a high detrimental environmental impact (Alert List).
- Preparation of contingency plans for high-risk species that although presently absent (Alert List) have a high likelihood of entering in the future, e.g. sacred ibis.

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APPENDIX I: SPECIES INFORMATION SHEETS

Arctic Fox *Alopex lagopus* ALERT LIST

Blue fox, Siberian polar fox

IDENTITY

Taxonomy: Mammalia, Carnivora, Canidae

Quarantine Status: None; not CITES listed.

Description: Medium-sized mammal with short legs and tail; body length 43-85cm; body weight 1.4-6.0 kg; pelage brown or greyish yellow (summer), white or cream (winter).

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Circumpolar distribution in all Arctic tundra habitats. Arctic and alpine tundra, forest borders.

Introduced Range: Introduced to Pacific Ocean islands and parts of northern Russia. Retrieval of arctic foxes in Scotland during the middle of the nineteenth century indicates their introduction. Historically, failed to establish following a number of escapes from fur farms in the UK. It is considered that the Arctic fox is unlikely to establish in the UK due to competition from the larger red fox.

England: Dispersed, sporadic escapes - 11 sightings involving 27 individuals (1970-1999).

BIOLOGY/ECOLOGY

General: Mainly nocturnal or diurnal; lives in excavated burrow or den or under rock piles; solitary or pairs but congregates at food sources; an opportunistic predator and scavenger – small mammals, eggs and fledglings of ground-nesting birds, fish, molluscs, crustaceans, carrion.

Movement and dispersal: Natural, following escape or release; wanders extensively.

RISK STATUS

Environmental Impact: Predation of ground-nesting birds; severe reductions in avifauna on islands where introduced.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos and collections.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

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Leopard Cat *Felis* (*Prionailurus*) *Bengalensis* ALERT LIST

IDENTITY

Taxonomy: Mammalia, Carnivora, Felidae

Quarantine Status: CITES Appendix I and II.

Description: Similar build to domestic cat but with longer legs and back; base fur colour ranges from yellow/brown to grey/brown, dark spots, spotted or ringed tail, with a black tip, four black bands running from the forehead to the back of the neck; 45-107 cm, 3-7 kg.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Indonesia, Philippines, Borneo, Malaysia, Thailand, Myanmar, Laos, Cambodia, China, Taiwan, Korea, India, Pakistan and Soviet Far East. Tropical forest, scrubland, pine forest, second-growth woodland, semi-desert, and agricultural regions - especially near water sources; may be found at heights up to 3000 m.

Introduced Range: No information on introduced range; known to be present in zoological collections; wild x domestic crosses (e.g. Bengal cat) owned privately.

England: Dispersed, sporadic escapes - 4 sightings involving 4 individuals (1970-1999).

BIOLOGY/ECOLOGY

General: Primarily solitary; mainly nocturnal; dens in tree hollows or small caves or under overhangs or large roots. Carnivorous - mammals (including hares and young deer), lizards, amphibians, birds, and insects, supplemented with grass, eggs, poultry, and aquatic prey.

Movement and dispersal: Natural, following escape or release; weakly territorial; mean home range 12-14 km^2.

RISK STATUS

Environmental Impact: Predation on a wide range of native fauna.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos and collections.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. Pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

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Nowak, R.M. & Paradiso, J.L. 1983. *Walker's Mammals of the World*, Vol II, 4th Edition. The Johns Hopkins University Press, Baltimore & London.

Capybara *Hydrochaeris hydrochaeris* ALERT LIST

IDENTITY

Taxonomy: Mammalia, Rodentia, Caviidae

Quarantine Status: None; not CITES listed.

Description: Largest rodent in the world; 100-130 cm; 27-79 kg; long, coarse, sparse pelage, brown to reddish colour.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Tropical and subtropical aspects of South America. Densely vegetated areas around waterbodies and swamps.

Introduced Range: Introduced to north-central Florida and possibly other subtropical regions in the United States. Many escapees from captivity can also be found in similar watery habitats around the world, including (July 2008) the River Arno in Florence, Italy.

England: Dispersed, sporadic escapes - 7 sightings involving 19 individuals (1970-1999).

BIOLOGY/ECOLOGY

General: Tropical, semi-aquatic; live in family groups (usually 10-30 but up to 100 individuals), typically controlled by a dominant male and made up of the females, younger males and young. Herbivore - grazing mainly on grasses and aquatic plants, as well as fruit and tree bark.

Movement and dispersal: Natural, following escape or release;

RISK STATUS

Environmental Impact: Impacts in Florida as yet unknown; but potential for similar damage to that caused by coypu.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos and collections.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. Pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

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Nowak, R.M. & Paradiso, J.L. 1983. *Walker's Mammals of the World*, Vol II, 4th Edition. The Johns Hopkins University Press, Baltimore & London.

Fuller, P.L. 2003. Freshwater aquatic vertebrate introductions in the United States: patterns and pathways. Pp. 123-152. In: Ruiz, G.G. & Carlton, J.T. (eds.) *Invasive Species – Vectors and Management Strategies*. Island Press, Washington, Covelo, London.

Raccoon Dog *Nyctereutes procyonoides* ALERT LIST

Raccoon-like dog

IDENTITY

Taxonomy: Mammalia, Carnivora, Canidae

Quarantine Status: None; not CITES listed.

Description: Medium (fox)-sized mammal with short legs and tail; body length 50-80cm; body weight 3-10 kg; long yellowish-brown pelage; hairs of shoulders, back and tail tipped with black.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Eastern Asia. Prefers wooded valleys and slopes.

Introduced Range: Introduced to Russia as a fur animal and subsequently spread westwards into central Europe to Romania, Poland, Hungary, Czech Republic, Slovakia, Switzerland, Finland, Austria, Netherlands, Germany, Sweden and Norway.

England: One confirmed sighting of a raccoon dog in Berkshire in July 2005. In the 1990s, there was a report of a raccoon dog killed near Loch Lomond.

BIOLOGY/ECOLOGY

General: Mainly nocturnal; lives in burrows or natural cavities; dormant in cold weather in northern regions; solitary, pairs or family groups. Omnivorous - a wide range of small mammals, reptiles, birds and eggs, fish, amphibians, invertebrates, acorns, nuts, fruits, berries, grain and roots, scrap food.

Movement and dispersal: Natural, following escape or release; average dispersal distance 20 km.

RISK STATUS

Environmental Impact: Predation on ground-nesting birds and amphibians; competition with badgers and foxes for food and den sites; one of the main vectors of rabies in Europe; also vector of sarcoptic mange, fox tapeworm and trichenellosis.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos and collections.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. Pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

Drake J.A. (Ed). 2009. Handbook of Alien Species in Europe. Invading Nature Springer Series in Invasion Ecology. Volume 3. University of Tennessee, Knoxville, TN, USA.

Long J.L 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

Nowak, R.M. & Paradiso, J.L. 1983. *Walker's Mammals of the World*, Vol II, 4th Edition. The Johns Hopkins University Press, Baltimore & London.

Raccoon *Procyon lotor* ALERT LIST

American raccoon, Common raccoon

IDENTITY

Taxonomy: Mammalia, Carnivora, Procyonidae

Quarantine Status: None; not CITES listed.

Description: Medium (cat)-sized mammal; body length 41-60cm; body weight 3.9-9.2kg; grey black to grey brown; distinctive facial 'bandit' mask and banded, bushy tail.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: North, Central and South America. Prefers woodland near water.

Introduced Range: Imported into numerous countries for fur farms, zoos and as non-native pets. Escapes have resulted in well-established populations in Germany, France and The Netherlands, Belarus, Caucasian region and Turkestan; also Belgium, Austria, Switzerland and the Czech Republic.

England: Dispersed, sporadic escapes - 32 sightings involving 34 individuals (1970-1999).

BIOLOGY/ECOLOGY

General: Nocturnal; partial hibernation or dormant for period in cold regions; terrestrial and arboreal; dens in natural cavities or abandoned burrows; solitary or family groups; more or less sedentary. Omnivorous - wide range of small vertebrates and invertebrates, including terrestrial, freshwater and marine species.

Movement and dispersal: Natural, following escape or release from captivity. Average migration distance 5-10km.

RISK STATUS

Environmental Impact: Predation on waterfowl, muskrats, quail, amphibians and many other forms of wildlife; predate game birds; major wildlife vector of rabies; consumption of corn and peanuts and root vegetables.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity. Recent removal (2007) from Dangerous Wild Animals Act may result in increased ownership and escapes.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

Drake J.A. (Ed). 2009. Handbook of Alien Species in Europe. Invading Nature Springer Series in Invasion Ecology. Volume 3. University of Tennessee, Knoxville, TN, USA.

Long J.L 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

Nowak, R.M. & Paradiso, J.L. 1983. *Walker's Mammals of the World*, Vol II, 4th Edition. The Johns Hopkins University Press, Baltimore & London.

Edible Dormouse *Glis glis*

WATCH LIST

Fat dormouse, Squirrel-tailed dormouse

IDENTITY

Taxonomy: Mammalia, Rodentia, Gliridae

Quarantine Status: None; not CITES listed.

Description: Squirrel-like dormouse; very bushy tail and short, thick silvery grey fur which is white or yellowish-white underneath; length 120-225 mm, 70-250 g.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Eurasia: northern Spain, south eastern and eastern France, eastwards to Israel, northern Iran and the Caucasus. Forest, deciduous woodland, plantations, scrub, orchards, vineyards, gardens; often inhabits human dwellings.

Introduced Range: UK.

England: In 1902, released as part of a wildlife collection, at Tring Park, Hertfordshire. Escapes led to the establishment of a population in the wild, which has been restricted to the Chiltern area of Buckinghamshire, Berkshire and Herefordshire. The current population is estimated to number at least 10,000 animals. There have been reports, however, from a number of locations up to 100km (New Forest) from Tring.

BIOLOGY/ECOLOGY

General: Mainly nocturnal or crepuscular; mainly arboreal; hibernates or dormant; shelters in tree hollows or in burrows; builds nest of plant material and moss in tree. Omnivorous - feeds on flowers, nuts, acorns, fruit, bark and fungi, insects, bird eggs and even small birds.

Movement and dispersal: Natural population expansion in England has been slow. Main population lies within 25 km of original 1902 release site. However, illegal translocations are occurring (homeowners releasing trapped individuals) and are likely to increase the distribution in a stepwise manner rather than through a steady spread. Isolated reports of individuals far from its original release site include Oxford (45km west) and the New Forest (100km south west).

RISK STATUS

Environmental Impact: Predates insects and the eggs and nestlings of birds; competition for food resources; bark-stripping of trees.

Invasion Stage (England): Self-sustaining localised population; still within 25 km of its release site.

Introduction pathways: Population self-sustaining; illegal translocations of individuals trapped in the population's main range.

Control: Trapping, shooting.

RISK CATEGORY

B_2 Medium/Locally Established

References

Harris, S., Morris, P., Wray, S. & Yalden, D. 1995. *A review of British mammals: population estimates and conservation status of British mammals other than cetaceans*. JNCC, Peterborough.

Macdonnald, D. W. & Tattersall, F. T. (2001) *Britain's mammals- the challenge for conservation*. The Wildlife Conservation research Unit, Oxford University.

Morris, P.A. 1997. A review of the fat dormouse (*Glis glis*) in Britain. Nat. Croat. 6(2): 163-176.

Chinese Water Deer *Hydropotes inermis* WATCH LIST

IDENTITY

Taxonomy: Mammalia, Artiodactyla, Cervidae

Quarantine Status: Proposal for addition to Schedule 9 part I.

Description: Small, antler-less deer with large ears and tusks; pelage is an overall golden brown colour, while the undersides are white; canines of males grow into tusks up to 8 cm; body length 77-100 cm, weight 9-15 kg.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Eastern Asia. Riparian vegetation such as swamps, reedbeds, and grasslands.

Introduced Range: UK and France; possibly unsuccessfully in Australia.

England: Escaped or released from parks since about 1850. First reported in the wild in 1945. Established in Bedfordshire, Cambridgeshire and the Norfolk Broads. Little expansion in numbers or range in recent years.

BIOLOGY/ECOLOGY

General: Nocturnal and diurnal; males are extremely territorial; singly or in pairs, rarely in herds; sedentary; herbivorous – reeds, grass, vegetables, root crops, sedges, brambles.

Movement and dispersal: Natural; excellent swimmers and can swim for several kilometres when travelling between islets in search of food and shelter.

RISK STATUS

Environmental Impact: Potential impact on sensitive riparian plants, with increasing population.

Invasion Stage (England): Localised self-sustaining population; <2,000 individuals.

Introduction pathways: Localised self-sustaining population; further escapes/releases from captivity.

Control: Shooting, trapping.

RISK CATEGORY

B_2 Medium/Locally Established

References

Battersby, J. (Ed.) & Tracking Mammals Partnership. 2005. UK Mammals: *Species Status and Population Trends. First Report by the Tracking Mammals Partnership*. JNCC/Tracking Mammals Partnership, Peterborough.

Long J.L. 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

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Striped Skunk *Mephitis mephitis*

WATCH LIST

Common skunk

IDENTITY

Taxonomy: Mammalia, Carnivora, Mustelidae

Quarantine Status: None; not CITES listed.

Description: Black with white stripes; length 51-80 cm, weight 0.95-4.5 kg; long, bushy tail.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: North America. Forest, woods, plains, desert, agricultural land, river valleys, suburban areas.

Introduced Range: Introduced into the Russian Federation and adjacent independent Republics, Ukraine and the Caucasus during the 1930s, but with little success. Introduced successfully to Prince Edward Island and Vancouver Island, Canada.

England: Dispersed sporadic sightings. During 2001-2003, the RSPCA responded to a total of 25 incidents associated with skunks, involving individuals that had escaped and others that had been abandoned.

BIOLOGY/ECOLOGY

General: Mainly nocturnal and crepuscular; lives in natural rock crevices or in underground burrows usurped from other species; hibernates in northern regions during winter; solitary, pairs or family groups; disperse in summer. Omnivorous - wide range of small mammals, reptiles, amphibians, fish, molluscs, insects, berries, buds, fruit, corn, nuts, leaves, grain, grass, carrion.

Movement and dispersal: Natural following escape or release; summer dispersal can be up to 22 km.

RISK STATUS

Environmental Impact: Consumes small mammals, birds' eggs, invertebrates, fruit, grains etc. In the USA it is a major wildlife vector of rabies.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets; possibly 100-200 kept as pets in GB.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Trapping.

RISK CATEGORY

$B_{0.5}$ Medium/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. Pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

Long J.L. 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

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Coatimundi *Nasua nasua*

WATCH LIST

Brown-nosed coati, Northern coati

IDENTITY

Taxonomy: Mammalia, Carnivora, Procyonidae

Quarantine Status: None; not CITES listed.

Description: Medium-sized mammal; reddish brown to black; body length 34-89 cm; body weight 1.0-7.75 kg; distinctive banded, bushy tail.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: South America and southern United States. Prefers forest and wooded areas.

Introduced Range: Introduced to the island of Juan Fernandez (Chile) for rat control and became established. Introduced into Oklahoma and Indiana in US.

England: Dispersed, sporadic escapes - 7 sightings involving 10 individuals (1979-2006). During 2003-06, there was a spate of sightings in southern Lakeland, Cumbria; all involved single animals, but with sightings sufficiently far enough apart to indicate that more than one animal had been in the region. Sightings further north are reported from Eden, Grizedale, Kendal, Kentmere, Langdale and Melmerby; the latter near Penrith.

BIOLOGY/ECOLOGY

General: Mainly diurnal; terrestrial and somewhat arboreal; roost in trees; groups, males solitary outside breeding season.

Movement and dispersal: Natural, following escape or release; cover 1.5-2.0 km/day foraging.

RISK STATUS

Environmental Impact: Reported depredations in orchards and chicken houses (South America); (unconfirmed) depredation of island avifauna (Juan Fernandez island).

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity. Spates of sightings during 2003-2006 were in relative 'close' proximity to a Wild Animal Park. Recent removal (2007) from Dangerous Wild Animals Act may result in increased ownership and escapes.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$B_{0.5}$ Medium/Absent-Enclosed

References

Baker, S.J. & Hills, D. 2008. Escapes and Introductions. Pp. 780-794. In: *The Mammals of the British Isles: Handbook, 4th Edition* (Eds. Harris, S. & Yalden, D). The Mammal Society, Southampton.

Long J.L. 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

Nowak, R.M. & Paradiso, J.L. 1983. *Walker's Mammals of the World*, Vol II, 4th Edition. The Johns Hopkins University Press, Baltimore & London.

Chipmunk *Tamias sibiricus* WATCH LIST

Asiatic chipmunk, Chipmunk, Siberian ground squirrel

IDENTITY

Taxonomy: Mammalia, Rodentia, Sciuridae

Quarantine Status: None; not CITES listed.

Description: Small, arboreal/ground rodent; 13-16cm, 50-120g; characteristic five longitudinal brown dorsal stripes alternating with yellowish white stripes.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Asia, Siberia. Forest near steppe, dwarf forest along tundra, deciduous undergrowth, thickets, plantations, areas near crop fields.

Introduced Range: Populations established following escapes and deliberate releases in parts of western Europe, including Austria, Belgium, France, Germany, Italy, The Netherlands, Switzerland and Japan.

England: Dispersed, sporadic escapes - 14 sightings involving 49 individuals (1979-2006); including group escapes. Sightings in Berks., Cheshire, Lancs., Wilts., N. Yorks., W. Yorks.

BIOLOGY/ECOLOGY

General: Diurnal; mainly terrestrial; burrows; hibernates in winter. Omnivorous – seeds, grass, sedges, weeds, trees, shrubs, pine nuts, grain, flowers, herbs, small fruits, berries, mushrooms, bulbs, amphibians, reptiles, young birds, invertebrates.

Movement and dispersal: Natural, following escape or releases; adults extremely sedentary.

RISK STATUS

Environmental: Predation of nesting birds and eggs in its native range and introduced range; competition with native forest rodents. A reported significant impact on the production of forest nuts and cereal grain crops; may consume bulbs of rare perennial wildflowers.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity. Over recent years, chipmunks have gained in popularity as pets, with some owners housing small colonies in outside enclosures – conditions that increase the risk of escape and establishment.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

$B_{0.5}$ Medium/Absent-Enclosed

References

Amori, G. 1999. *Tamias sibiricus*. In: Mitchell-Jones A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H, Spitzenberger, F., Stubbe, M., Thissen, J.B.M, Vohralik, V. & Zima, J. (1999). The Atlas of European Mammals. Poyser/Academic Press, London, pp. 194-195.

Fletcher, J.D., Shipley, L.A, McShea, W.J. & Shumway, D.L. 2001. Wildlife herbivory and rare plants: the effects of white-tailed deer, rodents, and insects on growth and survival of Turk's cap lily (Abstract). Biological Conservation 101: 229-238.

Forstmeier, W. & Weiss, I. 2002. Effects of nest predation in the Siberian chipmunk on success of the dusky warbler breeding (Abstract). Zoologicheskii Zhurnal 81: 1367-1370.

Long J.L 2003. *Introduced Mammals of the World*: *Their history, distribution and influence*. CABI Publishing, Oxford.

Verbeyen, G. 2001. Investigation of the Asian chipmunk in De Panne (Belgium).
www.squirrelweb.co.uk/articles/aliens

Egyptian Goose *Alopochen aegyptiacus* BLACK LIST

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae
Quarantine Status: None; not CITES listed.
Description: Pale brown and grey goose with distinctive dark brown eye-patches; black tail; yellow eyes; bills, legs and feet are pink; length 68 cm, wingspan 144 cm, 1.7-2.1 kg.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Western, eastern and southern Africa. Freshwater wetlands.

Introduced Range: Widely introduced into western Europe, largest breeding concentrations in The Netherlands, Belgium, Germany and the UK.

England: Introduced as an ornamental wildfowl species and has escaped into the wild, now successfully breeding in a feral state (78-130 pairs); found mainly in East Anglia in parkland with lakes; at least 2,500-3,000 wintering birds.

BIOLOGY/ECOLOGY

General: Inhabits a wide range of freshwater wetlands in open country; gregarious except when nesting; nest in a variety of habitats, including dense vegetation on the ground, tree holes, or vacated nests previously used by other birds; diet - seeds, leaves, grasses, and plant stems, occasionally locusts, worms, or other small animals.

Movement and dispersal: Natural. Largely sedentary over much of its range although it may make seasonal nomadic or dispersive movements related to water availability.

RISK STATUS

Environmental Impact: Egyptian geese are very aggressive towards other bird species, which may prevent their establishment of territories; anecdotal reports of ousting barn owls from nest boxes. Can cause habitat damage and eutrophication where large roosting groups are present.

Invasion Stage (England): Self-sustaining localised breeding populations.

Introduction pathways: Self-sustaining localised populations; accidental and deliberate releases from captivity.

Control: Shooting; destruction of nests, eggs and nestling.

RISK CATEGORY

A_2 High/Locally Established

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. *Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update*. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J., & Rehfisch, M.M. 2000. *Review of the Status of Introduced Non-Native Waterbird Species in the Agreement Area of the African-Eurasian Waterbird Agreement Research Contract CR0219*. BTO Research Report No. 299, BTO, Thetford, Norfolk.

Eagle Owl *Bubo bubo* BLACK LIST

IDENTITY

Taxonomy: Aves, Strigiformes, Strigidae

Legal Status: Proposal for addition to Schedule 9 part I under Wildlife & Countryside Act 1981.

Description: Largest owl in Europe, *c*.69 cm in length, up to 200 cm wingspan. Large beak and talons; plumage mostly mottled; distinctive orange eyes and ear tufts.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Eurasia – North Africa, most of Europe (except some western and northern parts), to eastern Asia (except south-east), India, the Middle East and North Africa. Forests, steep rock and ravine regions, mountain cliffs.

Introduced Range: No details on introductions available. In the UK, however, eagle owls are very commonly kept in captivity; over 2,000 licences to keep pet eagle owls were applied for between 1998 and 2003.

England: Around 20 eagle owls were believed to be living wild in Britain. RSPB data records a maximum of three nesting pairs in any one year during 1984-2007; a number of sightings of long-staying birds in Yorkshire, Lancashire and Warwickshire.

BIOLOGY/ECOLOGY

General: Occurs singly or in pairs; sedentary. Diet - wide range of small mammals, game birds, wildfowl, gulls, other birds (including raptors), snakes, lizards, amphibians, fish, invertebrates.

Movement and dispersal: Natural – dispersal of young from existing breeding sites; young hatched in Catterick, North Yorkshire, have been relocated as far away as Shropshire and the Scottish Borders (*c*.275 km). Also, dispersal of new escapes/releases.

RISK STATUS

Environmental: Predates a wide range of vertebrates, including the young and adults of almost all European raptors, up to the size of (and including) female goshawk *Accipiter gentiles*.

Invasion Stage (England): A few breeding pairs and single birds in the wild; first breeding in 1996. Also present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes - trapping and shooting.

RISK CATEGORY

A_1 High/Isolated Populations

References

Holling, M. and the Rare Breeding Birds Panel 2007. Non-native breeding birds in the United Kingdom in 2003, 2004 and 2005. British Birds 100: 638-649.

Ogilvie, M. 2003. The Guardian, December.

Newton, I. 1979. *Population ecology of Raptors*. T. & A.D. Poyser, London.

Common Mynah *Acridotheres tristis* ALERT LIST

Indian mynah, House mynah

IDENTITY

Taxonomy: Aves, Passeriformes, Sturnidae

Quarantine Status: None; not CITES listed.

Description: Brown body, black hooded head, bare yellow patch behind the eye, under-tail coverts, tail tip and the outer feathers are white, bill, legs and feet are bright yellow; length *c.*25-26 cm; relatively heavy build.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: India and the Middle East; open countryside, close to human establishments.

Introduced Range: Widely introduced around the world; into many Pacific islands to control insect pest populations of commercially important crops; reports of breeding in northern France.

England: Absent.

BIOLOGY/ECOLOGY

General: Prefers modified habitat; communal roosts; cavity nester; pairs stay together returning to the same territory each year; distinctive in that they walk rather than hop; predominantly ground feeders; an adaptable omnivorous scavenger - invertebrates, fruit, grain, birds' eggs, small reptiles and food scraps.

Movement and dispersal: Natural, following escape or release. Sedentary throughout the year but can travel up to 12 km between roosts and feeding areas.

RISK STATUS

Environmental: Prey on the eggs and nestlings of other birds and aggressively defend territories and nesting sites. In Australia, compete with native birds and small mammals for nesting sites and consume their eggs and chicks; will even evict large birds, such as kookaburras and dollar birds and small mammals, such as sugar gliders, from their nests; also exhibit "mobbing" behaviour against birds or mammals. Known to spread avian malaria to other birds.

Invasion Stage (England): Absent; present in the pet trade.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Trapping, shooting, destruction of nests, eggs and nestling, poisoning.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Department of Agriculture and Food, Government of Western Australia. Animal Pest Alert. No 3/2008. Common Mynah.
http://www.agric.wa.gov.au/content/pw/vp/bird/CommonMyna_NHT.pdf

Long, J.L. 1981. Introduced Birds of the World. Universe Books, New York

http://www.issg.org/database/species/ecology.asp?fr=1&si=108

Sacred Ibis *Threskiornis aethiopicus* ALERT LIST

IDENTITY
Taxonomy: Aves, Ciconiiformes, Threskiornithidae
Legal Status: None; not CITES listed.
Description: Large, short-legged waterbird having white plumage and a sooty black, naked head and neck; length 65-90 cm, weight 1.5 kg.
Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION
Native Range: Africa from south-western Mauritania, Senegal and Gambia East to Somalia, and Ethiopia and South to South Africa; south-eastern Iraq. Coastal lagoons, marshes, damp lowlands and flooded agricultural areas.
Introduced Range: Feral breeding populations established in Spain, Italy, France and Canary Islands following escapes from captivity. Stray birds reported in other countries. Colonies have been established along the French Atlantic seaboard (*c.*1,100 breeding pairs in 2005).

England: The 30-odd UK records (pre-2000) were assessed as birds wandering from the French coastal colonies; but no information on how these birds were differentiated from potential escapees from captivity. Since 2000, there have been sightings along the Norfolk coast, Ramsgate, and inland in the Midlands, Norfolk and Yorkshire.

BIOLOGY/ECOLOGY
General: Gregarious; large colonies near waterways. Opportunistic diet - small animals, vertebrates and invertebrates; including small fish, insects and insect-larvae, amphibians and other small aquatic animals, carrion, bird eggs and nestlings; utilises garbage dumps.

Movement and dispersal: Natural, following escape or release within England; dispersal of feral birds from France.

RISK STATUS
Environmental: Predator of other birds (some of conservation concern); egg predation at colonies of various species of terns, also at nests of mallard, black-winged stilts, lapwings and cattle egrets; nest site competition with cattle and little egrets. Potential detrimental effects of observed predation on discrete populations of endangered amphibians, such as newts.
Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos and collections.
Introduction pathways: Accidental and deliberate releases from captivity; dispersal of feral birds from France.
Control: Effective captive enclosures; trapping, shooting; destruction of nests, eggs and nestlings.

RISK CATEGORY
$A_{0.5}$ High/Absent-Enclosed

References

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. *Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update*. BTO Research Report No. 489. British

Yesou, P. & Clergeau, P. 2006. Sacred Ibis: a new invasive species in Europe. Birding World 18(12): 517-526. www.birdingworld.co.uk/images/SacredIbises.pdf

Indian House Crow *Corvus splendens* ALERT LIST

IDENTITY

Taxonomy: Aves, Passeriformes, Corvidae

Legal Status: None; not CITES listed.

Description: Plumage glossy black, except for nape, sides of the head, upper back and breast, which are grey; bill, legs, and feet black; body length *c.*40 cm; weight *c.*245 to 370 g.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Indian sub-continent in sub-tropical and tropical lowlands and hills.

Introduced Range: Established breeding colonies in *c.*20 tropical and sub-tropical countries outside its native range, including in the Middle East, Africa, islands of the Indian Ocean and East Asia. Sightings of solitary birds have been reported from a further 12 countries, including County Waterford, Ireland (1974). More recently, has established and bred (1997) in The Netherlands, NW Europe.

England: Sighting of a single bird in 1997 on Bournemouth seafront (although possibly a mis-identifed hooded crow *Corvus cornix*.

BIOLOGY/ECOLOGY

General: Omnivorous, wide-ranging and opportunistic diet, consuming a variety of plants and animal species. Closely associated with people, inhabiting urban/semi-urban areas; takes advantage of scavenging opportunities provided by discarded food items and refuse dumps.

Movement and dispersal: Can spread via natural flight or ship-assisted transfer. The majority of new sightings are from ports and other coastal locations, supporting the view that most spread is ship-assisted; although some records may be attributable to deliberate releases or escapes of captive birds.

RISK STATUS

Environmental: Regarded as a widespread and notorious pest in Asia and Africa. It is a predator of eggs, chicks and adults of other bird species; causes displacement of indigenous bird species through competition and aggression.

Invasion Stage (England): Absent. Not traditionally kept as pets, but at least one known case of attempted breeding in captivity by private owner.

Introduction pathways: Ship-assisted transfer from The Netherlands or other country; if kept, accidental and deliberate releases from captivity**.**

Control: Trapping and shooting; destruction of nests, eggs and nestlings; poisoning.

RISK CATEGORY

A_0 High/Absent

References

Brook, B.W., Sodhi, N.S., Soh, M.C.K. & Lim, H.C. 2003. Abundance and projected control of invasive house crows in Singapore. Journal of Wildlife Management 67(4): 808-817.

Mullarney, K., O'Sullivan, O. & Lovatt, J.K. 2000. House Crow *Corvus splendens* in County Waterford - an addition to the Irish List. Irish Birds 6(3): 427-430.

Ottens, G. & Ryall, C. 2003. House Crows in the Netherlands and Europe. Dutch Birding 25(5): 312-319.

Ryall, C. 1994. Recent extensions of range in the House Crow *Corvus splendens*. Bulletin of the British Ornithologists' Club 114 (2): 90-100.

Yap, C.A.M. & Sodhi, N.S. 2004. Southeast Asian invasive birds: ecology, impact and management. Ornithol. Sci. 3: 57-67.

Barnacle Goose *Branta leucopsis* WATCH LIST

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae

Quarantine Status: Proposal for addition to Schedule 9 part I under Wildlife & Countryside Act 1981.

Description: Medium-sized goose, with black head, neck and breast with creamy-white face, which contrasts with the white belly, blue-grey barred back and black tail.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Greenland, Svalbard, Northern Russia, East Baltic.

Introduced Range: Introduced breeding populations in Austria, Belgium, France, Germany, The Netherlands, UK; also non-breeding birds in Finland, Norway, Switzerland.

England: In addition to the wild winter migrants there is a well-established naturalised population with a substantial and increasing number of breeding pairs; in mainland Britain at least 1,000 naturalised birds are thought to be present; widely distributed with reports from 14 counties. Key areas include coastal Suffolk, Hornsea Mere in Humberside, the Willington area of Bedfordshire, and Eversley Cross in Hampshire.

BIOLOGY/ECOLOGY

General: In the native range its breeding habitat is on crags and rocky outcrops in Arctic tundra; over-wintering on coastal lowland meadows and grassland in northern Europe. Naturalised birds in England have adapted to breeding at ponds, pools and gravel pits. Herbivorous – grazing on coastal, riverine and agricultural grasslands.

Movement and dispersal: Natural dispersal from existing sites and following escape or release.

RISK STATUS

Environmental Impact: In Belgium they have been shown to damage small ponds or shallow mesotrophic waterbodies by faecal deposition and by overgrazing of aquatic vegetation. Known to breed with other introduced geese, potential for hybridisation with native species.

Invasion Stage (England): Self-sustaining localised populations.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Trapping, shooting, destruction of nests, eggs and nestling.

RISK CATEGORY

B_2 Medium/Locally Established

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J., & Rehfisch, M.M. 2000. *Review of the Status of Introduced Non-Native Waterbird Species in the Agreement Area of the African-Eurasian Waterbird Agreement Research Contract CR0219*. BTO Research Report No. 299, BTO, Thetford, Norfolk.

Bar-headed Goose *Anser indicus* WATCH LIST

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae

Quarantine Status: Proposal for addition to Schedule 9 part I under Wildlife & Countryside Act 1981.

Description: Pale grey and easily distinguished from other *Anser* species by the two distinctive black bars on its head.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Central and southern Asia.

Introduced Range: Introduced in several countries in Europe for ornamental purposes where the largest populations are in The Netherlands and Belgium - likely to be forming established and self-sustaining populations; also present in France and Germany.

England: Bar-headed geese are commonly kept in ornamental waterfowl collections and birds seen in the UK are all escapees; currently around 100 widely dispersed individuals in the UK, and *c*.10 pairs breeding annually. In 2006/07 WeBS, bar-headed geese were recorded at 45 sites throughout GB; the highest number (12) were recorded at Deben estuary, Suffolk.

BIOLOGY/ECOLOGY

General: From their native breeding grounds they migrate over the Himalayas to over-winter in India and northern Burma. During the breeding season, bar-headed geese live near mountain lakes and prefer areas with short grass. In winter they graze in areas cultivated for wheat, barley and rice crops; the diet occasionally includes crustaceans and invertebrates.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Potential aggression toward native species, and potential for hybridisation. It is considered that the establishment of large breeding populations would impact detrimentally on smaller waterbirds.

Invasion Stage (England): Approximately 10 breeding pairs and *c*.100 individuals widely dispersed in the UK; also present in waterfowl collections, occasional escapes.

Introduction pathways: Deliberate and accidental releases from captivity, including deliberate introductions into parks for ornamental purposes.

Control: Trapping, shooting, destruction of nests, eggs and nestling.

RISK CATEGORY

B_1 Medium/Isolated Populations

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J., & Rehfisch, M.M. 2000. *Review of the Status of Introduced Non-Native Waterbird Species in the Agreement Area of the African-Eurasian Waterbird Agreement Research Contract CR0219*. BTO Research Report No. 299, BTO, Thetford, Norfolk.

Black Swan *Cygnus atratus* WATCH LIST

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae.

Quarantine Status: Proposal for addition to Schedule 9 part I under Wildlife & Countryside Act 1981.

Description: Mostly black, with the exception of broad white wing tips, bill is a deep orange-red, paler at the tip, with a distinct narrow white band towards the end; body length up to 142 cm.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Throughout Australia with the exception of Cape York Peninsula, and are more common in the south. Prefer larger salt, brackish or fresh waterways and permanent wetlands.

Introduced Range: Widely introduced throughout Europe as an ornamental species. Increasing breeding populations in Belgium, The Netherlands, France, Italy and the UK.

England: In 2006/07 WeBS, black swans were recorded at 73 sites across GB; the majority of records were of single birds; 16 sites held peak counts of three or more birds.

BIOLOGY/ECOLOGY

General: Territorial and stay in solitary pairs when mating but are known to occasionally mate in colonies; diet - herbivorous, eating aquatic vegetation, also terrestrial plants in pastures or on farm land.

Movement and dispersal: Natural dispersal from existing sites and following escape or release of captive birds.

RISK STATUS

Environmental Impact: Very aggressive towards other swan species; can hybridise with mute swans; consumption of native aquatic plants; flocks can cause water quality problems.

Invasion Stage (England): Small breeding population (11-16 pairs) and c.150 individuals UK-wide.

Introduction pathways: Localised breeding pairs; accidental and deliberate releases from captivity.

Control: Shooting; destruction of nests, eggs and nestling.

RISK CATEGORY

B_1 Medium/Isolated Populations

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J., & Rehfisch, M.M. 2000. *Review of the Status of Introduced Non-Native Waterbird Species in the Agreement Area of the African-Eurasian Waterbird Agreement Research Contract CR0219*. BTO Research Report No. 299, BTO, Thetford, Norfolk.

Ruddy Shelduck *Tadorna ferruginea* WATCH LIST

Brahminy duck

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae

Quarantine Status: Proposal for addition to Schedule 9 part I under Wildlife & Countryside Act 1981.

Description: Orange brown duck with a buff coloured head, black primaries; male develops a black collar in breeding season.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Northern Africa, Eastern Mediterranean, Asia.

Introduced Range: Introduced breeding populations in Austria, Belgium, France, Germany, Netherlands, Switzerland and Ukraine.

England: Occasional records. Highest monthly count in 2006/07 WeBS was 10, five of which were on North Norfolk coast.

BIOLOGY/ECOLOGY

General: Mainly nocturnal; dispersed in pairs during the breeding season, although may form small nesting groups; congregates into larger flocks during the autumn and winter, but is more characteristically found in scattered small flocks; less dependent upon large water bodies for resting and feeding than most other Anatidae; omnivorous - grain, vegetable shoots, tubers, aquatic insects, molluscs, worms, small fish, amphibians, reptiles omnivorous.

Movement and dispersal: Natural dispersal from existing sites and following escape or release.

RISK STATUS

Environmental Impact: Potential displacement of native species and nest-site competition with native cavity nesters (e.g. kestrel, barn owl); possible hybridisation with common shelduck.

Invasion Stage (England): Occasional breeding, 3-5 pairs; present in waterfowl collections.

Introduction pathways: Deliberate and accidental releases from captivity.

Control: Trapping, shooting, destruction of nests, eggs and nestling.

RISK CATEGORY

B_1 Medium/Isolated Populations

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J .& Rehfisch, M.M. 2000. Review of the status of introduced non-native waterbird species in the Agreement area of the African-Eurasian Waterbird Agreement. British Trust for Ornithology, Thetford.

http://www.birdlife.org/datazone/species/index.html?action=SpcHTMDetails.asp&sid=397&m=0

Upland Goose *Chloephaga picta* WATCH LIST

Magellan goose

IDENTITY

Taxonomy: Aves, Anseriformes, Anatidae

Quarantine Status: None; not CITES listed.

Description: Male is white with black or black and white tail and black bars on underparts; female has rusty-brown head and neck, brown breast and flanks barred black.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: South America, Falkland Islands. Lagoons, rivers and coasts, also semi-arid grasslands away from coast.

Introduced Range: Belgium, Netherlands, UK.

England: Occasional escapes and records; has bred in the UK in the past.

BIOLOGY/ECOLOGY

General: Small flocks but up to 100 outside breeding season; partially migratory and sedentary; herbivorous – grass and other vegetation.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Aggressive towards other bird species and thought to displace native waterbirds. In Belgium, may contribute to eutrophication and habitat damage caused by introduced geese.

Invasion Stage (England): Occasional records.

Introduction pathways: Accidental or deliberate releases from captivity.

Control: Trapping, shooting, destruction of nests, eggs and nestling.

RISK CATEGORY

$B_{0.5}$ Medium/Enclosed

References

Austin, G., Collier, M., Calbrade, N., Hall, C. & Musgrove, A. 2008. Waterbirds in the UK 2006/07 The Wetland Bird Survey. British Trust for Ornithology, Wildfowl & Wetlands Trust, Royal Society for the Protection of Birds and Joint Nature Conservation Committee.

Banks, A.N., Wright, L.J., Maclean, I.M.D., Hann, C. & Rehfisch, M.M. 2008. Review of the status of introduced non-native waterbird species in the area of the African-Eurasian waterbird agreement: 2007 update. BTO Research Report No. 489. British Trust for Ornithology, Thetford, Norfolk.

Blair, M.J., McKay, H., Musgrove, A.J .& Rehfisch, M.M. 2000. Review of the status of introduced non-native waterbird species in the Agreement area of the African-Eurasian Waterbird Agreement. British Trust for Ornithology, Thetford.

http://www.birdlife.org/datazone/species/index.html?action=SpcHTMDetails.asp&sid=397&m=0

Long, J.L. 1981. Introduced Birds of the World. David & Charles, London

Alexandrine Parakeet *Psittacula eupatria*

Large parakeet, Great-billed parakeet

IDENTITY

Taxonomy: Aves, Psittaciformes, Psittacidae

Quarantine Status: CITES Appendix II.

Description: Mainly green, body length 56-62 cm; 250-260g. The male's head is green with grey-blue cheeks and nape; broad black neck ring and broad pink nape band; bill is red. Females and young birds lack the black neck ring and pink nape band and are duller.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Southern Asia: Sri Lanka to eastern Afghanistan and western Pakistan to Indochina and the Andaman Islands. Jungle, forest, mangroves, wooded country, cultivated farmland, parks, gardens, plantations, villages and urban areas.

Introduced Range: Pakistan and India; a favourite pet bird in India and Thailand; populations around major cities (e.g. Karachi and Bombay) may have originated from escapes.

England: Breeding Alexandrine parakeets have been recorded in three locations. In 2002, two nests producing hybrid young (Alexandrine x ring-necked) were recorded in Sidcup, Kent. Three Alexandrine parakeets and three hybrids were reported regularly at the ring-necked parakeet roost in Lewisham. The roost was believed to hold all Alexandrine parakeets living in south-east London. A colony of up to 12 Alexandrine parakeets was present in Fazackerley, Merseyside. But in 1998 many of these birds were shot. In 1999, however, a surviving pair successfully bred. A pair also successfully fledged young in Foots Cray Meadows, Kent, during 2001. Current status unknown.

BIOLOGY/ECOLOGY

General: Gregarious and noisy species, forming large flocks at evening roosts; mainly sedentary but with some nomadic movements. Diet - seeds, nuts, berries, fruits, blossom, grain, leaf buds and nectar.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Consumption and damage to orchard fruit and ripening crops, such as maize, wheat and rice. Potential competition for food resources with native species.

Invasion Stage (England): Sporadic incidences of single birds, small groups and breeding in the wild. Present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity.

Control: Effective captive enclosures; escapes – trapping, shooting, destruction of nests, eggs and nestling

RISK CATEGORY

$C_{0.5}$ Low/Enclosed

References

Butler, C., Hazlehurst, G. & Butler, K. 2002. First nesting of Blue-crowned Parakeet in Britain. British Birds 95: 17-20.

Marsh Frog *Pelophylax (Rana) ridibundus* BLACK LIST

IDENTITY

Taxonomy: Amphibia, Anura, Ranidae

Quarantine Status: Defra proposal for a ban on sale.

Description: Largest native European frog, adults up to 15 cm; generally dark green to black with dark spot on the back and sides and three clearly green lines on the back.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Central and eastern Europe and in the Chinese province of Xinjiang.

Introduced Range: Belgium, Spain, Switzerland, UK,

England: Translocated, in 1935, from Hungary into Romney, Kent; later (1973) translocated from Romney to Sussex. Now found in several areas of Kent and East Sussex; other colonies in southwest and west London and in south-west England.

BIOLOGY/ECOLOGY

General: Semi-aquatic, inhabiting (and breeding in) a wide variety of flowing and stagnant water habitats, from shallow puddles and ponds to large lakes, reservoirs, rivers and brooks; choose breeding sites such as dykes and ditches not generally chosen by UK's native amphibians; diet - dragonflies and other insects, spiders, earthworms and slugs; larger frogs also eat mice, and sometimes salamanders and fish.

Movement and dispersal: Natural dispersal from existing populations and following new introductions.

RISK STATUS

Environmental Impact: An aggressive competitor; displaces native frog species - females produce more progeny that grow faster and compete for food; hybridogenesis within the green frog complex (i.e. marsh, green and pool frogs) – marsh frog progeny produced from hybrid matings; possible reservoir of West Nile Virus disease (Russia). Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians.

Invasion Stage (England): Dispersed localised populations.

Introduction pathways: Dispersal from established populations; accidental or deliberate releases from captivity - present in the pet trade.

Control: Physical removal of adults and spawn.

RISK CATEGORY

A_2 High/Locally Established

References

Fisher, M.C & Garner, T.W.J. 2007. The relationship between the emergence of *Batrachochytrium dendrobatidis*, the international trade in amphibians and introduced amphibian species. Fungal Biology Reviews 21:2-9.

Froglife 1997. Exotic reptiles and amphibians in the wild. Froglife Advice Sheet 8. Halesworth.

Zeisset, I. & Beebe, T.J.C. 2003. Population genetics of a successful invader: the marsh frog *Rana ridibunda* in Britain. Molecular Ecology 12: 639-646.

http://www.nonnativespecies.org/documents/Marsh_Frog.pdf
http://www.iucnredlist.org/details/58705
http://www.herpetofauna.co.uk/marsh_frog.htm
http://www.ufz.de/index.php?en=15606
http://www.naturalengland.org.uk/Images/speciesherpetofaunard_tcm6-4619.pdf

North American Bullfrog *Rana Catesbeiana* BLACK LIST

Bullfrog

IDENTITY

Taxonomy: Amphibia, Anura, Pipidae.

Quarantine Status: Ban on import into EC in 1997; although the ban did not affect the sale of the species within the UK. Defra proposal for a ban on sale (2007 consultation).

Description: Largest North American frog; adults 10-20cm and 60-900g; dorsal colour is light green to olive to brownish-green; ventral surface mostly white; conspicuous eardrums.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Central and eastern USA and southeastern Canada. Lakes, water courses, wetlands.

Introduced Range: Hawaii, parts of western USA and southwestern Canada, Mexico and the Caribbean, South America, Europe and Asia.

England: Since 1999, Natural England (NE) has been controlling bullfrogs at a breeding site in Kent: around 12,000 bullfrogs (mostly tadpoles) have been removed; only one has been reported (and removed) in the last two years. Bullfrogs were reported at another site in southern England in late June 2006; NE initiated control in early August.

BIOLOGY/ECOLOGY

General: Highly aquatic; prefers water with thick aquatic vegetation. Nocturnal but calling also commonly occurs during the day. Winters at the bottom of water bodies. Diet - aquatic, terrestrial and flying invertebrates and vertebrates, including small birds and mammals.

Movement and dispersal: Natural dispersal from existing populations and new introductions; uses ditches and streams as corridors; capable of considerable overland travel.

RISK STATUS

Environmental Impact: Predation and competition. Adults are voracious opportunistic predators and will eat almost any animal it can overpower and swallow whole; tadpoles prey on the tadpoles of other species. Implicated in declines of native herpetofauna from native and introduced range. Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians.

Invasion Stage (England): The only two known breeding populations have been either removed or control is ongoing. Potentially still imported (illegally) for the pet trade.

Introduction pathways: Dispersal from established populations (if not controlled); accidental or deliberate releases from captivity.

Control: Fencing ponds; trapping; physical removal of adults and spawn; habitat drainage shooting.

RISK CATEGORY

A_1 High/Isolated Populations

References

Kraus, F. 2009. Alien Reptiles and Amphibians; A Scientific Compendium and Analysis. Springer Science and Business Media B.V.

www.nonnativespecies.org/01_Fact_File/05_Fact_Sheets/American_Bullfrog.cfm?tvk=NBNSYS0000041453
www.issg.org/database/species/ecology.asp?fr=1&si=80
www.snh.org.uk/press/detail.asp?id=762

African Clawed Toad *Xenopus laevis* BLACK LIST

Common platanna

IDENTITY

Taxonomy: Amphibia, Anura, Pipidae.

Quarantine Status: Defra proposal for a ban on sale.

Description: Distinctive flattened body and head profile; powerful looking hind limbs, dorsal colour is brown or grey, often with dark spots or blotches; adults 12 cm or more.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: South Africa. Lakes, water courses, wetlands.

Introduced Range: Pan global introductions for laboratory research and later as a pet.

England: Past colonies in Isle of Wight, South Wales and Lincolnshire.

BIOLOGY/ECOLOGY

General: Very aquatic and rarely seen out of water; a very wide range of habitats, including heavily modified anthropogenic habitats; high reproductive potential; capable of aestivation during dry periods; high environmental tolerance; diet - aquatic invertebrates, amphibians and fish, terrestrial prey, cannabalism of larvae.

Movement and dispersal: Natural dispersal from existing populations and following new introductions; overland as well as through water.

RISK STATUS

Environmental Impact: Predation of native amphibians, invertebrates and fish; capable of taking terrestrial prey. Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians. Also known to make water bodies turbid.

Invasion Stage (England): Restricted localised populations; present in trade for biomedical research and pets.

Introduction pathways: Dispersal from established populations; accidental or deliberate releases from captivity.

Control: Poisoning and habitat drainage, trapping; physical removal of adults and spawn.

RISK CATEGORY

A_1 High/Isolated Populations

References

Fisher, M.C & Garner, T.W.J. 2007. The relationship between the emergence of *Batrachochytrium dendrobatidis*, the international trade in amphibians and introduced amphibian species. Fungal Biology Reviews 21:2-9.

Froglife 1997. Exotic reptiles and amphibians in the wild. Froglife Advice Sheet 8. Halesworth.

http://www.herpetofauna.co.uk/african_clawed_toad.htm

http://www.issg.org/database/species/ecology.asp?si=150

http://www.iucnredlist.org/details/58174

http://www.naturalengland.org.uk/Images/speciesherpetofaunard_tcm6-4619.pdf

Midwife Toad *Alytes obstetricans* WATCH LIST

IDENTITY

Taxonomy: Amphibia, Anura, Discoglossidae

Quarantine Status: None; not CITES listed.

Description: Generally small and squat, with large head; dorsal surface usually a drab grey or brown occasionally spotted with dark green; average body size 5 cm.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Western Europe, northern Africa and Majorca.

Introduced Range: UK.

England: Isolated introductions into Bedfordshire, Yorkshire, Northamptonshire, Hampshire, Devon and South-West London.

BIOLOGY/ECOLOGY

General: Nocturnal ground dwellers; prefer permanent bodies of water, such as ponds and streams; larvae often overwinter; males care for the eggs by attaching them to their legs during amplexus and carrying them until they eggs hatch; diet - insects, arthropods, isopods, and snails.

Movement and dispersal: Natural dispersal from existing populations and following new introductions.

RISK STATUS

Environmental Impact: Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians.

Invasion Stage (England): Localised populations, pet trade.

Introduction pathways: Accidental and deliberate releases from captivity; transported in plant cargo.

Control: Physical removal of adults and spawn.

RISK CATEGORY

B_1 Medium/Isolated Populations

References:

Fisher, M.C & Garner, T.W.J. 2007. The relationship between the emergence of *Batrachochytrium dendrobatidis*, the international trade in amphibians and introduced amphibian species. Fungal Biology Reviews 21:2-9.

Froglife 1997. Exotic reptiles and amphibians in the wild. Froglife Advice Sheet 8. Halesworth.

http://www.herpetofauna.co.uk/midwife_toad.htm

http://www.iucnredlist.org/details/55268

Cane Toad *Bufo marinus*

CLIMATE LIST

Marine toad, Giant toad

IDENTITY

Taxonomy: Amphibia, Anura, Bufonidae.

Quarantine Status: None; not CITES listed.

Description: Heavily built with short legs; up to 15 cm; adults have a rough, warty skin, coloured tan, brown or dark brown, dull green or black; tympanum is distinct; dry warty skin.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Northern South America, Central America, and Mexico northward to extreme southern Texas.

Introduced Range: Introduced to many regions of the world, particularly the Pacific, for the biological control of agricultural pests, including Australia, Hawaii, Puerto Rica, Martinique, Barbados, Jamaica and Fiji.

England: Absent from the wild; present in the pet trade.

BIOLOGY/ECOLOGY

General: Nocturnal and terrestrial toad; occasionally found in pristine lowland and montane rainforests but thrives in degraded habitats and man-made environments; diet - any prey that it can consume, including reptiles, amphibians small mammals and insects; high fertility and environmental tolerance.

Movement and dispersal: Natural - primarily by adults hopping large distances; in Australia their range is expanding by 1.3 km a year, also transported accidentally on vehicles.

RISK STATUS

Environmental Impact: Voracious predator of native species. Cane toads have venomous glands, and can poison native predators that attack them – in Australia this has caused a decline in numerous snakes and mammals. Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians. Introduced animals are carrying salmonella in Puerto Rico

Invasion Stage (England): Absent. Present in the pet trade. Establishment in England is currently unlikely due to the species climate requirements. Recent research in Australia has shown that the toad requires temperatures above 15^{o}C to maintain activity.

Introduction pathways: Deliberate or accidental releases from captivity.

Control: Quarantine checks and public awareness and response; physical exclusion of adults from sites; physical removal of spawn and adults.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Fisher, M.C & Garner, T.W.J. 2007. The relationship between the emergence of *Batrachochytrium dendrobatidis*, the international trade in amphibians and introduced amphibian species. Fungal Biology Reviews 21:2-9.

Kearney, M., Philips, B.L., Tracy, C.R., Christian, K.A., Betts, G. & Porter, W.P. 2008. Modelling species distributions without using species distributions: the cane toad in Australia under current and future climates. Ecography 31: 423-434.

http://www.environment.gov.au/biodiversity/invasive/publications/cane-toad/pubs/cane-toad.pdf

http://www.iucnredlist.org/details/41065

http://www.issg.org/database/species/ecology.asp?si=113&fr=1&sts=&lang=EN

Cuban Tree Frog *Osteopilus septentrionalis* CLIMATE LIST

IDENTITY

Taxonomy: Amphibia, Anura, Hylidae.

Quarantine Status: None; not CITES listed.

Description: Largest tree frog in North America, reaching an adult size of 15 cm; brown, grey to yellow-green, often marbled or striped patterning; large eyes and sticky toe pads for climbing.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Cuba and nearby islands. Sub-tropical.

Introduced Range: Throughout the Caribbean and into southern Florida.

England: Absent. Present in pet trade.

BIOLOGY/ECOLOGY

General: Nocturnal; spends most of its time in trees or very large plants; in Florida they are found throughout a variety of natural and human-modified habitats; requires high temperature and humidity; diet - snails, millipedes, spiders, insects, native frogs, lizards, small snakes and are cannibalistic.

Movement and dispersal: Natural; accidental transport via vehicles and plant produce.

RISK STATUS

Environmental Impact: Predator of native amphibians. Carrier of chytridiomycosis a disease caused by the fungus *Batrachochytrium dendrobaditis* and can kill native amphibians.

Invasion Stage (England): Absent. Present in the pet trade. Establishment in England is currently unlikely as the species climate requirements – presently they are found only where temperatures fall no lower than 10°C, with daytime temperatures between 23°-29°C.

Introduction pathways: accidental transport in shipping; accidental and deliberate releases from captivity - present in pet trade.

Control: Physical removal and euthanasia of adult frogs.

RISK CATEGORY

$B_{0.5}$ Medium/Absent-Enclosed

References
http://edis.ifas.ufl.edu/UW259
http://www.iucnredlist.org/details/55811

Common Snapping Turtle *Chelydra serpentine* BLACK LIST
Alligator Snapping Turtle *Macrochelys temminckii*

IDENTITY

Taxonomy: Reptilia, Testudines, Chelydridae

Quarantine Status: *Macrochelys temminckii* CITES Appendix II.

Description: Very large freshwater turtles; large head, long thick spiky tail; can grow to an adult shell length of typically 40-50 cm (common) 60 cm (alligator) and a weight in excess of 76 kg. Common snapping turtle *Chelydra serpentine* has smooth carapace, the alligator snapping turtle *Macrochelys temminckii* has three distinct rows of spiny ridges.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: *C. serpentine* is found in N. America, Central America, and S. America, from southern Canada to Ecuador; inhabit shallow ponds or lakes, or streams, also brackish water, such as estuaries. *M. temminckii.* are native to slow-moving bodies of water in Georgia and southeastern USA, with a range extending along the Mississippi River as far north as Iowa.

Introduced Range: Reported from the Rio Grande in New Mexico, California, Oregon and Washington. No information available on the extent of its global introduction in zoological collections or in the pet trade.

England: Occasional individuals present in ponds in parts of England.

BIOLOGY/ECOLOGY

General: For the most part, snapping turtles remain in the water, rarely basking on the shore or other substrate. Omnivorous - consuming both plant and animal matter, and are important aquatic scavengers; also active hunters that prey on anything they can swallow, including invertebrates, fish, frogs, reptiles (including snakes and smaller turtles), birds and small mammals. Very long-lived species (*M. temminckii* up to 70 years in captivity).

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Predates native amphibians, waterfowl, other small birds and fish.

Invasion Stage (England): Individuals present in ponds in parts of England. Generally, it is believed that summer temperatures in the UK may not be sufficiently warm to regularly allow successful breeding. The incubation temperature of the egg determines the sex of hatchlings, for *C. serpentine* both extremes of warm (above 30°C) and cool (20°C) temperatures produced mainly females while intermediate (22-28°C) temperatures produced mainly males.

Introduction pathways: Accidental and deliberate release of captive individuals. Localised individuals could become source of growing population if climatic conditions became favourable.

Control: Trapping - floating basking traps and floating baited traps.

RISK CATEGORY

A_1 High/Isolated Populations

References

http://www.britishcheloniagroup.org.uk/testudo/v2n3sex.html

Red-eared Terrapin *Trachemys scripta elegans* BLACK LIST

Red-eared slider

IDENTITY

Taxonomy: Reptilia, Testudines, Emydidae

Quarantine Status: Import ban under European Wildlife Trade Regulations **(**EC Regulation 2551/97); but movement and sale within EU is not prohibited. Defra proposal for a ban on sale.

Description: Freshwater turtle with distinctive red flashes on the side of the head; average length of females is 20 cm and males 12-13 cm.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Mississippi Valley area of the United States; lakes, water courses, wetlands; fresh and brackish waters, including coastal marsh ponds.

Introduced Range: Introduced and established in many parts of the world, including Europe, Australia and Asia, via the pet trade.

England: Individuals present in over 100 sites in England.

BIOLOGY/ECOLOGY

General: Prefers larger bodies of quiet water with soft bottoms, an abundance of aquatic plants and suitable basking sites; diet – omnivorous, insects, crayfish, shrimp, worms, snails, amphibians and small fish, as well as aquatic plants.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Predates native amphibians, waterfowl, other small birds and fish.

Invasion Stage (England): Individuals present in ponds in many parts of England. Generally, it is believed that summer temperatures in the UK may not be sufficiently warm to regularly allow successful breeding - red-eared terrapins have a pivotal egg incubation temperature of *c*.29°C, below which only male offspring are produced and above which only females. Global warming could alter this situation, while local microclimates (e.g. heated water outlets and compost heaps) could allow occasional successful breeding. There has been one recorded case of a viable clutch of eggs - unearthed in Hampstead Heath in London (discovered and removed before hatching).

Introduction pathways: During the late 1970s and early 1980s red-eared terrapins were the most commonly traded reptiles in the UK with around 33,000 imported each year; many of these pets became unwanted and were released into the wild. Many localised individuals present that could become source of growing population if climatic conditions became favourable. Although now under an EU import ban, they are still a common pet.

Control: Trapping - floating basking traps and floating baited traps.

RISK CATEGORY

A_1 High/Isolated Populations

References

Froglife 1997. Exotic reptiles and amphibians in the wild. Froglife Advice Sheet 8. Halesworth.
http://www.issg.org/database/species/ecology.asp?si=71&fr=1&sts=sss&lang=EN
http://www.naturalengland.org.uk/Images/speciesherpetofaunard_tcm6-4619.pdf

Rat Snakes and King Snakes *Elaphe & Lampropeltis spp* WATCH LIST

IDENTITY

Taxonomy: Reptilia, Squamata, Colubridae

Quarantine Status: None

Description: The family Colubridae, or 'back-fanged' snakes, is a broad classification of snakes that includes well over half of all snake species; most of these are non-venomous, harmless, temperate-to-tropical terrestrial, arboreal or aquatic snakes. A number of genera are very popular with herpetoculturists, including *Elaphe* and *Lampropeltis*, which include the most common pet species the corn snakes and kingsnakes.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: North America. Corn snakes - south-eastern and central United States. Kingsnakes have largest natural geographical range of any land snake - from southeastern Canada to Ecuador.

Introduced Range: No information on introductions available. However, corn snakes and king snakes are very popular as pets and as such will have been introduced widely around the world.

England: A member of the *Elaphe* genus, the Aesculapian snake, has established a self-sustaining colony in North Wales since the 1970s**.** There are also anecdotal reports of individuals of this species in central London (2007).

BIOLOGY/ECOLOGY

General: Corn snakes prefer habitats such as overgrown fields, forest openings, trees, and abandoned or seldom-used buildings and farms; they are constrictors with a diet primarily consisting of rodents, mostly mice and rats. Kingsnakes occupy a diversity of habitats, ranging from deserts to riverine wetlands, from valleys to rolling hills, from coastal estuaries to grasslands, from shrublands to forested mountain foothills; diet - small mammals, birds, snakes, lizards, amphibians, and bird eggs.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Predates a range of small mammals, birds, amphibians and reptiles.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets. Corn and king snakes are the most commonly owned pet snakes; like some other Colubrids they are adapted to a temperate climate.

Introduction pathways: Accidental and deliberate releases from captivity. The Colubrid Aesculapean snake successfully established following escape from captivity.

Control: Trapping.

RISK CATEGORY

$B_{0.5}$ Medium/Absent-Enclosed

References

http://www.kingsnake.com/ratsnake/corn.htm
http://nationalzoo.si.edu/Animals/ReptilesAmphibians/Facts/FactSheets/Commonkingsnake.cfm
http://nationalzoo.si.edu/Animals/ReptilesAmphibians/Facts/FactSheets/Cornsnake.cfm

Burmese Python *Python* molurus bivittatus

CLIMATE LIST

IDENTITY

Taxonomy: Reptilia, Squamata, Boidae

Quarantine Status: CITES Appendix II.

Description: Largest subspecies of the Indian python and one of the six largest snakes in the world; typically grows 18-33 ft. in length and weighs 200-300 lbs; light coloured with many dark brown blotches bordered in black down the back; they are constrictors.

Signs & Symptoms: NA

GEOGRAPHICAL DISTRIBUTION

Native Range: Throughout southeast Asia including Myanmar (formerly Burma), Thailand, Vietnam, China, and Indonesia. It lives in grasslands, swamps, marshes, rocky foothills, woodlands, jungles and river valleys, and requires a permanent water source.

Introduced Range: Southern Florida (USA) and Puerto Rico.

England: Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets.

BIOLOGY/ECOLOGY

General: Mainly nocturnal; diet - includes a wide range of birds and mammals; an excellent swimmer and good climber.

Movement and dispersal: Natural, following escape or release.

RISK STATUS

Environmental Impact: Threatens native species of amphibians, birds, lizards, snakes, and bats by predation, competition, and disease transmission. In the Everglades National Park, USA, hundreds of accidentally and intentionally released pet Burmese pythons have been captured and removed in recent years - it is recognised that pythons have the potential to adversely impact on valued resources, including state and federally listed native species.

Invasion Stage (England): Absent from the wild. Present in enclosed environments – zoos, collections and domestic pets.

Introduction pathways: Accidental and deliberate releases from captivity - commonly sold in the exotic pet trade. In the UK, the colder climatic conditions compared to its native range means that these animals are presently unlikely to flourish in the wild. However, it cannot be ruled out that individuals may survive in more clement regions of the UK, with periods of torpor or hibernation during colder periods; a scenario which may become more of a possibility in the event of climate warming.

Control: Radio tracking, pheromone lures, traps, hand capture and locator dogs have been employed in Florida.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Snow, R. 2007. Disposable pets, unwanted giants: pythons in Everglades National Park (Abstract). International Symposium: Managing Vertebrate Invasive Species, August 7-9, Hilton Fort Collins, Fort Collins, Colorado, USA.

http://www.issg.org/database/species/ecology.asp?si=1207&fr=1&sts

Gypsy Moth *Lymantria dispar* BLACK LIST

IDENTITY

Taxonomy: Insecta, Lepidoptera, Lymantriidae

Quarantine Status: None

Description: Adults sexually dimorphic. Females larger (31-35mm) than males (20-24mm) with black and white wings; males have less distinct markings on a brown background. Male antennae are very feathery. Yellow-brown egg masses, 3-4 cm long. Caterpillars (4.5-7 cm) very distinctive, with red and blue, paired dorsal warts.

Signs & Symptoms: Severe defoliation can occur. Larger larvae feed at night and shelter lower down on the trunk of the tree or in leaf litter during the day.

GEOGRAPHICAL DISTRIBUTION

Native Range: Widespread from Western Europe throughout Asia to Japan.

Introduced Range: North America

England: The indigenous British strain was last recorded at Wicken Fen in 1907. Reappeared in 1995 in NE London where it has persisted. More recently, found in Jersey (2002) and Guernsey (2003), Aylesbury, Bucks (2005) and several parks in central London (2006).

BIOLOGY/ECOLOGY

General: Caterpillars emerge from the eggs in the spring and develop through 5 to 6 moults; adults occur from late July onwards; egg masses present from September to April.

Movement and dispersal: Active dispersal by flying males and 'ballooning' first instar caterpillars on strands of silk. Females of the Asian strain fly readily.

RISK STATUS

Environmental Impact: Preferred trees are *Quercus* spp., but larvae will eat many broadleaved trees, and even some coniferous ones. Climatic conditions in the UK are probably unfavourable for the massive *L. dispar* outbreaks (and severe defoliation of trees) that occur cyclically on the continent. Nevertheless, *L. dispar* could probably colonise large areas of southern England and sporadic outbreaks may occur causing damage to amenity trees.

Invasion Stage (England): Isolated outbreaks.

Introduction Pathways: Females lay their eggs on any substrate, including vehicles (car tyres) and wood, so inadvertent introductions and spread by Man are possible.

Control: Destruction of egg masses, spraying of larvae with insecticide and pheromone trapping of adults (including mating disruption and mass trapping).

RISK CATEGORY

A_2 High/Locally Established

References
Anon. 2008. USDA Gypsy moth programme manual.
http://www.aphis.usda.gov/

Emerald Ash Borer *Agrilus planipennis* ALERT LIST

IDENTITY

Taxonomy: Insecta, Coleoptera, Buprestidae

Quarantine Status: EC listing: will be listed from April 2009 as IIA1; EPPO listing: A1

Description: Adults are 8.5-14.0 mm long and 3.1-3.4 mm wide, wedge shaped and metallic blue green with a fine dense sculpture. The eyes are kidney shaped and bronze coloured.

Signs & Symptoms: Larvae feeding cause general yellowing and thinning of the foliage, dying of branches, crown dieback and death of the tree after 2 to 3 years of infestation.

GEOGRAPHICAL DISTRIBUTION

Native Range: NE China, Japan, Korean Rep., Mongolia, Russia (far East) and Taiwan.

Introduced Range: USA, Canada and Russia (around Moscow).

England: Not intercepted in UK.

BIOLOGY/ECOLOGY

General: In China, *A. planipennis* typically has one generation per year, but it the generation time may be two years in colder areas. Larvae burrow through the bark after hatching and feed on the cambium. Adults appear from mid-May to late July and feed on ash foliage. Hosts include *Fraxinus americana*, *F. nigra* and *F. pennsylvanica*. In the Moscow region, nearly all of the infestations were observed on *F. pennsylvanica*, but there has been at least one case of *A. planipennis* having killed a *F. excelsior*.

Movement and dispersal: *A. planipennis* adults are strong fliers flights of more than 1 km are also possible. Also, the adults are small and subject to dispersal by air currents.

RISK STATUS

Environmental Impact: If *A. planipennis* became a significant pest on *F. excelsior*, losses of complete stands are likely to lead to impacts on the soil and on the general biodiversity of the affected area. *Fraxinus* sp. make up 15% of all broadleaved woodland in the UK.

Invasion Stage (England): Not present.

Introduction pathways: This insect can be transported with plants and wood products containing bark, moving in international trade. Between 1985 and 2000, 38 confirmed detections of *Agrilus* spp. were made at points of entry in USA.

Control: The only control method available is the destruction of host trees. Movement bans (for firewood etc.) can be established to prevent spread.

RISK CATEGORY

A_0 High/Absent

References

Anon. 2005. Data sheets on quarantine pests, *Agilus planipenis*. OEPP/EPPO Bulletin 35, 436–438.

Baranchikov, Y., Mozolevskaya, E., Yirchenko, G. and Keris, M. 2008. Occurrence of the emerald ash borer, *Agrilus planipennis* in Russia and its potential impact on European forestry. OEPP/EPPO Bulletin 38, 233-238.

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Agrilus planipennis* (Last modified: 09/05/2007). Available at: http://www.cabi.org/compendia/cpc/index.htm

Evans, H. 2004. Pest risk analysis: *Agrilus planipennis* (Coleoptera: Bupestridae). Forest Research report, UK.

Citrus Longhorn Beetle *Anoplophora chinensis* ALERT LIST

Synonym: Anoplophora malasiaca

IDENTITY

Taxonomy: Insecta, Coleoptera, Cerambycidae

Quarantine Status: EC Listed: IAI as *Anoplophora chinensis & Anoplophora malasiaca*

EPPO listed: A2

Description: Adult beetles are 21-37 mm long and black with variable white markings. Their antennae are 1.2–2 times body length and are black with white/light blue bands.
Signs & Symptoms: Adult exit holes are 10-20 mm across and are generally found towards the base of host tree trunks. Also, bleeding sap at oviposition sites, piles of frass (small woodchips) at the base of an attacked tree and bulges in the trunk indicating a pupal chamber.

GEOGRAPHICAL DISTRIBUTION

Native Range: Primarily in China, Korea and Japan, but has been recorded from Vietnam, Taiwan, Indonesia, Philippines and Malaysia.

Introduced Range: Introduced population in Lombardy, Italy, first detected in 2000.

England: In 2005, 38 *A. chinensis* larvae and adults were detected at a nursery in Hampshire. In 2008, *A. chinensis* were detected in private gardens across the UK after emerging from Chinese *Acer palmatum* that had been distributed by mail order.

BIOLOGY/ECOLOGY

General: *A. chinensis* has a life cycle of 1-3 years. They spend most of their lives as larvae, feeding inside their host trees. Hosts include: citrus, apples, beech, birch, hawthorn, hazel, horse chestnut, plane, poplar, oak and willow.

Movement and dispersal: Adults disperse naturally by flight, evidence from studies with *A. glabripennis* indicate dispersal is generally less than 400 m, but can be 1-2 km. Can also be moved within logs or host trees.

RISK STATUS

Environmental Impact: The tunnels created by the feeding, render trees susceptible to diseases and wind damage.

Invasion Stage (England): Not believed to be present, but given the number of introductions an undiscovered infestation is possible.

Introduction pathways: The trade in hardy ornamental nursery stock (principally Acers) and dwarfed trees from Asia.

Control: Destruction of infested and potentially infested trees, foliar insecticide treatments, trunk injections and prohibitions on moving potentially infested trees or logs.

RISK CATEGORY

A_0 High/Absent

References

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Anoplophora chinensis* (Last modified: 05/06/2006): http://www.cabi.org/compendia/cpc/index.htm

van der Gaag, D.J., Ciamppitti, M., Canagna, B., Maspero, M. & Herard, F. 2009. Pest Risk Analysis for *Anoplophora chinensis*. http://library.wur.nl/WebQuery/catalog/lang/1885182

Lingafelter, S.W., Hoebeke, E.R., 2002. Revision of Anoplophora (Coleoptera: Cerambycidae). Entomological Society of Washington, Washington

Asian Longhorn Beetle *Anoplophora glabripennis* ALERT LIST

Starry sky beetle

IDENTITY

Taxonomy: Insecta, Coleoptera, Cerambycidae

Quarantine Status: EC Listed: IAI as *Anoplophora glabripennis*; EPPO listed: A1

Description: Adult beetles are approx 25-35 mm long and black with variable white markings. Their antennae are 1.3–2.5 times body length, each segment with a whitish blue base.

Signs & Symptoms: Round exit holes, 6-15 mm in diameter. Resin bleeds from oviposition holes and larval tunnels in the bark. Larval activity is recognized by the presence of galleries under the bark and, later, tunnels in the wood. Frass (wood shavings) may be found.

GEOGRAPHICAL DISTRIBUTION

Native Range: China, Korea and Japan.

Introduced Range: There have been outbreaks in the USA, Canada, Austria, France, Poland and Germany.

England: Intercepted only.

BIOLOGY/ECOLOGY

General: *A. chinensis* has a life cycle of 1-2 years in eastern China. They spend most of their lives as larvae, feeding inside their host trees. Hosts include: maple, poplar, willow, elm, alder, birch, ash, apple, plane, *Prunus*, pear, and rose.

Movement and dispersal: Adults disperse naturally by flight, dispersal is generally less than 400m, but can be 1-2km. Can also be moved within logs or host trees.

RISK STATUS

Environmental Impact: The boring larvae damage the phloem and xylem vessels, resulting in heavy sap flow from wounds that are then liable to attack by secondary pests and infection.

Invasion Stage (England): Believed to be absent.

Introduction pathways: The movement of wood packaging from infested areas.

Control: Destruction of infested and potentially infested trees, foliar insecticide treatments, trunk injections and prohibitions on moving potentially infested trees or logs.

RISK CATEGORY

A_0 High/Absent

References

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Anoplophora glabripennis* (Last modified: 21/04/2006) Available at: http://www.cabi.org/compendia/cpc/index.htm

Pinewood Nematode *Bursaphelenchus xylopilus* ALERT LIST

IDENTITY

Taxonomy: Nematoda, Aphelenchoididae

Quarantine Status: EU listed II/A1; EPPO A1 list.

Description: Small slender nematode, *c*.0.5-1.3 mm long.

Signs & Symptoms: The first symptoms shown by trees are of 'drying out', i.e. reduced oleoresin exudation. Infected trees show wilt symptoms and die rapidly.

GEOGRAPHICAL DISTRIBUTION

Native Range: Native to North America; reported from the US, Canada and Mexico.

Introduced Range: Introduced to Japan, China, Taiwan and South Korea. Absent in Europe, apart from Portugal (introduced in 1999) where it is under eradication.

England: Absent.

BIOLOGY/ECOLOGY

General: PWN is a pathogen of pines. It has a propagative mode and a dispersal mode in its life cycle. In both cases, nematodes are transmitted from one host to the next by *Monochamus* spp. beetles (Coleoptera: Cerambycidae). In the propagative mode, L4 stage nematode larvae are transmitted during oviposition by female beetles. After the initial invasion, the PWN population declines and 'dispersal third-stage juveniles' are produced. These 'dispersal' larvae, which are able to resist adverse conditions, gather in the wood surrounding the pupal chambers of the vectors, and close to emergence, moult into special 4th-stage 'dauer' larvae. These dauer larvae are then picked up off fungal projections and dispersed by emerging adult beetles. The dauer larvae emerge from the spiracles and enter a new tree via wounds caused by the beetle feeding. Secondary transmission can occur via oviposition wounds.

Movement and dispersal: A number of *Monochamus* spp. are vectors of *B. xylophilus* in the northern hemisphere. *Monochamus galloprovincialis*, has taken on the role of vector in Portugal. *Monochamus* spp. are not present in Great Britain and Ireland.

RISK STATUS

Environmental Impact: Economic impacts only occur in countries where both the nematode and its vector are present. PWN occurs mainly on *Pinus* spp., although only a limited number are susceptible to attack as living trees. In Europe, *P. sylvestris*, *P. nigra* and *P. pinaster* would be at risk.

Invasion Stage (England): Absent.

Introduction Pathways: Infested wood, including wood packaging material, wood chips, logs and sawn wood.

Control: Eradication involves identifying and removing diseased trees, as well controlling the insect vector population during spring-summer and all year round control of the movement of coniferous wood. Wood is treated to prevent spread.

RISK CATEGORY

A_0 High/Absent

References

Dwinell, L.D. 1997. The Pinewood Nematode: Regulation and Mitigation. Annu. Rev. Phytopathol. *35:153–66*

EPPO Diagnostic Protocols for Regulated Pests, PM 7/4(1): *Bursaphelenchus xylophilus*.

Oak Processionary Moth *Thaumetopoea processionea* WATCH LIST

IDENTITY

Taxonomy: Insecta, Lepidoptera, Notodontoidea, Thaumetopoeidae.

Quarantine Status: None

Description: Adult moths with a wingspan of 30-40 mm; newly-hatched larvae have a uniformly brown body and dark head. Mature larvae have a grey body and dark head. Older larvae also have a single dark stripe running down the middle of the back and a whitish line along each side. Clumps of extremely long white hairs arise from reddish-orange warts along the length of the body.

Signs & Symptoms: Abandoned nests with shed skins, pupal cases and hairs.

GEOGRAPHICAL DISTRIBUTION

Native Range: Central and southern Europe, where it is widely distributed, but its range has been expanding northwards, probably in response to climate change.

Introduced Range: Established in northern France and the Netherlands, and reported from southern Sweden. Resident in the Channel Islands.

England: Adults occasionally appear as vagrants on the south coast of England. Recently, colonies of larvae have been found in parts of London.

BIOLOGY/ECOLOGY

General: Between 100-200 eggs are laid in July and August, on twigs and small branches in the canopy. Larvae occur the following year, from April to June, and feed in groups. When not feeding, they congregate in communal nests made of white silk webbing spun up under a branch or on the trunk.

Movement and dispersal: The larvae typically follow one another head-to-tail in long processions. Adult moths fly at night from July until early September and are attracted to light.

RISK STATUS

Environmental Impact: A major defoliator of oaks (*Quercus* spp.) in Europe. Larvae are also a risk to human health as they are covered in irritant hairs (setae) that contain a toxin. Contact or inhalation of these hairs can result in severe skin irritation and allergic reactions.

Invasion Stage (England): Moth first appeared in Great Britain in summer 2006 and has begun to breed in oak trees in several locations in the west and south west of London.

Introduction Pathways: Trade in oak logs, however all oak trees imported into the UK from other EU countries now require a 'plant passport'.

Control: Destruction of nests.

RISK CATEGORY

B_1 Medium/Isolated populations

References

Forest Research: Oak processionary moth. http://www.forestresearch.gov.uk/oakprocessionarymoth

Forest Research Tree Health: Tree pest advisory note: Oak Processionary Moth http://www.forestresearch.gov.uk/pdf/fr_advice_note_oak_processionary_moth.pdf/$FILE/fr_advice_note_oak_processionary_moth.pdf

Oriental Chestnut Gall Wasp *Dryocosmus kuriphilus* WATCH LIST

IDENTITY

Taxonomy: Insecta, Hymenoptera, Cynipidae

Quarantine Status: EC listed: no; EPPO listed: A2

Description: Adult females are 2.5-3.0 mm long on average, the body is black, apex of clypeus and mandibles are yellow brown. Antennae are 14 segmented and apical segements not expanded into a club.

Signs & Symptoms: Galls are unilocular or multilocular, 5-20 mm in diameter, green or rose-coloured, often containing portions of developing leaves, stems and petioles. They develop on young twigs, on leaf petioles or on the midrib of the leaves. After adult emergence, the gall dries, becomes wood-like, and remains attached to the tree for up to 2 years.

GEOGRAPHICAL DISTRIBUTION

Native Range: China.

Introduced Range: Japan (1941), Korea (1961), USA (1974), Italy (2002), France and Slovenia (2005).

England: Not recorded in the UK.

BIOLOGY/ECOLOGY

General: The hosts are *Castanea* spp. including *C. sativa*, sweet chestnut. *D. kuriphilus* is a univoltine species, reproducing parthenogenetically. No males of this species have been collected. Females emerge from galls in mid summer and lay eggs in the buds, 30-40 days later first instar larvae emerge. The presence of the larvae causes gall formation in the following spring and this is where the larvae develop and pupate.

Movement and dispersal: Evidence from other invasive cynipids suggests that and natural dispersal may be in the region of 16-25 km per year.

RISK STATUS

Environmental Impact: Severe infestations may result in the decline and death of chestnut trees.

Invasion Stage (England): Not present.

Introduction pathways: The pest can be spread by the introduction of planting material including infested twigs or shoots.

Control: In small chestnut orchards the pest can be controlled by pruning. The parasitoid wasp, *Torymus sinensis* has been effective in mass-release programmes in Japan and Korea.

RISK CATEGORY

B_0 Medium/Absent

References

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Dryocosmus kuriphilus*. Last amended 9/5/2007. http://www.cabi.org/compendia/cpc/index.htm

Melika, G. 2006. Natural dispersal of cynipid wasps (Hymenoptera: Cynipidae). Eppo workshop on *Dryocosmus kuriphilus*, Cuneo, Italy, 26-28 June 2006.
http://archives.eppo.org/MEETINGS/2006_meetings/dryocosmus_presentations/workshop_dryocosmus.htm#pres

Eight-toothed Bark Beetle *Ips typographus* WATCH LIST

Engraver beetle

IDENTITY

Taxonomy: Insecta, Coleoptera, Curculionidae

Quarantine Status: EC listed: IIB Eppo listing: not listed

Description: The beetle is 4-5 mm long and dark brown. Both sexes have four spines at each side of the elytral declivity (groove), the third is the largest and is capitate (swollen at tip).

Signs & Symptoms: Adult females lay eggs along a linear gallery system from which larval galleries radiate, becoming wider as larvae grow. This pattern is visible in both the bark and in the surface of the wood and is unique to *I. typographus.*

GEOGRAPHICAL DISTRIBUTION

Native Range: Widespread in Europe, China, Japan, Korea, Tajistan.

Introduced Range: Turkey, Canada (formerly present), USA (intercepted only)

England: Absent. Intercepted at a wood mill in August 1997.

BIOLOGY/ECOLOGY

General: *Ips typographus* has one generation a year at high altitude and latitudes, but two and sometimes three generations per year in warmer locations. Major hosts include *Abies sachalinenesis, Picea abies, P. obovata* and *P. orientalis. Pinus sylvestris* is a minor host. After a dispersal flight males attract females to potential hosts. Mated females lay eggs in egg galleries parallel to the wood grain. Newly hatched larvae mine outward and perpendicularly to the main gallery.

Movement and dispersal: *I. typographus* has been found to disperse well beyond 500 m and with the assistance of wind has been known to disperse as far as 43 km.

RISK STATUS

Environmental Impact: The mortality of spruces *Picea* spp. can result in changes in the species composition of forests. Tree mortality can result in the deforestation of mountain slopes and disturbances in the water regime on large areas. The reforestation of such damaged areas can be very problematic.

Invasion Stage (England): Absent from the UK.

Introduction pathways: The pest can be moved in timber, especially timber with bark.

Control: The most effective control method is the felling and removal of infested trees from forests.

RISK CATEGORY

B_0 Medium/Absent

References

Anon. Forest pest alert for *Ips typographus*. http://www.forestpests.org/france/ipstypo.html

Anon. Forestry Commission exotic pest alert: *Ips typographus*. http://www.forestry.gov.uk/forestry/hcou-4u4j4k

CABI/EPPO. 1997. Data sheet on quarantine pests: *Ips typographus*.

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Ips typographus.* Last amended 23/2/2004. http://www.cabi.org/compendia/cpc/index.htm

Wermelinger, B. 2004. Ecology and management of the spruce bark beetle *Ips typographus* - a review of recent research. [Journal article] Forest Ecology and Management 202 (1/3): 67-82.

American Water Weevil *Lissorhoptrus oryzophilus* WATCH LIST

Synonym: Lissorhoptrus simplex

IDENTITY

Taxonomy: Insecta, Coleoptera, Curculionidae

Quarantine Status: EC: not listed EPPO: on alert list.

Description: Adults are dark-brown to black with grey scales; small, oblong (2.8 mm long by 1.2-1.8 mm wide). The female is more robust than the male and the first two ventral abdominal sternites are flat to convex at the midline of the female, whereas they are broadly concave in the male. Females have a large darkened area on the elytra and a deep notch in the seventh tergal segment.

Signs & Symptoms: Adults rasp the leaf epidermis of rice leaves, leaving skeletonized, longitudinal, slit-like scars on the upper leaf surface. Root pruning by larvae causes stunting and chlorosis of seedling plants and lodging, a delay in maturity and yield reduction in mature plants.

GEOGRAPHICAL DISTRIBUTION

Native Range: Canada, USA and Mexico.

Introduced Range: Japan (1976), China, Korea, Taiwan and Italy (2004).

England: Not recorded in UK.

BIOLOGY/ECOLOGY

General: Highly polyphagous, primarily feeding on aquatic grasses and sedges. The primary host is rice *Oryza sativa*. Females lay eggs in submerged leaf sheaves. Larvae crawl down the plant to the roots where they pupae. The adults emerge and either prepare to overwinter (where there is one generation per year) or re-infest the rice (in areas where there are two generations per year).

Movement and dispersal: In China, *L. oryzophilus* has spread at a rate of 10-30 km per year by flying, swimming and hitchhiking on human transportation.

RISK STATUS

Environmental Impact: *L. oryzophilus* could have an environmental impact by feeding and damaging native grasses such as sedges.

Invasion Stage (England): Not present.

Introduction pathways: *L. oryzophilus* is assumed to have entered Japan with hay from California and possibly entered Italy with plant material from the USA or Asia.

Control: Generally chemical control is used, but cultural methods can be effective.

RISK CATEGORY

B_0 Medium/Absent

References

CABI. 2009. CABI Crop protection Compendium. Datasheet: *Lissorhopturs oryzophilus*. Last amended 21/04/2006. Available at: http://www.cabi.org/compendia/cpc/index.htm

Chen, H., Chen ZhongMei & Zhou YongShu. 2005. Rice water weevil (Coleoptera: Curculionidae) in mainland China: invasion, spread and control. Crop Protection. 24 (8): 695-702.

MacLeod, A. 2001. Pest risk analysis for *Lissorhoptrus oryzophilus*. Internal CSL document.

Sawyer beetle *Monochamus sartor* WATCH LIST

Monochamus sartor has a strong genetic affinity with *Monochamus urussovii*

IDENTITY

Taxonomy: Insecta, Coleoptera, Cerambycidae

Quarantine Status: Not listed

Description: These shiny, black metallic beetles are 21 to 35 mm long and have sparse yellow hairs on the elytra. Antennae are twice the body length in males but only slightly longer than the body in females. Antennae of both sexes are black but the bases of the 3rd to 11th antennal segments in females are whitish-grey.

Signs & Symptoms: Funnel shaped pits in the bark (oviposition sites) and exit holes of 8-12mm diameter.

GEOGRAPHICAL DISTRIBUTION

Native Range: Across Europe from eastern France to the Ukraine mainly in mountainous regions.

Introduced Range: None known.

England: Numerous interceptions, mostly in association with imported wood.

BIOLOGY/ECOLOGY

General: Mated females lay their eggs singly in small holes in the bark of a tree. The larvae feed under the bark for a month and then burrow into the wood and construct a pupal chamber from which adults will emerge. The main host is *Picea abies*, minor hosts include *Pinus sylvestris*, *P. cembra*, *P. mugo* and *Abies alba.* There is generally one generation per year, but it can be one per two years.

Movement and dispersal: *M. sartor* is able to make flights of 5km.

RISK STATUS

Environmental Impact: *M. sartor* is not considered a very aggressive pest, usually causing wounding and timber damage, but not killing the hosts. Of greater concern is the possibility that *M. sartor* could be a vector for pinewood nematode, *Bursaphelenchus xylophilus*. Other *Monochamus* spp. are vectors of pinewood nematode, but the potential for *M. sartor* to vector *B. xylophilus* is unclear.

Invasion Stage (England): Not established.

Introduction pathways: *M. sartor* is most likely to enter the UK with imported wood, wooden packaging or wood products, such as furniture.

Control: In Romania attacks by *Monochamus spp*. are inhibited by physical debarking of trees, forest sanitation, chemical spraying of felled trees and trapping out beetles.

RISK CATEGORY

B_0 Medium/Absent

References

Anderson, H. 2008. CSL pest risk analysis for *monochamus sartor*. Internal report. Canadian Food Inspection Agency (2007).
http://www.inspection.gc.ca/english/plaveg/pestrava/monsar/tech/monsare.shtml

Japanese Beetle *Popillia japonica* WATCH LIST

IDENTITY

Taxonomy: Insecta, Coleoptera, Scarabaeidae

Quarantine Status: EC Lisited: IAII; EPPO Listed: A2

Description: Adults are broadly oval, 8-11mm long and 5-7 mm wide. The head and body are dark metallic green with darker coppery-green legs. The larvae are typical of scarabaeids, with a yellowish brown head with strong dark coloured mandibles. The body consists of 3 thoracic segments, each with a pair of jointed legs and a 10 segmented abdomen.

Signs & Symptoms: Skeletonised foliage is the most common symptom of adult feeding. Larval feeding in grass leads to thinning, yellowing and wilting, culminating in large patches of dead, brown grass.

GEOGRAPHICAL DISTRIBUTION

Native Range: China, Japan, far East Russia

Introduced Range: Canada, USA, the Azores (Portugal)

England: Intercepted at Prestwick airport in 2003 with computer parts from Taipei, but otherwise very rarely intercepted.

BIOLOGY/ECOLOGY

General: There is one generation per year in most of its range, but it can be two years in cool regions. Adults emerge from the soil in the summer. Mated females lay eggs in turf or agricultural fields, the emerging larvae will feed on the roots of grasses, vegetables or ornamental plants. Adult beetles feed on a very wide range of hosts including *Acer*, *Malus*, *Prunus*, *Rosa*, *Rubus* and *Ulmus*.

Movement and dispersal: Japanese beetles can infest new areas from several miles away.

RISK STATUS

Environmental Impact: Adults skeletonize the leaves of their hosts (over 400 species of broad-leaved plants) including a range of tree species. Beetle grubs feed on plant roots including pastures.

Invasion Stage (England): Absent.

Introduction pathways: Adults have been intercepted on agricultural produce, on packaging and on ships and aircraft. Larvae can be present in soil around plants for planting.

Control: Methods include soil applied insecticides, entomopathogenic bacteria and cultural methods.

RISK CATEGORY

B_0 Medium/Absent

References

Gyeltshen, J. and Hodges, A. 2005. Featured creatures: Japanese beetle. University of Florida.
http://creatures.ifas.ufl.edu/orn/beetles/japanese_beetle.htm
CABI. 2009. CABI Crop protection Compendium. Datasheet: *Popillia japonica*. Last amended 5/5/1999.
http://www.cabi.org/compendia/cpc/index.htm

Ghost Slug *Selonochlamys ysbryda* WATCH LIST

IDENTITY

Taxonomy: Gastropoda, Stylommatophora, Trigonochlamydidae

Quarantine Status: Not listed

Description: The slugs have a white body, faint grooves on their back, no eyes and differ from native slugs by having a breathing hole very near their tail. When contracted the slugs appear cylindrical and tuck in their heads.

Signs & Symptoms: *S. ysbryda* is exceptionally extensible and adopts such a slender and flexible form that it could be mistaken for a pale earthworm.

GEOGRAPHICAL DISTRIBUTION

Native Range: Turkey and Georgia.

Introduced Range: Wales.

England: Wales (Cardiff, Caerphilly and Swansea).

BIOLOGY/ECOLOGY

General: *S. ysbara* resembles certain troglobitic (cave-dwelling) molluscs of the Caucasus but may be a deeply esaphobitic (soil dwelling) animal. The ghost slug is carnivorous, killing earthworms at night with powerful blade-like teeth.

Movement and dispersal: Natural dispersal would be relatively slow. Crawling is slow relative to many slugs.

RISK STATUS

Environmental Impact: The loss of earthworms is likely to have an impact on nutrient recycling and other earthworm predators such as moles, hedgehogs, ground beetles and birds.

Invasion Stage (England): Not yet established.

Introduction pathways: It was probably introduced with garden plants.

Control: On a small scale the slug could be controlled by squashing or home and garden molluscides or biocontrol agents (In agricultural fields commercial molluscicides could be used, however control would be very difficult in natural environments.

RISK CATEGORY

B_0 Medium/Absent

References

Rowson, B. & Symondson, W.O.C. 2008. *Selonochlamys ysbryda* sp. nov. from Wales, UK: a Testacella-like slug new to western Europe (*Stylommatophora: Trigononchlamydidae*). Journal of Conchology: 39(5) 537-552

Argentine Ant *Linepithema humile*

CLIMATE LIST

IDENTITY

Taxonomy: Insecta, Hymenoptera, Formicidae

Quarantine Status: None

Description: *Linepithema humile* is a small (body length 2-3 mm) omnivorous ant. The workers (there is no soldier caste) are monomorphic: medium to dark brown, with smooth, hairless head, thorax and abdomen. *L. humile* does not possess a sting.

GEOGRAPHICAL DISTRIBUTION

Native Range: South America (Argentina, Brazil, Paraguay, Uruguay)

Introduced Range: The species occurs throughout the world on all continents, especially in Mediterranean climates, and many oceanic islands.

England: Occurrences in England are all in buildings. It does not persist out of doors.

BIOLOGY/ECOLOGY

General: In cool-temperate climates, *L. humile* persists in glasshouses or other climate-controlled buildings. The population size of colonies varies from 12 individuals to many thousands. Colonies may include hundreds of queens. During warm months satellite nests are established near to food sources. Workers move in with eggs and larvae for a short period and abandon the nest when disturbed or if food resources are depleted. Fertilisation of new queens takes place in the nest and the new queens lose their wings and walk with the workers to establish new nests.

Movement and dispersal: Natural spread may exceed 200 m per year or further if there are floods, when *L. humile* may be dispersed by rafting. The main dispersal mechanism over longer distances is transport by humans, especially with potted plants and garden refuse.

RISK STATUS

Environmental Impact: Workers can reach high densities (supercolonies). *L. humile* is a dominant ant and aggressive competitor, which has displaced native ant species in many parts of the world, even causing local extinction of some. It competes for nectar resources and may harm pollinator insects. It does not bury seeds, and in South Africa has been shown to displace two seed-burying ant species.

Invasion Stage (England): Present at several locations in buildings, but not persisting out of doors. Climate change or adaptation by the ant to the climate of England could result in *L. humile* becoming established in the wild.

Introduction pathways: Transported with vehicles (aircraft, ships, trains, lorries, cars) together with imported goods, soil and plants.

Control: Toxicants, including insect growth regulators, can be applied as ‘ant baits’.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Holway, D.A., Lach, L., Suarez, A.V., Tsutsui, N.D., Case, T.J. 2002. The causes and consequences of ant invasions. Annual Review of Ecology and Systematics *33*: 181-233.

Roura-Pascual N, Suarez A.V, Gómez C., Pons P, Touyama Y., Wild A.L, Peterson A.T. 2004. Geographical potential of Argentine ants (*Linepithema humile* Mayr) in the face of global climate change. Proceedings of the Royal Society of London B 271: 2527-2534

Suarez, A.V., Holway, D.A., Case, T.J. 2001: Patterns of spread in biological invasions dominated by long-distance jump dispersal: Insights from Argentine ants. Proceedings of the National Academy of Sciences of the United States of America 98*:* 1095–1100.

Round Goby *Neogobius melanostomus* ALERT LIST

(and related species)

IDENTITY

Taxonomy: Osteiichthyes, Teleostei, Perciformes, Gobiidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England).

Description: A small-bodied, short-lived fish species, but large for a gobiid, reaching ≈ 25 cm total length and 4 years of age. Is distinguished by the presence of a fused pelvic fin that forms a suction disk on the ventral surface. The body is brownish-yellowish gray with dark brown lateral spots, with a large, oblong, black spot usually at the end of the first dorsal fin.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Ponto-Caspian region, including Black Sea, Caspian Sea and Sea of Azov.

Introduced Range: Has invaded several river and canal systems in Europe (e.g. Rhine) as well as the Baltic Sea, and the Great Lakes and surrounding river systems in North America.

England: Not known to be present anywhere in the British Isles.

BIOLOGY/ECOLOGY

General: Occupies benthic rocky habitat, but occurs over gravel and sand, both shallow (near-shore) and demersal areas of lakes, rivers, canals and brackish seas. Has wide salinity and temperature tolerances. Is oviparous, with male protecting a nest. The omnivorous diet includes invertebrates, small fish and fish eggs, and varies with size, location and time of day.

Movement and dispersal: More mobile than believed, species is able to migrate, but wider dispersal is either as a ballast water contaminant or as a 'hitch-hiker' (i.e. hull foulant).

RISK STATUS

Environmental Impact: Known to prey on the eggs and young of native fishes, with adult males aggressively defending crevice (nesting) habitat, thus excluding native species. May out-compete native fish for food resources and known to be a healthy host native parasites (i.e. occupies a disease refuge that facilitates invasion).

Invasion Stage (England): Not known to be present anywhere in the British Isles.

Introduction Pathways: Natural expansion and via shipping, either as a ballast water contaminant (i.e. to North America) or a hull foulant (i.e. throughout Europe).

Control: Possible use of pheromone traps, and if necessary, use of rotenone.

RISK CATEGORY

A_0 High/Absent

References

Copp, G.H., Zweimüller, I., Kováč, V., Dias, A., Nascimento, M. & Ľavrinčíková, M. 2008b. Preliminary study of dietary interactions between invading Ponto-Caspian gobies and some native fish species in the River Danube near Bratislava (Slovakia). Aquatic Invasions 3: 193–200.

Corkum, L.D., Arbuckle, W.J., Belanger, A.J., Gammon, D.B., Li, W., Scott, A.P. & Aielinski, B. 2006. Evidence of a male sex pheromone in the round goby (*Neogobius melanostomus*). Biological Invasions 8: 105–112.

Ľavrinčíková, M. & Kováč, V. 2007. Invasive round goby *Neogobius melanostomus* from the Danube mature at small size. Journal of Applied Ichthyology 23: 276–278.

Ondračková, M., Dávidová, M., Pečínková, M., Blažek, R., Gelnar, M., Valová, Z., Černý, J. & Jurajda, P. 2005. Metazoan parasites of *Neogobius* fishes in the Slovak section of the River Danube: a preliminary study. Journal of Applied Ichthyology 21: 345–349.

Tomczak, M. & Sapota, M. 2006. The fecundity and gonad development cycle of the round goby (*Neogobius melanostomus* Pallas (1811) from the Gulf of Gdansk (Baltic Sea, Poland). Oceanological and Hydrobiological Studies 35: 353–367.

Ictalurid Catfishes *Ameiurus melas* & *Ictalurus punctatus* WATCH LIST

IDENTITY

Taxonomy: Actinopterygii, Siluriformes, Ictaluridae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: *A. melas* – stout bodied with a broad flattened head, has an adipose fin and 8 long and unequal barbels around mouth, which is large and terminal. *I. punctatus* is similar but is larger and liberally spotted, has a deeply forked tail. Max. total body lengths, weights and ages are: *A. melas* – 66 cm, 3.6 kg, 10 years; *I. punctatus* – 132 cm, 26.3 kg, 24 years.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: North America: *A. melas* (Great Lakes to northern Mexico); *I. punctatus* (Central drainages of the United States to southern Canada and northern Mexico)

Introduced Range: Europe: both species have been introduced to most countries from Poland and Germany down to Spain and Portugal. Note that some records for *A. melas* are mis-identifications of *A. nebulosus*, which occurs in Belgium but not England and has been displaced in some Central European countries by *A. melas* in recent years.

England: A few isolated populations of both species

BIOLOGY/ECOLOGY

General: Benthic and reasonably tolerant of adverse environmental conditions, both occur in lakes, ponds and lentic parts of rivers, and with diverse diets (worms, crustaceans, plants, and small fishes). Spawning is in summer (21–29 °C), with upstream migrations by *I. punctatus*, over a nest (dug by female, guarded by both sexes). Young hatch in ≈ 5 days and form a dense ball, following the female about. Growth can be rapid. In introduced range, *A. melas* appears to have reduced age at maturity.

Movement and dispersal: Known to migrate considerable distances for spawning.

RISK STATUS

Environmental Impact: Possible impacts include predation on other fish, resource competition with native fishes, novel disease introduction and increased turbidity.

Invasion Stage (England): Confirmed recordings from a number of ponds and rivers, but no known reproducing populations in the wild.

Introduction Pathways: Ornamental fish trade, aquaculture, research facilities.

Control: Depletion, and if necessary, use of rotenone.

RISK CATEGORY

B_1 Medium/Isolated Populations

References

Braig, E.C. & Johnson, D.L. 2003. Impact of black bullhead (*Ameiurus melas*) on turbidity in a diked wetland. Hydrobiologia 490: 11–21.

Novomeská, A. & Kováč, V. 2009. Life-history traits of non-native blackbullhead *Ameiurus melas* with comments on its invasive potential. Journal of Applied Ichthyology 25: 79–84.

Scott, W.B. & Crossman, E.J. 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada. Ottawa.

Wheeler, A.C. 1978. *Ictalurus melas* (Rafinesque, 1820) and *I. nebulosus* (Lesueur, 1819): the North American catfishes in Europe. Journal of Fish Biology 12: 435–439.

Wheeler, A.C., Merrett, N.R. & Quigley D.T.G. 2004. Additional records and notes for Wheeler's (1992) List of Common and Scientific Names of Fishes of the British Isles. J. Fish Biology 65 (supplement B), 35 pp.

Sterlet Sturgeon *Acipenser ruthenus*

IDENTITY

Taxonomy: Actinopterygii, Acipenseriformes, Acipenseridae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: Snout and caudal peduncle are subconical. Spiracle is present. Gill membranes joined to isthmus. Mouth is transverse and lower lip with a split in the middle. Barbels are fimbriate. Basic meristic and morphometric characters: 14–26 gill rakers, number of rays in dorsal fin = 32–48, anal fin = 16–39. Back is usually dark greyish-brown, the belly is yellowish white, fins are grey and scutes are dirty white but colouration varies greatly.
Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: The sterlet is a Eurasian freshwater species inhabiting rivers flowing into the Caspian, Black, Azov, Baltic, White, Barents, and Kara Seas.

Introduced Range: Numerous European countries such as Germany, Poland, Sweden, France, Estonia, Finland, Czech Republic and England.

England: In captivity, throughout England. In the wild, found occasionally in ponds and rivers in various locations.

BIOLOGY/ECOLOGY

General: Inhabits lowland and foothill zones of the rivers and usually stays in the current in deep depression on river beds. Two typical types of spawning grounds are found in the main river bed at depths of 7–15 m, and in floodplain during rising spring water. They spawn mainly on pebbles and occasionally on gravelly-sandy substratum. It generally behaves as a resident fish and does not undertake long migrations. Their main diet is composed of benthic organisms, mainly insect larvae, small molluscs, annelids, other invertebrates , and also fish eggs. The optimal water temperature for the reproduction of sterlets ranges 12–17 ºC. The sterlet has the shortest life span (22–24 years old) in the genus *Acipenser*.

Movement and dispersal: Small migration upstream during reproduction.

RISK STATUS

Environmental Impact: Is known to hybridize with other *Acipenser* species, but otherwise there are no adverse effects reported until date.

Invasion Stage (England): Present in ornamental trade throughout England, with occasional reports of specimens in public ponds and water courses.

Introduction Pathways: Aquaculture and angling.

Control: Depletion, and if necessary, use of rotenone.

RISK CATEGORY

C_1 Low/Isolated Populations

References

Bănărescu, P.M. 1964. Pisces-Osteichthyes. In: P. Bănărescu (ed.) *Fauna Republicii Populare Romîne Pisces – Osteichthyes (Pești Ganoizi și Osuși)* Volume XIII. Editura Academiei Republicii Populare Romîne, București.

Copp, G.H., Stakėnas, S. & Davison, P. 2006b. The incidence of non-native fishes in water courses: example of the United Kingdom. Aquatic Invasions 1: 72–75.

Hensel, K, Holčík, J. 1997. Past and current status of sturgeons in the upper and middle Danube River. Environmental Biology Fishes 48: 185–200.

Bighead Carp *Hypophthalmichthys nobilis*

IDENTITY

Taxonomy: Osteiichthyes, Teleostei, Cypriniformes, Cyprinidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: Head and mouth are disproportionately large. Has long, thin gill rakers that are not fused. The eyes have a more ventral orientation than the silver carp. Colouration of the body is dark grey above and cream-colored below with dark grey to black irregular blotches on back and sides. Maximum published total length and weights are: 112 cm and 21.3 kg.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native range: The native range of the bighead carp is western China.

Introduced Range: Bighead carp has been introduced to a number of countries mainly for aquaculture purposes, resulting in a near global distribution.

England: Importation in the UK is limited to one importer in East Yorkshire. Occasional reports are made from single individual found in the wild.

BIOLOGY/ECOLOGY

General: A bottom feeding fish that is found mainly in lakes and rivers, especially large rivers, taking mainly zooplankton, but also fish larvae and clumps of algae. Little information is available on habitat after the larval period except in the River Missouri (USA), where telemetry data indicate a preference by adult bighead for pools behind simple wing dams. Bighead carp are found at temperatures 4–26 ^{o}C.

Movement and dispersal: Known to migrate for reproduction and feeding. Telemetry data from the River Missouri (USA) suggest little movement <4 °C, relatively short movements (<15 km) during normal river discharges and long distance movements during high discharge.

RISK STATUS

Environmental Impact: For most introductions, no records of impacts exist. Information on ecological effects has been reported for only 16 % (n = 12) of bighead carp introductions, with varying degrees of certainty. Of these, three were considered to have beneficial ecological effects and only two were reported as having some level of ecological impact.

Invasion Stage (England): Not reproducing in the wild. Bighead carp are often stocked together with silver carp to control phytoplankton and improve water quality.

Introduction pathways: Mainly aquaculture; occasionally weed control and angling.

Control: Bioacoustic barriers have been considered or explored in the US such as that combine sound and bubbles and are effective if proper sound frequencies are employed. The most thoroughly researched population control in the USA is the use of pesticides.

RISK CATEGORY

C_1 Low/Isolated populations

References

Britton, J.R. & Davies, G.D. 2007. First U.K. recording in the wild of the bighead carp *Hypophthalmichthys nobilis*. Journal of fish Biology 70: 1280–1282

Kolar, C.S., Chapman, D., Courtenay, W.R., Housel, C.M., Williams, J.D. & Jennings, D.P. 2005. Asian Carps of the Genus *Hypophthalmichthys* (Pisces, Cyprinidae) - A Biological Synopsis and Environmental Risk Assessment, U.S. Fish and Wildlife Service, 183 pp.

Lever, C. 1996. *Naturalized fishes of the world*. Academic Press, California, USA. 408 pp.

White Sucker *Catostomus commersoni*

IDENTITY

Taxonomy: Osteiichthyes, Teleostei, Cypriniformes, Cyprinidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: A large-bodied, torpedo-shaped freshwater fish, distinguished by a blunt-rounded snout and terminal, sucker-like mouth. Pigmented olive-green/coppery-brown above and whitish on sides and belly. Ripe males develop a prominent dark stripe on their sides. Maxima achieved: total body lengths of 65 cm, body weight of 2.94 kg, life span of 12 years.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Widely-distributed throughout most of Canada and the USA.

Introduced Range: Parts of North America outside its native range, with only one location outside of North America, the River Gade in England.

England: Reported on two separate occasions (1992, 2004) in the same section of the River Gade on the upstream outskirts of Hemel Hempstead, Hertfordshire (NGR: TL 044 061).

BIOLOGY/ECOLOGY

General: Mainly a stream-dwelling species, found in pools, runs and backwaters, it prefers low-to-moderate water velocities and rip-rap banks, bridge abutments, boulders, and undercut banks. Great dietary plasticity, with specialisation on either benthic (Chironomidae, Mollusca, Trichoptera, Entomostraca), including detritus or zooplankton (Cladocerans) prey, especially the largest individuals - this is thought to be a key aspect of the species' invasive character.

Movement and dispersal: Known to migrate considerable distances for spawning.

RISK STATUS

Environmental Impact: Reported impacts after introductions outside its native North American range include displacement of native fish species.

Invasion Stage (England): Present in the wild in one watercourse only. It is said to have reproduced in earthen ponds adjacent to the River Gade with little human assistance but evidence of establishment in the wild has not been observed.

Introduction Pathways: A popular bait fish in North America, it is said to have entered the UK accidentally with a shipment of small goldfish from the USA.

Control: Depletion, and if necessary, use of rotenone.

RISK CATEGORY

C_1 Low/Isolated populations

References

Copp, G.H., Vaughn, C. & Wheeler, A.C. 1993. First occurrence of the North American white sucker *Catostomus commersoni* in Great Britain. Journal of Fish Biology 42: 615–617.

Copp, G.H., Carter, M.G., England, J. & Britton, J.R. 2006a. Re-occurrence of the white sucker *Catostomus commersoni* in the River Gade (Hertfordshire). The London Naturalist 85: 115–119.

Corbett, B.W. & Powles, P.M. 1986. Spawning and larva drift of sympatric walleyes and white suckers in an Ontario stream. Transactions of the American Fisheries Society 115: 41–46.

Pigg, J. & Parham, R. 1999. Range extension into Western Oklahoma of the white sucker, *Catostomus commersoni* (Lacepède). Proceedings of the Oklahoma Academy of Sciences 71: 51.

Saint-Jacques, N., Harvey, H.H. & Jackson, D.A. 2000. Selective foraging in the white sucker (*Catostomus commersoni*). Canadian Journal of Zoology 78: 1320–1331.

Scott, W.B. & Crossman, E.J. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Ottawa.

Weather Fishes (*Misgurnus fossilis* & *Misgurnus anguillicaudatus*)

IDENTITY

Taxonomy: Actinopterygii, Cypriniformes, Cobitidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: Both species have five pairs of barbels. *M. fossilis* has a long, slender body, with a blunt, scale-less head. Dorsal fin is small and rounded, with 3 hard and 5–6 soft rays. Anal fin is small and rounded, with 3 hard and 5 soft rays. Basic colour is yellowish-brown with distinct dark horizontal stripes. In *M. anguillicaudatus*, body is mottled, with darker greenish-grey to dark brown markings against a yellow-brown to brown background, with conspicuous adipose crests along the caudal peduncle and a suborbital spine hidden in the skin. Adult total body lengths are up to 30 cm in *M. fossilis* and 25 cm in *M. anguillicaudatus*.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: *M. fossilis*: Eastern and central Europe, from River Rhine to Caspian Sea Basin. *M. anguillicaudatus*: Asia: Myanmar and N.E. Asia and southward to Central China.

Introduced Range: *M. fossilis*: Croatia, Italy, Spain and the UK, with establishment in Spain and Italy. *M. anguillicaudatus*: Hawaii, Philippines, USA, Australia, Germany and Italy, with establishment of one population (now eradicated) in a garden pond in southern England.

England: Three reports from in the wild; of these, one confirmed as *M. anguillicaudatus*.

BIOLOGY/ECOLOGY

General: Both are facultative air-breathers and batch spawners, occurring in lower reaches of slow-flowing rivers, in lakes, oxbows or ponds, preferring still or lentic waters over sand and mud substrata. Both species are usually nocturnal and may stay buried in sand during daylight. Spawning occurs in April–May, with up to 150,000 eggs laid. Larvae move into fine sediments, their bronchial filaments permitting use of anoxic habitats (i.e. down to -1.5m in mud). Diet consists mainly of molluscs, chironomids, small crustaceans, insect larvae, and other small aquatic organisms. Tolerates temperatures between 2–30 °C.

Movement and dispersal: Known to migrate considerable distances for spawning.

RISK STATUS

Environmental Impact: Little information available. Likely impact is the introduction of new parasites or exotic diseases.

Invasion Stage (England): There have been three occurrences recorded, with only one known reproducing population (in a garden pond in southern England). *M. anguillicaudatus* are likely to appear in the wild due to their presence in the ornamental fish trade.

Introduction Pathways: Ornamental fish trade.

Control: Drain down and liming of pond bottom was successful in eradicating *M. anguillicaudatus* a small garden pond of southern England, otherwise use of rotenone.

RISK CATEGORY

C_1 Low/Isolated populations

References

Freyhof, J. & Korte, E. 2005. The first record of *Misgurnus anguillicaudatus* in Germany. Journal of Fish Biology 66: 568–571.

Wheeler, A.C., Merrett, N.R. & Quigley D.T.G. 2004. Additional records and notes for Wheeler's (1992) List of Common and Scientific Names of Fishes of the British Isles. Journal of Fish Biology 65 (supplement B): 35 pp.

Fathead Minnow *Pimephales promelas*

IDENTITY

Taxonomy: Actinopterygii, Cypriniformes, Cyprinidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: A small-bodied fish of brown greenish colour. Juveniles have a dark band along the body; adults have a dark spot anterior on the dorsal fin and at base of caudal fin. The lateral line is often incomplete, ending at dorsal fin.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native range: Over much of North America from Quebec to Northwest Territories, Canada and south to Alabama, Texas and New Mexico, USA. Also in Mexico (FishBase, 2008).

Introduced Range: Belgium, France, Germany, UK, British Columbia (Canada), Iran, and Puerto Rico. Established populations in all locations except British Columbia.

England: Established populations in ponds in England and Scotland.

BIOLOGY/ECOLOGY

General: Short-lived (min. pop. doubling time <15 months), sub-temperate (0–33 °C), demersal freshwater fish that inhabits muddy pools of headwaters, creeks and small rivers but can also found in ponds and lakes. High resilience and tolerates turbid, hot, poorly-oxygenated, intermittent streams conditions; maintains a relatively high metabolic rate and under hypoxic conditions. Individuals that survived such conditions during winter had rapid growth rates after ice-off. Diet - detritus, plant material, aquatic invertebrate and zooplankton.

Movement and dispersal: Body shape suggests a strong swimmer, so capable of migrating long distances.

RISK STATUS

Environmental Impact: Reported to have some ecological impact in Iran but none reported elsewhere in introduced range. However, in northern Europe, introductions have been responsible for the spread of the enteric red-mouth disease, which has infected wild and farmed trout and eels.

Invasion Stage (England): Self-reproducing populations in ponds, initially only garden ponds but recently found established in open, farmland ponds containing ornamental fishes.

Introduction Pathways: Research and aquaculture. Bait bucket transfers (reported in North America) not known to occur in UK, but fathead was used in ecotoxicological research and the rose-coloured (rosy red) variety was imported as ornamental fish.

RISK CATEGORY

C_1 Low/Isolated populations

References

Coad, B.W. 1995 Freshwater fishes of Iran. Acta Scientiarum Naturalium Academiae Scientiarum Bohemoslovacae Brno 29: 1–64.

Maitland, P.S. 2004 Keys to the freshwater fish of Great Britain and Ireland with notes on their distribution and ecology. Scientific Publication No. 62, Freshwater Biological Association, Ambleside, Cumbria. 248 pp.

Page, L.M. &. Burr, B..M. 1991 A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston. 432 pp.

Scott, W.B. & Crossman, E.J. 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada. Ottawa.

Red Shiner *Cyprinella lutrensis* (aka *Notropis lutrensis*)

IDENTITY

Taxonomy: Actinopterygii, Cypriniformes, Cyprinidae

Quarantine Status: Listed under orders of the *Import of Live Fish Act 1980* (England)

Description: A small-bodied freshwater fish, notable for brilliant pigmentation, which varies by season in both sexes. Maxima achieved are: total body lengths = 9 cm, life span = 3 years.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: North America: Mississippi River basin from southern Wisconsin and eastern Indiana to South Dakota and Wyoming and south to Louisiana, USA; Gulf drainages west of Mississippi River to Rio Grande in Texas, New Mexico and Colorado, USA.

Introduced Range: Parts of North America outside its native range, also in northern Mexico.

England: Some unconfirmed reports of the species in ornamental ponds in the London area.

BIOLOGY/ECOLOGY

General: Abundant in larger rivers, it flourishes when introduced to still waters. Is plastic in microhabitat use, which includes range of substrata, (irregular) water velocities and depths in slow-moving streams, impoundments and backwaters. Is tolerant of turbid, silty, polluted conditions. Diet includes various small invertebrates (insects, crustaceans), and plant material.

Movement and dispersal: Dispersal patterns are unknown, but thought to spread after introduction and establishment in new waters, aided by irrigation ditches and canals.

INVASIVENESS STATUS

Environmental Impact: Information derives from North America only, where known to be very aggressive, posing risks of: genetic dilution (hybridization with related species), of inciting decline of native species, and of exotic disease introducing. When introduced to degraded watercourses, the species has become amongst the most abundant fishes. Considered second in risks only to mosquitofish.

Invasion Stage (England): Held in aquaria and likely, but not yet confirmed, to be present in the wild. The species native range suggests it could establish in the wild in England, and this is likely to be enhanced under conditions of global warming.

Introduction Pathways: Bait/forage/aquarium releases. Most North America introductions attributed to bait bucket releases, some to use as a forage fish and others to aquarium releases.

Control: Depletion, and if necessary, use of rotenone.

RISK CATEGORY

$C_{0.5}$ Low/Absent-Enclosed

References

Cross, F.B. & Collins, J.T. 1995. Fishes in Kansas. University of Kansas Natural History Museum, Public Education Series No. 14, Lawrence, Kansas. 315 pp.

Farringer, R.T., Echelle, A.A. & Lehtinen, S.F. 1979. Reproductive cycle of the red shiner, *Notropsis lutrensis*, in central Texas and south central Oklahoma. Transactions of the American Fisheries Society 108: 271–276.

Jennings, M.R. & Saiki, M.K. 1990. Establishment of red shiner, *Notropis lutrensis*, in the San Joaquin Valley, California. California Fish and Game 76: 57–57.

Minckley, W.L. & Deacon, J.E. 1968. Southwestern fishes and the enigma of "endangered species". Science 159: 1424–1432.

Moore, R.H., Garrett, R.A. & Wingate, P.J. 1976. Occurrence of the red shiner, *Notropis lutrensis*, in North Carolina: a probable aquarium release. Transactions of the American Fisheries Society 102: 220–221.

False Dark Mussel (*Mytilopsis leucophaeata)* BLACK LIST

IDENTITY

Taxonomy: Mollusca, Bivalvia, Veneroida, Dreissenidae, *Mytilopsis*, *M. leucophaeata* (Conrad 1831).

Quarantine Status: Not subject to quarantine.

Description: Small bivalve mollusc, very similar to zebra mussel *Dreissena polymorpha*, distinguished from this species only by internal shell structure, in particular a tooth-like project inside the end of the shell. Less of a freshwater threat than zebra mussel owing to preference for brackish water habitat.

Signs & Symptoms: Mass coating of machinery/ channel infrastructure leading to increased sedimentation.

GEOGRAPHICAL DISTRIBUTION

Native Range: The native range for this species is poorly known. It may have originated on the Atlantic coast of North America, or possibly from West Africa or the Caribbean.

Introduced Range: A localised population is present in the Gulf of Finland

England: Hoo Peninsula, Kent.

BIOLOGY/ECOLOGY

General: A bio-fouling mussel, this short lived (3–5 years) species is similar in appearance to the zebra mussel but typically inhabits more brackish water habits. Attaches to hard substrates (epifaunal) at salinities >5 ppt. Small, shell length varies between <1–2 cm, with a mean length of 1 cm.

Movement and dispersal: Natural movements, following escape or release. High potential for rapid dispersal and population expansion but only within brackish water habitats.

RISK STATUS

Environmental Impact: Similar threat to zebra mussel. High potential for bio-fowling machinery and coating native bivalve species by growing on their shells. Unlikely to pose a serious threat to non-tidal water courses.

Invasion Stage (England): Localised population within Kent (Hoo Peninsular). This population is not known to be colonising to other areas at present.

Introduction Pathways: Accidental dispersal in ship ballast waters followed by natural dispersal.

Control: No known effective form of control. May potentially be treated using biocides in a controlled environment.

RISK CATEGORY

A_1 High/Isolated populations

References

Marelli, D.C. & Gray, S. 1983. Conchological redescription of *Mytilopsis sallei* and *Mytilopsis leucophaeata* of the brackish western Atlantic. *The Veliger* **25**, 185–193.

Rajagopal, S., van der Velde, G., & Jenner, H.A. 1997. Shell valve movement response of dark false mussel, *Mytilopsis leucophaeata*, to chlorination. *Water Research* **31**, 3187–3190.

Verween, A. 2007. Biological knowledge as a rool for an ecologically sound biofaouling control: a case study of the invasive bivalve *Mytilopsis leucophaeata* in Europe. PhD Thesis, Universiteit Gent, Faculteit Wetenschappen, Gent, X, 202 pp.

Marbled Crayfish (*Procambarus* sp. aka *P. marmorkrebs*) ALERT LIST

IDENTITY

Taxonomy: Arthropoda, Crustacea, Decapoda, Astacidae. Scientific name is unclear, believed close to *P. fallax* (Hagen, 1870) but is called *P. marmorkrebs* in some grey literature.

Quarantine Status: Listed in amendment to '*Keeping of Live Fish (Crayfish) Order*' (1996).

Description: Small Cambarid crayfish reaching a total length up to 13 cm but often less than 10 cm.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Southern USA.

Introduced Range: Germany and Madagascar.

England: No known wild populations. Cefas fish health inspectorate report increasing instances of this species being offered sale illegally in the UK.

BIOLOGY/ECOLOGY

General: Assumed to use similar habitat as *P. fallax*, i.e. lentic and lotic situations and burrows. Withstands wide temperature range, from <8 °C to >30 °C and is omnivorous but seems to prefer plant material and snails. Sexually maturity at 4 months old (4 cm length). Females can reproduce parthenogenetically (unfertilized, haploid eggs), yielding female only progeny (50–150 eggs). Egg incubation is highly dependant on water temperature (≈2 weeks at 27 °C). Can breed all year round at 8–9 week intervals. Maximum life span is 2 years.

Movement and dispersal: Natural movements following escape or release. Capacity for asexual reproduction means this species exhibits extremely high potential for rapid population expansion. Dispersal in the wild may arise from disposal of unwanted individuals kept as decorative pets.

RISK STATUS

Environmental Impact: Exhibits no aggression towards con-specifics or fish, but high potential for habitat displacement of native species. Known host of exotic crayfish plague *Aphanomyces* astaci. High plasticity and parthenogenetic reproduction suggest highly invasive and potential threat to indigenous native crayfish and aquatic ecosystems.

Invasion Stage (England): Absent in wild (believed present in UK aquaria).

Introduction Pathways: Pet aquarist trade escape or illegal release, followed by natural dispersal.

Control: No known effective form of control.

RISK CATEGORY

$A_{0.5}$ High/Absent-Enclosed

References

Jones, J.P.G., Rasamy, J.R., Harvey, A., Toon, A., Oidtmann, B., Randrianarison, M.H., Raminosoa, N. & Ravoahangimalala, O.R. 2009. The perfect invader: a parthenogenic crayfish poses a new threat to Madagascar's freshwater biodiversity. *Biological Invasions* (in press)

Pockl, M., Holdich, D.M. & Pennerstorfer, J. 2006. Identifying native and alien crayfish species in Europe. CRAYNET Publication. 33 pp.

Vogt, G., Tolley, L. & Scholtz, G. 2004. Life stages and reproductive components of the marmokrebs (marbled crayfish), the first parthenogenetic decapod crustacean. *Journal of Morphology* **261**, 286–311.

Noble Crayfish *Astacus astacus*

red-footed/red-clawed crayfish

IDENTITY

Taxonomy: Arthropoda, Crustacea, Decapoda, Pleocyemata, Astacidae

Quarantine Status: Keeping of this species is banned under an amendment to the 'Keeping of Live Fish (Crayfish) Order' (1996).

Description: Usually <15 cm, can grow to 18 cm total length, colour variable, morphology plastic. Easily confused with the signal crayfish *Pacifastacus leniusculus*.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Most of Europe (39 countries), with eastern native limit being in Russia, Belarus, Ukraine and Georgia, and the western limit being Greece, Albania, Finland.

Introduced Range: Introduced to Norway and Sweden in the middle ages.

England: Introduced to England in the 1980s, with extremely localised distribution confined to the South West (Bath, North Bristol).

BIOLOGY/ECOLOGY

General: Inhabits streams and rivers with variable substrate, flow and aquatic vegetation. Broad European distribution suggests high plasticity to environmental conditions. Polytrophic feeder, similar preferences to signal crayfish but out competed by this species where they co-exist as highly susceptible to crayfish plague. Autumn breeding, maximum 260 eggs. Maximum life span about 20 years. This species IUCN listed as 'vulnerable'.

Movement and dispersal: Natural movements, following escape or release. Potential for human translocation between water bodies owing to high commercial value in aquaculture. Low potential for natural dispersal and population expansion where found among plague bearing signal crayfish populations.

RISK STATUS

Environmental Impact: Possible competition for food and habitat leading to displacement of native species. Individuals infected with crayfish plague may contaminate native white-clawed crayfish populations.

Invasion Stage (England): Extremely localised in English waters. May be present in private aquaria. Unclear as to whether the wild population is self-sustaining,

Introduction Pathways: Releases from private aquaria/ natural dispersal.

Control: No known effective form of control. Biocides or pheromone traps may have potential application in isolated still waters.

RISK CATEGORY

$C_{0.5}$ Low/Absent-Enclosed

References

Ackefors, H.E.G. 2000. Freshwater crayfish farming technology in the 1990s: a European and global perspective. Fish and Fisheries 1, 337–359.

Bohman, P., Nordwall, F. & Edsman, L. 2006. The effect of the large-scale introduction of signal crayfish on the spread of crayfish plague in Sweden. Handbook of Environmental Chemistry. Water Pollution 380–381, 1291–1302.

IUCN Red List of Threatened Species. IUCN. 2006

Pockl, M., Holdich, D.M. & Pennerstorfer, J. 2006. Identifying native and alien crayfish species in Europe. CRAYNET Publication. pp. 19.

Asiatic clam, *Corbicula fluminea* WATCH LIST

IDENTITY

Taxonomy: Mollusca, Bivalvia, Veneroida, *Corbicula fluminea* (Muller, 1774).

Quarantine Status: N/A

Description: A bivalve mollusc with a yellowish brown to black shell with concentric, evenly spaced ridges on the shell surface. Adult clams are usually less than 25mm but can grow up to 50 to 65mm in length (Aguirre & Poss 1999).

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Korea, South-eastern China and southeastern Russia, including Ussuri Basin.

Introduced Range: South America (Argentina, Panama), USA (introduced to 38 states and the District of Columbia), Japan, widespread in Europe.

England: Invaded in 1998. It remained confined to an isolated network of rivers in Eastern Britain until 2004, when it was discovered in low densities in the River Thames, London.

BIOLOGY/ECOLOGY

General: It requires well-oxygenated waters and prefers fine, clean sand, clay, and coarse sand substrates. Maximum densities can range from 10,000 to 20,000 per square metre. Average lifespan is 2 to 4 years.

Movement and dispersal: Hermaphrodite capable of self-fertilisation. Larvae are released into the water column. Spawning requires water temperatures >16 C and this is the minimum temperature for the clams to release their larvae. A single clam can release up to 400 juveniles a day and 70,000 per year. Larvae spawned late in spring and early summer can reach sexual maturity by the next autumn. *C. fluminea* spreads when it is attached to boats or carried in ballast water, used as bait, sold through the aquarium trade, and carried with water currents.

RISK STATUS

Environmental Impact: It may cause much damage to intake pipes used by power, water, and other industries that is very expensive to remedy. Many native clams are declining as *C. fluminea* outcompetes them for food and space.

Invasion Stage (England): Since 2004 it has been discovered at three more sites on the tidal River Thames. Surveys indicate that the clam has now established dense populations at Ham, with evidence of annual recruitment. Given the substantial connectedness of the Thames to many of Britain's other rivers, it is likely that it will now continue to spread through Britain's waterways (Elliott & zu Ermgassen, 2008).

Introduction Pathways: Ballast water, hull fouling, live bait, aquarium trade.

Control: Where possible, heat treatment (>37 C) is effective. Mechanical measures, such as using screens and traps, can eliminate older clams and remove body tissue and shells from pipe systems. Chemicals, such as small concentrations of chlorine or bromine, are very effective for killing juveniles and sometimes adults.

RISK CATEGORY

B_1 Medium/Isolated Populations

References

Aguirre, W. and Poss, S. G. 1999. Non-Indigenous Species In the Gulf of Mexico Ecosystem: *Corbicula fluminea* (Muller, 1774). Gulf States Marine Fisheries Commission (GSMFC).

Elliott, P. and zu Ermgassen, P.S.E. 2008. The Asian clam (*Corbicula fluminea*) in the River Thames, London, England Aquatic Invasions 3, 54-60.

A Colonial Ascidian *Didemnum vexillum* BLACK LIST

IDENTITY

Taxonomy: Tunicata, Ascidiacea, Aplousobranchia. Species uncertain.

Quarantine Status: N/A

Description: Colonial sea squirt; yellow/orange in colour with a sponge-like appearance; its surface has darkish leaf-like veins with pores.

Signs & Symptomsbb N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Its origin is unknown. It was first officially documented on the east coast of the USA in 1988 though it may have been present as far back as the 1970s.

Introduced Range: From Maine to Virginia on the east coast, and from British Columbia to southern California on the west coast of North America. It is a significant pest species in New Zealand. In Europe, it is recorded as established in Ireland and The Netherlands. Several colonies recently (September 2008) detected in Holyhead Harbour, Anglesey, Wales.

England: Recently (September 2008) detected in Plymouth harbour, Devon (single colony).

BIOLOGY/ECOLOGY

General: An aggressive and rapidly spreading colonial ascidian. Persistent and may become a dominant member of new communities.

Movement and dispersal: Colonies can reproduce sexually by releasing tailed larvae, which can be dispersed via water currents. Alternatively, colonies can reproduce asexually by budding; hence fragments can break off and grow into new colonies. These fragments can be transferred on hulls of vessels or on aquaculture equipment and fragments can be transported in ballast water.

RISK STATUS

Environmental Impact: Responsible for severe fouling problems in aquaculture, especially suspended mussel cultivation. Rapid population explosions are known to reduce the abundance of previously established benthic species and cause significant changes in benthic community structure.

Invasion Stage (England): Isolated populations in harbour at Plymouth.

Introduction Pathways: Hull fouling, ballast water and with aquaculture transfers.

Control: Can treat farm equipment and suspended cultures with fresh water for at least one hour, although there are logistic problems associated with this.

RISK CATEGORY

A_1 High/Isolated populations

References

Bullard, S.G., Lambert, G., Carman, M.R., Byrnes, J., Whitlatch, R.B., Ruiz, G., Miller, R.J., Harris, L., Valentine, P.C., Collie, J.S., Pederson, J., McNaught, D.C., Cohen, A.N., Asch, R.G., Dijkstra, J. & Heinonen, K. 2007. The colonial ascidian *Didemnum* sp. A: Current distribution, basic biology and potential threat to marine communities of the northeast and west coasts of North America. Journal of Experimental Marine Biology and Ecology 342: 99–108.

Lambert, G. 2001 A global overview of ascidian introductions and their possible impact on endemic fauna. pp. 249–257 In: H. Sawada, H. Yokosawa & C.C. Lambert (Eds.) *The Biology of Ascidians*. Springer-Verlag, Tokyo.

Minchin, D. & Sides E. 2006. Appearance of a cryptogenic tunicate, a *Didemnum* sp. fouling marina pontoons and leisure craft in Ireland. Aquatic Invasions 1: 143–147.

Red King Crab *Paralithodes camtschaticus* ALERT LIST

IDENTITY

Taxonomy: Arthropoda, Crustacea, Anomura, Lithodidae

Quarantine Status: None

Description: A large-bodied stone crab, attaining a carapace width of 28 cm and a leg span of *c*.1.8 m. The fifth peropod (leg) is small and hidden, thus easily distinguishing it from spider crabs (Majidae), with the remaining four pairs of limbs (the first pair with claws) well developed. The carapace is spiny.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Bering Sea

Introduced Range: The red king crab was introduced by Russian scientists into the Barents Sea in the 1960s and established a viable population, which has spread into Norwegian waters and into Svalbard. This is a high value commercial species, with considerable interest in their exploitation. A fishery is established in Norway.

England: No sightings.

BIOLOGY/ECOLOGY

General: Larvae develop in coastal zone, passing four pelagic stages in ≈ 2 months. Salinity tolerances are unknown, but the species is known to tolerate temperatures of –1.7 to +11ºC. Fecundity, size and age of maturity, average annual growth varies throughout its native range.

Movement and dispersal: Has two migrations: mating-molting and feeding. Natural spread of adults and planktonic larvae, e.g. following introduction to Barents Sea. Dispersal to England across the North Sea may be restricted by depth and insufficiently low temperature.

RISK STATUS

Environmental Impact: There is concern over the potential impact of this species on epibenthic communities, including commercial bivalves.

Invasion Stage (England): Absent from the wild, but present in nearby regional seas.

Introduction Pathways: Natural dispersal of naturalised populations. Larvae could be transported in ballast water.

Control: Commercially important species (natural harvesting).

RISK CATEGORY

A_0 High/Absent

References

Joergensen, T., Loekkeborg, S. Fernoe, A. & Hufthammer, M. 2007. Walking speed and area utilization of red king crab (*Paralithodes camtschaticus*) introduced to the Barents Sea coastal ecosystem. Hydrobiologia 582: 17–24.

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A Bryozoan *Watersipora subtorquata* WATCH LIST

IDENTITY

Taxonomy: Bryozoa, Gymnolaemata, Cheilostomata.

Quarantine Status: N/A

Description: A loosely encrusting bryozoan. Colonies may become quite large and grow outward from the substrate in lobes and frills, forming a striking, cauliflower-like mass up to 25 cm in height. It is typically a bright orange or red, with varying (sometimes large) amounts of black.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Unknown.

Introduced Range: USA (California and Oregon), south Australia, New Zealand, Northern France and Guernsey. Taxonomy is difficult, requiring molecular methods, and so it may be under-recorded and could be cosmopolitan and widely invasive among cool temperate water ports, where it thrives.

England: Detected in marina at Plymouth, Devon and at Poole Quay, Dorset in 2008.

BIOLOGY/ECOLOGY

General: It grows on a wide range of hard and soft substrates, including kelp and other bryozoans. It is especially efficient at colonizing artificial structures. It lives at temperatures of 12–28 °C, salinities of 25–49 ppt and to depths to tens of meters.

Movement and dispersal: Larvae settle to a substrate within a few hours, where they metamorphose into a zooid, which then replicates asexually, budding into a colony. Notable as a fouling organism, it is tolerant to copper based antifouling biocides so able to facilitate the spread of other invasive species by providing a non-toxic surface.

RISK STATUS

Environmental Impact: It is an abundant fouling organism and is the most common inter-tidal bryozoan in many areas of introduction.

Invasion Stage (England): Two colonies found at Plymouth and one on a settlement plate at Poole Quay, Dorset.

Introduction Pathways: Mainly hull fouling but also possibly with transfer of aquaculture animals.

Control: None.

RISK CATEGORY

B_1 Medium/Isolated populations

References

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Glasby, T.M, Connell, S.D., Holloway, M.G. & Hewitt, C.L. 2007. Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? Marine Biology 151: 887–895.

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Japanese Tiger Prawn *Marsupenaeus* (*Penaeus*) *japonicus* WATCH LIST

Kuruma shrimp, Kuruma prawn, Japanese tiger shrimp

IDENTITY

Taxonomy: Arthropoda, Crustacea, Decapoda, Dendrobranchiata, Penaeidae

Quarantine Status: NA

Description: Large penaeid prawn reaching a total length of 22.5 cm (66 mm carapace length).

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Indo-West Pacific (Red Sea, Eastern Africa to Korea, Japan and Malay Archipelago). The species has also entered the eastern Mediterranean through the Suez Canal.

Introduced Range: Cultured in French aquaculture facilities and has escaped so that individuals are taken in the Atlantic waters of France and the western English Channel. There have been occasional captures of the species by UK fishing vessels in the western English Channel.

England: A few sightings in the English Channel.

BIOLOGY/ECOLOGY

General: Prefers sandy sediments in waters down to about 90 m deep.

Movement and dispersal: Natural movements, following escape or release.

RISK STATUS

Environmental Impact: Habitat displacement of native species and possible hosting of exotic viruses.

Invasion Stage (England): Occasional individuals recorded in English waters, present in nearby regional seas. Unclear as to whether the population is self-sustaining.

Introduction Pathways: Escapees from aquaculture facilities. Natural dispersal from established populations (if they exist).

Control: Commercially important species (natural harvesting).

RISK CATEGORY

B_0 Medium/Absent

References

Gollasch, S., Cowx, I.G. & Nunn, A.D. 2008. Analysis of the impacts of alien species on aquatic ecosystems. Report D2 to the European Commission, Project IMPASSE, Environmental Impacts of Alien Species in Aquaculture. Brussels. 148 pp.

Holthuis, L.B. 1980. Shrimps and prawns of the world. An Annotated Catalogue of Species of Interest to Fisheries. FAO Species Catalogue, Volume 1.

Streftaris, N., Zenetos, A. & Papathanassiou, E. 2005. Globalisation in marine ecosystems: the story of non-indigenous marine species across European seas. Oceanography & Marine Biology: An annual Review 43: 419–453.

Veined (Asian) Rapa Whelk *Rapana venosa* WATCH LIST

IDENTITY

Taxonomy: Mollusca, Gastropoda, Muricidae

Quarantine Status: N/A

Description: Large predatory gastropod (up to 18 cm shell height). The shell is rounded and has a short spire and large body whorl. The shell is grey or red/brown with markings on the spiral ribs and the aperture has a deep-orange colour. Specimens often have characteristic black veins throughout the shell

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Waters of China, Korea and Japan

Introduced Range: Non-native populations in NE Atlantic (French/Dutch waters), the Mediterranean Basin (Mediterranean, Adriatic, Aegean and Black Seas), Rio de la Plata (SE Atlantic), and Chesapeake Bay (NW Atlantic).

England: Two specimens recovered from southern North Sea.

BIOLOGY/ECOLOGY

General: Inhabits coastal waters. Populations in the NW Atlantic and Mediterranean basin have been well studied. It has fast growth rate and reproductive ability. Egg capsule production is influenced by water temperature and, in the NE Atlantic, begins at 18 ºC. Predated on by large crabs.

Movement and dispersal: Veliger larvae may be transported in ballast water. Egg cases may be attached to aquaculture animals.

PEST STATUS

Environmental Impact: Important predator on bivalves, including commercial species such as mussels, oysters and clams.

Invasion Stage (England): Uncertain

Introduction Pathways: Natural dispersal of adults from nearby areas. Veliger larvae from ballast waters. Egg cases attached to aquaculture animals or products.

Control: No direct methods.

RISK CATEGORY

B_0 Medium/Absent

References

Chandler, E.A., McDowell, J.R. & Graves, J.E. 2008. Genetically monomorphic invasive populations of the rapa whelk, *Rapana venosa*. Molecular Ecology 17: 4079–4091.

Harding, J.M., Mann, R. & Kilduff, C.W. 2008. Influence of environmental factors and female size on reproductive output in an invasive temperate marine gastropod *Rapana venosa* (Muricidae). Marine Biology 155: 571–581.

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Kerckhof, F., Vink, R.J., Nieweg, D.C. and Post, J.N.J. 2006. The veined whelk *Rapana venosa* has reached the North Sea. Aquatic Invasions 1: 35–37

Savini, D. & Occhipinti-Ambrogi, A. 2006. Consumption rates and prey preference of the invasive gastropod *Rapana venosa* in the Northern Adriatic Sea. Helgoland Marine Research 60: 153–159.

Sea Spider *Ammothea hilgendorfi*

IDENTITY

Taxonomy: Arthropoda, Pycnogonida, Ammotheidae

Quarantine Status: NA

Description: Small sea spider with a narrow, segmented body, four pairs of long, slender legs, a proboscis and pair of chelifores. Identification requires use of specialist keys.

Signs & Symptoms: N/A

GEOGRAPHICAL DISTRIBUTION

Native Range: Pacific Ocean

Introduced Range: Reported in two locations only: Southampton Water (England) and Venice lagoon (Italy, Adriatic Sea).

England: First observed in Southampton Water in 1978.

BIOLOGY/ECOLOGY

General: The biology of this species is little studied. In general, sea spiders (Pycnogonida) associate with algae and hydroid/bryozoan turfs.

Movement and dispersal: May be dispersed through shipping. Natural dispersal limited due to the males brooding the eggs.

RISK STATUS

Environmental Impact: Unknown

Invasion Stage (England): Occasional individuals recorded in Southampton water. Status elsewhere in England is unknown.

Introduction Pathways: Shipping (carried on hulls or through ballast water).

Control: None

RISK CATEGORY

C_1 Low/Isolated populations

References

Bamber, R.N. 1985. The itinerant sea spider *Ammothea hilgendorfi* (Böhm) in British waters. Proceedings of the Hampshire Field Club & Archaeological Society 41: 269–270.

Barreto, F.S. & Avise, J.C. 2008. Polygynandry and sexual size dimorphism in the sea spider *Ammothea hilgendorfi* (Pycnogonida: Ammotheidae), a marine arthropod with brood-carrying males. Molecular Ecology 17: 4164–4175.

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Krapp, F. & Sconfietti, R. 1983. *Ammothea hilgendorfi* (Boehm, 1879), and adventitious pycnogonid new for the Mediterranean Sea. Marine Ecology 4: 123–132.

Reise, K., Gollasch, S. & Wolff, W.J. 2002. Introduced marine species of the North Sea coasts. pp. 260–266 In: E. Leppäkoski, S. Gollasch & S. Olenin (eds.) *Invasive Aquatic Species of Europe.* Kluwer Academic Publishers, Dordrecht. 583 pp.

APPENDIX II: RISK ASSESSMENT SUMMARY SPREADSHEETS

KEY

	List
	Black List
	Alert List
	Watch List
	Climate List
	Environmental Risk
A	High
B	Medium
C	Low
	Invasion Stage
0	Absent
0.5	Enclosed
1	Isolated Populations
2	Locally Established
	Current Trend
0	Absent
Inc	Increasing
Stab	Stable
Dec	Decreasing
DD	Data deficient
	Dispersal
Nat	Natural
Trans	Transported
	Pathway
R	Released
E	Escaped
T	Transported
D	Dispersed

Mammals

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Alopex lagopus	Arctic fox	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Castor canadensis	American beaver	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Felis bengalensis	leopard cat	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Hydrochoerus hydrochoaeris	capybara	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Myocastor coypus	coypu	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Nyctereutes procyonoides	raccoon dog	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Ondatra zibethicus	muskrat	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Procyon lotor	raccoon	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Glis glis	edible dormouse	B	2	inc	Nat, Trans	D,T	Dispersal/translocation from localised pops.
Hydropotes inermis	chinese water deer	B	2	inc	Nat	D,E,R	Dispersal from localised populations
Aony x cinerea	short-clawed otter	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Cynomys ludovicianus	black-tailed prairie dog	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Mephitis mephitis	striped skunk	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Nasua nasua	coatimundi	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Tamias sibiricus	Siberian chipmunk	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Tamias striatus	Eastern chipmunk	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Callithrix spp	marmoset	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Cebus spp	capuchin	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Chinchilla spp	chinchilla	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Eliomys quercinus	garden dormouse	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Hystrix brachyura	Himalayan porcupine	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Hystrix cristata	crested porcupine	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Mesocricetus auratus	golden hamster	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Petaurus breviceps	sugar glider	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Atelerix albiventris	African pygmy hedgehog	B	0.5	0	Nat	E,R	Potential escape/release from captivity

Birds

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Alopochen aegyptiacus	Egyptian goose	A	2	Inc	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Bubo bubo	eagle owl	A	1	Stab	Nat	D,E,R	Dispersal; escape/release from aviary collections.
Acridotheres tristis	common mynah	A	0.5	0	Nat	E,R	Potential escape/release from collections.
Threskionis aethiopicus	sacred ibis	A	0.5	0	Nat	D,E,R	Potential dispersal from French colonies
Corvus splendens	Indian House Crow	A	0	0	Nat	D	Ship-assisted transfer from Netherlands or other
Branta leucopsis	barnacle goose	B	2	Inc	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Anser caerulescens	snow goose	B	1	Stab	Nat	E,R	Dispersal; escape/release from waterfowl collections.
Anser indicus	bar-headed goose	B	1	Inc	Nat	D,E,R	Dispersa; escape/release from waterfowl collections.
Bubulcus ibis	cattle egret	B	1	Stab	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Cairina moschata	Muscovy duck	B	1	Stab	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Cygnus atratus	black swan	B	1	Inc	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Netta rufina	red-crested pochard	B	1	Inc	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Tadorna ferruginea	ruddy shelduck	B	1	Stab	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Acridotheres cristatellus	crested mynah	B	0.5	0	Nat	E,R	Potential escape/release from collections.
Acridotheres ginginianus	bank mynah	B	0.5	0	Nat	E,R	Potential escape/release from collections.
Chloephaga picta	upland goose	B	0.5	Stab	Nat	E,R	Escape/release from waterfowl collections.
Nycticorax nycticorax	night heron	B	0.5	Stab,	Nat	D,E,R	Escape/release from waterfowl collections.
Molothrus spp	cowbirds	B	0	0	Nat	E,R	Not known to be present in pet trade; unlikely to enter.
Aix galericulata	Mandarin duck	C	1	Inc	Nat	D,E,R	Dispersal; escape/release from waterfowl collections.
Myiopsitta monachus	monk parakeet	C	1	Inc	Nat	D,E,R	Dispersal; escape/release from aviary collections.
Aratinga acuticaudata	blue-crowned parakeet	C	0.5	Stab	Nat	E,R	Escape/release from aviary collections.
Branta sandvicensis	Hawaiian goose	C	0.5	0	Nat	E,R	Escape/release from waterfowl collections.
Psittacula eupatria	Alexandrine parakeet	C	0.5	Stab	Nat	E,R	Escape/release from aviary collections.
Pycnonotus cafer	red-vented bulbul	C	0.5	0	Nat	E,R	Escape/release from aviary collections.
Passer hispaniolensis	Spanish sparrow	C	0	0	Nat	E,R	Escape/release from aviary collections.

Amphibians and Reptiles

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Pelophylax ridibundus	marsh frog	A	2	Inc.	Nat	D, E,R	Dispersal; Escape/release from captivity
Rana catesbeiana	North American bullfrog	A	1	Dec.	Nat	D, E,R	Dispersal; Escape/release from captivity
Xenopus laevis	African clawed toad	A	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Alytes obstetricans	midwife toad	B	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Rana esculenta	edible frog	B	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Triturus carniflex	Italian crested newt	B	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Triturus alpestris	Alpine newt	B	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Bombina spp	fire-bellied toads	C	1	Stab, inc	Nat	D, E,R	Dispersal; Escape/release from captivity
Hyla arborea	European tree frog	C	1	DD	Nat	D, E,R	Dispersal; Escape/release from captivity
Bufo marinus	cane toad	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Eleutherodactylus coqui	Carribean tree-frog	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Osteopilus septentrionalis	Cuban tree frog	B	0.5	0	Nat	E,R	Potential escape/release from collections.
Chelydra serpentina	snapping turtle	A	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Trachemys scripta	red-eared terrapin (slider)	A	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Chrysemys picya	painted turtle	B	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Emys orbicularis	European pond terrapin	B	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Mauremys caspica	stripe-necked terrapin	B	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Elaphe spp	rat snakes	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Lampropeltis spp	king/milk snakes	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Thamnophis spp	garter snakes	B	0.5	0	Nat	E,R	Potential escape/release from captivity
Elaphe longissima	Aesculapian snake	C	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Lacerta viridis	green lizard	C	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Podarcis muralis	wall lizard	C	1	Stab	Nat	D, E,R	Dispersal; Escape/release from captivity
Boa constrictor imperator	common boa	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Python molurus bivittatus	Burmese python	A	0.5	0	Nat	E,R	Potential escape/release from captivity
Agamidae	dragons	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Chamaeleonidae	chamaeleons	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Gekkonidae	geckos	C	0.5	0	Nat	E,R	Potential escape/release from captivity
Iguanidae	iguanas	C	0.5	0	Nat	E,R	Potential escape/release from captivity

Terrestrial Invertebrates

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details*
Lymantria dispar	gypsy moth	A	2	Inc.	Nat, Trans	D/T	Natural dispersal / transported with plants or plant material or inert materials such as car tyres
Agrilus planipennis	emerald ash borer	A	0	0	Nat, Trans	T	Transported with plants or plant material
Anoplophora chinensis	citrus longhorn beetle	A	0	0	Nat, Trans	T	Transported with plants or plant material
Anoplophora glabripennis	Asian longhorn beetle	A	0	0	Nat, Trans	T	Transported with plants or plant material
Bursaphelenchus xylophilus	pinewood nematode	A	0	0	Nat, Trans	T	Transported with plants or plant material
Thaumetopoea processionea	oak processionary moth	B	1	Stab.	Nat, Trans	D/T	Natural dispersal / transported with plants or plant material
Dryocosmus kuriphilus	oriental chestnut gall wasp	B	0	0	Nat, Trans	T	Transported with plants or plant material
Ips typographus	eight-toothed bark beetle	B	0	0	Nat, Trans	T	Transported with plants for planting / timber
Lissorhoptrus oryzophilus	American water weevil	B	0	0	Nat, Trans	T	Transported with plants or plant material
Monochamus sartor	sawyer beetle	B	0	0	Nat, Trans	T	Transported with plants for planting / timber
Popillia japonica	Japanese beetle	B	0	0	Nat, Trans	T	Transported with plants or plant material
Selonochlamys ysbryda	ghost slug	B	0	DD	Nat, Trans	T/D	Transported with plants or plant material / natural dispersal
Leptoglossus occidentalis	western conifer seedbug	C	2	Inc.	Nat	D/T	Natural dispersal / transported with plants or plant material
Diaphania perspectalis	a pyralid moth	C	1	Inc.	Nat, Trans	T/D	Transported with plants or plant material / natural dispersal
Dasineura oxycoccana	blueberry gall midge	C	1	DD	Nat, Trans	T/D	Transported with plants or plant material / natural dispersal
Nysius huttoni	green chinch bug	C	1	Inc.	Nat, Trans	D/T	Natural dispersal / transported with plants or plant material
Tinocallis takachihoensis	aphid feeding on Ulmus sp.	C	1	DD	Nat, Trans	T/D	Transported with plants or plant material / natural dispersal
Callidiellum rufipenne	cedar longhorned beetle	C	0	0	Nat, Trans	T	Transported with plants or plant material
Ceresa alta	buffalo treehopper	C	0	0	Nat, Trans	T	Transported with plants or plant material
Corythucha arcuata	oak lace bug	C	0	0	Nat, Trans	T	Transported with plants or plant material
Diaspidiotus perniciosus	San Jose scale	C	0	0	Nat, Trans	T	Transported with plants or plant material
Enapholodes rufulus	red oak borer	C	0	0	Nat, Trans	T	Transported with plants or plant material
Liriomyza chinensis	onion leafminer	C	0	0	Nat, Trans	T	Transported with plants or plant material
Listrodes difficilis	vegetable weevil	C	0	0	Nat, Trans	T	Transported with plants or plant material
Matsucoccus feytaudi	maritime pine scale	C	0	0	Nat, Trans	T	Transported with plants or plant material
Megastigmus nigrovariegatus	American rose seed chalcid	C	0	0	Nat, Trans	T	Transported with plants or plant material
Metcalfa pruinosa	frosted moth-bug	C	0	0	Nat, Trans	T	Transported with plants or plant material
Mogulones geographicus	a weevil	C	0	0	Nat, Trans	T	Transported with plants or plant material
Monochamus alternatus	Japanese pine sawyer	C	0	0	Nat, Trans	T	Transported with plants or plant material
Monochamus sutor	small white-marmorated longicorn	C	0	0	Nat, Trans	T	Transported with plants or plant material
Monema flavescens	oriental moth	C	0	0	Nat, Trans	T	Transported with plants or plant material
Naupactus leucoloma	white-fringed weevil	C	0	0	Nat, Trans	T	Transported with plants or plant material
Pseudaulacaspis pentagona	white peach scale	C	0	0	Nat, Trans	T	Transported with plants or plant material
Sitona discoideus	a weevil	C	0	0	Nat, Trans	T	Transported with plants or plant material
Stephanitis oberti	blackberry lacebug	C	0	0	Nat, Trans	T	Transported with plants or plant material
Linepithema humile	Argentine Ant	A	0.5	Inc	Trans	T	Air and sea tranport of goods, especially potted plants

Fish

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Neogobius melanostomus	Round goby	A	0	0	Nat	T,D	Hull fouling
Proterorhinus marmoratus	Tubenose goby	A	0	0	Nat	T,D	Hull fouling
Ameiurus melas/Ictalurus punctatus	Ictalurid catfishes	B	1	Stab	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Gambusia holbrooki	Eastern mosquitofish	B	0	0	Nat, Trans	T,R	Human-assisted transfer and introduction
Acipenser ruthenus	Sterlet	C	1	Inc	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Aristichthys nobilis	Bighead carp	C	1	Inc	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Catostomus commersoni	White sucker	C	1	Inc	Nat	T,E	Escape/release from aquaculture
Ctenopharyngodon idella	Grass carp	C	1	Inc	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Hypophthalmichthys molitrix	Silver carp	C	1	Inc	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Misgurnus fossilis/anguillicaudatus	Weatherfishes	C	1	Stab	Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Pimephales promelas	Fathead minnow	C	1	Inc	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds
Cyprinella lutrensis	Red shiner	C	0.5	Stab	Nat, Trans	T,R	Releases from aquaculture/aquaria/garden ponds

Freshwater Invertebrates

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Eriocheir sinensis	Chinese Mitten Crab	A	2	Inc	Nat, Trans	E,T,D	Natural spread of current pop. Maratime transportation through balast water release.
Mytilopsis leucophaeata	False Dark Muscle	A	1	Stab	Nat, Trans	R,E,T,D	Human-assisted transfer and introduction. First UK record 1998 (Hoo Peninsula, Kent). Species believed to have been transported in ballast
Orchonectes limosus	Spiny Cheeked Crayfish	A	1	Inc	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Procambarus sp.	Marbled Crayfish	A	0.5	Stab	Trans	R,E,T	Releases from aquaria/garden ponds, human-assisted transfer and
Astacus leptodactylus	Turkish Narrow-Clawed Crayfish	B	1	Inc	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Corbicula fluminea	Asian Clam	B	1	Inc	Nat, Trans	R,E,T,D	Human-assisted transfer and introduction
Procambarus clarkii	Red Swamp Crayfish	B	1	Stab	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Achtheres percarum	Parasitic Copepod	C	1	Stab	Nat, Trans	R,E,T,D	Natural spread + Human-assisted transfer and introduction
Branchiura sowerbyi	Oligochaete Worm	C	1	Stab	Trans	R,E,T,D	Releases from aquculture/aquaria/garden ponds
Corophium curvispinum	Freshwater Malacostracan	C	1	Inc	Trans	T,D	Human-assisted transfer and introduction
Craspedacusta sowerbyi	Amazonian Jellyfish	C	1	Inc	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Ergasilus sieboldi	Parasitic Copepod	C	1	Inc	Nat, Trans	E,T,D	Stocking of infected fish is most common means of dissemination, free living stages may be transferred in water, on equipment or by aquatic
Ergasilus briani	Parasitic Copepod	C	1	Inc	Nat, Trans	E,T,D	Stocking of infected fish is most common means of dissemination, free living stages may be transferred in water, on equipment or by aquatic
Ferissia wautieri	Wautier's Limpet	C	1	Stab	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Masculinium traversum	Long fingernail clam, Oblong orb mussel	C	1	Dec	Nat, Trans	R,T,D	Unknown innoculation pathway. Introduced 1856 predominantly inhabiting canal basins of the industrial north-west.
Marstoniopsis scholtzi	Taylor's Spire Shell	C	1	Dec	Nat, Trans	R,E,T,D	Releases from aquculture/aquaria/garden ponds
Menetus dilatatus	Trumpet Ramshorn	C	1	Inc	Nat, Trans	R,E,T,D	Human-assisted transfer and introduction
Neoergasilus japonicus	Parasitic Copepod	C	1	Inc	Nat, Trans	E,T,D	Stocking of infected fish is most common means of dissemination, free living stages may be transferred in water, on equipment or by aquatic
Physella acuta	Tadpole snail	C	1	Stab	Nat, Trans	R,E,T,D	Releases from aquculture/aquaria/garden ponds
Physella gyrina	Pouch snail	C	1	Stab	Nat, Trans	R,E,T,D	Releases from aquculture/aquaria/garden ponds
Physella heterostopha	Pond snail	C	1	Stab	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds
Tracheliastes polycolpus	Parasitic Copepod	C	1	Stab	Nat, Trans	R,E,T,D	Stocking of infected fish is most common means of dissemination, free living stages may be transferred in water, on equipment or by aquatic
Astacus astacus	Noble Crayfish	C	0.5	Stab	Nat, Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Asellus communis	Freshwater Malacostracan	C	0.5	Stab	Trans	R,E,T,D	Human-assisted transfer and introduction
Dugesia tigrina	Freshwater triclad	C	0.5	Stab	Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Planaria torva	Freshwater triclad	C	0.5	Stab	Trans	R,E,T,D	Releases from aquaria/garden ponds, human-assisted transfer and
Limnodrilus cervix	Oligochaete Worm	C	0	Abs	Trans	R,T	Potential for releases from aquculture/aquaria/garden ponds
Phagocata woodworthi	Freshwater triclad- American freshwater flatworm	C	0	Abs	Trans	R,E,T,D	Accidental releases from poorly dissinfected survey equipment (human-assisted transfer and introduction)

Marine Invertebrates

Scientific name	Common name	Risk category	Invasion Stage - England	Current trend in records or population	Mode of Dispersal in England	Pathway of introduction	Pathway details
Didemnum vexillum	Colonial ascidian	A	1	Inc	Nat, Trans	T	Hull fouling, ballast water and with aquaculture transfers
Paralithodes camtschaticus	Red king crab	A	0	0	Nat	D	Natural dispersal from stocks introduced for commercial exploitation
Watersipora subtorquata	Bryozoan	B	1	Inc	Nat, Trans	T	Hull fouling
Marsupenaeus (Penaeus) japonicus	Japanese tiger prawn	B	0	0	Nat	D	Potential for escape from aquaculture facilities.
Rapana venosa	Veined (Asian) rapa whelk	B	0	0	Nat, Trans	T, D	Natural dispersal of adults from nearby areas. Veliger larvae from ballast waters. Egg cases attached to aquaculture animals or products.
Ammothea hilgendorfi	Sea spider	C	1	Stab	Nat, Trans	T	Shipping (carried on hulls or through ballast water).