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Control and eradication of invasive mammals in Great Britain

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Summary
This paper provides a 'long view' of the eradication and control of invasive mammals by reviewing the management of 24 mammalian species that have been introduced into Great Britain since the Neolithic period and have subsequently established free-living populations in the wild. The approach provides examples of the issues faced when managing populations and examines some of the lessons that can be learned from successes and failures. The species are covered in the order of introduction, with the control/eradication of rabbit (*Oryctolagus cuniculus*), muskrat (*Ondatra zibethicus*), coypu (*Myocastor coypus*) and American mink (*Mustela vison*) considered in more detail. The species accounts are set within the context of commitments for the control of invasive alien species made by parties to the Convention on Biological Diversity and guidance provided by the International Union for Conservation of Nature and the Council of Europe. These have led to improvements in the process for assessing risks and co-ordinating action. However, despite some notable cases documented here, there have been few successful eradication programmes carried out in Europe. This paper argues that there is a case for building on the improved frameworks that are being developed in the United Kingdom and elsewhere and for being more ambitious with goals for the management of invasive alien species.

Keywords
Control – Eradication – Great Britain – Invasive alien species – Mammals.

Introduction

Invasive alien species have been defined as those whose introduction and/or spread outside their natural, past or present distribution threatens biological diversity (13). Quantifying the environmental damage caused by them or summarising management options is complicated by the scale of the problem; for example, Pimental *et al.* (67) estimated that a total of over 120,000 known species of plants, animals and microbes had invaded the six nations they studied for their paper. However, their impact on biodiversity and human society is beyond doubt and the United Nations Convention on Biological Diversity (CBD) (article 8h) states that signatories should 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species' (14). The International Union for Conservation of Nature (IUCN) has produced guidelines on how to best prevent loss of biodiversity caused by invasive species (40), which are aligned with the guidelines produced by the CBD (14). These promote a hierarchical approach, recognising that preventing introduction should be the first goal, but where this fails the next options are eradication, containment and control. The IUCN also recommends that, where it is achievable, eradication is the best management option. It gives six criteria needed to achieve it, which, in summary, are:

– the rate of population increase should be negative at all densities

– immigration must be zero

– the eradication techniques used must be effective against all individuals in the population

– monitoring techniques should be able to detect individuals at low densities

– adequate funds and commitment must exist to complete the eradication in the time required

– the socio-political environment must be supportive throughout the eradication effort.

Control should be pro-active and aim for long-term reduction in the abundance or density of invasive species. However, in practice, control is often a reactive response to an actual or perceived problem and, unfortunately, this has a disappointing record (50). Worldwide support for the control of invasive species is available through the Global Invasive Species Programme (GISP) (www.gisp.org) of the IUCN Invasive Species Specialist Group (www.issg.org). Additional information on management and control is available on the Global Invasive Species Database (www.issg.org/database) and other published sources (12, 64). Not surprisingly, expertise about eradication and control varies widely, with a wealth of experience available in a few areas, such as on islands (39, 62, 95), where a total of 322 different rodent species have been eradicated (39).

This review focuses on the management of the mammals that have been introduced into Great Britain (England, Scotland and Wales and their outlying islands), as illustrative of the approaches that can be adopted and the outcomes that can result. All species except feral populations of domestic species are considered. To put this in a European context, there is a European Strategy on Invasive Alien Species (26), but despite this there have been relatively few eradication attempts of any kind in Europe. Even when considering all taxa, Genovesi (28) was only able to document 37 such attempts, 33 of which were on islands. This illustrates that most effort is put into control even though it is not the preferred response to introduced species.

The first introduction discussed here was in the Neolithic period and looking at species invasions over such a long time period helps to illustrate the dynamic nature of the interaction between introduced species, their environment and developments in human society. The eradication and control histories of each species are considered in three sections, based on the date of first introduction, with some common themes within the sections. The three sections are, as follows:

– long-established species, from the Neolithic period to the 18th Century

– deliberate introductions and the fur trade, from the 19th Century to the mid-20th Century

– escapes from captivity, from the mid-20th Century to the present.

The problems caused by these species and reasons for control are largely outside the scope of this review and not discussed.

The Neolithic period to the 18th Century

Table I lists the species that have long been established in Great Britain. Their management is now typically focused on control, operating within the prevailing legal framework (55, 65). This group includes the Orkney and Guernsey vole (*Microtus arvalis*), which only occurs on a few offshore islands and is not intensively controlled. The house mouse (*Mus domesticus*) is much more widespread, but its distribution is likely to be influenced by competition with common rats in buildings and, in the wider environment, by the wood mouse (*Apodemus sylvaticus*) (7). Control options for house mice

Table I
Mammals introduced into Great Britain from the Neolithic period to the 18th century [(a)]

Species	Approximate time of introduction (years BP)	Summary of recent wildlife management
Orkney & Guernsey vole (*Microtus arvalis*)	5700	Negligible control
House mouse (*Mus domesticus*)	2600	*Ad hoc* widespread control
Brown hare (*Lepus europaeus*)	2000	Game species, little control, subject of conservation measures
Ship rat (*Rattus rattus*)	2000	Rare. Eradicated from Lundy Island
Rabbit (*Oryctolagus cuniculus*)	950	Heavily controlled, mainly through *ad hoc* measures
Fallow deer (*Dama dama*)	950	Shot with rifles for both sport and for control when necessary
Common rat (*Rattus norvegicus*)	290	Heavily controlled, mainly through *ad hoc* measures. Eradicated from five islands

(a) Species and date of introduction from Harris & Yalden (38)
BP: before present, in this context before 2010

are available (61) but their use is *ad hoc* and their effectiveness limited, because mice have become resistant to first generation anticoagulant rodenticides.

Brown hare

The brown hare (*Lepus europaeus*) is unique amongst introduced species in Great Britain because it is the subject of specific conservation measures under the United Kingdom (UK) Biodiversity Action Plan (www.ukbap.org.uk). This is part of the UK Government's response to the CBD, which it signed in 1992. Brown hares were particularly valued as quarry to be hunted with dogs (85), but hunting is now banned for all species (76, 94). Control methods and measures for brown hare conservation are available from Natural England, a government advisory body (61).

Black rat

The black rat (*Rattus rattus*) was widespread for much of its history in Great Britain, but is now found in only a few locations, mainly islands and ports, and has a maximum population size estimated at 1,300 animals, mainly on one island (the main island of the Shiant group on the west coast of Scotland) (37). It has now been replaced by the more recent arrival, the common rat (*Rattus norvegicus*). The decline in black rats appears to be because of a reduction in immigration through shipping, the destruction of dockside seed and flour mills, where they were difficult to control, and their habit of living almost exclusively within buildings, making them more susceptible to localised domestic control than common rats (6, 92). The species was eradicated from Lundy Island (off the south-west coast of England) by 2005 along with the common rat (68). An eradication campaign involving both black rats and house mice in the Galapagos has shown that interspecific competition is a factor to consider if more than one species is being eradicated at one time (36), but this appears not to have been an issue on Lundy.

Common rat

There have been seven successful attempts to eradicate common rats from islands within Great Britain (24, 39, 44, www.ntsseabirds.org.uk):

– Cardigan (off the coast of south Wales; 14 ha) in the 1980s

– Ailsa Craig (off the west coast of southern Scotland; 104 ha) in 1990

– Handa (off the west coast of northern Scotland; 363 ha) in 1997

– Puffin (off the coast of north Wales; 32 ha) in 1998

– Ramsey (off the coast of south Wales; 253 ha) in 2000

– Lundy (430 ha) in 2004

– Canna (off the west coast of Scotland: 1,130 ha) in 2006.

The eradication campaign on Ailsa Craig, where the first generation anticoagulant warfarin was the rodenticide used, is the best documented (100). Development of rodenticides has increased the options available and later eradication attempts have used the more acutely toxic anticoagulants difenacoum and bromodialone. Howald *et al.* (39) reviewed 332 successful rodent eradication programmes worldwide; brodifacoum, even more acutely toxic to common rats, was used in 71% of these campaigns and on 91% of the total area treated. The campaign on Ailsa Craig illustrated the value of monitoring outcomes for target and non-target species and was an early example of the use of helicopters to help move large quantities of bait (2,700 kg) to a relatively inaccessible location (100). There was no evidence in this, or any of the other eradication programmes documented here, of a subsequent increase in the number of intermediate predators following the eradication of a top predator. This phenomenon, when it occurs, has been termed 'mesopredator release' and can lead to unintended ecological consequences for some eradication campaigns (86).

European rabbit

The biology and history of the European rabbit (*Oryctolagus cuniculus*) in Great Britain has been comprehensively reviewed (17, 49, 78, 89, 90) and details of current control options are available (61). The need to control the rabbit population has mainly arisen in the last 150 years, following changes in agricultural practices and increased predator control to protect game birds. During this period attitudes towards rabbits have fluctuated: they have been viewed both as a valuable resource and a pest. Until the outbreak of myxomatosis in 1953, leghold 'gin' traps were an important method of control, with over three million in regular use in Great Britain (48). These were used in conjunction with ferrets (to chase rabbits out of their burrows), shooting, nets (in various ways) and snares. There had been concern about the humaneness of gin traps as early as the 1920s, if not before (88). Following the reduction in rabbit numbers after the introduction of myxomatosis, the use of gin traps was finally outlawed by the Pests Act of 1954. Thereafter, only approved spring traps, which killed effectively and humanely, could be used and then only within the overhang of a burrow.

The introduction of myxomatosis resulted in almost instant control of the British rabbit population and the viral

disease and its consequences have been reviewed by Fenner and Ross (20). The disease was first recognised in 1896, although it was not until much later that the forest rabbit (*Sylvilagus brasiliensis*) from South America was identified as the natural host. The use of myxomatosis as a means of controlling pest rabbits in Australia was first suggested as early as 1918. In Britain, as a trial, three attempts were made to introduce the disease on the island of Skokholm off the coast of south-west Wales (which had a dense rabbit population) between 1936 and 1938, but all failed. It was 20 years later that the reason for the failure became apparent; the rabbits on Skokholm, very unusually, do not have rabbit fleas, the main vector of the disease in Great Britain (49). During World War II the use of myxomatosis was discussed officially but dismissed as unpromising (89). Following tests in Australia, where mosquitoes are an important vector, the virus escaped from a trial site and the disease spread with dramatic speed into the wild population throughout south-eastern Australia (20). It was introduced into France by a private individual in 1952 (49) and, following the impact on wild rabbits there, an individual brought a myxomatous rabbit into England to try for a similar result. This resulted in an outbreak in Kent in October 1953 and one in East Sussex shortly afterwards. The introduction of the disease was not officially sanctioned and the government tried to control the outbreaks, but by February 1954, nine further outbreaks had been detected. By the end of 1955 the disease had spread over most of Great Britain and had reduced the population by 99% (88). The speed of transmission throughout the country was increased by the illegal transport of infected animals (49). The possibility of windborne spread of infection has also been suggested (77).

Since the virus was first introduced, its virulence has declined (72) through increased transmissibility of weaker strains (53). Genetic resistance in rabbit populations has also been confirmed (71) and is increasing (17).

Following the arrival of myxomatosis there have been further developments in rabbit control techniques, particularly the availability of the fumigants hydrogen cyanide and phosphine (70). There was also the start of more strategic rabbit control, with landowners using the New Zealand model of Rabbit Boards to set up Rabbit Clearance Societies in Britain. These started on a voluntary basis in 1954 and in 1958 the Government introduced a 50% grant for them. By 1964, 46% of the farmed land in England and Wales was included within 750 societies (88). However, with myxomatosis still taking a toll, and concern over rabbit damage declining, the numbers of societies fell and, following the withdrawal of the government grant in 1971, only 280 remained; by 1987 this number had fallen to 75 (51, 88).

The rabbit population in Great Britain has also been impacted more recently by rabbit haemorrhagic disease (RHD) (also known as viral haemorrhagic disease or rabbit calicivirus disease). This disease entered the wild population in 1992 (11). It is specific to *Oryctolagus cuniculus*, but many British rabbits are immune, possibly because of exposure to putatively non-pathogenic RHD-like virus strains (91). Mortality rates are around 30%. They may have a geographical bias that depends upon the prevalence of the putative non-pathogenic strain, but there is no clear age or sex bias (98). The likely future changes to the population in response to two diseases, variable control pressure and a range of environmental conditions are potentially complex but have been studied by Garciá-Bocanegra *et al.* (23).

Fallow deer

Fallow deer have been managed for 950 years for hunting purposes and as a parkland species, but the wild population increased greatly between the two world wars (10, 45, 99). Control is normally through shooting, often with the aim of controlling the population at an appropriate level and providing an income. In Scotland, the Deer Commission for Scotland (www.dcs.gov.uk) promotes the sustainable management of populations of all deer species. In England and Wales, deer control is supported by the Deer Initiative, which is a broad partnership of statutory, voluntary and private stakeholders that promotes the delivery of sustainable, well-managed wild deer populations (www.thedeerinitiative.co.uk). Hunting of fallow deer on horseback with hounds was last practised in the New Forest and ceased in 1997 (45).

The 19th Century to the mid-20th Century

Most of the species in this section were either deliberately introduced or escaped from fur farms. Populations of the first four species in Table II, the sika deer (*Cervus nippon*), grey squirrel (*Sciurus carolinensis*), Reeves' muntjac (*Muntiacus reevesi*) and edible dormouse (*Glis glis*), derive from a period when it was fashionable to deliberately release exotic species. The control of sika and muntjac deer is carried out by shooting when necessary (20, 21). Muskrat (*Ondatra zibethicus*), coypu (*Myocastor coypus*) and American mink (*Mustela* [or *Neovison*] *vison*) all established following escapes from fur farms. Populations of red-necked wallaby (*Macropus rufogriseus*) and Chinese water deer (*Hydropotes inermis*) probably originate from escapes from private collections (4, 15, 47): there is no population control for either of these species.

Table II
Mammals introduced into Great Britain from the 19th Century to the mid-20th Century [a]

Species	Approximate time of introduction (years BP)	Summary of recent wildlife management
Sika (*Cervus nippon*)	150	Shot with rifles for sport and control when necessary
Grey squirrel (*Sciurus carolinensis*)	134	Heavily controlled, mainly through *ad hoc* measures
Reeves' muntjac (*Muntiacus reevesi*)	109	Shot with rifles for both sport and for control when necessary
Edible dormouse (*Glis glis*)	108	Controlled under licence, mainly through *ad hoc* measures
Muskrat (*Ondatra zibethicus*)	80	Eradicated
Red-necked wallaby (*Macropus rufogriseus*)	70	No control, small populations
Coypu (*Myocastor coypus*)	66	Eradicated
Chinese water deer (*Hydropotes inermis*)	65	Negligible control
American mink (*Mustela vison*)	53	Heavily controlled, mainly through *ad hoc* measures. Eradication being attempted in Western Isles

(a) Species and date of introduction from Harris & Yalden (38)
BP: before present, in this context before 2010

Grey squirrel

There are an estimated 2.5 million grey squirrels in Great Britain (37) and there have been several localised and regional control efforts since their establishment. In 1947, 100,000 grey squirrels were shot after free shotgun cartridges were made available to Grey Squirrel Shooting Clubs. Between 1953 and 1958 the Forestry Commission offered a bounty; over one million squirrel tails were handed in and £100,000 was paid out. Despite this, there was no decline in the overall population or the rate of expansion (66, 80). The methods most commonly used for control at present are live trapping, spring trapping, shooting or poisoning with warfarin (61), but most control has only a short-term and local effect on population levels (35). Studies have been carried out on immunocontraception (56, 57), but this is not an option currently available in Britain, although it is likely to remain a potentially attractive, if challenging, addition to the wildlife management toolkit (16, 21, 84).

In Scotland, there are currently two organisations, supported by the Scottish Government and a range of environmental and conservation bodies, devoted to encouraging the wide-scale control of grey squirrels to help conserve the native red squirrel (*Sciurus vulgaris*) (www.red-squirrels.org.uk; www.scottishsquirrels.org.uk). In Wales, an attempt to control grey squirrels started on the Isle of Anglesey (71,900 ha) in 1998, over 8,000 had been killed by 2006, and the project's objective is to eradicate them by 2010/11 (22). Research into the effectiveness of widespread control of grey squirrels in the north of England concluded that it had played a part in ensuring that people could still see red squirrels in the area. The research also concluded that grey squirrel control must be a key component of any red squirrel conservation strategy (66).

Edible dormouse

Edible dormice are restricted to a relatively small area of Great Britain centred on the Chiltern hills in south-east England, where they were released in 1902 (59). All Gliridae are protected under the Berne Convention, to which the UK is a signatory, so they are, ironically, protected under UK legislation. To ease the potential licensing burden for their management, a general licence is issued by Natural England permitting their control, by appropriate methods, for purposes such as the prevention of serious damage. The control methods normally used are live trapping followed by humane dispatch or the use of approved (lethal) spring traps.

Muskrat

Muskrats, which are native to North America, became established at three sites in England and one in Scotland during the 1920s. The populations were all successfully eradicated by 1937, with at least 4,388 muskrats killed (30, 60, 79, 96, 97). Leghold traps were used and Munro (60) details the extensive non-target mortality of the trapping in Scotland: 945 muskrat were caught in two years but over 6,500 non-target individuals were caught from 27 different species.

The most extensive eradication campaign was in Shropshire, in England close to the Welsh border, where up to 39 trappers laid traps over an area of 1,000 km^2. The attributes that helped this campaign to succeed were: the need for control was clear and the campaigns were well supported; action was taken at a relatively early stage and was well organised; there was no immigration from outside the control areas; and trapping continued well after the last muskrat had been caught (30). Whilst it is difficult to be

certain how populations would have expanded if left unchecked, the present extensive range of muskrat in Europe, from the Mediterranean to the northern European coast (54), indicates that they may well have otherwise been present throughout most of Great Britain today.

Coypu

Coypus were reported to have escaped from 50% of fur farms, with reports of them in the wild from 1932 (46). Between 1943 and 1944 there were three campaigns to try and control them in east England, in Norfolk. Gin traps were used and 193 coypus were killed. However, the trapping did not contain the population and between 1945 and 1962 coypus steadily increased their range. In the late 1950s the damage being caused resulted in drainage and agricultural interests seeking financial support to control the coypu population. In 1960 the 50% grant given to Rabbit Clearance Societies was also made payable for controlling coypus and 97,000 were killed between 1961 and August 1962.

In 1962 a campaign was launched to get as near to extermination as possible, with any remaining animals confined to a core area in the Norfolk Broads (19, 63). Twelve trappers were employed for most of the time and there was also considerable trapping done by Rabbit Clearance Societies. The trapping technique had now changed to cage trapping, allowing captured coypus to be shot and non-target animals to be released. The strategy used was to divide the majority of the known coypu distribution area into nine strips and start the trapping at the outermost strip (Fig. 1). Traps were set throughout that strip until all coypus were thought to have been caught and this process continued inwards, towards the sea, through successive strips until all of the area had been covered. The campaign finished in 1965; it had covered 6,850 km^2, the trappers had travelled over 800,000 km, recorded over 600,000 'trap nights' (1 trap night = 1 trap set for one night) and nearly 40,500 coypus had been trapped. Coypu numbers were greatly reduced both by the trapping and, as later research would demonstrate (30), by the exceptionally cold winter of 1962/63. It was also clear in hindsight that there were flaws in the strategy. Too much time was spent trying to clear low-density areas outside the main trapping area (Fig. 1), rather than maximising capture rates. Insufficient weight was also given to the problems of immigration into areas that had already been 'cleared'.

Coypu numbers rose again over the 1970s and, in April 1981, following the recommendation of an independent Coypu Strategy Group, a second eradication campaign was started (28). Half the funding was provided by central government, 40% by the local water authority and 10% by local drainage interests. The campaign was ultimately successful in eradicating a population which had a distribution similar to that in the first campaign (Fig. 1) and which was estimated to number about 6,000 adults at the start of the campaign. It started with the advantage of being able to utilise results from long-term research into the coypu population (29). This important process of collecting data during control operations, analysing, processing and feeding back results to improve field operations, possibly using models, has been termed 'adaptive resource management' (73). Methods were devised to both estimate the size of the population (32) and to build simulation models of the population (31) to help plan the campaign. Based on the modelling, a trapping force of 24 trappers, three foremen and a manager were employed with the aim of eradicating coypus within ten years. This size of operation assumed an average number of cold winters, as together, trapping and weather accounted for 82% of the change in the coypu population (30). It also assumed an improvement in trapping effectiveness, which was achieved by using more traps per trapper and using baited rafts to support traps, which made them 50% more effective than traps on land (5).

The strategy for trapper deployment in the second campaign was based on eight 'strategic regions' (Fig. 2) designated to cover the area over which coypus were found. Effort was deployed in the regions using a weighted index, such that the more coypus that were killed per trapper in one three-month period, the proportionally greater the trapping effort put in for the next three-month period. However, no areas were left without any control effort (27). The latter stages of the campaign were also considered at an early stage and an incentive bonus was built into employment contracts. Contracts were limited to ten years but trappers could earn a bonus of three years' salary if coypus were eradicated within six years. The bonus then declined *pro rata* with none payable if coypus were not eradicated. The trapping force was disbanded in 1989 when it was unlikely that a breeding population remained, with trappers receiving almost the maximum bonus. Research staff independently monitored the campaign and continued to look for coypus using bait rafts; three adult male coypus were found after 1987, the last in December 1989.

Baker (3) drew out seven features that helped make this large-scale eradication a success:

– there was a clear case for eradication

– the strategy was viable and well costed

– a publically acceptable control technique was used

– there was a sound management structure and sufficient finances were available

– the progress could be monitored and there was continual improvement

Fig. 1
Strategy for the first coypu eradication campaign in east England: 1962 to 1965
Numerals 1 to 9 illustrate the main trapping phases, with dots indicating the locations of outlying coypus (19, 63)

– there was an incentive for the trapping force

– a practical end point was defined as it takes a long time to be certain that eradication has been achieved.

American mink

American mink were breeding in the wild by 1957 and by 1962 had become established on several river systems in England and Wales (87). Initially there was *ad hoc* control but nine trappers were engaged between 1965 and 1970 to try and at least halt their spread. Over 4,000 mink were caught by 1970 but it was then clear that mink were more widespread than had been thought and organised control was stopped (87). Control in Scotland was similar: breeding was confirmed in 1962 and there was organised trapping by four trappers between 1965 and 1970, which was then discontinued (18).

Control continues today but is now largely *ad hoc* using spring or cage traps, often with rafts used both for detection and trapping (69). There were about 20 packs of hounds hunting mink (9), but this practice is now illegal. The recent increase in otter density following the banning of the toxic organochlorine insecticides has been tracked by a decline in mink, suggesting that lethal intraguild aggression (summary in 43) may help control the mink population.

The Hebridean Mink Project, designed to protect important seabird colonies on the Western Isles archipelago through the control of mink, initially ran between 2001 and 2006. It cost a total of €2,762,834, half funded as a European life Project (58, 74). It aimed to eradicate mink from South Uist, Benbecula and North Uist and reduce populations on South Harris (Fig. 3) to try to prevent further immigration. The project employed

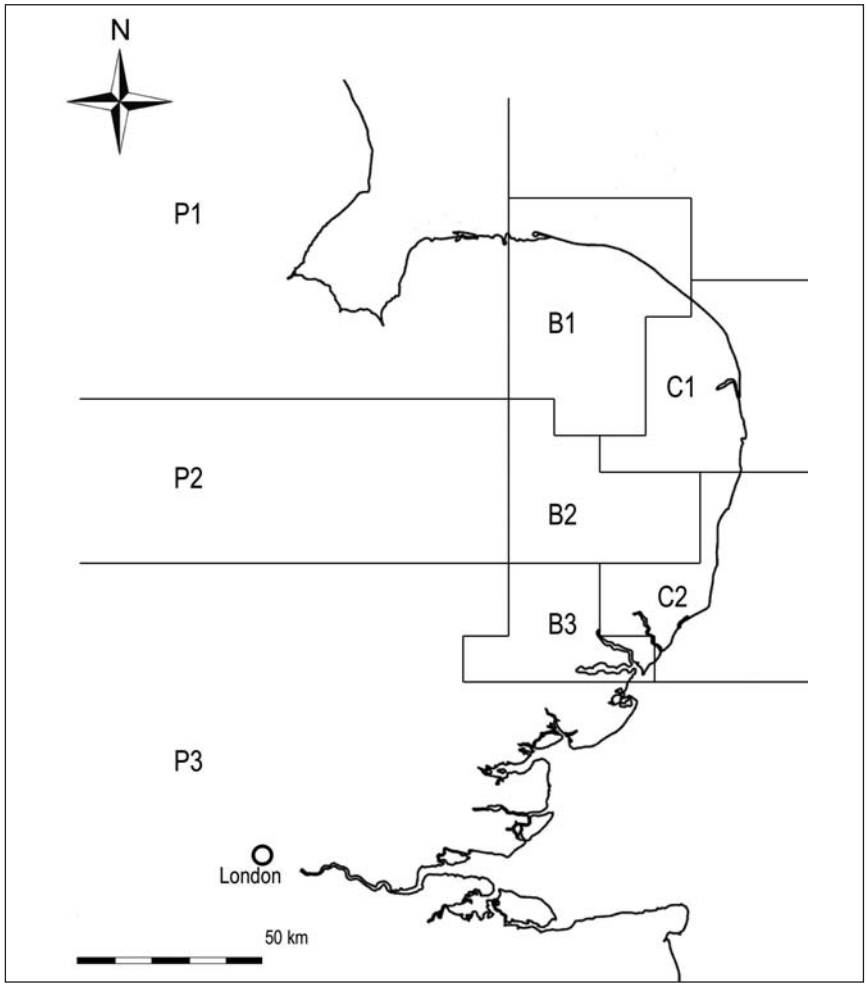

Fig. 2

Strategy for the second, successful, coypu eradication campaign in east England: 1981 to 1989

In any one three-month trapping period trapping effort was deployed between the two highest-density regions (C), three medium-density regions (B) and three low-density regions (P) in proportion to the number of coypus killed per trapper in the preceding three-month trapping period (i.e. the more coypu trapped, the greater the effort). This was in order to maximise the numbers trapped and minimise emigration (after 30)

11 trappers and a manager, and 230 mink were caught in cage traps from the Uists and 302 from Harris. Traps were set over an area of 1,114 km^2, with over 200,000 trap nights of effort. Thanks to the knowledge gained from research and analysis from operational elements of the project itself continual improvements were made through adaptive resource management. The success rate was improved by the use of dogs to locate mink dens during denning periods, when mink are difficult to trap, and trapping effectiveness increased by 50% through the use of a chemical attractant. Mink were eradicated, despite their distribution being found to be 50% greater than expected once trapping had started (European Union LIFE Project Report, 2006, LIFE NAT/007073, 'Mink control to protect important birds in the SPAs [Special Protected Areas] in the Western Isles', unpublished). Phase two of the Hebridean Mink Project is now under way, with the objective of eradicating mink completely from the Western Isles by 2011. A total of 1,235 mink had been caught in this phase by February 2010, with the rate of capture having reduced significantly since the start of the project (I. MacLeod, personal communication).

The mid-20th Century to the present

Species included in Table III have all escaped from captivity in the last 50 years. Apart from wild boar, they are all recorded by Baker (4) as breeding out of captivity, but none has persisted or had a population of more than 100 free-living animals for more than ten years.

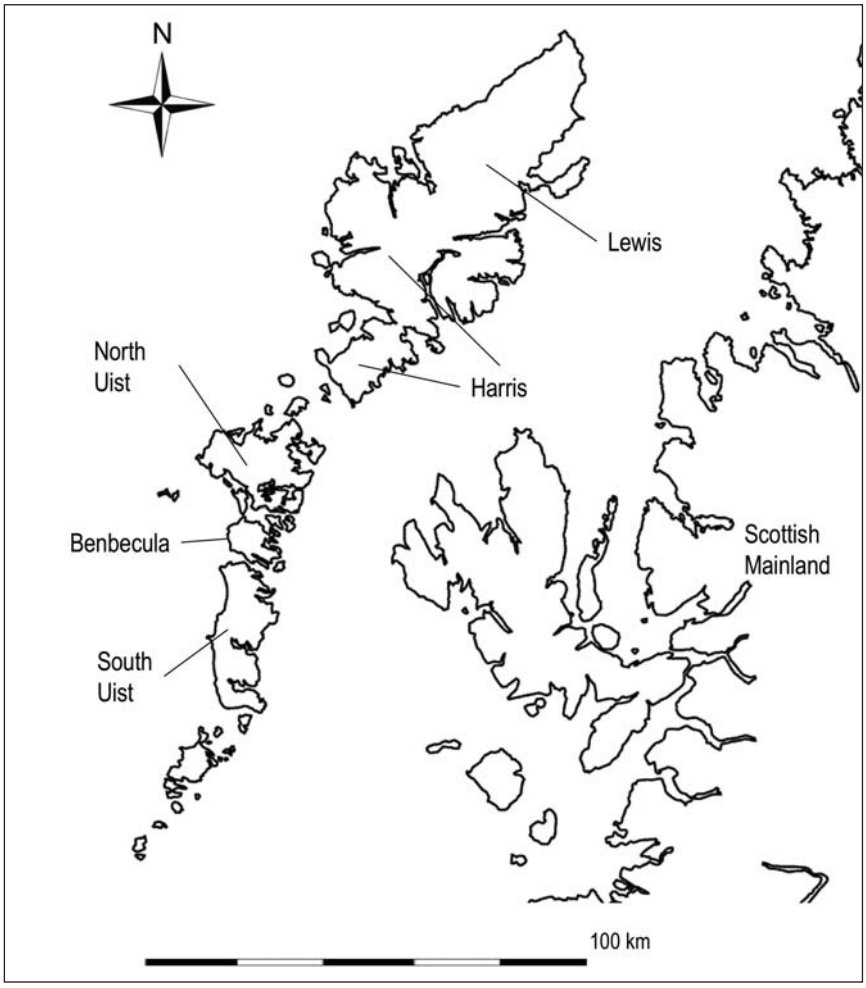

Fig. 3
Map of the Western Isles archipelago in Scotland, where programmes to control mink (Hebridean Mink Project) and hedgehogs (Uist Wader Project) are currently underway

Table III
Mammals introduced into Great Britain from the mid-20th Century to the present [(a)]

Species	Approximate time of introduction (years BP)	Summary of recent wildlife management
Golden hamster (*Mesocricetus auratus*)	52	Occasional small colonies eradicated/not survived
Himalayan porcupine (*Hystrix brachyura*)	41	Eradicated
Mongolian gerbil (*Meriones unguiculatus*)	39	Did not survive
Black-tailed prairie dog (*Cynomys ludovicianus*)	34	Occasional small colonies eradicated/not survived
Asian short-clawed otter (*Aonyx cinerea*)	27	Appears not to have survived
Hedgehog (*Erinaceus europaeus*)	26	Introduced to offshore islands, eradication in progress on Western Isles
Père David's deer (*Elaphurus davidianus*)	13	Very localised, some shot
Wild boar (*Sus scrofa*)	12	Was native but not present for 300 years. Now returned following escapes from captivity, shot

(a) Species and date of introduction from Harris & Yalden (38)
BP: before present, in this context before 2010

Populations of golden hamster (*Mesocricetus auratus*) and black-tailed prairie dog (*Cynomys ludovicianus*) disappeared after a relatively short period, in some cases after control (1). In one case, prairie dogs were controlled with fumigants, a potentially effective method but, as there is no product approved for this purpose in Britain, this was illegal. The Mongolian gerbil (*Meriones unguiculatus*) and Asian short-clawed otter (*Aonyx cinerea*) both appear to have been unsuccessful in establishing themselves out of captivity for an extended period and both populations are unlikely to still exist. It is possible that competition with a resurgent native otter (*Lutra lutra*) population might have impacted on the short-clawed otter (4). There is a small population of Père David's deer (*Elaphurus davidianus*) around an estate in Northamptonshire in central England, where they are kept unenclosed and are occasionally shot. This section also considers the control of hedgehogs that have been introduced to offshore islands.

Himalayan porcupine

The eradication of the Himalayan porcupine (*Hystrix brachyura*) is a good example of early action preventing a potentially significant long-term problem. A pair escaped from a wildlife park in 1969 and established a small population living in south-west England within a 16-km radius of Oakhampton in Devon. A cage-trapping programme was started in 1973 and by 1979, when the last animal had been caught, six animals had been accounted for. This was out of an estimated 12 individuals that could have been at large (4, 83). The cost-effectiveness of acting early, in line with CBD precautionary principles, is clear when you compare, on a standardised basis, the cost of the campaign to eradicate Himalayan porcupine (£78,000) with the costs of campaigns against coypu (£2.75 million) and muskrat (£1.4 million), and the failed mainland mink eradication attempt (£0.5 million) (2).

Hedgehogs

Western European hedgehogs (*Erinaceus europaeus*) were introduced to the Western Isles in 1974. Although a native of the mainland, this species had not previously been present on these islands. The Uist Wader Project (75) has been controlling them there since 2002 to try to protect breeding birds (41, 42), using a combination of trapping, capture using spotlights and the use of dogs to locate them. The plan now is to eradicate them from North Uist and Benbecula and limit their distribution on South Uist. What to do with hedgehogs captured in this project has proved controversial. In the early years all were killed by lethal injection; since 2007 they have been transferred to the mainland and released at suitable sites, although mortality is likely to be high (75).

Wild boar

The native wild boar (*Sus scrofa*) probably became extinct in Great Britain at least 700 years ago and, allowing for reintroductions to parks for hunting, there have been none present for about 300 years (33). Following escapes, likely to be of farmed animals, there were at least three populations established by 2008, estimated at no more than 500 animals in total. Following a programme of research and consideration of management options, including fertility control (52), the government department responsible published an action plan for the management of wild boar (93). This considers regional management, with no direct government intervention, to be the most appropriate approach. The conclusion was based on the findings of a formal risk assessment for which researchers used a methodology available through the GB Non-native Species Secretariat (34) that provides a standardised method for assessing the risk to biodiversity and socio-economic interests. The most significant possible impacts of wild boar populations were thought to be the maintenance of an exotic disease, such as classical swine fever, and the involvement of the animals in road traffic accidents.

Conclusion

Taking a long-term view of species control and eradication in a defined area provides an opportunity to reflect on the lessons, trends, challenges and successes. There is a risk that we may view the management of introduced species too simplistically and could lose sight of more holistic, ecosystem-based approaches, which may ultimately be needed to protect our biodiversity (82). For example, mink trapping alone might help protect the water vole (*Arvicola terrestris*) but efforts to protect this species are likely to be much more effective if mink trapping is coupled with water vole habitat restoration and recovery of native predators (50). However, single species management has many advantages and has had some considerable successes and is likely to continue to be an important practical approach.

One of the clear findings emerging from this review is that public perception on which species management methods are acceptable changes. The demand for humaneness and less impact on non-target species resulted in the banning of gin traps. The bans on fur farming and hunting with hounds, the translocation of captured hedgehogs rather than their euthanasia and the interest in immunocontraception reflect a concern about animal welfare. This is welcome but more extreme animal rights views are unlikely to be compatible with eradication and control. The successful attempt of animal rights activists to prevent a campaign to try to eradicate introduced grey

squirrels from Italy, at a relatively early and easy-to-manage stage of invasion (25), demonstrates the potential significance of such challenges. The result in this case is that the disruption to the eradication campaign will undoubtedly lead to more squirrels ultimately being controlled and the decline of the native red squirrel in Europe (8). Education and public engagement will become increasingly important in achieving outcomes, but it is unlikely that these will remove all opposition, particularly from those with more extreme animal rights views or vested interests (82).

The largely unintentional and unpredictable impact that changes to the countryside and built environment can have on introduced species is striking. Ship rats have been all but eradicated after 2,000 years through changes in lifestyle, modes of transport, and buildings and improved control techniques. The full impact of rabbits on biodiversity and as an agricultural pest was not felt until 700 years after they were introduced. American mink may well have been able to colonise more quickly because of the low levels of otters and may now be, at least in part, controlled by otters following their population recovery. These examples underline the complexity of natural systems and emphasise the importance of keeping our ecosystems robust and healthy to better withstand invasion. They also highlight the value of the Precautionary Principle, promoted under the CBD, in managing introduced species (14).

There was a high cost for some of the failed control exercises (grey squirrel, rabbit and early mink and coypu control) and they had short-lived impacts on population density and dispersal. Control may often be the only practical option and can be successfully used strategically, for example, as a precursor to eradication (suggested for cats on islands by S. Roy, personal communication) or to prevent range expansion. However, in general, control offers little improvement in the long term. This illustrates the value of eradication programmes, which, although sometimes challenging and costly, have been successful at a range of scales, and each one provides more knowledge and experience to draw on. Techniques are also continually improving and using an adaptive resource management approach allows an eradication campaign to improve as it progresses.

Mammals are the only group for which eradication campaigns have been successful in Europe (24) and even here, for the most part, goals have been modest. Europe has a strategy on invasive species (26), and building on this and on the work of the CBD (13) we are beginning to see a more structured and risk-based approach to considering the management of introduced species. Great Britain has established the GB Non-native Species Secretariat and Programme Board (www.nonnativespecies.org) to provide a focus for information and initiatives and to commission risk assessments for potentially invasive species. The formal risk assessment approach was also used to more objectively determine the action plan for wild boar management (93). The challenge now, as persuasively argued by Simberloff (81), is to aim higher in our aspirations to control invasive species, particularly through the use of eradication programmes.

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Contrôle et éradication des mammifères envahissants en Grande-Bretagne

S.J. Baker

Résumé
Cet article examine la question de l'éradication et du contrôle des espèces envahissantes de mammifères dans une perspective historique de longue durée, en retraçant la gestion de 24 espèces de mammifères ayant réussi à s'introduire en Grande-Bretagne à partir du Néolithique et ayant établi des populations sauvages dans ces nouveaux territoires. Cette approche permet à l'auteur d'examiner un certain nombre de problèmes rencontrés dans la gestion des populations et de tirer les enseignements des réussites et des échecs passés. Les espèces sont étudiées dans l'ordre de leur apparition, en accordant une attention particulière au contrôle et à l'éradication du lapin (*Oryctolagus cuniculus*), du rat musqué (*Ondatra zibethicus*), du ragondin (*Myocastor coypus*) et du vison d'Amérique (*Mustela vison*). Les recensements de ces espèces sont présentés dans le contexte des engagements pris par les Parties à la Convention sur la diversité biologique en matière de contrôle des espèces allochtones envahissantes, ainsi que des orientations fournies par l'Union internationale pour la conservation de la nature (UICN) et par le Conseil de l'Europe. Ces différents cadres ont permis d'améliorer le processus d'évaluation des risques et la concertation sur les actions à mener. Néanmoins, à l'exception de quelques cas exemplaires décrits dans cet article, peu de programmes d'éradication ont effectivement réussi en Europe. L'auteur recommande de s'inspirer des stratégies mises en place et perfectionnées en Grande-Bretagne et dans d'autres pays, et de fixer des objectifs plus ambitieux dans le domaine de la gestion des espèces allochtones envahissantes.

Mots-clés
Contrôle – Éradication – Espèce allochtone envahissante – Grande-Bretagne – Mammifère.

Control y erradicación de mamíferos invasores en Gran Bretaña

S.J. Baker

Resumen
El autor ofrece una 'profunda panorámica` de la erradicación y el control de mamíferos invasores pasando revista a los métodos de gestión de 24 especies introducidas en Gran Bretaña desde el periodo Neolítico y que posteriormente se han asentado como poblaciones salvajes en libertad. El autor ofrece así ejemplos de los problemas que surgen al tratar de manejar a esas poblaciones y examina algunas de las enseñanzas que cabe extraer de los éxitos y fracasos habidos en la empresa, exponiendo el caso de las distintas especies en el mismo orden por el que fueron introducidas y deteniéndose especialmente en el control o la erradicación del conejo común (*Oryctolagus cuniculus*), la rata almizclera (*Ondatra zibethicus*), el coipo (*Myocastor coypus*) y el visón americano (*Mustela vison*). En cada caso sitúa el control de la especie en el

contexto del compromiso de luchar contra las especies foráneas invasoras suscrito por las Partes en el Convenio sobre la Diversidad Biológica y de las orientaciones al respecto formuladas por la Unión Internacional para la Conservación de la Naturaleza y el Consejo de Europa. Estas orientaciones han propiciado mejoras en el proceso de determinar los riesgos y coordinar las actividades. No obstante, pese a una serie de casos notables aquí descritos, en Europa ha habido pocos programas de erradicación que hayan funcionado bien. El autor sostiene que hay buenas razones para profundizar en los dispositivos que se están elaborando en Gran Bretaña y otras partes del mundo y para establecer objetivos más ambiciosos de lucha contra las especies foráneas invasoras.

Palabras clave
Control – Erradicación – Especie foránea invasora – Gran Bretaña – Mamíferos.

References

1. Baker S.J. (1986). – Free living golden hamsters (*Mesocricetus auratus*) in London. *J. Zool.*, **209**, 285-296.

2. Baker S.J. (1990). – Escaped exotic mammals in Britain. *Mammal Rev.*, **20**, 75-96.

3. Baker S.J. (2006). – The eradication of coypus (*Myocastor coypus*) from Britain: the elements of a successful campaign. *In* Assessment and control of biological invasion risks (F. Koike, M.N. Clout, M. Kawamichi, M. De Poorter & K. Iwatsuki, eds). Shoukadoh Book Sellers, Kyoto, Japan and International Union for Conservation of Nature, Gland, Switzerland, 142-147.

4. Baker S.J. (2008). – Escapes and introductions. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 780-794.

5. Baker S.J. & Clarke C.N. (1988). – Cage trapping coypus (*Myocastor coypus*) on baited rafts. *J. appl. Ecol.*, **25**, 41-48.

6. Bentley E.W. (1959). – The distribution and status of *Rattus rattus* L. in the United Kingdom in 1951 and 1956. *J. anim. Ecol.*, **28**, 299-308.

7. Berry R.J., Tattersall F.H. & Hurst J. (2008). – House mouse *Mus domesticus*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 141-149.

8. Bertolino S. & Genovesi P. (2003). – Spread and attempted eradication of the grey squirrel (*Sciurus carolinensis*) in Italy and consequences for the red squirrel (*Sciurus vulgaris*) in Eurasia. *Biol. Conserv.*, **109**, 351-358.

9. Birks J. (1986). – Mink. Anthony Nelson, Oswestry, Shropshire, United Kingdom.

10. Chapman D.I. & Chapman N.G. (1997). – Fallow deer: their history, distribution and biology. Coch-y-bonddu Books, Machynlleth, Wales.

11. Chasey D. & Trout R.C. (1995). – Rabbit haemorrhagic disease in Britain. *Mammalia*, **59**, 599-603.

12. Clout M.N. & Williams P.A. (2009). – Invasive species management: a handbook of techniques. Oxford University Press, Oxford.

13. Convention on Biological Diversity (CBD) (2002). – Available at: www.cbd.int/convention/ (accessed on 23 February 2010).

14. Convention on Biological Diversity (CBD) (2002). – Decision VI/23 on alien species that threaten ecosystems, habitats or species. Available at: www.cbd.int/decision/cop/?id=7197 (accessed on 28 February 2010).

15. Cooke A.S. & Farrell l. (2008). – Chinese water deer *Hydropotes inermis*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 617-622.

16. Cooper D.W. & Larsen E. (2006). – Immunocontraception of mammalian wildlife: ecological and immunogenetic issues. *Reproduction*, **132**, 821-828.

17. Cowan D.P. & Hartley F.G. (2008). – Rabbit *Oryctolagus cuniculus*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 201-210.

18. Cuthbert J.H. (1973). – The origin and distribution of feral mink in Scotland. *Mammal Rev.*, **3**, 97-103.

19. Davis R.A. (1968). – A note on the feral coypu in the United Kingdom 1930-1967. European and Mediterranean Plant Protection Organisation [EPPO] Publication, Series A, No. 47. EPPO, Paris, 63-66.

20. Fenner F. & Ross J. (1994). – Myxomatosis. *In* The European Rabbit. The history and biology of a successful colonizer (H.V. Thompson & C.M. King, eds). Oxford University Press, Oxford, 205-240.

21. Ferro V.A. (2002). – Current advances in antifertility vaccines for fertility control and noncontraceptive applications. *Expert Rev. Vaccines*, **1**, 443-452.

22. Friends of Anglesey Red Squirrels (2008). – Grey squirrels on Anglesey. Available at: www.redsquirrels.info/greys.html (accessed on 22 February 2010).

23. Garciá-Bocanegra I., Astorga R.J., Napp S., Casal J., Huerta B., Borge C. & Arenas A. (2010). – Myxomatosis in wild rabbit: design of control programs in Mediterranean ecosystems. *Prev. vet. Med.*, **93**, 42-50.

24. Genovesi P. (2005). – Eradications of invasive alien species in Europe: a review. *Biol. Invas.*, **7**, 127-133.

25. Genovesi P. & Bertolino S. (2001). – Human dimension aspects in invasive alien species issues: the case of the failure of the grey squirrel eradication project in Italy. *In* The great reshuffling: human dimensions of invasive alien species (J. McNeely, ed.). International Union for Conservation of Nature, Gland, Switzerland, 113-119.

26. Genovesi P. & Shine C. (2003). – European Strategy on Invasive Alien Species. Doc.t-pvs(2003)7 rev, Council of Europe, Strasbourg, 50 pp.

27. Gosling L.M. (1981). – The dynamics and control of a feral coypu population. *In* Proc. Worldwide Furbearer Conference (J.A. Chapman & D. Pursley, eds), 3-11 August, 1980, Frostburg, Maryland. Frostburg State College, Maryland, 1806-1825.

28. Gosling L.M. (1989). – Extinction to order. *New Scientist*, **121**, 44-49.

29. Gosling L.M. & Baker S.J. (1987). – Planning and monitoring an attempt to eradicate coypus from Britain. *Symp. zool. Soc. (London)*, **58**, 99-113.

30. Gosling L.M. & Baker S.J. (1989). – The eradication of muskrats and coypus from Britain. *Biol. J. Linnean Soc.*, **38**, 39-51.

31. Gosling L.M., Baker S.J. & Skinner J.R. (1983). – A simulation approach to investigating the response of a coypu population to climatic variation. *EPPO Bulletin*, **13**, 183-192.

32. Gosling L.M., Watt A.D. & Baker S.J. (1981). – Continuous retrospective census of the East Anglian coypu population between 1970 and 1979. *J. anim. Ecol.*, **50**, 885-901.

33. Goulding M., Kitchener A.C. & Yalden D.W. (2008). – Wild boar *Sus scrofa*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 561-564.

34. Great Britain Non-native Species Secretariat (2009). – Risk assessments. Available at: https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51 (accessed on 9 June 2010).

35. Gurnell J., Kenward R.E., Pepper H. & Lurz P.P.W. (2008). – Grey squirrel *Sciurus carolinensis*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 66-72.

36. Harper G.A. & Cabrera L.F. (2009). – Response of mice (*Mus musculus*) to the removal of black rats (*Rattus rattus*) in arid forest on Santa Cruz Island, Galapagos. *Biol. Invas.*, Invasion Note. E-pub. 18 August 2009.

37. Harris S., Morris P., Wray S. & Yalden D. (1995). – A review of British mammals. Joint Nature Conservation Committee, Peterborough, United Kingdom.

38. Harris S. & Yalden D.W. (eds) (2008). – Mammals of the British Isles Handbook, 4th Ed. The Mammal Society, Southampton, United Kingdom.

39. Howald G., Donlan C., Galvan J., Russell J., Parkes J., Samaniego A., Wand Y., Veitch D., Genovesi P., Pascal M., Saunders A. & Tershy B. (2007). – Invasive rodent eradication on islands. *Conserv. Biol.*, **21**, 1258-1268.

40. International Union for Conservation of Nature (IUCN) (2000). – IUCN Guidelines for the prevention of biodiversity loss caused by alien invasive species. IUCN, Gland, Switzerland. Available at: http://intranet.iucn.org/webfiles/doc/SSC/SSCwebsite/Policy_statements/IUCN_Guidelines_for_the_Prevention_of_Biodiversity_Loss_caused_by_Alien_Invasive_Species.pdf (accessed on 3 March 2010).

41. Jackson D.B. (2006). – The breeding biology of introduced hedgehogs (*Erinaceus europaeus*) on a Scottish Island: lessons for population control and bird conservation. *J. Zool.*, **268**, 303-314.

42. Jackson D.B., Fuller R.J. & Campbell S.T. (2004). – Long-term population changes among breeding shorebirds in the Outer Hebrides, Scotland, in relation to hedgehogs (*Erinaceus europaeus*). *Biol. Conserv.*, **117**, 151-166.

43. Jeffries D.J. & Woodroffe G.L. (2008). – Otter *Lutra lutra*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 437-447.

44. Johnstone I.G., Gray C.M. & Noble D.G. (2005). – The state of birds in Wales 2004. Royal Society for the Protection of Birds, Cymru, Cardiff, Wales. Available at: www.rspb.org.uk/Images/stateofwelshbirds04_tcm9-133193.pdf (accessed on 19 February 2010).

45. Langbein J., Chapman N.G. & Putman R.J. (2008). – Fallow Deer *Dama dama. In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 595-604.

46. Laurie E.M.O. (1946). – The coypu (*Myocastor coypus*) in Great Britain. *J. anim. Ecol.*, **15**, 22-34.

47. Lever C. (1977). – The naturalized animals of the British Isles. Hutchinson, London.

48. Lloyd H.G. (1962). – Humane traps. The Review (June). Royal Agricultural Society of England, Stoneleigh Park, Warwickshire, 15-16.

49. Lockley R.M. (1964). – The private life of the rabbit. André Deutsch, London.

50. Macdonald D.W. & Harrington L. (2003). – The American mink: the triumph and tragedy of adaptation out of context. *N.Z. J. Zool.*, **30**, 421-441.

51. McKillop I.G. (1988). – The operation of coordinated rabbit control organizations in England and Wales. *In* Proc. 13th Vertebrate Pest Conference (A.C. Crabb & R.E. Marsh, eds). University of Nebraska, Lincoln, 174-179. Available at: http://digitalcommons.unl.edu/vpcthirteen/36 (accessed on 18 February 2010).

52. Massei G., Cowan D.P., Coats J., Gladwell F., Lane J.E. & Miller L.A. (2008). – Effect of the GnRH vaccine GonaCon on the fertility, physiology and behaviour of wild boar. *Wildl. Res.*, **35**, 540-547.

53. Mead-Briggs A.R. & Vaughan J.A. (1975). – The differential transmissibility of myxoma virus strains of differing virulence grades by the rabbit flea *Spilopsyllus cuniculi. J. Hyg. (Camb.)*, **75**, 237-247.

54. Mitchell-Jones A.J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P.J.H., Spitzenbrger F., Stubbe M., Thissen J.B.M., Vohralík V. & Zima J. (1999). – The Atlas of European mammals. T. & A.D. Poyser, London.

55. Mitchell-Jones A.J., Marnell F., Matthews J.E. & Raynor R. (2008). – Mammals and the law. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 32-52.

56. Moore H.D.M. (1997). – On developing an immunocontraceptive vaccine for the grey squirrel. *In* The conservation of red squirrels, *Sciurus vulgaris L.* (J. Gurnell & P.W.W. Lurz, eds). People's Trust for Endangered Species, London, 127-132.

57. Moore H.D., Jenkins N.M. & Wong C. (1997). – Immunocontraception in rodents: a review of the development of a sperm-based immunocontraceptive vaccine for the grey squirrel (*Sciurus carolinensis*). *Reprod. Fertil. Dev.*, **9**, 125-129.

58. Moore N.P., Roy S.S. & Helyar A. (2003). – Mink (*Mustela vison*) eradication to protect ground-nesting birds in the Western Isles, Scotland, United Kingdom. *N.Z. J. Zool.*, **30**, 443-452. Available at: www.royalsociety.org.nz/Site/publish/Journals/nzjz/2003/034.aspx (accessed on 24 February 2010).

59. Morris P.A. (2008). – Edible dormouse *Glis glis. In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 82-85.

60. Munro T. (1935). – Note on musk-rats and other animals killed since the inception of the campaign against musk-rats in October 1932. *Scottish. Nat.*, **4**, 11-16.

61. Natural England (2009). – Advisory leaflets. Available at: www.naturalengland.org.uk/ourwork/regulation/wildlife/default.aspx (accessed on 2 March 2010).

62. Nogales M., Martín A., Tershy B.R., Donlan C.J., Veitch D., Puerta N., Wood B. & Alonso J. (2004). – A review of feral domestic cat (*Felis catus L.*) eradication on islands. *Conserv. Biol.*, **18**, 310-319.

63. Norris J.D. (1967). – A campaign against feral coypus (*Myocastor coypus*) in Great Britain. *J. appl. Ecol.*, **4**, 11-16.

64. Orueta J.F. & Ramos Y.A. (1998). – Methods to control and eradicate non-native terrestrial vertebrate species. Nature and Environment, No. 118. Council of Europe, Strasbourg, 66 pp.

65. Parkes C. & Thornley J. (1997). – Fair game: the law of country sports and the protection of wildlife. Pelham Books, London.

66. Parrott D., Quy R., Van Driel K., Lurz P., Rushton S., Gurnell J., Aebischer N. & Reynolds J. (2009). – Review of red squirrel conservation activity in northern England. Natural England Commissioned Report NECR019. Available at: http://naturalengland.etraderstores.com/NaturalEnglandShop/NECR019 (accessed on 28 February 2010).

67. Pimental D., McNair S., Janecka J., Wightman J., Simmonds C., O'Connell C., Wong E., Russel L., Zern J. Aquino T. & Tsomondo T. (2001). – Economic and environmental threats of alien plant, animal, and microbe invasions. *Agric. Ecosyst. Environ.*, **84**, 1-20.

68. Quy R.J. & Macdonald D.W. (2008). – Common rat *Rattus norvegicus. In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 149-155.

69. Reynolds J.C., Short M.J. & Leigh R.J. (2004). – Development of population control strategies for mink *Mustela vison*, using floating rafts as monitors and trap sites. *Biol. Conserv.*, **120**, 533-543.

70. Ross J. (1986). – Comparison of fumigant gases used for rabbit control in Great Britain. *In* Proc. 12th Vertebrate Pest Conference (T.P. Salmon, ed.). University of Nebraska, Lincoln, 153-157. Available at: http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1053&context=vpc12 (accessed on 2 March 2010).

71. Ross J. & Sanders M.F. (1987). – Changes in the virulence of myxoma virus strains in Britain. *Epidemiol. Infect.*, **98**, 113-117.

72. Ross J. & Tittensor A.M. (1981). – Myxomatosis in selected rabbit populations in southern England and Wales. *In* Proc. World Lagomorph Conference (K. Myers & C.D. McInnes, eds), University of Guelph, Ontario. International Union for Conservation of Nature, Gland, Switzerland, 830-833.

73. Roy S., Smith G.C. & Russell J.C. (2009). – The eradication of invasive mammal species: can adaptive resource management fill the gaps in our knowledge. *Human–Wildlife Interactions*, **3**, 30-40.

74. Scottish Natural Heritage (2010). – Hebridean Mink Project. Available at: www.snh.org.uk/scottish/wisles/intro.asp (accessed on 3 March 2010).

75. Scottish Natural Heritage (2010). – Uist Wader Project. Available at: www.snh.org.uk/scottish/wisles/waders/about.asp (accessed on 24 February 2010).

76. Scottish Parliament (2002). – The Protection of Wild Mammals (Scotland) Act 2002. Available at: www.statutelaw.gov.uk (accessed on 18 February 2010).

77. Sellers R.F. (1987). – Possible windborne spread of myxomatosis to England in 1953. *Epidemiol. Infect.*, **98**, 119-125.

78. Sheail J. (1971). – Rabbits and their history. David & Charles, Newton Abbott, United Kingdom.

79. Sheail J. (1988). – The extermination of the muskrat (*Ondatra zibethicus*) in inter-war Britain. *Arch. nat. Hist.*, **15**, 155-170.

80. Shorten M. (1962). – Squirrels, their biology and control. *MAFF Bulletin*, **184**, 1-44.

81. Simberloff D. (2002). – Today Tiritiri Matangi, tomorrow the world! Are we aiming too low in invasives control? *In* Turning the tide: the eradication of invasive species (C.R. Veitch & M.N. Clout, eds). *In* Proc. International Conference on Eradication of Island Invasives. International Union for Conservation of Nature, Gland, Switzerland, 414 pp.

82. Simberloff D. (2008). – Successes, failures and challenges in protecting biodiversity: DOC and the next 20 years. *In* Proc. Conserv-Vision Conference, 2-4 July 2007, University of Waikato (B. Clarkson, P. Kurian, T. Nachowitz & H. Rennie, eds). University of Waikato, Hamilton, New Zealand, 1-13. Available at: www.waikato.ac.nz/wfass/Conserv-Vision/ (accessed on 29 February 2010).

83. Smallshire D. & Davey J.W. (1989). – Feral Himalayan porcupines in Devon. *J. Devon wildl. Trust*, **10**, 62-69.

84. Suri A. (2005). – Sperm-based contraceptive vaccines: current status, merits and development. *Expert Rev. mol. Med.*, **7**, 1-16.

85. Tapper S. (1997). – Game heritage: an ecological review from shooting and gamekeeping records. The Game Conservancy Ltd., Fordingbridge, Hampshire, United Kingdom.

86. Terborgh J., Estes J.A., Paquet P., Boyd-Heger D., Miller B.J. & Noss R.F. (1999). – The role of top carnivores in regulating terrestrial ecosystems. *In* Continental conservation (M.E. Soulé & J. Terborgh, eds). Island Press, Washington, DC, 39-64.

87. Thompson H.V. (1971). – British wild mink – a challenge to naturalists. *Agriculture*, **78**, 421-425.

88. Thompson H.V. (1994). – The rabbit in Britain. *In* The European rabbit: the history of a successful colonizer (H.V. Thompson & C.M. King, eds). Oxford University Press, Oxford, 64-107.

89. Thompson H.V. & King C.M. (1994). – The European rabbit: the history of a successful colonizer. Oxford University Press, Oxford.

90. Thompson H.V. & Worden A.N. (1956). – The rabbit. Collins, London.

91. Trout R.C., Chasey D. & Sharp G. (1997). – Seroepidemiology of rabbit haemorrhagic disease (RHD) in wild rabbits (*Oryctolagus cuniculus*) in the United Kingdom. *J. Zool.*, **243**, 846-853.

92. Twigg G.I., Buckle A.P. & Bullock D.J. (2008). – Ship rat *Rattus rattus*. *In* Mammals of the British Isles: handbook, 4th Ed. (S. Harris & D.W. Yalden, eds). The Mammal Society, Southampton, 155-158.

93. United Kingdom Department for Environment and Rural Affairs (DEFRA) (2008). – Feral wild boar in England: an action plan. DEFRA PB 12997. DEFRA, London. Also available at: www.naturalengland.org.uk/Images/feralwildboar_tcm6-4508.pdf (accessed on 25 February 2010).

94. United Kingdom Government (2004). – The Hunting Act 2004. Available at: www.statutelaw.gov.uk (accessed on 18 February 2010).

95. Veitch C.R. & Clout M.N. (eds) (2002). – Turning the tide: the eradication of invasive species. *In* Proc. International Conference on Eradication of Island Invasives. International Union for Conservation of Nature, Gland, Switzerland, 414 pp.

96. Warwick T. (1934). – The distribution of the muskrat (*Fiber zibethica*) in the British Isles. *J. anim. Ecol.*, **3**, 250-265.

97. Warwick T. (1940). – A contribution to the ecology of the musk-rat (*Ondatra zibethica*) in the British Isles. *Proc. zool. Soc. Lond.*, **110**, 165-201.

98. White P.J., Norman R.A., Trout R.C., Gould E.A. & Hudson P.J. (2001). – The emergence of rabbit haemorrhagic disease virus: will a non-pathogenic strain protect the UK? *Philos. Trans. roy. Soc. Lond., B, biol. Sci.*, **356**, 1087-1095.

99. Whitehead G.K. (1964). – The deer of Great Britain and Ireland. Routledge & Kegan Paul, London.

100. Zonfrillo B. (2000). – Ailsa Craig: before and after the eradication of rats in 1991. Available at: www.ayrshire-birding.org.uk/ABR/2000/ailsa_craig.htm (accessed on 28 February 2010).