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The effect on the environment of Great Britain's naturalized Greater Canada *Branta canadensis* and Egyptian Geese *Alopochen aegyptiacus*

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Greater Canada and Egyptian Geese are amongst the most abundant introduced bird species in Great Britain, both numerically and by biomass. Both species have increased rapidly in numbers and range within Great Britain. Greater Canada Goose numbers have increased by over 8% per annum since 1962. Although estimates of Egyptian Goose numbers are less reliable, in 2000 there were more than twice as many individuals of this species in Great Britain than in the early 1980s. The population growth of both species is showing no sign of slowing down. The species have been recorded as being aggressive towards native species of waterbird, to hybridize with native species of waterbird, to cause water eutrophication, to be agricultural pests and to pose an aircraft birdstrike risk. However, much of the evidence that these species affect the environment and native species is anecdotal or in grey literature that has not been peer-reviewed. We argue that there is a clear need for more work to assess the effects of non-native species on the environment, and that the Greater Canada Goose would be a particularly good model species for research on non-native species more generally.

Introduction

Whether deliberate or accidental, the translocation of species beyond their native range is a major cause of loss of biodiversity throughout the world (IUCN 1998) and results in economic damage to agriculture, forestry, aquaculture and other sectors (Williamson 1996). In the United States alone the economic damage to these sectors has been estimated to have costed $97 billion between 1906 and 1991 (Bright 1998). At the 2000 Exotic and Invasive Species Conference of the Institute of Ecology and Environmental Management, 98% of an informed audience considered non-native species as a major problem for conservation in Great Britain, and that, where feasible, every effort should be made to eradicate invasive, non-native plants, invertebrates and vertebrates (McLean 2001).

A requirement to prevent the introduction of or to control established non-native species that threaten native biodiversity is expressed in the following legislation, conventions and agreements: EU Birds Directive (1979), Bern Convention (1982), EU Habitats Directive (1992), Convention on Biological Diversity (1993) and Bonn Convention (1985) (Hughes *et al.* 2006). It is most strongly expressed in the African–Eurasian Migratory Waterbird Agreement (AEWA) under the Convention on the Conservation of Migratory Species (Bonn Convention). The AEWA agreement encourages member states to assess the impact of introduced and non-native species on their migratory waterbirds. Article III in the General Conservation Measures Section 2 (g) states that '… the Parties shall prohibit the deliberate introduction of non-native waterbird species into the environment and take all appropriate measures to prevent the unintentional release of such species if this introduction or release would prejudice the conservation status of wild flora and fauna; when non-native waterbird species have already been introduced, the Parties shall take all appropriate measures to prevent these

species from becoming a potential threat to indigenous species.' In AEWA's 'Draft conservation guideline on avoidance of introductions of non-native migratory waterbird species' (http://www.unep-aewa.org/meetings/en/mop/mop2_docs/pdf/mop_docs/mop2_13_introduced_waterbirds_guideline.pdf) Greater Canada Geese *Branta canadensis* (henceforth, Canada Goose) and Egyptian Geese *Alopochen aegyptiacus* are listed as being of medium biodiversity risk as a result of some evidence of local problems through grazing, competition and eutrophication of wetlands, even though their 'negative impacts on biodiversity [are] little understood'.

In this paper we briefly review the known effects of these two species – the commonest species of naturalized goose in Great Britain – on their environments. In so doing we demonstrate that surprisingly little is known about introduced bird species, even when they are a major component of the total British avifauna biomass. We conclude by highlighting some urgent areas for future monitoring and research.

Study approach

We have selected to review information on the two commonest species of introduced naturalized geese in Great Britain, Canada and Egyptian Geese (categories C1E* and C2E* in the British List, respectively: for full details see Dudley 2005). During the 1991 survey of introduced and escaped geese, Canada Goose was the most frequently recorded species (43 871 adults), followed by Egyptian Goose (660); only 74 adult Bar-headed Geese *Anser indicus*, the next most common such species, were recorded (Delany 1993).

We have reviewed published and 'grey' literature for evidence of Canada and Egyptian Goose impacts on the environment in Great Britain. In some instances we have used evidence from outside Great Britain, including from within their native range, to highlight issues that we think could be of particular relevance.

We conclude by identifying the major gaps in knowledge about the species and suggest priorities for future work.

Effect of the geese on the wider environment

Clearly, the severity of any impacts that a species has on its environment is related to its numbers. Although estimates of numbers are of varying quality and reliability there is a clear strong upward trend in the numbers of both species in Great Britain (Figs 1 & 2).

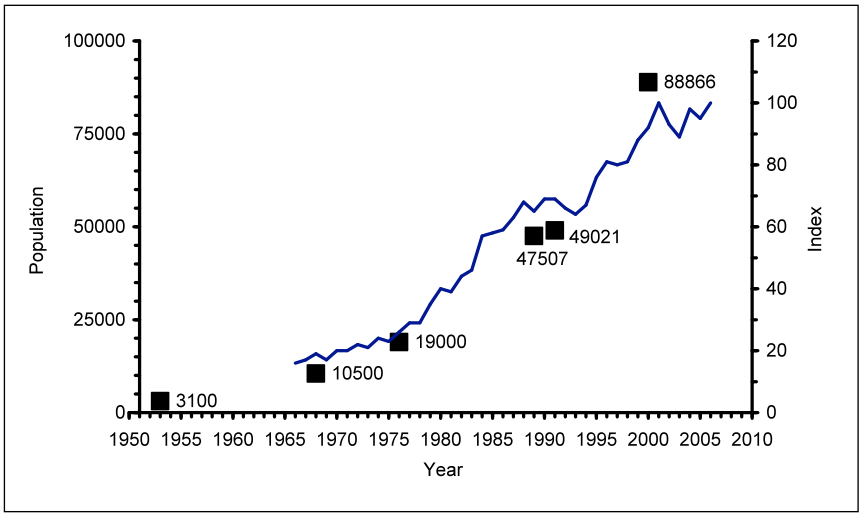

Figure 1. Canada Goose population estimates in Great Britain from 1953 to 2000 (Owen *et al.* 1986: mean value of 2200–4000, Atkinson-Willes 1963, Lack 1986, Gibbons *et al.* 1993, Delany 1993 & Austin *et al.* 2007, respectively) and 1966/67 to 2006/07 winter indices based on Wetland Bird Survey data (Austin *et al.* 2008). See text for further details.

The Canada Goose is the most numerous goose in the world (e.g. Wetlands International 2006), and has been introduced from its native North America to both Europe and Australasia. It was first introduced to Great Britain in 1665 as part of the waterfowl collection of Charles II (Madsen *et al.* 1999). Between 1962 and 1976 the population increased by about 8% per annum (Owen *et al.* 1986) and between 1976 and 1991 by 8.3% per annum (Delany 1993). The 2000 stratified survey of introduced and re-established geese in Great Britain estimated that there were 88 866 (95% confidence intervals: 86 127–91 914) full-grown Canada Geese in the country, and that the species had increased by 9.3% per year between 1991 and 2000 (Austin *et al.* 2007). This species has continued to increase in numbers since 2000 (Fig. 1; Austin *et al.* 2008). Such impressive rates of increase are not uncommon for this species; partly due to increased food resources made available by changes in agricultural practices, Canada Goose numbers in Ontario, Canada, grew from fewer than 1000 in 1967 to 190 000 in 1994 (Ankey 1996).

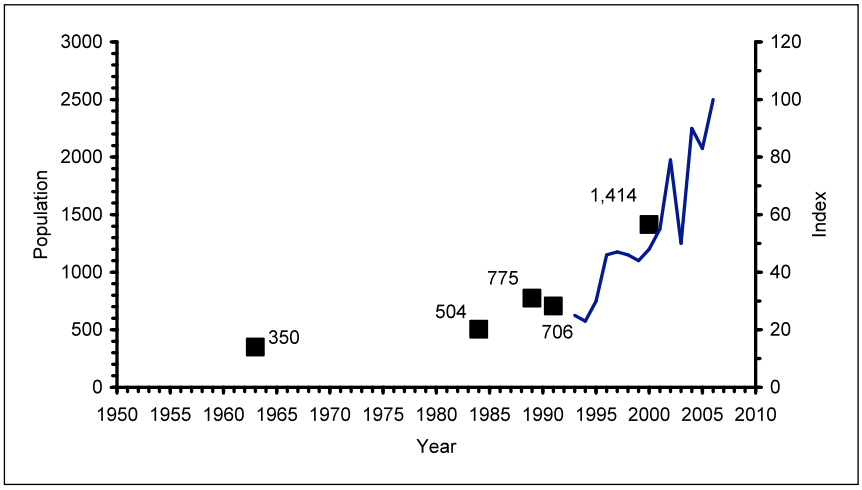

Figure 2. Egyptian Goose population estimates in Great Britain from 1963 to 2000 (Atkinson-Willes 1963: mean value of 300-400, Lack 1986, Gibbons *et al*. 1993, Delany 1993 & unpublished following approach of Austin *et al*. 2007, respectively) and 1993/94 to 2006/07 winter indices based on Wetland Bird Survey data (Austin *et al*. 2008). See text for further details.

Egyptian Geese were first recorded in Great Britain in the late 17th century (Lever 1987) and were not uncommon on some estates by the late 18th century (Sutherland & Allport 1991). The 2000 survey of introduced and re-established geese in Great Britain estimated that there were 1414 (95% confidence intervals: 1264–1576) full-grown Egyptian Geese in Great Britain, but these estimates have to be treated with caution and have remained unpublished as the survey stratification was based on the distribution of Canada Geese. Earlier, and not necessarily very reliable, estimates of the number of Egyptian Geese present in Great Britain have suggested 300–400 individuals in the early 1960s (Atkinson-Willes 1963), about 504 in the early 1980s (Lack 1986), 750–800 between 1988 and 1991 (Gibbons *et al.* 1993), and 1000 between 1991 and 1999 (Kershaw & Cranswick 2003). Data from the Wetland Bird Survey (WeBS) indicate that this species is increasing rapidly (Figure 2).

Aggression in defence of nests and young

Geese can demonstrate aggressive behaviour toward people while defending their nesting territory. Delacour (1975) states that breeding pairs of Canada Geese in captivity can prove dangerous to other geese and killed one of his swans. In Canada, the landscape of Toronto Zoo is being modified as a result of concerns about Canada Goose defecation and aggression (http://secure.torontozoo.com/Conservation/invasive.asp?pg=goose). In Michigan, as a result of Canada Geese losing their fear of humans and becoming abnormally aggressive, artificial feeding is being discouraged (http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_25065-59467--,00.html). In other parts of the United States no-feeding ordinances have been established. In an Ohio business park, reports of Canada Goose aggression and injury to people were reduced from 32 and two cases, respectively, in 2001 to zero in 2002 through use of alarm and alert calls (Whitford 2003; http://www.bird-

x.com/pdfs/research.pdf). Whitford reported that 'employee time spent in harassment declined from 3-4 hours/day to under 15 minutes/day' by the end of the study period.

Introduced Egyptian Geese exhibit dominant and aggressive behaviour towards other bird species and this may prevent native species, particularly smaller species such as ducks and Coot *Fulica atra*, from establishing territories where Egyptian Geese are present (Anselin & Devos 2007). In their native range, tree-nesting Egyptian Geese have been shown to reduce the productivity of Black Sparrowhawks *Accipiter melanoleucus* through aggressive nest usurpation (Curtis *et al.* 2007) and represented a bigger impact on productivity than other factors such as climate, habitat or nest-site characteristics. In Great Britain, Canada Geese and Egyptian Geese outcompete Ospreys *Pandion haliaetus* for artificial nesting platforms; Egyptian Geese also limit nesting opportunities for Barn Owl *Tyto alba* as they occupy nestboxes first during the breeding season (T. Appleton pers. comm.).

Hybridization with native species of waterbirds

The Canada Goose 'interbreeds freely with other geese, particularly the Barnacle, more rarely with swans and the larger species of Anatidae' (Delacour 1975). Largely in captivity, but also in the wild, the species has hybridized with 16 species of Anatidae including Barnacle *Branta leucopsis*, Greylag *Anser anser* and White-fronted Geese *Anser albifrons* (e.g. Delany 1993), Black *Cygnus atratus*, Trumpeter *Cygnus buccinator*, Whooper *Cygnus cygnus* and Mute Swans *Cygnus olor*, Muscovy Duck *Cairina moschata* and Egyptian Goose (Rutgers & Norris 1970, Kolbe 1979, Tarsnane 1982, Woolham 1987). Wild hybrids have been reported with White-fronted, Snow *Anser caerulescens* and Brent Geese *Branta bernicla* (Johnsgard 1965). Welch *et al.* (2001) consider Canada Geese to be a potential threat to other goose populations including native Greylag Geese in Scotland through hybridization and introgression.

The Egyptian Goose may hybridize with other introduced goose species such as Canada Goose (Lever 2005) and Greylag Goose, or with ducks, such as Mallard *Anas platyrhynchos*.

Water eutrophication

There is much circumstantial evidence that nutrients from roosting waterbirds cause damaging eutrophication of lakes (Callaghan & Kirby 1996, Watola *et al.* 1996). A study comparing phosphorus levels in two small lakes in Yorkshire, Great Britain, one heavily used by Canada and Greylag Geese and one not, found that levels were 54% higher in the lake used by geese, this increase being almost exactly explained by the estimated input from waterbirds (Broughton 1998). Some 39 and 26% of the additional phosphorus was attributable to Canada and Greylag Geese, respectively, making it clear that the geese had the potential to seriously affect the fertility of the lake. The lake used by geese had chlorophyll *a* concentrations 2.7 times greater than those of the other lake, and a much greater algal growth probably in part due to the phosphorus input of the geese. Broughton suggests that the possible input of phosphorus by geese into the already nutrient-rich lakes of east Yorkshire could lead to fish-kills, changes in species structure, negative impacts on amphibians, changes to plant communities dominated by fewer species and an overall loss of biodiversity.

Egyptian Geese have also been found to cause habitat damage and in areas where large roosting groups are present eutrophication may be caused by faecal deposition (Anselin & Devos 2007). As justification to control Egyptian and Canada Geese in licence applications, it has been suggested that the species cause damage to the waterside vegetation used as breeding habitat by native species; however, the literature does not appear to provide any empirical evidence to corroborate this.

Potential vectors of disease

Most complaints about geese are from residents and businesses frustrated with the aesthetically unpleasant aspect of goose droppings (http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_25065-59467--,00.html). However, Canada Goose droppings, like those of other waterbirds, contain bacteria that can be pathogenic to humans and that can survive and multiply in the droppings for up to 1 month after deposition (Feare *et al.* 1999). Although Feare *et al.* (1999) were unable to quantify the risk that these droppings would lead to any disease spreading to humans, they believed that as these geese ranged further from water than other waterbirds they posed a greater potential health risk in park grassland than the other waterbirds studied. Persistently high goose numbers in shallow water areas may elevate bacteria levels via faecal coliforms which, coupled with other contaminants, has led to the temporary closure of lakeside beaches in the United States (http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_25065-59467--,00.html).

Agricultural pests

In the 1950s, Canada Geese came increasingly into conflict with agricultural interests due to their predilection for new-sown grass-leys and spring and winter wheat (Lever 1977). In New Zealand, legal protection for Canada Geese was removed as a result of them competing with domestic stock for grazing (Lever 1987, Kear 1990). In Great Britain, whereas Kear (1970) reported no significant grain loss as a result of winter and spring grazing, White-Robinson (1984) found that significant crop damage could occur, with the geese feeding in stubble fields, on root crops and grazing newly sprouted winter cereals. Simpson (1991) reported that even when localized damage was severe, landowners and farmers had to bear the costs. In the United States, Canada Goose populations have probably increased greatly as a result of their ability to take advantage of agricultural products including grain and cereals, and on the West Atlantic Flyway they have largely forsaken aquatic plants for upland crops (Bellrose 1980). In some areas of Michigan State, Canada Geese may cause agricultural damage to crops through consumption or trampling. Sprouting crops can be severely damaged by grazing, and muddy fields can be compacted by trampling, resulting in reduced yields to the farmer (http://www.michigan.gov/dnr/0,1607,7-153-10370_12145_25065-59467--,00.html). In Scotland, Welch *et al.* (2001) identify Canada Geese as having an adverse impact of moderate significance on farmland, lakesides and riversides and predict that in about 20 years this impact is likely to become potentially highly significant with increasing goose population size. They state that at high concentration these geese trample down vegetation (see also references in Underhill 2001). Owen *et al.* (1986) state that 'continued population growth of Canada Geese would undoubtedly be a major concern to farmers'.

Egyptian Geese have also been shown to cause damage to cereal crops in their native range. In South Africa they caused localized damage to wheat and barley crops, with a mean yield loss of 65% (Mangnall & Crowe 2002).

Air traffic hazards

In the United States, there is a close relationship between breeding Canada Goose numbers and aircraft birdstrike incidents. Birdstrikes have increased from 40 per year in 1990 to over 100 per year in 1999 (Cleary *et al.* 2000). This increase has closely paralleled a rise in North American Canada Goose populations over the same period (Dolbeer & Eschenfelder 2003). Canada Geese and other large flocking birds present a particular danger to aircraft. The increasing trend towards twin-engined aircraft means that the probability of ingesting birds into all engines on an aircraft during an encounter with a flock of birds is increased and if the engine is unable to withstand the impact without loss of power, the probability of simultaneous power loss on all engines of an aircraft, and hence an accident, increases accordingly. Before being allowed into service all aircraft engines must pass a series of certification tests, which includes the ingestion of specified numbers of birds of a given weight and the maintenance of a specified level of performance (Cleary & Dolbeer 2005). The vast majority of large turbofan engines in use today are certified to ingest a single bird of 4 lbs in weight without catching fire,

suffering an uncontained engine failure or losing the ability to be shut down safely. Newer engine designs coming into service have more severe test requirements, but there is no engine currently in use that is tested to ingest a bird as large as a Canada Goose (7.5 lbs or more) and keep running. Construction of even more robust engines is theoretically possible, but the penalty in terms of weight, fuel consumption and consequent carbon production makes this uneconomic with current materials technology. In the absence of a goose-proof engine, geese, and Canada Geese in particular, form the most significant large bird hazard to aircraft worldwide (Alge 1999, Allan *et al.* 1999). The increasing populations of Canada Geese in the UK have been recognized as a potential risk to aircraft for some time (Allan & Feare 1994) and the UK Civil Aviation Authority (CAA) now advocates management of Canada Geese around airports and possibly in the wider population due to the increasing risk (CAA 2002). Following a number of serious birdstrikes with Canada Geese at London Heathrow Airport, the Department for Transport has set up a working group to explore solutions to the problem and the UK Air Accident Investigation Branch (AAIB) has made a number of recommendations concerning the management of the birdstrike risk from large flocking bird species (primarily Canada Geese) at Heathrow (AAIB 2001). Implementation of these measures has effectively controlled the problem at Heathrow and the airport has not had a birdstrike with Canada Geese since 2004 (UK CAA birdstrike database), showing that management of the risk is possible given the necessary investment of time resource.

Conclusion and research needs

Only 'about one percent of invaders [are known to] become pests' (Williamson 1996) probably because so few introduced species are studied carefully. This review of the impacts of introduced Canada and Egyptian Geese on their environments has shown how sparse the information is. Information on the effects of Canada Geese has had to be taken largely from the non peer-reviewed grey literature to avoid having to extrapolate from other introduced species. Almost certainly much would be gained by a detailed study of Canada Geese and other non-native geese in Great Britain.

In Great Britain and other human-dominated landscapes, human actions often determine the species that thrive and those that decline (e.g. the effect of some agricultural methods on the status of farmland birds). We suggest, therefore, that we have an obligation to consider not only declining species, but also species that are increasing perhaps to the detriment of others. In the latter case the need for any possible management should be based on a combination of sound science and ultimately an often subjective assessment of the relative value of species. We would argue that any introduced species that would not have reached a new habitat without the aid of humans and that is not threatened in its native range is of less 'value' than a native species, particularly if the latter is of conservation concern through its declining population, localized distribution or rarity. So far the negative impacts of Great Britain's introduced Canada Geese on their surroundings have only been recorded at a small spatial scale. Sooner or later, increasing at over 9% per annum (Rehfisch *et al.* 2002, Austin *et al.* 2007) and with much apparently suitable habitat still unused (G. Austin, unpubl. data), Canada Geese are likely to start having a more dramatic effect on Great Britain's biodiversity. This may also be true for introduced Egyptian Geese, but even less is known about the effects of this species, now common in southern Great Britain, than those of Canada Geese.

Scientific papers help influence policy-makers, and clearly there is an urgent need for more peer-reviewed, published, scientifically rigorous work before any case can be made for or against Canada and Egyptian Geese (and many other introduced species). It is imperative that the population estimates of both species be updated and that detailed research be carried out into their effect on the biodiversity and wider landscape of Great Britain. This arguably is a requirement under international legislation. In our opinion, the greatest research priority should be to quantify the effects that varying densities of introduced species have on the range and

abundance of native biodiversity, information that can subsequently be used to inform policy towards non-native species.

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References

Air Accident Investigation Branch (AAIB). 2001. *AAIB Bulletin No: 4/2001*. Farnborough: Air Accident Investigation Branch.

Alge, T. 1999. Airport bird threat in North America from large flocking birds (geese) (as viewed by an engine manufacturer) – Part 1. *Proceedings of Birdstrike '99*. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1000&context=birdstrike1999

Allan, J.R, Bell, J.C. & Jackson, V.S. 1999. An assessment of the world-wide risk to aircraft from large flocking birds. *Proceedings of Birdstrike '99*. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1003&context=birdstrike1999

Allan, J.R. & Feare, C.J. 1994. *Feral Canada Geese (*Branta canadensis*) as a Hazard to Aircraft in Europe: Options for Management and Control*. 22nd Meeting Bird Strike Committee Europe, Vienna.

Ankey, C.D. 1996. An embarrassment of riches: too many geese. *J. Wildl. Manage*. **60**: 217–223.

Anselin, A. & Devos, K. 2007. *Review of the Status of Introduced Non-native Waterbirds and their Effects in Flanders, Belgium*. INBO.A.2007.115. Brussels: Instituut voor Natuur - en Bosonderzoek.

Atkinson-Willes, G.L. (ed.) 1963. *Wildfowl in Great Britain*. Nature Conservancy Council Monograph 3. London: Nature Conservancy Council.

Austin, G.E., Rehfisch, M.M., Allan, J.R. & Holloway, S.J. 2007. Population size and differential population growth of introduced Greater Canada Geese *Branta canadensis* and re-established Greylag Geese *Anser anser* across habitats in Great Britain in the year 2000. *Bird Study* **54**: 343–352.

Austin, G.E., Collier, M.P., Calbrade, N.A., Hall, C. & Musgrove, A.J. 2008. *Waterbirds in the UK 2006/07: The Wetland Bird Survey*. Thetford: BTO/WWT/RSPB/JNCC.

Bellrose, F.C. 1980. *Ducks, Geese and Swans of North America*. Harrisburg, PA: Stackpole Books.

Bright, C. 1998. *Life Out of Bounds*. Washington, DC: WW Norton and World Watch.

Broughton, R.K. 1998. *Eutrophication of a Shallow Lake in Northeast England: the Impact of Feral Geese*. Hull: Hull University.

Callaghan, D.A. & Kirby, J.S. 1996. Releases of Anatidae for hunting and the effects on wetland biodiversity: a review and evaluation. *Gibier Faune Sauvage*, *Game Wildl.* **13**: 1049–1068.

Civil Aviation Authority (CAA). 2002. *CAP 721 Large Flocking Birds*. London: Civil Aviation Authority.

Cleary, E.C. & Dolbeer, R.A. 2005. Multi-engine birdstrikes to turbine-powered aircraft. *Proceedings of the 27th International Birdstrike Committee*. http://www.int-birdstrike.org/Athens_Papers/IBSC27%20WPVI-2.pdf

Cleary, E.C., Wright, S.E. & Dolbeer, R.A. 2000. *Wildlife Strikes to Civil Aircraft in United States*. Washington, DC: US Federal Aviation Administration.

Curtis, O.E., Hockey, P.A.R. & Koeslag, A. 2007. Competition with Egyptian Geese *Alopochen aegyptiaca* overrides environmental factors in determining productivity of Black Sparrowhawks *Accipiter melanoleucus*. *Ibis* **149**: 502–508.

Delacour, J. 1975. *The Waterfowl of the World*, 7th edn. London: Country Life.

Delany, S.N. 1993. Introduced and escaped geese in Great Britain in summer 1991. *Br. Birds* **86**: 591–599.

Dolbeer, R.A. & Eschenfelder, P. 2003. Amplified birdstrike risks related to population increases of large birds in North America. *Proceedings of the 26th International Birdstrike Committee*. http://www.int-birdstrike.org/Warsaw_Papers/IBSC26%20WPOS4.pdf

Dudley, S.P. 2005. Changes to Category C of the British List. *Ibis* **147**: 803–820. http://onlinelibrary.wiley.com/doi/10.1111/j.1474-919X.2005.00470.x/pdf

Feare, C.J., Sanders, M.F., Blasco, R. & Bishop, J.D. 1999. Canada Goose (*Branta canadensis*) droppings as a potential source of pathogenic bacteria. *J. Roy. Soc. Promot. Health* **119**: 146–155.

Gibbons, D.W., Reid, J.B. & Chapman, R.A. 1993. *The New Atlas of Breeding Birds in Great Britain and Ireland: 1988–1991*. London: T. & A.D. Poyser.

Hughes, B., Henderson, I. & Robertson, P. 2006. Conservation of the globally threatened White-headed Duck in the face of hybridization with the North American Ruddy Duck: results of a control trial. *Acta Zool. Sin.* **52** (Supplement): 576–578.

International Union for Conservation of Nature (IUCN). 1998. *Draft IUCN Guidelines for the Prevention of Biodiversity Loss due to Biological Invasion*. Gland, Switzerland: IUCN.

Johnsgard, P.A. 1965. *Handbook of Waterfowl Behaviour*. London: Constable & Co. Ltd.

Kear, J. 1970. The experimental assessment of goose damage to agricultural crops. *Biol. Conserv.* **2**: 206–212.

Kear, J. 1990. *Man and Wildfowl*. London: T. & A.D. Poyser.

Kershaw, M. & Cranswick, P. A. 2003. Numbers of wintering waterbirds in Great Britain, 1994/95–1998/99: I. Wildfowl and selected waterbirds. *Biol. Conserv.* **111**: 91–104.

Kolbe, H. 1979. *Ornamental Waterfowl*. Old Woking, UK: Gresham Books.

Lack, P. 1986. *The Atlas of Wintering Birds in Great Britain and Ireland*. London: T. & A.D. Poyser.

Lever, C.L. 1977. *The Naturalized Animals of the British Isles*. London: Hutchinson & Co.

Lever, C.L. 1987. *Naturalized Birds of the World*. Harlow, UK: Longman.

Lever, C.L. 2005. *Naturalized Birds of the World*. London: Poyser.

Madsen, J., Cracknell, G. & Fox, T. 1999. *Goose Populations of the Western Palearctic. A Review of Status and Distribution*. Wetlands International Publication No. 48. Wageningen, the Netherlands: Wetlands International.

Mangnall, M.J. & Crowe, T.M. 2002. Population dynamics and the physical and financial impacts to cereal crops of the Egyptian Goose *Alopochen aegyptiacus* on the Agulhas Plain, Western Cape, South Africa. *Agr. Ecosyst. Environ.* **90**: 231–246.

McLean, I. 2001 Exotic and invasive species – your views? *Proceedings of the 11th Conference of the Institute of Ecology and Environmental Management, 6 April 2000*, pp. 5–11.

Owen, M., Atkinson-Willes, G.L. & Salmon, D.G. 1986. *Wildfowl in Great Britain*. Cambridge: Cambridge University Press.

Rehfisch, M.M., Austin, G.E., Holloway, S.J., Allan, J.R. & O'Connell, M. 2002. An approach to the assessment of change in the numbers of Canada *Branta canadensis* and Greylag Geese *Anser anser* in southern Great Britain. *Bird Study* **49**: 50–59.

Rutgers, A. & Norris, K.A. 1970. *Encyclopaedia of Aviculture*. London: Blandford Press.

Simpson, W. 1991. Agricultural damage and its prevention. In Harradine, J. (ed.) *Canada Geese Problems and Management Needs*: 21–24. Rossett, UK: British Association for Shooting and Conservation.

Sutherland, W.J. & Allport, G. 1991. The distribution and ecology of naturalized Egyptian Geese (*Alopochen aegyptiacus*) in Great Britain. *Bird Study* **38**: 128–134.

Tarsnane, S. 1982. *Manual of Ornamental Waterfowl Management*. UK: British Waterfowl Association.

Underhill, M. 2001. Integrated management of urban Canada Geese. *Proceedings of the 11th Conference of the Institute of Ecology and Environmental Management, 6 April 2000*: 12–24.

Watola, G.V., Allan, J. & Feare, C. 1996. Problems and management of naturalised introduced Canada Geese *Branta canadensis* in Great Britain. In Holmes, J.S. & Simons, J.R. (eds) *The Introduction and Naturalisation of Birds*: 71–77. London: HMSO.

Welch, D., Carss, D.N., Gornall, J., Manchester, S.J., Marquiss, M., Preston, C.D., Telfer, M.G., Arnold, H. & Holbrook, J. 2001. *An Audit of Alien Species in Scotland*. Scottish Natural Heritage Review No. 139. Battleby, UK: SNH Publications.

Wetlands International. 2006. *Waterbird Population Estimates*, 4th edn. Wageningen, the Netherlands: Wetlands International.

White-Robinson, R. 1984. *The ecology of Canada Geese in Nottinghamshire, and their importance in relation to agriculture*. PhD thesis, University of Nottingham.

Whitford, P.C. 2003. Use of alarm/alert call playback and human harassment to end Canada Goose problems at an Ohio business park. *Proceedings of the 10th Wildlife Damage Management Conference*: 245–255.

Williamson, M. 1996. *Biological Invasions*. London: Chapman and Hall.

Woolham, F. 1987. *The Handbook of Aviculture*. Poole, UK: Blandford Press.

