Indirect estimation of the number of migratory Greylag and Pink-footed Geese shot in Britain

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Greylag and Pink-footed Geese, breeding in Iceland and wintering in Britain, are popular quarry species for wildfowl hunters. However, the size of the British hunting bag is unknown. By using the Icelandic bag statistics, recoveries of geese shot in Iceland and Britain, and population models developed by Frederiksen *et al.* (unpubl. b), it is possible to derive indirect estimates of the size of the British bag. The estimates indicated that about 25,000 Pink-footed Geese and 20,000-25,000 Greylag Geese are shot annually in Britain. The proportion of juveniles in the bag appeared to be higher for Greylag Geese (45-50%) than for Pink-footed Geese (about 30%), and in both cases higher than the proportion in the population. Hunting exerts a strong impact on the dynamics of both species, and a bag reporting system should be introduced in Britain to monitor this.

Key Words: *Anser anser, Anser brachyrhynchus*, bag statistics, hunting mortality

Two populations of grey geese breed in Iceland and winter primarily or exclusively in Britain: the Greylag Goose *Anser anser* (Mitchell & Sigfússon 1999) and the Pink-footed Goose *A. brachyrhynchus* (Mitchell *et al.* 1999). Both species are popular quarry for hunters in both countries, and information about the hunting pressure to which they are exposed is necessary for informed management of the populations. While Iceland introduced a mandatory bag recording system in 1995 (Sigfússon 1996), to date no com-

parable survey has been implemented in Britain. Thus, little is known about how many geese are shot annually on the wintering grounds, although sample surveys of members of BASC (British Association for Shooting and Conservation), provided estimates of between 15,000 and 25,000 for each species (Reynolds & Harradine 1996). A multi-organisational working group, (formerly the National Goose Forum NGF, superseded by the Goose Scientific Advisory Group GSAG), was established by the Scottish Executive to investigate and advise on goose issues. Government, non governmental organisations, agricultural groups, and hunting organisations are represented. The final NGF report identified the lack of reliable monitoring of how many geese are shot in Scotland as an impediment to sound management, and a more comprehensive survey among all shotgun certificate holders was among one of the key recommendations (Anonymous 2000). Furthermore, the UK government is a signatory to the African-Eurasian Waterbird Agreement (AEWA), which requires the development of a sound monitoring system of hunting bags.

During the period 1996-2000, the Icelandic Institute of Natural History (IINH), in collaboration with the Wildfowl & Wetlands Trust (WWT) and the Highland Ringing Group (HRG), carried out a colour-ringing programme for both species of Icelandic-breeding grey geese (Hearn & Sigfússon 2000; Hearn *et al.* 1999; Mitchell *et al.* 1997). This programme has provided new and important information about the dynamics of the two populations, including survival estimates (Frederiksen *et al.* unpubl. a), and preliminary population models (Frederiksen *et al.* unpubl. b). Here, these results are used in conjunction with the Icelandic bag statistics to derive estimates of the numbers of Greylag and Pink-footed Geese shot annually on the wintering grounds. Pink-footed Geese winter exclusively in Britain, whereas a small proportion (5%) of the Greylag Goose population winters in Ireland. The estimates for Greylag Geese thus strictly refer to shooting in Britain and Ireland, although the vast majority of the hunting takes place in Britain.

Methods

The available data provided two options for estimating the size of the British goose hunting bag. The first relied on the assumption that hunters report shot, ringed geese with the same probability in Iceland and Britain. Tentative support for this assumption comes from the seasonal survival analysis of Greylag Geese (Frederiksen *et al.* unpubl. a), which showed no difference in the reporting probability of adults between summer to early autumn, when the geese are in Iceland, and late autumn to winter, when they are in Britain. The estimated reporting probability represents a mean for all causes of mortality. Geese shot by

hunters are much more likely to be reported than those dying from natural causes. However, Greylag Geese are heavily hunted throughout their range, and hunting is likely to be by far the most important cause of mortality during both periods. Thus, if causes of mortality are similar between Iceland and Britain and the mean reporting probability is the same, hunter reporting probability is likely to be the same or similar. Assuming this to be the case, the size of the British bag could be estimated from the ratio of shot recoveries in the two countries and the Icelandic bag statistics: $B^{GB}=B^{IS}(R^{GB}/R^{IS})$ where B indicates the size of the hunting bag, R indicates the number of geese recovered as shot by hunters, and superscripts indicate the country: (GB for Britain, IS for Iceland). The analyses of Frederiksen *et al.* (unpubl. a) also demonstrated the occurrence of large-scale non-hunting mortality of goslings between fledging and arrival in Britain, and the calculation of the estimated British bag was therefore performed separately for adults and juveniles. The age composition of the Icelandic bag was estimated through a survey of wings submitted to the IINH by hunters (Frederiksen *et al.* unpubl. b). During the study period (1996-2000), goose ringing occurred both in Iceland and in Britain, and ringing in Britain took place during the autumn hunting season (as well as in spring). Geese ringed in Britain in the autumn were obviously not available for shooting in Iceland in the same year, and if ringed late in autumn, might also have a smaller chance of being shot in Britain than those ringed in previous years, by virtue of being exposed to hunting for a shorter period. R^{GB} therefore only included geese ringed prior to the autumn in question. Sample sizes for individual years were small, and the ratio was therefore estimated from pooled data from all years; the estimate of B^{IS} was correspondingly the mean for 1996-2000 (data from the Wildlife Management Institute, Akureyri, Iceland). Whereas B^{GB} for juveniles could only be estimated based on goslings ringed in summer in Iceland, two independent estimates for adults could be calculated based on geese ringed either in Iceland or Britain. A third estimate could be obtained by pooling the two data sets; such pooling was only strictly justifiable if the ratio (R^{GB}/R^{IS}) was not significantly different for the two data sets.

The second estimates of B^{GB} arose as a by-product of the population models of Frederiksen *et al.* (unpubl. b). These models produced estimates of the size and age composition of the two goose populations, both at arrival in Britain in autumn and before departure in spring. The difference between these two estimates represented the estimated total mortality over the period when the geese were in Britain, and thus a maximum estimate of the British hunting bag. As above, the mean for 1996-2000 is presented here. For Greylag Geese, Frederiksen *et al.* (unpubl. b) showed that the population size estimate differed by a factor two depending on whether the autumn

counts or the Icelandic bag statistics were taken as reliable. Two estimates (maximum and minimum) are therefore also presented here for total mortality on the wintering grounds.

Results

During 1996-2000, 36 Icelandic-ringed adult Greylag Geese were reported shot on the wintering grounds (one of these in Ireland) and 75 in Iceland; the corresponding numbers for British-ringed geese were 56 and 104. The two ratios were not significantly different (χ_1^2=0.19, P=0.66), and the pooled estimate of the ratio (R^{GB}/R^{IS}) for adults was 0.51. Among juveniles, 28 were reported shot in Britain and 27 in Iceland, giving an estimated ratio (R^{GB}/R^{IS}) of 1.04. The resulting estimate of the British Greylag Goose bag was 26,385 (**Table 1a**), with 57% being juveniles; the wing survey showed 40% juveniles in the Icelandic bag.

The calculation was more problematic for Pink-footed Geese, because the ratio of shot recoveries in Britain and Iceland was very different between adults marked in Iceland and those marked in Britain (70/37 and 97/17, respectively); the difference was statistically significant (χ_1^2=11.6, P=0.001). The estimated ratio (R^{GB}/R^{IS}) was thus 1.89 based on Icelandic-ringed geese, 5.71 based on British-ringed birds and 3.09 based on pooled data. Among juveniles, 42 were reported shot in Britain and 28 in Iceland, leading to an estimated ratio (R^{GB}/R^{IS}) of 1.50. Three estimates of the British Pink-footed Goose bag could then be derived (**Table 1b**): 24,547, 59,206 or 35,458, with respectively 30%, 12% or 21% juveniles. According to the wing survey, juveniles made up 35% of the Icelandic bag.

For Greylag Geese, the model-based estimate of total mortality in Britain was about 27,200 if the Icelandic bag statistics were assumed to be correct, and about 13,300 if the autumn counts were assumed to be correct. In both cases, 46% of the total mortality was estimated to be juveniles. For Pink-footed Geese, the estimated total mortality in Britain was about 26,800, with 33% being juveniles.

Discussion

A possible cause for the variation in (R^{GB}/R^{IS}) for adult Pink-footed Geese was that geese ringed in Britain are a mixture of Icelandic breeders, Greenlandic breeders and non-breeders. The two latter groups, which moult primarily in Greenland, are presumably less exposed to hunting in Iceland than the Icelandic breeders, although all Pink-footed Geese are believed to stage in Iceland during the autumn (Fox *et al.* 1997; Mitchell *et al.* 1999). However, it is not clear, why so few British-ringed geese are recovered in Iceland, since Greenlandic breeders probably only make up 15-25% of the total population (Fox *et al.* 1997). This would seem to imply that catches in Britain preferentially target Greenlandic breeders or non-breeders; however, observations

Table 1: Estimates of the number of grey geese shot by hunters in Britain (B^{GB}), based on the Icelandic bag statistics (B^{IS}) and the ratio of geese recovered shot in Britain and Iceland (R^{GB}/R^{IS}). Means for 1996-2000 are presented.

a) Greylag Goose

	B^{IS}	R^{GB}/R^{IS}	B^{GB}
Adults	22,136	92/179 = 0.51	11,377
Juveniles	14,472	28/27 = 1.04	15,008
Total	36,608		26,385

b) Pink-footed Goose

	B^{IS}	R^{GB}/R^{IS}	B^{GB}
Adults			
i) Ringed in Iceland	9,087	70/37 = 1.89	17,192
ii) Ringed in Britain	9,087	97/17 = 5.71	51,851
iii) Pooled	9,087	167/54 = 3.09	28,103
Juveniles	4,903	42/28 = 1.50	7,355
Total			
i)	13,991		24,547
ii)	13,991		59,206
iii)	13,991		35,458

of 77 geese ringed in Greenland in 1988 indicated that they occurred in the same areas as Icelandic breeders (C. Mitchell, pers. comm.). Another possible explanation is that the Pink-footed Geese ringed in Iceland are not entirely representative of the breeding population, because the areas targeted during ringing expeditions are among the most accessible, and geese breeding at these sites might have a higher probability of being shot in Iceland than those breeding in more inaccessible areas. Notwithstanding this confusion, an estimate of the British Pink-footed Goose hunting bag during the period 1996-2000 of about 25,000 annually, of which about 30% are juveniles, seems to be the most robust in the light of the estimate of total mortality derived from the population model. A higher estimate of the British bag would imply either that winter survival has been overestimated or that the true autumn population size is substantially larger than 230,000 (1996-2000 mean of WWT counts).

The data indicated that if the Icelandic bag statistics are reliable, about 26,000 Greylag Geese were shot

annually in Britain during the period 1996-2000. The proportion of juveniles appeared to be higher than in the Pink-footed Goose bag, at about 46-57%. The sample size of juveniles reported shot was small, and if the ratio (R^{GB}/R^{IS}) for juveniles was an overestimate, this would cause both the total bag and the proportion of juveniles to be overestimated. If, however, the autumn census is considered more reliable, the bag may have been as low as about 13,000. No quantitative studies of the reliability of the two surveys (autumn counts and bag survey) have been carried out, but modelling clearly showed that only one of the estimates can be correct (Frederiksen *et al.* unpubl. b). Given the estimate based on ratios of ring recoveries, it seems most likely that the British Greylag Goose bag is towards the upper end of this interval, ie about 20,000-25,000, with about 50% juveniles.

The estimated age ratios in the British bag are similar to those found in empirical studies of this question. Wright & Boyd (1983) aged geese shot over fifteen hunting seasons at Loch Leven in Scotland and found an average of 41% juveniles among Greylag Geese and 34% young among Pink-footed Geese. Also at Loch Leven, Hearn & Mitchell (1995) found an even higher proportion of juveniles in the Pink-footed Goose bag (60%), although their sample size was small (n=84). The difference in age ratio among species is probably related to a generally higher proportion of juveniles in the Greylag Goose population (estimated 30% in autumn vs. 20% for Pink-footed Geese; Frederiksen *et al.* unpubl. b). For both species, juveniles thus seem to be more exposed or vulnerable to hunting than adults.

The estimates of the British goose hunting bag presented here are at the high end of what has previously been believed (Reynolds & Harradine 1996). Current knowledge of the dynamics of the goose populations thus suggests that up to 50,000 grey geese, approximately evenly split between these two species, are bagged annually by British and Irish hunters, with the largest numbers being shot in Scotland. A similar number are shot in Iceland, although there, more Greylag Geese than Pink-footed Geese are bagged (about 70% Greylag Geese), and clearly the removal of around 100,000 geese annually means that the dynamics of these populations are to a large extent determined by hunting. This issue is treated in detail by Frederiksen *et al.* (unpubl. b), but in summary, any change in hunting pressure for Greylag Geese is likely to affect population growth rate. The situation is more complex for Pink-footed Geese, where density-dependent regulation of the size and/or success of the breeding population may be involved. Given UK obligations under AEWA and the EC Birds Directive, informed management of these goose populations, which are also involved in important interactions with agricultural activities in the wintering areas (Kirby *et al.* 1999), could be

improved by the establishment of a reliable system of bag reporting in Britain. A Flyway Management Plan would provide a useful tool for inter-governmental cooperation on goose management, including possible restrictions on hunting bag size.

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