RACING PIGEONS – IMPACT OF RAPTOR PREDATION

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RACING PIGEONS – IMPACT OF RAPTOR PREDATION

Report to

SCOTTISH NATURAL HERITAGE
&
SCOTTISH HOMING UNION

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

- This report addresses important aspects of losses of racing pigeons to raptors. Peregrines *Falco peregrinus* and sparrowhawks *Accipiter nisus* kill pigeons (*Columbidae*), including racing pigeons (*Columba livia* (domest.). The extent of this varies geographically and temporally. In recent decades, the UK peregrine population has recovered from the low levels resulting from persecution and organochlorine poisoning during the 1950s and 60s. Currently, the UK peregrine population numbers 1,402 breeding pairs. The UK sparrowhawk population numbers 34,500 breeding pairs having recovered significantly since the late 1970s, though numbers have declined during the 1990s. For some time, the Scottish Homing Union (SHU) has been concerned over the number of incidents of raptor attacks on racing pigeons reported by their members and believe that their occurrence is now unacceptably high and threatens the future of pigeon racing. The current estimate of the Scottish racing pigeon population is 340,000 birds. This study specifically focuses on the predation of Scottish racing pigeons by peregrines and sparrowhawks but does not concern itself with other predation.

- Scottish Natural Heritage (SNH) and the SHU commissioned this project to: (i) quantify the nature and extent of losses of racing pigeons to peregrines and sparrowhawks in Scotland, (ii) determine whether there are any techniques and guidance which are likely to be effective in minimising the losses of racing pigeons from attacks by peregrines and sparrowhawks, and (iii) investigate the effectiveness of selected deterrent techniques in reducing predation away from the loft.

1.2 TOTAL REPORTED LOSSES TO ALL CAUSES FROM SCOTTISH LOFTS

- Losses of pigeons from lofts were investigated in four principal regions of Scotland. A total of 31 lofts (out of 40 which originally agreed to supply information) provided summary data on all losses over the 2002 season. Data were used to estimate losses of young birds (YBs), old birds (OBs), and overall losses (i.e. YB and OB) and the circumstances of losses (i.e. relative contributory losses from the loft area, during training and during races). Data were analysed from 28 of the 31 lofts due to anomalies in the data from three lofts.

- The total of losses reported by SHU members to all causes over the racing season (April to September) averaged 67 birds per loft representing 56% of the loft population. The mean number of birds held in the study lofts was 122 birds.

- Examining the circumstances of losses, mean reported losses of all birds (OB+YB) from a) the loft area, b) during training and c) races, were 8 (8%), 18 (16%) and 44 (35%) birds respectively.

- The *number* of young birds reported lost per loft to all causes was significantly greater than the number of old birds reported lost per loft during training (median: YB=10, OB=5), racing (median: YB=27, OB=13) and collectively (median: YB=41, OB=22). There was a significantly greater number of young birds than old birds in the loft population at the start of the season (median: YB=60, OB=48). Collectively, however, the *percentage* of young bird losses per loft was also significantly greater than old bird losses (median: YB=67, OB=57).

- Overall reported losses to all causes for the four different Scottish regions ranged from 50% to 66%. There was no significant difference between regions, however, in overall reported losses or in the total losses of old birds and young birds individually. Examining the circumstances of reported losses, there was a significant regional difference in the percentage of young birds lost during training, with greatest reported losses in the Dundee/Fife/Perth region (mean=31%) and lowest reported losses in Stirling/Dunbartonshire (mean=11%).

- It is extremely difficult to provide an estimate of percentage losses to all causes given the different husbandry systems employed by racing pigeon fanciers. There are also concerns over the accuracy of some of the summary data on reported losses provided by some of the 31 lofts. At two of these lofts (6.5% of lofts), the total number of birds reported lost exceeded the number of birds in the loft at the start of the season. Also, at another loft a summary data sheet of reported losses was provided by the owner on two separate occasions, with the number of birds recorded not the same on the two forms. Errors in reported losses, therefore, at other lofts in the trial sample cannot be ruled out.

- The returns from the SHU's 1996/97 questionnaire survey of its members were examined with the aim of analysing the data in order to develop an overview of the extent and distribution in the reported losses of (and injuries to) racing pigeons. Due to the design of the questionnaire and the quality of some of the data returned, very limited analysis was possible. However, there were significant differences between regions in the percentage of lofts reporting attacks, with, for example, very high proportions of lofts in Glasgow and surrounding areas reporting attacks, and lower proportions reporting attacks in the north of Scotland and along the east coast. Across individual lofts there was no significant difference in the numbers of old birds reported lost during training between 1986 and 1996, although at the Federation level the general trend was for a decrease in training losses between 1986 and 1996. Across Federations the number of old birds reported lost whilst racing increased significantly between 1986 and 1996. The magnitude of the change in old birds lost between 1986 and 1996 during both training and racing varied significantly between Federations. Mean training losses to all causes decreased (range -8% to -68%) in 11 Federations and increased in four (range +4% to +54%). Mean racing reported losses increased in all 15 Federations by 3% to 156%.

- A number of race diaries supplied by loft-owners were assessed for historical data on losses. Data, however, were only extractable from the diaries of four fanciers (one of which covered four years). The three remaining diaries produced contradictory indications of historical changes in numbers of total losses since the 1980s or 1990s. Such loft-specific data on historical losses cannot be extrapolated to the wider racing pigeon fraternity.

1.3 REPORTED LOSSES TO SPARROWHAWKS

- Volunteer loft owners were asked to search for pigeon corpses in the event of any birds going missing from around the loft, rather than from races or training flights (data supplied from 32 lofts). Such losses from the loft area are often attributed by pigeon fanciers to sparrowhawk predation. Reported losses to sparrowhawks were allocated to one of three categories dependent on the level of evidence collected – 'substantiated', 'probable' and 'possible'. Substantiated losses were those where a pigeon carcass was recovered bearing diagnostic features consistent with sparrowhawk predation; probable losses involved the reported recovery of a carcass but without the carcass being provided to Central Science Laboratory (CSL) for examination, possible losses were those in which no carcass was recovered following a loss, but the loft-owner considered that sparrowhawk predation was the most likely of all possible causes.
- Nearly half of the lofts (47%, n=15) reported losses to sparrowhawks, and these losses were categorized as substantiated at five lofts (16%), probable at a further six lofts (19%) and possible at four more (13%). At eight lofts that reported losses but not sparrowhawk attacks, seven fanciers thought that other factors were responsible for the losses and provided the following explanations: attacks by peregrines, goshawks *Accipiter gentilis* and crows *Corvus* spp., collision with pylons and 'fly-aways'. Attacks by sparrowhawks, however, could not be excluded as a potential cause of at least some of these losses.

- Considering all substantiated, probable and possible losses, the number of losses from the loft area attributed to sparrowhawks was 29, representing an average of 0.91 birds per loft. Nationally, this represents 0.7% of the Scottish racing pigeon population. For substantiated losses only (five validated carcasses), the loss was 0.16 birds per loft, and substantiated plus probable losses accounted for 0.47 birds per loft. Considering only the 15 lofts that reported losses to sparrowhawks the mean loss was 1.9 birds per loft.

- There was variation in attributed sparrowhawk losses (all three categories pooled) between the four principal regions of Scotland, ranging from 0.2 birds per loft in Ayrshire to 1.4 birds per loft in Stirling/Dunbartonshire. The comparative figures for substantiated plus probable losses ranged from 0.2 to 0.9 birds for Ayrshire and Stirling/Dunbartonshire respectively.

- At the level of the individual loft, reported losses ranged from zero to four birds for all three categories pooled, and from zero to three for substantiated plus probable kills only. Amongst the 15 lofts which reported losses to sparrowhawks, seven recorded losses of single birds whilst eight reported multiple losses of two to four birds. Considering only substantiated and probable losses, only three out of 11 lofts reported more than a single kill (two or three birds).

- At the 15 lofts reporting attacks, losses to sparrowhawks (substantiated plus probable plus possible – 1 to 4 birds) over a 12-month period represented a median of 20% of the total reported losses to all causes in the loft area (range 2% to 100%) during the racing season.

- The risk of sparrowhawk predation at individual lofts was related to the surrounding habitat. The group of lofts with 'substantiated' and 'probable' losses to sparrowhawks were surrounded by a significantly greater percentage cover of woodland than the group of lofts with only 'possible' losses and no losses to sparrowhawks.

- Of the 32 lofts studied, 13 used some form of avian deterrent, including 8 of the 11 lofts with substantiated or probable losses to sparrowhawks. Deterrents used were replica owls, terror-eye balloons and reflective discs. The strategy of deterrent deployment at individual lofts, however, is not known.

- There were a further seven reported incidences in which losses from the loft area were attributed to raptors other than sparrowhawks - six peregrine and one goshawk. Five of the six reported peregrine incidents took place in the Stirling/Dunbartonshire region. Stirling is a region in which a number of peregrine eyries are located relatively near to lofts.

1.4 LOSSES TO PEREGRINES

- A total of sixteen releases (thirteen races and three training flights) were attended at a range of locations to check for raptor activity. The only evidence of raptor activity was one peregrine attack in the vicinity of pigeons training in the Largs area. No scattering of the flock was noted due to the attack, although one pigeon did not return to the loft until the following day.

- A total of 59 eyries in eight regions were searched for racing pigeon rings. Overall 17% of all inland eyries in these eight regions were searched, representing *c.*2% (NW England) to 66% (Dumfries & Galloway) of all inland eyries in individual regions.

- A total of 1,213 pigeon rings were recovered during the eyrie searches, of which 720 belonged to the SHU or its predecessors. A total of 308 rings of recent origin over six years (i.e. 1997-2002) belonged to Scottish pigeon fanciers. Altogether 74% of these provided some information on the history of the bird in question and 91% of these provided full information on where and when the pigeon was last released. A total of 117 pigeons were reported by their owners as having been last released in 2002 and therefore taken that year by peregrines. This gives a mean of 1.98 Scottish racing pigeons per eyrie searched. Correction factors were used to take into account the fact that some owners could not provide the required information and that a proportion of rings would not have been recovered at many sites (based on re-searches of six sites). By applying these correction factors, a mean of 4.76 Scottish racing pigeons killed per eyrie searched is obtained. This suggests that the number of Scottish racing pigeons taken by peregrines is approximately 4,100 (1.2% of the Scottish population). As the work progressed it became clear that this method has limitations. As such, it provides only a minimum figure of pigeons killed and does not accurately reflect the actual number predated.

- Peregrine nesting sites and the SHU Federations of the pigeon rings recovered at each eyrie were allocated to one of three regional categories (East, West, and Central). This was done separately for old birds (95 rings) and young birds (58 rings) for those pigeons last released in either 2001 or 2002. More pigeons were taken by peregrines in their home regions than by peregrines in other regions. This was particularly notable for rings recovered in north-west England and south-west Scotland belonging to pigeons from SHU Federations in western Scotland (75% for old birds and 88% for young birds). This is in spite of the greater use of eastern release points in recent years, particularly for old birds. This suggests that a proportion of pigeons from west coast federations, although released on the east coast of England, cross the Pennines before flying up the west side of the country.

- The home origin of racing pigeons killed by peregrines in the western region probably reflects the paucity of pigeons from the central and eastern federations that were available as prey. Pigeons from lofts in the western federations comprised 75% and 88% of old and young birds respectively (sample includes Scottish pigeons only). In contrast, peregrines inhabiting the eastern region killed a greater proportion of pigeons from federations outside the nesting region, probably reflecting the fact that a proportion of pigeons from the western and central federations are also expected to pass through the eastern region on their route back to their home loft.

- A detailed investigation was conducted into the feasibility of deriving an estimate for the potential maximum kill of Scottish racing pigeons based on the daily food requirements of peregrines (Annex 1). This analysis produced a very wide range of estimates for total loss but indicated that the figure is likely to lie between 7,820 to 117,581 Scottish racing pigeons. The analysis illustrated the high degree of uncertainty associated with the use of this approach. Given this high range of uncertainty we believe it would be unwise to attribute any significance to any specific values within the range of estimates derived. It may be possible, however, to refine the parameter estimates in future to reduce the inherent uncertainty in this approach, and hence narrow the range of estimates produced.

- Estimates of potential spatial strays were derived from the flight histories of birds identified from rings recovered from eyries (‘race-strays’). Two methods of estimating strays were undertaken, each based on the actual recovery location of the racing pigeon ring in relation to its expected location. In the first method, following Shawyer *et al.* (2000) and Dixon *et al.* (unpublished) pigeons were categorised as potential strays if they were recovered ‘off-line’ from the direct homeward route by a distance equivalent to 33% or more of the intended straight-line distance. In this method, 58% of pigeons killed by peregrines were estimated to be potential strays. In the second method, the race routes were described by fanciers and followed topographical features rather than assuming a straight-line route as in method 1. These followed features such as river valleys and the east-coast, and specific routes were identified in the study area which would be expected to be used by pigeons released from points in southern Scotland and England back to their home lofts. Three estimates for potential strays were derived, with a pigeon being classed as a potential stray if its ring was recovered at a perpendicular distance of 20km, 30km or 50km ‘off-line’ from the race route respectively. In this method, 44% to 61% of young birds and 31% to 54% of old birds killed by peregrines were estimated to be potential strays. We did not estimate any additional numbers of temporal strays (i.e. “race-ferals”).

1.5 REVIEW OF DETERRENTS

- A review was conducted of avian deterrent/protection techniques with respect to alleviating attacks by raptors on racing pigeons. The review consisted of two parts: (i) an evaluation of questionnaire returns from a survey conducted by SHU investigating deterrent/protection techniques that have been used by SHU members, and (ii) an evaluation of avian deterrents used in other circumstances and settings for their suitability for protecting racing pigeons from raptor predation.

- A total of 366 SHU members reported the use of deterrents, of which 86 (23.5%) provided information on deterrent use. The deterrents used fell into two distinct categories: (i) loft-based, and (ii) pigeon-based. Loft-based deterrents are located on, or near the loft, and are aimed at deterring attacks, principally by sparrowhawks, in the immediate vicinity of the loft. Sixty-nine (80%) of the 86 respondents had deployed loft-based deterrents. Pigeon-based deterrents are fixed directly onto the pigeons and attempt to discourage attacks, principally by peregrines, during exercise, training flights and races. Fifty-eight (64%) respondents had used pigeon-based deterrents.

- Overall, the majority of respondents perceived each of the five main types of loft-based deterrent used (balloon, whistle, eyespots, replica owl, mirrors/reflectors) to be ineffective. Over 20% of respondents, however, reported at least partial effectiveness for eyespots, replica owls and mirrors/reflectors. Replica owls and eyespots were most commonly used (73% and 55% of respondents respectively). The deterrent perceived to be the most effective, however, was mirrors/reflectors; 33% of respondents who used this technique perceived it to be at least partially effective.

- Of the 55 lofts for which perceived deterrent effectiveness was reported, it was reported significantly more often for lofts which had used more than one type of deterrent technique (36 lofts) than lofts deploying a single technique only (19 lofts). Partial effectiveness (or better) was reported for 21 lofts (58%) which had used multiple-techniques compared with 5 lofts (26%) which used a single technique only.

- Three types of pigeon-based deterrent have been used: wing transfers, sequins and Bali-bells. Respondents overwhelmingly regarded sequins as ineffective, with only 4% rating them, at best, as partially effective. Wing transfers were also generally regarded as ineffective, being categorised as partial or very effective by only 7% of respondents. Bali-bells, however, were reported to be partially effective by 16% of respondents.

- Avian deterrent techniques, used in a range of bird control circumstances, were reviewed and evaluated for their potential applicability in reducing raptor predation at racing pigeon lofts. Human disturbance, bioacoustics, mirrors/reflectors (including Mylar tape), moving visuals (animated models) and habitat modification were all considered to have some potential as loft-based deterrents. Supplementary (diversionary) feeding in the wider landscape may provide a means of redirecting raptors' attentions away from lofts. A potential novel area of investigation was identified involving an innovative method of exposing raptors to a chemical repellent in the form of an aerosol in the loft area.

1.6 FIELD TRIALS OF RACE DETERRENTS

- The effect of wing transfers and sequins on the return rates of racing pigeon from races was investigated in six old bird races and four young bird races. A total of 140 old birds from four different lofts and 281 young birds from eight lofts were used in the trials (the same birds flew in more than one race). Total numbers of birds used in each race ranged from 17 to 114 for old birds (total birdage over six races was 453) and 55 to 183 for young birds (total birdage over four races was 430). The distances raced were 35 to 65 miles and 65 to 105 miles for old and young birds respectively.

- There was no significant difference in the return rates of either old birds or young birds from the three experimental groups. That is, the level of losses was unaffected by the use of wing transfers and sequins.

- There were a number of differences in return rates between categories of birds that were unrelated to deterrents. First, old birds had higher return rates than young birds. Second, there were highly significant differences in the return rates of young birds between lofts. Third, there were highly significant differences in the return rates of young birds between races. Finally, for old birds the variation between lofts in the return rate approached significance. These latter differences may reflect variation in the quality of birds and in the rearing and training practices between lofts.

1.7 CONCLUSIONS AND RECOMMENDATIONS

- The study has highlighted the very complex nature of the interactions between racing pigeons and peregrines and sparrowhawks. The many gaps in knowledge that currently exist severely constrain the ability to derive reliable estimates of the impacts of these raptors on Scottish racing pigeons.

- Overall reported losses (from all causes) from lofts represented, on average, 56% of the loft population at the start of the racing season. Examining the circumstances of losses, mean losses of birds from a) the loft area, b) during training and c) during races were 8 (8%), 18 (16%) and 44 (35%) respectively. There are, however, concerns over the accuracy of the reported loft losses due to a number of anomalies in the data supplied by some loft-owners. Clearly, any problems in the accurate recording of losses from lofts has critical implications with respect to confounding the evaluation of the impact of raptors. It is reasonable to assume that previous studies may also have been subject to inaccuracies in the recording of losses, and previous results should also be considered with this in mind.

- The mean loft population (OB+YB) in the study lofts was 122 birds. This however, is probably larger than for Scotland as a whole, for which 82 birds per loft (Shawyer *et al*. 2000) is probably more representative. Therefore, with 4,151 SHU lofts the Scottish population of racing pigeons will be around 340,382 birds.

- Overall reported losses to sparrowhawks represented around 1% of the Scottish racing pigeon population, but varied regionally and at individual lofts (zero to four birds per loft). Substantiated and probable losses were even lower. Management of sparrowhawks, therefore, should be directed at the level of the individual loft with the deployment of deterrent techniques.

- For peregrines, the study has produced a minimum estimate (derived from ring recoveries) for predation on Scottish racing pigeons of *c*.4,100 birds (less than 2% of the Scottish population). This estimate, however, cannot be used to assess total losses of pigeons to peregrines and can only provide a minimum figure, above which the real figure must lie. Further analysis, based on the daily food intake (DFI) of peregrines produced a very wide range of estimates for potential total loss (Annex 1). These ranged from a minimum estimate of 7,820 Scottish racing pigeons taken by peregrines, to a maximum estimate of 117,581 Scottish racing pigeons taken. There are serious concerns, however, over the validity or representativeness of some of the currently available data on which these DFI estimates are based. Therefore, no significance should be attributed to any specific values within the range of estimates. Further research is required to narrow the range of estimates produced using this approach.

- There is a widespread view amongst the racing pigeon fraternity that deterrents are ineffective. However, reviews of SHU data on members' use of deterrents, literature on the use of avian deterrents in other settings and recent trials at game release pens indicates that the dismissal of deterrents is premature. Currently, the deterrent technique (mirror/reflectors) most frequently perceived by loft-owners to be effective is actually deployed by fewer loft-owners than other techniques regarded as less effective. A number of deterrents and modes of deployment used in other avian conflict settings appear suitable for testing at pigeon lofts.

- In contrast to loft-based deterrents, trials of deterrents to protect pigeons during races showed no sign of being effective, indicating no benefit in terms of increasing the return rates of birds from races. Thus, the present study confirms earlier work indicating that the currently available pigeon-based deterrents (wing transfers and sequins) are ineffective.

1.8 FUTURE RESEARCH

- Further studies of the impact of raptors on racing pigeons that are based on fully substantiated recording of losses of racing pigeons from lofts need to be conducted.

- The issues of straying and scattering are critical in evaluating the impact of raptors on pigeon racing, but to date the dynamics of straying and scattering have been little understood. Very recent advances in the development of micro-GPS transmitters, however, have enabled devices to be fitted to homing pigeons and individual flight paths recorded. Studies using a combination of GPS technology, radio-tracking and direct observation (or use of radar) are required to investigate the issues of straying and scattering, including the mapping of actual race routes.

- Micro-GPS tracking technology could be used to investigate the ranging and hunting behaviour of sparrowhawks. GPS data would provide a temporal and spatial plot of sparrowhawk activity with respect to racing pigeon lofts and the wider habitat, which could be related to loft-owners' records of losses.

- Studies are required to investigate peregrine diet in relation to the contemporary availability of racing pigeons and alternative prey. These studies are needed to provide reliable estimates for the various parameters required for a DFI-based estimation of the potential maximum kill of racing pigeons.

- This study did not address the issue of goshawk predation on Scottish racing pigeons. In regions where goshawk numbers exceed that of peregrines or sparrowhawks there is the potential for goshawks to be the major predator of racing pigeons. The extent of goshawk predation on Scottish racing pigeons, therefore, needs to be investigated.

- Guidelines should be drawn up outlining the recommended techniques for maximising the potential effectiveness of existing loft-based deterrents. That is, deterrents should be realistic, unpredictable, threatening, supplemented and deployed in an integrated manner.

- To date, fully adequate field-testing of loft-based deterrents has not been conducted. Controlled, replicated field trials are recommended for testing mirrors/reflectors (including Mylar tape), animated models and bioacoustics. Dismissal of loft-based deterrents is premature without rigorous field trials of both deterrents currently deployed at lofts and potential alternatives techniques used in other settings.

2. INTRODUCTION

2.1 BACKGROUND

Peregrines *Falco peregrinus* and sparrowhawks *Accipiter nisus* kill pigeons *Columba livia*, including racing pigeons, the extent to which this occurs varying geographically and temporally (Newton 1986, Ratcliffe 1993). This report is specifically focussed on the predation of Scottish racing pigeons by sparrowhawks and peregrines, and does not concern itself with goshawk predation. Peregrines generally attack racing pigeons away from the loft during training flights or races, although this depends on the proximity of eyries, whilst sparrowhawks generally predate racing pigeons close to lofts (SHU 1998, UK Raptor Working Group 2000). In recent decades populations of most British raptors have recovered from the low levels resulting from persecution and organochlorine poisoning during the 1950s and 1960s (UK Raptor Working Group 2000). Currently, peregrine numbers (1,402 UK breeding pairs in 2002 – Banks *et al*. 2003) are higher than previously recorded, especially in southern Scotland, northern England and Wales. However, some decreases have occurred in other regions so that overall numbers in Scotland have declined (Crick *et al*. 2003). Sparrowhawk numbers (34,500 breeding pairs) although having recovered significantly since the late 1970s, have declined during the 1990s in the UK (UK Raptor Working Group 2000). In Scotland, however, the sparrowhawk population is believed to be stable (Thompson *et al*. 2003). For some time, the Scottish Homing Union (SHU) has been concerned over the number of incidents of raptor attacks on racing pigeons and believes that their occurrence is now unacceptably high and threatens the future of pigeon racing (SHU 1998).

The aim of the project was to quantify the nature and extent of losses of racing pigeons to peregrines and sparrowhawks in Scotland, and to investigate the effectiveness of selected deterrent techniques in reducing predation.

2.2 OBJECTIVES

The objectives of the study were to:

- quantify the nature and extent of racing pigeon losses to sparrowhawks. These typically occur close to lofts;
- quantify the nature and extent of racing pigeon losses to peregrine falcons. These can occur close to lofts in certain areas but are more commonly associated with training flights and races;
- determine whether there are any techniques or guidance likely to be effective in minimising the losses of racing pigeons from attacks by peregrines and sparrowhawks; and
- determine the efficiency of on-bird deterrents in reducing losses to raptors.

2.3 APPROACH

Data from SHU's 1996/97 questionnaire survey of its members were examined with the aim of investigating the extent and distribution in the reported losses of (and injuries to) racing pigeons throughout Scotland.

During the 2002 racing season, losses of pigeons were studied from a total of 32 lofts located across four representative regions in Scotland. At the end of the season, loft owners provided a summary of the numbers of old and young birds held at the beginning of the season, the racing system used, and the losses of old and young birds from the area of the loft, on training flights, and on races.

To investigate losses specifically to sparrowhawks the 32 loft owners were asked to search for pigeon carcasses in the event of any birds going missing from around the loft rather than from races or training flights. Data on losses, searches for remains, and recording of the diagnostic attributes of remains were recorded onto standardised forms by loft owners following methodological instructions. Loft-owners were requested to return any recovered carcasses to CSL for examination.

Losses of pigeons during races were investigated through collection of racing pigeon rings from a sample of peregrine eyries, and by direct observation at liberation sites for a sample of races. At each eyrie, a search was conducted for rings following the breeding season. The flight history of the pigeons identified from recovered rings was investigated to identify when and from where they were lost. From these data, an estimate for the number of birds killed that were potential 'strays' was derived. Also, the relative distribution of rings issued to individual SHU Federations recovered amongst peregrine eyries in different regions was examined.

A review was conducted of avian deterrent/protection techniques. This review consisted of two parts: (i) an investigation of deterrent/protection techniques that have been used by SHU members, and (ii) an evaluation of avian deterrents used in other circumstances and settings, for their suitability for protecting racing pigeons from raptor predation. The aim of the review was to identify techniques that appeared most worthy of further detailed investigation both for protecting pigeons at the loft (loft-based deterrents) and during training/races (pigeon-based deterrents). The two potentially most effective pigeon-based deterrents identified (wing transfers and sequins) were investigated in controlled, replicated field trials as part of this overall study. Recommendation of specific loft-based deterrents considered worthy of further investigation in field trials (outwith this study) are presented. In addition to the review of deterrent/protection techniques, guidelines for the deployment of loft-based systems to maximise their potential effectiveness are discussed.

2.4 PEREGRINE

2.4.1 Population History

In the UK, the peregrine breeds in traditional sites on cliffs and rock faces, which, as a rule, are occupied year after year. Less favourable sites, however, are often less regularly occupied and even long-favoured haunts are occasionally deserted. On average, the "normal" occupation level of all known territories in any year has been estimated at about 85% (Ratcliffe 1972).

The period 1930-1939 is regarded as a standard period to provide a baseline assessment of the peregrine population in Great Britain (Ratcliffe 1963). An initial evaluation estimated that at least 805 different territories have been used in Great Britain since 1930, with an average population during 1930-39 of at least 700 pairs (Ratcliffe 1972). Subsequent discovery of previously unknown territories prompted reassessment of the 1930-39 population and the current estimate is 928 territories and 820 pairs (Ratcliffe 1984). In Northern Ireland there are 64 known territories that held an estimated 54 pairs during 1930-39 (Ratcliffe 1984). In the whole of the UK, therefore, the baseline 1930-39 population was 874 pairs.

During the Second World War (1939-45) the population suffered a severe reduction following a campaign of control by the Air Ministry in order to protect carrier pigeons. The species was virtually exterminated in southern counties of England, but was less affected in other regions, including northern England and Wales. Over much of Scotland there was very little disturbance to the species. Following the war many territories were rapidly recolonised and by the mid 1950s populations in many regions were on the way to recovery to pre-war levels (Ferguson-Lees 1957). In southern England, however, only a partial recovery was apparent.

During 1961-62 a Government-sponsored census of the UK peregrine population was carried out; subsequently repeated at 10-yearly intervals. The first census was initiated in response to reports from pigeon fanciers that there was a considerable and consistent increase in peregrines that were predating significant numbers of racing pigeons (Ratcliffe 1963). The census revealed, however, that the peregrine population was actually suffering a catastrophic decline. Occupation of breeding territories had fallen to 60% in 1961 and to 50% in 1962, with only 19% and 13% of pairs respectively known to have reared young. Sample censuses in subsequent years indicated that the decline levelled off in 1963 with 44% of territories occupied and 16% producing young, and the population stabilised during 1964-66 (Ratcliffe 1965, 1967). The cause of the high rates of breeding failure was subsequently identified as due to organochlorine pesticide poisoning.

Following restrictions on the use of organochlorine pesticides and conservation efforts to protect nest sites the population decline was arrested and gradually reversed. The 1971 census (Ratcliffe 1972) revealed 54% (341) occupancy of traditional territories with 25% producing young. In 1981 the census was expanded to include Northern Ireland and covered 1,142 known nesting territories (Ratcliffe 1984). Territory occupancy, by 1981, had recovered to 88% from the estimated low of 44% in the 1960s (Ratcliffe 1984). The census estimate of 768 breeding pairs represented about 90% of the estimated average population for 1930-39. The recovery, however, was not uniform nationwide. Numbers were at unprecedented levels (165%) in northern England, southern Scotland and North Wales. In a discrete area of south-west Scotland, for example, the overall density of breeding peregrines more than doubled between 1974 and 1982 (Mearns & Newton 1988). In other regions, however, numbers remained low.

By 1991, the population had reached its highest known level that century, with an estimated 1,283 breeding pairs - a 47% increase on the estimated 1930-39 population. The total population will have exceeded this due to non-breeding birds (*c.* 640), and would have been at a maximum post-breeding due to recruitment of fledglings (*c.* 1,540) (UK Raptor Working Group 2000). The increase remained geographically uneven, with the greatest net increase in a broad zone between the eastern Grampians and South Wales (Crick & Ratcliffe 1995). For example, between 1981 and 1991 territory occupancy increased by 177% in north-east Scotland (Hardey 1992), and 300% in Breconshire (Dixon & Lawrence 2000). Conversely, in south-east England and east Yorkshire the species has remained below pre-1940s levels. In some regions there have been more recent reductions in peregrine numbers (UK Raptor Working Group 2000). For example, between 1991 and 1998, territory occupancy in eight different regions of Scotland decreased by 2-37%.

Of the 1,283 breeding pairs in the UK during 1991, Scotland held 626 (49%) (Crick & Ratcliffe 1995). Approximately 95% of the peregrine's UK breeding range was considered to be occupied, based on the available suitable habitat – specifically the availability of food and nest sites (Newton 1994 cited in UK Raptor Working Group Report 2000).

The most recent survey was conducted in 2002. The total number of breeding pairs in the UK increased by 10% from 1,283 pairs to 1,402 pairs. The population now stands at 161% of the estimated 1930-39 population. Although the overall UK population has continued to increase, there have been substantial declines in some regions, notably northern Scotland and North Wales. In the Highlands of Scotland, the decline between 1981 and 1991 has continued into 2002. More recent declines between 1991 and 2002 have also occurred in Argyll and central regions. The total number of pairs in Scotland declined from 626 in 1991 to 544 in 2002 (13% decrease), representing 49% and 39% of the UK population respectively. The UK population represents *c.* 15% of the European population (see Thompson *et al.*, 2003).

During the 25-year period between the start of the population crash in the late 1950s and its recovery during the early 1980s, many racing pigeon regions would have been exposed to relatively low pressure from predation by peregrines. During this period most of the surviving population was located in regions least exposed to organochlorine pesticides, which were also the areas with few racing pigeon lofts and race routes. In Scotland, during the period 1971 to 1981, there would have been an increase in predation pressure as peregrine numbers increased to their highest recorded levels in this region. The predation pressure, between 1981 and 1991, would have been maintained or increased as peregrine numbers further increased. The Scottish Homing Union (1998) reported increased losses during races between 1986 and 1996. Average losses, from 13 Federations, increased from 10 birds per loft to 21 birds per loft over this period. During the same period, the peregrine population in Scotland has shown two contrasting phases, increasing up to 1991 and decreasing during 1991-1998. Regional decreases noted between 1991-1998 (UK Raptor Working Group 2000) were confirmed by the 2002 National Survey. A number of SHU Federations are centred in census regions that have experienced declines in peregrine numbers over the last decade (Tables 2.1 and 2.2). It is possible therefore, that in some Federations, predation pressure actually peaked mid-way through the decade (1986-1996) over which the SHU reported increased race losses.

2.4.2 Peregrine Diet

Ratcliffe (1993) outlined the diet of peregrines determined in 14 studies from five different regions throughout Great Britain: Lakeland (Cumbria), Snowdonia, Southern Uplands, Highlands – inland and Highlands – coastal. The studies involved breeding pairs during March-July with diet assessed from prey remains at or near the eyrie. A total of 137 prey species were found. Although there was variation in species composition in the diet between regions, a number of species were constant. Overall, domestic/feral pigeon was the principal prey species and comprised a mean of 34% (by number) of total prey (range 14-70% per study).

Table 2.1. Changes in the peregrine population in Scotland between 1961 and 2002. Data from the National Peregrine Surveys.

	Pairs	Territories Occupied *			Pairs		1991	Pairs	2002
Region	**1930-39**	**1961**	**1962**	**1971**	**1981**	**1991**	**% of 1981**	**2002**	**% of 1991**
S. Scotland - coastal	26	7	5	11	20	33	+65	49	+48
S. Scotland - inland	30	29	25	29	44	93	+111	104	+12
S & E Highlands west coast	31	37	29	31	36	49	+36	38	-22
S & E Highlands fringe inland	69	66	48	59	247	341	+38	261	-23
S & E Highlands centre inland	71	80	76	76					
N & W Highlands inland	78	80	70	84					
S & E Highlands east coast	14	7	11	1	5	14	+180	21	+50
N & W Highlands west coast	70	73	58	48	90	96	+7	71	-26
N & W Highlands east coast	65	67	66	27					
Total	454	446	388	366	442	626		544	

* Data for territories occupied from Ratcliffe (1993)

** 1991 data reanalysed to fit changes in regional analysis (Banks *et al*. 2003); some minor differences exist compared to Crick & Ratcliffe (1995).

Table 2.2. Location of SHU Federations in relation to Scottish census regions used in the National Peregrine Survey. The number of peregrine pairs represent the number of territories observed to be occupied plus additional estimated extras (Banks *et al.* 2003).

1981 Region	2002 Region	Change in no. peregrine pairs 1991 to 2002	SHU federation *
S. Scotland **- coastal	South Strathclyde - coastal Dumfries & Galloway - coastal Lothian & Borders - coastal	+16	Ayrshire, East of Scotland, Glasgow, Kyle & District, Lanarkshire, Midlothian, Pentlands, Scottish Border, Solway, South Lanarkshire, West Lothian
S. Scotland - inland	South Strathclyde - inland Dumfries & Galloway - inland Lothian & Borders - inland	+11	Ayrshire, Ballochmyle, East of Scotland, Glasgow, Kyle & District, Lanarkshire, Midlothian, Pentlands, Scottish Border, Solway, South Lanarkshire, West Lothian
S & E Highland west coast	Argyll - coastal	-11	
S & E Highlands fringe -inland S & E Highlands centre - inland N & W Highlands inland	Tayside - inland Argyll - inland Central Highlands - inland NE Scotland - inland	-80	Aberdeen, Angus, Central, Dundee, Fife, Highlands & Islands, Midland, Moray Firth, North of Scotland, North West, Renfrewshire
S & E Highlands east coast	Tayside - coastal NE Scotland - coastal	+7	Aberdeen, Angus, Dundee, Fife, North of Scotland
N & W Highlands west coast N & W Highlands east coast	Shetland Orkney Western Isles Highlands - coastal	-25	Highlands & Islands, Moray Firth

* Location of SHU Federations taken from SHU (1998)

** S. Scotland is here defined as Southern and Central Scotland

In southern Scotland there was consistency between studies, spread over 80 years, in the estimates of domestic/feral pigeon in peregrine diet. Blezard (1923-1969), Ratcliffe (1946-74) and Roxburgh and Mearns (1974-75) estimated that pigeon comprised 49%, 44% and 54% (by number) of total prey respectively, based on prey remains (Ratcliffe 1993). Mearns (1983) investigated the diet of peregrines in south-west Scotland occupying different habitats (coast, forest, heather moor, sheepwalk and inland mixed) during the breeding season between 1975-80. During March-July, pigeon (domestic/feral/rock dove) constituted 49% of kills (by number) and was the most numerous prey species, both by numbers and weight, at all eyries investigated. The proportion that individual groups of birds (seabirds, passerines, waders, game birds, pigeons) formed in the diet varied by less than 10% between years. Differences in diet between habitats were minor, probably due to peregrines ranging widely and hunting over a variety of habitats, and also to a supply of transient species (domestic pigeon, thrushes and waders). During winter (October-March) the percentage of pigeon in peregrine diet was lower, constituting 30% of prey remains at coastal eyries and 13% at inland eyries (Mearns 1982). Fieldfares *Turdus pilaris* and redwings *Turdus iliacus* were important components of the diet during the winter months, constituting 71% and 17% of prey items at inland and coastal eyries respectively. At inland eyries pigeon remains were few in winter but increased in April as the breeding season and racing pigeon season got underway. On the coast, pigeons were found in the diet throughout the year but again increased in April. Redpath & Thirgood (1999) found that racing/feral pigeon constituted 55% (by number) of peregrine diet during summer, over the period 1992-96. The percentage of pellets containing pigeons varied between seasons, being highest in the order: summer (73%), spring (61%) and winter (31%).

In the Highlands of Scotland domestic/feral pigeons constitute a lower proportion of peregrine diet. Ratcliffe (1993), details five studies in the Highlands, between the years 1904 and 1977, in which domestic/feral pigeon constituted only 14-24% (by number) (mean 19%) of total prey. In more recent years, pigeons have been reported to constitute a higher proportion of the peregrine diet from studies in the Highlands: 30% domestic pigeons (1981-1991) (Hardey 1981 cited in Shawyer *et al.* 2000) and 31% racing/feral pigeons (1992-96) (Redpath & Thirgood 1999). At inland Highland sites gamebirds (mainly red grouse *Lagopus lagopus*) and ducks and waders become important constituents of the diet, whilst at some coastal sites seabirds are frequent prey species. Domestic pigeons are less available to peregrines in the Highlands as fewer racing pigeons pass through or are lost in this region compared to southern Scotland.

In northwest England, Ratcliffe (1993) reported data from five studies conducted in Lakeland, in which domestic/feral pigeons constituted 15-53% (mean 34%) of prey. Redpath and Thirgood (1999) found that racing/feral pigeons constituted 46% of prey in northern England during summer, between 1992-96.

In Snowdonia (1950-79), Ratcliffe (1993) reported that domestic/feral pigeon constituted 70% of prey. In South Wales (1985-98), Richards and Shrubb (1999) found domestic pigeon constituted 69% of prey during April to September and 24% of prey during October to March. Dixon reported regional variation across Wales, during the racing season, in the proportion of racing pigeons constituting peregrine diet: South Wales Valleys 87%, Brecon Beacons 73% and Mid Wales 54% (RPRA website, 2002). In South Wales, Dixon (2002) reported that the percentage of domestic pigeon in peregrine diet was higher during the racing season (69%) than outside (25%). In Northern Ireland (1970-71), domestic pigeons were found to constitute 62% of prey (McKelvie 1973 cited in Shawyer *et al*. 2000).

In summary, domestic/feral pigeon is the principal component of peregrine diet in the UK and can constitute up to 87% of total prey items. The percentage of pigeon in the diet, however, varies regionally and seasonally. Pigeon is more prevalent in the diet during the peregrine breeding season than during the winter. The increase and decrease in the pigeon component of the diet coincides with the start and end of the racing pigeon season respectively, indicating the importance of racing pigeons as a food supply (Richards & Shrubb 1999, Dixon *et al*. 2003). Regional differences in the availability of racing pigeons are also reflected in peregrine diet, with racing pigeons constituting a lower percentage of the diet in regions more remote from lofts and race routes. Predation on domestic/feral pigeons, however, may not be entirely related to availability but also to the peregrine's food requirements during the different stages of its breeding cycle.

All these studies estimated peregrine diet from investigation of prey remains and/or regurgitated pellets collected at or near eyries. Both techniques, however, have inherent potential biases (Mearns 1982, Oro & Tella 1995, Redpath *et al*. 2001). Feathers from larger and lighter-coloured species (e.g. pigeons) are more likely to be found than those from smaller, duller species, especially if searches are infrequent. Also, remains from a single prey item may be dispersed in a number of locations around the eyrie, making quantification of prey numbers difficult. Analysis of prey remains, therefore, may over-estimate the frequency of pigeon in the diet.

Comparative estimates of diet from analysis of prey remains and pellets collected from the same eyries have been shown to vary. Mearns (1983) estimated that, in south-west Scotland, domestic pigeons constituted 51% and 46% of peregrine diet from remains and pellets respectively. A more marked difference in estimates was found by Oro and Tella (1995), in north-eastern Spain – remains 39%, pellets 9%. An alternative measure, the direct observation of prey delivered to nests is usually assumed to give the most reliable measure of diet. Bias may also exist in this technique, however, due to for example, selective delivery of larger prey to eyries where nestlings are being reared (Sonerud 1992). All three techniques have been compared during a study of hen harrier *Circus cyaneus* diet (Redpath *et al*. 2001). The main findings were: pellets over-represented mammalian prey and under-represented avian prey, prey remains over-represented large prey and under-represented small prey, pellets gave higher diversity values than direct observation and detected more small prey species.

Dixon (2002) investigated the diet of nesting peregrines, during May and June in South Wales, using both direct observation and prey remains. Direct observations at 16 eyries recorded a total of 46 kills delivered to nests. All larger prey items (>120g) were identified to species, 17 of which were domestic pigeon. From these observations, the proportion of pigeon in the diet was 52.9% in May and 27.5% in June, which compared with estimates of 77.8% and 64.2% from prey remains respectively. Domestic pigeon, therefore, was over-represented in prey remains by 24.9% and 36.7% during May and June respectively. Dixon (2002) concluded that the proportion of domestic pigeon estimated from prey remains should be corrected by a factor of 0.54 to be more representative of the actual proportion present. The corrected estimate for the proportion of pigeon in the diet for May and June was, therefore, 37% (*cf.* 68% from prey remains).

Dixon's (2002) observation that analysis of prey remains markedly over-estimates the percentage of domestic pigeon in peregrine diet confirms the supposition made by other authors and has implications for other studies of diet composition, and estimates of numbers of pigeons killed based on prey remains, e.g. Ratcliffe (1993).

2.5 SPARROWHAWK

2.5.1 Population History

The sparrowhawk's preferred nesting habitat is mature woodland. Regional differences in nesting sites exist, however, with hawks utilising whatever nesting habitat is locally available, such as small woods or patches of scrub. Sparrowhawks may now be encountered in suburban and urban areas in many parts of Britain. As for the peregrine, changes in the population status have resulted mainly from human activities.

Before 1900, the sparrowhawk was widespread throughout the UK. Systematic persecution of the species began around 1850 with the rise in game management. In eastern regions, where a high proportion of land was managed for game, sparrowhawk numbers were depressed below natural levels for long periods. During the period of the Second World War there was a large increase in numbers following a marked reduction in persecution as a result of a decline in gamekeeping. Toward the end of this period the species was probably more numerous than at any time since 1800. The population then suffered a dramatic decline as a result of organochlorine pesticide poisoning following their introduction and extensive use from the late 1940s. By 1960, the species had virtually disappeared from eastern arable districts. Concern over the population status led to full legal protection in 1961.

Following the restrictions on the use of organochlorine pesticides in the late 1960s and 1970s, together with legal protection and the creation of new breeding habitat through a national afforestation programme, the population gradually recovered. The recovery was slowest in the eastern regions where pesticide use was heaviest and breeding did not recommence until the early 1980s. Since peaking in the early 1990s, the UK population has declined. The smoothed Common Bird Census (CBC) index has declined by 12% between 1994 and 1999 (BTO unpublished cited in UK Raptor Working Group 2000). This recent decline has been suggested to be due to a decrease in prey species on farmland (UK Raptor Working Group 2000). In Scotland, the sparrowhawk population is believed to have remained stable in recent years (Thompson *et al*. 2003).

The current UK population estimate is 34,500 breeding pairs with a further *c.*7,400 non-breeding birds (Gibbons *et al.* 1993). Scotland holds *c.*7,000 breeding pairs which represents *c.*20% of the UK breeding population. It was estimated that 100% of the potential UK breeding range was occupied in the early 1990s (Newton 1994). The UK population represents *c.*11% of the European population.

2.5.2 Sparrowhawk Diet

Sparrowhawk diet and feeding behaviour have been detailed during a ten-year study in southern Scotland (Newton & Marquiss 1982, Newton 1986). Sparrowhawks fed almost entirely on other birds; the smaller male hawk taking smaller prey-species (5-120g, especially 5-80g) than the larger female (mainly 20-120g, but up to 500g or more). All bird species of appropriate size present in the sparrowhawk's foraging range were taken during some period of the year. In April-August, the species taken most frequently were chaffinch *Fringilla coelebs*, song thrush *Turdus philomelos*, blackbird *Turdus merula*, robin *Erithacus rubecula*, starling *Sturnus vulgaris* and meadow pipit *Anthus pratensis*, whilst in terms of weight the most important species were woodpigeon *Columba palumbus*, blackbird, song thrush, starling and chaffinch. Throughout this period large numbers of fledglings were taken, with each prey species increasing in the diet for a short period after its young left the nest. Sparrowhawks switched from one prey species to another coincident with the species' respective fledgling periods. Breeding by sparrowhawks each year coincided almost exactly with the fledgling period of song birds. In September-March, the most frequent prey species were redwing, blackbird, fieldfare, chaffinch and goldcrest *Regulus regulus*, whilst in terms of weight the most important were woodpigeon, blackbird, fieldfare and redwing.

Domestic pigeon constituted 0.19% and 0% of kills during April to August and September to March respectively (Newton & Marquiss 1982). The most important prey item, by weight, was the woodpigeon, constituting 24% and 34% during April to August and September to March respectively. The location of the study, however, was centred on the valleys of Annan and Esk, which are not primarily within hunting range of racing pigeon lofts or race routes.

2.6 PEREGRINE AND SPARROWHAWK PREDATION ON RACING PIGEONS

Peregrine predation on racing pigeons has a long history, whilst sparrowhawk attacks at lofts appears to be a more recent phenomenon (Dixon 2002).

Racing pigeons are potential targets for raptor attack under three different situations, in the loft area, during races and on training/exercise flights. Racing occurs during the months of April to September and is split into two seasons – 'old bird' (>1 year old) and 'young bird'. The 'old bird' season extends from mid-April to mid-July, and the 'young bird' season from mid-July to the end of September. Before the racing seasons and between races during the season pigeons are trained over short training flights (20-40 miles on average). Exposure to raptor predation is minimised during winter when birds are exercised less frequently or confined entirely to the loft.

Ratcliffe (1993) estimated the maximum number of racing pigeons that might be taken by peregrines annually in the UK, based on peregrine daily food intake (DFI). Using this method, Ratcliffe (1993) estimated a total annual catch of 224,447 pigeons. This estimate was based on a DFI of 127g and 157g per adult and young peregrine respectively, and a total population of 2,378 adults and 1,486 young (average life 240 days) giving a total annual food requirement of 166,224kg - adjusted to 207,780kg by applying a 20% wastage factor for parts of prey not consumed. With domestic pigeon constituting 50% of peregrine diet and an average weight of 425g per pigeon this total annual food requirement equated to the final estimated annual catch of 224,447 birds.

It was estimated that this annual catch represented, at most, just over 3% of the UK's racing pigeon population (estimated as at least 7 million birds in 1991).

More recently, three published studies in the UK have attempted to estimate the extent and circumstances of losses of racing pigeons to raptors. First, the Scottish Homing Union conducted a survey of its members to determine the extent to which fanciers experienced problems with raptors (SHU 1998). Second, a report by the Hawk & Owl Trust to the UK Raptor Working Group (Shawyer *et al.* 2000). Third, a report by Lancaster University for the Confederation of Long Distance Racing Pigeon Unions of Great Britain and Northern Ireland (Dixon 2002).

2.6.1 Scottish Homing Union

The SHU is comprised of 23 Regional Federations with a total of 4,151 lofts. Almost 90% of members' lofts are located in the central lowland belt between Dunfermline and Edinburgh in the east to Glasgow in the West.

During 1996/97 the SHU conducted a survey of its members to gather information on the nature and extent of attacks by birds of prey on racing pigeons in Scotland (SHU 1998). Questionnaires were circulated to 250 clubs (95% of all Scottish clubs). The number of lofts returning questionnaires was 1,937 (47% of lofts in Scotland), of which 1,752 (42% of lofts in Scotland or 90% of respondents) reported problems with birds of prey (mainly peregrines and sparrowhawks).

Of the 1,752 ***lofts*** which reported problems with raptors, 1,587 (91%) stated that attacks had occurred in the loft area. At these 1,587 lofts, peregrines were cited as responsible for attacks at 828 lofts (52%) with a greater number of attacks in regions in the west and south west – lofts in Strathclyde and South West Scotland suffered 70% of the attacks. Attacks by sparrowhawks at the loft substantially exceeded those by peregrines and were reported at 1,424 lofts (90%). Over 100 lofts reported they had pigeons killed due to these attacks, 57 of which indicated the numbers killed or lost as a result. At these 57 lofts a total of 570 birds had been killed or lost due to attacks – an average of 10 birds per loft. This average, however, will be an over-estimate as the figure is weighted by those lofts most affected, although the sample does illustrate that the range of losses between lofts can be high. Elsewhere, in the SHU report a mean of five birds lost per loft is reported (7,935 birds from 1,587 lofts).

Racing pigeons lost during ***training*** flights totalled 33,043 from 1,713 lofts, an average of 19 birds per loft. This total will include losses to other causes in addition to direct raptor kills. Pigeon fanciers consider that many deaths and injuries are sustained during the panic which ensues when a flock is targeted by a raptor. Pigeons may be killed, whilst trying to escape, by flying into the ground, colliding with trees or from entanglement in undergrowth. Although pigeons may stray, get lost or collide with objects, fanciers do not accept that this can happen to experienced birds during 20-30 mile training flights when they have previously completed races over a few hundred miles (SHU 1998). There is no objective basis, however, for owners to dismiss all non-raptor causes of training losses. Birds returning from training which had sustained injuries (attributed to raptors) were reported from 1,644 lofts and involved 8,368 birds.

In 1996 a total of 34,685 birds from 1,643 lofts were reported lost during ***races***, an average of 21 birds per loft. This was a marked increase in losses compared to 1986 when a total of 10,131 birds were lost from 973 lofts, an average of 10 birds per loft.

The SHU (1998) reported that overall losses have increased during the last 20 years. Members are reported to breed 59% (19 pigeons per loft) more young birds than in 1975 to maintain a sufficient population of old birds to compete the following season.

The Scottish racing pigeon population is estimated to be 340,382 birds, based on there being 4,151 lofts with an average of 82 birds per loft (Shawyer *et al.*, 2000).

2.6.2 Hawk & Owl Trust Study

Losses to peregrines were estimated by comparing the total annual losses of racing pigeons in regions of the UK which support breeding peregrines with a control region (eastern England) in which breeding peregrines are scare. Peregrine predation was estimated to account for 7.1% and 7.0% of the loft populations of ‘old’ and ‘young’ birds during their respective race seasons, throughout the UK excluding eastern England. The average loft population at the start of their respective seasons were estimated as 27 ‘old’ birds and 46 ‘young’ birds. For the whole of the UK, losses were 3.2% and 4.2% respectively.

From examination of the flight histories of racing pigeons, whose rings had been recovered post-breeding from a random sample of 105 peregrine eyries, it was estimated that, at a national level, attacks by peregrines were predominantly on birds which had been liberated in races (72%) rather than those in training flights (17%) or at the loft (11%). There was a regional difference, however, in the proportions of pigeons lost whilst racing, training or at the loft. Losses during racing were highest in Scotland (95% of total losses), during training in Northern Ireland (48%) and from lofts in the Western Area (15%).

Thirty-six percent of the rings recovered from eyries belonged to race-feral pigeons, that is birds which had been liberated a year or more before discovery of their ring in an eyrie. Of the other 64% (i.e. non race-ferals), which were liberated in the same year as their ring was found, 46% were flying on a direct line to their lofts, 41% were off-line and 12% had overshot their loft when predated. It was concluded that at least 70% of the racing pigeons predated by peregrines were pigeons that were already feral, or had strayed significantly from their flight routes.

Sparrowhawk attacks at the loft were examined from a telephone questionnaire survey of 255 lofts throughout the UK. Overall, 63% of lofts annually experienced attacks and an average of 2.7 birds were lost per loft, representing 3.7% of the UK racing pigeon population. There was regional variation in the proportion of lofts attacked (42-87%) and the number of birds lost per loft (1.2-4.6 or 1.9-6.3%), with rates highest in Scotland (86% of lofts and 3.5 birds per loft or 4.1 birds per attacked loft) and Northern Ireland (87% of lofts and 4.6 birds per loft). It was reported that a similar estimate was supplied to the UK Raptor Working Group by the RPRA of 2.3 birds per loft (0.2-5.2) for 14 regions throughout Britain and Ireland.

In comparison to the estimated losses to peregrines and sparrowhawks, ***total losses*** from all causes were 35% and 48% for ‘old’ and ‘young’ birds during their respective race seasons. A further 27% of young birds were lost during their pre-race period to July. Collectively, losses of racing pigeons in the UK totalled 52%. Straying was estimated to account for 42% of these total losses. In Scotland alone 48% and 58% of old and young birds were lost to all causes during their race seasons, with a further 22% of young birds lost during their pre-race period. Collectively, reported losses of racing pigeons in Scotland totalled 60%.

CSL note that there are some concerns over the estimates derived in this study (Dixon & Hartley 2002, RPRA in UK Raptor Working Group 2000).

2.6.3 Lancaster University Study

Dixon (2002) reported estimates of racing pigeon ***losses per loft to peregrines*** derived using two different methods. First, total annual losses were compared between a control region (eastern England) and a study region (Wales). Losses were found to be 12% greater for old birds and 9% greater for young birds in Wales than in the control region. This compared with Shawyer *et al.*'s (2000) estimate for Wales of 6.5% old birds and 15.9% young birds. For overall losses, the two studies are in close agreement with around 10% more losses in Wales than in the control region. Dixon (2002) states, however, that Shawyer *et al.*'s (2000) assumption that no peregrine kills occurred in the control region was incorrect and that the estimate of 10% losses to peregrines must be regarded as a minimum. The second method relied on an estimation of the total peregrine kills in South Wales and identifying the home loft of those pigeons. The majority of pigeons killed were within 8km of their loft. The level of losses at a loft was primarily influenced by peregrine breeding density within 8km of the loft. This method also estimated that peregrines killed around 10% of the loft population.

Dixon (2002) also estimated the numbers of pigeons killed per pair of peregrines. In this method, the proportion of domestic pigeon in the diet was estimated from prey remains at the nest. The percentage of pigeon in the diet was higher during the racing season (April-September: 69% of kills) than outside this period (25% of kills). Data from direct observations of nests, during May and June, were used to validate whether prey remains (collected in those months) accurately reflected the number of pigeon kills brought back to the nest. The observations indicated that examination of prey remains over-represented the proportion of pigeon in peregrine diet. A correction factor (0.54) was derived using the observational and prey remains data collected in May and June. The corrected percentage of domestic pigeon in the diet for May and June was 37.0%, compared to the direct estimate from prey remains of 68.3%. The kill rate of domestic pigeons was estimated from the observations of the rate of prey delivery to the nest and the available hunting hours. During May and June, peregrines with two dependent young were estimated to kill prey at a rate of 0.29 birds per hour, equivalent to 4.6 birds per day. Two adults without young killed at a rate of 0.19 birds per hour, equivalent to 3.0 birds per day. Estimates for the number of pigeons killed in all other months were derived using the prey remains correction factor and kill rate. It was estimated that a typical breeding pair in South Wales, rearing two chicks would kill around 285 domestic pigeons during the race season (April to September), and 355 over the whole year. Dixon *et al.* (MS) concluded from examination of remains at eyries, that in south and central Wales, 92% of pigeons killed by peregrines were racing pigeons, giving corresponding numbers of racing pigeons killed per breeding pair of 262 and 327 respectively.

Dixon (2002) also estimated the number of racing pigeons killed using the recovery rate of leg rings from wing-stamped birds found in peregrine territories. It was estimated that racing pigeons were killed at a rate of 0.7 per day during the old-bird season (April-June), equivalent to a total of 65 birds per peregrine pair. This compares to a total of 136 racing pigeons per pair during the old-bird season using the previous estimation method.

In South Wales, Dixon (2002) estimated annual losses to sparrowhawks of 3.5 pigeons per loft, with losses from individual lofts more frequent in those located close to woodland.

2.7 OTHER CAUSES OF RACING PIGEON LOSSES

Some losses of racing pigeons are inevitable and are accepted by their owners. On occasion, however, losses from individual races can be exceptionally high. For example, 250 (68%) of the 774 starters failed to make it home from the 1995 annual race from Barcelona to northern European countries, and losses of 10-20% are not uncommon in shorter races in the Netherlands (MacKenzie 1995). In 1997, an estimated 15,000 birds (25%) failed to return from 60,000 liberated in Nantes during the Centenary Race organised by the RPRA (BHW 1997 cited in Shawyer *et al.* 2000).

Total losses of pigeons during races will comprise birds lost to a number of causes in addition to direct predation by raptors. The other potential causes of racing pigeons failing to home, detailed in Shawyer *et al.* (2000), are:

- Scattering (i.e. getting lost or injured as a result of panicking following raptor attack or as a result of other causes of disorientation).
- Straying.
- Exhaustion.
- Collision with wires or solid structures (e.g. buildings, windows, cars).
- Predation by mammals.
- Other deaths, e.g. shooting, entanglement, oiling, poisoning, disease and parasitism.

2.7.1 Scattering

In addition to directly taking racing pigeons, raptors are considered by fanciers to cause further indirect losses as a result of the panic induced in other flock members when an individual is attacked (SHU 1998). It is stated that whilst trying to escape pigeons may collide with objects, or go to ground to hide, some becoming entangled in vegetation. Disorientation as a result of scattering was considered to make it difficult for birds to fix their home direction. Ratcliffe (1993) reports that woodpigeons and domestic pigeons will "...plunge headlong..." into woody cover to escape pursuit by a peregrine. Lindquist (1963) reported that the heaviest losses due to scattering occurred following an attack shortly after the flock had started off, although presented no data to substantiate the claim. The potential for scattering to occur at race liberation points, however, is probably low as few liberation points are located within peregrine territories. The risk of scattering may be more associated with training flights rather than races, as over the shorter training distances there will be a greater tendency for birds to remain bunched up into flocks.

Shawyer *et al.* (2000) reported observations of peregrine attacks during old bird races. Four successful and eight unsuccessful attacks were recorded. Most flocks contained 9-20 birds but occasionally only two or three. In both successful and unsuccessful attacks, the pigeons regrouped almost immediately. It was considered that pigeons at the front of the flock showed little indication of being aware of the attack and made no attempt to 'go to ground'.

2.7.2 Straying

Shawyer *et al.* (2000) estimated that 42% of all racing pigeon losses could be attributed to straying. This figure was derived from the condition of racing pigeons handed in to wildlife hospitals throughout Great Britain. As recognised by Dixon & Hartley (2002), however, this figure overestimates the proportion of pigeons lost to straying. Clearly, only pigeons injured by raptors will be handed in to hospitals, whilst those actually killed will not be represented in the sample.

Shawyer *et al.* (2000) also estimated the percentage of racing pigeons killed by peregrines which were strays. Stray pigeons were classified into two categories – 'race-feral' and 'race-strays'. A race-feral pigeon was defined as a bird the remains of which were recovered from an eyrie (which had previously been cleared of all remains) one year or more after it had been liberated in race or training flight. That is, the bird would have adopted a feral existence prior to being killed by a peregrine. Race-feral birds do not represent a direct loss to the fancier due to predation as not returning to the loft for at least one year means they could be considered as permanently lost. Race-strays were defined as birds which were 'off-line' during racing or training. A bird was classed as off-line if it was recovered (from an eyrie) more than 33% of its intended flight distance perpendicular to its direct line of flight. It was reported that 36% of racing pigeons predated by peregrines were race-feral birds. Of the pigeons killed that were not race-feral, 41% were off-line when predated. It was concluded that 70% of birds taken by peregrines had either adopted a feral existence or had strayed significantly off-line from their training or race routes.

Dixon (in press) concluded that up to 54% of racing pigeons killed in Northumberland were either significantly off course or strays already lost to their owners. In Wales, Dixon *et al.* (unpublished) concluded that potential strays constituted 60%, 40% and 20% of racing pigeons killed in Central Wales, the Brecon Beacons and South Wales respectively. These estimates were based on the flight histories of birds, whose rings were recovered from peregrine eyries, together with the location of the home loft and liberation site. The definition of a stray was the same as that used by Shawyer *et al.* (2000) for race-strays. It was concluded that strays were over-represented in the sample of predated birds relative to their constituent proportion in the population as a whole. Strays provide a more constantly available prey compared to the more sporadically available homers during races and training flights. Dixon *et al.* (unpublished) reported that younger, inexperienced pigeons were more likely to be further off-line than older more experienced birds, and were, therefore more likely to stray.

The definition of a race-stray used in these studies, however, was purely arbitrary, i.e. a bird which was 'off-line' by 33% or more of its supposed flight distance perpendicular to its direct line of flight. The assumption of straight line courses, however, may not represent the actual flight paths followed by pigeons, which may be more likely to follow natural features such as valleys and coasts. Also, it is possible that pigeons may alter their flight path from the ‘normal’ route in response to external factors. As noted by the critique of Dixon (2002), the method to classify race-strays adopted by Shawyer *et al.* (2000) and Dixon *et al.* (unpublished) needs to be tested and the proportion of ‘off-line’ birds that eventually return home should be determined before any significance can be attached to the findings.

The definition of race-feral birds is also arbitrary, i.e. a bird whose remains were recovered from an eyrie one year or more after it had been lost. Shawyer *et al.*’s (2000) definitions of race-feral and race-stray do not allow the identification of birds which turned feral in the same season that they were predated. In practice, a bird reported as lost during a race may have adopted a feral existence prior to being killed later in the season by a peregrine.

The issue of straying is critical in evaluating the impact of raptors on pigeon racing. Birds that are killed after having adopted, or in the process of becoming, feral do not represent a direct loss to fanciers as a result of predation, as these birds would have been lost to their owners anyway. The duration of absence before which a bird is deemed to have strayed varies with the racing system. Pigeons raced on the widowhood system that fail to return to their loft after about 36 hours are rarely seen again. Pigeons raced on the natural system, however, will often home as late as four weeks after liberation (RPRA statement in UK Raptor Working Group Report 2000).

2.7.3 Exhaustion

MacKenzie (1995) reported research conducted by Wageningen Agricultural University in the Netherlands which indicated that a major contributory factor to losses during races was weakness due to the conditions imposed on pigeons during transport to liberation points. Lack of drinking water, or the opportunity to utilise it, caused birds to dehydrate and overheat. Pigeons, thus weakened, were more likely to die on the race route. MacKenzie (1995) also reported that overheating may be exacerbated by overcrowding birds into poorly ventilated transporters.

Shawyer *et al.* (2000) reported that the majority of 40 racing pigeons handed in to Wildlife Hospitals demonstrated exceptionally low body weights (mean 315g, range 207-402g) compared to healthy birds averaging 425g. It was suggested that the reduced availability, over the last 30 years, of feeding opportunities in the form of cereal stubbles and spilt grain have made it more difficult for racing pigeons to replenish energy reserves *en route*.

2.7.4 Collisions

Shawyer *et al.* (2000) reported that collisions with wires, solid objects and vehicles accounted for injury or death to 40% (n=417) and 30% (n=756) of racing pigeons handed in to UK Wildlife Hospitals (1996-1997) and to Rehabilitation and Stray Pigeon Centres in Britain and Ireland (1997) respectively. The number of birds involved in collisions, however, will be under-represented in the data as, unlike injured birds, birds killed by collisions will not be handed in.

Collisions during training flights are believed by fanciers to be associated with young birds only. Fanciers do not accept that experienced birds will suffer collisions when flying in familiar territory (SHU 1998). Young birds are said to fly in tighter flocks which renders individuals more prone to hit obstructions that the flock encounters. Currently (2003) at a site in the Vale of York, the National Grid is investigating the potential use of bird diverters to prevent racing pigeon collisions with power lines (S. Grant, per comm.). This is in response to fanciers reporting numerous collisions between flocks of young birds and local power lines during training flights.

2.7.5 Predation by mammals and other deaths

Shawyer *et al*'s (2000) data collated from UK Wildlife Hospitals and Rehabilitation Centres indicated that predation by mammals accounted for 3.1% and 10.2% of racing pigeons handed in respectively. Injury or death to other causes (shot, poisoned, entangled, oiled) accounted for 8.2% and 6% respectively.

2.7.6 Loft conditions

Loft conditions may also have important effects on losses but most fanciers adhere to veterinary guidelines.

3. TOTAL REPORTED LOSSES FROM SCOTTISH LOFTS

3.1 LOFT MANAGEMENT SYSTEMS

Old Birds

The Natural System
Cocks and hens are paired and have free access to enter or leave the loft. Both sexes are stimulated to return to the loft to attend nest, eggs or young. Birds usually have several training flights (tosses) of 20-30 miles during the week and race at the weekend.

The Widowhood System
Lofts are designed so that cocks and hens can be physically separated from each other. Cocks are motivated to return to the hen with whom he is only allowed contact for a short period prior to basketting for the race (motivation) and for a few hours on return (reward). Cocks are exercised for one hour both morning and evening during the week and race at the weekend.

The Roundabout System
Both cocks and hens are raced at the weekend but are only allowed contact just prior to the race and for a short period on return. The sexes are exercised separately for one hour both morning and evening.

"Prisoner Birds"
The loft population of many fanciers is comprised of racing birds and birds kept for breeding purposes only ("prisoners"). Breeding birds are permanently confined to lofts or aviaries, so that it is only the racing birds that are potentially exposed to predation during exercise, training and racing.

Young Birds

Traditional System
Parents are paired up around 14th February with resultant young (10 days laying, 18 days incubation) weaned out of the nest at 24 days old. Young birds are on the wing at 6 weeks old and training and racing from 12 weeks old. Hens usually lay the second round of eggs when youngsters in the nest are 14-20 days old.

Darkness System
Parents breed at the beginning of December with eggs hatching in early January. Young birds are on the wing at 6 weeks old and training and racing from 12 weeks old. Young birds are restricted in their loft and the amount of daylight is controlled with lofts darkened from 4pm to 8am until mid-June. Darkening the loft modifies the normal biological processes and induces a quick feather moult (also encouraged with vitamin D supplements). Putative benefits of the darkness system are that birds are older with more training completed before the start of the young bird racing season, are fully moulted and so are freed of moult stress during racing, and are more sexually mature and can be mated on the widowhood or roundabout system to motivate.

3.2 REPORTED LOSSES IN 2002

This part of the study was carried out using loft owners who volunteered to assist with the project by providing data on numbers of pigeons lost during the 2002 season. Three regional meetings were held initially in order to meet local pigeon fanciers and obtain volunteers to take part in the study. These were held in Prestwick (17 April 2002), Moffat (24 April 2002), and Fife (4 June 2002).

A total of 35 single lofts and one loft complex were initially included in the study. This compares to a total of 4,151 SHU-affiliated lofts across Scotland (Figure 3.1). Twenty-eight of the lofts were included following the regional meetings, with 12 in the Moffat/Annan area, seven in Ayrshire and nine in Fife/Perth. The locations of the first two of these meetings were determined by SHU while the location of the third was requested by CSL in order to give a good geographical spread across the main pigeon racing areas of Scotland. In addition to these twenty-eight lofts, a further two were studied in Dunbartonshire, two in Dundee/Angus and four in the Stirling area. Of the four in Stirling, three were single lofts and the fourth was a loft complex containing approximately eight lofts. At the loft complex, five owners initially agreed to assist. Those lofts owners which subsequently provided information held a total of 3,889 pigeons at the beginning of the 2002 season. The inclusion of the loft complex was made at the suggestion of Scottish Natural Heritage in order to provide information on whether the larger numbers of birds present at the complex lead to a greater risk of attack by sparrowhawks. However, such complexes are rare in Scotland, where most lofts are found singly.

3.2.1 Methods

At the end of the project loft owners provided information on the numbers of old and young birds held at the beginning of the 2002 season, the racing system used, and the losses of old and young birds from the area of the loft, on training flights, and on races. In most cases a CSL researcher visited the fanciers to obtain this information, although in four cases this was not possible and the forms were completed by the fanciers and either posted to CSL or collected at a later date. Six of the original volunteers were unwilling or unable to provide the information requested. The reasons for this varied from an apparent unwillingness to co-operate, to illness and, in one case, the loss of records stored on a computer database. Contact with one fancier was lost following changes of address.

3.2.2 Results

3.2.2.1 Regional losses

Data on racing pigeon losses were collected at the end of the 2002 season from a total of 31 lofts in seven different regions in Scotland (Figure 3.2). The number of lofts in some of the regions, however, was too small for statistical comparisons. Geographically close regions, therefore, were combined for analysis (Table 3.1). Loft populations, at the start of the season and losses for all individual lofts during the 2002 racing season are presented in Table 3.2.

The reported losses of racing pigeons were compared between regions using a logistic regression model with overdispersion. Analysis was based on the number of birds lost as a percentage of the loft population at the start of the racing season. Comparisons were made for *total reported losses* (old birds and young birds combined) and individually for overall losses of *old birds* and *young birds* (Table

3.3a). The circumstances of losses were investigated by comparing losses of *old birds* and *young birds* at the *loft*, during *training* and during *races* (Table 3.3b-d).

Table 3.1 Combined regions and number of lofts used in the analysis of regional differences in racing pigeon losses.

	Combined Region	Region	No. Lofts	Total Lofts	No. lofts analysed
1	Ayrshire	Ayrshire	5	5	5
2	Dumfriesshire	Dumfriesshire	9	9	8
3	Dundee/Fife/Perth	Dundee	2	9	8
		Fife	6		
		Perth	1		
4	Dunbartonshire/Stirling	Dunbartonshire	2	8	7
		Stirling	6*		

* Stirling: 3 lofts within the same compound and 3 single lofts

CSL was unable to obtain data from a small number of fanciers who had originally agreed to take part in the study. In addition, three lofts were excluded from the analysis: two lofts because the reported number of losses exceeded the number of birds present in the loft at the start of the season, and one loft because it was not clear which season's losses were being reported.

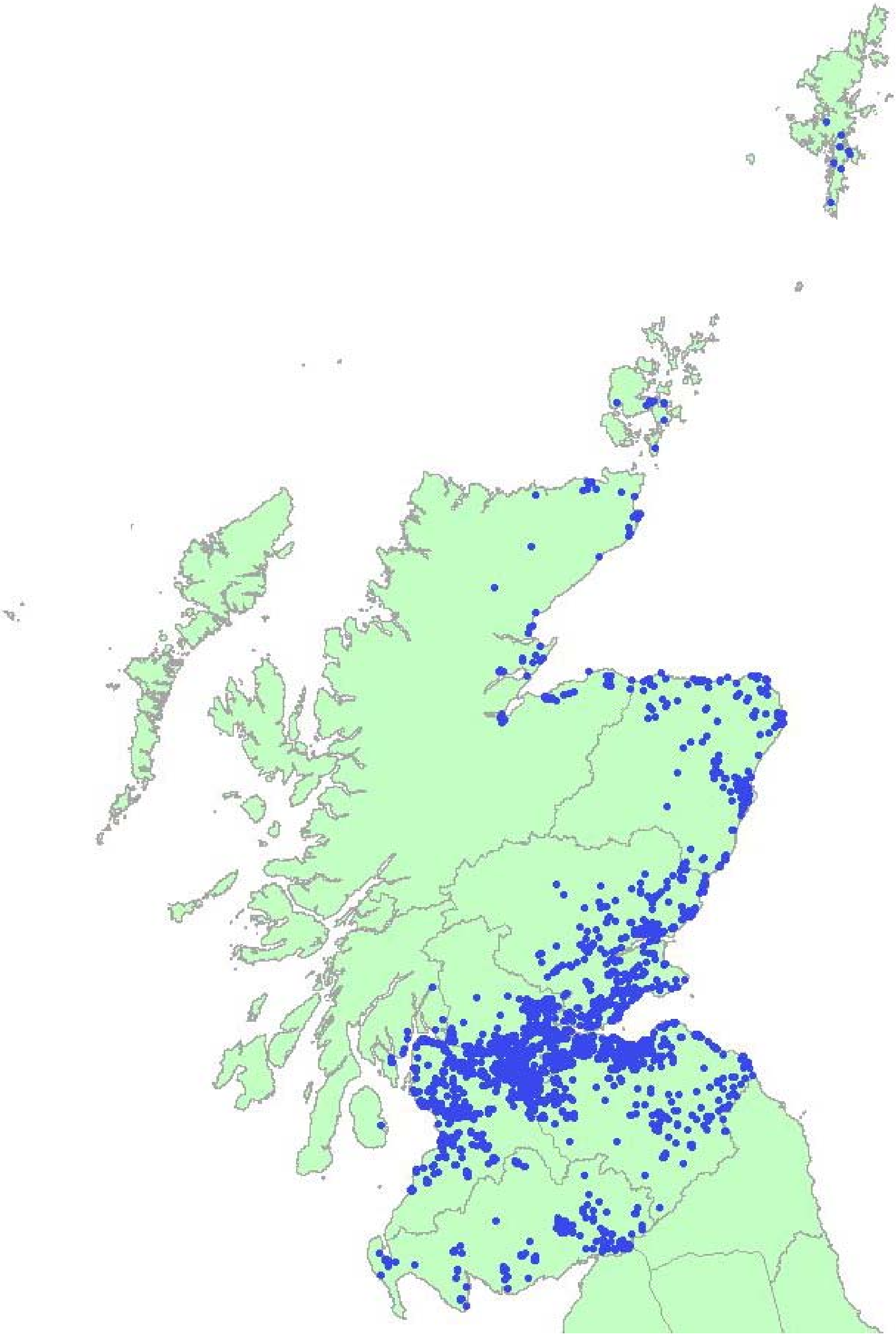

Figure 3.1. Distribution of SHU members' lofts across Scotland

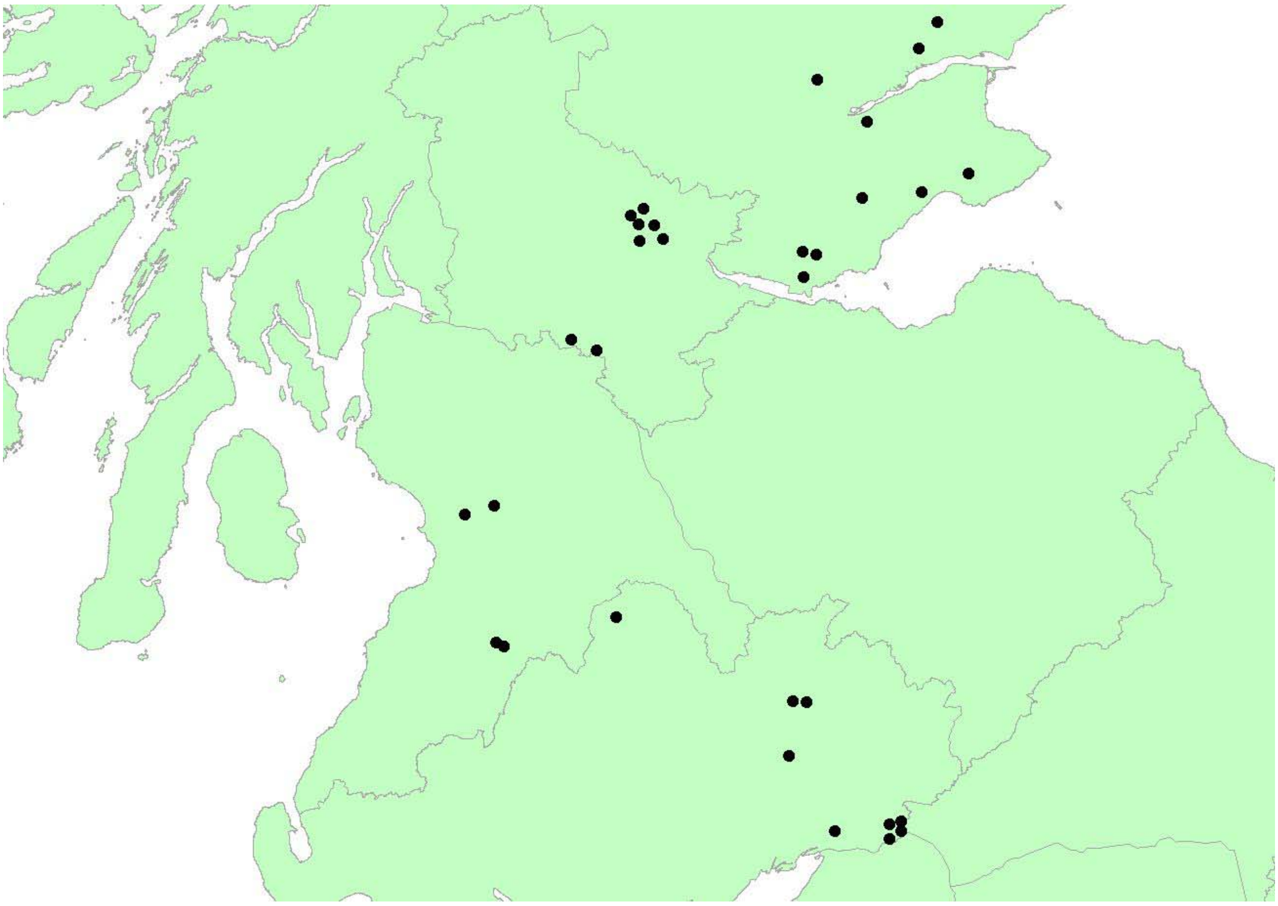

Figure 3.2. Location of lofts used in the investigation of total seasonal losses to all causes and losses to sparrowhawks. Lofts were located across four principal regions: (i) Dundee/Fife/Perth, (ii) Stirling/Dunbartonshire, (iii) Ayrshire and (iv) Dumfriesshire.

Table 3.2 Loft populations and total losses from 31 monitored lofts during 2002 race season

					OB Losses					YB losses					OB + YB	
Region	**Loft**	**Combined Region**	**OB**	**YB**	**Loft**	**Train**	**Race**	**Total**	**%**	**Loft**	**Train**	**Race**	**Total**	**%**	**Total**	**%**
Ayrshire	1	Ayrshire	60	78	2	5	37	44	73	3	6	26	35	45	79	57
Ayrshire	2	Ayrshire	23	65	0	6	13	19	83	5	18	27	50	77	69	78
Ayrshire	3	Ayrshire	30	40	3	8	6	17	57	12	4	4	20	50	37	53
Ayrshire	4	Ayrshire	12	51	0	0	9	9	75	5	11	27	43	84	52	83
Ayrshire	5	Ayrshire	53	47	2	0	22	24	45	2	0	32	34	72	58	58
Dumfriesshire	1	Dumfriesshire	62	80	6	22	10	38	61	3	13	42	58	73	96	68
Dumfriesshire	2	Dumfriesshire	38	30	5	2	10	17	45	5	8	10	23	77	40	59
Dumfriesshire	3	Dumfriesshire	29	90	0	11	7	18	62	22	17	31	70	78	88	74
Dumfriesshire	4	Dumfriesshire	80	70	2	0	20	22	28	0	6	46	52	74	74	49
Dumfriesshire	5	Dumfriesshire	35	64	1	4	8	13	37	0	2	42	44	69	57	58
Dumfriesshire	6	Dumfriesshire	76	70	42	15	28	85	112	49	23	40	112	160	197	135
Dumfriesshire	7	Dumfriesshire	120	60	0	2	4	6	5	1	7	24	32	53	38	21
Dumfriesshire	8	Dumfriesshire	40	40	1	5	10	16	40	2	4	20	26	65	42	53
Dumfriesshire	9	Dumfriesshire	45	32	0	6	20	26	58	2	2	na	4	13	30	39
Dundee	1	Dundee/Fife/Perth	36	50	3	6	13	22	61	4	14	10	28	56	50	58
Dundee	2	Dundee/Fife/Perth	80	140	4	15	23	42	53	5	35	67	107	76	149	68
Fife	3	Dundee/Fife/Perth	30	46	5	4	11	20	67	4	12	16	32	70	52	68
Fife	4	Dundee/Fife/Perth	93	92	3	2	29	34	37	4	18	17	39	42	73	40
Fife	5	Dundee/Fife/Perth	64	68	14	4	10	28	44	?	4	?	4	6	32	24
Fife	6	Dundee/Fife/Perth	40	60	2	0	24	26	65	6	36	na	42	70	68	68
Fife	7	Dundee/Fife/Perth	48	60	4	18	18	40	83	24	6	6	36	60	76	70
Fife	8	Dundee/Fife/Perth	44	35	0	7	6	13	30	0	10	na	10	29	23	29
Perth	9	Dundee/Fife/Perth	97	120	8	6	51	65	67	6	60	32	98	82	163	75
Dunbartonshire	1	Dunbartonshire/Stirling	24	50	0	10	9	19	79	16	12	20	48	96	67	91
Dunbartonshire	2	Dunbartonshire/Stirling	86	98	3	8	35	46	54	6	10	36	52	53	98	53
Stirling	3	Dunbartonshire/Stirling	52	84	6	0	30	36	69	?	?	?	?	?	36	27
Stirling	4	Dunbartonshire/Stirling	92	50	4	5	7	16	17	0	1	2	3	6	19	13
Stirling	5	Dunbartonshire/Stirling	86	110	0	3	23	26	30	0	8	45	53	48	79	40
Stirling	6	Dunbartonshire/Stirling	40	70	25	10	14	49	123	25	20	35	80	114	129	117
Stirling	7	Dunbartonshire/Stirling	60	70	5	5	30	40	67	2	0	40	42	60	82	63
Stirling	8	Dunbartonshire/Stirling	58	52	5	6	8	19	33	4	11	8	23	44	42	38
		Mean	56	67	3	6	18	26	53	5	12	26	41	60	67	56
		Median	50	60	3	5	13	22	57	4	10	27	39	65	67	58

Three lofts (shaded light grey) excluded from analysis due to losses being greater than the loft population at start of season, or due to other data anomalies.
At one loft (shaded dark grey) only 26 of 120 OBs actually raced; % losses in training and races therefore based on 26 OBs.
At 3 lofts no YBs were raced (na).

Table 3.3 Regional comparison of old bird (OB), young bird (YB) and collective losses (OB+YB), reported from the four principal study regions, in respect to (a) total losses, (b) losses from the loft area, (c) losses during training, and (d) losses during races.

(a) Total Losses

	OB+YB		YB		OB	
Region	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
Ayrshire	65.8	13.6	65.7	17.3	66.6	15.2
Dumfriesshire	54.4	17.0	69.8	8.5	41.9	19.4
Fife/Perth/Dundee	63.2	12.9	64.3	14.5	57.7	17.6
Stirling/Dunbarton.	49.8	26.1	51.2	28.9	49.8	23.3
all lofts	56.4	18.5	60.1	21.1	52.8	20.3

YB: F3,20 = 1.31, p>0.05
OBF: F3,24 = 2.03, p>0.05
OB+YB: F3,20 = 1.26, p>0.05

(b) Loft

	OB+YB		YB		OB	
Region	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
Ayrshire	8.5	7.4	11.1	10.8	3.4	4.1
Dumfriesshire	6.1	6.8	7.2	8.8	3.8	4.9
Fife/Perth/Dundee	8.5	7.9	10.0	12.6	6.9	4.9
Stirling/Dunbarton.	7.1	7.6	8.1	12.1	5.2	4.5
all lofts	7.5	7.1	9.0	10.6	5.0	4.6

YB: F3,23 = 0.12, p>0.05
OB: F3,24 = 0.59, p>0.05
OB+YB: F3,23 = 0.26, p>0.05

(c) Training

	OB+YB		YB		OB	
Region	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
Ayrshire	14.0	10.4	13.4	11.1	12.2	13.4
Dumfriesshire	12.4	8.0	12.7	7.6	15.5	13.8
Fife/Perth/Dundee	23.5	7.3	30.9	16.3	13.8	11.9
Stirling/Dunbarton.	11.4	10.0	10.8	9.9	11.2	13.9
all lofts	15.8	9.7	17.8	14.2	13.3	12.6

YB: F3,23 = 5.34, p = 0.006
OB: F3,24 = 0.46, p>0.05
OB+YB: F3,23 = 5.46, p = 0.006

(d) Racing

	OB+YB		YB		OB	
Region	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
Ayrshire	43.3	17.0	41.2	21.8	50.9	21.0
Dumfriesshire	35.1	11.2	48.8	13.6	24.9	8.9
Fife/Perth/Dundee	31.4	7.8	26.3	13.4	37.1	14.2
Stirling/Dunbarton.	31.2	17.5	32.4	19.3	33.4	18.4
all lofts	34.9	13.6	37.5	18.2	35.2	17.1

YB: F3,20 = 1.79, p>0.05
OB: F3,24 = 2.01, p>0.05
YB+OB: F3,20 = 1.06, p>0.05

Total losses (OB + YB) ranged from 50% to 66%, for old birds from 42% to 67% and for young birds from 51% to 70%. There was no significant difference between regions in the total losses, or in the overall losses of old and young birds separately (Table 3.3a). Examining the circumstances of losses, there was a significant difference in the percentage of young birds lost during training between regions, with a greater percentage lost in Dundee/Fife/Perth (Table 3.3c). There was no significant difference between regions in the percentage of old birds lost in training, or for the percentage of old birds or young birds lost during races or at the loft.

3.2.2.2 Losses per loft

For OB and YB individually, *mean* losses per loft comprised 26 old birds and 41 young birds, representing 53% and 60% of the old and young bird loft populations respectively at the start of the racing season (April).

The *number* of losses per loft were significantly higher for young birds than old birds during training and racing but not from the loft area (Table 3.4). Collectively, the total number of young birds lost per loft was significantly greater than the total number of old birds lost per loft. There was no significant difference between the *percentage* of young birds and old birds lost per loft either from the loft area or during training or races. Collectively, however, the percentage loss of young birds was significantly greater than for old birds. There was a significantly larger population of young birds in the loft compared to old birds at the start of the racing season (median: YB=60, OB=48; Wilcoxon Matched Pairs Test, n=27, P<0.05).

Table 3.4. Comparison between old birds and young birds in the number and percentage of losses per loft, from the loft area, during training, during races and combined losses.

	Median Number of Birds Lost per Loft				Median % Birds Lost per Loft			
	OB	**YB**	**n**	**P***	**OB**	**YB**	**n**	**P***
Loft	3	4	27	ns	3.6	5.0	27	ns
Training	5	10	27	<0.05	9.8	16.3	27	ns
Races	13	27	24	<0.05	33.6	38.4	24	ns
Total	22	41	24	<0.001	57.2	66.9	24	<0.05

* Wilcoxon Matched Pairs Test

3.2.2.3 Circumstances of losses

Examining the circumstances of losses, mean losses of all birds (OB+YB) from the loft area, during training and during races were 8 (8%), 18 (16%) and 44 (35%) birds respectively.

3.2.2.4 Total losses in Scotland

The total losses of Scottish racing pigeons averaged 67 birds per loft, representing 56% of the loft population. The mean number of birds held in the study lofts was 122 birds. The loft population in the CSL study lofts, however, is larger than for Scotland as a whole, for which 82 birds per loft is more representative (SHU data; Shawyer *et al.*, 2000).

3.2.3 Discussion

Total reported losses of racing pigeons (OB+YB) from 28 lofts across four principal regions of Scotland, during April to September 2002, averaged 67 birds per loft, or 56% of the loft population. There was, however, a marked variation in the levels of reported losses between individual lofts (13-91%). This variation, and its causes, merits further study on a larger sample size of lofts. The number of young birds lost per loft was significantly greater than the number of old birds lost during training, during races and collectively. This numeric difference in losses between age groups would be expected as a consequence of a significantly greater number of young birds compared to old birds in the loft population at the start of the season. However, the percentage of total losses per loft was also significantly greater for young birds than for old birds. A relatively greater loss of young birds is consistent with inexperienced birds having a greater susceptibility to most causes of mortality and a less developed homing instinct compared to old birds. Across the four combined regions, the only variation in percentage birds lost was in respect to young birds lost during training. Losses were greatest in Dundee/Fife/Perth (31%) and lowest in Stirling/Dunbartonshire (11%).

In a previous study, Shawyer *et al.* (2000) reported mean losses from Scottish lofts of 15 old birds and 34 young birds, representing 48%, 67% and 60% of old bird, young bird and collective loft populations respectively. The study reported an average pre-season loft population of 50 young birds and 31 old birds (n=53 lofts). There is close agreement between the current CSL study and Shawyer *et al.* (2000) in the percentage losses of racing pigeons reported lost to all causes.

The SHU's questionnaire survey of its members reported a mean total loss of 45 birds per loft during the racing season: loft 5, training 19, racing 21 (SHU 1998), but the report does not indicate the size of the mean loft population. However, using Shawyer *et al.*'s (2000) estimate of a mean 82 birds per Scottish loft, then a loss of 45 birds represents a loss of 55% of the loft population. Total losses of young birds were numerically greater than losses of old birds during training in all Federations. Relative losses of young and old birds from the loft or in races were not reported.

There are concerns over the accuracy of data on reported losses from the 31 lofts in the present study. It was necessary to exclude two lofts from the analysis because reported losses at these lofts (for OB and YB) exceeded the numbers of birds in the loft at the start of the season. For a third loft it was not clear which season's losses were being reported. Finally, at a fourth loft, two loss summary forms were returned, having been completed at different times following the end of the racing season, which recorded different numbers of young bird losses. In view of the anomalies associated with a number of lofts (13% of all trial lofts), it raises uncertainties concerning data from the other lofts. Therefore, as in previous studies attempting to quantify loft losses (and in many other studies that rely on non-scientists to provide data) there are questions about the data's accuracy.

There are a number of further limitations in the study which should be noted when considering the data on reported losses. Firstly, the sample size of 31 study lofts was small. Secondly, the study lofts were a self-selected sample (i.e. loft-owners volunteered their lofts for inclusion in the study) with 50% of the study regions chosen by SHU. As with any self-selected sample, therefore, there are concerns over its representativeness. Finally, data on reported losses provided by loft-owners was collected retrospectively at the end of the season. Accuracy may have been improved if data recording sheets had been provided at the start of the season.

3.3 SHU QUESTIONNAIRE SURVEY DATA (1996-97)

3.3.1 Methods

The SHU questionnaire survey returns were examined with the aim of analysing data to investigate differences in losses between Federations, and differences in losses between 1986 and 1996. The analysis conducted corresponds only to the data in CSL's possession and not to the data presented in the SHU report (SHU 1998). Furthermore, the nature of the data (e.g. no information on loft populations collected) limits the scope of analysis possible.

Data were available for a total of 18 Federations. However, data for three of these Federations (Ballochmyle, Central and Midland) were severely limited. Therefore, data for each of these three Federations were pooled with data for the nearest geographical neighbouring Federation. Data from neighbouring Federations were further pooled into Regions (Table 3.5).

Analysis tested for: (i) differences between Regions in the percentage of lofts reporting raptor attacks (logistic regression), (ii) differences in the numbers of birds lost during training and racing between 1986 and 1996 across individual lofts (Wilcoxon test), and (iii) differences in the magnitude of the change in these losses between Federations (Kruskall-Wallis test).

Table 3.5 Comparison of the percentage of lofts reporting raptor attacks in each Federation and in the combined Federations used in regional analysis.

Federation	**No. lofts**	**No. lofts reporting attacks**	**% lofts reporting attacks**	**Region**	**% lofts reporting attacks**	
					mean	**s.e.**
Glasgow	47	46	97.9	Region 1	97.1	0.90
Lanarkshire	204	198	97.1			
Midland	*4*	*4*	*100.0*			
Renfrewshire	37	36	97.3			
South Lanarkshire	54	52	96.3			
Highlands and Islands	24	22	91.7	Region 2	83.0	3.76
North of Scotland	76	61	80.3			
Central	*1*	*1*	*100.0*	Region 3	95.9	1.65
West Lothian	21	19	90.5			
North West	123	119	96.7			
Dundee	56	37	66.1	Region 4	86.9	1.79
East of Scotland	64	58	90.6			
Fife	164	148	90.2			
Pentlands	38	35	92.1			
Scottish Borders	36	33	91.7			
Ballochmyle	*1*	*1*	*100.0*	Region 5	96.8	1.40
Kyle and District	25	25	100.0			
Solway	130	125	96.2			
All	1105	1020	92.3		92.3	0.78

Data from Midland was pooled with Lanarkshire; Central with North West, and Ballochmyle with Kyle & District.

3.3.2 Results

There was a significant difference between the five regions in the percentage of lofts reporting attacks (X_4=11.24, $p<0.001$). A higher percentage of lofts reported attacks in central and south-west regions than in northern and east coast regions.

Across individual lofts there was no significant difference in the numbers of old birds lost during training between 1986 and 1996 (Wilcoxon Test: W=0.34, df=373, p>0.05), although at the Federation level the general trend was for a decrease in training losses between 1986 and 1996 (Table 3.6). The number of old birds lost racing increased significantly between 1986 and 1996 (W= 14.96, df=438, p<0.001).

The magnitude of the change in old birds lost between 1986 and 1996 during both training and racing varied significantly between Federations (Kruskall-Wallis: training, H=24.75, df=14, p<0.05; racing, H=27.13, df=14 p<0.05). Mean training losses decreased (range -8% to -68%) in 11 Federations and increased in four (range 4% to +54%). Mean racing losses increased in all 15 Federations by 3% to 156%.

Table 3.6. Comparison of the number of old birds lost during training and racing in the different SHU Federations between 1986 and 1996.

	OB Lost Training					OB Lost Racing				
	1986		1996			1986		1996		
Federation	**Mean**	**s.e.**	**Mean**	**s.e.**	**% Change**	**Mean**	**s.e.**	**Mean**	**s.e.**	**% Change**
Glasgow	9.1	3.2	8.4	1.0	-7.7	11.7	2.1	24.3	2.4	107.7
Lanarkshire	23.6	3.5	9.3	0.5	-60.6	11.2	0.9	24.8	1.2	121.4
Renfrewshire	28.9	9.9	9.3	1.2	-67.8	17.3	2.9	27.6	3.1	59.5
South Lanarkshire	10.0	2.9	10.4	1.1	4.0	13.4	2.0	25.3	2.3	88.8
Highlands & Islands	17.5	9.1	7.4	1.3	-57.7	18.9	4.9	19.4	3.0	2.6
North of Scotland	8.5	2.7	6.5	0.7	-23.5	13.7	2.4	22.3	2.0	62.8
West Lothian	12.4	6.1	7.5	1.4	-39.5	10.8	3.0	22.1	3.3	104.6
North West	24.8	4.6	9.3	0.6	-62.5	12.4	1.2	24.7	1.5	99.2
Dundee	9.0	3.3	5.6	0.7	-37.8	10.4	2.0	20.7	2.3	99.0
East of Scotland	13.0	3.6	7.1	0.7	-45.4	13.0	1.8	19.4	1.7	49.2
Fife	13.7	2.4	7.2	0.5	-47.4	13.2	1.3	20.4	1.2	54.5
Pentlands	8.1	2.7	10.4	1.3	28.4	8.9	1.7	22.8	2.5	156.2
Scottish Borders	6.1	2.4	9.4	1.3	54.1	12.5	2.6	21.4	2.5	71.2
Kyle and District	7.3	3.4	8.9	1.4	21.9	14.2	3.7	20.2	3.1	42.3
Solway	13.4	2.5	10.0	0.7	-25.4	11.1	1.1	21.0	1.3	89.2

3.3.3 Discussion

Although the number of old birds lost racing increased significantly between 1986 and 1996, there was no significant increase in the numbers of old birds lost during training between these years. Why this should be the case is unclear. However, it should be noted that some extremely high losses were reported by some fanciers for training losses in 1986 (100 or more birds for training losses alone in a number of cases), but not 1996, which have influenced the data. Whilst it is possible that these data are incorrect, we were not able to exclude them from the analysis without firm evidence that this was indeed the case.

3.4 HISTORICAL RACE DIARIES

3.4.1 Methods

A series of annual race diaries were provided by a number of SHU members that were examined by CSL to investigate losses at individual lofts over a number of years. It was possible to extract data from diaries belonging to three loft-owners, one each in Ayrshire, Glasgow and Lanarkshire.

3.4.2 Results

The three loft-owners' diaries provided data from a different series of years: Ayrshire 1981-1993, Lanarkshire 1994-2002 and Glasgow 1980-2002. The data from the

Glasgow loft, which spanned the greatest time period, was discontinuous with data missing for five individual years within that period (1985, 1989-1991 and 1999). Data were examined for any pattern in losses over the respective periods. Data were expressed as the total percentage of race-flights lost annually (Figure 3.3), and the total percentage of races in which birds were lost annually (Figure 3.4). At the Lanarkshire loft for example, in 1994 pigeons took part in a total of 318 race-flights (1 race-flight = 1 bird flown in 1 race) in which 50 birds (representing 15.7% of total race-flights) were lost. Also, pigeons took part in a total of 16 races with one or more bird being lost from each race (i.e. 100% races with losses).

The general trends at these lofts seem to show a marked reduction in losses at the Ayrshire loft in late 1980s and early 1990s, a gradual reduction in losses at the Lanarkshire loft over the 1990s and early 2000s, but in contrast a marked increase in losses in the 1990s and early 2000s at the Glasgow loft.

Losses presented in the graphs are not directly comparable with data on reported losses from the 31 lofts presented in section 3.2. The race diaries do not report the total loft population at the start of each race season. Losses, therefore, are related to the total annual race-flights rather than the loft population, as is the case for the 31 study lofts. However, a comparison can be made in terms of the actual number of birds lost. The total mean number of birds lost annually at each of the three lofts were: Ayrshire 27 (range 10-69), Lanarkshire 49 (range 33-64), Glasgow 6 (range 0-16). For 2002 only, the total annual losses were 42 birds and 8 birds for the Lanarkshire and Glasgow loft respectively. In comparison, total race losses for the 31 study lofts averaged 44 birds (range 9-90).

3.4.3 Discussion

A series of race diaries belonging to loft-owners were examined for patterns in the losses of racing pigeons over an extended period of years. The intention was to closely analyse this data and attempt to correlate it to other factors including changes in the national and regional peregrine populations. However, data of a suitable quality was extractable from the diaries of only three loft owners. Each of the lofts was located in a different region and the data covered different time periods. For these reasons, proper analysis and comparison were impossible due to the limited quality and quantity of the data. Apart from its historical significance to the respective loft-owners, the data does not contribute towards an understanding of patterns in the losses amongst the wider racing pigeon fraternity.

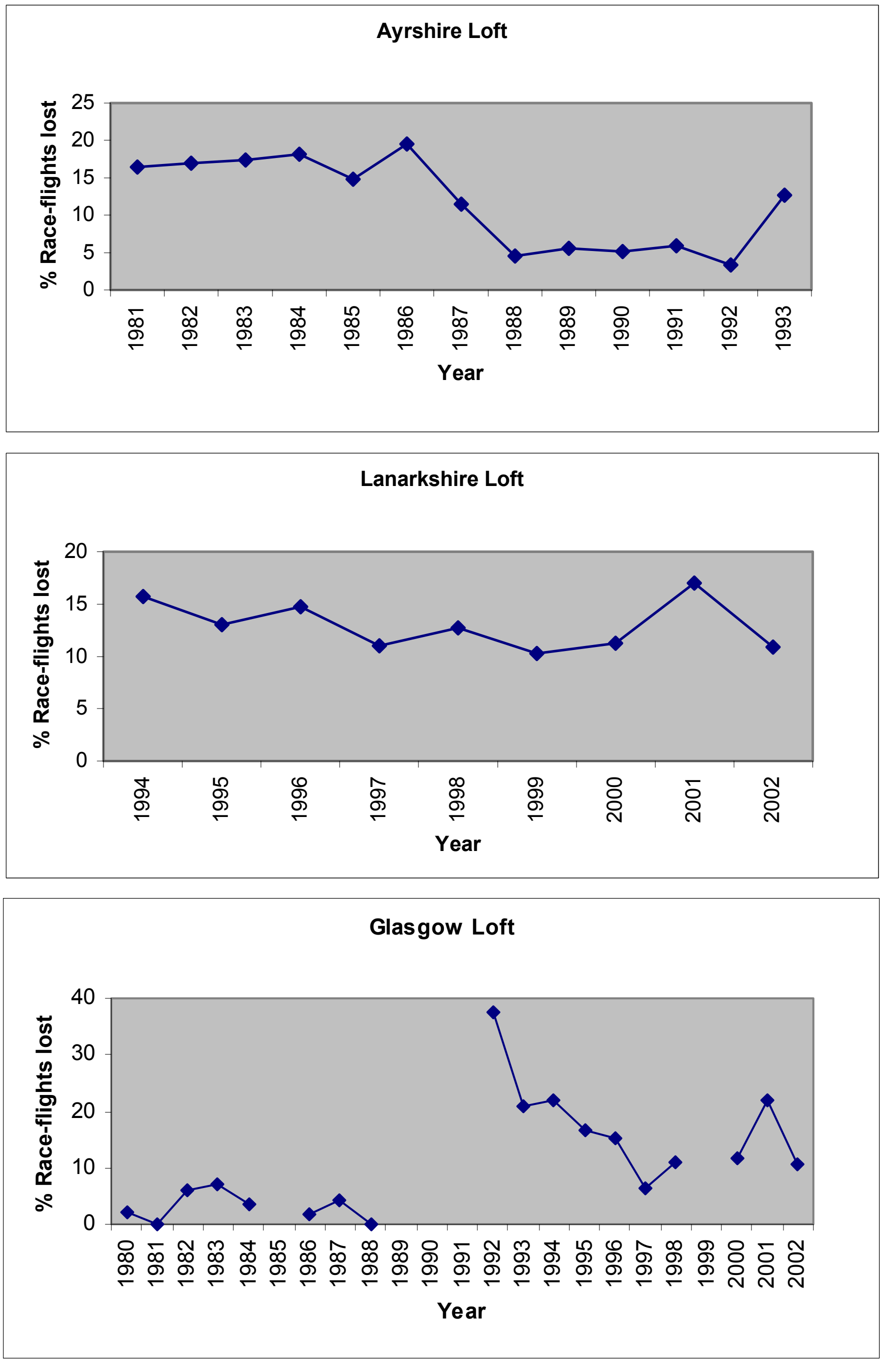

Figure 3.3 Historical losses of pigeons during races experienced by three Scottish lofts. Values represent the annual percentage of total race-flights lost (1 race-flight = 1 bird flown in 1 race). For the Glasgow loft there was no data for the years 1985, 1989-1991 and 1999.

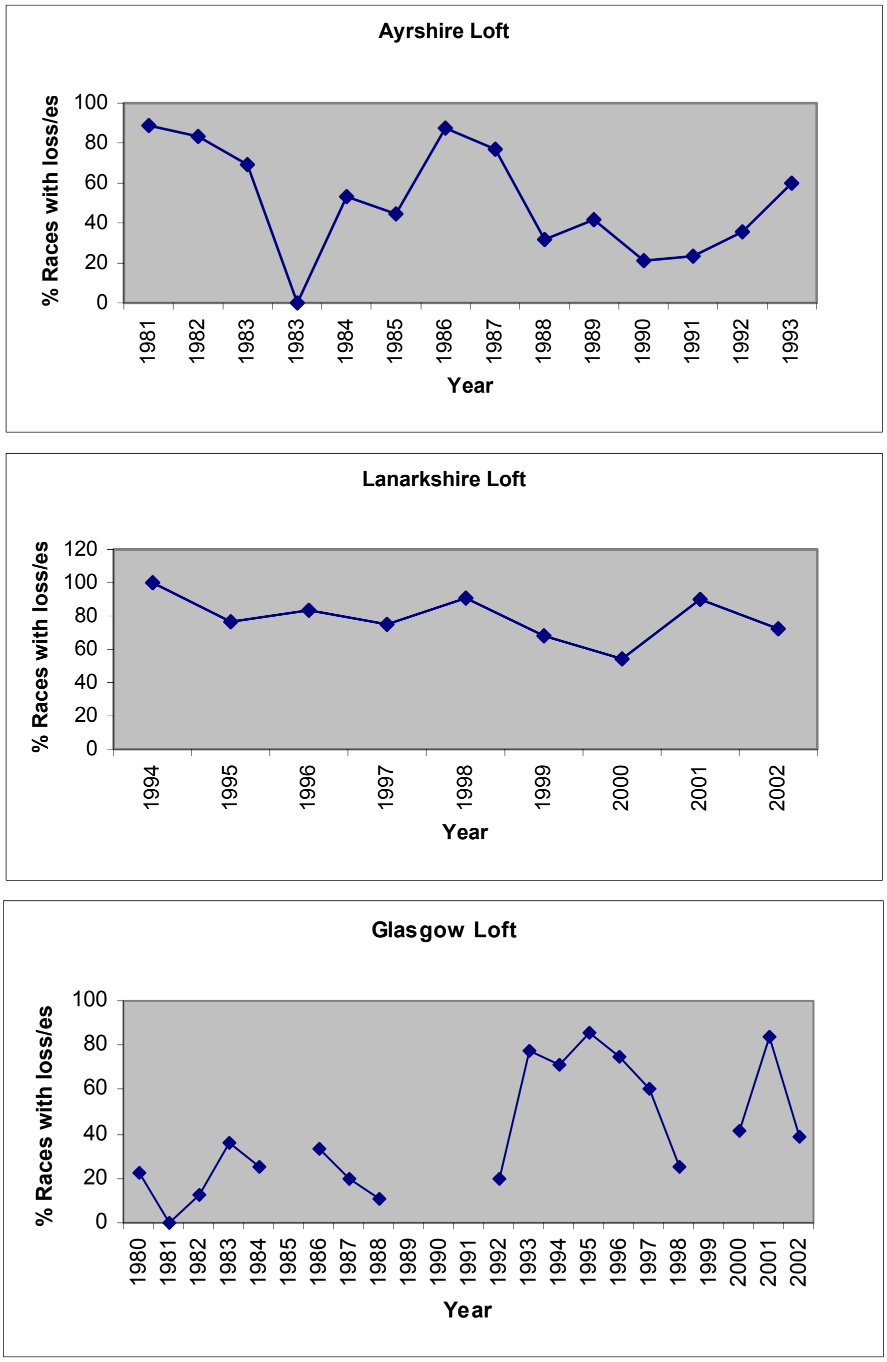

Figure 3.4. Historical losses of pigeons during races experienced by three Scottish lofts. Values represent the annual percentage of total races in which one or more birds were lost. For the Glasgow loft there was no data for the years 1985, 1989-1991 and 1999.

4. REPORTED LOSSES TO SPARROWHAWKS

4.1 METHODS

4.1.1 Reported Losses

Volunteer loft-owners agreed to co-operate in searching for pigeon corpses in the event of any birds going missing from around the loft rather than from races or training flights (data supplied from 32 lofts). A pro-forma and instruction sheet were supplied for information regarding when the bird was last seen, the state of any corpse found, its location when found etc. The corpse and the form were then to be returned to CSL for analysis. The forms and instructions were given to all volunteers for completion and CSL staff maintained regular contact with each volunteer to discuss the numbers of birds being lost to sparrowhawks during the twelve months of the study. It was stressed throughout the year that the searches for missing birds would have to be comprehensive. Loft-owners were also asked to report any losses at the loft that they considered were due to sparrowhawks, or to other raptors. Each loft was studied for one year, between 2002 and 2003, the study start and end dates for individual lofts being dependent on when arrangements for inclusion of a loft in the study was completed. Study start dates all fell in the period April to June 2002.

It should be noted that part of the original plan was to ask loft-owners to also search for corpses placed by CSL as well as for any of their own birds which might have been taken by a sparrowhawk. This was intended to assess the effectiveness of the searches being undertaken but was not carried out for two reasons. The first is the low levels of losses reported, and the second is that many lofts are in urban or suburban areas and searches for remains would have to be carried out in neighbours' gardens. In many cases neighbours may report finding a dead pigeon to the loft owner if the loft is nearby, but the loft-owner is unlikely to approach the owners of all nearby houses to ask permission to search for a lost bird, or for that matter, for a corpse placed by CSL.

Following the end of the study, volunteer loft-owners were contacted by phone. Owners were asked whether all losses, searches and carcasses had in fact been recorded and reported to CSL. Fanciers were also asked, whether in their opinion, sparrowhawk activity around their loft during the twelve months of the study had been lower, similar or greater than in previous years.

4.1.2 Effect of Habitat on Sparrowhawk Predation

Using GIS software, lofts were plotted and the distance between each loft and the nearest woodland in excess of 1ha was measured. In addition, the land cover as described in Landcover 2000 Dataset (CEH) was determined within a circle of radius 1km around each loft. The area of woodland (broad-leaved, mixed and coniferous) and urban (urban/sub-urban) land cover types were calculated. Comparisons were made between lofts at which sparrowhawk kills had been recorded and lofts at which no kills had been recorded with respect to: (i) distance to the nearest woodland, (ii) percentage cover of mature woodland, (iii) percentage cover of all woodland, and (iv) percentage cover of urban/sub-urban habitat.

4.2 RESULTS

4.2.1 Reported Losses

Reported losses of racing pigeons to sparrowhawks were allocated to one of three categories dependent on the level of evidence collected which gave support to the loss being in fact due to sparrowhawk predation. Only five losses were followed by recovery of a carcass and its return to CSL. Examination of these carcasses confirmed diagnostic features consistent with sparrowhawk predation (substantiated losses). A further 10 incidents were reported where a carcass was recovered following a loss. In most of these cases the reason given for not passing on the carcass was that the loft-owner ‘forgot’. In a further 63 incidents of reported losses to all causes, 14 losses were ‘believed’ by the loft owner to have been due to sparrowhawks but no substantiating evidence was provided (possible losses). Also, among these 63 incidents, seven losses were believed to be due to raptors other than sparrowhawks - six peregrine and one goshawk. Data on categories of losses at all lofts are summarised in Table 4.1 and illustrated in Figure 4.1. However, the possibility cannot be excluded that some of the ‘possible’ losses were not caused by sparrowhawks, or that some losses attributed to other causes were in fact the result of sparrowhawk attack.

Considering all substantiated, probable and possible losses the number of reported losses from the loft area attributed to sparrowhawks was 29, representing an average of 0.91 birds per loft (Table 4.2). There was variation in attributed sparrowhawk losses between the four principal regions of Scotland, ranging from 0.2 birds per loft in Ayrshire to 1.4 birds per loft in Dunbartonshire/Stirling. Considering only the 15 lofts which reported losses, the mean loss per loft was 1.9 racing pigeons (range 1 to 4 birds per loft – all categories).

At the level of the individual loft, reported losses (all three categories pooled) ranged from zero to four birds (Figure 4.2). Nearly half of the sampled lofts (47%, n=15) reported losses to sparrowhawks. These losses were regarded as substantiated at 5 lofts (16% of all lofts), probable at a further 6 lofts and possible at 4 more. Seven lofts recorded losses of single birds whilst eight reported multiple losses of two to four birds. Considering only substantiated losses, single losses only were reported from each of the five relevant lofts. For substantiated plus probable losses, reported losses ranged from one to three for the 11 relevant lofts.

Losses to sparrowhawks were considered in relation to the total reported losses to all causes from the loft area (Table 4.3). For individual lofts, substantiated sparrowhawk losses (5 lofts) represented a median of 20% of total losses to all causes from the loft area: range 7% (1/14) to 100% (1/1); substantiated plus probable losses (10 lofts): median of 14%, range 4% (1/28) to 100% (1/1); substantiated plus probable plus possible losses (15 lofts): median of 20%, range 2% (2/91) to 100% (1/1). Two lofts (Fife 8 and Stirling 5) each reported a single probable loss to a sparrowhawk during the 12 month study period but reported no losses from the loft area to other causes during the associated six month racing season.

Table 4.1. Summary of reported losses to sparrowhawks at all lofts.

Region	**Loft**	**Loft Pop.**	**System**	**Deterrent**	**Number Carcasses Returned**	**Number Carcasses NOT returned**	**Searches but NO carcasses Found***	**Month of loss**	**Loft-owners comments on searches where no carcasses were found**
Ayrshire	1	138	Natural and Widowhood	None	0	0	0		
Ayrshire	2	88	Natural	None	**1**	0	5	Jan-April	Could have been pylons
Ayrshire	3	70	Natural	Terror eyes	0	0	0		
Ayrshire	4	63	Natural	CDs	0	0	3	June/July	YBs lost training at loft. Pylons?
Ayrshire	5	100	-	-	0	0	0		
Dumfriesshire	1	142	Natural	None	0	0	12	April	Witnessed goshawk attack.
Dumfriesshire	2	68	Natural	None	0	**1**	0		
Dumfriesshire	3	119	OB Natural, YB Roundabout	None	0	0	Some YBs	May	
Dumfriesshire	4	150	Natural	None	0	0	0		
Dumfriesshire	5	99	Widowhood	None	0	0	0		
Dumfriesshire	6	146	Roundabout	None	0	0	**2**	Sept.	
Dumfriesshire	7	180	Widowhood	CDs	**1**	0	0		
Dumfriesshire	8	80	Natural	None	0	0	0		
Dumfriesshire	9	77	Roundabout	None	0	0	6		No search - "Flyaways"
Dundee	1	86	Widowhood	CDs	0	0	8		Could have been pylons
Dundee	2	220	Widowhood	None	0	0	**3**		One OB, two YB
Fife	3	76	-	-	0	0	**1**		
Fife	4	185	Natural	2 Owls & Terror eyes	**1**	0	**2**	April/May	
Fife	5	132	Natural and Darkness for YBs	Owl	0	0	0		
Fife	6	100	-	-	0	0	0		
Fife	7	108	Natural	Owl	0	**1**	**2**		YB lost
Fife	8	79	Natural	None	0	**1**	0		
Fife	-	?	Natural	Owls and scarecrow	0	0	4		Believed crows and peregrines responsible
Perth	9	217	Natural	Owl decoy	**1**	**1**	0		
Dunbartonshire	1	74	Natural	None	0	0	0		
Dunbartonshire	2	184	Natural	Owl and CDs	0	**1**	2	Jan/Feb	Assumed peregrine responsible
Stirling	3	136	Natural	None	0	0	Yes		Assumed peregrine responsible
Stirling	4	142	Natural	CDs	**1**	**2**	1	August	YB lost. Assumed peregrine responsible
Stirling	5	196	Roundabout	CDs	0	**1**	Yes		Assumed peregrine responsible
Stirling	6	110	Natural	None	0	0	7-8		Assumed peregrine responsible
Stirling	7	130	Natural	None	0	0	**4**		Believed sparrowhawks responsible
Stirling	8	110	Natural	Owl	0	**2**	0	March/April	
TOTAL	32	3805			**5**	**10**	**14** + 49		

* Figures in bold indicate that the loft-owner perceived the loss to be due to a sparrowhawk; figures in normal type indicate that the loft-owner believed the loss was due to an alternative cause.

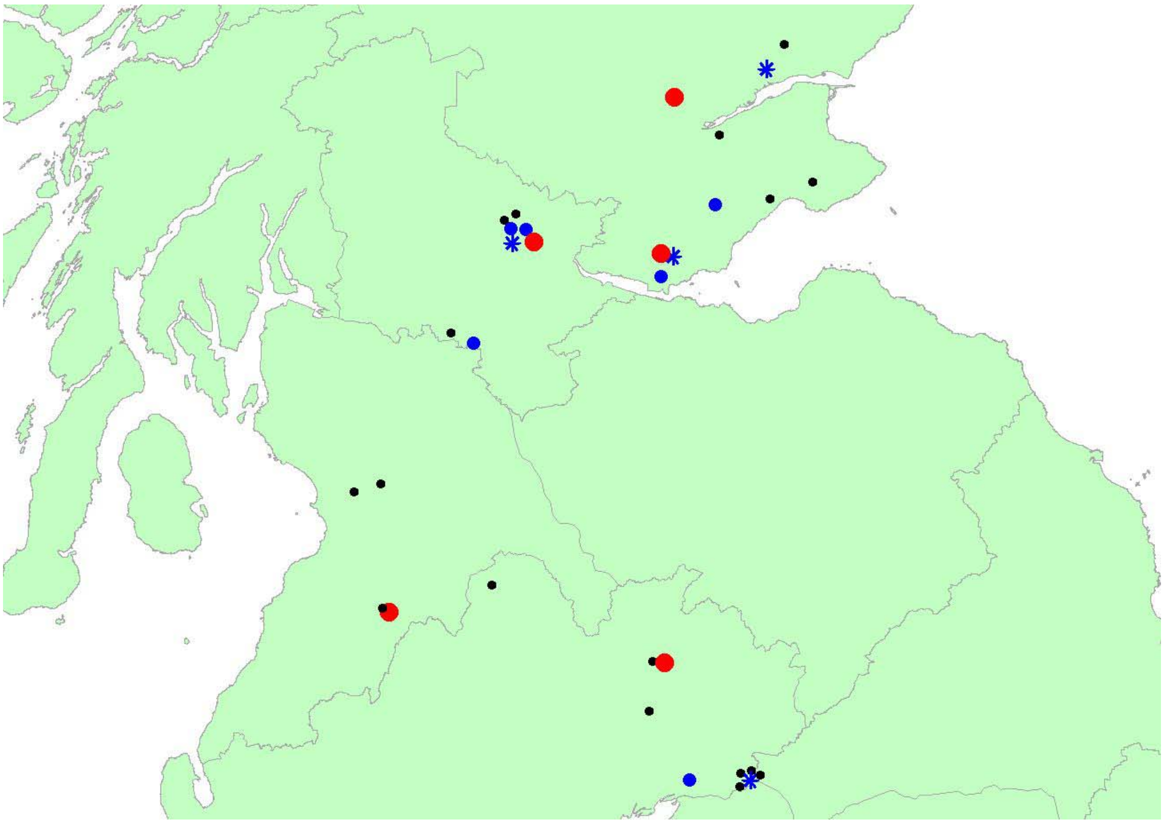

Figure 4.1. Summary of reported losses to sparrowhawks. Losses were categorised according to the level of evidence collected.

● substantiated loss **● probable loss** **✱possible loss** **• no loss**

Table 4.2. Comparison of reported losses to sparrowhawks between four principal regions of Scotland. Losses were categorised as substantiated, probable and possible, dependent on the level of supporting evidence.

	Lofts		Reported Losses to Sparrowhawks				
Region	**No. in region**	**No. reporting losses**	**Substantiated**	**Probable**	**Possible**	**Total**	**Mean birds per loft**
Ayrshire	5	1	1	0	0	1	0.20
Dumfriesshire	9	3	1	1	2	4	0.44
Dundee/Fife/Perth	10	6	2	3	8	13	1.30
Dunbartonshire/Stirling	8	5	1	6	4	11	1.38
TOTAL	32	15	5	10	14	29	

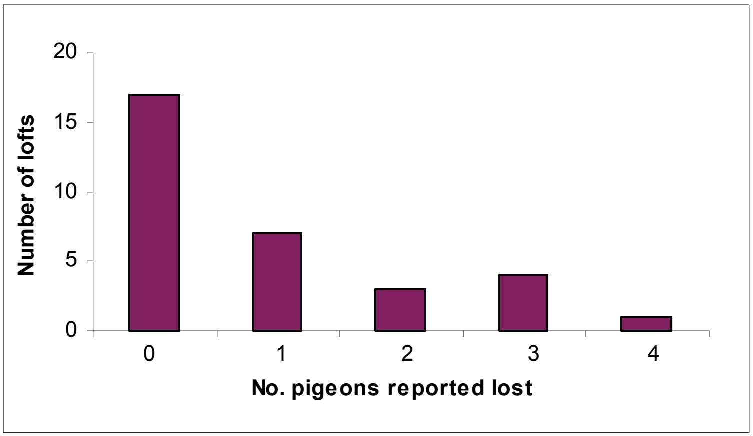

Figure 4.2. Frequency of reported losses (substantiated, probable and possible losses pooled) to sparrowhawks amongst the 32 study lofts.

Table 4.3. Comparison of reported losses to sparrowhawks (Sub. = substantiated, Prob. = probable, Poss. = possible) and reported losses from the loft area to all causes.

				Reported Losses to Sparrowhawks **					
				No. Pigeons Lost			As % of Total Losses		
Region	**Loft no.**	**Loft pop.**	**Total birds lost ***	**Sub.**	**Prob.**	**Poss.**	**Sub.**	**Sub. + Prob.**	**Sub. + Prob. + Poss.**
Ayrshire	2	88	5	1	0	0	20	20	20
Dumfriesshire	2	68	10	0	1	0	0	10	10
Dumfriesshire	6	146	91	0	0	2	0	0	2
Dumfriesshire	7	180	1	1	0	0	100	100	100
Dundee	2	220	9	0	0	3	0	0	33
Fife	3	76	9	0	0	1	0	0	11
Fife	4	185	7	1	0	2	14	14	43
Fife	7	108	28	0	1	2	0	4	11
Fife	8	79	0	0	1	0	0	?	?
Perth	9	217	14	1	1	0	7	14	14
Dunbartonshire	2	184	9	0	1	0	0	11	11
Stirling	4	142	4	1	2	0	25	75	75
Stirling	5	196	0	0	1	0	0	?	?
Stirling	7	130	7	0	0	4	0	0	57
Stirling	8	110	9	0	2	0	0	22	22
Median							20	14	20

* Total reported losses from the loft area to all causes during the 2002 race season (from Table 3.2).

** Total reported losses to sparrowhawks during a 12 month period which encompassed the 2002 race season.

Of the 32 lofts, 13 loft-owners reported using some form of raptor deterrent and five of these did not report any loss to sparrowhawks. Eight of the 11 lofts with substantiated and probable losses used deterrents. Four of the five lofts with substantiated losses used deterrents.

4.2.2 Effect of Habitat

Comparisons between habitat variables were made between: (i) lofts which reported substantiated losses (5 lofts) and all other lofts (27 lofts), (ii) lofts which reported substantiated losses + probable losses (11 lofts) and lofts which reported no losses + possible losses (21 lofts), and (iii) lofts which reported substantiated losses + probable losses + possible losses (15 lofts) and lofts that reported no losses (17 lofts) (Table 4.4).

Table 4.4 Comparison of median habitat variables between lofts which were subjected to sparrowhawk kills and lofts without kills.

	Median Value of Habitat Variable			
	Dist. to nearest woodland (m)	**% Mature woodland**	**% All woodland**	**% Urban/sub-urban**
(I) SUBSTANTIATED				
Lofts with Kills	105	10.3	11.4	10.8
Lofts without Kills	234	4.8	4.8	21.3
$U_{5,27}$	42.5	34.0	28.0	52.0
P	NS	NS	<0.05	NS
(II) PROBABLE				
Lofts with Kills	206	9.7	10.3	21.7
Lofts without Kills	234	3.6	4.0	18.4
$U_{11,21}$	102.5	56.5	50.0	104.5
P	NS	<0.05	<0.01	NS
(III) POSSIBLE				
Lofts with Kills	206	6.6	9.4	21.7
Lofts without Kills	234	3.6	4.0	14.8
$U_{15,17}$	124.5	89.5	87.0	97.5
P	NS	NS	NS	NS

U =MannWhitney U-Test

Lofts with substantiated kills were surrounded by a significantly greater percentage cover of woodland than lofts at which no substantiated kills occurred. Lofts with substantiated and/or probable kills were surrounded by a significantly greater percentage cover of both general woodland and mature woodland than lofts with possible kills or no kills. However, when possible kills were pooled with substantiated and probable kills there was no significant difference in surrounding habitat compared to lofts without kills.

4.2.3 Loft-owners Perceptions

Twenty-nine of the 32 loft-owners were successfully contacted again following the end of the study. Of these, 83% stated that sparrowhawk activity during the study was similar or greater than in previous years, 10% that activity was less and 7% had no opinion.

4.3 DISCUSSION

The total annual losses of racing pigeons attributed to sparrowhawks by loft-owners from 32 lofts, distributed between four principal study regions in Scotland, was 29 birds, a mean of 0.91 birds per loft. Of the 32 study lofts, 15 lofts (47%) reported losses to sparrowhawks (all categories), a mean of 1.9 birds per loft. For individual lofts, losses ranged from 0-4 birds. Considering only the five substantiated losses there was a loss of 0.2 birds per loft. These estimates are below or fall towards the lower end of the range of losses found in previous studies: 3.5 birds per loft in South Wales (Dixon 2002: although this estimate was derived only from lofts that had previously reported hawk attacks), 2.3 birds per loft (range 0.2-5.2) for 14 regions throughout Britain and Ireland (RPRA), and 2.7 birds per loft (range 1.2-4.6) throughout the UK (Shawyer *et al.* 2000). For Scotland, Shawyer *et al.* (2000) estimated 3.5 birds per loft. The SHU (1998) reported a mean loss of 5 birds per loft, across Federations, as a result of raptor attacks in the loft area. The SHU figure however, does not differentiate between losses to sparrowhawks and other raptors. There is some agreement between these various studies in the level of overall losses of racing pigeons to sparrowhawks. The current study was designed to improve on previous estimates by incorporating a standard objective methodology for recording and investigating losses in order to substantiate the involvement of sparrowhawks. Previous studies have relied *solely* on loft-owners' potentially subjective assessments of the cause of losses, without any independent validation process, unlike the present study. The CSL study, therefore, includes an absolute minimum measure (substantiated) in addition to a reported measure (substantiated plus probable plus possible).

Nationally, these levels of losses are relatively low, representing <1% (this study) to 4.3% (Shawyer *et al.* 2000) of the loft population in Scotland, and 3.7% of the UK loft population (Shawyer *et al.* 2000). Losses to sparrowhawks, however, are not spread evenly between regions. Shawyer *et al.* (2000) reported that the percentage of lofts reporting attacks varied across the UK, from 42% in Central and Southern England to 87% in Northern Ireland, with losses of 1.2 to 4.6 birds per loft respectively. In Scotland, the percentage of lofts reporting attacks varied between Federations - range 57% to 100% (SHU 1998). In the current study, of the four principal study regions in Scotland, the percentage of lofts reporting attacks was greatest in Stirling/Dunbartonshire (63%) and Dundee/Fife/Perth (60%) compared to Dumfriesshire (33%) and Ayrshire (20%).

The frequency of sparrowhawk attacks can also vary as greatly within a region as between regions (Dixon 2002). In South Wales, attack rates at individual lofts were related to the surrounding habitat. Attacks were more frequent at lofts located near blocks of mature woodland or forestry compared to lofts situated in non-wooded, urban areas. In the current study, there was also an association between sparrowhawk attack and habitat. Lofts with substantiated kills were surrounded by a significantly greater percentage cover of woodland than lofts at which no substantiated kills occurred. This relationship also held when lofts with probable kills were pooled with those with substantiated kills. When lofts with possible kills were also pooled with substantiated and probable kills however, there was no significant difference in habitat variables in comparison to lofts at which no kills occurred. From this it is reasonable to conclude that at least some of the possible kills (i.e. those that relied solely on the judgement of loft-owners) were not necessarily due to sparrowhawk predation.

At the level of the individual loft, reported losses to sparrowhawks (substantiated plus probable plus possible) ranged from 0 to 4 birds over the 12 months of study. For the 15 lofts which reported sparrowhawk predation losses ranged from 1 to 4 birds. The impact of sparrowhawk predation at these lofts can be examined by comparing the reported numbers lost to sparrowhawk predation with the total reported numbers lost from the loft area to all causes (see Table 3.2). The contribution of sparrowhawk predation to the total losses from the loft area to all causes ranged from 0% to 100% (median 20%) for substantiated losses, and from 2% to 100% (median 20%) for substantiated, probable and possible losses pooled. Considering substantiated and probable losses, sparrowhawk predation was the major contributory factor to overall losses from the loft area at two of the 15 lofts, representing 3 losses to sparrowhawks from an overall reported loss of 4 birds and 1 loss to a sparrowhawk from an overall reported loss of 1 bird, respectively.

Clearly, sparrowhawks are a concern for some individual loft-owners, rather than being a regional or national problem. As the study was designed to assess overall losses at the national level however, specific problems at individual lofts have not been identified. For example, the relative impact of sparrowhawk kills may vary between lofts with respect to both the overall quantity of birds killed and the quality of specific birds killed (e.g. champion birds may be killed). Further, as the study addressed only the specific issue of the number of birds killed by sparrowhawks, the potential impact of unsuccessful attacks (e.g. the potential scattering of young birds) has not been evaluated. However, irrespective of the specific problems at individual lofts, as sparrowhawk attacks are a concern for individual loft-owners rather than a regional or national problem, mitigation measures should be directed at the level of the loft rather than at a regional or national scale (Dixon 2002).

The UK Raptor Working Group Report (2000) recommended field trials of deterrents to determine their efficacy in reducing sparrowhawk predation at lofts. Subsequently, limited field trials of selected deterrents (recommended in the UK Raptor Working Group Report 2000) were carried out by Lancaster University (Dixon 2002), the results of which were interpreted as providing no evidence for deterrent effectiveness. These results appeared to support the conclusions of a questionnaire survey of SHU members that loft-based deterrents are ineffective (SHU 1998). However, the contention that loft-based deterrents are ineffective is premature. First, the field trials conducted by Lancaster University (Dixon 2002) were designed only to evaluate whether deterrent use resulted in complete cessation of attacks and not whether attack rates were reduced. Furthermore, the field trials tested only replica owls and eyespot balloons. Alternative deterrent devices and integrated management measures remain to be tested (see section 6 Review of Deterrents).

5. LOSSES TO PEREGRINES AWAY FROM LOFTS

5.1 LOSSES TO PEREGRINES AT LIBERATION POINTS

5.1.1 Methods

As part of the study, CSL was asked to attend training and race releases and to check on any raptor activity. A total of sixteen releases (thirteen races and three training flights) were attended at a range of locations including Arniston (Midlothian) Huntingdon (Cambridgeshire), Appleby (Cumbria), Wooler and Hexham (both Northumberland), Kelso, Soutra Hill (Midlothian) and Fraserburgh. The sixteen releases involved approximately 25,000 birds in total (approximate range for training flights, 9-200 birds; approximate range for races 350-5,500 birds). On five other occasions CSL staff were present at planned releases but these were postponed or cancelled due to weather conditions. A pro-forma was used to record information such as date and time of release, weather conditions at the release point, wind direction, the direction of pigeons following release and whether any raptors were observed.

5.1.2 Results

One peregrine attack was observed by CSL staff at a training/exercise flight of nine pigeons in Largs (North Ayrshire). No scattering of the flock was noted due to the attack, although seven of the pigeons arrived back at the loft soon after the attack in a panicked state, with one returning later the same day, and one the following day.

Two buzzards were seen floating on thermals near the release of 1,200 pigeons at Cupar Angus and one kestrel was observed at the release of 5,500 birds at Coldstream. On neither of these occasions did the raptors attempt to attack the pigeons, and their presence did not seem to affect the behaviour of the pigeons.

5.1.3 Discussion

Only one example of raptor activity affecting pigeons was observed, this being close to a loft in Ayrshire with a peregrine eyrie nearby. This involved only a small number of pigeons on an exercise flight and caused no significant problems, although one pigeon did not return to the loft until the following day. That no other raptor activity was observed is perhaps not surprising. Most of the release points used for training and race releases are not in close proximity to peregrine eyries, with most being on the edge of towns in southern Scotland and England. It must be assumed that any evidence of regular raptor activity at a release point would be noted by the persons responsible for the release of the birds and that the race convoyers would be informed and the release point changed.

5.2 RECOVERY OF RINGS FROM NESTING SITES

5.2.1 Methods

Introduction

During the breeding season, pigeon remains are concentrated in the nesting area. The nesting area encompasses the actual eyrie and the surrounding area routinely used by breeding birds for plucking and eating their prey, and for perching and roosting. The size of the nesting area may vary according to its characteristics (for example depending on whether the eyrie is in a small isolated quarry or in an extensive range of natural cliffs) and also as a result of differences in behaviour between particular pairs of peregrines.

Racing pigeon rings can be eaten by peregrines and many rings recovered from nesting areas are deposited in pellets. Pellets can be regurgitated anywhere, both within and without the nesting area. Obviously, any rings deposited in pellets outside the nesting area will not be recovered during a search of the nesting area alone. The number of rings deposited in the nesting area is determined by (a) the number of racing pigeons killed, (b) whether the site is occupied by a single bird or a pair, (c) whether an attempt to breed is made at the site, and (d) the degree of breeding success.

The recovery rate of rings resulting from searches also varies according to a number of factors, principally (a) the search effort, (b) the extent of the nesting area, (c) the topography of the nesting area, and (d) the type of vegetation cover in the nesting area.

Information on peregrine eyrie locations was collected from a number of sources (Table 5.1) with the intention of minimising any bias in the sample. There was a significant delay in obtaining information from the Scottish Raptor Study Groups, which meant that many of the sites could not be visited until the autumn and winter.

Table 5.1. Sources of information on eyrie locations

Source of information	Proportion of total sample
Scottish Raptor Study Groups	35.6%
Scottish Homing Union consultant	22.0%
Central Science Laboratory staff	16.9%
Pigeon fanciers	11.9%
Gamekeepers	8.5%
Others	5.1%

Preliminary searches of nesting areas began in July 2002 but all sites searched in July or August were also visited in September 2002. All sites were subject to at least one visit after the end of the racing season with one exception, where the final visit was made three days before the end of the season. All initial searches were completed by February 2003. Most of the eyries searched were in the border counties of Dumfries and Galloway, Borders, Northumberland and Cumbria (Figure 5.1, Table 5.2). The great majority of Scottish pigeons are either released in these counties or have to fly through them on their way back to the home loft. A limited number of nesting areas were searched in other counties. These were either close to the end of race routes or concentrations of lofts (Ayrshire, East Lothian and some in Stirling) or were north of the main concentrations of lofts (Perth and Kinross and one site in Stirling). Nesting areas in the latter category were searched to obtain information on the numbers of pigeons which might be overshooting their home loft. The nature of the nest sites inspected is summarised in Table 5.3.

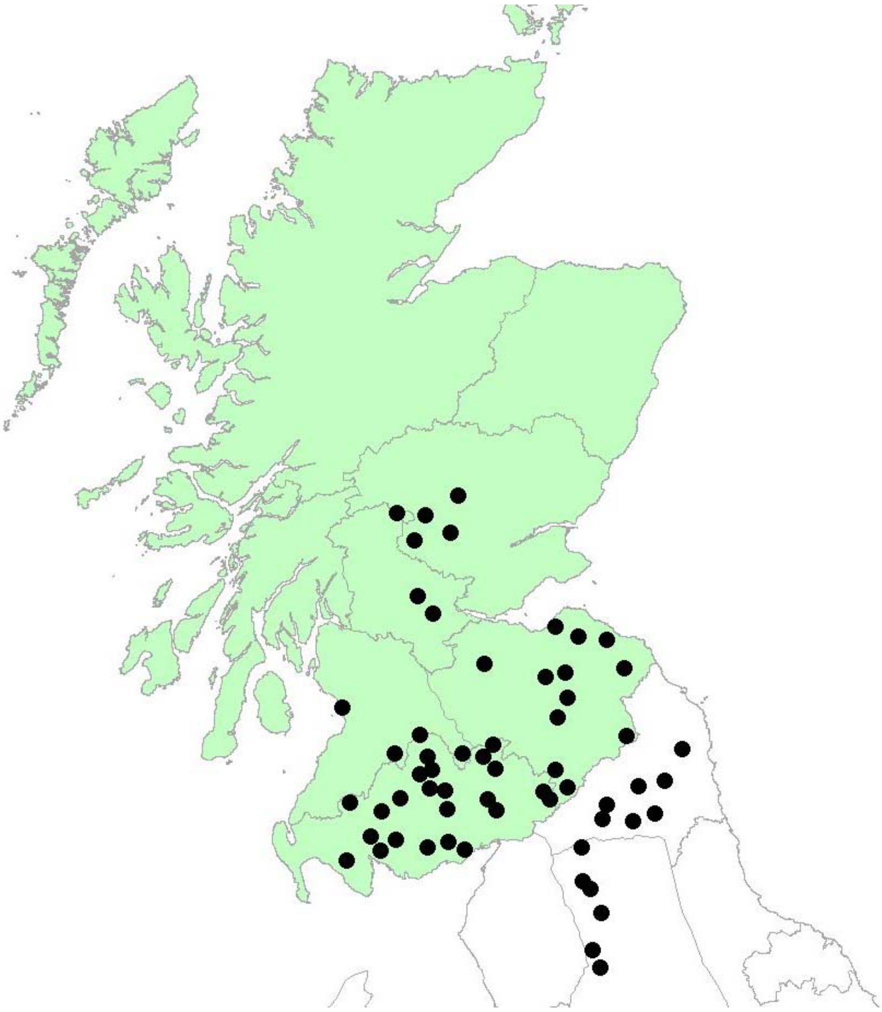

Figure 5.1. Regional distribution of peregrine eyries searched. For reasons of confidentiality the plots are illustrative only and do not correspond with precise locations of actual eyries.

Table 5.2. Regional distribution of the eyries searched

Region	No. Known Eyries* Total	Inland	No. Eyries Searched Number Searched	% Total Searched	% Inland Searched
Dumfries & Galloway	74	49	23	31.1	66.2
Lothian & Borders	36	27	14	38.9	51.9
S. Strathclyde	27	18	2	7.4	11.1
Central	28	28	3	10.7	10.7
Tayside	71	67	4	5.6	6.0
Cheviots	21	21	6	28.6	28.6
NW England - inland	62	61	1	1.6	1.6
Pennines	73	73	6	8.2	8.2
TOTAL	392	344	59	15.1	17.2

* data from 2002 National Peregrine Survey

Table 5.3. Details of type of eyrie locations inspected

Eyrie location	No. sites
Natural sites	39
Disused quarries	9
Working quarries	8
Buildings/man-made structures	3
TOTAL	59

Once the grid references of eyries had been obtained and, in most cases, the landowner approached for consent, each site was subject to a visit. In 83% of cases two CSL staff or one CSL staff member accompanied by a mountaineer undertook the visits. In most cases the mountaineers attended sites at random but in some cases where the ground search had revealed significant numbers of rings, a second visit was made with the mountaineer to search the nest ledge as well. In one case two visits were made with one mountaineer on the first occasion and two on the second to ensure that the search was comprehensive. The length of time spent searching for rings varied between approximately one staff-hour and eighteen staff-hours depending on the nature of the terrain being searched, the numbers of rings being found, and the ease of access to the nest ledge. Searches ceased when all relevant areas had been searched fully, and, in the case of buried rings, when searches of areas already examined using a metal detector did not find any additional rings. All visits were completed in a time when it was felt no further rings could be discovered. The exact location of the eyrie nest ledge was confirmed by a number of means including the presence of faecal stains on the crag, the presence of suitable ledges, flushes of vegetation resulting from the addition of nutrients associated with droppings, and the presence of pigeon rings below the nest ledge. In addition to the location of the nest ledge, other points on the surrounding crags were identified as plucking points, perches or roosts based on faecal staining of rocks and the presence of pellets, prey remains and pigeon rings.

Ring recovery

Once these points had been identified, searches for rings took place at the base of the crag, both below the nest site and below plucking points. Plucking points at the top of crags were also examined unless it was unsafe to do so. Of the 59 eyries visited, professional climbers were used to abseil or climb into the nest ledge of 25. In a further four cases the nest ledge was accessed by CSL staff without the need for specialist equipment. Health and safety concerns and logistical problems meant that it was not possible to gain access to all of the nest ledges.

Pigeon rings were found either by visual inspection or by use of a metal detector, and were placed in plastic bags marked with the date of the visit and the location of the eyrie. The metal detectors were used to find buried rings in most cases, which were dug out with a garden trowel, and staff were instructed to completely search specific areas methodically using the detector before beginning a search of a new area.

Staff collected all pellets that were located and all pellets found were scanned with the metal detector to determine whether or not a ring was concealed inside. Searches continued until all accessible areas had been surveyed or, in the case of areas searched by detector, until no more responses were obtained. At some sites where the rocks were of igneous origin, including many of the quarry sites, the metal detectors reacted to the presence of minerals in the rocks and could not be used to search for rings. At such sites, visual inspections only were feasible.

Additional items of interest including pigeon feet and any pigeon feathers stamped with contact details of the owner were also collected. However, relatively few of the latter were found, most probably because the searches were carried out principally in the autumn and winter and large feathers would have been removed in many cases from the immediate area of an eyrie by the action of the wind.

At the beginning of the eyrie searches it was decided to re-search a limited number of eyries using different staff and under different conditions. This was intended to allow an assessment of the number of rings that might have been missed on the original search. A second ground search was carried out at a total of six eyries that were re-visited between December 2002 and March 2003.

Flight histories

Details of the owners of all recent Scottish rings found (i.e. those dated 1997-2002 inclusive) were obtained from the Scottish Homing Union and a questionnaire sent to the owner of the bird asking for information on where and when the bird was last released. More general information on overall losses of young and old birds from the same loft was also requested for the 2002 season. Details of the few French, Dutch and Belgian rings recovered were also passed to the SHU to confirm whether or not the bird had been bought and flown by a Scottish fancier. Information on the owners of all rings issued by the North of England Homing Union (NEHU) and Royal Pigeon Racing Association (RPRA) was also sought from these two bodies. In the ten cases where the bird had an RPRA or NEHU ring but was held by a Scottish fancier, a questionnaire was also sent out to the owner or an attempt was made to contact them by telephone. Where no completed questionnaire was returned, attempts were made to contact the owners by telephone to obtain the information needed.

Following investigation of the ages of pigeons raced at the Newmains Club in Lanarkshire in May and June 2000, it was decided to concentrate effort in determining the histories of rings dated 1997 to 2002. This was because 98.8% of the old birds raced over this period in the middle of the old bird season were five years old or less. Although it would have, in theory, been possible to investigate older rings, this would have meant substantial additional effort, with only a small chance that the pigeon had still been racing during the 2002 season.

5.2.2 Results

A total of 1,213 pigeon rings were recovered during the eyrie searches, of which 720 belonged to the SHU or its predecessors. However, many of these were old rings (the oldest dated 1921) which had no relevance to the effects of peregrines on racing pigeons in the present day (Figure 5.2).

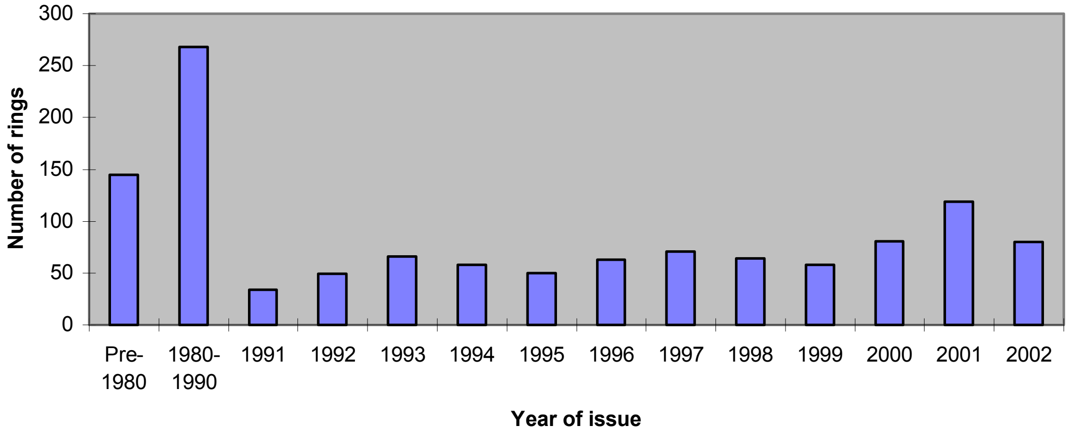

Figure 5.2. Number of rings recovered by year of issue (all issuing bodies)

A total of 308 recent (i.e. 1997-2002) rings belonging to Scottish pigeon fanciers were found during the eyrie searches. Of these, 298 were SHU rings, eight were Royal Pigeon Racing Association rings, and two were North of England Homing Union rings.

The owners of 229 of these 308 recent rings provided some information on the history of the bird in question. Of these, 209 (91.3%) provided full information on where and when the pigeon was last released. This was required to allow a determination of whether or not the bird had strayed and whether or not it had definitely been killed during the 2002 season. However, this information was not subject to checking by CSL, although the design of the questionnaire had attempted to ensure that fanciers checked records before completion. Although some racing pigeons released in previous years may have been killed during the 2002 season, these birds would have been leading a feral existence for a period of at least several months (i.e. since the end of the last racing season) before being killed. Unfortunately it is outwith the scope of this study to determine the levels of “race-feral” racing pigeons which are taken by peregrines.

There were a number of reasons for fanciers either failing to reply or not providing complete information. Change of address and telephone number certainly accounted for a proportion of these. Some fanciers had not kept detailed records or records had been lost or destroyed, often on giving up pigeon racing. A number of fanciers had also died between the time of the ring being issued and the CSL questionnaire being sent.

A total of 117 fanciers confirmed that the rings recovered belonged to birds released during the 2002 season. The equates to 1.98 pigeons per eyrie searched. However, the range varied from 0-10 (Figure 5.3). A correction factor can be applied to take into account pigeons whose details were not returned to CSL. This is based on the proportion of birds from each of the years 1997-2001 which were known to have been lost in 2002. If this is done, the figure rises to 144 pigeons, which equates to 2.44 pigeons per eyrie.

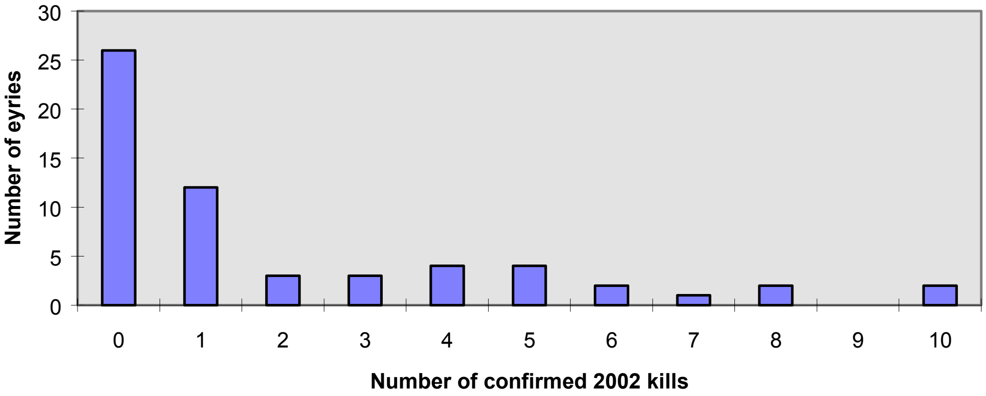

Figure 5.3. Number of confirmed kills of Scottish racing pigeons per eyrie (2002)

An additional factor which must be taken into account is that some rings were missed on the original searches. A total of six sites were subject to re-searches with a view to assessing the possible level of rings not recovered on a first visit. The mean period between the original search and the re-search was between 17 and 18 weeks (range four to 23 weeks). Two of the sites were recently-closed quarries where no additional rings were found. The remaining four were natural sites where varying number of additional rings were recovered on the second search. There appear to be a number of reasons for this. One is that the suppliers of the metal detectors used advise that the equipment is 5% more efficient when the soil is wet compared to when the soil is dry. Thus sites searched in dry conditions in the early autumn would be expected to produce some additional rings when re-searched in wet conditions. Two other factors to consider are that searching in winter when vegetation has died back should allow both better visual searches and more effective use of the detector, and that if a territory has continued to be occupied by peregrines between the original search and the re-search, pigeons may have been killed during the period between the two searches.

The total number of rings recovered from the six re-searches was 193 (0, 0, 83, 81, 18 and 11 respectively) compared to 180 rings found on the original searches (Figure 5.4). It should be noted that recent rings made up a much lower proportion of the rings found on re-searches than was the case with the original searches, and relatively few were from birds either confirmed as being lost in 2002 or which were potentially lost in that year.

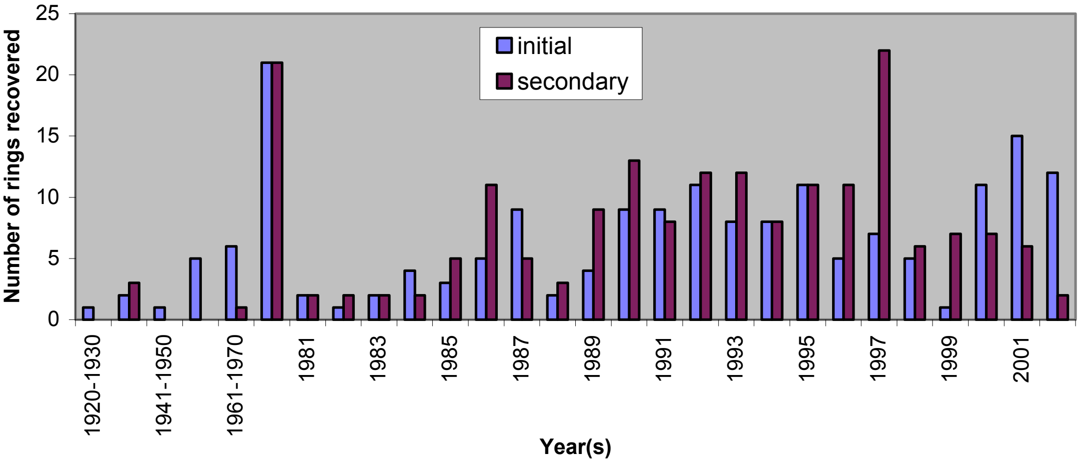

Figure 5.4. Comparison of the number of rings recovered from eyries during initial and secondary searches.

Using this information, a further correction factor can be applied to those sites where second searches were not carried out as it is highly likely that some rings from these sites were also not recovered on the first visit. Thus a total of 259 recent Scottish rings were found on sites with only one visit. On the second searches which were carried out, an additional 87.7% recent rings were found compared to the original search. Overall, 65.1% of the rings recovered originated in Scottish lofts, so second searches could be expected to lead to around 244 additional recent Scottish rings. Analysis of the flight history information provided by fanciers shows that 56% of the recent rings belonged to birds killed in 2002. Applying this factor to the possible 244 additional Scottish rings missed gives a figure of 137 pigeons. If this figure is added to the 144 birds known to have been killed or the rings of which were recovered but no flight history was provided, a total of 281 pigeons killed arises, or an average of 4.76 racing pigeons per eyrie.

The eyries and nest sites searched during this study had varying degrees of breeding success during the 2002 season, ranging from four young successfully reared to territories held by non-breeding pairs. If it is assumed that these were representative of the situation nationally in 2002, the above results on minimum racing pigeon losses can be extrapolated nationally. Thus, with a peregrine population of 630 breeding pairs and 65 non-breeding pairs (see Table 5.6) within areas which will be used by Scottish racing pigeons to varying degrees, this suggests a minimum of 3,308 Scottish racing pigeons killed by peregrines. The 2002 peregrine census also identified 348 single birds either on or off territory. If it is assumed that each single peregrine takes 50% of the racing pigeons taken by a pair, this means that an additional 828 Scottish racing pigeons may be lost to single peregrines, giving a total minimum loss of 4,136 Scottish racing pigeons to peregrines.

5.2.3 Discussion

It was always recognised that searches for rings would reveal only an absolute minimum number of the total number of racing pigeons taken by peregrines because an unknown proportion of rings are not deposited in the nesting area, and furthermore an unknown proportion would remain unrecovered from the nesting area. In addition to rings not found during searches (due to being missed or being in situations where safety dictated could not be searched), it is known that some rings are removed from eyries and surrounding areas by a range of people. However, although rings were probably removed from some sites (and certainly removed from at least one site), CSL has no reason to believe that rings were removed in an organised manner from any eyries in the study prior to the visit by CSL staff.

It should also be noted that only the remains of racing pigeons killed close to the eyrie (or those where pellets containing rings were regurgitated close to the eyrie) can be recovered by this method. Thus any racing pigeons killed away from the eyrie cannot be accounted for by the recovery of rings from the vicinity of the eyrie.

There are many reasons, therefore, for concluding that the results of eyrie searches can only provide a minimum figure for the total losses of racing pigeons to peregrines, above which the real figure must lie, as also recognised by Dixon (2002).

Estimates for the potential number of pigeons killed by peregrine could be derived, in turn, for domestic pigeons (i.e. feral/racing/rock dove etc.), racing pigeons and Scottish racing pigeons based on the daily food intake (DFI) of peregrines. This approach would require data on: (i) peregrine numbers, (ii) peregrine daily food requirements, (iii) the proportion of peregrine diet which is pigeon, (iv) the proportion of the pigeon component of peregrine diet that is Scottish racing pigeon. The methodology for this approach is outlined in Annex 1.

5.3 REGIONAL VARIATION IN RECOVERY OF RINGS AMONGST FEDERATIONS

5.3.1 Method

Analysis of ring recoveries was conducted to determine the relative abundance of rings from individual Federations recovered from eyries in different regions. This provides information on whether birds from specific Federations are more vulnerable to predation from peregrines in particular regions. Data were collated separately for old birds (95 rings) and young birds (58 rings) last released in either 2001 or 2002. The rings of pigeons released in earlier years were not included in the analysis because of the change in the location of the release points, with a switch to the east of the country in recent years.

Because of the relatively low numbers of rings involved it was not possible to analyse data at the level of the individual Federation. Therefore, both eyries and the Federations which issued the recovered rings were allocated to one of three regional categories (Table 5.4).

Table 5.4. Grouped locations of SHU Federations and peregrine eyries

Region		
Western	**Central**	**Eastern**
FEDERATION		
Ayrshire	North-West	Fife
Ballochmyle	Central	Pentlands
Kyle and District	Midland	East of Scotland
Glasgow		Midlothian
Renfrewshire		Scottish Borders
Lanarkshire		
Solway		
South Lanarkshire		
EYRIE LOCATION		
Dumfries and Galloway	Cumbria (east of M6)	Lothian and Borders
Ayrshire	Perth and Kinross	Eastern Northumberland
Cumbria (west of M6)	Stirling	
	Western Northumberland	

5.3.2 Results

There was a high degree of association between the origin of the rings and the region in which they were found (Gamma statistic for old birds = 0.66, Normal probability <0.001, Gamma statistic for young birds = 0.57, Normal probability 0.013) i.e. more pigeons were taken by peregrines in areas relatively close to their home loft rather than by peregrines in other regions (Table 5.5). This was particularly noticeable in the case of rings recovered from eyries in western areas belonging to pigeons from SHU Federations in western Scotland, with 74.5% of old bird rings and 87.5% of young bird rings from western eyries belonging to home lofts in the west of Scotland.

There was no significant difference in the regional recovery between Old Birds and Young Birds (Chi-square Test, X-squared = 39, P>0.05).

Table 5.5. Percentages of pigeon rings recovered from birds lost in 2001/2002, in relation to the locations of loft and eyrie

	Western Federations	Central Federations	Eastern Federations
Western eyries OB	74.5	17.0	8.5
Western eyries YB	87.5	0.0	12.5
Central eyries OB	40.0	40.0	20.0
Central eyries YB	28.6	42.8	28.6
Eastern eyries OB	28.9	21.1	50.0
Eastern eyries YB	28.6	25.0	46.4

5.3.3 Discussion

It was notable that a large proportion of the rings recovered from western eyries (i.e. those located in north-west England and south-west Scotland) belonged to pigeons from SHU Federations in western Scotland (74.5% for Old Birds and 87.5% for Young Birds), despite the greater use of eastern release points in recent years, particularly for Old Birds. This suggests that a proportion (albeit an unquantifiable one) of pigeons from west coast Federations, although released on the east coast of England, cross the Pennines before flying up the west side of the country.

5.4 ESTIMATE OF POTENTIAL STRAYS

5.4.1 Methods

It is recognised that some racing pigeons stray from the route back to their home loft, and a proportion of these will inevitably be lost to their owners ("race-strays"). As part of the work involving the recovery of rings from peregrine territories, we have also investigated what proportion of the birds known to have been killed by peregrines were 'off-line' at the time they were killed. In recent years there has been a change in the release points for many Scottish racing pigeons, with many Old Birds from west of Scotland federations now being released on the east coast of England rather than from the traditional west of England release points. This has been done in an attempt to reduce the chance of attack by peregrines.

During training flights or races, racing pigeons are expected to remain within certain spatial limits relative to the line of flight between the liberation point and their home loft. Information on the magnitude of these 'certain limits', however, is lacking due to a lack of knowledge on the ranging behaviour of racing pigeons when training and racing. Pigeons are more likely to become strays, however, if they deviate significantly from the homeward route, rather than remaining close to the route (Dixon *et al*. unpublished). Without information on the normal ranging behaviour of racing pigeons, the definition of the distance 'off-line' from the homeward route outwith which pigeons are categorised as potential strays is inevitably arbitrary.

In the present study, two methods for the estimation of potential strays were conducted, which involved investigating the flight histories of birds identified from rings recovered from eyries. Each method related the actual recovery location of the racing pigeon rings to their expected location. The first method followed procedures adopted by previous research on this issue, whereas the second was adopted in response to a criticism of the first method by pigeon fanciers, namely that straight-lines between release and return points did not accurately describe the routes normally taken by racing pigeons.

method 1: To enable comparison between studies, the method used by Shawyer *et al.* (2000) and Dixon *et al*. (unpublished) was used. Here, pigeons were categorised as 'off-line' if they were recovered a perpendicular distance equivalent to 33% or more of the intended flight distance along a straight line route between the liberation point and home loft. For example, a bird would be categorised as 'off-line' if recovered at a perpendicular distance of 33km or more from a point on the direct route that was 100km ahead of the liberation point, and at a perpendicular distance of 20km or more from a point 60km ahead of the liberation point. The distance 'off-line' was measured relative to the home loft in instances when this distance was shorter than the distance to the liberation point. Pigeons were also categorised as 'off-line' if recovered more than 16km from the liberation point and between 90° and 180° from the intended flight line. Two further categories of pigeons 'off-line' were those that had 'overshot' their home loft by at least 40km, and those birds lost during exercise that were recovered more than 25km from their loft ('wanderers'). All pigeons categorised as 'off-line', 'overshot' and 'wanderers' were regarded as potential strays.

method 2: Three estimates for potential strays were derived, with a pigeon being classed as a potential stray if its ring was recovered 'off-line' by a set perpendicular distance of 20km, 30km or 50km from the homeward route respectively. In addition, birds were also categorised as potential strays if they overshot their home loft by 10km, 20km and 30km respectively for the three above distance estimates. In this method, the intended flight path was assumed to follow routes as described by fanciers. These routes followed major topographical features (such as valleys or coasts) rather than a straight line as in method 1.

Race routes for method 2

Fanciers suggested that when homing most pigeons follow topographical features and river valleys in particular. A number of routes were suggested by fanciers as those which would be used by pigeons racing from England to lofts in different parts of Scotland. Some additional routes (particularly trans-Pennine routes) were added by CSL staff given the lack of information from fanciers. The principal race routes (defined by river valleys or roads) for Scottish pigeons are shown in Figure 5.5, but can be summarised as follows:-

(i) Pigeons released in eastern England or Scotland were defined as on–line if their ring was recovered within a certain distance of the following roads or features - A68, A697, A7, A1, the east coast, or the M8. This applied to pigeons with home lofts in Borders, Lothians, Fife, Dundee, Aberdeen, Stirling, East and West Dunbartonshire, Glasgow, Lanarkshire (north of Carluke and Larkhall) and Renfrewshire.

(ii) Pigeons released in either eastern or western parts of England or Scotland were defined as on-line if their ring was recovered within a certain distance of the following roads or features - A66, A69 (for birds released in eastern England), M6 north of the release point, A74(M)/Annandale. This applied to pigeons with home lofts in Dumfriesshire, North and South Lanarkshire, Glasgow, East and West Dunbartonshire, Falkirk, and Stirling.

(iii) Pigeons released on either the eastern or western parts of England or Scotland were defined as on-line if their ring was recovered within a certain distance of the following roads or features - A66, A69 (for birds released in eastern England), M6 north of the release point, and Nithsdale. This applied to pigeons with home lofts in New Cumnock, Cumnock, Ayr, and Ayrshire north of Ayr.

(iv) Pigeons released on either the eastern or western parts of England or Scotland were defined as on-line if their ring was recovered within a certain distance of the following roads or features - A66, A69 (for birds released in eastern England), M6 north of the release point, along the north Solway coast from Dumfries to the River Dee or the Ken-Doon valley. This applied to pigeons with home lofts in Dalmellington and Ayr.

(v) Pigeons released on the west coast were defined as on-line if their ring was recovered within a certain distance of the M6 or A7 in the case of pigeons with home lofts in Borders, Lothians, Fife and Dundee.

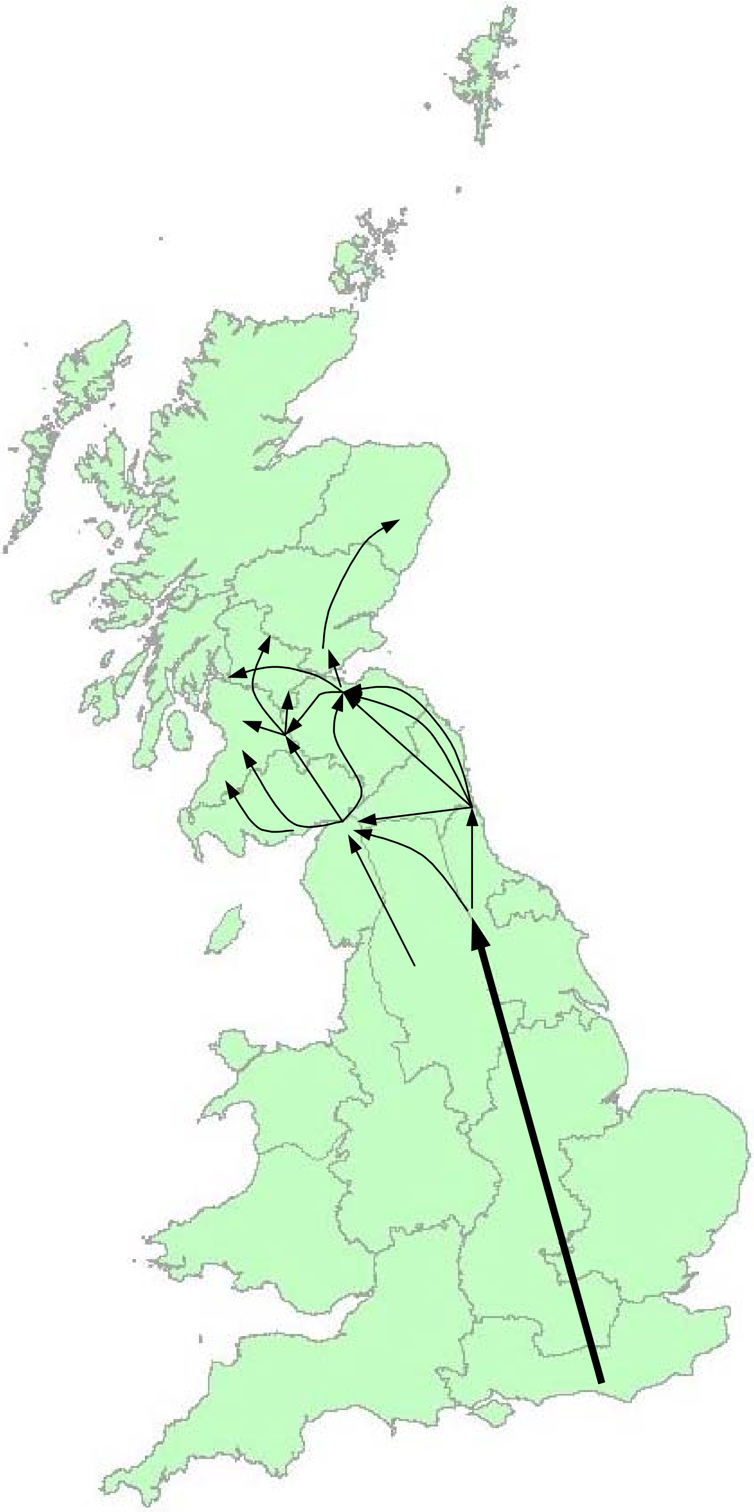

Figure 5.5. Principal race routes for Scottish racing pigeons.

5.4.2 Results

method 1: A total of 58.4% of the Scottish racing pigeons assessed were potential strays, with no difference between old and young birds (Table 5.6). For both old and young birds, 55.6% were off-line and 2.8% had overshot their home loft.

Table 5.6 Estimation of the rate of potential straying by deviation from direct line of flight between release point and loft (method 1).

	No.	%
YOUNG BIRDS (n=36)		
Off-line	20	55.6
Overshot	1	2.8
On-line	15	
OLD BIRDS (n=72)		
Off-line	40	55.6
Overshot	2	2.8
On-line	30	
ALL BIRDS (n=108)		
Off-line	60	55.6
Overshot	3	2.8
On-line	45	

method 2: Estimates of the percentage of Scottish racing pigeons killed by peregrines which were potential spatial strays ranged from 44% to 61% for young birds, from 31% to 54% for old birds, and 38% to 57% collectively (Table 5.7).

Table 5.7. Estimation of the rate of potential straying using three categories for the distance between the race route and the eyrie in which rings were recovered (method 2).

	Potential Stray Distance Definition					
	>20km		>30km		>50km	
	No.	%	No.	%	No.	%
YOUNG BIRDS (n=36)						
Off-line	21	58.3	19	52.8	16	44.4
Overshot	1	2.7	0	0	0	0
On-line	14		17		20	
OLD BIRDS (n=72)						
Off-line	35	48.6	26	36.1	22	30.6
Overshot	4	5.6	3	4.2	3	4.2
On-line	33		43		47	
ALL BIRDS (n=108)						
Off-line	46	51.9	45	41.7	38	35.2
Overshot	5	4.6	3	2.8	3	2.8
On-line	47		60		67	

5.4.3 Discussion

The rate of potential straying was estimated as 58% (method 1) and from 38% to 57% (method 2). The rate of straying was the same for old birds as for young birds with method 1 but with method 2 the rate was greater for young birds compared to old birds for each of the three defined straying distances. The straying rates estimated in the current study fall within the range of estimates derived in previous studies.

Shawyer *et al.* (2000) used the term ‘race-stray’ to define a bird that was significantly ‘off-line’ from its homeward route. It was reported that 41% of pigeons killed by peregrines were off-line when predated, and a further 12% had overshot their home loft. A total of 53% of pigeons were, therefore, categorised as race-strays. However, the method used to define straying is not universally accepted.

Using Shawyer *et al.*’s (2000) definition of a race-stray, Dixon (in press) concluded that up to 54% of racing pigeons killed by peregrines in Northumberland were either significantly off course or strays already lost to their owners. In Wales, Dixon *et al.* (unpublished) concluded that potential strays constituted 60%, 40% and 20% of racing pigeons killed in Central Wales, the Brecon Beacons and South Wales respectively. Older and more experienced birds were less likely to have deviated from the intended homeward route than younger and less-experienced birds, in keeping with the present study. It was also concluded that strays were over-represented in the sample of predated birds relative to their constituent proportion in the population as a whole. Strays provide a more constantly available prey compared to the more sporadically available homers during races and training flights.

6. REVIEW OF DETERRENTS

6.1 INTRODUCTION

A review was conducted of avian deterrent/protection techniques with respect to the issue of alleviating attacks by raptors on racing pigeons. The review consists of two parts: (i) an investigation of deterrent/protection techniques that have been used by SHU members, and (ii) an evaluation of avian deterrents used in other circumstances and settings, including game bird release pens, for their suitability for protecting racing pigeons from raptor predation. The 'success' of a deterrent can be measured at two levels – complete or partial. The latter is a reduction in the numbers of the pest species or in the extent of damage caused (in the case of racing pigeons a reduction in attacks and kills). Although complete success is the ideal outcome, most deterrents are usually deployed to reduce rather than completely prevent pest activity.

The aim of the review was to identify techniques which appeared most worthy of further detailed investigation both for protecting pigeons at the loft (loft-based deterrents) and during training/races (pigeon-based deterrents). The two potentially most effective pigeon-based deterrents identified (wing transfers and sequins) were investigated in controlled, replicated field trials as part of this overall study (Section 7). Recommendation of specific loft-based deterrents considered worthy of further investigation for future field trials (outwith this study) are presented. In addition to the review of deterrent/protection techniques, guidelines for the deployment of loft-based systems to maximise their potential effectiveness are discussed.

6.2 DETERRENTS USED BY SCOTTISH HOMING UNION

During 1996/97 the SHU conducted a survey of its members to gather information on the nature and extent of attacks by birds of prey on racing pigeons in Scotland (SHU 1998). The number of lofts returning questionnaires was 1,937 (~47% of lofts in Scotland), of which 1,752 reported problems with birds of prey (mainly peregrines and sparrowhawks). Out of these 1,752 lofts, 366 (20.9%) had tested one or more avian deterrents, either available on the commercial market or self-designed. The deterrents used fell into two distinct categories: (i) loft-based, and (ii) pigeon-based. Loft-based deterrents are located on, or near the loft, and are aimed at deterring attacks, principally by sparrowhawks, in the immediate vicinity of the loft. Deterrents included: balloons, whistles, eyes painted on structures (e.g. loft roof, house walls), replica and cut-out owls, Hawk Eyes, scarecrows, targets, mirrors and decoy geese. Pigeon-based deterrents are fixed directly onto the pigeons and attempt to discourage attacks, principally by peregrines, during exercise, training flights and races; deterrents used included wing transfers, sequins and Bali-bells. Overall, the survey indicated that no deterrent was considered to be effective in a consistent and sustained manner (SHU 1998). Thirty-nine of the 366 lofts (10.7%), however, did report that some techniques deterred attacks in the short-term; although attacks resumed when the "surprise" effect of the novel stimulus wore off.

In May 2001, SHU circulated a follow-up questionnaire to the 366 lofts which had tested deterrents, requesting more detailed information on techniques used and perceptions of their effectiveness. A total of 89 (24.3%) questionnaire returns were received; 86 (23.5%) of which provided information on deterrent use.

These 86 questionnaire returns were examined by CSL to quantify deterrent use and assess respondents' perceptions of the deterrents' effectiveness. In the analysis, respondents remarks with respect to the effectiveness of each deterrent were categorised as 'none', 'partial' or 'very', corresponding to completely ineffective, having some deterrent effect and highly effective respectively. 'Partial' effectiveness was assigned to responses such as "useful for short period" and "worked for a few weeks". 'Effective' was assigned to responses such as "seems to kept sparrowhawks away from loft (*sic*)", and "do have an effect in deterring sparrowhawks". In a number of cases respondents did not indicate the perceived effectiveness of a deterrent; these were categorised as '?'.

A detailed evaluation and comparison of the effectiveness of the deterrents was not possible from the survey data due to the survey design and small sample size. *Post hoc* analysis is confounded by many factors. For loft-based deterrents this includes the loft site, location of deterrent, and frequency of human activity, and for pigeon-based deterrents the age and quality of the bird. Further confounding factors include the time of year, racing season and raptor breeding season, and the magnitude of the potential threat from exposure to raptor attack. In addition, sample sizes for some of the deterrents were relatively low; whistles and mirrors were each tested at no more than fifteen lofts. Consequently, investigation of the data was restricted to: (i) quantification of the number of different types of deterrent used, and their relative frequency of deployment amongst lofts, and (ii) discussion of the perceived effectiveness of deterrents, from which inferences were drawn as to which particular techniques were worthy of more detailed investigation.

6.2.1 Loft-based deterrents

Sixty-nine of the 86 respondents used loft-based deterrents, between them deploying a total of 18 different techniques (Table 6.1).

Table 6.1. Loft-based deterrents used by SHU members and an assessment of their effectiveness.

	Lofts		Effectiveness							
	n = 69		?		none		partial		very	
Deterrent	**no.**	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**
balloon	18	26.1	9	50.0	7	38.9	2	11.1	0	0.0
whistle	13	18.8	5	38.5	7	53.8	1	7.7	0	0.0
painted eye spots	38	55.1	9	23.7	21	55.3	8	21.1	0	0.0
replica owl	50	72.5	13	26.0	24	48.0	9	18.0	4	8.0
mirrors/reflectors	15	21.7	5	33.3	5	33.3	4	26.7	1	6.7
other	14	20.3	6	42.9	1	7.1	3	21.4	4	28.6
flags	1		1							
"eyes on bottles"	1								1	
"old drinkers with eyes"	1				1					
butterfly models	1		1							
hooded crow replica (mobile)	1		1							
peregrine replica	1						1			
anti-hawk deterrent	1		1							
bang wood	1						1			
sonic device	1								1	
model birds/propelling wings	1						1			
fishing line tripwire	1								1	
encourage jackdaws	1		1							
illegal (shotgun/larsen trap)	2		1						1	

? respondent did not indicate perceived effectiveness of deterrent

The five most frequently used techniques (balloon, whistle, eye spots, replica owl, mirrors), however, accounted for 90% of all deterrents deployed. Overall, the majority of respondents perceived each of these five main types of loft-based deterrent to be ineffective. Over 20% of respondents, however, reported at least partial effectiveness for eye-spots, replica owls and mirrors. In these cases, the deterrents appeared to have some effect following initial deployment but the effectiveness usually decreased over time. Replica owls and eyespots were most commonly used (73% and 55% of respondents respectively). The most effective deterrent, however, was mirrors/reflectors which was regarded to be at least partially effective by 33% of respondents using them.

Fourteen other types of deterrent were also recorded. Of these, "eyes on bottles", "sonic device" and "fishing line tripwire" were all regarded as very effective at the one loft each where they were deployed. The latter technique interfered with the hunting strategy used by sparrowhawks and involved stretching a length of fishing line 6-8 inches above a hedge which bordered the loft site. A sparrowhawk approaching along the opposite side of the hedge would collide with the line as it attempted to flip over the crown of the hedge. A collision was reported to deter the sparrowhawk for 3-4 weeks. The legality of this technique, however, is questionable as there is a high risk of injury to the sparrowhawk and deliberately inflicting injury is illegal under the Wildlife and Countryside Act (1981). An interesting attempt at biological control was reported which tried to utilise the propensity of corvids to mob raptors. With this aim, one respondent encouraged jackdaws *Corvus monedula* into the loft area with food; the effectiveness of this measure, however, was not reported. All 'other' deterrents were used at single lofts and so it is not possible to draw any conclusions about their effectiveness.

Only two (2.9%) respondents using loft-based deterrents reported the use of animated rather than inanimate models: (i) "flying owl with wing movement" (partially effective) and "hooded crow replica with plenty movement" (effectiveness not reported) and (ii) "wooden birds with propelling wings" (partially effective). However, the questionnaire did not explicitly request respondents to differentiate between the two types of model. Therefore, it is not known whether the survey data accurately reflected the relative use of inanimate and mobile models. With respect to regularly changing the location of deterrents, only six (8.7%) respondents stated that this was carried out for any device. Again, however, this information was not explicitly requested, therefore it is not known what proportion of loft-owners did actually vary the position of deterrents.

Alarmingly, two respondents recorded illegal control techniques, specifically "shotgun and Larsen trap works fine" and "shotgun". It is not clear, however, whether these techniques were actually being used (and birds killed illegally) or were merely being advocated.

Over half of respondents (65%) who used loft-based deterrents had deployed more than one type of device (Table 6.2); although it is not clear to what extent different deterrents were deployed concurrently or sequentially. Around 20% of lofts had not used any type of loft-based deterrent; using only pigeon-based deterrents (Table 6.5).

Table 6.2. Frequency of multiple loft-based deterrent use amongst SHU lofts.

No. different deterrents	1	2	3	4	5
no. lofts	24	27	8	6	4
% respondents	34.8	39.1	11.6	8.7	5.8

Overall, 26 (38%) of the 69 respondents who had used loft-based deterrents reported, at least, partial effectiveness for a deterrent technique. Of the 55 lofts for which perceived deterrent effectiveness was reported, effectiveness was reported significantly more often for lofts which had used more than one type of deterrent (36 lofts) than lofts deploying a single technique only (19 lofts). Partial effectiveness (or better) was reported for 21 lofts (58%) which had used multiple-techniques compared with 5 lofts (26%) which used a single technique only ($\chi^2 = 5.22$, df = 1, $P < 0.05$).

6.2.2 Pigeon-based deterrents

Fifty-eight of the 86 respondents used pigeon-based deterrents. Three types of pigeon-based deterrent have been primarily used: wing transfers, sequins and Bali bells (Table 6.3). Wing transfers, made from waterproof inks, are brightly coloured roundels or "eyes" which are applied to the upper surface of a pigeon's wings. The transfers are intended to mimic the eyes of a larger bird and so deter attack by birds of prey. Sequins are small reflective discs which are glued to the feathers on the pigeons head and back. Reflections off the sequins are intended to repel or startle any attacking bird of prey. Bali bells are actually small whistles which are attached to the base of the tail. When the pigeon is in flight the "bells" produce a high pitched noise, the sound of which is intended to deter raptors from attacking the bird, and possibly also from approaching the flock as a whole.

Respondents overwhelmingly regarded sequins as ineffective, with only 4% rating them, at best, as partially effective. Wing transfers were also generally regarded as ineffective and categorised as partial or very effective by only 7% of respondents. Bali-bells, however, were reported to be partially effective by 16% respondents.

Although Bali-bells were overall rated the most effective of the three pigeon-based deterrents, limitations to their efficacy were reported. Firstly, as was the case with loft-deterrents, the effectiveness of Bali-bells was suggested to decrease over time, as peregrines seemed to habituate to the device. It was even suggested that over time the sound of the Bali-bells actually attracted peregrines. Secondly, Bali-bells were not effective within the vicinity of the loft. Bali-bells function by producing a whistling noise when the pigeon is in flight, a stimulus which ceases when the pigeon alights. Thus, even if Bali-bells effectively deterred peregrines during training or race flights, once having alighted in the vicinity of the loft birds would then be unprotected and vulnerable to attack.

A further number of negative aspects were reported for each of the three deterrents. Bali-bells were reported to: be difficult to fit, cause damage to tail feathers, "upset" the birds, and to be expensive and impractical. Wing transfers were described as time consuming to apply, whilst sequins quickly became detached.

Table 6.3. Pigeon-based deterrents used by SHU members and an assessment of their effectiveness.

	Lofts		Effectiveness							
	n = 58		?		none		partial		very	
Deterrent	**no.**	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**
wing transfers	42	72.4	13	31.0	26	61.9	2	4.8	1	2.4
sequins	24	41.4	9	37.5	14	58.3	1	4.2	0	0.0
Bali-bells	25	43.1	8	32.0	13	52.0	4	16.0	0	0.0
other	2	3.4	1	50.0	1	50.0	0	0.0	0	0.0
“painted eyes”	1		1							
glitter on head/dye wings	1				1					

? respondent did not indicate perceived effectiveness of deterrent

Around 41% of the respondents who had used pigeon-based deterrents had used more than one type of deterrent system (Table 6.4), whilst 33% of all respondents had not used any pigeon-based deterrent at all.

Table 6.4. Frequency of multiple pigeon-based deterrent use amongst SHU lofts.

No. different deterrents	**1**	**2**	**3**	**4**
no. lofts	34	15	8	1
% respondents	58.6	25.9	13.8	1.7

Not all loft-owners used both loft-based and pigeon-based deterrents. Around half used only one category of deterrent, i.e. either loft-based or pigeon-based (Table 6.5). It is not clear whether this reflected a difference in the relative rates of attack by peregrines and sparrowhawks between these sub-groups of respondents, a more general difference in willingness to test a range of deterrents, or a resignation on the part of some loft-owners that certain deterrents were ineffective and so not worthwhile. Six (7%) respondents reported confining birds to the loft during autumn and winter. Information on confining birds, however, was not explicitly requested, therefore it is not known what proportion of loft-owners did actually carry this out.

Table 6.5. Proportion of lofts using each category of raptor deterrent.

Category of deterrent used	**Respondents**	
	no.	**%**
Loft-based only	28	32.6
Pigeon-based only	17	19.8
Loft-based and Pigeon-based	41	47.7

6.3 DETERRENTS USED IN OTHER CIRCUMSTANCES

A large number of different management techniques (Table 6.6) have been used in attempts to alleviate problems caused by avian species. Deterrents are frequently deployed in attempts to scare mixed flocks from a sensitive area, e.g. landfill sites or grain stores. In many instances, however, deterrents are used in response to the activities of a specific species, e.g. woodpigeons feeding on fields of crops and piscivorous species, such as great cormorants *Phalacrocorax carbo*, at aquaculture facilities. Whatever the impetus for use, however, with very few exceptions most deterrents are non-targetable, i.e. the aversive stimuli produced affects *all* bird species within the area of application. The problem of deterring raptors from attacking racing pigeons, therefore, provides a task for which most deterrents were not designed, i.e. targeted scaring of one species whilst concurrently having minimal effect on another. With this requirement, therefore, the majority of currently available deterrents are unsuitable for protecting racing pigeons against raptors. Further, many techniques emit noise or light stimuli at such a high intensity that it would not only scare the pigeons but also render their use unacceptable in urban areas (where most lofts are located). Other deterrents are inappropriate due to safety and/or legal reasons (e.g. shooting).

The various deterrent techniques available were assessed for their potential applicability to protecting racing pigeons from raptor attacks (Table 6.6). Each deterrent was assessed on three criteria: evidence for effectiveness, practicality and acceptability. A deterrent was considered inappropriate if it clearly failed to fulfil any one of these criteria. For example, ultrasonic devices were not considered suitable as there is no evidence that such devices deter birds. In fact, evidence indicates that most species of birds do not hear in the ultrasonic range (>20kHz) (Erickson *et al.* 1992, Harris & Davis 1998) and so there is no biological basis for their use. Some exclusion methods have proved fully effective in some circumstances, for example netting over small commercial fishponds prevents predation by piscivorous birds. Clearly, such exclusion methods are impractical for use at racing pigeon lofts. Finally, some methods which are both effective (at least in the short-term) and practical were considered to be unsuitable due to their nuisance potential in the urban environment. For example, gas canons and intense lights would be unacceptably intrusive to neighbouring properties, in addition to scaring the pigeons themselves.

Scientific evidence for the effectiveness of the various deterrents has been evaluated by CSL as part of a recent review of international literature (Bishop *et al.* 2003). Out of a total of 432 documents, 73 involved replicated field trials and these were evaluated using the principles of meta-analysis – the quantitative synthesis, analysis and summary of a collection of studies (Hedges & Olkin 1985). For auditory deterrents, bioacoustics, pyrotechnics and shooting appeared to be more effective than sonic devices or gas cannons. In the case of visual deterrents, raptor models and human effigies appeared to be more consistently effective than kites/balloons, tapes, lines and flags.

Of the available techniques the following were considered to be potentially suitable for use at racing pigeon lofts: human disturbance, bioacoustics, visual deterrents (model raptors, eyespots, mirrors/reflectors and moving visuals) and habitat modification. Two other measures may have some potential for addressing overall predation: supplementary feeding (or buffer prey) and Conditioned Taste Aversion (CTA), although concerns over the use of CTA would probably prevent its use. Each of these techniques is discussed further with respect to their potential applicability specifically to deterring raptors and to any context in which they are currently deployed by pigeon fanciers. Mirrors and reflectors were also included from consideration of the SHU deterrent survey, their use by gamekeepers and recent field trials (see Sections 6.4 and 6.5).

Human disturbance

Human activity can disturb birds from specific areas both deliberately by direct harassment (Vickery & Summers 1992), or indirectly through, for example, leisure activities (Bell & Austin 1985). A full-time human bird scarer was more cost-effective than traditional visual and acoustic deterrents in reducing grazing by Brent geese *Branta bernicla* on winter crops; habituation to the human scarer was also absent (Vickery & Summers 1992). Human disturbance was found to be the only consistently effective scaring technique in deterring cormorants *Phalacrocorax carbo* from aquaculture facilities (Boudewijn & Dirksen 1996). A number of respondents in the SHU survey reported that to prevent sparrowhawk attacks at the loft, birds were only released for exercise when the owner was able to remain in attendance. Frequent and prolonged human surveillance in the loft area, however, is clearly a time-consuming and impractical deterrent strategy.

Bioacoustics

Many sonic pest devices (e.g. gas canons, sirens and electronic noises) are available which can be programmed to produce a range of different sounds at varying intervals and loudness. The synthetic noises produced, however, have no biological relevance and are therefore less repellent and less resistant to habituation than biologically meaningful sounds, i.e. bioacoustics (Feare *et al*. 1988, Harris & Davies 1998).

Bioacoustic deterrents are a category of sonic device which transmit sounds of biological relevance, e.g. recorded bird alarm and distress calls. In general, alarm calls are given when birds perceive danger, whilst distress calls are vocalised when birds are captured, restrained or injured. These calls are species-specific and can cause conspecifics to take flight. Alarm and distress calls, however, may also evoke a response in other species which closely associate with the call-producing species. Responding to alarm/distress calls has a high survival value, therefore such biologically meaningful sounds are more repellent and more resistant to habituation than other sounds (Bomford & O'Brien 1990, Harris & Davis 1998). Such devices are widely used for bird control on airfields and various industrial situations (e.g. Bridgman 1980). In some species (e.g. gulls) alarm/distress calls initially act as an attractant with birds approaching the source, apparently to investigate, before flying away.

Broadcasts of recorded raptor calls have been used in attempts to deter pest species from, for example, airports (Harris & Davis 1998). Raptors, however, hunt silently and so the use of recorded raptor calls has no clear biological basis for use in such circumstances. The alternative use of raptor alarm or distress calls to deter raptors themselves has not, to CSL's knowledge, been attempted. The alarm calls of both sparrowhawks and peregrines, if not currently recorded, are readily obtainable. At lofts, playback of calls could be conducted either manually or automatically (using a loop recording), as a stand alone deterrent or in conjunction with another deterrent.

A single case of the use of a sonic device was recorded by SHU loft-owners, and was reported as very effective; the type of device, however, was not reported. The most commonly used acoustic deterrent used by SHU members is a whistle. The deployment of a whistle, however, is inevitably linked with the presence of a person. Thus, any deterrent effect may be due to human disturbance rather than to the acoustic effect of the whistle.

Table 6.6. Management techniques which have been used to alleviate nuisance bird problems and an evaluation of their potential suitability for use at pigeon lofts.

Deterrent	**Description**	**Effective** [a]	**Practical** [b]	**Acceptable** [c]	**Suitable for protecting racing pigeon at lofts?**
Human disturbance	people scare birds through deliberate harassment or by simply moving in the vicinity for work or leisure activities.	*	?	yes	**suitable -** but constant human presence generally impractical.
Dogs	dogs have been trained to harass and scare off birds.	?	no	?	impractical - used against ground feeding birds; chase or scare pigeons
Conditioned Taste Aversion (CTA)	crops/prey are treated with illness-inducing chemicals to condition birds to avoid untreated crops/prey from certain areas.	?	?	?	probably unacceptable – concerns over safety and legality
Shooting (to kill)	killing of a no. of birds of certain spp. (under license) in order to enhance scaring techniques.	***	yes	no	unacceptable - illegal; licenses not issued to kill raptors.
Shooting (blanks)	firing blank cartridges (or firing live cartridges to miss) to scare; in practice usually used in conjunction with shooting to kill.	***	yes	no	unacceptable - noise nuisance; safety issues
Pyrotechnics	a variety of noise-producing shells (also with a visual component) usually fired from shotguns and pistols.	***	yes	no	unacceptable - noise nuisance; safety issues
High intensity sound	sonic booms, horns, air-raid sirens.	?	yes	no	unacceptable - noise nuisance
Gas cannons	propane gas guns, controlled by timers, that produce explosions (max. ~105 dB at source).	**	yes	no	unacceptable - noise nuisance
Acoustics	electronic devices that produce a range of artificial noises at varying intensities (max. ~95 dB at source).	*	yes	no	unacceptable - noise nuisance
Bioacoustics	electronic devices that broadcast species-specific distress or alarm calls at varying intensities (max. ~95 dB at source).	***	yes	?	**suitable -** some potential at lofts in less urban habitat
Ultrasonics	electronic devices that emit frequencies above 20 kHz.	no	yes	yes	ineffective - most birds do not hear ultrasonics
Laser light	a medium-power laser light that is aimed at, or close to, individual birds.	?	no	no	impractical/unacceptable - only effective in low ambient light; safety issues
Intense lights	search lights, strobes, rotating lights.	?	yes	no	unacceptable - visual nuisance
Static visuals	*scarecrows, eyespots,* models, mirrors, etc.	*	yes	yes	**suitable -** but habituation quicker than for moving visuals
Moving visuals	*'pop-up' effigies, kites, helium balloons, flags*, etc.	**	yes	yes	**suitable**
Model aircraft	radio-controlled model aircraft.	?	no	no	impractical - requires constant human operation unacceptable - nuisance in urban environment
Model/stuffed specimen raptors	*models/stuffed specimens*.	***	yes	yes	**suitable**
Netting	the complete enclosure of sensitive areas.	yes	no	no	impractical - pigeons require access
Wires/tapes	the use of stretched *wires* or *tapes* above sensitive areas.	**	no	no	impractical - pigeons require access
Habitat modification	reducing attractiveness of habitat, e.g. removal of roost structures.	?	?	yes	**suitable**- but opportunities specific to individual lofts
Supplementary feeding (buffer prey)	provision of an alternative food source	?	?	yes	**suitable -** if deployed away from loft

[a] 'Effectiveness' based on results of replicated field trials reviewed in Bishop *et al*. (2003) in which deterrents were categorised as either very effective (>50% reduction in damage or numbers of birds), partially effective (up to 50% reduction in damage or number of birds) or ineffective (no significant reduction). Asterisks denote the overall effectiveness of deterrent categories with respect to the percentage of studies in which the deterrent exhibited at least partial effectiveness: * ≤50% studies ** 51-74% studies *** ≤ 75% studies. Specific techniques within a deterrent category which were tested in the replicated trials are indicated in italics.

[b] 'Practical' denotes whether in CSL's assessment it is practical to deploy the technique in the vicinity of a racing pigeon loft.

[c] 'Acceptable' denotes whether in CSL's assessment it is acceptable to deploy the technique in the vicinity of a racing pigeon loft.

? denotes insufficient data to draw conclusions on criteria.

Visual deterrents

Static visuals, such as scarecrows and raptor models, are common, traditional methods used in attempts to scare avian pests. In general, however, motionless devices either provide only short-term protection or are ineffective; some birds may even come to associate them with favourable conditions (Inglis 1980). To maximise effectiveness devices should possess biological significance, appear lifelike, be highly visible and their location changed frequently in order to extend the period of habituation (Feare *et al.* 1988, Mott & Boyd 1995). The effectiveness of scarecrows may be enhanced if fitted with loose clothing and bright streamers which move and create noise in the wind (Vaudry 1979) - effectively becoming a moving visual.

Ultimately, however lifelike, under most circumstances scarecrows and raptor models do not present a threat which is sufficiently alarming to birds (Inglis 1980). Over a period of time birds learn that effigies or models do not represent an actual threat and are no longer alarmed by them. To increase the threat, therefore, it is recommended that these devices are reinforced with other sound-producing or visual deterrents. Ideally, for example, scarecrows should be periodically reinforced by human activity.

Model raptors

The basis for this deterrent is mimicry of real predators and evocation of fear and avoidance in the target species. Most potential prey species react to predator models; the strength of the response, however, varies between species (Conover 1979). In USA, museum-mounted models of a sharp-shinned hawk *Accipiter striatus* and goshawk both reduced the numbers of birds visiting feeding stations. Habituation to the models, however, was relatively quick with birds re-entering the feeding area after only 5-8 hours exposure.

Model raptors fail to incorporate behavioural cues which may be critical to the induction of fear and avoidance in the target species. Falcons which are “in the mood” to hunt are said to be “sharp set”, such birds are invariably hungry enough to fly at quarry (Inglis 1980). Although it is difficult for human observers to differentiate between a falcon when it is sharp set or conversely, well fed, birds will mob a hawk more frequently when sharp set than when well fed. Thus, model raptors will be inherently less threatening and consequently less effective than live raptors.

For some bird species the avoidance response to large avian predators appears to be, in part, a learned behaviour. Juvenile gray jays *Perisoreus canadensis* showed little response to a model great horned owl *Bubo virginianus*, whereas adult jays reacted intensely (Montevecchi & Maccarone 1987). Interestingly, with repeated exposure adults habituated to the decoy, whereas juveniles developed a stronger fear toward the model.

Large predatory owls, such as eagle owls *Bubo bubo* and great horned owls have been have been known to kill smaller birds of prey (Newton 1979); such owls, however, are absent from the UK. In south Scotland the main avian predator of sparrowhawks is the tawny owl *Strix aluco*, which in most cases take nestlings but occasionally adults (Newton 1986). In regions where their ranges overlap, goshawks may prey on adult sparrowhawks, with probably the more vulnerable recently fledged young mostly taken (Newton 1986). Finally, sparrowhawks do kill and eat conspecifics, e.g. juveniles may be predated by larger females after leaving their natal territory (Newton

1986). Peregrines in Britain, likewise, do not have to contend with large, powerful owls. Indeed all five species of British owl have been recorded amongst the prey of peregrines (Ratcliffe 1993). Larger raptors, such as the golden eagle *Aquila chrysaetos*, may represent a direct threat to a peregrine caught unaware, however the two species generally avoid each other (Ratcliffe 1993).

In the UK, therefore, the predator pressure on sparrowhawks and peregrines from other raptors is low. Thus, sparrowhawks and peregrines are unlikely to be strongly conditioned to fear and avoid resident owl species. In fact the opposite response of close approach may occur: tawny owls can evoke a mobbing response from nesting sparrowhawks (Newton 1986). Evidence for an underlying biological basis for the efficacy of model owls in deterring sparrowhawks and peregrines from loft areas is thus equivocal.

An alternative use of models to deter birds has involved deploying replicas or actual dead specimens in a manner which signals danger to conspecifics. This approach has been frequently used in attempts to deter gulls from airports (Harris & Davies 1998). Some success has been achieved both with dead gulls and model gulls deployed in positions to mimic dead or injured birds. The effectiveness of this technique varied under different circumstances and depended on, for example, frequently moving models (to prevent habituation), the availability of alternative loafing sites (to which birds could relocate) or reinforcement with additional deterrent techniques (e.g. pyrotechnics, alarm/distress calls).

A replica owl was the deterrent most commonly used by SHU members; deployed at 50 (73%) of the 69 lofts at which loft-based deterrents had been used. Although there is an equivocal biological basis for sparrowhawks to avoid owls, thirteen fanciers (26%) reported the technique to be at least partially effective. It may be the case that sparrowhawks, especially the smaller males or young birds, do indeed possess some level of innate fear toward other larger raptors. Alternatively, apparent deterrence at these lofts may have been associated with other factors.

Alternatives to replica owls worthy of investigation at lofts are model corvids. Raptors are frequently mobbed by corvids and can be robbed of their prey by crows (Newton 1986, Cresswell & Whitfield 1994). There is, therefore, a biological basis for sparrowhawks to avoid crows.

Eyespots

Eyespot patterns are a commonly used deterrent, either painted onto a substrate or on devices such as balloons and kites. These patterns are images of eyes composed of a small circle (the 'pupil') centred in a larger circle of another colour (the 'iris'). The basis for their use is the same as for predator models: mimicry of real predators. Laboratory studies have shown that eyespot patterns can induce an aversive response in birds (Blest 1957, Scarife 1976, Inglis *et al*. 1983). McNamara *et al*. (2002) found that 'eyes' painted on the black plastic which covered silage bales reduced damage to the bales by 65%. Inglis *et al*. (1983), in an investigation of the efficacy of eyespots as bird deterrents, concluded that simple eye patterns could deter starlings from foraging within their vicinity; effectiveness was dependant on a distinction between 'pupil' and 'iris'. Habituation to eyespots, however, was rapid.

For the same reasons as discussed for model owls, evidence for the existence of an underlying biological basis for sparrowhawks and peregrines to fear and avoid eyespot patterns, in the absence of strong predation pressure from large predators, is equivocal.

The SHU survey revealed that eyespot patterns were the second most commonly used loft-based deterrent, deployed at 38 lofts (55%). Eight (21.1%) fanciers reported the technique to be at least partially effective. Thus, again it may be the case that sparrowhawks do indeed possess some level of innate fear toward other larger raptors. Alternatively, apparent deterrence at these lofts may have been associated with other factors.

Mirrors and reflective objects

Mirrors and reflectors work on the principle that sudden bright flashes of light produce a startle response and scare the bird from the area.

Reflecting tape (e.g. Mylar tape) has been used in attempts to deter birds in a number of circumstances. The tape has a silver metal coating on one side which reflects sunlight and also produces a humming or crackling noise when moved by the wind. Birds have been deterred by tape suspended in parallel rows over ripening crops (Bruggers *et al*. 1986). Other studies, however, found reflective tape to be ineffective (Tobin *et al*. 1988); deployment of an insufficient amount of tape in this latter study, however, may have contributed to its ineffectiveness. Mylar flags reduced gull *Larus* spp. use of loafing sites (Belant & Ickes 1997 cited in Harris & Davis 1998).

The response of free-living birds to mirrors has been investigated in only a handful of species. Foraging by black-capped chickadees *Parus atricapillus* at feeding stations was depressed by the presentation of either a standard mirror or an aluminium foil covered mirror; feeding was depressed the most by the standard mirror (Censky & Ficken 1982). When placed in nesting territories mirrors evoked aggressive responses from blue grouse *Dendragapus obscurus* (Stirling 1968) and glaucous-winged gulls *Larus glaucesens* (mirror combined with playback of gull calls) (Stout *et al*. 1969). Mirrors placed inside nest-boxes did not deter starlings from nesting within (Seamans *et al*. 2001).

Reflective objects have been reported as effective in deterring raptors, such as sparrowhawks and goshawks, from game release pens (Lloyd 1976; and see Sections 6.4 and 6.5).

In the SHU survey, mirrors/reflectors were reported to be at least partially effective at 33% of lofts where they were deployed (15 lofts).

Moving visuals

Moving visuals increase the perception of threat and thus are more effective than static visuals. A number of animated devices are available with movements that are generated either by the wind or are battery-powered.

In recent years, a number of animated inflatable scarecrows have become commercially available. One of these, Scarey Man® is a life-size plastic effigy powered by a 12-volt car battery, that inflates rapidly (at intervals), emits a high pitched wail and may illuminate at night. At aquaculture facilities, Scarey Man® has been deployed against black-crowned night herons *Nycticorax nycticorax* and great blue herons *Ardea herodias* (Andelt *et al*. 1997) and double-crested cormorants *Phalacrocorax auritus* (Stickley & King 1995). In each study, however, an initial decrease in bird numbers was followed by habituation and subsequent recovery of numbers. Another device combining an inflatable scarecrow with a propane exploder was effective at deterring blackbirds from sunflowers in some fields (Cummings *et* al 1986).

An animated crow-killing owl model was more effective in protecting vegetable plots from crows *Corvus corone* than an unanimated model (Conover 1985). This model consisted of a plastic owl model with a plastic crow model in its talons. This device maximised the deterrent effect by combining movement with an implicit risk.

A mobile kite-hawk (i.e. a kite bearing an image of a soaring raptor) was more effective in deterring birds from feeding stations than immobile museum mounted raptor models (Conover 1979). To be effective, however, kite-hawks need to be 'flown' beneath helium balloons in order to possess sufficient 'threatening' movement (Conover 1984). Other studies have found kite-hawks to be ineffective (Hothem & DeHaven 1982) or are quickly habituated to (Inglis 1980).

A further type of moving visual deterrent is eyespot balloons. There are number of different designs of eyespot balloon commercially available (e.g. 'Terror-Eyes'). Balloons may bear either a single pair of eyespots on one side or multiple eyespots encircling the entire balloon. The device combines the scaring/startling effect of predator eyes with movement.

Studies indicate that the deterrent effect of eye-spot balloons varies between species, with the specific eyespot design and with the mode of presentation. Other studies postulate that the deterrent effect is due to the balloon itself rather than the eyespots. In New Zealand, numbers of house sparrows *Passer domesticus* visiting a bird-feeding table were significantly reduced by deployment of both a commercially available eye-spot balloon and a home-made device (eyes painted on a beach ball) (McLennan *et al*. 1995). The commercial device had a greater deterrent effect than the beach ball. The effect of both devices decreased with distance and was negligible at 40m. The deterrent effect increased when reinforced with a rotating light and playback of alarm calls. With continuous use, however, the deterrent effect declined and ceased after nine days. Flight pen evaluation of eyespot balloons on rufous turtle doves *Streptopelia orientalis* indicated that the scaring effect was mainly due to the stimulus of the balloon itself rather than specifically to the eyespot patterns (Nakamura *et al*. 1995). Conversely, in studies of gray starlings *Sturnus cineraceus* it was concluded that it was the eyespots themselves that were the aversive component of eyespot balloons (Shirota *et al*. 1983).

The only moving visual deterrents commonly used by SHU members are balloons. Only 11% of survey respondents, however, regarded this technique as having any deterrent effect. To maximise effectiveness, as is the case for static devices, it is essential to change the location of animated devices frequently.

Habitat modification

Habitat modification involves manipulating the environment to physically exclude from or render an area less attractive to the pest species, e.g. netting over fishponds, removal of roost structures, or promoting specific vegetation (e.g. tall grass at airports). With respect to raptor attacks at lofts, sparrowhawks will use physical features of the surrounding habitat to provide cover during approach. In practice, in the urban environment opportunities for habitat manipulation are limited, as features will include for example permanent buildings. There may be some scope, however, for removal or modification of garden hedges, fences and shrubs in the vicinity of the loft, which may provide cover for a sparrowhawk during its approach.

A further potential technique which may be possible in some circumstances would be to fit anti-perching devices to any known raptor perching site overlooking a loft, thus removing a potential observation post. Some loft-owners, however, reported sparrowhawks perching on the roof of the loft itself.

The only example of habitat modification reported in the SHU survey was the use of a “fishing line tripwire” set above a hedge to impede passage by sparrowhawks. This method was reported as very successful, with sparrowhawks being deterred for 3-4 weeks following collision with the wire. This technique, however, has animal welfare implications and is probably illegal. An ‘invisible’ barrier, such as a fishing line, has the potential to injure or kill a fast-moving sparrowhawk, actions which are unlawful under the Wildlife and Countryside Act (1981). It is possible that this technique could be modified to remove the risk of injury by substituting barrier tape for the wire. Such an approach to impede sparrowhawks which are hunting using contour-hugging flight (Wilson & Weir 1989) may have an application at lofts where a consistent approach path can be identified.

Conditioned Taste Aversion

Conditioned Taste Aversion (CTA) is generated through a subconscious association between taste and a feeling of illness experienced after ingesting food. It is a natural phenomenon that has evolved in many vertebrates to prevent poisoning. Conditioned Taste Aversion can be generated deliberately in an animal by the addition of an undetectable illness-inducing chemical to a specific foodstuff, thus causing the animal to associate the taste of that food with illness. Conditioned Taste Aversion has been found to be long-lasting in various mammals (e.g. Nicolaus *et al.* 1989a, 1989c) but has not been extensively researched in birds (Nicolaus *et al.* 1989b). However, CTA has successfully been induced in avian predators. Egg predation by crows on artificial nests was significantly lower following aversive conditioning using Landrin treated chicken eggs, but remained unchanged at sites were no conditioning occurred (Dimmick & Nikolaus 1990). Aversion was retained in conditioned sites the following year without further treatment. Captive cormorants, at CSL, were conditioned to avoid trout *Salmo trutta*, aversion persisting for seven months without reinforcement (McKay *et al*. 1999).

The application of CTA to deter raptor attacks on racing pigeons has been investigated (Musgrove 1996). In 1994, Musgrove identified a chemical (methyl anthranilate) that was aversive to falcons when presented on meat but appeared benign to pigeons when applied to their plumage. Field testing of the technique, however, has been very limited (Musgrove 1998). The technique requires further development to ensure that the chemical is not only effective but also completely safe to pigeons and fanciers. Unfortunately, at its current state of development, and specifically in view of health, safety and legality issues, there are concerns over advocating this technique. A further problem with CTA is that a relatively large percentage of the potential prey would need to be treated in order to maximise the chances of predation of a treated individual.

An alternative mode of application (aerosol spray) of methyl anthranilate as a bird repellent has been investigated in preliminary experiments (Stevens & Clarke 1998). In a test chamber, starlings exhibited behavioural responses indicating sensory irritation on exposure to a methyl anthranilate aerosol. Moreover, habituation was not apparent following repeated exposure to the aerosol. Potential applications postulated for such an aerosol repellent technique are the protection of birds through deterrence from hazardous waste sites and the dispersal of roosts to protect public health and safety.

Supplementary (diversionary) feeding

The provision of supplementary, diversionary or ‘buffer’ prey has been used in a number of circumstances in attempts to reduce raptor predation. The predation rate in a colony of little terns *Sterna albifrons,* in Norfolk, UK, decreased when the two pairs of resident kestrels *Falco tinnunculus* were provided with supplemental prey (dead mice) (Durdin 1993). Supplementary feeding of peregrines, however, had little success during attempts to protect a roseate tern *Sterna dougallii* colony (Avery & Winder 1990). At pheasant release pens, the provision of an alternative food source was suggested to be effective in reducing predation by sparrowhawks (Lloyd 1976) and buzzards *Buteo buteo* (Harradine *et al.* 1997). On grouse moors, the provision of supplementary food to hen harriers *Circus cyaneus* significantly reduced their predation on red grouse *Lagopus scoticus* chicks (Redpath *et al.*, 2001). Hinsley & Redpath (1996) reported the establishment of pigeon lofts on grouse moors in attempts to protect grouse *Lagopus lagopus* from peregrines.

There is, however, a potential danger in providing supplementary food, which is that in the long-term it may lead to an increase in predator-density, if prey availability is limiting predator numbers. In Sweden, goshawk range size was smaller and breeding density higher in areas rich in rabbits than elsewhere (Kenward 1982a). In one such area goshawk predation on wild pheasants *Phasianus colchicus* was particularly high (Kenward 1982b, 1986). It was suggested that the predation on pheasants was exacerbated by the abundance of rabbits drawing more hawks into the area than would normally have occurred in such a habitat. Conversely, in Langholm, Scotland, there was little evidence that providing supplementary food for hen harriers in spring increased breeding density (Redpath *et al.* 1999 cited in UK Raptor Working Group 2000). For commercial fisheries it has been suggested that higher overall fish densities, due to stocking buffer prey alongside commercial species, may serve as an increased attraction to predators (Elson 1962, Draulans 1987). To avoid this, the provision of buffer prey at alternative sites away from important fisheries was suggested as a preferred option (Mott & Boyd 1995).

With respect to raptor predation on racing pigeons supplementary feeding may be suitable for use during the limited period of peak attacks: sparrowhawks - March and April, peregrine - May and June. Carcasses from pest control operations by local farmers (e.g. woodpigeons) or at local grain mills/stores (e.g. feral pigeons *Columba livia*) may represent a resource which could be exploited for the provision of supplementary prey. Sparrowhawks are known to take carrion from incidents of poisoning due to the provision of poisoned meat baits by gamekeepers; females are reported to take carrion more frequently than males (Newton 1986). Provision of supplementary food was reported as successful in reducing raptor predation at game release pens (Lloyd 1976; see later section: 'Deterrent/protection techniques at game bird rearing pens').

Motivational state

The effectiveness of any bird deterrent will depend on a number of factors in addition to the deterrent itself, such as the motivational state of the animal and the availability of alternative resources.

Birds are more difficult to deter from nesting sites than non-nesting sites. Mylar flags reduced gull use of loafing sites but not nesting colonies (Belant & Ickes 1997). Nesting feral pigeons were not deterred from gaining access to their nests even by wire-point anti-perching systems that inflicted wounds (Haag-Wackernagel 2000). The response of individual birds to a deterrent may also depend on dominance rank. In black-capped chickadees, the presentation of a mirror at a feeding site evoked threatening behaviour only from the more dominant birds (Censky & Ficken 1982). With respect to raptor predation at pigeon lofts, the propensity for a sparrowhawk to either mob (or inspect) or avoid a model predator may be influenced by the season, the distance of the loft from the raptor's nest and the raptor's sex or age.

Motivational state will also be influenced by the degree of hunger and availability of alternative resources. Cost-effective deterrence of brent geese *Branta bernicla* was achieved by suspending lines of tape across a field of winter wheat, when alternative untaped fields were available. However, when all fields were taped geese readily grazed in taped fields (Summers & Hillman 1990). Optimal Foraging Theory predicts that birds select feeding sites so that food intake is 'optimised' (Krebs & Cowie 1976). In this respect, racing pigeons probably represent a very cost-effective prey, in that they have a relatively large body mass providing a high return in energy costs and they are highly predictable in their location. To reduce or prevent predation at a loft a level of deterrence is required that reduces the raptor's net energy gain below a critical threshold, prompting the bird to switch to alternative, more profitable prey. This will be more easily achieved if alternative prey is available locally.

6.4 DETERRENT TECHNIQUES AT GAME BIRD REARING PENS

The problem most similar to the protection of racing pigeons at lofts is that of preventing raptor depredation at game bird release pens. Raptor attacks at release pens mostly involve tawny owls, sparrowhawks and buzzards, with pheasants most affected (Lloyd 1976, Harradine *et al*. 1997). Gamekeepers deploy a wide variety of deterrents in attempts to ameliorate raptor predation (Harradine *et al*. 1997). Few studies, however, have been conducted which have investigated the effectiveness of the methods used (but see Lloyd 1976, Allan 2001).

Lloyd (1976) concluded that release of more mature poults, high levels of vegetative cover within the pen, and deployment of scaring devices were all beneficial in reducing losses to raptors (particularly tawny owls). It was also recommended that deterrents were regularly moved and changed. Although, only effective in the short-term, hanging devices, flashing lights and bangers were recognised as useful in protecting poults until they became larger and more self reliant in avoiding predators. However, whilst these methods were recommended, there was no experimental evaluation of their relative effectiveness.

Lloyd (1976) reported experiments in Europe which had shown that large silvered balls were effective in protecting reared game and chickens from diurnal raptors, particularly sparrowhawks and goshawks (Mansfield 1954 and Pfeiffer & Keil 1963 reported in Lloyd 1976). Also reported was the advocacy of reflective objects by various gamekeepers in the UK: opportunistic trials using such suspended materials successfully ended sparrowhawk predation at three different release pens. Finally, providing alternative feeding opportunities (e.g. dead pigeons) were also suggested as effective in reducing predation by sparrowhawks.

More recently, to assist the UK Raptor Working Group, the British Association for Shooting and Conservation (BASC) undertook a survey of its gamekeeper membership to determine their problems with raptors and how they dealt with them. Information provided by almost 1,000 gamekeepers was subsequently assessed (Harradine *et al*. 1997). The survey revealed that many different deterrent and scaring techniques were used, either in isolation or combined, e.g. bangers, gas guns, alarms, hangers and mobiles, lights, mirrors, radios, owl decoys, scarecrows and human presence, but with varied and generally little success. The most effective methods involved habitat manipulation and game management, rather than deterrent devices. Increasing cover inside pens, roofing pens (e.g. using overhead wires) and delaying poult release until birds were older and larger appeared to be most beneficial. The Group concluded that there was no consistent application of deterrents, some of the most commonly used were those which appeared least successful, whilst some of the apparently most successful were less frequently used. Field trials were recommended to address the urgent need to assess the effectiveness of different deterrent measures.

6.5 RECENT FIELD TRIALS ON RAPTOR DETERRENTS

Two further studies relevant to the issue of raptor predation on racing pigeons have been recently completed:

- An investigation by Lancaster University into attacks by birds of prey on racing pigeons, which included evaluation of selected loft-based and bird-based deterrents (Dixon 2002).
- Field trials by ADAS to evaluate the effectiveness of deterrent and management techniques to reduce raptor activity at game bird release pens.

Trials of loft-based and pigeon-based deterrents (Lancaster University)

Lancaster University's research, funded by the Royal Pigeon Racing Association (RPRA), included trials of selected loft-based and pigeon-based raptor deterrents (Dixon 2002). The trials, which commenced in March 2002, were conducted in South Wales. Loft-based trials evaluated the effectiveness of two visual deterrents: a great horned owl model and eyespot balloons. Pigeon-based trials evaluated wing-transfers, sequins and Bali-bells. It was concluded that loft-based deterrents did not prevent attacks by sparrowhawks and goshawks at lofts, neither did bird-based deterrents reduce the level of racing pigeon losses during exercise and training flights.

The loft-based trials assessed whether or not deployment of these deterrents resulted in complete cessation of attacks at lofts but did not evaluate whether deterrents reduced the frequency of raptor attacks.

The trials of loft-based deterrents involved three treatment groups: replica owls (n=17 lofts), replica owls plus balloons (n=3 lofts) and control (no visual deterrents) (n=16 lofts). The deterrents were evaluated over a single season only.

Of the 20 lofts with deterrents, 14 reported a total of 39 attacks by sparrowhawks. These attacks resulted in the loss of 24 birds (59% of attacks resulted in a kill) representing approximately 11% of all birds lost during exercise. The use of these deterrents, therefore, did not result in complete cessation of attacks by sparrowhawks at the loft.

The Lancaster University study then compared the loss rate of pigeons at lofts with visual deterrents (3.5 pigeons per loft per year) with loss rates recorded in two previous studies in different geographic areas. In Wales and western England, fanciers reported an average loss of 2.7 pigeons per loft per annum (Shawyer et *al.* 2000), whilst a Royal Pigeon Racing Association (RPRA) survey, covering 14 UK regions, reported a loss of 2.3 pigeons per loft per annum (range 0.2-5.2). As the estimate for loss rate at lofts with deterrents fell within the ranges reported for the other two studies it was suggested that the frequency of attacks at lofts with visual deterrents were not significantly reduced. Such a comparison, however, clearly does not constitute a valid full evaluation of deterrent efficacy.

Dixon (2002) states that the attack rate was highly variable between lofts and that lofts located close to (<200m) mature woodland (>1ha) suffered significantly higher rates of sparrowhawk attack compared with lofts located well away from woodland. This highlights the loft-specific risk of attack. With the rate of attack strongly influenced by local conditions a comparison between attack rates at lofts with deterrents in Dixon (2002) and attack rates in previous studies located in different geographic areas (and in other years) does not provide a valid evaluation of deterrent effectiveness. The appropriate experimental design and analysis would involve comparison of attack rates at lofts with and without deterrents within the same study area. Deterrent and control lofts should be matched for the risk of exposure to attack, for example with respect to distance from mature woodland, or randomly assigned in a larger study. In Dixon (2002) attack rates at control lofts were not reported. It is unknown, therefore, whether attack rates would have been higher in the absence of deterrents.

As the report of the Lancaster University study acknowledges, there is little firm evidence to suggest that either of these devices (model owl and eyespot balloons) act as a deterrent to raptors. In addition, subsequent deployment of these devices also failed to apply basic principles designed to optimise deterrent effectiveness. The trials used inanimate rather than mobile model owls and the schedule of repositioning models at weekly intervals was too infrequent. Frequent re-siting of deterrent devices is an essential requisite of avian control. For example, in protecting crops it is recommended that gas cannons are re-positioned at least every two or three days (e.g. Harris & Davis 1998, Transport Canada undated).

A robust evaluation of pigeon-based deterrents was constrained by small sample sizes. *Wing transfers* were applied to a total of 174 young-birds from 15 different lofts. During exercise flights around the loft one marked pigeon was lost (subsequently located at another loft) and two unmarked pigeons were lost. It was concluded that the use of wing transfers was impractical as they were extremely time-consuming to apply and faded relatively quickly. *Bali-bells* were used at three lofts. Records of pigeon losses were kept for two of these lofts, with no losses occurring at one of them (before or after use of Bali-bells). The evaluation of Bali-bells thus involved a single loft. This loft was not typical in that it was remote from neighbouring lofts and overlooked by a peregrine eyrie, which the exercising flock often flew very close to. The use of a Bali-bell on one bird in this flock did not prevent attacks on the flock and kills by the pair of peregrines. Dixon (2002) suggested, however, that other peregrines without a regular routine of hunting a particular flock may react differently to a Bali-bell. There were problems with the Bali-bells becoming detached and lost during normal exercise. A further potential problem identified was noise nuisance; in the trials the whistle of the Bali-bells could be heard when the pigeon was up to 800m away. *Sequins* were applied to a total of 171 old-birds from 26 different lofts. Birds with sequins were released on 572 training tosses and birds without sequins on 3037 training tosses. During these tosses 12 (2.1%) marked pigeons and 36 (1.2%) unmarked pigeons were lost. There was no significant difference in loss rates between groups of pigeons with and without sequins. A problem with the use of sequins was feather damage as sequins became dislodged. Both wing transfers and sequins were tested in training tosses only and not in races.

Trials of deterrents at game bird release pens (ADAS)

Recommendations from the UK Raptor Working Group included a proposed study to evaluate the relative effectiveness of different deterrent and management techniques in and around pheasant release pens in reducing the attentions of raptors (UK Raptor Working Group 2000). A project contract, funded by BASC, DETR, SNH, National Trust and the RSPB was awarded to the Agricultural Development and Advisory Service (ADAS) and commenced in May 1999.

The study investigated the effectiveness of three deterrent techniques (bags, mirrors/lights and Mylar tape) in reducing raptor predation at game release pens (Allan 2001). Suspended bags and mirrors/lights are traditional methods used by gamekeepers, whilst the use of Mylar tape is a more novel technique in this environment. On each of two estates, each deterrent was applied to a single release pen and a fourth pen was left unprotected (control). The effectiveness of the deterrents was assessed by comparing predation levels between the pens via twice-daily searches and examination of carcasses. Statistically, no significant difference in predation rates by raptors was observed between any of the treatments. A lack of statistical difference was not surprising, however, as there was an extremely low replication of treatments and a high variability in predation rate within one treatment (bags). Whilst not statistically significant, on both estates a greater predation rate was recorded from control pens than from mirror/lights pens (slight difference), and from control pens and mirror/lights pens than from Mylar pens. Predation rates inside Mylar pens was 45% and 73% lower than in the respective control pens on the two estates. Further trials on the effectiveness of the deterrents were recommended.

6.6 OVERVIEW

6.6.1 Loft-based deterrents

An SHU questionnaire survey of its membership provided information on the use of raptor deterrents from 86 loft-owners. Sixty-nine of these 86 fanciers reported the use of loft-based deterrents. Five main types of loft-based deterrents were used, in the order of frequency: replica owls (73%), painted eyespots (55%), balloons (26%), mirrors (22%) and whistles (19%). Overall, the majority of loft-owners using each deterrent perceived them to be ineffective. Some degree of effectiveness, however, was reported for each deterrent at 26%, 21%, 11%, 33% and 8% of lofts respectively. Overall, mirrors/reflectors were perceived as the most effective deterrents yet were deployed at fewer lofts than apparently less successful techniques. The use of more than one type of deterrent appeared to be more effective than deploying a single technique only. At the 55 lofts that reported effectiveness, partial effectiveness (or better) was reported by 58% of loft-owners who had used two or more different techniques, compared to 26% of respondents who had used only a single technique. Sample sizes in the SHU deterrent survey were small and data were based on the subjective assessment of loft-owners. The results, however, are of practical importance and further investigation in the form of controlled, replicated field trials are necessary to evaluate whether the differences are real.

SHU members have used a wide range of loft-based raptor deterrents and in some cases great initiative has been demonstrated in attempts to protect the loft area. Overall, however, there appears to be scope for improvement in the manner in which deterrent use is approached and conducted. It is important that loft-owners are made aware of the biological concepts on which visual and auditory deterrents are based, in order to: (i) select the most appropriate types of deterrents, (ii) improve methods of deployment and (iii) avoid unrealistic expectations of their performance.

These points can be illustrated with some examples highlighted by the SHU survey. As stated above, the deterrent perceived to be the most effective was deployed at fewer lofts than other deterrents perceived to be less effective. The use of two-dimensional, cut-out owl figures and un-lifelike models do not represent as realistic a threat to raptors as more elaborate, mobile devices. With respect to the deployment of painted eyes, one respondent stated “after month were no use unless moved constantly”. It is unrealistic to expect a deterrent to retain effectiveness without changing its presentation in any way. If deterrents are not regularly moved or modified raptors will habituate to them very quickly.

Habituation is a problem associated with virtually all visual and auditory deterrents. Most animals exhibit fear or wariness towards any novel object placed in their environment and will avoid it. Dispersal can also be induced through a startle reflex as a result of the sudden presentation of visual or auditory stimuli. However, animals come to realise that the deterrent does not actually present a real threat and gradually ignore the stimulus. Thus, for all visual and auditory deterrents any initial effectiveness will inevitably decline. To maximise effectiveness, through prolonging the process of habituation, deterrents should: (i) be as realistic as possible, (ii) be temporally and spatially unpredictable, (iii) present as real a threat as possible, (iv) be presented as infrequently as possible, and (v) be reinforced or replaced with alternative type/s of devices. To achieve this, effigies and models, for example, should be constructed to be physically lifelike and animated, moved frequently between different locations, interchanged with alternative models, and reinforced with other stimuli. Essentially, the more biologically meaningful a deterrent is the greater the period of habituation. Deterrence is an ongoing process in which a pro-active and integrated approach is necessary. In this respect, SHU loft-owners who deployed more than one type of deterrent reported more frequent success compared to owners who used a single type of device only. The problem of sparrowhawks habituating to a loft-based deterrent may be less compared with other bird control situations. Sparrowhawk attacks at lofts occur most frequently in April and May (Shawyer *et al.* (2000). Therefore, an effective loft-based deterrent may only need to resist habituation for a relatively short, but critical period, for the impact of sparrowhawk predation to be reduced.

A wider review of avian deterrent techniques, used in a range of bird control circumstances, was conducted. Techniques were evaluated for their potential applicability in reducing raptor predation at racing pigeon lofts. Human disturbance, bioacoustics, mirrors/reflectors (including Mylar tape), moving visuals (animated models – particularly corvids, eyespots) and habitat modification were all considered to have some potential as loft-based deterrents. Supplementary feeding in the wider landscape may provide an additional means of redirecting raptors' attentions away from lofts.

There is a widespread view amongst the racing pigeon fraternity that deterrents are ineffective (e.g. SHU 1998, BHW website 2003). In the current CSL study, field trials of pigeon-based deterrents (wing transfers and sequins) in races provided no evidence for higher return rates of pigeons bearing deterrents, compared to control birds. For loft-based deterrents, however, adequate testing of deterrents has not yet been carried out. Recent field trials at racing pigeon lofts suffered from limitations in the experimental design (Dixon 2002), whilst trials at game release pens were limited by small sample size (Allan 2001). Until loft-based deterrents are rigorously tested in well designed controlled, replicated field trials conclusions about their efficacy cannot be drawn. Further, if such field trials indicate that the specific deterrents tested are ineffective, assumed lack of efficacy should not be extrapolated to other untested alternative or novel devices, or to alternative modes of deterrent deployment. For example, although scarecrows have generally been shown to be ineffective in reducing crop damage by birds, a recent innovative method of deploying this measure (random human reinforcement), in Israel, has proved to be effective (Nemtzov & Galili 2003).

A potentially promising novel area of investigation was identified which would involve the application of an innovative method of exposing raptors to a chemical repellent. Previous research has shown the potential for delivering bird repellents in the form of aerosols (Stevens & Clark 1998). Such an approach, however, would require a program of research and development.

6.6.2 Pigeon-based deterrents

Only three types of pigeon-based deterrent are currently commercially available which are designed for protecting pigeons during exercise, training flights or races: wing transfers, sequins and Bali-bells. Fifty-eight of the 86 loft-owners using deterrents reported the use of these pigeon-based methods, which were used in the order of frequency wing transfers (72%), Bali-bells (43%) and sequins (41%). Overall, the majority of 58 loft-owners using pigeon-based deterrents perceived them to be ineffective. Some degree of effectiveness, however, was reported for Bali-bells, wing transfers and sequins by 16%, 7% and 4% of fanciers respectively. Bali-bells are not suitable for use during races or training flights as they are likely to produce drag and slow a bird down, and hence are only practical for exercise. Wing transfers and sequins have only previously been scientifically tested in field trials of training flights (Dixon 2002). In the current CSL study, therefore, wing transfers and sequins were selected for controlled, replicated field trials in races. Subsequent data from these trials provided no evidence that either wing transfers or sequins increased the return rates of birds bearing them compared to birds without the deterrents (see Section 7). A number of practical problems have been highlighted with pigeon-based deterrents (Dixon 2002), including feather damage (sequins, Bali-bells), fading (wing transfers) noise (Bali-bells) and time-consuming to apply (sequins and transfers).

7. FIELD TRIALS OF RACE DETERRENTS

7.1 METHODS

Eye-spots and sequins were identified during the literature review as two of the on-bird deterrents with most potential. Trials of these were carried out in late summer 2002 on young birds and spring 2003 on old birds.

7.1.1 Young Birds

In the case of young birds, CSL requested that 300 birds be made available to take part in the trials. A total of 281 birds were supplied by volunteer fanciers from the area around Ayr and marking of the birds took place on 24 July 2002, in advance of the first race which was due to take place on 27 July 2002. Each pigeon was allocated randomly to a treatment category - eye-spots, sequins or control group (no deterrent). The eye-spots were applied to each wing using a stencil and three colours of stock marker (black in the centre, red, then yellow). A total of five small silver sequins were applied with glue to birds in this category - two on primary feathers on each wing and one on the back of the neck. The total numbers of birds in each group at the time of marking was 95 with eye-spots, 95 sequins, and 91 birds in the control group.

CSL requested that all the pigeons be raced over the same races and that the owners record the return or loss of each bird in the trial for each race. A total of four races were held, with the birds being released from Annan (Dumfriesshire) on three occasions and from Appleby (Cumbria) on one occasion. The return distances from these points to the area of the home lofts are approximately 65 miles and 105 miles respectively. After the second race of the season, it became apparent that the eye-spots were beginning to fade or, in some cases, the pattern had been disrupted by the loss of some feathers, and that the birds would need to be re-marked. In a small number of cases, sequins (mainly those on the back of the neck) also had to be replaced. A meeting was organised for 19 August to allow re-marking to take place, but most of the volunteers failed to attend with their birds. A further meeting was arranged for 26 August which was attended by a number of fanciers. The birds belonging to these were re-marked, but three owners also failed to attend this second meeting. It was therefore not possible to re-mark the pigeons belonging to these, which represented 42% of those birds originally marked with eye-spots and 37% of those originally marked with sequins.

At the end of the young bird races, CSL staff contacted all of the volunteer fanciers to obtain the details of the birds entered into each race and whether they had subsequently returned or not. The “pool sheets” (race entry forms) were also obtained from the club secretary, thus allowing a method to cross-check the information supplied. The data initially supplied by the fanciers gave cause for concern in a number of areas, such as owners stating that birds had been entered into all races while there was no evidence of this on the “pool sheets”. As a result, CSL drew up a pro-forma detailing the dates and release points of each race, and the ring numbers of the birds forming part of the trial which had been entered. CSL staff then returned to confirm with the pigeon owners whether or not each bird had returned.

These returns were then analysed on a race-by-race and an overall basis in order to determine whether the birds with eye-spots or sequins had a return rate which was significantly different from birds in the control group.

7.1.2 Old Birds

A similar trial of deterrents involving old birds began in March 2003. CSL requested that a total of 300 birds also be made available for this trial, but in the event the trial had to proceed with only 140 birds. All of these came from home lofts in the Falkirk/ Cumbernauld/Stirling area. As with the young birds, the pigeons were supplied by volunteers and divided randomly into three treatment groups - those marked with eye-spots, those marked with sequins, and those receiving no markings (the control group). The eye-spots and sequins were applied in the same way as had been done with the young Birds. Initial marking took place on 26 March 2003. The total numbers of birds in each group at the beginning of the trial was 44 with eye-spots, 50 sequins, and 46 birds in the control group.

The first race was held on 10 April 2003 and the last on 7 May 2003. With the exception of the first race, which took place from Arniston (Midlothian), all of the races took place from Kelso. The return distances from these points to the area of the home lofts were approximately 35 miles and 65 miles respectively. Each bird flew over the same five races unless previously lost, and the owners were asked to record the return or loss of each bird in the trial for each race. Fading of the eye-spots was again an issue and all the owners except one attended a session on 5 May 2003 to re-mark the eye-spots after the fourth race of the series. The birds which could not be re-marked represented 23% of those originally marked with eye-spots and 20% of those originally marked with sequins.

Details of the birds entered into each race and whether they returned or not were provided by all fanciers at the end of the five races, with one exception where the fancier lost the pro-forma and could only provide details on which birds remained at the end of the series. This data could not be analysed effectively and so was excluded from the analysis.

The proportions of returns were then analysed on a race-by-race and an overall basis using logistic regression in order to determine if there was a difference between the three treatments and in particular whether the birds with eye-spots or sequins had a return rate which was significantly different from birds in the control group. The proportion of birds returning from a given race was analysed again with logistic regression. This was done for each race for data on old and young birds respectively. Difference in return rates between pigeons from different fanciers was analysed in the same way.

7.2 RESULTS

There was no significant difference between the treatment groups in the return rates for either old birds (Table 7.1) or young birds (Table 7.2). The return rates of old birds were markedly greater than that of young birds.

There were significant differences in return rates unrelated to treatment groups. For young birds there were significant differences in return rates between lofts (Table 7.3) and between races (Table 7.4). For old birds the variation in return rate between lofts approached significance.

Table 7.1. Return rates of racing pigeons from old bird races.

OB		Proportion of Birds Returned			
Race	No. birds	Control	Eyespots	Sequins	P
1	114	0.90	0.94	0.90	NS
2	93	0.94	0.89	0.94	NS
3	90	1.0	0.96	0.91	NS
4	88	0.91	0.92	1.0	NS
5	51	0.95	1.0	1.0	NS
6	17	1.0	1.0	1.0	NS
pooled	453	0.94	0.94	0.94	NS

Table 7.2. Return rates of racing pigeons from young bird races.

YB		Proportion of Birds Returned			
Race	No. birds	Control	Eyespots	Sequins	P
1	183	0.70	0.66	0.68	NS
2	112	0.86	0.70	0.94	<0.001
3	80	0.92	0.96	0.90	NS
4	55	0.78	0.80	0.82	NS
pooled	430	0.79	0.74	0.81	NS

Table 7.3. Comparison of the return rates between different lofts.

Loft	No. Bird Races	Proportion of Returns	P
OLD BIRD			
1	114	0.96	0.06
2	109	0.89	
3	116	0.94	
4	115	0.97	
YOUNG BIRD			
1	13	1.0	<0.001
2	31	0.48	
3	41	0.71	
4	83	0.72	
5	97	0.90	
6	49	0.76	
7	43	0.77	
8	73	0.82	

Table 7.4. Comparison of return rates between races

Race	No. Birds	Proportion of Returns	P
OLD BIRD			
1	114	0.91	NS
2	93	0.92	
3	90	0.96	
4	88	0.94	
5	51	0.98	
6	17	1.0	
YOUNG BIRD			
1	183	0.68	<0.001
2	112	0.82	
3	80	0.93	
4	55	0.80	

7.3 DISCUSSION

Groups of old birds and young birds bearing wing transfers and sequins did not exhibit increased return rates from races compared to the control group of birds without these deterrents. In fact, in the second young bird race there was a significant difference in return rates between the three treatment groups, with the wing transfer group exhibiting the lowest return rate. The fate of birds failing to home is unknown. It is clear, however, that the level of losses was unaffected by the use of wing transfers and sequins.

There were a number of differences in return rates between categories of birds that were unrelated to deterrents. First, old birds had markedly higher return rates than young birds. This clearly reflects the more developed homing ability in older, more experienced birds than in young, inexperienced birds that are more likely to stray or suffer accidents. Second, there were highly significant differences in the return rates of young birds between lofts. All young birds came from the area around Ayr, and competed in the same races so the exposure risk to raptors would have been the same. The differences in return rates, therefore, may reflect the variation in the inherent quality of the birds and their preparation between lofts, including the potential racing of birds by some owners when they are too young. Third, there were highly significant differences in the return rates of young birds between races. Finally, for old birds the variation between lofts in the return rate approached significance, which may reflect variation in the quality of birds and training between lofts.

8. CONCLUSIONS AND RECOMMENDATIONS

The study has highlighted the very complex nature of the interactions between racing pigeons and peregrines and sparrowhawks. The many gaps in knowledge that currently exist severely constrain the ability to derive robust estimates of the impacts of these raptors.

Total reported losses

Overall reported losses from lofts represented, on average, 56% of the loft population at the start of the racing season. Examining the circumstances of losses, mean reported losses of birds from the loft area, during training and during races were 8 (8%), 18 (16%) and 44 (35%), respectively. There was some regional variation in the percentage of young birds reported lost during training; the greatest percentage of the loft population was lost in Dunbartonshire/Stirling (31%) and least in Fife/Perth/Dundee (11%). There was a significantly greater number and percentage of young birds lost per loft than old birds. With respect to the numeric losses of racing pigeons from the study lofts, it should be noted that the population of the study lofts (mean 122 birds) was very probably larger than for Scotland as a whole, for which 82 birds is considered to be more representative (Shawyer *et al*. 2000).

There are concerns over the accuracy of the reported loft losses from the study lofts due to a number of anomalies in the data supplied by some loft-owners. The problem of the validation of questionnaire data supplied by loft-owners has also been highlighted by Dixon (pers. comm.). Clearly, any problems in the accurate recording of losses from lofts has critical implications with respect to confounding the evaluation of the impact of raptors. It is reasonable to assume that previous studies may also have been subject to anomalies in the recording of losses, and previous results should also be considered with this in mind. Future studies need to devise reliable methods of verifying loft losses.

Reported losses to sparrowhawks

For sparrowhawks, this study attempted to substantiate reported losses to sparrowhawks using standardised methodology and is considered to represent an improvement on previous studies, which relied solely on the subjective assessment of loft owners. Overall reported losses to sparrowhawks represented <1% of the Scottish racing pigeon population, but varied regionally and at individual lofts (0 to 4 birds per loft). Nearly half of the lofts (47%, n=15) reported losses to sparrowhawks, with substantiated or probable losses at around a third of lofts (34%, n=11). At the 15 lofts reporting attacks, losses to sparrowhawks over a 12-month period represented a median of 20% of the total losses to all causes from the loft area (range 2% to 100%) during the racing season. Management of sparrowhawk impacts should be directed at the level of the individual loft, as also concluded by Dixon (2002).

Losses to peregrines

For peregrines, analysis of ring recoveries produced a minimum estimate for predation on Scottish racing pigeons away from the loft of *c*.4,100 birds. This is only a minimum, above which the true figure for total losses will be, and should not be considered as an indication of the total loss. An alternative method to calculate the total potential losses was investigated which involved an outline of calculations based on the daily food requirements of peregrines (Annex 1). This analysis produced a very wide range of estimates for total loss. The minimum estimate obtained using this method was 7,820 Scottish racing pigeons taken by peregrines (2.3% of the total loft population) and the maximum estimate was 117,581 pigeons taken by peregrines (34.5% of the loft population). However, there is a large degree of uncertainty associated with a number of the parameters required in the calculations used in this method. Therefore, no significance should be attributed to any specific values within any derived range of estimates. Further research is necessary to derive or refine the required parameter estimates before this method can be used to provide a reliable estimate of the extent of losses.

The frequency of potential strays amongst racing pigeons killed by peregrines was estimated using two methods: 58% (method 1) and 38% to 57% (method 2). These estimates fall within the range of estimates derived in previous studies. The reasons for and the dynamics of straying, however, are little understood and further research is required to elucidate the role of straying in overall losses of racing pigeons.

Deterrents

There is a widespread view amongst the racing pigeon fraternity that deterrents are ineffective. However, reviews of SHU data on members' use of deterrents, literature on the use of avian deterrents in other settings and recent trials at game bird release pens indicated that this dismissal of deterrents is premature. Guidelines on the choice of deterrents and methods of deployment to maximise their effectiveness should be produced and circulated to all loft-owners. It cannot be stressed enough that deterrent use must involve a proactive, integrated approach. Communication between loft-owners needs to be improved with respect to successes in the use of deterrents and not confined to failures. Currently, the deterrent technique (mirror/reflectors) most frequently perceived by loft-owners to be effective is actually deployed by fewer loft-owners than other techniques regarded as less effective. A number of deterrents and modes of deployment used in other avian conflict settings appear suitable for testing at pigeon lofts, including Mylar tape, animated models and bioacoustics. Adequate controlled, replicated field trials of loft-based deterrents, have not been conducted to date, but are essential before any conclusions can legitimately be drawn about the effectiveness of deterrents deployed to protect pigeons in the loft area.

In contrast to loft-based deterrents, trials of deterrents to protect pigeons during races showed they were not effective, indicating no benefit in terms of increasing the return rates of birds from races. Thus, the present study confirms earlier work indicating that the currently available pigeon-based deterrents (wing transfers and sequins) are ineffective.

9. FUTURE RESEARCH

Accurate recording of loft populations and losses

Accurate recording of loft populations and all pigeons lost from lofts is fundamental to establishing the overall level of losses and the relative contribution of various factors, including raptors, to those losses. The present study, however, has highlighted anomalies in the reporting of losses from lofts, which inevitably raises concerns over the accuracy of the extent and circumstances of losses. Studies need to be designed that are based on fully substantiated recording of loft populations and losses.

Race routes and the nature of homing

The issue of straying is critical in evaluating the impact of raptors on the sport of pigeon racing. Strays that are killed by peregrines would have been lost to the owner anyway and cannot be regarded as a *direct* loss to fanciers through peregrine predation. A further concern of the SHU, however, is that peregrine attacks can cause *indirect* losses of pigeons through scattering, which may subsequently cause birds to become lost or to stray. If such events do occur, then birds straying as a result of scattering would represent a loss to fanciers due to peregrines, unlike birds straying 'normally' in the absence of peregrines. One further unknown component of the scattering/straying issue, however, is the number of scattering-induced strays which are not killed by peregrines; failure of these birds to home would also represent a loss to fanciers.

Currently, however, the dynamics of straying and scattering are little understood. In relation to straying, gaps in knowledge include the exact homeward routes taken by pigeons, the normal ranging behaviour around the homeward route, and behavioural and environmental parameters which promote straying. Any relationship between straying and scattering is unclear. It is not known to what extent peregrines may cause scattering of pigeon flocks, and whether any of those birds affected subsequently stray as a result of the incident. The frequency of incidents of scattering, the number of birds typically affected by an incident and their relative contribution to overall losses to straying are unknown.

An investigation of race routes and the extent and nature of incidences of scattering and their impact was outwith the scope of the current study, due to budgetary limitations. Such an investigation would require substantial monitoring effort and costly GPS-based tracking equipment. Recent advances in the development of micro-GPS transmitters have enabled devices to be fitted to homing pigeons to record individual flight paths. Studies using a combination of GPS technology and direct observation would elucidate many facets involved in straying and scattering. GPS-based tracking would enable the accurate mapping of actual homeward routes in terms of the direction and spread of flight paths, and the temporal and spatial location of incidents of straying. Direct observation could then be used to investigate the parameters involved at locations where straying has been identified.

Radio-tracking of sparrowhawks

GPS technology could also be used to investigate the ranging and hunting behaviour of sparrowhawks. Tracking sparrowhawks fitted with GPS tags would elucidate many facets concerning the role that racing pigeon lofts play in sparrowhawk foraging strategies, such as the extent to which sparrowhawks range in the vicinity of lofts, the number of lofts over which individual birds range, how specific habitat features are utilised when approaching lofts, and the relationship of these habitat features to attack frequency at individual lofts. Also, GPS data would provide a temporal and spatial plot of sparrowhawk activity, which could be related to loft-owners' records of losses.

Dietary analysis of peregrines

Peregrines exhibit a functional response to prey, so that the contribution of pigeon to the diet is related to the spatial and temporal availability of pigeons. Most dietary studies on peregrines, however, have been limited in respect to region or habitat, and were also mainly conducted many years ago. Most critically, studies investigated peregrine diet in general and were not designed specifically to assess the impact of peregrine predation on racing pigeons. There are concerns, therefore, about how representative the available dietary data is in respect to the present day. Studies are required that investigate peregrine diet in relation to the contemporary availability of racing pigeons and alternative prey. Such studies could provide reliable estimates for the various parameters required for a DFI-based estimation of the potential kill of racing pigeons (Annex 1). Coverage would need to be comprehensive and encompass regions throughout Scotland and England in which Scottish racing pigeons are available to peregrines.

Population dynamics – relationship between peregrine and racing pigeon populations

The inter-relationship between the population dynamics of peregrines and racing pigeons requires detailed investigation. Peregrine numbers and breeding success vary regionally but it is not known to what extent racing pigeon availability affects the various parameters of regional peregrine populations. Such an investigation would require detailed data on regional variation in racing pigeon numbers with respect to both permanent (lofts) and transient availability of birds (races) to peregrine predation.

Quantifying losses of racing pigeons to goshawks

This current study did not address the issue of goshawk predation on Scottish racing pigeons. Marquiss and Newton (1982), showed that goshawk diet varied with altitude and reflected variation in prey availability; feral pigeon/rock dove comprised up to 14.9% of the prey items recorded at nest sites (mostly upland areas) throughout Britain, during March to August 1974-1980. Also, in upland Britain (1977-1983), Cooper and Petty (1988) estimated that feral pigeons comprised 34% of goshawk prey remains. In Central Wales (1991-1993) feral pigeon comprised 5.3% of the prey items collected at goshawk nest sites, during March to September (Toyne 1998). In regions where goshawk numbers exceed that of peregrines or sparrowhawk there is the potential for goshawks to be the major predator of racing pigeons. The magnitude and extent of goshawk predation of Scottish racing pigeons, therefore, needs to be investigated.

Deterrents

Guidelines for deployment of deterrents

Guidelines should be drawn up outlining the recommended techniques for maximising the potential effectiveness of existing loft-based deterrents. That is, deterrents should be realistic, unpredictable, threatening, supplemented and deployed in an integrated manner.

Trials of loft-based deterrents

The present study has highlighted several deterrent techniques that could be tested in field-trials, including mirrors/reflectors (especially Mylar tape), animated models and bioacoustics.

Field trials must be designed carefully to take into account variation in the potential level of raptor attack between different lofts. The experimental design, therefore, should either match deterrent and control lofts for attack frequency (which is related to proximity to woodland), or if attack rates are sufficiently frequent compare attack rates at the same loft during periods of deployment and non-deployment of the deterrent.

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ANNEX 1:

Method for estimating the potential peregrine kill of Scottish racing pigeons based on the daily food requirements of peregrines

An estimate for the potential number of Scottish racing pigeons killed by peregrines can theoretically be derived from calculations based on the daily food intake (DFI) of peregrines. Using this approach, Ratcliffe (1993) estimated an annual kill of 224,447 domestic pigeons (feral/racing/rock dove) for the whole of Britain. Redpath and Thirgood (1997) refined this methodology by calculating peregrine prey biomass requirements individually for incubation, nestling and post-fledgling phases in their estimation of peregrine predation on grouse.

Using this approach, the estimation of the potential number of Scottish racing pigeons killed requires a four stage calculation:

(i) Estimation of peregrine total seasonal prey biomass.

number of peregrines	**x**	**daily food intake (DFI)**	**x**	**days**	**=**	**total seasonal prey biomass**

(ii) Estimation of the proportion of the total seasonal prey biomass which is comprised of domestic pigeon.

total seasonal prey biomass	**x**	**proportion diet which is domestic pigeon**	**x**	**correction factor for over-representation of domestic pigeon in prey remains**	**=**	**wt. domestic pigeon in total seasonal prey biomass**

(iii) Estimation of the number of racing pigeons which comprise the domestic pigeon biomass component of peregrine total seasonal prey.

wt. domestic pigeon in total seasonal prey biomass	**÷**	**mean wt. domestic pigeon**	**=**	**total domestic pigeons killed**	**x**	**propn. of domestic pigeons killed which are racing pigeons**	**=**	**total racing pigeons killed**

(iv) Estimation of the number of racing pigeons in the total kills of racing pigeons which originated from Scottish lofts.

total racing pigeons killed	**x**	**propn. of racing pigeons killed which are Scottish racing pigeons**	**=**	**total Scottish racing pigeons killed**

In Ratcliffe's (1993) calculation, a single mean value for the percentage of peregrine diet comprised of pigeon was used across Britain as a whole. Due to variation in peregrine diet between different regions (Table 1) a more refined approach would be to determine estimates separately for each individual region in which Scottish racing pigeons are predated by peregrines (Figure 1). As studies of peregrine diet, however, have been conducted in only five of the 15 regions in Britain in which Scottish racing pigeons are available to peregrines, it was also necessary to adopt the approach of deriving a single nationwide estimate.

Table 1. Contribution of domestic pigeons to the summer diet of peregrines, assessed from prey remains, in different National Peregrine Survey census regions.

Region	% Pigeon in Diet		Source
	Number	Weight	
Highlands	31	31	Redpath & Thirgood 1997
Dumfries & Galloway	49	70	Mearns 1983
Dumfries & Galloway (Langholm)	55	64	Redpath & Thirgood 1997
Cheviots	36	51	Dixon (in press)
NW England - inland	53	77	Ratcliffe 1993
Pennines	46	47	Redpath & Thirgood 1997

Each parameter, and the associated available data, required in each of the four stages of the derivation of a nationwide estimate of peregrine kills of Scottish racing pigeons are discussed below:

(i) Estimation of peregrine total seasonal prey biomass

Number of peregrines

From the 2002 National Peregrine Survey the total numbers of breeding pairs, non-breeding pairs and single birds on territory in the 15 relevant census regions (Figure 1) are 630, 65 and 93 respectively (Table 2). A further 255 non-territorial single birds were estimated for these regions. Breeding success was assumed to be an average of 2 nestlings per territorial pair for 14 days (total 1390 nestlings) with a fledging rate of 1.2 per territorial pair (total 834 fledglings).

Table 2. Numbers of peregrines in different regions of Scotland and England in which Scottish racing pigeons are available to peregrines. Data from the 2002 National Peregrine Survey.

Region	Territories Occupied			No Territory
	Breeding pairs	Non-breeding pairs	Single birds	Single birds*
Highlands	83	6	31	14
Argyll	49	8	16	13
NE Scotland	54	2	3	25
Tayside	71	13	14	28
Central	28	5	4	13
S. Strathclyde	27	4	3	13
Lothian & Borders	36	5	6	15
Dumfries & Galloway	74	0	4	33
Cheviots	21	2	0	12
NW England - inland	62	8	7	28
NE England - coastal	6	0	0	3
NE England - inland	4	0	0	2
Pennines	73	7	4	36
Central Eastern England	7	2	0	5
Southeast England	35	3	1	18
	630	65	93	255

* One single peregrine assumed for each pair (UK Raptor Working Group 2000)

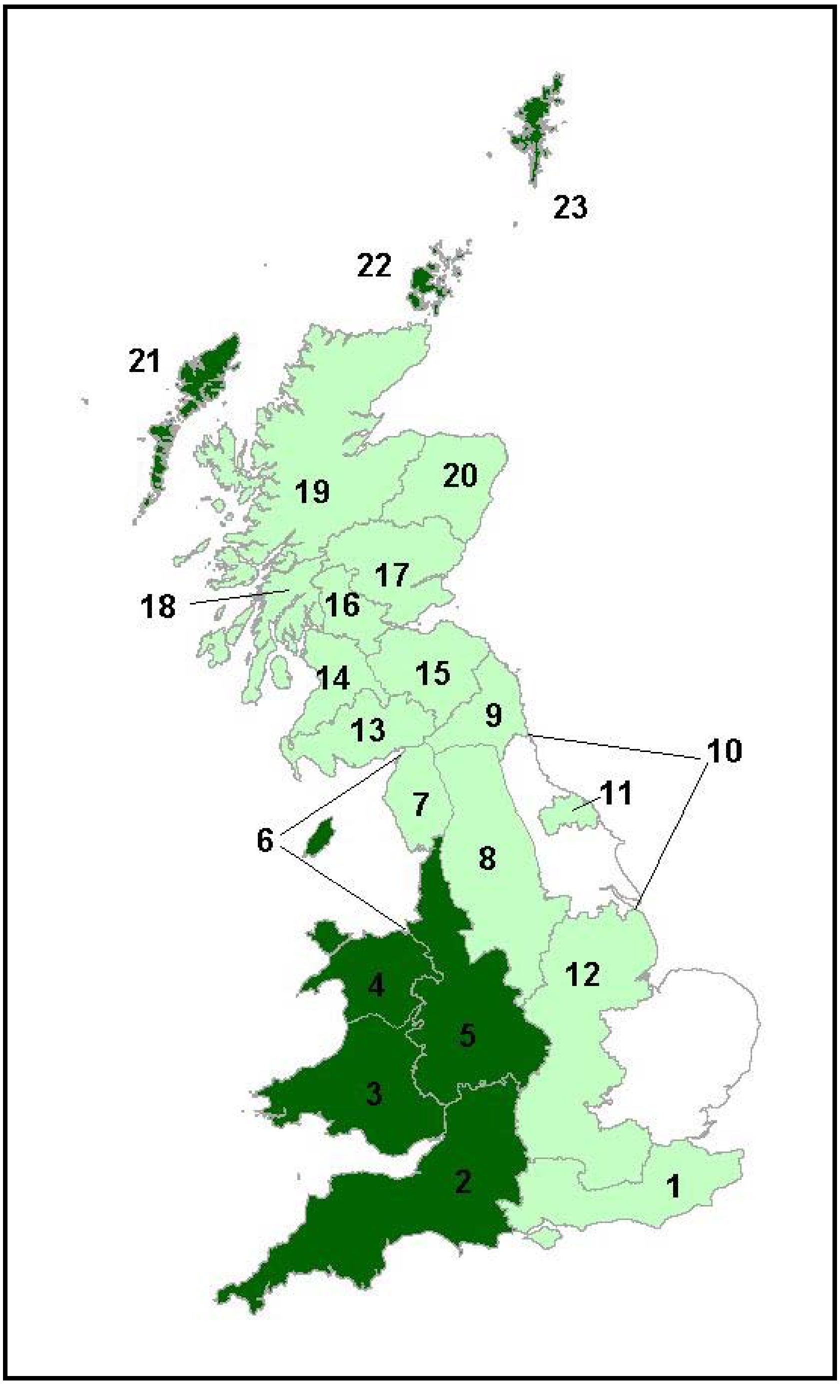

Figure 1. National Peregrine Survey census regions. 1. South-east England, 2. South-west England, 3. South Wales, 4. North Wales, 5. West Midlands & Lancashire Lowlands, 6. North-west England coast & Isle of Man, 7. North-west England inland, 8. Pennines, 9. Cheviots, 10. North-east England coast, 11. North-east England inland (North York Moors), 12. Central Eastern England, 13. Dumfries & Galloway, 14. South Strathclyde, 15. Lothian & Borders, 16. Central Region, 17. Tayside, 18. Argyll, 19. Highland Region, 20. North-east Scotland, 21. Western Isles, 22. Orkneys, 23. Shetlands, 24. Northern Ireland.

🟩 **Regions in which Scottish racing pigeons are available to peregrines – assessed from the locations of lofts and race routes.**

🟩 **Regions in which Scottish racing pigeons are not available to peregrines – assessed from the locations of lofts and race routes.**

Daily Food Intake (DFI)

Redpath & Thirgood (1997) calculated from prey delivery rates that 222g of food was delivered per nestling (and dependent fledgling) per day and that an adult peregrine used 188g of prey per day. These values are based on the amount of prey delivered to the nest and thus make no assumptions about prey wastage

Days

Adult DFI is assumed to be constant throughout the breeding cycle, and hence an adult food requirement of 188g per day is used throughout the 183 day duration of the racing pigeon season (1st April to 30th September). For young, however, the DFI will change over the rearing period. Peregrine chicks remain in the nest for 5 to 6 weeks, and can continue to be fed at the same rate by parents for up to two weeks after fledging (Ratcliffe 1993). It was assumed, therefore, that young consumed more than their parents for 8 weeks. Peregrines have a mean first egg date of 8th April, a seven day laying period for an average four egg clutch, a mean incubation period of 31 days and a mean nestling period of 42 days (Figure 2). Fledged young are dependent on their parents for a further 14 days. Thus, fully independent young are present for 85 days before the end of September. Young peregrines, therefore, will have a DFI of 222g for a period of 56 days, and a DFI of 188g for 85 days during the pigeon racing season.

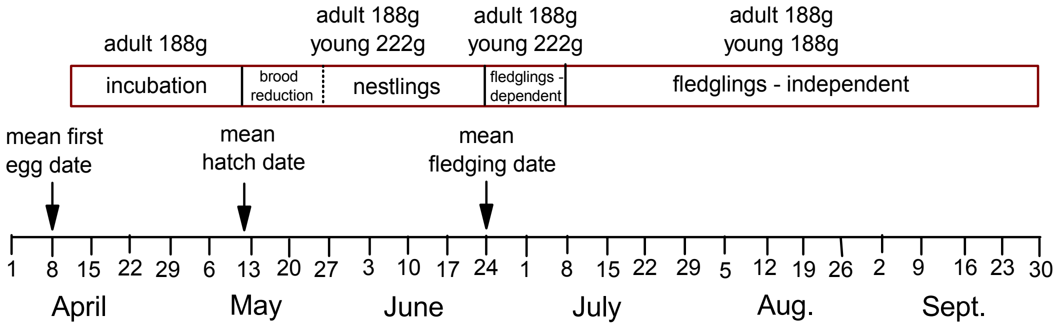

Figure 2. Peregrine breeding cycle relative to the racing pigeon season (April – September). The mean first egg date is 8th April. The mean clutch size is four, with eggs laid at 24 hour intervals. Mean incubation period is 31 days and the mean hatch date is 12th May. Nestlings remain in the nest for a mean of 42 days. Any brood reduction usually occurs in the first two weeks of the nestling stage. The mean fledging date is 24th June. Adults continue to provide young with food during the first two weeks after fledging, after this young reduce their DFI to that of adults.

(ii) Estimation of the proportion of the total seasonal prey biomass which is comprised of domestic pigeon.

Proportion of diet - that is domestic pigeon

There have been several studies of the summer diet of peregrines breeding in southern Scotland and northern England (Table 1) and most involved analysis of prey remains. The contribution of pigeon to the diet can be expressed numerically, which is the proportion of prey items that were pigeons, and by weight, which is proportion of prey biomass that was pigeon. The biomass contribution is usually higher than the numerical contribution because pigeons are heavier than most other prey species.

Correction factor for over-representation of domestic pigeon in prey remains

Analysis of prey remains, however, can give a biased estimate of diet, because some prey species are more likely to be found. For example, the large numbers of pale feathers of pigeons are more conspicuous and stay visible longer than the smaller numbers of dark feathers of passerines and this will tend to lead to an overestimation of their contribution to diet (e.g. Mearns 1983). By comparing the results of prey collections against observations of prey deliveries (generally considered to represent the most accurate method for determining diet), Dixon (2002) concluded that in south-central Wales, the actual contribution by numbers of domestic pigeons to the diet was 0.54 of that estimated by collecting prey remains. A similar correction factor can be derived using data collected at Langholm in southwest Scotland (Redpath & Thirgood 1997). The observations at Langholm suggested that, from prey delivered to the nest, pigeons constituted about 0.65 to 1.0 of the diet as estimated from collecting prey remains. From this it can be tentatively concluded that collection of prey remains gives about 0.83 of the actual diet of peregrines by weight. Hence, assuming that collecting prey remains overestimates the contribution of pigeons to peregrine diet, if, for example, 60% of diet by weight is estimated to be domestic pigeon from analysis of prey remains, the actual contribution to the diet is about 50% (i.e. 60% x 0.83).

Mearns & Newton (1988) found no difference in diet according to breeding status, suggesting it is reasonable to assume that the summer diet of non-breeding birds is similar to the diet of breeding birds.

(iii) Estimation of the number of racing pigeons which comprise the domestic pigeon biomass component of peregrine total seasonal prey.

Mean weight of a domestic pigeon

A mean weight for a domestic pigeon of 375g was assumed (Dixon & Richards 2003).

Proportion of domestic pigeons killed which are racing pigeons

Dixon (2002) estimated that, in south-central Wales, 92% of all domestic pigeons killed were racing pigeons.

(iv) Estimation of the number of racing pigeons in the total kills of all racing pigeons which originated from Scottish lofts.

Proportion of all racing pigeons killed which were SHU birds

The final stage of the calculation involves estimating the number of racing pigeons killed which originated from Scottish lofts. The current CSL study found that in 59 eyries searched in the study area the percentage of recent rings (1997-2002) that were Scottish ranged from 37% to 88% (mean = 63%) across the five regions surveyed.

Reliability of the available data

There are a total of eight parameters involved in a DFI-based estimation of the potential peregrine kills of Scottish racing pigeons. Available data on peregrine numbers, daily food requirements, days and the mean weight of a domestic pigeon are considered to be relatively reliable. There are serious concerns, however, over the applicability or representativeness of the available data associated with the other four parameters: the proportion of peregrine diet that is domestic pigeon, the correction factor for over-representation of pigeon in prey remains, the percentage of all pigeons killed that are racing pigeons, and the percentage of all racing pigeons killed that originated from Scottish lofts. Specific limitations are discussed below:

Proportion of diet that is domestic pigeon

Most of the studies on peregrine diet are likely to have overestimated the dietary contribution of domestic pigeons by weight due to: (i) using 425g as the weight for a domestic pigeon which is probably too high, and/or (ii) excluding months at the beginning and end of the pigeon racing season as ‘summer’ when the contribution of domestic pigeons to diet was lower. Also, these studies estimated the contribution of pigeon to diet from samples of prey remains pooled from a number of eyries. Care is required, however, in sample selection to ensure that eyries are included that are associated with the entire range of variation in the availability of racing pigeons. Dietary studies to date have sampled with respect to peregrines’ general diet rather than to racing pigeons specifically.

In addition to the inherent methodological bias behind the available estimates of the contribution of pigeon to peregrine diet, there are serious concerns over how representative past estimates are to peregrine diet in the present-day. Peregrines have been shown to exhibit a functional response to prey in relation to red grouse (Redpath & Thirgood 1999) and racing pigeons (Richards & Shrubb 1999; Dixon *et al*. 2003, Dixon *et al*. unpublished). That is, the proportion of these species in peregrine diet has been shown to vary with their availability. For racing pigeon, its relative frequency in peregrine diet has been shown to vary both temporally and regionally (Dixon *et al*. 2003, Dixon *et al*. unpublished). Estimates for the percentage of peregrine diet, during the summer, comprised of domestic pigeon vary between studies, from 31% in the Highlands (Redpath & Thirgood 1997) to 77% in NW England (Ratcliffe 1993).

Although, regional variation would be expected as a consequence of the peregrine’s functional response to prey, there are temporal implications in respect to the correlation between peregrine diet in the past and present day. If the relative numbers of racing pigeons and feral pigeons/rock doves or other prey available to peregrines has changed in regions where diet studies have previously been conducted, then it is possible that the racing pigeon constituent of the diet may also have changed. Such changes in the numbers of racing pigeons are known to have occurred through changes in training and race routes, and from the numbers of fanciers in the sport declining over the years. Therefore, there is a potentially significant degree of uncertainty over the current veracity of the available dietary data and its application in any present-day calculations.

Correction factor for over-representation of domestic pigeon in prey remains
The conversion factor to correct for the over-representation of domestic pigeon in the analysis of prey remains has only been determined in two studies, one of which was conducted in Wales, where small passerines were the main alternative prey to pigeons. This may be similar to some Scottish or English regions, but it is clearly not similar in others, as suggested by the findings at Langholm where alternative large prey, particularly grouse were available (Redpath & Thirgood 1997). It is, therefore, unclear how representative these estimates are, and how the correction factor may vary between different regions and habitats. It may also vary within regions and habitats according to the search regime used to determine diet from prey remains. In addition, there are no reliable estimates for the number of prey items deposited away from the eyrie, which may be biased to prey species of a specific size range. Dixon (2002) suggests that it is likely that virtually all of the larger prey will be brought back to the nest site.

Proportion of domestic pigeons killed which are racing pigeons
Dixon (2002) estimated that, in south-central Wales, 92% of all domestic pigeons killed were racing pigeons. This estimate, however, was derived from a sample of only 30 pigeon carcasses. Several lines of evidence suggest that it is highly likely that the percentage of all pigeons killed which are racing pigeons is lower in Scotland than in south-central Wales. Firstly, in South Wales the majority of pigeon lofts are in much closer proximity to peregrine territories than is the case in Scotland. Virtually every racing pigeon club in South Wales is centred within 8km of a peregrine eyrie, with a median of four eyries per club (Dixon *et al*. unpublished). Secondly, there may be greater availability of alternative pigeon-prey in central and southern Scotland (where the majority of Scottish lofts are located) than in south-central Wales. The distribution and abundance of feral pigeons and rock doves is greater across racing pigeon regions in southern Scotland than in south-central Wales (Gibbons *et al*. 1993). Also, in the BTO's Garden Bird Watch survey the reporting rate for feral pigeons is twice as high in southern Scotland compared to Wales. For the Highlands and Argyll, in particular, the availability of racing pigeons to peregrines is likely to be markedly lower than in South-central Wales and other regions of Scotland. In these two Scottish regions, which have relatively high peregrine populations, there are relatively very few racing pigeons lofts.

Consequently, there are concerns in extrapolating Dixon's (2002) estimate of 92% of pigeons in peregrine diet being racing pigeons to Scottish regions. No other data are available.

Proportion of all racing pigeons killed which are SHU birds
The final stage of the calculation involves estimating the number of racing pigeons killed which originated from Scottish lofts. The current CSL study found that in 59 eyries searched in the study area the percentage of recent rings (1997-2002) that were Scottish ranged from 37% to 88% across the five regions surveyed. With such a range in the relative occurrence of Scottish rings between regions there are concerns in extrapolating data to unsampled regions. Ideally, estimating the number of Scottish racing pigeons killed should also account for any that were killed when they were effectively lost to owners (race-strays and/or race-ferals).

Estimates of potential peregrine kills of Scottish racing pigeons derived from the DFI-based calculations

Of the eight parameters, four could be quantified with some accuracy (Table 3), while the remaining four could only be estimated within wide bounds (Table 4). For these latter four parameters, the probable upper and lower limits within which realistic values were likely to lie were estimated. Distributions based around these upper and lower limits were then used in a series of 375 simulations to examine the uncertainty inherent in using this approach to estimate loss. This analysis produced a very wide range of estimates for total loss but indicate that the figure is likely to lie between 7,820 (2.3%) and 117,581 (34.5%) Scottish racing pigeons. The distribution of the estimates is highly skewed to the left, i.e. toward lower numbers of potential kills (Figure 3). These estimates would also include stray birds.

This analysis illustrates the high degree of uncertainty associated with the use of these figures. **Given this high range of uncertainty we believe it would be unwise to attribute any significance to any specific values within the range of estimates derived.** However, it may be possible to refine these parameter estimates in future to reduce the inherent uncertainty in this approach, and hence narrow the range of estimates produced.

Table 3. Values for the four parameters which could be quantified with some accuracy used in a series of DFI-based simulations to estimate the potential number of Scottish racing pigeons killed by peregrines.

Parameter	Category	Value
Number of peregrines	Breeding pairs	630
	Non-breeding pairs	65
	Single	348
	Young (dependent) *	1390
	Young (independent) **	834
Daily food intake (g/day) of	Adult	188
	Young (dependent)	222
	Young (independent)	188
Days present ***	Adult	183
	Young (dependent)	56
	Young (independent)	85
Mean weight of domestic pigeon (g)		375

*/** Assumes a mean of 2 young hatched per territorial pair and all surviving for 14 days but then numbers of young decreased through brood reduction to a mean of 1.2 young per territorial pair fledged.

*** Number of days that adult and young peregrines are present during the 183 day racing pigeon season.

Table 4. Values for the four parameters whose accuracy was uncertain but nonetheless used in a series of DFI-based simulations to estimate the potential number of Scottish racing pigeons killed by peregrines.

Parameter	Values used in the analysis
% peregrine diet that is pigeon derived from prey remains *	31, 45, 57, 65, 77
Correction factor for over-representation of pigeon in prey remains **	0.60, 0.70, 0.83
% of all pigeons killed that are racing pigeons **	50, 60, 70, 80, 92
% of all racing pigeons killed that are estimated to be Scottish birds *	37, 50, 63, 75, 88

* minimum and maximum value from empirical data
** maximum value only from empirical data

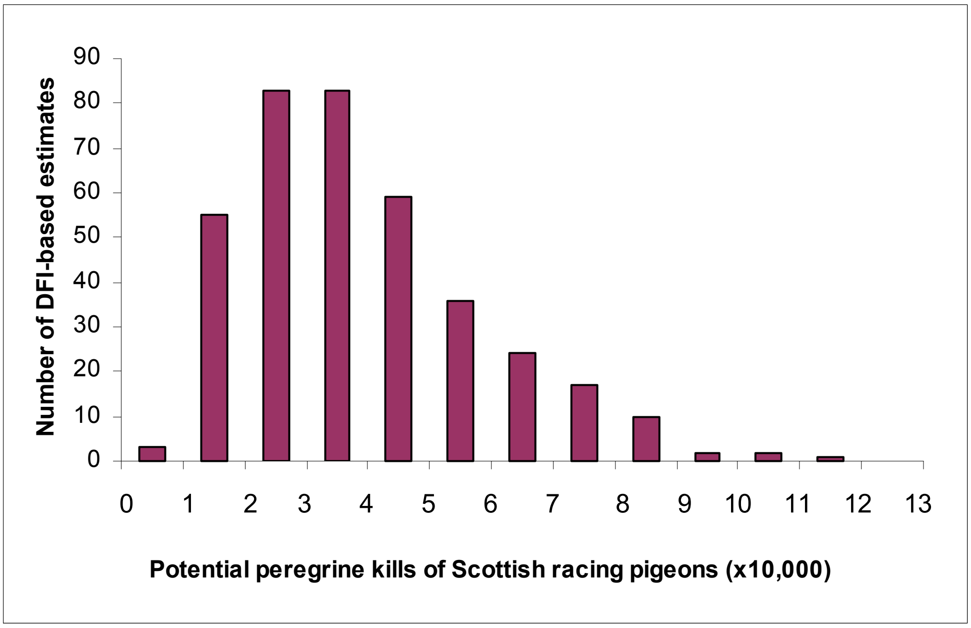

Figure 3. Frequency distribution of the estimates derived from DFI-based calculations of the potential number of Scottish racing pigeons killed by peregrines throughout Britain during the racing pigeon season.