

A review of the status and decline in abundance of the Irish Hare (*Lepus timidus hibernicus*) in Northern Ireland

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ABSTRACT

The Northern Ireland Hare Survey documented the distribution of the Irish Hare (*Lepus timidus hibernicus*). Historical game bag records and other, more contemporary, records of hare distribution were examined. These data indicate how numbers of *L. t. hibernicus* may have changed over the last 140 years. The results of the Northern Ireland Hare Survey suggested that *L. t. hibernicus* was widespread throughout Northern Ireland. Current average densities are no more than 0.65 hares/km². Game bag records indicate that hare densities may have been much higher in the past, with a maximum of 138 hares/km² recorded on Crom Estate, Co. Fermanagh, in 1864. Evidence from hare distribution recorded during the Northern Ireland Rabbit Survey indicates that hare numbers declined between 1984 and 1994. Evidence from all sources suggests that *L. t. hibernicus* has declined in abundance substantially, with present total population estimates for Northern Ireland ranging from 8250 to 21000 individuals. Flushing data indicate that rushes and hedgerows are important diurnal resting areas for hares. While the principal reason for the decline in numbers of *L. t. hibernicus* in Northern Ireland is not clear, more species-rich pasture and provision of areas of cover, such as rushes, may arrest further declines, or indeed promote numbers of hares, particularly in lowland areas.

Keywords: flushing data, game records, Irish Hare, *Lepus timidus*, survey

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INTRODUCTION

The Irish Hare (*Lepus timidus hibernicus*) is endemic to Ireland. Unlike the Scottish Mountain Hare (*L. t. scoticus*), *L. t. hibernicus* is found in habitats ranging from sea level (Wolfe, Whelan & Hayden, 1996) to mountain top (Walker & Fairley, 1968). Until the completion of the Northern Ireland Hare Survey (Dingerkus & Montgomery, 1997) there were very few reliable data for the distribution and abundance of *L. t. hibernicus*. Previous studies lacked stratified survey techniques and systematic or randomized sampling programmes (Arnold, 1978; Ní Lamhna, 1979; Anonymous, 1993). Hence, early surveys are not suitable baselines against which to measure changes in distribution and abundance of hares. Nor can they ascertain what might have happened in the past.

The present study investigated recent distribution and abundance of *L. t. hibernicus* using data from the Northern Ireland Hare Survey (Dingerkus & Montgomery, 1997) and previously unpublished survey data. Hare numbers are low. Game bag records suggest changes that may have occurred over the last 140 years. Other data collected during the survey indicate important requirements of hares, especially in relation to shelter characteristics, which assist in interpretation of distribution data and may indicate how to arrest further decline in abundance.

METHODS

Hare records: historical data from three sources

Unlike Britain, there is no centralized collection of game bag records in Northern Ireland. Records, therefore, are patchy and scarce. However, through contacts with estates, the Ulster Museum and the Public Records Office, the following records were found: Clondeboye Estate (national grid reference J480795, 1856–1865); Parkanaur Estate (H739615, 1876–1954); Castle Archdale Estate (H175590, 1859–1941); Finnebrogue Estate (J482473, 1875–1886); Castlecoole Estate (H258431, 1863–1895); Crom Estate (H368245, 1858–1864) and Mountray Estate, also known as Favour Royal (H612515, 1928–1933).

The Northern Ireland Rabbit Survey, carried out by the Department of Agriculture for Northern Ireland, was based on a survey of 12 randomly selected 1-km² areas from each of the six Northern Irish counties. The same 72 squares were surveyed each year over a 9-year period, 1986–94. In each square, a 2.25-km transect was chosen following field boundaries. Each transect was split into 3075-m lengths, along which evidence of the presence of rabbits or hares was recorded (A. Bell, unpublished data).

The Northern Ireland Badger Survey, conducted between 1990 and 1993 (Feore, 1994), was a systematic survey based on selected 1-km² areas (each square at the south-west corner of each 10 km² of the National Grid). Hares were recorded if observed, if evidence was observed, or if farmers confirmed presence in the area.

Flushing data from Northern Ireland Hare Survey

For details of the techniques used in the Northern Ireland Hare Survey see Dingerkus & Montgomery (1997). Details for all hares flushed were recorded during the survey. These were flushing distance (i.e. the distance between the observer and the hare when it was flushed from its form), the habitat in which the hare was observed and the specific type of vegetation from which the hare was flushed. Habitat type in the 1 km² was recorded fully in order to evaluate the selectivity of hares with respect to habitat. Habitat classifications were those used in The Northern Ireland Hare Survey, based on the Land Classification for Northern Ireland (Murray, McCann & Cooper, 1992). A goodness-of-fit test was used to assess whether hares used habitats in relation to their availability. Habitat types were grouped together to form sta-

tistically more reliable larger groups. The groups included semi-natural grasslands, heath/bog habitats, semi-improved grasslands, improved grasslands and arable land, and finally forestry, including plantation conifers and broadleaf woodland. A Bonferroni Z -statistic was used to construct confidence intervals for habitat groups (Neu, Byers & Peck, 1974; Feore, 1994). The form of the confidence intervals was as follows:

$$P_i - Z(1 - a/2k)(\sqrt{P_i(1 - P_i)/n}) \leq P_i \leq P_i + Z(1 - a/2k)(\sqrt{P_i(1 - P_i)/n})$$

(Neu *et al.*, 1974)

where P_i is the proportion of hares seen in the i th habitat category and n is the sample size or total number of hares seen. The Z -statistic ' a ' refers to the confidence interval used and k is the number of habitat groups. The level of significance was set at 80% (Feore, 1994).

RESULTS

Historical data – game records

The quality and extent of the game records from the seven estates varied considerably. Castle Archdale Estate records provided the most extensive records. Others had little annotation. Definite fluctuations in numbers were visible in all records, although how much these were due to actual fluctuations in hare densities is unknown (Dingerkus, 1997). Hares were either shot, netted or both. In all cases, numbers were combined. At Castle Archdale, the numbers recorded in any one year reached a peak in 1918–19, when more than 300 hares were removed (Table 1). Castlecoole records were for a period of 32 years, with a peak of 42 hares removed in 1 month. Records for Clandeboyne Estate suggested that there were few organized shoots, with most of the hares shot by the gamekeeper, probably as a pest rather than game (Dingerkus, 1997). The peak occurred in 1859 when over 120 hares were killed (Table 1). Records from Crom Estate only ran for a period of 7 years. Large numbers of hares were shot in 1864, when 621 hares were recorded as killed on the estate, 497 of them shot in November (Table 1). Large numbers were also shot on Finnebrogue Estate. Most hares were killed in December 1884, when 355 hares were shot. In general, Parkanaur Estate and Mountray Estate had lower numbers than the other estates (Table 1). Of all the estates, Crom had the record of the highest number of hares killed per km², followed by Finnebrogue and then Castle Archdale (Table 1). It is not clear in all the game books examined whether the deaths of hares recorded were only of those shot on the estates, so that the accuracy of density figures is uncertain.

Historical data – other records

The results of the Northern Ireland Rabbit survey are shown in Table 2. The average percentage of 1-km² areas recording hares present over the 9 years indicated that Co. Fermanagh had the highest (35.2%), while Co. Down (13%) recorded the least. There appeared to be a general decline in hare presence in the 72 1-km² areas surveyed over the 9-year period (Table 2) but there were large fluctuations in the data. To examine the relationship between hare presence and time period, tests of association between the presence or absence of hares and three periods, 1986–88, 1989–91 and 1992–94, were conducted. Proportionally fewer records of hares were found in the latter 3-year period in the overall data ($\chi^2 = 13.321$, d.f. = 2, $P = 0.001$) and data for Co. Fermanagh ($\chi^2 = 10.313$, d.f. = 2, $P = 0.006$) and Co. Tyrone ($\chi^2 = 9.947$, d.f. = 2, $P = 0.007$).

The distribution of positive records of hares from data collected during the Northern Ireland Badger Survey (S. Feore, unpublished data) indicated a widespread distribution

Table 1. Available game bag records from estates showing the length of game bag records, the maximum numbers of hares recorded (shot and/or netted), the year the maximum occurred, the minimum number recorded in any year, the year the minimum was recorded and the maximum number recorded for any one

Map number*	Estate	Approximate area km ²	Period of records	Maximum number in one year	Year of maximum	Minimum number in one year
1	Castle Archdale	4.5	1859–1941	323	1918–19	0
2	Castlecoole	4.0	1863–1895	98	1865	0
3	Clandeboyne	2.0	1856–1865	125	1859	4
4	Crom	4.5	1858–1864	621	1864	12
5	Finnebrogue	4.0	1875–1885	504	1884	48
6	Mountray	5.5	1923–33	13	1928	0
7	Parkanaur	2.5	1876–1954	37	1877–78	0

Table 2. The percentage of 1-km² areas recording hare presence in 12 squares from each county during the Northern Ireland Rabbit Survey, 1986–94 (A. Bell, unpublished data)

Year	Antrim	Armagh	Down	Fermanagh	Londonderry	Tyrone	Overall
1986	8.3	41.7	16.7	16.7	25.0	50.0	26.4
1987	16.7	16.7	0.0	83.3	25.0	50.0	31.9
1988	8.3	41.7	16.7	58.3	16.7	33.3	29.2
1989	16.7	8.3	8.3	50.0	16.7	33.3	22.2
1990	41.7	41.7	0.0	25.0	25.0	25.0	26.4
1991	25.0	41.7	16.7	33.3	33.3	41.7	31.9
1992	33.3	16.7	16.7	16.7	16.7	0.0	16.7
1993	16.7	16.7	25.0	25.0	8.3	8.3	16.7
1994	8.3	0.0	16.7	8.3	16.7	25.0	12.5
Overall	19.4	25.0	13.0	35.2	20.4	29.6	

Table 3. Percentage of habitat types from which hares were flushed during the Northern Ireland Hare Survey ($n = 67$). The differences in the sample numbers between this table and Fig. 3 reflect the fact that the importance of detailed habitat features was only realized and recorded in the second year of the survey

	Rushes	Tall grass	Short grass	Hedgerow	Stubble	Heather	Sedges
% of hares flushed	50	7	6	23	4	9	1

(Dingerkus, 1997). Hares were recorded as present in 34% of the squares surveyed, while evidence of hares or reported presence of hares was recorded in a further 6% and 16% of the squares, respectively. In the remaining squares, hares were recorded as absent (44%) (Fig. 5).

Northern Ireland Hare Survey

Hares were recorded as observed (32%), evidence found (15%), reported (16%) or absent (37%). In general, the present results suggest that, while *L. t. hibernicus* is widespread, densities are low throughout Northern Ireland (Fig. 1). Anecdotal evidence from landowners gathered during the survey indicated that the distribution of declines and extinctions of hares was also widespread (Fig. 2).

month and when that was, approximate area of estate and maximum number of hares killed per 1 km² per year. *Map number refers to Fig. 2

Year of minimum	Number year of last record	Maximum number in one month	Year and month	Maximum number per 1 km ²
1939–40	5	125	October 1923	72
During 12 year of records	0	42	November 1866	63
1856	7	?	?	25
1858	621	497	November 1864	138
1876	104	355	December 1884	126
1933	0	16	November 1928	2
Over 10 years	14	?	?	15

Table 4. Habitat selection of hares in 1-km² areas with hares observed. Confidence intervals, calculated using the Bonferroni Z-statistic, show habitat selection more or less than expected in proportion to habitat availability

Habitat types	Proportion of total area	Observed number of hares	Expected number of hares	Proportion observed in area	Lower confidence intervals	Upper confidence intervals
Semi-natural						
grassland	0.023	7	1.945	0.082	0.021	0.144
Heath/bog	0.244	20	20.768	0.235	0.141	0.330
Semi-improved	0.360	33	30.576	0.388	0.279	0.497
Improved	0.369	23	31.376	0.271	0.171	0.370
Forestry	0.004	2	0.335	0.024	-0.010	0.057

Hares flushed from rushes (*Juncus* spp.) on half of the occasions they were disturbed (Table 3). Hedgerows were also important diurnal lie-up sites for hares and accounted for nearly a quarter of habitats from which hares flushed. Grasses in total accounted for 13% of the habitats, and heather 9%, while the remaining categories were less important (Table 3). The habitat types of fields where hares were disturbed were collated into four categories, namely semi-natural grassland, heath/bog, semi-improved agriculture and improved agriculture. The majority of hares were flushed from areas of semi-improved agriculture (38%), with lower percentages being flushed from the other three categories (Fig. 3).

Habitats from which hares flushed were grouped into semi-natural grassland, heath/bog habitats, semi-improved grasslands, improved grassland and arable, and forestry. A goodness-of-fit test indicated that hares were not flushed from habitat groups in relation to the availability of those habitat groups ($\chi^2 = 23.885$, d.f. = 4, $P < 0.0001$). The Bonferroni Z-statistic was used to construct confidence intervals for each habitat group (Neu *et al.*, 1974). However, hares neither selected nor avoided habitat groups in relation to their availability (Table 4). The categories closest to significance were semi-natural grassland, which was favoured, and improved grassland, which was avoided.

The mean flushing distance was much greater in areas of improved agriculture than in any of the other three habitat categories, being nearly twice that of semi-improved agriculture, the next highest flushing distance (Fig. 4). The effect of habitat on flushing distance was sig-

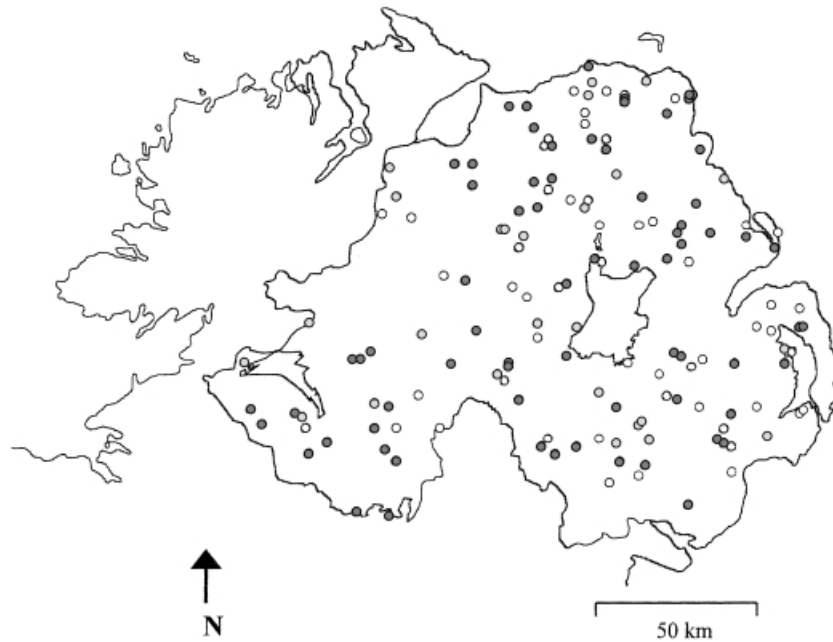


Fig. 1. The distribution of *L. t. hibernicus* from data collected during the Northern Ireland Hare Survey. Solid circles indicate where hares were observed or where evidence of hare presence was found. Grey circles indicate where hares were reported to be present by local landowners but no evidence was found. Open circles indicate where hares were absent.

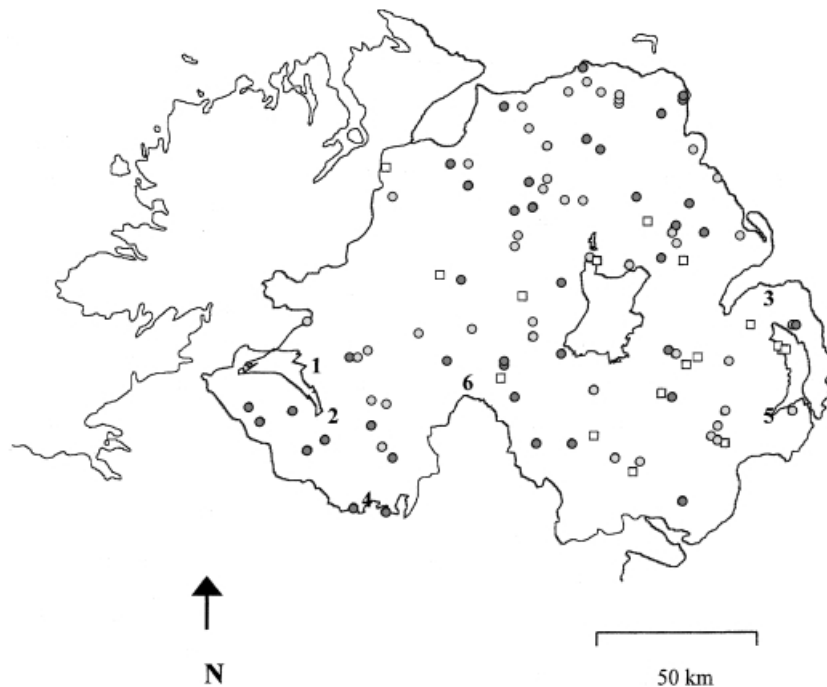


Fig. 2. The distribution of *L. t. hibernicus* declines and local extinctions from anecdotal evidence collected during the Northern Ireland Hare Survey. Open squares indicate 1-km squares where hares were reported as locally extinct. Grey circles denote squares where hares were reported to have declined in numbers in the last 10–20 years. Solid circles denote areas where hares were present and were not reported to be declining. The numbers indicate the location of the estates. 1, Castle Archdale; 2, Castlecoole; 3, Clandeboye; 4, Crom; 5, Finnebrogue; 6, Mountray; 7, Parkanaur.

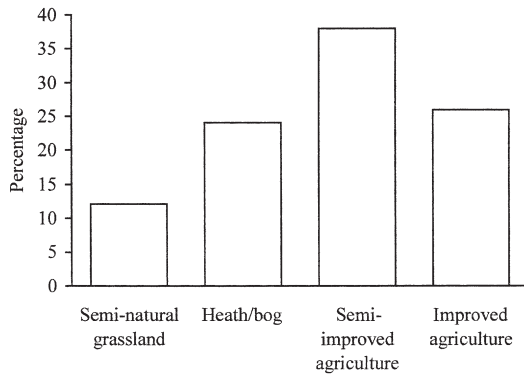


Fig. 3. Percentage of field habitat categories from which hares were flushed from during the Northern Ireland Hare Survey ($n = 90$).

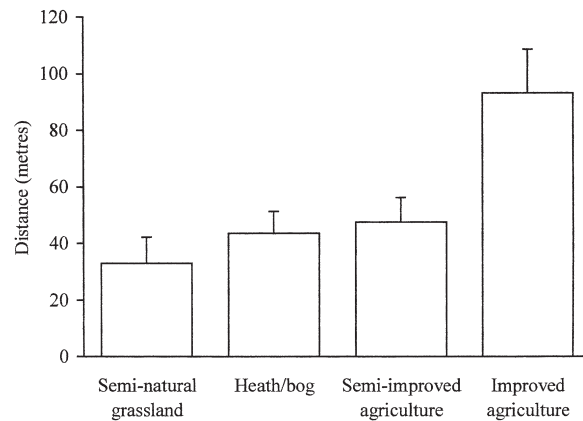


Fig. 4. Average flushing distances (SE) of hares in different habitat categories recorded during the Northern Ireland Hare Survey ($n = 90$).

nificant (Kruskal–Wallis, $\chi^2 = 13.52$, d.f. = 3, $P = 0.0036$). To examine habitat effect on flushing distance further, these categories were grouped into unimproved (semi-natural vegetation, heath/bog and semi-improved) and improved. There was a significant difference in flushing distances (Mann–Whitney U -test Z statistic = -3.57 , $P = 0.00036$), with shorter distances in semi-natural grassland and heath/bog (Fig. 4).

An estimate of the minimum numbers of *L. t. hibernicus* in Northern Ireland was calculated using mean densities in each of the eight land class groups (Table 5a). These means were based on the number of hares observed within each square. The maximum densities were recorded for land class groups II and VII, with the lowest densities recorded in III and IV. The minimum overall population estimated for Northern Ireland was just over 8250. It was also possible to estimate maximum numbers using the proportion of squares in any land class group where hares occurred, and maximum numbers of hares observed in any land class group. A population of 21 000 hares was calculated using this method (Table 5b).

DISCUSSION

While *L. t. hibernicus* was found to be widespread throughout Northern Ireland, there is evidence to suggest densities are low. The majority of sightings involved only one or two hares (Dingerkus & Montgomery, 1997). There is also evidence to suggest that hares are declining, and in some squares hares were reported to be locally extinct (Fig. 2). Evidence from game bag records suggests that densities were much higher in the last century (Table 1). Although limited in number and duration, the records suggest that hares occurred at high densities at least on some estates in the past. A maximum of 138 hares/km² was recorded as shot in 1864 on Crom Estate in Co. Fermanagh (Table 1). The use of game records to estimate hare populations overestimates densities (Hutchings & Harris, 1996). Estates are often managed in such a way as to favour hares and other game species.

Anecdotal evidence from farmers suggests that hare numbers were also higher 20 years ago (Dingerkus, 1997). The Northern Ireland Rabbit Survey suggests that numbers were still declining during the 1980s, possibly stabilizing in the 1990s (Table 2). This is supported by the findings of the Northern Ireland Badger Survey (1992–94), which had similar results to

Table 5a. A minimum estimate of the number of *L. t. hibernicus* in Northern Ireland using the area of each of the eight land class groups in Northern Ireland and the approximate hare density in each land class group. Habitat data adapted from Cooper, Murray & McCann (1992)

Land class group	Description	Area km ²	Percentage area of Northern Ireland	Mean hare density per km ²	Estimated hare numbers
I	Drumlin farmland	2350	17.4	0.6	1355.8
II	Lakelands	589	4.3	1.0	589.0
III	Marginal lowlands	1591	11.7	0.2	334.9
IV	Central lowlands	2080	15.4	0.3	668.6
V	Marginal uplands	2462	18.2	0.6	1515.1
VI	Settled uplands	1891	14.0	0.8	1512.8
VII	High uplands	1454	10.7	0.9	1342.2
VIII	Mountains	1127	8.3	0.8	939.2
Total		13544	100	0.6	8257.5

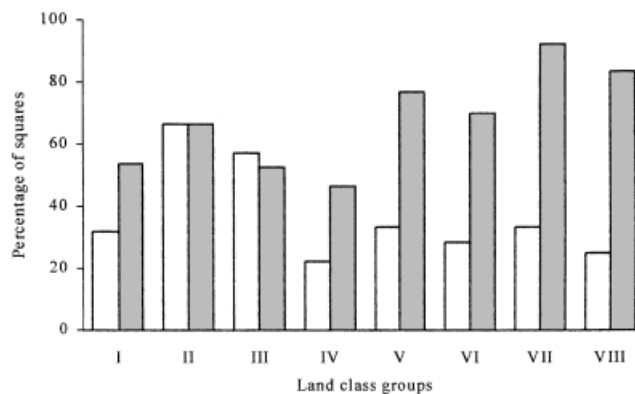
Table 5b. A maximum estimate of the number of *L. t. hibernicus* in Northern Ireland, using the maximum number of hares seen in any 1-km² area within a land class group and the percentage of squares within each land class group recording hare observations

Land class group	Maximum number observed in 1 km ²	Area km ²	% of squares with hare observations	Total number of hares
I	5	2350	26.9	3163.5
II	3	589	66.7	1178.0
III	2	1591	15.8	502.4
IV	4	2080	17.9	1485.7
V	4	2462	30.8	3030.2
VI	7	1891	50.0	6618.5
VII	4	1454	46.2	2684.3
VIII	6	1127	33.3	2254.0
Total		13544		20916.6

the Northern Ireland Hare Survey (1994–96) (Dingerkus & Montgomery, 1997) (Fig. 5). A likely scenario is that numbers of hares declined during the late 1800s and early 1900s and again during the last 20–40 years.

The reasons for the very low densities of *L. t. hibernicus* found in the Northern Ireland Hare Survey are unknown. It is unlikely that densities were always as low as at present since evidence from game bags suggests otherwise. There is contemporary evidence that *L. t. hibernicus* can occur at high densities. Areas of high density include Aldergrove International Airport (S.K. Dingerkus, personal observation) and Wexford Wildfowl Reserve (Jeffery, 1996). On the Wexford Wildfowl Reserve density estimates range from 24.5 to 126.6 hares/km² (Jeffery, 1996), much higher than found during the Northern Ireland Hare Survey. The Wexford Wildfowl Reserve may be experiencing high densities of *L. t. hibernicus* because it is managed in a way that benefits hares (Jeffery, 1996). At Aldergrove International Airport the grass is only cut once a year, there is no application of fertilizer, there is little human disturbance and the boundary fence reduces access to ground predators. In the Scottish Highlands, the grouse moors (where hare densities are highest; Watson & Hewson, 1973; Watson *et al.*, 1973) are also managed in a way that appears to benefit hares.

Fig. 5. A comparison of the percentage of squares recording hare presence (observed, evidence or reported) in data collected during the Northern Ireland Badger Survey (1991–93) (white bars) and the Northern Ireland Hare Survey (1994–96) (grey bars).



Lepus t. hibernicus requires some form of shelter or cover and access to adequate food. Shelter or cover is important to hares to give them protection from extreme weather conditions and to provide a place of concealment from predators (Thirgood & Hewson, 1987; Gray, 1993). For *L. t. hibernicus* rushes and hedgerows are among the most important diurnal resting sites (Table 3). These refuge areas are threatened by ‘land improvements’ (Lewandowski & Nowakowski, 1993). Field sizes have become larger in Northern Ireland consequent upon loss in hedgerows (Dingerkus, 1997). Between 1947 and 1977 over half the total agricultural land in Northern Ireland came under some kind of field drainage (Wilcock, 1979), hence reducing the abundance of rushes.

Lepus t. hibernicus may require habitats that provide a diversity of grasses. Up to 14 species of grass were found in faecal pellets of hares from a number of different sites in Northern Ireland (Dingerkus, 1997), and grasses occurred at high percentage frequencies (up to 94%) in faecal pellets (Wolfe *et al.*, 1996; Jeffery, 1996; Dingerkus, 1997). Diversity of grasses in agricultural fields has fallen, with farmers growing *Lolium* spp. because it grows and matures quickly and therefore is ideal for silage production (Donaghy & Mellon, 1998). Even the fact that the grass grows quickly may make it unpalatable for hares as there is evidence that hares consistently select short stock-free grass and avoid taller (> 30 cm) grass (Jeffery, 1996). Stocked pasture was avoided particularly when stock was present at high densities (Jeffery, 1996). The density of stocking has increased dramatically over the last 40 years, for example the Northern Ireland sheep flock grew from 870 000 in 1955 to nearly 2.5 million in 1995 (Donaghy & Mellon, 1998).

Intensification of agriculture may therefore have a role in the perceived decline in numbers of *L. t. hibernicus*. Data on hare populations from other countries suggest that agricultural change is a major factor in the decline of hare numbers, particularly *L. europaeus*, throughout Europe (Barnes & Tapper, 1982; Sostaric *et al.*, 1991; Hutchings & Harris, 1996). Although modern agricultural methods have been blamed for the decline in hare numbers (Barnes & Tapper, 1982; Tapper & Barnes, 1986; Meriggi & Alieri, 1989; Hutchings & Harris, 1996), actual proof is scarce (Meriggi & Alieri, 1989). In Ireland, agriculture has changed dramatically in the last four decades. Losses have occurred in mixed farmland and marginal land, particularly wet grassland and rough grazing (Donaghy & Mellon, 1998). From the 1950s onwards, silage production increased dramatically in Northern Ireland (Donaghy & Mellon, 1998). The increase in silage production is a general indication of intensification of agriculture. Increased yields of winter fodder have allowed increased stocking densities (Donaghy & Mellon, 1998).

The demise of the Corncrake (*Crex crex*) has also been linked to intensification of agriculture (Williams, Stowe & Newton, 1991). There are similarities between the declines of hare populations and Corncrake populations in Ireland. The decline in Corncrake populations was first noted at the end of the 19th century, became more widespread by the early 1900s (Norris, 1945, cited in Williams *et al.*, 1991), and by the 1950s, Corncrakes had become restricted to the islands of north and west Scotland and Co. Fermanagh in Northern Ireland (Williams *et al.*, 1991). Declines were also being experienced in other parts of Europe (Stowe & Hudson, 1988; Mellon, 1993). Habitat requirements of Corncrakes have some similarities to those of *L. t. hibernicus*. Mowing of meadows results in high chick mortality and nest destruction of Corncrakes (Stowe & Hudson, 1988). High stocking densities, particularly of sheep where pasture is grazed almost permanently, result in swards that are too short to provide cover for Corncrakes (Williams *et al.*, 1991). Habitat change and increased use of machinery have led to the loss of suitable places for Corncrakes to breed and may have had a similar detrimental effect on *L. t. hibernicus*.

It is concluded that *L. t. hibernicus* has suffered a decline in population levels, at least within the area studied, like many hare species throughout the world. It is possible that the decline in *L. t. hibernicus* is the direct result of intensification of agriculture through its reduction of diurnal refuge areas and variety of grass species available and increased stocking levels. Increased mechanization may also have increased mortality, especially among leverets, and there is also a possibility that other factors, such as predation pressure, may affect survival rates. Without further research, it is impossible to establish the principal reasons for decline in abundance of *L. t. hibernicus*.

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