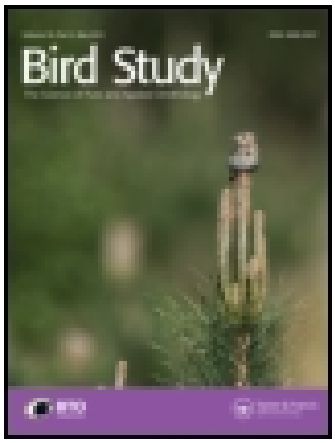

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Evaluating the success of translocating Red Kites *Milvus milvus* to the UK

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In an attempt to extend the breeding range of the Red Kite within the United Kingdom, 93 (48 males and 45 females) juvenile Red Kites, originating from Spain, Sweden and Wales, were released in southern England in 1989–94, and 93 (52 males, 40 females and one unsexed) juvenile Red Kites, originating from Sweden, were released in northern Scotland in 1989–93. Minimum estimates for first-year survival were 83.1% and 78.0% for male and female Red Kites in England, and 50.0% and 52.5% in Scotland, respectively. Annual survival then improved in the second and third years. Several sick or injured birds were recaptured, treated and returned to the wild, and some of these eventually bred. In their first year, birds released in Scotland tended to disperse greater distances than those released in England, females travelled further than males, and birds released during the early years dispersed further than those released during the later years. Successful breeding started in 1992 in England and Scotland. The mean age of first breeding was 1.9 years and 2.6 years for males and 1.8 years and 1.7 years for females in England and Scotland, respectively. There was a minimum of 59 clutches laid in England and 29 in Scotland in 1991–95. Clutch size averaged 2.9 (England) and 3.0 (Scotland), fledged brood size per breeding pair was 1.9 (England) and 1.6 (Scotland), and fledged brood size per successful pair was 2.3 (England) and 2.2 (Scotland). Demographic parameters were used to construct deterministic models for population growth. At current rates of growth, it is predicted that the English and Scottish populations will exceed 100 breeding pairs by 1998 and 2007, respectively.

The Red Kite *Milvus milvus* was once widespread within Great Britain but due to persecution in the past it is now very rare and, until recently, confined to central Wales.[1–3] It was exterminated from England by 1871 and from Scotland by 1879.[4] The population in Wales is now increasing[5] and reached at least 129 breeding pairs in 1996.[6] However, the capacity of this population to grow and spread outside Wales is hindered by its small size, relatively low breeding success, low rate of immigration from continental Europe and continued illegal persecution.

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Population re-establishment by translocation was considered as a means of restoring the former UK range of the Red Kite. This would reduce the vulnerability of the British population in the short term, and contribute to safeguarding the Red Kite on a global scale in the long term. Translocation has been used successfully to restore several bird of prey populations (e.g. Mauritius Kestrel *Falco punctatus*,[7] Griffon Vulture *Gyps fulvus*,[8] Peregrine *Falco peregrinus*,[9] Osprey *Pandion haliaetus*[10]). However, several past efforts to restore raptors in the UK by translocation have failed (e.g. Barn Owl *Tyto alba*,[11] Buzzard *Buteo buteo*,[12] Red Kite,[1] White-tailed Eagle *Haliaeetus albicilla*[13–15]), emphasising a need for careful planning and monitoring of the releases.

During the 1980s, there was much debate within conservation organizations concerning the translocation of the Red Kite into parts of its historical UK range.[16] In light of these discussions, it was agreed that the proposed project complied with international criteria for re-establishment[17] and could be undertaken. However, the potential range of the Red Kite in the UK is extensive,[1] and regional variations in land use and habitats have to be taken into account as they could influence population performance and viability. Consequently, the Joint Nature Conservation Committee and the Royal Society for the Protection of Birds established two release sites in 1989, one in southern England and another in northern Scotland, to assess whether translocated birds would survive to breeding age, breed successfully and develop sustainable populations. It was considered that populations established in lowland eastern districts of the UK would achieve higher rates of growth compared to Wales, and thereby potentially encourage a faster rate of population growth and range recovery in the UK.

This paper reports on survival data up to 1 July 1995 and to August 1995 on the breeding productivity in the two Red Kite populations established by translocation. Success of the translocation programme was based on whether the populations can grow and expand. Therefore, we have made predictions of growth rates and future population levels in England and Scotland.

METHODS

The Red Kites used in these translocations were from a number of sources. Seven chicks were hatched in captivity from eggs taken from nests in Wales. Nestlings were also obtained from southern Sweden and northeast Spain (Table 1) at about four to six weeks old and subsequently kept until fledged. There is no evidence of natural genetic differences between Welsh and Continental populations.[18] After collection, the Red Kites were reared in groups of two to four in quarantine aviaries until their release in July and August.[19–22] Those released in southern England were imported from Spain, Sweden and Wales, and those released in northern Scotland were from Sweden (Table 1).

To facilitate subsequent identification, a coded British Trust for Ornithology metal leg ring and patagial wing tags[21,22] were fitted to the juveniles prior to their release or fledging from nests. In addition, a TW2 Biotrack 19 g

Table 1. Number and country of origin of the Red Kites released during 1989–94 in England (E) and Scotland (S).

Area	*Origin*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*Total*	*Proportion of males*
E	Sweden	4	0	0	0	0	0	4	0.00
		(0,4)						(0,4)	
E	Wales	1	2	4	0	0	0	7	0.29
		(0,1)	(1,1)	(1,3)				(2,5)	
E	Spain	0	11	11	20	20	20	82	0.56
			(7,4)	(5,6)	(9,11)	(12,8)	(13,7)	(46,36)	
E	Total	5	13	15	20	20	20	93	0.52
		(0,5)	(8,5)	(6,9)	(9,11)	(12,8)	(13,7)	(48,45)	
S	Sweden	6	19	20	24	24	0	93	0.57
		(4,2)	(11,8)	(13,7)	(12,12)	(12,11)		(52,40)*	

Numbers of males and females are given in parentheses (males, females). *One bird in Scotland was not sexed.

radio-transmitter[22,23] was mounted on the central tail feathers of each bird released between 1989 and 1993, allowing monitoring for up to 12 months over a maximum range of 40 km. Blood samples were taken for genetic assessment, sex determination and health monitoring.

Birds fitted with a radio-transmitter were located using a hand-held directional three-element Yagi antenna attached to a 173 MHz band receiver.[24] Searches were undertaken by car with a roof-mounted omnidirectional whip antenna, whilst in Scotland additional aerial searches were undertaken occasionally from a light aircraft.[24] Individuals fitted solely with wing tags were located at communal roosts (mainly October to February) and breeding territories (February to August) as well as other areas on a casual basis by project fieldworkers and the general public.

Minimum annual survival values (expressed as a percentage of birds known to have survived from year n to $n + 1$) were determined from radiotelemetry data and wing tag observations for released and wild-raised birds. When a bird disappeared in a particular year, it was never detected later in a subsequent year. For this reason, a Pollock mark–resighting analysis[25] was not undertaken. Logistic modelling was carried out, testing the effects of factors and combination of factors on the probability of survival. Data for first-year birds in England were pooled for the 1989–94 cohorts, and in Scotland, the data were pooled from 1989 to 1993. For second-year birds, data were pooled for the 1989–93 cohorts in England and Scotland, while for third-year, fourth-year and fifth-year age groups, the data were pooled for 1989–92, 1989–91 and 1989–90 cohorts, respectively. Trends in survival rates for given age classes were also examined.

From 1991, we searched for potential breeders during February to May when pairs establish territories and indulge in aerial displays. Nest searches were undertaken from March when pairs begin building their nests.[26] All nests were probably located in 1989–94 in southern England and northern Scotland. In 1995, several nests were not detected in southern England but the nest survey was relatively complete in northern Scotland. When pairs occupied a territory or built a nest they were classified as 'territorial pairs'. 'Breeding pairs' refer to those that laid eggs. 'Successful pairs' refer to those which fledged at least one chick. Single males holding territories were also recorded. Daily clutch and brood survival was estimated using the Mayfield method.[27] Failures were assumed to have occurred midway between nest checks. Standard errors were obtained using the method of Johnson.[28] The proportion of nests that survived from laying to hatching was calculated by raising the daily survival rate to the power of 32 (the period of egg-laying and incubation[29]). Similar calculations were carried out for brood survival, assuming a period of 55 days between hatching and fledging.[30] Differences in the daily survival of clutches and broods between England and Scotland were tested for significance by using logistic models in which the outcome of each day that a clutch or brood was exposed to the risk of failure was regarded as the dependent variable and the country as a factor. Fidelity to nest site territory and mate was also assessed during 1991–94 in southern England and 1992–95 in northern Scotland.

Standard deterministic life table analyses[31,32] were undertaken to calculate the exponential growth rate and the annual multiplicative growth rate. The analyses assumed that reproduction was density independent. Simulations of population growth were undertaken from 1995 in southern England and from 1994 in northern Scotland, the year after releases had been suspended. The analyses utilized male and female first-year mortality estimates from the 1989–94 cohorts in England and from the 1989–93 cohorts in Scotland. Second-year mortality estimates were determined from the 1989–93 cohorts in both England and Scotland, and the age of first breeding was assumed to be two years old (i.e. when birds were in their third calendar year). All pairs were monogamous and all adult males (i.e. third-year or older) bred. Initial population size in England was based on the number of birds from the 1989–94 cohort surviving on 1 July 1995. In Scotland, initial population size was based on the number of birds from the 1989–93 cohorts surviving on 1 July 1994. Maximum life expectancy and adult survival are not yet available but were assumed to be 24 years[33] and 95%, respectively.[34] The life table analyses for England utilized 1992–94 brood size data (as 1995 data were incomplete) from 1989–92

cohorts, while for Scotland, brood size data from 1992–95 (all cohorts) were utilized. Additional analyses were carried out on the English dataset to assess the outcome of suspending releases in 1992 and continuing releases after 1994.

The 'birthday' of the Red Kites was taken as 1 July in each year. 'First-year' refers to Red Kites less than one year old. These can be identified by juvenile plumage characteristics.[35] During their second year (i.e. between one and two years old), Red Kites moult their flight and body feathers and lose their juvenile plumage. The 'adult' stage refers to Red Kites in their third year or older (i.e. at least two years old) as this is the time when they usually initiate breeding, although it may take up to seven years for birds to enter the breeding population in some circumstances.[34]

RESULTS

Sex ratio and survival

During 1989–94, 93 first-year Red Kites were released in southern England, of which 48 were male and 45 were female. In northern Scotland, the same number of first-year Red Kites was released during 1989–93, of which 52 were male, 40 were female and one was not sexed. Overall, the proportion of males released was 0.52 and 0.57, for southern England and northern Scotland respectively (Table 1).

In England, 80.4% of Red Kites that were released or wild-raised during 1989–94 survived their first year, while in Scotland, 51.6% of the birds released in 1989–93 survived (Table 2). Logistic analysis of the data for survival showed that these differences were significant ($\chi^2 = 6.2$, df = 1, $P < 0.02$). There was also a difference between the 1989–94 cohorts ($\chi^2 = 28.8$, df = 5, $P < 0.001$) with survival being higher during the latter part of the release scheme than during the earlier part (Table 3). There was no difference between the survival of male and female Red Kites, when tested either independently or in combination with other factors. Despite the lack of significant differences, the small differences in survival did result in changes in the sex ratio. In England, the loss of females in the 1989–92 cohorts changed the sex ratio from an excess of females at release to an equal number of males and females in the adult population in 1994. In Scotland, more males were released and this led to an imbalance in the sex ratio of adult birds in 1994. There was no difference in survival rates of released birds compared with naturally raised birds for those years (1992–94) when both groups of birds were present. This applied even when the effects of country and cohort had been accounted for in the analysis.

Second-year survival was also found to differ between countries, with English Red Kites surviving better than Scottish birds ($\chi^2 = 12.6$, df = 1, $P < 0.001$) (Table 2). However, there were no differences in survival between cohorts (Table 3). Second-year birds also had a significantly better survival rate than first-year birds ($\chi^2 = 14.4$, df = 1, $P < 0.001$) after the effects of country and year had been taken into account (Table 2). The survival of the older age groups was commonly 100% in England and Scotland. Clearly, a larger sample size is required to achieve more realistic estimates for adult survival.

In addition to the released birds, an immigrant adult female Red Kite bred with a released bird in the English study area during 1993–95 (P.J. Cordero, pers. comm.), while an immigrant juvenile Red Kite was observed with released and wild-raised birds in the winter of 1993/94.

Before 1 July 1995, a total of 14 Red Kites originating from the study area in England, and 17 originating from the study area in Scotland, were recovered dead. The majority of recoveries were birds in their first year. In both countries, birds found dead from natural or unknown causes were closer (median distance 3.8 km, range 1–272 km) to the release or nest sites than those which were poisoned (median distance 73.7 km, range 5.3–806 km) (Table 4). There was no additional significant effect of country or an interaction between country and cause of death.

Rehabilitation

Five Red Kites from the study area in southern England were captured and taken into captivity for veterinary treatment in 1989–94. Two (both in their first year) were not rehabilitated as one died before treatment from aspergillosis (Table 4) and the injuries of the other prevented rehabilitation. One Red Kite, of Welsh origin

Table 2. Annual minimum survival of each age-group of released and wild-raised fledged Red Kites for England and Scotland.

	Sex	*First-year*	*Second-year*	*Third-year*	*Fourth-year*	*Fifth-year*
England						
Released and wild-raised	Male	83.1%	96.8%	100%	100%	100%
		(71)	(31)	(20)	(10)	(4)
	Female	78.0%	92.5%	85.7%	100%	100%
		(82)	(40)	(21)	(7)	(1)
	Both sexes	80.4%	94.4%	92.7%	100.0%	100.0%
		(153)	(71)	(41)	(17)	(5)
	Cohorts	1989–94	1989–93	1989–92	1989–91	1989–90
Released	Male	83.3%	96.3%	100%	100%	100%
		(48)	(27)	(18)	(10)	(4)
	Female	68.9%	87.5%	80.0%	100%	100%
		(45)	(24)	(15)	(7)	(1)
	Cohorts	1989–94	1989–93	1989–92	1989–91	1989–90
Wild-raised	Male	82.6%	100%	100%		
		(23)	(4)	(2)		
	Female	89.2%	100%	100%		
		(37)	(16)	(6)		
	Cohorts	1992–94	1992–93	1992		
Scotland						
Released	Male	50.0%	65.4%	93.3%	100.0%	66.7%
		(52)	(26)	(15)	(7)	(3)
	Female	52.5%	71.4%	80.0%	75.0%	100.0%
		(40)	(21)	(10)	(4)	(1)
	Both sexes	51.6%	66.7%	88.0%	90.9%	75.0%
		(93)*	(48)*	(25)	(11)	(4)
	Cohorts	1989–93	1989–93	1989–92	1989–91	1989–90
Wild-raised	Both sexes	42.9%	100.0%	100.0%		
		(21)	(5)	(1)		
	Cohorts	1992–94	1992–93	1992		

The numbers alive at the beginning of each year are given in parentheses. The wild-raised birds in Scotland have not been sexed. *Includes one kite not sexed.

and released in 1991, was found in May 1993, unable to fly due to severely bruised carpal joints. After treatment, it was rehabilitated in June 1993 and bred unsuccessfully in 1994 and successfully in 1995. One wild-raised Red Kite (from the 1992 cohort) was thought to have the symptoms of trichomoniasis (caused by the flagellate protozoan parasite *Trichomonas gallinae*) while it was still a chick. After treatment, it was returned to its nest in southern England where it fledged successfully. It bred successfully in 1994 and 1995. Another wild-raised Red Kite (from the 1994 cohort) was found caught in a fence in July 1994 soon after fledging. It was treated with antibiotics and rehabilitated in August 1994.

Only one Red Kite was treated in Scotland in 1989–94. This bird, in its third year, was found at a garden bird table in southern Scotland at Inverleithen, Galashiels, suffering from alpha-chloralose poisoning. It recovered and was rehabilitated in the study area in northern Scotland.

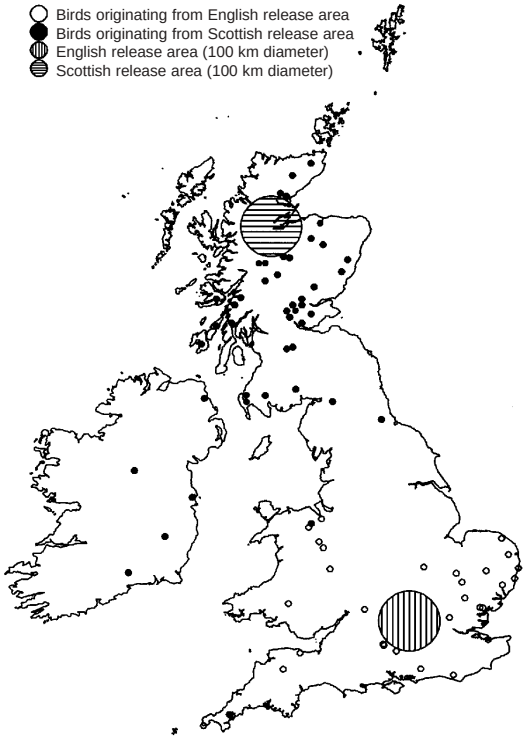
Dispersal

In southern England, 37.1% of the 1989–92 cohorts left the intensive study area in their first year (i.e. moved more than 50 km). Most dispersed soon after their release in late summer (69.6%), while the remainder (40.4%) dispersed after spending their first winter within the English study area. Reports were received from Cornwall, Wales, East Anglia

Table 3. Comparison of annual survival of first- and second-year Red Kites in England (E) and Scotland (S) for the 1989–91 and 1992–93 cohorts.

		1989–91			*1992–93*		
		Number released	*First-year survival*	*Second-year survival*	*Number released and wild-raised*	*First-year survival*	*Second-year survival*
Annual survival (both sexes)	E		63.6%	90.5%		79.4%	96.0%
		(33)	(21)	(19)	(63)	(50)	(48)
	S		46.7%	66.7%		57.1%	71.9%
		(45)	(21)	(14)	(56)*	(32)*	(23)
Annual survival (male)	E		71.4%	100.0%		80.8%	95.2%
		(14)	(10)	(10)	(26)	(21)	(20)
	S		42.9%	66.7%		61.5%	68.8%
		(28)	(12)	(8)	(26)	(16)	(11)
Annual survival (female)	E		57.9%	81.8%		78.4%	96.6%
		(19)	(11)	(9)	(37)	(29)	(28)
	S		52.9%	66.7%		57.7%	80.0%
		(17)	(9)	(6)	(26)	(15)	(12)

The numbers of birds in the 1989–91 and 1992–93 cohorts and alive after first and second years are given in parentheses. *Includes kites that were not sexed.



and northern France (Fig. 1). The Red Kites of Swedish origin left the English study area on dry sunny days in August and September. Three birds dispersed in a southwesterly direction and one in a northwesterly direction. The survivors returned in the following spring and summer. Two juvenile Red Kites of Welsh origin also left the English study area in August and September but dispersed in a northwesterly direction, while two left in April and May in a southerly direction and a northeasterly direction, respectively. None was recorded subsequently in southern England. Juvenile Red Kites of Spanish origin dispersed in all directions from the study area in August and September, and also between March and June. Some were not observed in the English study area for almost two years, although some were resighted there only a few weeks after their

Figure 1. Furthest locations of Red Kites marked as nestlings in aviaries or at nest sites within their respective release areas in England and Scotland, and reported subsequently outside these areas. Only one location per bird is plotted, although each location can refer to more than one bird. One Red Kite released in England is not shown but was recovered 15 km north of Rouen, France.

Table 4. Causes of mortality in Red Kites released in, or fledged from, nests in England and Scotland, and recovered dead subsequently, prior to 1 July 1995.

Class	*Age*	*Cause/country recovered*	*Date found*	*Distance moved (km)*
England				
Released	First-year	Illegal abuse of Endrin[36]/England	20 Nov 89	148.9
Released	First-year	Illegal abuse of Metaldehyde[37]/England	12 Oct 90	11.3
Released	First-year	Unknown/northern France	14 Jan 91	272.0
Released	First-year	Unknown, probably poisoned illegally/England	26 Jun 92	55.2
Released	First-year	Unknown/England	17 Sep 92	2.7
Released	First-year	Illegal abuse of Phorate[38]/England	08 Apr 93	62.6
Wild-raised	First-year	Fungal (*Aspergillus fumigatus*) infection/England	23 Jan 94	19.0
Released	Second-year	Haemorrhage in the abdominal cavity/England	10 Apr 94	4.1
Released	First-year	Unknown/England	12 Jun 94	3.6
Released	Third-year	Abdominal cyst or tumour/England	30 Dec 94	4.6
Wild-raised	First-year	Collided with power lines and electrocuted/England	20 Feb 95	3.2
Wild-raised	First-year	Avian tuberculosis/England	05 Mar 95	3.3
Released	Second-year	Poisoned with Phorate (not illegal abuse as insecticide was used in an approved manner)/England	26 Mar 95	5.3
Wild-raised	First-year	Hit by a car/England	31 May 95	5.2
Scotland				
Released	First-year	Illegal abuse of alpha-chloralose[36]/Scotland	18 Dec 89	8.0
Released	First-year	Hit by a train/Scotland	01 Oct 90	9.0
Released	First-year	Poisoned with alpha-chloralose/Republic of Ireland	08 Dec 90	577.0
Released	First-year	Poisoned with alpha-chloralose/Republic of Ireland	08 Feb 91	434.0
Released	First-year	Illegal abuse of alpha-chloralose[39]/SW England	14 Dec 91	806.0
Released	First-year	Allegedly killed and the body plus transmitter incinerated to prevent detection/Scotland	22 Feb 92	84.0
Released	First-year	Collided with power lines and electrocuted/Scotland	27 Apr 92	2.0
Released	Second-year	Unknown/Scotland	05 May 92	2.0
Released	First-year	Unknown/Scotland	23 May 92	57.0
Released	First-year	Unknown/Scotland	02 Dec 92	60.0
Released	First-year	Found egg-bound on nest/Scotland	18 May 93	4.0
Released	Fourth-year	Unknown/Scotland	21 Jul 93	1.0
Released	Third-year	Unknown/Scotland	10 Aug 93	2.0
Released	First-year	Long dead, probably choked on bone/Scotland	17 Nov 93	1.0
Wild-raised	First-year	Hit by a car/Scotland	21 Aug 94	1.0
Released	Second-year	Collided with power lines and electrocuted/Scotland	? Oct 94	6.0

Table 4a. ANOVA of log-transformed distances, testing the effect of cause of death (poison against not poisoned and unknown causes) on distance recovered.

Factor	*df*	*MS*	*F*	P
Cause of death	1	45.75	18.2	<0.001
Error	28	2.52		

initial departure. These movements and their timing were confirmed by radiotelemetry. Of the birds from the 1989–92 cohorts that left the English study area, 27.3% returned and subsequently entered the breeding population.

From the study area in northern Scotland, 60.9% of the birds from the 1989–92 cohorts dispersed in their first year, mainly in a southerly or southwesterly direction. The majority of birds (90.5%) left during late summer/early winter, while the remainder (9.5%) dispersed in the following spring. They were reported from south and southwest Scotland, Wales, Northern Ireland, the Republic of Ireland and Cornwall (Fig. 1). In the following spring, Red Kites that had dispersed the previous autumn returned to the Scottish study area, and in 1994, 16.7% of the birds from the 1989–92 cohorts that dispersed, bred in the

Table 5. Percentage of released Red Kites which moved >50 km from their release areas in their first-year.

	England		*Scotland*	
Cohort/sex	*Sample size*	*Percent moving >50 km*	*Sample size*	*Percent moving >50 km*
1989	5	100.0	6	100.0
1990	13	38.5	19	78.9
1991	15	40.0	20	60.0
1992	20	35.0	24	37.7
1993	20	35.0	24	25.0
Male	35	28.6	52	42.3
Female	38	52.6	40	57.5

Scottish study area.

As the project progressed, a smaller proportion of Red Kites dispersed from the Scottish study area ($\chi^2 = 21.4$, df = 4, $P < 0.001$, Table 5). The proportion dispersing from the English study area was most marked in 1989 when mainly Swedish birds were released. The proportion then declined to a relatively constant level in 1990–93 when mainly Spanish birds were released. Overall, a greater proportion of Red Kites (in the 1989–92 cohorts) dispersed from the study area in Scotland compared with the English study area ($\chi^2 = 6.53$, df = 1, $P < 0.05$). In the English study area, there was a sex bias in dispersal, since over two-thirds of the Red Kites that left there were female ($\chi^2 = 6.25$, df = 1, $P < 0.05$).

The data on dispersal were also expressed in terms of the maximum distance moved between the site of release/fledging and records during the first year of life (Table 6). There were annual differences in the extent of movements from the two study areas, with birds tending to be found further away during the early years of the project. There was also a tendency for females to travel further than males, and for Scottish birds to travel further than those originating from England. A comparison between the distance moved by released and wild-raised Red Kites in the 1992 and 1993 cohorts in England revealed no significant difference.

Breeding

Two pairs bred unsuccessfully in 1991[40] and five pairs successfully in 1992 (Table 7). This

Table 6a. ANOVA on log-transformed distances moved.

Factor	*df*	*MS*	*F*	P
Year	4	14.59	11.69	<0.001
Sex	1	10.68	8.56	0.004
Country	1	28.25	22.63	<0.001
Error	158	1.25		

No interactions were significant.

Table 6. Median maximum distances (km) moved during the first year of life by individual Red Kites released in England (E) and Scotland (S).

	Median maximum distance (km)		*Range (km)*		*Sample size*	
Cohort/Sex	*E*	*S*	*E*	*S*	*E*	*S*
1989	197	108	185–379	55–225	5	6
1990	15	100	9–272	7–640	13	19
1991	55	80	10–226	10–830	15	20
1992	9	26	3–126	5–470	20	24
1993	10	19	5–189	5–532	20	23
Female	21	80	3–379	5–830	38	40
Male	12	45	6–189	7–480	35	52

Table 7. Number of non-breeding pairs and breeding pairs of Red Kites found in England (E) and Scotland (S).

Year	*Region*	*No. of territorial pairs*	*No. of breeding pairs*	*No. of successful pairs*	*No. of young fledged*
1991	E	2	2		
	S				
1992	E	7	4	4	9
	S	2	1	1	1
1993	E	12	9	8	14
	S	8	5	3	7
1994	E	22	20	17	37
	S	11	8	6	13
1995	E	26	24	22	55
	S	17	15	11	26

was the first time that Red Kites had bred successfully in England and Scotland for over 100 years. The number of breeding pairs then increased annually (Table 7), and in 1994 six wild-raised Red Kites (the first offspring from nests established by released birds) bred for the first time in southern England. These birds were in four pairs (two pairs composed of wild-raised birds – one comprising a brother and sister – and two pairs composed of one wild-raised and one released bird) and reared a total of six young. In northern Scotland, an unsuccessful pair in 1994 included a wild-raised bird, reared in 1993.

By 1995, 26 pairs were located in southern England and 17 pairs in northern Scotland (Table 7). Not all pairs in England were located and we estimate that about 30 pairs (excluding first-year breeders) bred. This is based upon the number of males (in their second year or older) present in the winter roosts in February 1995 prior to pair establishment and an excess of females (in their second year or older). It is likely that over 60 young were reared based on current breeding performance.

During 1991–95, there were fewer breeding attempts in Scotland than in England (Tables 7 & 8). This resulted in 47 chicks fledging in Scotland in 1991–95 compared to at least 115 in England. Logistic regression models of the daily clutch and brood survival data indicated that there were no significant differences between England and Scotland for either part of the breeding cycle (χ^2 = 1.71, df = 1 for clutch data, and χ^2 = 0.20, df = 1 for brood data) (Table 8). Clutch size varied from two to four eggs whereas the number of young fledged per nest varied between one and three in England, and one and four in Scotland. Male Red Kites bred for the first time in England when they

Table 8. Breeding statistics of Red Kites in England in 1991–95 and Scotland in 1992–95.

	England	*Scotland*
Known number of clutches laid (includes replacements)	59	29
Known number of replacement clutches laid	0	1
Clutch survival (%)	89.6 (80.3–100.0)	77.7 (63.2–95.4)
Brood survival (%)	91.3 (80.3–100.0)	87.2 (74.5–100.0)
Nest survival (%)	80.3 (67.1–96.1)	67.2 (51.5–87.5)
Clutches not fledging young (%)	13.6	27.6
Clutches fledging at least one chick (%)	86.4	72.4
Mean clutch size	2.9 ± 0.4 (n = 8)	3.0 ± 0.8 (n = 24)
Mean number of young fledged/breeding pair	1.9 (n = 59)	1.6 (n = 29)
Mean number of young fledged/successful pair	2.3 ± 0.7 (n = 49)	2.2 ± 0.9 (n = 21)

95% confidence limits (CL) are given for clutch, brood and nest survival. Standard deviations (±sd) are given for clutch and brood size; n = sample size.

Table 9. Breeding parameters of male and female Red Kites in England in 1991–95 and Scotland in 1992–95.

	England		*Scotland*	
	Male	*Female*	*Male*	*Female*
Mean number of young by one-year old birds	0.8 ($n = 4$)	1.0 ($n = 5$)	($n = 0$)	0.5 ($n = 4$)
Mean number of young by two-year old birds	1.8 ($n = 23$)	1.7 ($n = 27$)	0.9 ($n = 8$)	1.6 ($n = 14$)
Mean number of young by three-year old birds	2.2 ($n = 19$)	2.5 ($n = 17$)	1.9 ($n = 13$)	1.7 ($n = 7$)
Mean number of young by older birds	2.3 ($n = 13$)	3.0 ($n = 7$)	1.9 ($n = 8$)	2.8 ($n = 4$)
Proportion of sex in 1992–94 cohorts at fledging	0.383	0.617		
Mean age (years) of first breeding (1989–92 cohorts) (range)	1.9 (1–3)	1.8 (1–2)	2.6 (2–4)	1.7 (1–2)

were one to three years old, while females bred at one to two years old. In Scotland, males bred for the first time at two to four years old, and females at one to two years old (Table 9). There was no difference in the mean age of first breeding between male and female Red Kites (in the 1989–92 cohorts) in England, although in Scotland females initiated breeding at a significantly younger age than males ($t = 3.08$, df = 19, $P = 0.006$).

The size of broods at fledging was correlated with the age of the mother ($r = 0.53$, df = 83, $P < 0.001$) and to a lesser extent with the age of the father ($r = 0.29$, df = 86, $P < 0.01$) (Table 9). In a regression analysis, examining the relationship between brood size and parents' age, the age of the fathers had no additional effect in explaining brood size once the mothers' age had been taken into consideration first. The lack of any additional effect is probably because parent ages in the pairs were highly correlated ($r = 0.82$, df = 83, $P < 0.001$). There was no significant effect of either country or interactions with parents' age in the regression analysis.

All breeding attempts (nests with clutches) were recorded within about 50 km of the release areas (Fig. 1). Nest site locations are not being revealed in order to preserve their confidentiality. At least 40 occupied territories were located in England and 34 in Scotland during 1991–95. In a small establishing population, the natal dispersals of the males and females are not independent. Therefore, as it is the males that establish territories, only the data for males were analysed. Natal dispersal was taken as the distance between either the place of release or natal nest and the place where the bird first bred. For the years 1991–94 in England and 1992–95 in Scotland, there was a slight difference between countries, with Scottish birds dispersing slightly further than the English birds (Table 10). There was no effect of year, showing that there was no significant expansion of range as the populations grew.

Nest sites were not fixed and pairs would shift to new nests within a territory and to new territories between years. The distance moved by pairs between nesting attempts in succeeding years ranged from 0 to 55 km, although the majority of breeding pairs moved less than 6 km. In England, where pair composition

Table 10. Natal dispersal distances (km) by male and female Red Kites in England and Scotland.

Country	*Sex*	*Median distance (km)*	*Range (km)*	*Sample size*
England	Male	4.2	0.6–8.1	18
	Female	4.1	0.8–8.3	15
Scotland	Male	5.6	0.6–27.9	15
	Female	9.4	1.1–18.5	16

Table 10a. ANOVA on log-transformed data of the distance moved by male Red Kites.

Factor	*df*	*MS*	*F*	P
Country	1	4.01	4.80	0.036
Error	31	0.84		

between successive years did not change between 1992 and 1995, 56.2% of successful pairs returned the following year to breed again in the same nest. In Scotland, during the same period, only one successful breeding pair out of 15 returned to the nest it had used previously. Pairs vacated territories in England following breeding failure (five cases) and as a result of the loss of the female partner through death (two cases) or infidelity (two cases). In three cases, vacated territories were taken over by new pairs which bred successfully in the nest built by the previous pair. Some successful pairs in both areas moved only relatively short distances (i.e. up to 400 m) to a new nest site, often within the same wood. One English pair moved 400 m between years and built a nest within 100 m of the nest of another pair. This is the closest inter-neighbour distance recorded so far for Red Kites in the UK. Both pairs bred successfully.

Changes in pair composition between years occurred in eight pairs (out of 21 pairs that held territory in two or more years) in southern England during 1991–94, and in two pairs (out of 16 pairs that held territory in two or more years) in northern Scotland during 1992–95. In three cases in England and one in Scotland, the change was due to the death of the female. In the six (five in England and one in Scotland) other cases, the males lost their mates to other males. These changes in pair composition occurred after establishment of a nesting territory, and in two cases after successful breeding. It appears that the females left the males as the estranged male then attempted to attract another female to the established territory, and in four of the six cases they succeeded.

Population growth

Simulations of deterministic growth of the Red Kite populations in southern England and northern Scotland indicate that both populations will increase at an estimated exponential growth rate of 0.332 and 0.184, respectively, assuming an equal sex ratio and a stable age distribution. In terms of the annual population multiplicative growth rate, the English and Scottish populations are predicted to increase by 1.394 and 1.202 per annum, respectively. At these rates, the population should exceed 100 breeding pairs in England by the year 1998 and in Scotland by 2007.

If releases had been suspended in southern England in 1992 when the initial population size was 42 individuals, the model predicts that the population would exceed 100 breeding pairs in the year 2000 (assuming an equal sex ratio and an exponential growth rate of 0.332). Similarly, annual supplements of ten male and ten female Red Kite nestlings for two, three and five years in southern England after 1994 would have achieved 100 pairs in 1998 (i.e. no difference).

It is unlikely that the growth rates currently estimated will apply in the long term (particularly in England), since proximate and ultimate factors will vary, both temporally and spatially, and influence population growth in a complex manner. However, the current models are useful in setting short-term targets or expectations which can then be compared with observed future population levels.

DISCUSSION

The project has demonstrated that naturalized breeding populations of Red Kites can be established in England and Scotland by translocation. However, releasing equal numbers of birds and use of the same methods at each release site has not achieved similar results, probably because the birds originated from different source populations and the release environments differed.

Red Kites in Sweden,[41] in common with other raptors in northern latitudes,[42] migrate from their breeding areas in autumn and return in spring, presumably to avoid the harsh winter. The Red Kites of Swedish origin, released mainly in Scotland, appear to have retained the migratory instinct in terms of the timing and direction of movement. However, it is also possible that the longer movements were a consequence of where they were released rather than the origin of the birds. Juvenile Red Kites of Spanish and Welsh origins, which

dispersed from the study area in southern England, differed in that their movements were not directional, seasonal or as far. This behaviour is similar to that recorded in Wales, where Red Kites are also known to disperse in all directions during their prebreeding years.[5]

In Sweden, winter feeding is believed to have helped increase the over-wintering Red Kite population[43] and similar results may have been achieved in Scotland by food provisioning near release and roost sites during the winters of 1991/92 and 1992/93. In contrast, no supplementary feeding during the winter was undertaken in southern England, but released and wild-raised Red Kites dispersed similar distances and initiated dispersal mainly in late summer and spring during their first year. It is likely, therefore, that Red Kites may display different dispersal behaviour depending on the source population from which the translocated birds were taken, and the environment in which they are released. For instance, the proportion of juveniles (of Swedish origin) dispersing declined as a breeding population developed in northern Scotland. A similar pattern occurred in Sweden, as migratory behaviour was more prevalent when the population was very small but over-wintering became more frequent as the population increased.[44] Hence, there may be an alternative explanation for the increased tendency for migratory Red Kites to over-winter within their breeding areas, since increased population size may be linked to improved foraging efficiency, irrespective of food provisioning. This is because carrion, important in winter,[26,45,46] is irregularly distributed both spatially and temporally. By forming loose groups as opposed to foraging individually, Red Kites can search larger areas more efficiently for food.[47,48]

Individual Red Kites of Spanish and Welsh origins exhibited similar dispersal behaviour to that described in sedentary Buzzard populations, where a proportion of the annual production of juveniles displayed a mixed dispersal strategy.[49,50] It is therefore possible that autumn dispersal displayed by some of the Red Kites, taken from non-migratory populations, is related to residual migratory behaviour as some individuals returned in the following spring. However, if some dispersing individuals settled and bred in other subpopulations (as may have been the case when Red Kite populations were more widespread in Britain), such behaviour would enhance genetic heterogeneity in Red Kite populations.

In this study, Red Kites released in northern Scotland suffered greater losses and this led to a smaller breeding population establishing there compared to southern England. However, in comparison with the native population of Red Kites in Wales,[34] birds released in Scotland are surviving at least as well. Nevertheless, once Red Kites reached adulthood, when dispersal was less likely, survival was very high in both England and Scotland, similar to other raptors.[42]

It is likely that some birds died undetected. Most of the Red Kites known to have been poisoned by pesticide-laced baits, or deliberately killed, were killed after dispersing. Several other Red Kites were also suspected of being killed deliberately or poisoned but there was insufficient proof for them to be included in this analysis. This suggests that outside the areas where Red Kites were studied intensively, the number of deaths caused by persecution was the minimum recorded. Two incidents of illegal poisoning were also recorded within the intensive study areas in 1989–90 but none was recorded from 1991 to 1994, probably because the majority of countryside users gradually accepted that Red Kites did not harm their interests. However, this acceptance has not been universal, because in 1995 and 1996, when Red Kites could no longer be located by radiotelemetry, persecution was again recorded within the intensive study area of southern England.[51] A vital element in future Red Kite conservation work must therefore be to encourage more people who use the countryside to accept Red Kites. For example, a recent government-led campaign against illegal poisoning of wildlife in the UK[52] may help to reduce this form of persecution in the future. In addition, by educating the public to report suspected poisoning incidents, deaths caused by the abuse, misuse and approved use of certain pesticides can be highlighted, and may lead to action to reduce their damage to the environment.

Rehabilitation of sick or injured birds played a minor role in the establishment and maintenance of the populations due to the small number of Red Kites taken into captivity when ill or injured. In England, at least two Red Kites

that received treatment entered the breeding population, suggesting that rehabilitation can be of value when breeding populations are small. Other studies[53] suggest, however, that establishing populations from sick or injured wild birds is not effective, since these birds are likely to be less fit and their offspring are likely to have poorer chances of survival. In this study, from the rehabilitation work and post-mortems undertaken, it is clear that Red Kites are vulnerable to a range of accidents and diseases, but the risks that these pose to the viability of Red Kite translocation programmes in the UK are insufficient to warrant concern.

One important factor affecting the population dynamics of small populations is the sex ratio.[54] In this project, the chicks taken for translocation could not be sexed at the time of collection. However, sex determination after collection revealed that roughly equal numbers of males and females were released. Even so, a small bias in sex ratio during the early stages of the project did lead to some males remaining unpaired in Scotland.

The naturalized breeding populations are still largely confined to relatively small areas of southern England and northern Scotland, despite wide-ranging dispersal by released and wild-raised Red Kites during the first few years of life. This high degree of natal philopatry is exhibited by Red Kite populations elsewhere[34] and by other raptors,[42,49,50] and is considered to hinder recolonization.[49,55] However, in suitable habitats Red Kites will breed at relatively high densities without affecting breeding productivity[56,57] or population growth.[57] The ranges of the naturalized Red Kite populations in England and Scotland may therefore be expanding relatively slowly at present because the breeding populations are still achieving the carrying capacity of the currently occupied habitats.

The productivity of the populations in England and Scotland was similar. In comparison with the native population in Wales,[5,34] naturalized pairs laid larger clutches (14% more eggs), fledged on average one-and-a-half times more young per breeding pair, and some started breeding at one year old.[40] These data show that the naturalized Red Kite populations, re-established in lowland districts of England and Scotland by translocation of continental birds, will make a major contribution to range recovery in the UK and complement the conservation action that is continuing in Wales. Both naturalized populations in England and Scotland are self-sustaining, as their current survival and reproduction levels are similar to or better than those of the expanding population in Wales. Predictions of population growth suggest that the English population will grow faster than the Scottish, due mainly to higher rates of annual survival (reproductive success is similarly high in both countries). There is therefore a need to focus on minimizing persecution,[58] particularly in areas where Red Kites are now colonizing.[59]

Determining when to stop releases is an important aspect of any translocation scheme. In this project, population models of the Red Kite population in southern England suggest that releases could have been suspended in 1992 (when the size of the population was similar to the 1994 Scottish population) or perhaps even sooner. However, in practice, a time lag exists between release and breeding, and this delays assessment of population performance. In addition, small naturalized populations with little or no natural immigration are less able to compensate for detrimental stochastic effects and this increases their probability of extinction.[60] Consequently, releases should be suspended only at the point when performance (in terms of survival and reproduction) of the naturalized population can be reliably established and when further releases contribute little to the population's rate of growth. In order to reach this conclusion, it is essential that long-term monitoring of basic survival and breeding parameters is an integral part of any release scheme. This project has demonstrated that such data can be used to assess what current action is required, and also to predict future population sizes, and set objectives on which further conservation action can be based.

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