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Authors: Warren, Philip, Atterton, Frances, Anderle, Matteo, and Baines, David

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Expanding the range of black grouse *Tetrao tetrix* in northern England through translocating wild males

Philip Warren, Frances Atterton, Matteo Anderle and David Baines

P. Warren (pwarren@gwct.org.uk), F. Atterton, M. Anderle and D. Baines, The Game and Wildlife Conservation Trust, The Coach House, Eggleston, County Durham, DL12 0AJ, UK

Black grouse were once widespread in England, but have declined over the past 150 years due largely to habitat changes. In 1998, 773 males remained and following the instigation of conservation measures population size increased to 1029 in 2006, but population range remained similar. We hypothesized that range expansion was limited by the short dispersal ranges of males (up to 1 km) relative to females (up to 19 km), resulting in yearling females dispersing into areas without males. We tested this hypothesis by moving males to establish new leks and to stimulate range expansion.

Three release sites were chosen beyond the southern edge of the male range, but were within the perceived dispersal distance of females, and where habitats were considered suitable and generalist predators were controlled. Between 2006 and 2010, 17 males were released at the first site, and a further 18 and 27 respectively at two sites between 2011 and 2014. Males were caught at night, fitted with radio-transmitters and hard released. In the first spring following translocation, 98% of males were observed displaying. Males displayed an average 3.6 km (range 0.6 to 27.1 km) from their release point. Leks were established at all sites, with 14 different leks occupied in spring 2015 contributing to the re-colonisation of seven 10 km grid squares. Mean annual survival in the first year following translocation was 0.77 (0.63–0.86, 95% CL) and was similar to that of birds measured in previous studies in the core northern England range. This suggests that under appropriate circumstances translocation can be a helpful conservation tool in stimulating range expansion.

Black grouse *Tetrao tetrix* were once widespread in England, but have declined in numbers and range over the past century (Sim et al. 2008, Balmer et al. 2014). In 1998, 773 males remained and were largely confined to the North Pennines area of Outstanding Natural Beauty (AONB) in northern England (Warren and Baines 2008). Due to their recent declines they have been red-listed as a species of high conservation concern (Eaton et al. 2009) and were a 'Priority species' of the UK government's Biodiversity Action Plan (Anonymous 1995) with its own Species Action Plan (SAP) to restore both numbers and range. The English SAP objectives set in 1995 were 1) to stem or reverse the decline in numbers relative to the lower 95% confidence interval estimate of 800 males recorded in 1995/1996 (Hancock et al. 1999) by 2005, and 2) in the long term (20 years) increase the range to its 1988–1991 extent of 61, 10-km grid squares (occupied by displaying males in spring) (Gibbons et al. 1993). Following the instigation of a range of conservation measures (Calladine et al. 2002, Warren and Baines 2004) population size increased to 1029 in 2006 (Warren and Baines 2008) thus achieving the set target. However, range only increased from 37 to 42, 10-km grid squares and the delivery period for the range target of 61, 10-km squares was extended to 2030.

In northern England, black grouse occupy a largely treeless landscape and are associated with the moorland fringe, where extensively grazed grasslands meet heather *Calluna vulgaris* moorland managed primarily for red grouse *Lagopus lagopus scotica* shooting (Baines 1994, Warren et al. 2013). Here, they utilise a range of habitat mosaics including heather moorland, rough pastures, species-rich meadows, semi-improved pastures and pockets of scrubby woodland which provide feeding habitats throughout the year (Starling-Westerberg 2001, Beeston et al. 2005). Suitable formerly occupied habitats were present adjacent to/ or beyond the southern fringe of the existing range in the Yorkshire Dales National Park and Nidderdale AONB. Natural range expansion was considered to be limited by juvenile males which moved only short distances (up to 1 km) in comparison to females which dispersed up to 19 km (mean 9.3 km) (Warren and Baines 2002). These findings, confirmed by field observations, suggest that yearling females may disperse into suitable habitat, where few or no males are present. To stimulate sustained range expansion, we commenced a male translocation programme into three formerly occupied sites in the Yorkshire Dales

National Park and Nidderdale AONB. By translocating males we aimed to contribute to the range expansion target through encouraging male recolonisation of formerly occupied sites to establish leks, which would then attract dispersing females to settle and breed. The degree of success was evaluated in a) the short term (1–3 years post release) using radio telemetry to assess settling patterns, behaviour and survival of translocated individuals, and b) the longer term (1–9 years post release) through annual lek surveys to assess the persistence of established leks through successful breeding and their contribution to the range target.

Material and methods

Release sites

The study was undertaken in the Yorkshire Dales National Park and the adjoining Nidderdale AONB in north Yorkshire (Fig. 1). Releases began at Mossdale in the Yorkshire Dales National Park (2006–2010), located 5.0 km to the south of an existing lek in 2006 (Fig. 1). Following range expansion, further releases were undertaken at Coverdale in the Yorkshire Dales National Park (2011–2013) and at Nidderdale in the Nidderdale AONB (2011–2014), located 6.3 km and 8.5 km

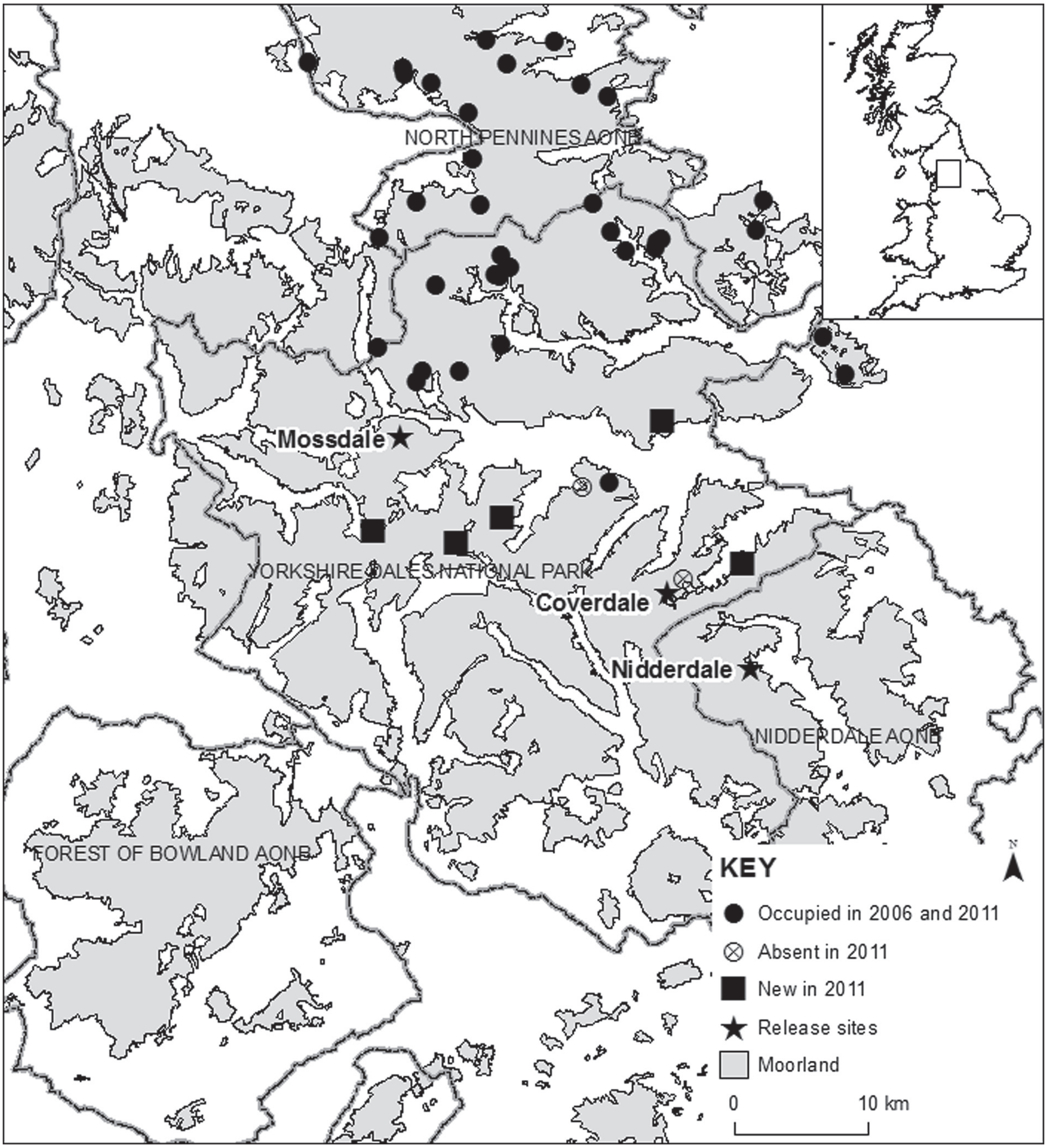

Figure 1. The location of the release sites at Mossdale and Coverdale in the Yorkshire Dales National Park and Nidderdale in the Nidderdale AONB, and the distribution of black grouse leks prior to translocation in spring 2006 and 2011.

respectively to the south of known leks in 2011. The landscape and habitats here are influenced by the two main land uses, hill farming and red grouse shooting. The farms are predominantly sheep farms, with most having small numbers of beef cattle. The high ground at altitudes > 500 m a.s.l. are dominated by heather moorland and blanket bog. The valley sides are generally characterised by a mosaic of grass moorland and drystone wall enclosed rough grazing fields dominated by soft rush *Juncus effusus*. Woodland cover was sparse and restricted to stream sides along the valley slopes and floor. The specific release sites were selected for having a) suitable habitat mosaics of heather, cotton grass *Eriophorum vaginatum*, grasses and herbs, insect rich areas for foraging chicks and pockets of scrubby woodland (Baines 1994, Beeston et al. 2005), b) gamekeepers that controlled corvid species, red fox *Vulpes vulpes*, stoat *Mustela erminea* and weasel *Mustela nivalis* (Hudson and Newborn 1995) to help maintain high black grouse survival rates (Baines et al. 2007), and c) were within the natural dispersal range of females (Warren and Baines 2002) to enable females to find the translocated males.

Catching and release

Donor leks, i.e. those from which males were translocated, had to have ≥ 10 males and where numbers were considered to be either stable or increasing. Up to two males were taken following breeding years when ≥ 1.2 chicks per hen (the six year average productivity in August) were produced (Baines et al. 2007). These criteria limited translocation to seven of the nine potential release years (Table 1). Males were caught and moved in late autumn/winter. Males were first observed feeding, followed flying into roosts, from where they were later caught at night using a high-powered lamp and a hand-held net, placed in transportation boxes and taken to release sites. Males were moved > 15 km to reduce the likelihood of them returning to their natal home range (McEwen et al. 2009). All birds were fitted with 17-g necklace radio-transmitters (Biotrack Ltd, UK) (2006-10) or 14-g necklace transmitters with mortality sensors (Holohil Ltd) (2011–2014) (lifespan 12 to 30 months) and released into tall heather within three hours of capture. No birds were found dead within two weeks of catching, suggesting there were no immediate measurable impacts of catching and handling on survival.

Behaviour

Birds were located weekly by triangulation, only being flushed if they had not moved from their last location and their locations plotted in ArcMap 10.2.1. To assess settling following release we measured the straight-line distance from the release point to the lek where they subsequently displayed in the first spring (n = 48 males). To assess lek fidelity across subsequent years, we measured the straight-line distance from the lek occupied in year one to the lek occupied in year two (n = 18 males) and between leks occupied in years two and three (n = 4).

Home ranges using a minimum convex polygon were calculated for each bird. Twenty five males had breeding or summer ranges (April to September) separate from their initial post release range. For these individuals, we excluded pre-settling movements and home ranges were constructed from the date they were first observed at a lek in April. The timing of this movement was taken as the last recorded date within the release home range. Thirteen males had winter home ranges (October to March) separated from summer ranges by a mean of 7.3 km (range 2.9 to 14.6 km). For these males, the winter and summer home ranges were calculated separately and summed to give an overall home range size. All remaining males (n = 24) had continuous annual home ranges where post-release, winter and summer home ranges overlapped.

To establish whether released males displayed at leks, males were tracked between dawn and 07:00, once in April and then again in May every spring using standard lek survey procedures (Baines 1996, Hancock et al. 1999). No formal surveys of females were undertaken, but we recorded any females that were seen in attendance at leks or with broods during the course of radio-telemetry fieldwork at Mossdale (2006–2010) and at Coverdale and Nidderdale (2011–2015).

Table 1. Numbers of translocated males released each year into three sites in the Yorkshire Dales National Park and Nidderdale AONB in northern England, and the subsequent numbers of males observed displaying at leks the following spring (2006–2015).

		Numbers of males released each autumn/winter (numbers of juveniles in brackets), numbers of males observed displaying in the following spring (numbers of radio tagged birds in brackets), females observed* broods reported**																			
		2005/06		2006/07		2007/08		2008/09		2009/10		2010/11		2011/12		2012/13		2013/14		2014/15	
Release site		Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring	Aut/win	Spring
Mossdale	released			7		8(1)				2(1)											
	displaying males		0		8(6)		5(5)		3(2)		5(2)		9		14		7		12		16
	females				*		*		*		**										
Coverdale	released													7(5)		3		8(7)			
	displaying males		1		0		0		0		0		0		9(9)		7(7)		10(9)		16(5)
	females														*		**		**		**
Nidderdale	released													8(2)		2		8(5)		9(4)	
	displaying males		0		0		0		0		0		0		3(3)		3(3)		9(9)		12(10)
	females																		**		**

Lek persistence

The persistence of leks across years established by translocation was monitored by counting males (both tagged and untagged) attending leks annually in spring prior to and following translocation. Total numbers of males were calculated as the sum of all maximum counts from the two visits to each lek.

Changes in occupied range (10 km grid squares) were compared between national surveys completed in 2006 and 2014 (Warren et al. 2015). Surveyors searched all formerly occupied lek sites and suitable habitats. The open landscapes of the study area and good network of roads and tracks meant that the majority of displaying males could be observed from suitable vantage points. Occupied 10 km grid squares re-colonised by translocation were defined as where leks had been established by radio-tagged males and were still occupied.

Statistical analyses

To consider differences in the two dependent variables, 1) settling distances following release (log transformed to normalise), and 2) home range sizes we used two separate general linear models in Genstat 17 both fitted with a normal distribution and identity link function. The main effects included in the model were the categorical independent variables age class (adult or juvenile), release site ($n = 3$) and release year ($n = 7$) and all first order interactions. Estimates of home range size increased in a linear manner in relation to the numbers of fixes, before levelling off after 25 fixes. Therefore, differences in home range size were considered by entering the log transformed number of fixes as a co-variate.

We estimated survival rates of 62 translocated males by determining, for each bird, the length of time in days from the date of release to date of death (mid-point between last location alive and body recovered), loss of radio signal or date last since alive (for those birds still alive). Birds in the latter two categories were considered to be censored in a Kaplan–Meier survival analysis (Kalbfleisch and Prentice 1980) in Genstat 17 (<www.vsni.co.uk>). This analysis assumed that all birds were released at the same point in time, and separate survival rates calculated for each interval between events (release, death, right-censoring). The survival rate over the first year (365 days) after release was obtained as the product of the separate interval-specific survival rates up to the 365th day, which coincided with a death event. We calculated survival rates over the first after release for juveniles and adults separately and tested for differences using a Wilcoxon (Breslow) test. If the test was not significant at $p < 0.05$, we calculated the survival over the first year after release across all birds.

Results

Behaviour

Between 2006 and 2015, 62 males (37 adults and 25 juveniles) were caught, translocated and released (Table 1). In the first spring following translocation, 47 (98%) males were observed displaying. Males settled at leks a geometric mean of 3.6 km (range 0.6–27.1 km) from the release point (Fig. 2). Following the removal of non-significant first-order interactions, movements by males from their release point to lek location did not differ between sites ($F_{2,38} = 0.13$, $p = 0.869$), years ($F_{6,38} = 1.65$, $p = 0.170$) or age class ($F_{1,38} = 2.11$, $p = 0.154$). One moved in winter (5 November), with all others ($n = 24$) moving between mid-February and mid-April, median date 18 March. Eighteen males displayed in two consecutive years, 13 (72%) at the same lek, the others at leks a mean 3.2 km from their lek the previous year (range 1.4–6.1 km). Four males were observed for three consecutive springs, three attended the same lek, while the other male attended different leks in each year, 5.1 and 2.1 km respectively from the lek the previous year. In the first spring following translocation, females were observed with radio-tagged males at the Mossdale and the Coverdale release sites, but no females were observed at Nidderdale until three springs after male translocation commenced (Table 1).

Males had home ranges on average 5.4 km^2 (range 1.3 to 8.9 km^2). Home range area did not differ between sites ($F_{2,26} = 0.04$, $p = 0.846$), years ($F_{5,26} = 1.54$, $p = 0.211$) or age class ($F_{1,26} = 0.80$, $p = 0.380$) having controlled for differing numbers of radio fixes.

There were no significant differences in survival rates over the first year after release between adults and juveniles (Wilcoxon $(\text{Breslow})_1 = 2.44$, $p = 0.118$). The combined survival rate over the first year after release ($n = 62$) was 0.77 (0.63–0.86, 95% CL).

Lek persistence

Three radio-tagged males (two from Mossdale and one from Coverdale) moved north and joined already established leks, 5.0, 14.0 and 27.1 km from the release points (Fig. 2) and were not considered when assessing lek persistence.

Following the initial release of seven males at Mossdale, eight males (six radio-tagged) were observed the following spring displaying at six leks, with four of these still occupied by 16 males (0 radio-tagged) in 2015. In Coverdale, following the first release of seven males, nine males (all radio-tagged, plus two males originally released in Nidderdale) were observed the following spring displaying at four leks, with three of these and a further two occupied by 16 males (five radio-tagged) in 2015. In Nidderdale, following the first release of eight males, three males were observed at three new lek sites the following spring, with these and a further two leks occupied by 12 males (10 radio-tagged) in spring 2015. The total numbers of displaying males at release areas increased from one male in 2006 to 44 occupying 14 leks in 2015 (Fig. 3).

Translocation resulted in the recolonisation of seven occupied 10 km grid squares between 2006 and 2014. Translocated males from the Mossdale and Nidderdale release points each recolonised three grid squares and males from the Coverdale release point recolonised one.

Discussion

Black grouse males are relatively sedentary (Warren and Baines 2002) and translocating them impacted on their

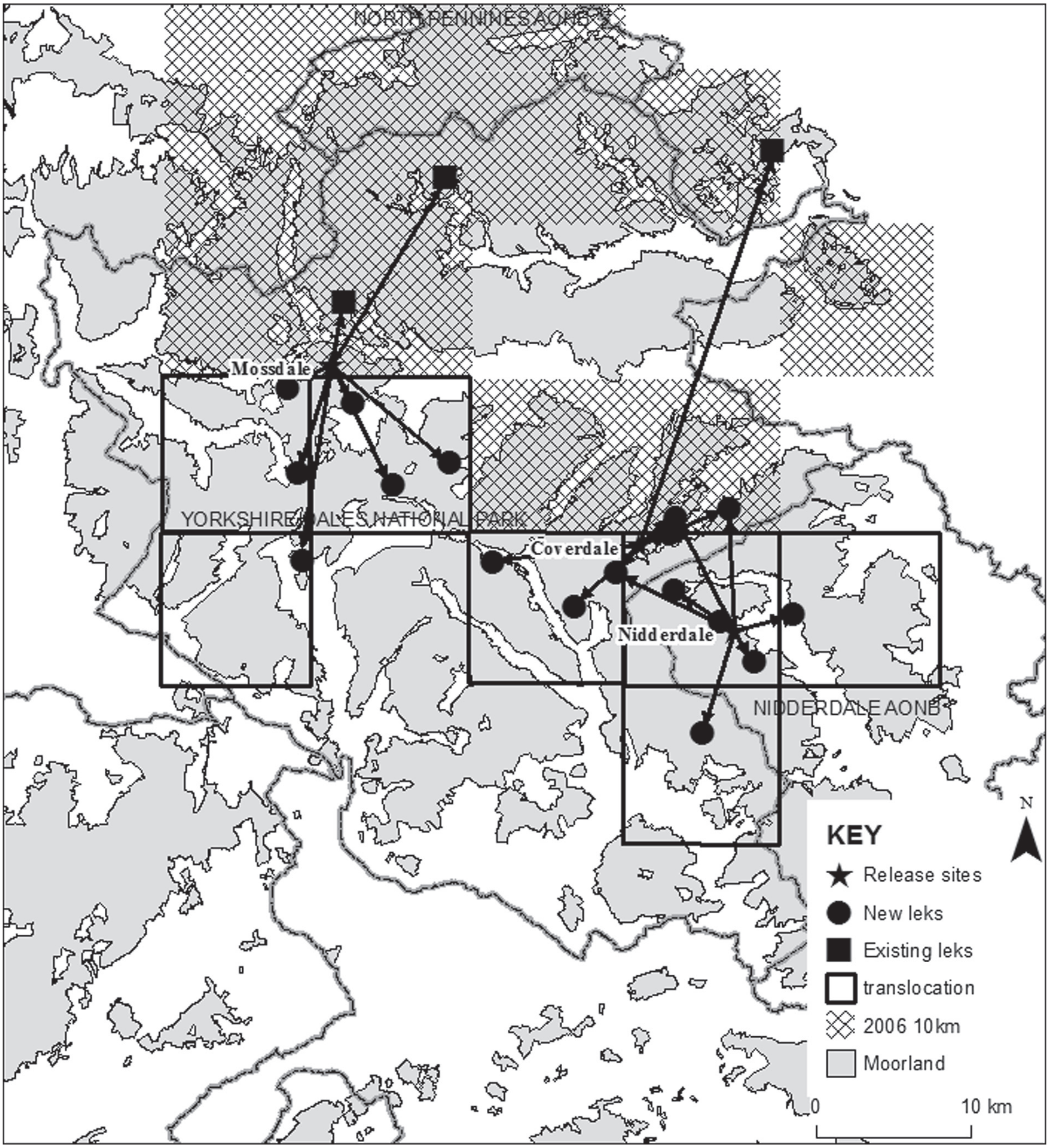

Figure 2. Movements by translocated males from their release points at Mossdale, Coverdale and Nidderdale to the leks where they displayed the following spring. Establishment of new leks by translocated males resulted in occupied range increasing by 7, 10 km grid squares between 2006 and 2015.

typical behaviour with half of all males moving from their release point and subsequently displaying at leks > 3 km away. These movements were three-fold greater than non-translocated males in northern England (Warren and Baines 2002). This may be explained by males actively searching for their natal lek (Alatalo et al. 1992, Rintamäki et al. 1995) where unoccupied central territories are quickly reoccupied by other males (Hovi et al. 1994, Rintamäki et al. 1999). Furthermore, 40% of translocated males were juveniles which may have higher mobility, having not have yet secured a territory on a lek (Kervinen et al. 2012). However, no differences in movements between adults and juveniles were found in this study. Few females at/ or in the vicinity of the release sites may have also contributed, with males actively searching for females. Translocated males also found and displayed with other males, with three males (two males from the Mossdale and one from the Coverdale release point), locating and settling at three already established lek sites to the north. Translocated males at Mossdale in the first year following release were also observed with non-tagged males at newly established sites and these may have been individuals which were already present, and not previously recorded due to low densities. Another hypothesis is that some females disperse into these areas and breed after visiting a lek in the

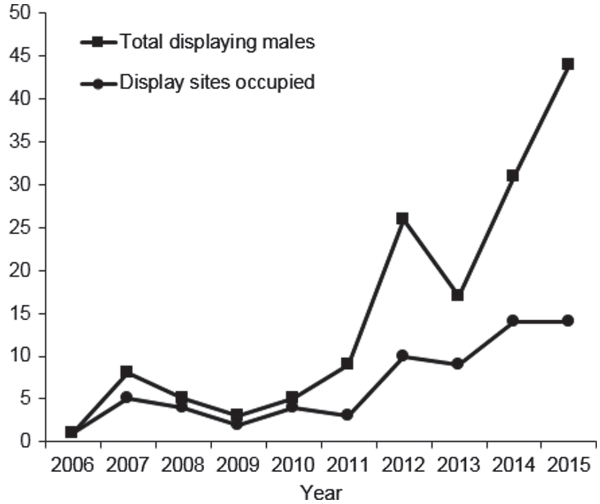

Figure 3. Total numbers of males observed at leks and numbers of leks occupied following translocation to three sites, Mossdale, Coverdale and Nidderdale (2006–2015).

core area, with subsequent local recruitment of young males. Differing display behaviour has been reported in low density populations in Sweden, where males did not aggregate on leks (Höglund and Stöhr 1997). Thus, males at low densities may be more mobile to increase their chances of securing a mating by locating females, compared to males in high density areas where females come to leks and therefore males remain close to the home lek (Rintamäki et al. 1995). Pre-settling movements in the winter have been observed by juvenile males at high density in the core North Pennines range, but in both cases males returned (Warren and Baines 2002). The movements observed, along with three males moving back to donor leks far away from their release point (McEwen et al. 2009) suggests there is no dispersal barrier within the study area and that a corridor of suitable habitat still persists between the different parts of the range.

The pre-settling movements from the release point helped to establish new leks in the landscape and this maybe important to facilitate future consolidation and expansion. Once males had undertaken initial pre-settling movements they settled, but home ranges were larger than those within the core of the range, which are typically 1 to 3 km^2 (Warren and Baines 2002). The annual survival rate of 0.77 was high and similar to that of adults in the core North Pennines range (0.70) and Scotland (0.66) (Baines et al. 2007) and tended to be higher than estimates from other European studies, Finland (0.53) (Lindén 1981), Sweden (0.54) (Angelstam 1984) and the French Alps (0.56–0.84) (Caizergues and Ellison 1997) suggesting that the release environs were suitable.

Translocated males established leks and following the release at Mossdale have persisted for nine years. The continued annual monitoring of lekking males will determine longer term persistence without further translocations. The project has contributed to the delivery of range expansion objectives in northern England with seven, 10 km grid squares recolonised between 2006 and 2014. However, some natural range expansion may have occurred in the absence of the project as other untagged males were seen in the first spring following release at Mossdale. Also, during the project period, overall numbers increased from 1029 to 1437 males in 2014 and range expanded in the absence of translocation by four, 10 km grid squares (Warren et al. 2015). Progress has been made to delivering SAP targets, but has been negated by range contraction further north, with population range increasing to 48, occupied 10 km grid squares in 2014, but still short of the 2030 target of 61 grid squares. Our initial results suggest that translocation may be a conservation tool to help stimulate re-colonisation beyond the current range of males where habitats are suitable and connected.

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