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The use of predator-exclusion fencing as a management tool improves the breeding success of waders on lowland wet grassland

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ABSTRACT

Waders breeding on lowland wet grassland have undergone dramatic declines across Europe in recent decades. Few species now achieve the levels of breeding success required for population stability and recovery, with predation from large mammals acting as a key compounding factor limiting nest survival and productivity. Predator management through lethal control is often controversial, yet alternative non-lethal methods are little tested in the context of grassland breeding waders. Excluding predators through the use of electric fences has led to improvements in nest and chick survival in other habitats. To test the applicability of this method to lowland wet grassland we constructed predator-exclusion fences on sites across the UK and, with Lapwing *Vanellus vanellus* as a study species, used historical and contemporary data to test whether excluding large mammalian predators leads to an increase in wader nest survival and productivity, and whether effects differ between fence designs. Lapwing nest survival was significantly higher in the presence of any type of predator-exclusion fence, with significantly fewer nests predated each day. Overall productivity also improved, with significantly higher numbers of chicks fledged per pair in years when fences were operational. Different designs and methods of powering fences resulted in different levels of success, with combination design fences and those powered by mains electricity performing best. Excluding large mammalian predators from areas of lowland wet grassland with predator-exclusion fencing successfully improves Lapwing nest survival and productivity, allowing breeding success to exceed the levels required for population recovery. Other wader species breeding in the same habitat are also likely to benefit from the increased protection from predation provided by fences. Predator-exclusion fencing is therefore an effective management tool for protecting restricted and declining populations of breeding waders on lowland wet grassland.

Introduction

Many waders breeding on lowland wet grassland in Britain and Europe (Lapwing *Vanellus vanellus*, Redshank *Tringa totanus*, Curlew *Numenius arquata*, Black-tailed Godwit *Limosa limosa* and Snipe *Gallinago gallinago* L. in particular) have undergone significant breeding population declines and range contractions in recent decades (Donald et al. 2006; Henderson et al. 2002; PECBMS 2012; Wilson et al. 2005). Historical declines were driven largely by the substantial degradation and loss of suitable breeding areas through wetland drainage and agricultural intensification (e.g. Fuller et al. 1995; Taylor & Grant 2004), and nature reserves or land managed by agri-environmental schemes are now increasingly important refuges for these species in lowland UK (Ausden & Hirons 2002; Wilson et al. 2004). There has been much research into the management of lowland wet grassland reserves to increase habitat favourability for nesting waders (Eglington et al. 2010, 2009b, 2007; Smart et al. 2006). However, despite evidence that improvements in habitat management have benefitted wader populations (Ausden & Hirons 2002), such measures have so far failed to facilitate population recovery (Wilson et al. 2005). It is thought that predation, predominantly from mammalian predators, acts as a compounding factor on wader populations, particularly those restricted to small areas of suitable breeding habitat, and may prevent populations from recovering even when habitat conditions are favourable (Ausden et al. 2009; MacDonald & Bolton 2008a).

Predation is a key factor in determining wader breeding success (Bellebaum & Bock 2009; Eglington et al. 2009a; Grant et al. 1999; Grimm 2005; Teunissen et al. 2008) and experimental studies

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indicate beneficial effects of reducing the abundance of avian and mammalian predators on the subsequent survival of wader nests (Bolton et al. 2007; Fletcher et al. 2010; Nordström et al. 2003; Smith et al. 2010; Tharme et al. 2001). Lethal control methods are however time-consuming, highly skilled and often controversial activities, and rarely succeed in lowering target predator densities to an extent that completely removes the threat of predation from these species (Bolton et al. 2007; Smith et al. 2010), partly due to rapid immigration from surrounding populations (Rushton et al. 2006). The removal of top predators may also result in mesopredator-release, where the relaxation of prey competition or direct predation pressure allows populations of other predator species to increase (Crooks & Soulé 1999; Ellis-Felege et al. 2012; Latham 1952; Ritchie & Johnson 2009).

Alternative non-lethal control methods may involve habitat manipulation to channel predator activity away from breeding birds and to encourage them to nest at higher densities (Bodey et al. 2010; Gibbons et al. 2007; Seymour et al. 2003), or methods which directly prevent predators from reaching colonies or individual nests (predator-exclusion fencing or nest exclosures, e.g. Isaksson et al. 2007; Mayer & Ryan 1991). Techniques to protect individual nests are successful in increasing hatching success for small populations of waders such as Lapwing (Isaksson et al. 2007), Dunlin *Calidris alpina* L. (Pauliny et al. 2008) and Piping Plover *Charadrius melodus* Ord. (Murphy et al. 2003a) but are unsuitable for species that rely on nest crypsis, where nest exclosures result in high levels of adult mortality (Isaksson et al. 2007; Murphy et al. 2003b; Smith et al. 2011). Individual nest protection is also impractical for sites with large wader populations, and cannot improve the survival of precocial chicks when predation is a key cause of mortality (Smith et al. 2011). In contrast, predator-exclusion fencing – which can be used to enclose large areas and can deter large mammalian predators in two ways: either by presenting a physical barrier or by modifying behaviour through the use of unpleasant stimuli such as a small electric shock (Poole & McKillop 2002) – may be a more practical management tool for localised populations (Jackson 2001; LaGrange et al. 1995; Mayer & Ryan 1991; Rickenbach et al. 2011). A recent review of multiple species and habitats identified a significant 92% increase in avian hatching success with the use of predator-exclusion fencing (Smith et al. 2011). Fencing has also led to improvements in overall wader breeding success (i.e. the number of fledglings produced) in arable and mixed farmland habitats (Rickenbach et al. 2011; Schifferli et al. 2009). The applicability of this method to the protection of waders breeding on lowland wet grassland is however unknown.

In this trial, we test the effect of erecting predator-exclusion fencing on lowland grassland wader nesting success and overall productivity, using Lapwing as a study species. Lapwing breeding ecology is well-studied and the species is relatively easy to locate and monitor as it nests in short, open vegetation. Although other waders nesting in lowland wet grassland habitats have different nesting requirements (preferring to nest in longer vegetation; Durant et al. 2008), all are subject to similar predation rates (Green 1988; MacDonald & Bolton 2008b; Mason & Macdonald 1976). These factors mean that Lapwing is an ideal study species to use as an indicator of whether the exclusion of large mammalian predators could facilitate lowland wader population recovery.

Methods

Study sites

Ten lowland wet grassland sites managed as extensive grazing marshes in England, Wales and Northern Ireland were selected to test the general applicability of predator-exclusion fencing over multiple years across lowland habitats (Fig. 1 and Table 1). All sites were nature reserves or protected areas, selected for inclusion based on the presence of high levels of large predatory mammal activity (predominantly red fox *Vulpes vulpes*, but also European badger *Meles meles*) and the identification of mammalian predation as the major cause of low wader breeding success (nest camera images of 141 predated wader nests on these sites plus five other UK lowland wet grassland reserves between 2003 and 2009 indicated 63% of nests predated by foxes, 13% predated by badgers; RSPB unpublished data).

At some sites lethal control of foxes before the wader breeding season (late winter–early spring) and/or carrion crows *Corvus corone* during the wader breeding season (March–June) was conducted in addition to fencing to protect vulnerable breeding populations outside of the fenced area (Table 1, "additional control"). Fox control was conducted at night by trained marksmen and carrion crows were trapped with Larsen cage traps, both operating according to legal welfare requirements. Badgers are protected by law in the UK, so no lethal control of this species was performed.

Routine habitat management was also conducted at each site to maintain sward structures and hydrological conditions required by breeding Lapwing and other waders (see Eglington et al. 2010, 2007; Smart et al. 2006 for the evidence informing these management guidelines). This trial is therefore a practical evaluation of predator-exclusion fencing as a non-lethal predator control technique in the presence of additional lethal control of foxes and crows and ongoing habitat management practises characterising lowland wet grassland areas managed for breeding waders in the UK.

Fence specifications

Predator-exclusion fences were constructed by trained site staff or specialist contractors and were of two designs: stranded electrical fencing (hereafter 'stranded' fencing); and, a combination of electric and standard stock fencing (hereafter 'combination' fencing; Table 1, see Appendix 1 for fence specifications). Stranded fencing was the design of choice used at the majority of sites as it was less expensive (£1.50–£3.50 per m, compared to GBP£10–£12 per m for combination fencing; Ausden et al. 2011), less time consuming to erect and more flexible in design. It was however less durable (lasting c.10 years) and was limited when enclosing large areas. Combination fencing, by providing a more formidable and durable barrier (>20 years lifetime), was used at sites where previous monitoring indicated the presence of badgers as a predator of Lapwing nests, and/or where stranded fencing would have presented an insufficient barrier to grazing stock.

Fence structures were permanent and operational February–July, with the exception of Greylake where a stranded fence was only in place for the wader breeding season. Some permanent fences were deactivated or intentionally breached by opening gateways in the winter to allow movements of non-target species (brown hare *Lepus europaeus*, otter *Lutra lutra*). Electricity was supplied via battery or mains power from the UK National Grid (Table 1).

Fences were checked weekly for signs of damage: fault-finding devices were used to identify any voltage loss, in which case the entire fence length was checked to determine the source (most often vegetation that had fallen against live wires). Vegetation under and adjacent to the fence line was controlled either by cattle or sheep grazing, the placement of weed-control matting, the application of a broad-spectrum systemic herbicide (glyphosate) or regular mowing.