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Community ecology

Is breeding of farmland wading birds depressed by a combination of predator abundance and grazing?

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Agri-environment schemes have been implemented across Europe to counter biodiversity loss in agricultural landscapes and halt the continual decline of farmland birds, including waders. Such schemes provide financial compensation for changes in agricultural practice, including livestock grazing regimes. Scheme uptake has been variable, partly because farmers believe that other factors, notably predation, are key to wader population declines. On the basis of wader breeding surveys across Shetland, UK, we show that predator density and livestock grazing, through reducing sward height, interact to influence territoriality and thereby are likely to affect wader breeding success. Our results appear to reflect views of both farmers and government agencies, which indicates that future agri-environment schemes would benefit from genuine stakeholder participation to maximize scheme uptake, implementation and beneficial effects on biodiversity. Our findings also imply that agri-environment schemes will reap the greatest benefits for waders through reducing stocking rate where avian predators are abundant.

Keywords: agri-environment scheme; farmers; lapwing; livestock grazing; oystercatcher; predation

1. INTRODUCTION

Agricultural intensification is generally considered the prime cause of large-scale declines in farmland breeding birds across Europe (Donald *et al.* 2001). Wading birds have declined particularly severely, and given several species' dependency on agricultural fields for breeding, there is concern about the fate of these highly appreciated 'cultural birds' (Herzon & Mikk 2007). Agricultural practices (weed control, early ploughing, drainage and intensive livestock grazing) are commonly seen as the main drivers of population decline (Newton 2004). Accordingly, European government agencies have established agri-environment schemes to help transform the fortunes of farmland breeding waders. Such schemes compensate farmers in return for land management modifications, notably relaxing livestock grazing. This approach potentially allows large areas of farmland to attract greater densities of breeding waders, though efficacy may be compromised by limited flexibility for adaptation to the local conditions or adjustment over time if progress were to fall short (Smallshire *et al.* 2004). In line with these concerns, the beneficial effects for breeding waders have indeed been limited or non-existent (e.g. Kleijn *et al.* 2001; Wilson *et al.* 2007), although the exact reasons remain poorly understood (Berendse *et al.* 2004).

A commonly suggested reason for the agri-environment scheme shortcomings for waders is predator abundance, as predation pressure exerted on breeding waders may override any potential positive effect of land-use modifications (Berendse *et al.* 2004; Newton 2004). Numerous studies have demonstrated that predation can dramatically decrease breeding success (e.g. Grant *et al.* 1999). The view that predation is key to wader declines is also widespread among farmers (Herzon & Mikk 2007). By not addressing predation in agri-environment schemes, the level of uptake and implementation by farmers, and thus the quality of environmental benefits obtained, may suffer (Morris & Potter 1995; Siebert *et al.* 2006).

However, there is a growing awareness that predation risk may be strongly influenced by agricultural practice, notably grazing (Baines 1990; Valkama *et al.* 1999; Wilson *et al.* 2005). If demonstrated compellingly, farmers may see agri-environment schemes as more realistic (Herzon & Mikk 2007), but such evidence is scarce (Evans 2004). Grazing is a strong determinant of grassland sward height and structure (Berg *et al.* 1997). Whereas intermediate grazing pressure may provide a heterogeneous sward with tall tussocks for cover and shorter vegetation for feeding, high stocking rates invariably generate short-cropped vegetation in which nest and chick predation may be high (Baines 1990; Valkama *et al.* 1999; Wilson *et al.* 2005; Ottvall & Smith 2006). There is now an urgent need to determine the interactive effects of grazing and predator abundance on farmland breeding waders (Evans 2004; Herzon & Mikk 2007).

We tested the hypothesis that the combined effect of grazing pressure, through reducing sward height, and predator abundance is detrimental to farmland breeding waders, by quantifying the proportion of breeding pairs showing territorial or distraction behaviour on farms participating in an agri-environment scheme.

2. MATERIAL AND METHODS

In 2004, breeding bird surveys for lapwing (*Vanellus vanellus*), oystercatcher (*Haematopus ostralegus*), redshank (*Tringa totanus*) and curlew (*Numenius arquata*) were conducted on 40 farms in Shetland, UK (60°30′ N, 1°15′ W). The farms were randomly selected from participants in the Environmentally Sensitive Area (ESA) agri-environment scheme. All enclosed ground on each farm (mean 28.4 ha per farm, 11.7 fields per farm) was surveyed in mid-April, late May and mid-June, covering the full breeding season. The observer walked through each field such that all parts were thoroughly searched (within 100 m, usually substantially less), and recorded whether pairs or single birds showed territorial (advertising/defence) or distraction behaviour (hereafter collectively called 'territoriality'). Flocks or lone feeding birds were ignored.

Soil moisture, vegetation height and sheep abundance were recorded at the individual field visit level. Soil moisture was estimated visually as the proportions (5% precision) of a field falling into four classes, namely standing water, wet (requiring waterproof boots), moist (traversable in normal footwear but squelching underfoot) and dry. Similarly, vegetation height was

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estimated as the proportions by area in five height classes: bare ground, less than 5, 5–10, 10–20 cm and more than 20 cm.

Potential avian predators of wader eggs and chicks were recorded at the farm level during each visit. These comprised, in descending order of total numbers, common gull (*Larus canus*), herring gull (*Larus argentatus*) plus lesser black-backed gull (*Larus fuscus*), great black-backed gull (*Larus marinus*), hooded crow (*Corvus corone cornix*), black-headed gull (*Larus ridibundus*), great skua (*Stercorarius skua*), raven (*Corvus corax*) and arctic skua (*Stercorarius parasiticus*). Mammalian predators (feral cat, stoat, ferret) occur on Shetland, but impacts on waders are unknown.

The nine soil and vegetation scores for each field visit were ordinated by principal components analysis (PCA) to produce three orthogonal axes for regression analysis (64% of variation explained). To test whether the presence of potential avian predators might affect wader breeding attempts, we modelled the probability that an observed pair showed territoriality when the observer approached. The data were fitted to generalized linear mixed models having a binomial error term, logit link function, farm and field as random effects, and a farm level index of predator pressure (square root of number seen) as an explanatory variable. Interaction terms of the predator index with field PCA scores were included to test whether taller vegetation might offer protection from predators. Relationships between territoriality of individual wader species and indices of the individual predator numbers were examined where there was sufficient behavioural variation, i.e. for lapwing, redshank and curlew in April (egg-laying stage), and for oystercatcher in May and June (egg-laying and chick stage). Non-significant predator terms were dropped by sequential backwards elimination.

3. RESULTS

PCA produced axes contrasting broad soil and vegetation characteristics likely to influence wader territoriality, of which the first (26% of variation explained) was the most influential and ordered fields along a gradient from relatively dry, very short swards (less than 5 cm) to wetter, medium–high swards (10–20 cm). Fields with livestock present had significantly lower scores on this axis than those without ($F_{1,1329}=48.8$, $p<0.001$); where sheep were present, this axis was inversely related to sheep density ($F_{1,456}=12.9$, $p<0.001$), thus suggesting that the high prevalence of very short swards (43% of total surveyed area) was principally due to high sheep grazing pressure.

Recorded densities remained constant over the season for oystercatcher (range 12.4–15.8 pairs km^{-2}), curlew (4.4–5.1) and redshank (3.4–3.9), but dropped for lapwing from 4.9 in April/May to 2.1 pairs km^{-2} in June. Territoriality of the relatively abundant lapwing and oystercatcher was strongly influenced by the interaction between PCA1 and predator abundance. On farms with few predators, most lapwing pairs behaved territorially, but with many predators, territoriality was associated only with pairs found in taller swards (figure 1*a*; PCA1–predator interaction $t_{180}=6.0$, $p<0.001$). Oystercatchers showed a similar less extreme pattern (figure 1*b*; interaction $t_{112}=2.5$, $p<0.005$). Reduced territoriality in lapwings was most strongly associated with high raven ($t_{70}=3.3$, $p<0.01$) and hooded crow numbers (interaction $t_{192}=6.8$, $p<0.001$). Oystercatcher territoriality was related to the egg predators common gull (interaction $t_{126}=3.1$, $p<0.01$) and black-headed gull (interaction $t_{126}=2.0$, $p<0.05$), as well as one potential chick predator, the great skua ($t_{31}=3.3$, $p<0.01$). There was no evidence that these patterns were due to associations between predator abundance, sheep density and PCA scores at the farm level (see electronic supplementary material).

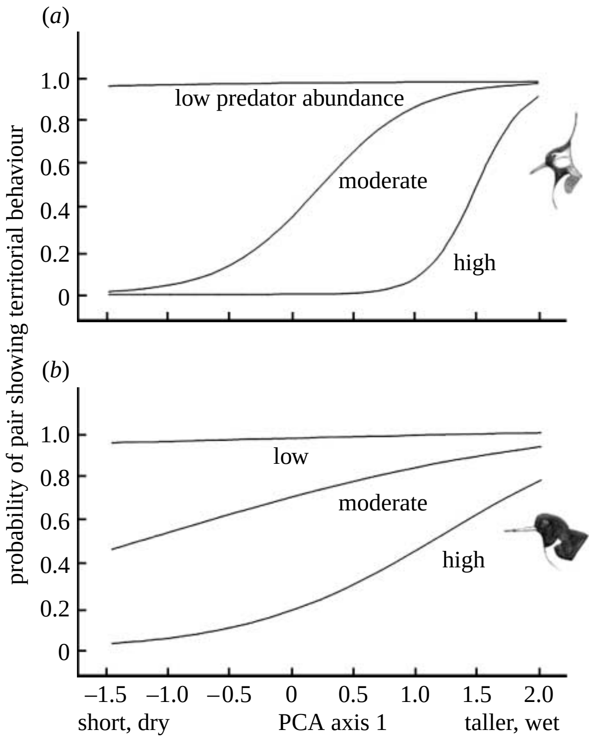

Figure 1. Predicted probability of a pair of (*a*) lapwing or (*b*) oystercatcher showing territorial behaviour in relation to the abundance of avian predators and soil-vegetation characteristics. Relationships are depicted for three representative predator index values (low = 1, moderate = 16 and high = 64 predators observed per farm visit).

For curlew and the less abundant redshank, no significant interactions between overall predator abundance and vegetation were established. However, a similar principle was observed: if common gulls were few, both waders showed a high instance of territoriality, but where gulls were abundant, curlew territoriality was confined to taller wet vegetation (interaction $t_{82}=2.6$, $p<0.05$), whereas redshank territoriality was consistently reduced ($t_{43}=3.1$, $p<0.01$).

4. DISCUSSION

Our data show that the combination of high densities of predatory birds and intense livestock grazing, through reducing sward height, can indeed reduce wader territoriality on farmland, which may indicate reduced breeding success. Territorial or distraction behaviour may be interpreted as an index of the willingness to start a breeding attempt, as adults without nest or chicks lack such vigilant behaviour (Grant *et al.* 1999). It was logistically infeasible to determine actual breeding success, but we recommend this for future studies. Although differential sward height preference has been identified, lapwing favouring shortest (Evans 2004) and curlew tallest swards (Grant *et al.* 1999), our study suggests that short swards may not pose a problem for oystercatcher and curlew as long as predator abundance is low. Sward height did not influence the likelihood of waders defending their territory when predators were infrequent, but they failed to do so in short swards when predators were prevalent.

We do not know whether our findings were influenced by spatio-temporal movements of birds, whereby pairs that lost eggs or chicks moved to short swards, while pairs with chicks moved to tall swards. Also, more birds may lay replacement clutches in tall swards when predator density is high. Both factors may help explain why pair density remained relatively constant between April and June for all species except lapwing. Here, the 57% late-season fall in density was reflected in greater numbers of flocking birds.

Our study provides clear management recommendations: since the abundance of avian predators is largely outwith individual farmers' control, sward height should not be reduced to the extent that predation risk is increased there where otherwise good quality wader habitat is present. This indicates that agri-environment schemes may reap the greatest benefits for waders through reducing stocking density, where avian predation pressure is high.

Many biodiversity support schemes fail either to attract farmers or to achieve their objectives (Kleijn & Sutherland 2003). Scheme uptake and implementation may depend on farmers' belief that environmental benefits will materialize (Morris & Potter 1995; Siebert *et al.* 2006). Our findings may help farmers to relate better to the agri-environment schemes aimed at improving conditions for farmland breeding waders. Although farmers recognize that the intensification is linked to farmland bird declines, many see predation as critical. For instance, 71% of Finnish and 37% of Estonian farmers attributed the farmland bird demise to increased predator abundance (Herzon & Mikk 2007), and 55% of English farmers believed that predators were responsible (Smallshire *et al.* 2004). We learned that Shetland farmers were frequently sceptical about the usefulness of the ESA scheme for waders, as predation was seen as far more important, thus downplaying the potential importance of relaxed livestock grazing to obtain taller swards, a main premise of the ESA scheme. Previous studies have highlighted that, whereas the main motivation of less-committed participants for entering schemes was financial, many farmers enter schemes for conservation motives and to attract a positive societal image (Morris & Potter 1995; Siebert *et al.* 2006; Herzon & Mikk 2007). Moreover, agri-environment schemes' effectiveness may be greatest if farmers believe in what they are asked to do, rather than just working for a financial reward (Kleijn & Sutherland 2003). Our results reflect both the views of farmers and government agencies, which indicate that future agri-environment schemes would benefit from genuine stakeholder participation to maximize scheme uptake, implementation and beneficial effects on biodiversity.

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