

Brief report

An artificial nest experiment indicates equal nesting success of waders in coastal meadows and mires

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Degradation of the distinct, diverse and abundant wader communities in Estonian coastal meadows has been recorded along with the ceasing agricultural management there. At the same time, the same species have been occupying adjacent inland mires. This study examined the possibility that waders are switching their habitat due to increased nest predation in coastal meadows. However, no differences in the average daily survival rates of artificial nests were found between meadows and mires. Data on real wader nests indicated that artificial nests reflect the fate of real nests. We suggest that meadows may have lost a past safety advantage and now the breeders are re-settling according to the current habitat quality. However, given the general decline of waders, the temporally increasing populations of mire breeders are hardly self-sustaining. Therefore, attempts to restore coastal meadows are crucial for the Baltic populations of several wader species.



1. Introduction

In recent decades, many European wader populations have declined (BirdLife International 2004) and nest predation is obviously a key factor in several cases (e.g. Jönsson 1991, Grant *et al.* 1999, Jackson & Green 2000, Rönkä *et al.* 2006). Though nest predation causes frequent reproductive failure for birds in general (Ricklefs 1969), its impact may be increasing concurrently with changes in habitats and in predator-prey ratios (Reynolds & Tapper 1996, Rönkä 1996, Koivula & Rönkä 1998). Because of predation, the current

breeding success of waders may be too low for population survival even in the areas managed in a way considered suitable for birds (Jönsson 1991).

In the 20th century, grasslands were the primary nesting habitat for many wader species in Estonia (Leibak *et al.* 1994) with the highest diversity and abundance of waders on managed coastal meadows (Lilleleht 1998). However, concurrent with the overgrowth of meadows due to ceased grazing (see Rannap *et al.* 2007 for a quantitative overview), short-grass dwellers (such as Lapwing *Vanellus vanellus*, Black-tailed Godwit *Limosa limosa* and Southern Dunlin *Calidris alpina*

schinzii) in particular, have dramatically decreased since the 1950s. For example, these three species have decreased by 50–80% within 30 years in the Matsalu National Park, the most important wetland site in Estonia (Kuresoo & Mägi 2004). At the same time, the waders have been gradually occupying inland mires, though these local increases have not balanced their general decline (Kumari 1972, Kuresoo & Mägi 2004). Despite the declining numbers (Elts *et al.* 2003), Estonia still supports a substantial part of the European populations of several wader species, such as one-third of the Baltic Dunlin population (Thorup 2006).

This study explores the possibility that waders are switching their breeding habitat according to the increased nest predation in coastal meadows. Such a switch may be caused by the loss of extensive short-grass areas (Rannap *et al.* 2007) where waders can better avoid predators (Koivula & Rönkä 1998). A disproportionately greater increase in predator numbers has occurred in agricultural landscapes after their reduced persecution since the 1970s and the recent more abundant and concentrated food base (Edula 1998, Tuule & Elts 2003). Thus, in terms of nesting success, mires may have become more favourable, acting as temporary refuges or even sustaining the populations eventually at some lower level. Indeed, higher breeding success of Curlew *Numenius arquata* in bogs than in other habitats has been reported from Sweden (Berg 1994). Below we compare predation rates on artificial nests in these two habitat types in Estonia and, to support the extrapolation of the results to real populations, we also present evidence for the link between the success of artificial and real wader nests.

2. Methods

The study was conducted in the West-Estonian coastal meadows and open mires (raised bogs, transitional mires and fens), where six species of waders breed in both habitats: Lapwing, Redshank *Tringa totanus*, Black-tailed Godwit, Dunlin, Curlew, and Common Snipe *Gallinago gallinago*. The most likely predators on wader nests in the study area are Marsh Harrier *Circus aeruginosus*, gulls *Larus* spp., Hooded Crow *Corvus corone cornix*, Raven *Corvus corax*, Red Fox *Vulpes vulpes*, Rac-

coon Dog *Nyctereutes procyonoides* and American Mink *Mustela vison*.

To reduce the impact of spatial and temporal variation, the experiment was designed as a spatially paired comparison of meadow and mire sites in a particular year. The *a priori* criteria for site selection were (1) they should support at least 10 pairs of breeding waders in meadows; (2) the occurrence of typical meadow breeders (Lapwing, Redshank, Black-tailed Godwit) in mires; and (3) up to a 30-km distance between the treatments of the same site pair. Data on breeding waders were obtained mostly from national bird-monitoring and conservation inventories (notably Leibak & Lutsar 1996, Lõhmus *et al.* 2001). From the 19 pairs of sites meeting the criteria, eight pairs were selected to represent a range of geographical locations and the characteristic mire types in western Estonia (Fig. 1). Meadows and mires were on average 15.9 (± 7.9 SD) km apart in these site pairs.

At each site, ten artificial nests, each containing four domestic Japanese Quail *Coturnix c. japonica* eggs, were placed at least 100 m apart. The nests were relatively well exposed, resembling Lapwing nests in this respect; their concealment depended on the vegetation and field-layer structure at each site, but kept as similar as possible between site pairs. The nests were surveyed at 5–7-day intervals over 21 days. The absence or destruction of any eggs was considered a clutch failure. Two site pairs were studied between 22 May and 17 June 2004, and six pairs between 15 May and 15 June 2005. During the same periods, real wader nests were sought from a distance using telescope, but only five meadow sites produced nest observations. Therefore, the survival comparison of real and artificial nests was restricted to meadows, and additional data were collected, using similar methods, between 12 May and 17 June 2006 at three previously studied meadow sites and between 16 May and 6 June 2007 at one new site.

Daily survival probability (Mayfield 1961) was calculated for artificial and, if found, natural wader nests at each site. Differences in survival rates of artificial nests at meadow and mire sites were examined using paired *t*-test; power analysis for this comparison was done using PS software (Dupont & Plummer 1997). Covariance between the survival probabilities of artificial and natural nests was compared using Pearson correlation; the

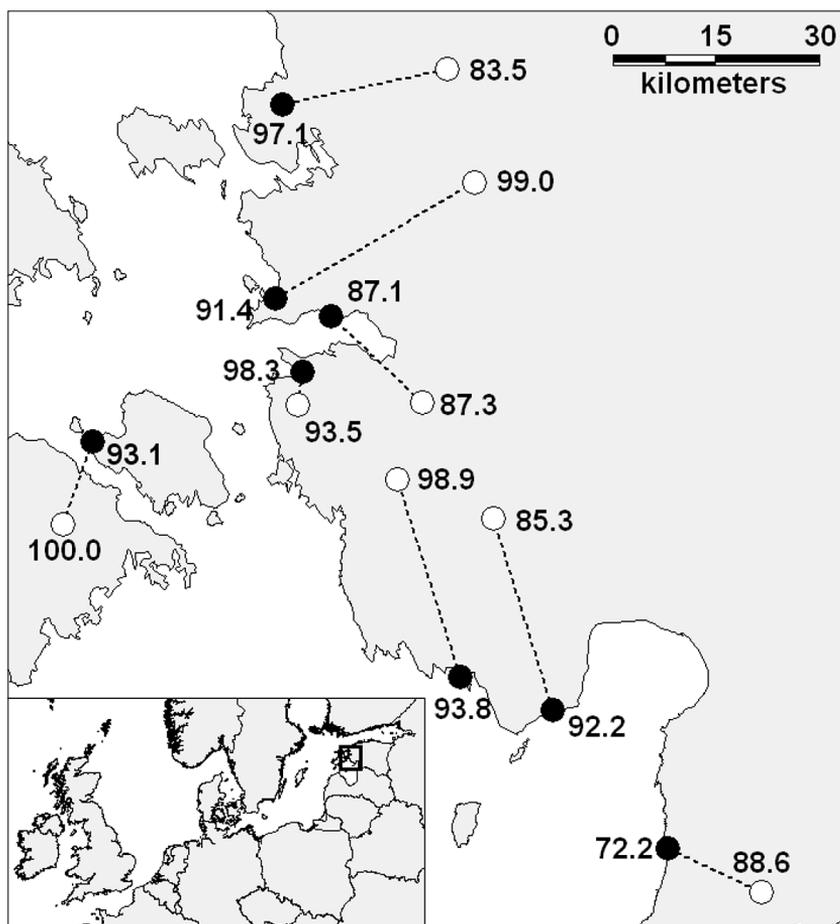


Fig. 1. Locations of the study sites in western Estonia, and the recorded daily survival rates (%) of artificial nests there.

sample unit was one meadow in a particular year. For this general comparison, the natural nests of all wader species were pooled, as their rather similar location and structure was such that large local between-species differences in predation rates were unlikely.

3. Results

Predation was the only cause of the 50 failures of artificial nests at the mire sites and the main cause at the meadow sites (48 of 56 nests; the rest were trampled by livestock). The predators remained mostly unidentified but, according to the tracks at 25 depredated nests, 17 of these could be attributed to mammalian and eight to avian predators. No evidence for adult wader mortality was found at the sites.

The average daily survival rates of artificial nests did not differ between meadows ($90.7 \pm 2.9\%$ SE) and mires ($92.0 \pm 2.4\%$ SE; paired t -test: $t_7 = 0.4$; $P = 0.70$). Among eight pairs of sites, the estimated survival rates were higher at mires in four cases and at meadows in three cases (once they were within 1%; Fig. 1). Statistical confirmation for such a small difference between the habitat types (sample mean $1.4 \pm 9.6\%$ SD) at 80% probability and $\alpha = 0.05$ would have required on average 389 pairs of sites.

In total, 39 natural wader nests were found and observed at six meadow sites. Chicks from nine nests hatched, 25 nests were depredated and one was abandoned, and the fate of four nests remained unknown. The daily survival rate of natural nests for all sites, species and years altogether was 91.3%. A correlation analysis indicated that the site- and year-specific variability in the sur-

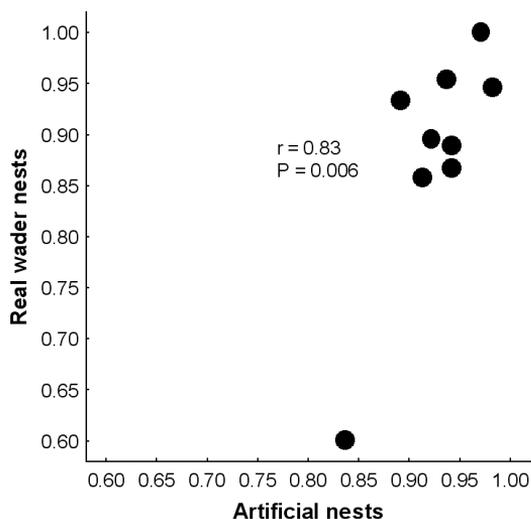


Fig. 2. Relationship between the daily survival probability of real wader nests (all species pooled) and artificial nests in six meadow sites (of which three were observed over two seasons).

vival rates of artificial nests reliably followed that of the real ones (Fig. 2).

4. Discussion

Contrary to our expectations, we found no evidence for elevated nest-predation rate in coastal meadows relative to that in mires. We do not believe that this result would be a Type II error for three reasons. First, the power analysis indicated that a huge sample would be necessary to demonstrate a habitat difference, while there is only a limited number of large coastal meadows and mires suitable for waders around the Baltic. In fact, the study included more than 40% of all such meadow-mire pairs in western Estonia. Second, the experiment followed all the principal requirements for reliable artificial nest experiments (Major & Kendal 1996). Indeed, the comparison with the survival of natural nests, albeit based on limited data, supported the assumption that artificial nests would reflect the fate of true wader nests. Third, the numerical estimates of the survival rates of both artificial and real nests in Estonia were similar to those recently reported for Swedish waders (Ottvall 2005) or only slightly lower than for Temminck's Stint *Calidris temminckii* at the coasts of

Bothnian Bay (Rönkä *et al.* 2006), suggesting that our results were representative both in time and space.

Theoretically, the quality of coastal meadows and mires for waders may have differed in aspects not studied, but we doubt that the nutrient-poor mires would provide more food, or that they would be superior in terms of fledging success, as they were not superior for clutch survival. The nearly equal nest predation in the two habitat types can be explained without rejecting the key role of nest predation in wader declines. Apparently predator impact has been lower in the meadows in the past (see Introduction). This safety advantage may have been lost by now and, as a consequence, the breeders are re-settling according to the current habitat quality (e.g., Newton 1998). A major mechanism causing this process may be adult dispersal triggered by individual failure experiences (Jackson 1994). This hypothesis could be verified by comparing failure rates among historical and current nest records. Rönkä *et al.* (2006) demonstrated such an increase in Finland. However, a risk of nest predation *per se*, with no additional impact on clutch success, may also reduce the population size via individual habitat selection (Wallerland *et al.* 2006).

Our results imply that the temporally increasing mire populations of waders are hardly self-sustaining given the nest predation rates equal to those on coastal meadows where the waders decline. This pattern corresponds to the view that the natural mire habitats (notably fens) of waders had degraded already centuries ago by drainage, which in fact accelerated the shift of open-land species to man-made grasslands (Kumari 1958). Moreover, nest predation may have increased in mires, as the generalist predators – corvids and medium-sized carnivores – have increased all over Estonia (Eltis *et al.* 2003, Randveer 2004). Therefore, attempts to restore coastal meadows are probably crucial for the Baltic populations of several wader species, although it is not clear whether the simple recreation of short-grass areas (Rannap *et al.* 2004) would be sufficient to ensure populations are sustained. Also, the recommended focus on restoring larger meadows first (Rannap *et al.* 2007) seems to be a reasonable precautionary strategy for waders, as nest predation may be more frequent in smaller patches (Burger *et al.* 1994, Sovada *et al.* 2000,

Seymour *et al.* 2004). However, the necessity for local predator control cannot be determined before future studies have demonstrated that the remarkable spatial variation in nest survival (see Berg *et al.* 1992, Kauhala 2004 and the present study) is related to predator abundance in the coastal meadows (Bolton *et al.* 2007). In general, management of meadows to support waders may be a more viable strategy than direct predator control to reduce the predation pressure on waders (Schneider 2001, Evans 2004).

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