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Coastal meadow management for threatened waders has a strong supporting impact on meadow plants and amphibians

Riinu Rannap[a,*], Tanel Kaart[b], Hannes Pehlak[c], Silja Kana[c], Elin Soomets[a], Kaire Lanno[c]

[a] Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, Tartu 51014, Estonia
[b] Institute of Veterinary Medicine and Animal Sciences, Estonian University of Life Sciences, Kreutzwaldi 48, Tartu 51006, Estonia
[c] Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Kreutzwaldi 5, Tartu 51014, Estonia

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ABSTRACT

Wet grasslands provide unique habitats for several taxa and offer multiple ecosystem services. Their degradation is therefore of increasing concern in many parts of the world. Baltic coastal meadows, which host diverse plant and bird communities and provide an essential breeding ground for amphibians, belong to the most threatened habitat types in Europe. In spite of the EU agri-environmental schemes, the threatened wader and toad populations, characteristic to these meadows, have not recovered, suggesting that the management efforts are failing to provide sufficiently high habitat quality for these species. In this paper we report the results of a large-scale survey determining the factors that influence the patterns of breeding habitat selection of four Charadriiform bird species on 24 coastal meadows in Estonia. We also examined whether the habitat conditions required by the threatened waders would benefit breeding amphibians and meadow plants and whether the threatened waders might act as focal species for managing coastal meadow biodiversity. In total, we analysed 23 landscape-variables, applying co-inertia analysis to discover common multivariate patterns in coastal meadow characteristics, breeding waders, plants and amphibians. We demonstrated that large (≥100 ha) and wide (mean width ≥200 m) meadows with extensive grazing, high water-table and no woody vegetation provide favourable breeding conditions for waders of conservation concern, but at the same time also support other Charadriiform birds, larger amphibian populations, and more diverse plant communities. Meadow management should therefore be targeted at threatened waders, especially Baltic dunlin, which could be considered as a focal species, and focus on the establishment of large and wide meadow areas with extensive grazing.

1. Introduction

Wet grasslands (e.g. coastal meadows; salt and freshwater marshes; brackish swamps) experienced a loss in area of at least 80% during the 20th century (Joyce, 2014). Due to their importance in providing multiple ecosystem services (Joyce & Wade, 1998; Isselstein & Kayser, 2014) and habitat for wildlife, degradation of wet grasslands continues to cause concern in many parts of the world (Williams & Hall, 1987; Kennish, 2001; Joyce, 2014).

The coastal meadows around the Baltic Sea are among the most threatened habitats in Europe, being listed as a priority habitat type in Annex I of the EU Habitats Directive (92/43/EEC). The Baltic coastal meadows are originally primary open grasslands that have retained their low vegetation due to the combined impact of brackish-water and traditional low-intensity grazing and mowing. These grasslands host diverse plant communities (Paal, 1998; Kull et al., 2002) and internationally important breeding populations of wildfowl and waders (Kuresoo and Mägi, 2004; Thorup, 2004). They are also vital stop-over sites for migrating birds (Ottvall & Smith, 2006) and essential breeding and foraging grounds for amphibians (Rannap, Lõhmus, & Jakobson, 2007; Rogell, Berglund, Laurila, & Höglund, 2011).

Baltic coastal meadows suffered a considerable decline during the second half of the 20th century due to the large-scale adverse impacts of agricultural intensification, drainage (Beintema, 1991), and later ceased management (Koivula & Rönkä, 1998; Kuresoo & Mägi, 2004; Ottvall & Smith, 2006). In Estonia, the area of managed coastal meadows decreased from 29 000 ha to 8000 ha (Luhamaa, Ikonen, & Kukk, 2001); similar losses took place in Sweden and Finland (Jutila, 2001; Ottvall & Smith, 2006). Overgrowing of the abandoned meadows, which have remained

* Corresponding author.
E-mail addresses: riinu.rannap@ut.ee (R. Rannap), tanel.kaart@emu.ee (T. Kaart), hannes.pehlak@eesti.ee (H. Pehlak), silja.kana@emu.ee (S. Kana), elin.soomets@ut.ee (E. Soomets), kaire.lanno@emu.ee (K. Lanno).

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without grazing and/or mowing for decades, has caused severe biotic impoverishment (Brunside, Joice, Puurmann, & Scott, 2007). Wader populations – particularly those of ruff (*Philomachus pugnax*), Baltic dunlin (*Calidris alpina schinzii*) and black-tailed godwit (*Limosa limosa*) – have undergone a drastic decline (Hellström & Berg, 2001; Kuresoo & Mägi, 2004; Thorup, 2004), whereas the Baltic populations of natterjack toad (*Epidalea calamita*) and green toad (*Pseudepidalea viridis*) are presently threatened with extinction (Rannap et al., 2007; Rogell et al., 2011). As grazing influences the structure and spatial heterogeneity of swards (Durant, Tichit, Kernéïs, & Fritz, 2008), it is a major determinant of the use of wet grasslands by breeding waders (Verhulst et al., 2011; Źmihorski, Pärt, Gustafson, & Berg, 2016) and amphibians (Rannap et al., 2007; Roche, Latimer, Eastburn, & Tate, 2012). It also increases plant species richness (Bos, Bakker, de Vries, & van Lieshout, 2002; Wolters, Garbutt, & Bakker, 2005), because absence of grazing results in succession, where costal grasslands become increasingly overgrown with high-sward communities (Brunside et al., 2007).

In order to retain the Baltic coastal meadow ecosystems, a restoration programme was initiated by the Estonian Ministry of the Environment in 2001. In 2004, EU agri-environmental schemes (AES) started providing financial incentives to farmers for maintaining or enhancing the coastal grassland landscapes. As a result of these measures, 9100 ha of the Estonian coastal meadows are currently under constant management. In spite of these actions, however, the wader and toad populations of conservation concern are not displaying any signs of recovery (Rannap et al., 2007; Elts et al., 2013), suggesting that the management efforts are failing to provide certain key conditions of habitat quality that were historically present. Thus, in order to ensure the success of meadow management targeted towards these struggling populations, exact determination of the habitat requirements of the species is vital. Furthermore, these species could act as focal species (*sensu* Lambeck, 1997) for other taxa, depending on the coastal meadow habitats.

In this paper, we examined the habitat relationships of breeding waders – northern lapwing (*Vanellus vanellus*), common redshank (*Tringa totanus*), ruff, Baltic dunlin and black-tailed godwit – on 24 coastal meadows in Estonia. We aimed to determine the key habitat factors of each wader species on managed coastal meadows and evaluate the state of the meadows as breeding grounds in terms of these habitat qualities. Based on knowledge gained from previous studies we assumed that extensively managed meadows with natural hydrology provide high quality breeding and foraging conditions for waders (e.g. Durant et al., 2008; Leito et al., 2014; Cuttriss, Maguire, Ehmke & Weston, 2015; Źmihorski et al., 2016), whereas meadows with dense ditch networks and low management intensities cause habitat quality to deteriorate, which includes an increase in predation risk (e.g. van der Vliet, Schuller, & Wassen, 2008; Kentie, Both, Hooijmeijer, & Piersma, 2015). As coastal meadows support diverse plant communities and are valuable breeding sites for amphibians, we compared, for the first time, the key habitat requirements of these species to the habitat requirements of meadow waders, asking (i) whether the habitat conditions required by threatened waders would also benefit breeding amphibians and plants characteristic to Baltic coastal meadows, and consequently; (ii) whether threatened waders could act as focal species for managing other taxa, depending on the meadow habitat.

2. Material and methods

2.1. Study species

Northern lapwing and common redshank are among the most numerous and widespread meadow waders on Baltic coastal grasslands in Estonia, while ruff, Baltic dunlin and back-tailed godwit are species of conservation concern with a restricted distribution and low abundances (Elts et al., 2013). The national population estimates for the latter species were, respectively, 10–30; 180–230 and 400–700 breeding pairs in 2012 (Elts et al., 2013). These species are considered to be habitat specialists, requiring extensively grazed wet grasslands with a natural micro-relief (no ploughing or levelling conducted) and no fertilizer application (Thorup, 2004). High groundwater level in late May – early June is also essential, as it creates favourable conditions for a second clutch (Beintema and Muskens, 1987; Green, 1988).

Regarding amphibians, because natterjack toad is currently surviving on a single coastal meadow in Estonia it could not be used for a wider study. Instead, we explored two other species that still extensively inhabit the meadows – moor frog (*Rana arvalis*; Annex IV species of the EU Habitats Directive) and common frog (*R. temporaria*). Both of these species are widely distributed in Western Estonia, with moor frog being generally more abundant than common frog (Rannap, unpublished).

2.2. Study area and field methods

We sampled 24 coastal meadows (hereafter 'study sites') in four Estonian counties where coastal grasslands primarily occur in Estonia (Fig. 1). Each sampled meadow was a coherent management unit that had been used as a pasture for at least five consecutive years by 2012 (database of Estonian Agricultural Registers). Grazing animals included mostly beef cattle, but to a lesser extent also sheep and horses. Mowing of hay was partially used on five meadows only. The mean area of the study sites was 99 ha, varying from 23 ha to 316 ha. We separated and independently sampled a subset of 11 meadows with natural hydrology and another subset of 13 ditched meadows (mainly drained in the 1970s and 1980s; Fig. 1), given the key importance of meadow wetness (i.e., presence of floods, depressions and pools) for breeding waders (e.g. Paillisson, Reeber, & Marion, 2002; Leito et al., 2014; Źmihorski et al., 2016).

The field study was conducted in two separate years (2012 and 2013) that featured a contrasting pattern of precipitation. In 2012, the mean precipitation amount (March to May) was 1.5–2 times higher (74–77 mm) than the long-term average (33–39 mm), whereas the spring of 2013 exhibited only an average level of precipitation (33–40 mm; data of the Estonian Meteorological and Hydrological Institute).

All study sites were visited twice in each year. The first visit was conducted in late April – early May, when the water level was the highest and the breeding of both frog species had been completed. The second visit took place in the first half of June, when meadow waders were feeding chicks or laying second clutches and amphibian larvae were reaching metamorphosis.

During every visit each study site was systematically walked through by two to four researchers (depending on the meadow area). All trees, bushes, reed-bed areas and wet patches with standing water (e.g. floods, depressions, pools, ditches) were mapped using GPS equipment. The density of the reed-bed along the coastline was estimated on a four-point scale: 0, missing, 1, solitary tussocks, 2, fragmentary, 3, continuous. The depth and width of ditches were measured.

To assess the intensity of meadow management, we used the following scale: missing/low (vegetation height >30 cm; ground covered by old grass); moderate (vegetation height >10–30 cm); intensive (vegetation height ≤10 cm). The meadow was considered to be extensively managed when over 50% of the total area had vegetation ≤10 cm high and the rest had vegetation >10–30 cm high. Low management intensity was designated when more than 50% of the meadow area was unmanaged and the rest had vegeta-