Biological Conservation 212 (2017) 86–95

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Non-native predator control increases the nesting success of birds: American mink preying on wader nests

Agnieszka Niemczynowicz[a], Piotr Świętochowski[b], Marcin Brzeziński[c], Andrzej Zalewski[a,*]

[a] Mammal Research Institute, Polish Academy of Sciences, 17-230 Białowieża, Poland
[b] Dubelt Natural Society, Juszkowy Gród 17, 16-050 Michałowo, Poland
[c] Faculty of Biology, University of Warsaw, Żwirki i Wigury 101, 02-089 Warszawa, Poland

A R T I C L E I N F O

Keywords:
Ground-nesting birds
Invasive species
Neovison vison
Nest survival
Predator control

A B S T R A C T

The ongoing decline of breeding wader populations in Europe has been mostly explained by habitat changes and the increasing impact of native predators, but the influence of non-native invasive predators has been neglected. A seven year study of the nesting success of the northern lapwing, common redshank and black-tailed godwit was carried out in Biebrza National Park in north-eastern Poland, alongside the American mink control programme, which was undertaken with low and high intensities of mink control. Indices of mink density, based on the percentage of floating rafts with mink tracks and the number of mink trapped per 100 trap-nights, declined with the increasing number of mink removed in consecutive years. In our model, the mink control and water level covariates explained most of the variation in daily nest survival rates. A decline in mink density led to increases in daily survival rates of nests and to the overall nesting success of all three wader species. Lower water levels led to a decrease in the overall daily survival rate (DSR) but this covariate affected DSR differently throughout the breeding season. These results demonstrate that predation by an introduced species, alongside low water levels during the nesting period, can limit the nesting success of multiple wader species, and that American mink should be considered as a key predator affecting ground-nesting wetland bird populations. Conservation plans for many wader species declining in numbers should include local reductions in mink populations in order to increase nesting success. Thus, intensive continuous mink control is recommended for important nesting refuges, utilising adaptive management to ensure control efforts remain sufficiently high.

1. Introduction

Population declines of numerous wader species observed in Europe over the last few decades are considered to have resulted from habitat loss and degradation (mainly due to decreasing water level or increased farming intensity), climate change and high predation impact (MacDonald and Bolton, 2008; Roodbergen et al., 2008). These factors, particularly heavy predation, negatively affect productivity of wader populations (MacDonald and Bolton, 2008). The declining population productivity of waders results mostly from the failure of nests and loss of chicks during the breeding season (Roodbergen et al., 2012). Nest losses in waders attributable to predation vary considerably between sites and years, but generally they are high and exceed 50% at over half of the wader nesting sites studied (reviewed in MacDonald and Bolton, 2008). Chick mortality in waders arises from a range of avian and mammalian predators, whereas mammals [mainly red fox (*Vulpes vulpes*)] are mostly responsible for the predation of eggs (MacDonald and Bolton, 2008; Teunissen et al., 2008; Bellebaum and Bock, 2009; Rickenbach et al., 2011). In Western Europe, invasive mammalian species are not usually recorded as important nest predators of waders (MacDonald and Bolton, 2008; Teunissen et al., 2008). However, non-native invasive carnivores [raccoon dog (*Nyctereutes procyonoides*), raccoon (*Procyon lotor*) and American mink (*Neovison vison*)] are common in some habitats and may predate wader broods (e.g., Grant et al., 1999).

Wetlands in river valleys that are regularly flooded in spring are important breeding areas for many waders (Żmihorski et al., 2016). In flooded areas, the access of most terrestrial predators to the nesting sites is limited and only semi-aquatic or avian predators may reach them. In such areas, positive effects of flooding on the occurrence of several bird species were observed (Żmihorski et al., 2016). However, a rapid decrease in the water level during the breeding season, or very low water level during flooding, increases the accessibility of nesting sites to predators and may decrease breeding success (Bellebaum and

* Correspondence author.
E-mail addresses: aniemczynowicz@ibs.bialowieza.pl (A. Niemczynowicz), psw85@op.pl (P. Świętochowski), marcinb@biol.uw.edu.pl (M. Brzeziński), zalewski@ibs.bialowieza.pl (A. Zalewski).

http://dx.doi.org/10.1016/j.biocon.2017.05.032
Received 12 July 2016; Received in revised form 24 May 2017; Accepted 30 May 2017
0006-3207/

Bock, 2009). Therefore, in habitats where the water regime is not stable (seasonally or annually), water level fluctuations should be considered as an important factor mediating predation pressure and affecting the nesting success of waders.

Protection of wader populations should include various activities, such as water management and curbing predator pressure (Smart et al., 2006). Apart from water management and controlling mowing, the control of predator populations, both native and introduced, is considered to be a main method of decreasing nest losses of ground-nesting birds (Smart et al., 2006; Bodey et al., 2011b). However, the success of predator management for increasing bird populations is variable, particularly for ground nesting species (Bolton et al., 2007; Smith et al., 2010; Bodey et al., 2011b). It can require extensive control programmes to reduce targeted predator populations to very low levels (Bolton et al., 2007). On the other hand, increased nesting success and population growth in birds can be found in areas where eradication programmes of invasive predators have been conducted (Nordström et al., 2003). Therefore, manipulative studies based on predator control should be designed, and those found to be successful should be incorporated into management practices to increase bird productivity (MacDonald and Bolton, 2008; Fletcher et al., 2010).

In Europe, the introduced American mink (hereafter mink) is an efficient predator of water birds and their broods. Evidence of population declines due to heavy mink predation has been documented for birds breeding at sea coasts and sea islands (Kilpi, 1995; Craik, 1997; Nordström et al., 2003; Magnusdottir et al., 2012; Roesler et al., 2012). There are also several studies that show the impact of invasive mink on waterfowl breeding in freshwater habitats (Peris et al., 2009; Brzeziński et al., 2012; Pescador et al., 2012), but there is no evidence that mink affect the nesting success and population number of waders. However, nesting sites of waders distributed in river valleys should be considered as particularly vulnerable to predation by mink, which intensively search for their prey close to river banks (Harrington and Macdonald, 2008).

The American mink colonised north-eastern Poland in the last two decades of the 20th century (Brzeziński and Marzec, 2003) and its densities gradually increased in this region and currently remain high (in most study sites 5–10 mink per 10 km of river; Brzeziński et al., 2010). In north-eastern Poland, mink are abundant in all riparian habitats and in national parks. This includes Biebrza National Park (BNP) which protects breeding populations of numerous wader species. Since 2009, a mink control programme has been conducted in BNP and the nearby Narew National Park (NNP). Evaluating the long-term control of mink in the BNP and NNP enabled us to address three aims: i) to assess the effectiveness of mink population control by relating mink density to removal effort, ii) to determine how mink control affects the nesting success of three wader species: northern lapwing (*Vanellus vanellus*), common redshank (*Tringa totanus*) and black-tailed godwit (*Limosa limosa*), and iii) to analyse the importance of year-to-year variation of the water level in the Biebrza river in relation to wader nesting success. In this study, we tested the hypotheses that i) nesting success of waders increases with an increase in the mink control effort, ii) low water levels increase access of predators to wader aggregations and reduce wader nesting success.

2. Materials and methods

2.1. Study area

The study was conducted in north-eastern Poland, in BNP (53.48°N, 22.63°E) and NNP (53.08°N, 22.83°E) (Fig. 1). Both national parks, which are approximately 30 km apart, protect well preserved wetland ecosystems in river valleys, and harbour a rich community of birds, with more than 190 breeding species. Biebrza river is a tributary of the Narew river and the two rivers join in BNP. The study was carried out in the southern part of the BNP, where the predominant habitat is fenland, which is characterised by regular seasonal flooding. The highest water level is recorded in March and April, after which it decreases gradually and small mineral soil islands start to emerge from the water (Byczkowski and Fal, 2004). These islands differ in size, shape, vegetation cover and abundance, depending on the water level, creating optimal nest sites for ground-nesting birds, including waders. During the breeding seasons in 2009–2015, the mean water level in the study area varied from 248.5 cm in 2015 to 334.5 cm in 2013 and the decrease in water level ranged from 45 cm in 2010 to 103 cm in 2009. Waders nested across several islands in varying numbers, but each year they formed a vast interspecific aggregation composed of several separate but not distant nesting groups. The wader nests in the aggregation were distributed over an approximate area of 10 ha.

The NNP was established to protect a 35 km long section of the Narew river valley. Around 90% of the park's area is covered by water or peat bogs. The width of the valley ranges from 1 to 4 km. The river splits into many river beds creating a typical anastomosing pattern. Spring flooding occurs, similar to the BNP. In both national parks, the community of ground nesting bird predators consists of native species such as red fox, polecat (*Mustela putorius*) and stoat (*Mustela erminea*) and two non-native invasive species (American mink and raccoon dog).

2.2. Mink control and density monitoring

American mink were removed from BNP and NNP within the framework of the invasive species control programme (LIFE+ 'Polish Important Bird Areas') that was carried out from December 2009 to April 2015 by national park staff. Mink were captured using wire mesh cage traps baited with fresh fish. Traps were deployed along the riverbanks at 400–500 m intervals and checked once per day. Captured animals were humanely dispatched by a veterinary surgeon using an overdose of anaesthetic. In each trapping season, mink were trapped during two sessions: in the autumn of one year (October–December) and in the spring (March–April) of the following year. The number of mink captured in both sessions was combined and treated as the total number of mink removed (per trapping season) before the birds' breeding season. For each season, the abundance of mink was calculated as an index of mink caught per 100 trap-nights.

In both national parks, the control programme developed during the study period. In the first and second seasons (2009/2010 and 2010/2011 respectively), the intensity of mink trapping was low, and in each park, mink were trapped on a 10–11 km long stretch of river over 8–10 days in each trapping session (20 traps deployed in each park; totalling 160–200 trap-nights per park). During the following four seasons (from 2011/2012 to 2014/2015) the number of deployed traps increased to 40 in BNP and 80 in NNP, the length of river along which traps were set was increased to 20 and 40 km, respectively, and the duration of trapping sessions was increased to 15–28 days in each season (totalling 600–1200 trap-nights per park). In BNP, the trapped section covered the main wader nesting areas and the sections up and down river from those sites.

Mink dispersal distances asymptote at over 30 km, and maximal distances reach up to 50 km (Oliver et al., 2016), therefore, we combined mink control effort from both national parks. Furthermore, mink densities recorded in NNP before the control programme were higher than in other sites in north-eastern Poland (over 10 mink per 10 km of river) and genetic studies have shown that mink disperse between BNP and NNP (Zalewski, unpublished data). It is highly probable that the mink population in NNP is a source population and the intensity of mink control in NNP affects the abundance of mink in BNP. Therefore, in our analyses, we combined the number of mink removed in both national parks as an index of total control effort.

Monitoring of the effectiveness of mink control was carried out between 2010 and 2014, using 20 floating rafts (except 2010 when 5 rafts were used), on the stretch of the Biebrza river running through the mink trapping site and the birds' breeding aggregation. Rafts are