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EFFECTS OF VISITOR DISTURBANCE TO THE GOLDEN PLOVER (*PLUVIALIS APRICARIA*) HABITAT SUITABILITY IN NIGULA BOG

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Summary. In the present study we analyze visitor disturbance effects to the Golden Plover (*Pluvialis apricaria*) population near a wooden footpath in Nigula mire, SW Estonia. Spatial location of territories in the vicinity (500 m) of the pathway was analyzed on two 13-year periods. The first period (1981–1993) was without disturbance and the second (1995–2007) with disturbance. A significant increase of 83 m in the average territory distance from the pathway was found. Comparison of mean distances between territories from pathway showed causal effect of disturbance on choice of breeding territories, and avoidance of disturbed habitat by the Golden Plover. Therefore, the results of the present study indicate clearly that near the footpath the habitat has become more unsuitable for the Golden Plover.

Introduction

One of the preconditions of today's adaptive ecosystem management is the availability of operative monitoring system (Meffe *et al.* 2002), that allows to receive information about changes in the conservation status of protected objects. Information collected for evaluation of the status depends on purposes of conservation management, because insofar as it is possible to determine the condition of the protected objects by monitoring them, the monitoring gives us also a signal about the effects that conservation

management activities and decisions have on these conditions. While considering the interests of community and public in nature conservation, the conservation management has an essential opportunity to allow visiting conservation areas and create necessary infrastructure (Bathe 2007). For reduction of direct effect of visitation in bog, and for preserving its soil and vegetation, the most widespread way is to build a wooden path (Stoneman & Brooks 1997). The first wooden path in Estonia was built in 1955, in Männikjärve bog. The negative effect of this wooden path to local avifauna has been described by Aivar Leito (1997). In last decade the building of wooden paths has become widespread measure of recreation and conversation management. Thereby, a relatively easy access has been established to previously undisturbed areas of wilderness, protection of which serves often as protection of bird species that are sensitive to disturbance. At the same time, the existence of visiting opportunities to the conservation areas appears to be important presumption of supporting the conservation arrangements by the publicity, and for avoiding the alienation from nature (Bathe 2007, Gill 2007).

So far, the effects of visitor disturbance on biota, particularly on birds, in Estonia have been very little studied. While generic species richness of bogs is relatively low, for many specialized wetlands' species (including those of sensitive to disturbance) it is still the only habitat. There are several hiking trails in Estonia, negative effects of which have provided primary data within the framework of national monitoring of breeding birds in bogs and swamps, and also within the framework of long-term studies of conservations. One of the possibilities to study the visitor disturbance is to study the on-site distribution of birds (Gill 2007), but also to analyse correlative relations on the basis of long-term time-series data (Sutherland 2007).

The object of this article is to analyse the effect of visitor disturbance to possible relocation of Golden Plover (*Pluvialis apricaria*) – wader, which in Estonia is breeding only in bogs – breeding territory near a wooden path in Nigula mire. Golden Plover has served as a model species in studying of the effects of visitor disturbance also on heatlands and blanket bogs of British Isles (Yalden & Yalden 1989, Yalden & Yalden 1990, Finney *et al.* 2005, Pearce-Higgins *et al.* 2007).

Material and methods

The first data of breeding birds in Nigula mire date from 1952, when team with Eerik Kumari in front studied the avifauna of natural landscape in south-west Estonia (Kumari 1955). After establishment of State Nature Reserve of Nigula in 1957, the studies of its breeding birds became more profound. Annual censuses of breeding birds started in 1968 (Irdt & Vilbaste 1974), before that only qualitative data about breeding birds was collected. During the years, Nigula mire has become the classical model area for studying population and spatial dynamics of breeding birds, where studies continue on the basis of the same methods to nowadays (Leivits 1990, Leivits *et al*. 2008). In census of breeding birds in bogs, mapping method for territorial pairs is used, according to routes that are planned earlier. Method, applied in inventory taking and monitoring of breeding birds in Estonian bogs since 1968, is analogous to simplified mapping method used in inventory taking of breeding birds in Swedish bogs (Svensson 1978, Boström & Nilsson 1983). Censuses take place early in the morning, for about 4 hours after the sunrise, when the sky is clear and birds are active. Period, proper for monitoring mire birds, lasts from the second decade of May until the second decade of June. The width of fixed counting strip, depending on accessibility of landscape, is 200–300 meters (100–150 m. on both sides). The whole mire complex is covered with parallel transects. On the field works, observed birds (interpreted as the centres of territories) are mapped in 1:10 000-scale. Maps, reflecting individual census routes will be added later to so-called final map, on which coinciding positions (contacts) between transects will be interpreted as a single territory. On this study we are using census data from 1981–1993 and 1995–2007 about Golden Plovers abundance in Nigula mire. The fact, that census by the footpath complex in these years was carried out by the same person, reduces the variation conditioned by differences between census takers. According to studies, carried out on British Isles (Yalden & Yalden 1989), the presence of human is disturbance for Golden Plovers up to 500 m maximum that serves as a basis for specification of the study area. Calculations of the distances from wooden paths were made by using *ArcGIS* software standard extension *Analysis Tools* function Near (ArcGIS Desktop Help, Near tool/command).

2.7 kilometres long wooden path that runs from the shore of Järve Lake

to Salupeaksi was built to Nigula mire in 1973–1974 with the intention to protect the soil from stomping of visitors, and to facilitate the access for researchers to observation areas on mire and Salupeaksi. In 1994, the second branch of wooden path was built with the two watchtowers, that along with the previous branch forms a 7.6 kilometres long circle on the east massif of the bog (Fig. 1). Due to peculiarity of the conservation program, according to which the visitation of the conservation area could be permitted only by administrator, most of the visitors in 1963–2005 were on record (Fig. 2).

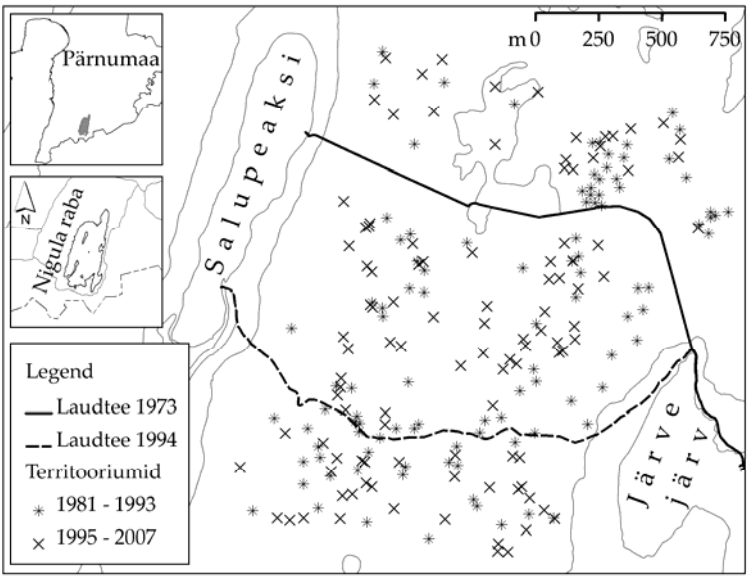

Figure 1. East massif of Nigula bog. Note the first footpath marked with a solid line and section made in 1994 marked with a dashed line. The section of the path, which runs on Salupeaksi mineral hump, is not marked. The point-clouds represent centroids of the territories of the Golden Plover.
Joonis 1. *Nigula raba idamassiiv. Pidevjoonega on tähistatud esimene laudtee (1973–74) ning katkendiga 1994. a. valminud lõik. Salupeaksil kulgevat lõiku pole kaardile kantud. Punktidega on tähistatud rüüda territooriumite keskmed.*

While the full circle of the footpath was established in 1994, we focused on finding possible change, caused by disturbance, between two periods, i.e. years 1981–1993 (N=13) and 1995–2007 (N=13). There

are point patterns concerning both periods, that represent territories of breeding birds in any given year (N=103 and N=107 respectively). In detecting the differences between these periods, we have based on the distance of point that is territory from the footpath. In case of the first period, this actually means finding the minimum distance between actual location of the footpath and the territory. While disturbance was absent in earlier period, we considered the location of the Golden Plover population as natural. Comparing the mean territory distances from footpath throughout years in periods both with disturbances and without should show the increase of the mean territory distances. As distributions of territories of both periods are different from normal distribution, nonparametric Mann-Whitney U-test was used to control statistical significance of these differences. Data of annual mean distances corresponded to preconditions of using the parametric tests. Software package STATISTICA 8 (StatSoft Inc. 2007) was used for statistical tests.

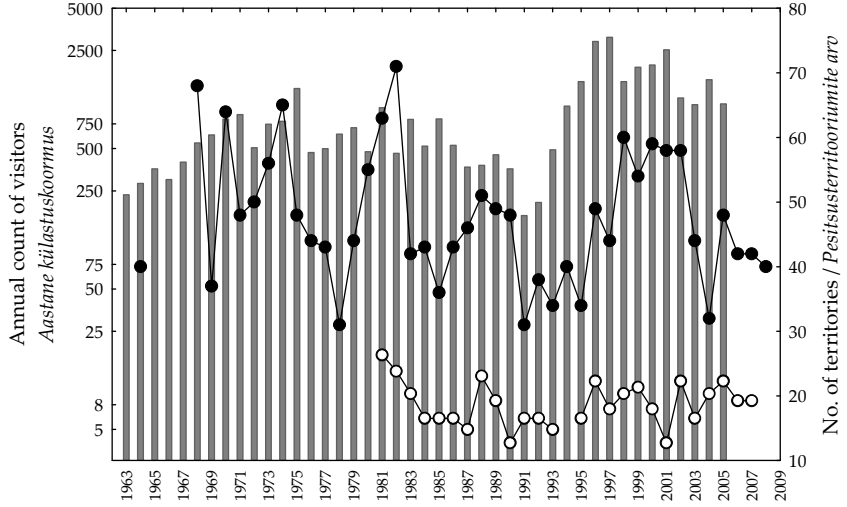

Figure 2. Annual count of visitors (columns, logarithmic scale), count of total (●) and near-footpath (○, d<500m) territories of Golden Plover (Pluvialis apricaria) in Nigula bog.

Joonis 2. *Külastuskoormus (tulbad, logaritmskaalas) Nigula raba laudteel ning rüüda (Pluvialis apricaria) territooriumite koguarv (●) rabamassiivil ja laudtee vahetus ümbruses (○, d<500 m).*

Due to data about visitor count collected until the end of 2005, it became possible to control the occurrence of correlation between the visitor disturbance and spatial location of Golden Plover population near footpath.

Results

There was a positive correlation (Spearman, r_s=0.64, p<0.001, Fig. 3) between annual visitor count (people per year) and mean territory distances (D) of Golden Plover population breeding near footpath (d<500m).

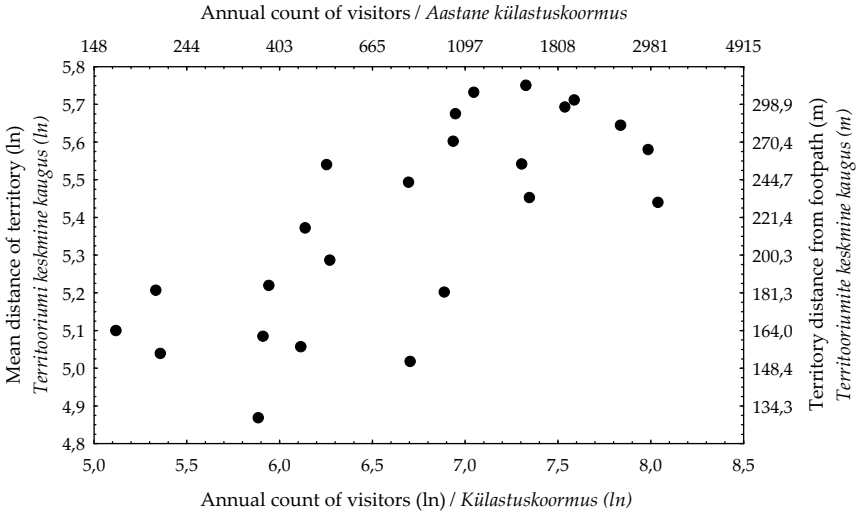

Figure 3. Correlation between mean territory distances from footpath and annual visitor count.

Joonis 3. *Korrelatsioon territooriumite keskmise kauguse ja aastase külastuskoormuse vahel.*

At the same time, the visitor disturbance did not have any effect on the number of territories near footpaths (Spearman, r_s=0.23, NS). A reliable correlation (Spearman, r_s=0.47, p=0.015) was also discovered between total number of territories in the bog massif and the number of territories within 500 m radius of footpath. After finishing the new footpath branch in 1994, the number of visitors soared (Fig. 2 & 4).

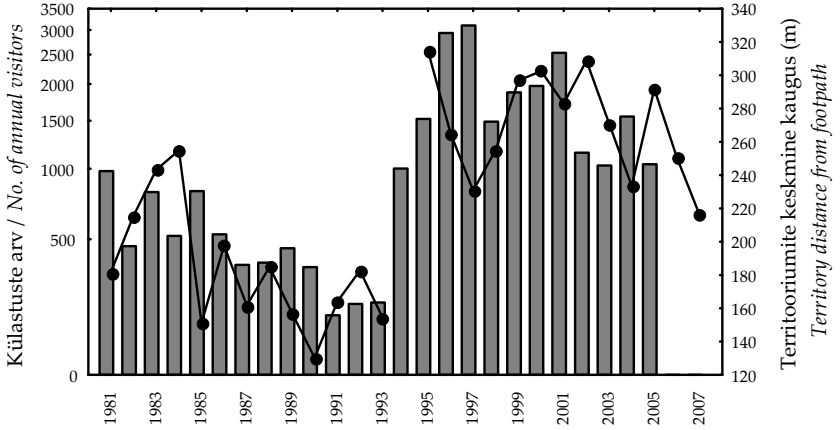

Figure 4. Mean territory distance from footpath (●) and number of annual visitors (columns, logarithmic scale).

Joonis 4. *Territooriumite keskmine kaugus laudteest (●) ja aastane külastajate arv (tulbad, logaritmskaala).*

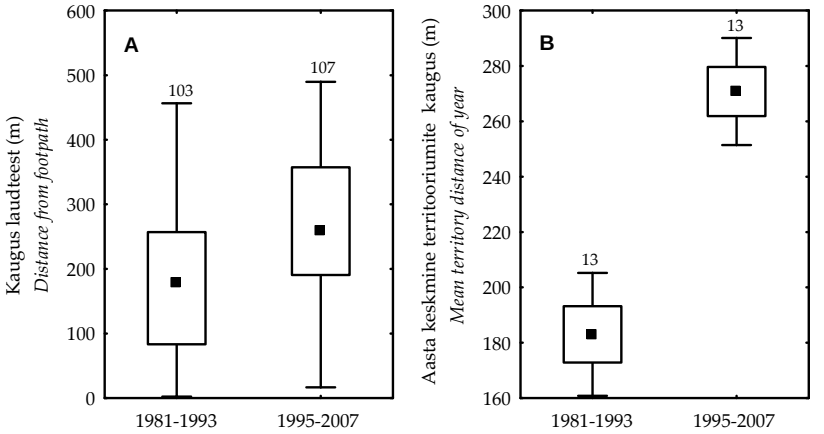

Figure 5. (A) distances of territories from footpath prior (1981–1993) and after (1995–2007) lengthening of the path (box – quartiles, whiskers –minimum-maximum); (B) mean territory distances of year from footpath by periods (box±SE, whiskers 95% confidence interval).

Joonis 5. *(A) territooriumite kauguste mediaanid laudteest enne (1981–1993) ja pärast (1995–2007) laudtee pikendamist (karp - kvartiilid, "vurrud"- miinimum-maksimum); (B) aasta keskmised territooriumite kaugused laudteest enne (1981–1993) ja pärast (1995–2007) laudtee pikendamist (karp±standardviga, "vurrud" 95% usalduspiirid).*

Territories of the period 1995–2005 were located significantly further from footpath (U-test: $Z=-4.78$, $p<0.001$, see Fig. 5A). Also, there are differences between periods, while comparing annual mean territory distances from footpath ($t=-6.49$, $p<0.001$, p-Var>0.5, $N_1=13$, $N_2=13$, see Fig. 5B).

For period 1, the average of all territory distances (d) was $d_1=188\pm12$ m (mean±standard deviation), and for period 2, accordingly $d_2=271\pm11$ m, which shows, that territories have shifted 83 meters away from the footpath. While comparing annual mean territory distances (D) between two periods, it appears, that averages of these periods were accordingly $D_1=183\pm10$ m and $D_2=251\pm9$ m, which means, that the mean territory distance has shifted 68 meters away from the footpath.

Discussion

From the results of this study, it appears that Golden Plovers avoid habitats with visitor disturbance. Golden Plovers breeding territories located on the average of 83 meters further in disturbance period than in period without disturbing factor. Besides, the annual visitor disturbance was positively related to annual mean territory distance from footpath (Fig. 3). This indicates to more extensive habitat abandonment that comes with increasing disturbances.

The effects of disturbances on habitats of *Charadriiformes* due to visitation have been studied on the occasion of several species (Yalden & Yalden 1989, Yalden & Yalden 1990, Gill *et al.* 2001, Finney *et al.* 2005, Pearce-Higgins *et al.* 2007, Holm & Laursen 2009). A common denominator in results of all these studies appears to be the effect of disturbances as essential factor of abandoning breeding territories. In case of Golden Plover, for example, it has been discovered in Great Britain, that disturbing during the breeding period causes shifting of territories from footpath up to 200 meters (Finney *et al.* 2005). Thus, if suitable habitat is large enough, but the same time close enough to the source of disturbance, it will not be inhabited. If, resource is limited, it may lead the extinction of local populations.

While the number of territories in whole Nigula mire varied year

by year without showing any long-term trend (Leivits *et al.* 2008), it may be assumed that on better years there are more territories near the footpath. And so it is, since there is a reliable correlation between total amount of territories and number of territories that lie within the range of 500 meters from footpath. But at the same time, the visitor disturbance itself doesn't seem to have much effect on the total number of territories, which refers to the fact that despite of higher density of population, plovers still seem to populate the habitats with footpaths nearby, although in choosing the suitable territory they avoid close vicinity with the footpath.

To the effects cited above, the effects related to changes in habitat may be added. In other words, during the last fifty year we have witnessed intense growth of pines on the central plateau of the mire, and the process shows signs of acceleration (Aaviksoo *et al.* 2008). Therefore, additional studies for examining the component arising from the changes in habitat are necessary.

Footpath allows the conservation organizer to direct and mitigate the effects of visitor disturbance to protected species and their habitats. While planning footpaths, one must always consider the necessity to soothe the effects of visitor disturbance: visitation must be directed so that visitors could have bog experience, but the negative effects of visitation to bird population would be minimized.

In addition to manageable disturbance, the conservation manager must consider the uncontrollable disturbance, i.e. those individuals who are roaming the conservation area illicitly. Yet more danger to the wader habitats comes with the growth of adventure tourism on nature reserves. The favourite habitats for waders – bog hollows with thin moss carpets and mud-bottoms usually inaccessible to human being – have become accessible, due to new hiking gear (e.g. snow shoes), for hikers, who leave out of census the breeding time of species that are sensitive to disturbance. This means that amount of occasional, uncontrollable disturbances in habitats, that are critically important in terms of preservation of certain species, is aggravating.

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KÜLASTUSKOORMUSE MÕJU RÜÜDA (*PLUVIALIS APRICARIA*) ELUPAIGASOBIVUSELE NIGULA RABAS

Käesolevas artiklis analüüsitakse kahe perioodi – 1981–1993 ning 1995–2007 – külastuskoormuse mõjusid rüüda (*Pluvialis apricaria*) pesitsusterritooriumite paiknemismustritele Nigula raba laudraja vahetus läheduses (500 m). 1994. aastal loodud laudtee täisringi valmimisel suurenesid külastuskoormusest tingitud häiringud oluliselt, kuna võrreldes esimese perioodiga täheldati territooriumite keskmise kauguse nihkumist teisel perioodil 83 m laudteest eemale. Tulemuste põhjal võib öelda, et laudtee ümbruses on rüüda pesitsustingimused halvenenud.

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