Do predators cause a change in passerine movement patterns as indicated by mist-net trapping rates?

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Trnka A. & Prokop P. 2006. Do predators cause a change in passerine movement patterns as indicated by mist-net trapping rates?
Ardea 94(1): 71–76.

Predation can act as a selective pressure on birds, which may be expected therefore to change habitat use in the presence of predators. To examine this, experiments were performed using Marsh Harrier *Circus aeruginosus* silhouettes. The effect of predators on movement patterns and capture efficiency of mist nets were investigated in two unrelated passerines, Reed Warblers *Acrocephalus scirpaceus* and Tree Sparrows *Passer montanus*, in natural reed beds and bushes, respectively. Birds were trapped at the end of the nesting period in eight study plots with intermittently placed silhouettes of raptors. We found that the presence of a predator depressed capture rates in Tree Sparrows, but not in Reed Warblers. Instead, raptor presence affected the vertical spatial distribution of this species. Apparently, each species responded to aerial predators in a different way, which may be species' specific or dependent on habitat type, or both. These results, therefore, strongly suggest that mist-net studies on capture rates and movement patterns of passerines can be affected by the presence of aerial predators.

Key words: Reed Warbler, Tree Sparrow, Marsh Harrier silhouette, risk assessment, predation

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INTRODUCTION

Movement patterns of birds are an important feature of foraging and migratory strategies (Chernetsov & Titov 2001). As small passerines inhabiting dense and extensive vegetation are difficult to monitor by standard observational or aural methods, their movements are predominantly studied using mist nets. However, results and their interpretation depend on the capture efficiency, which can be influenced by weather conditions, habitat (Jenni *et al.* 1996), time of day (Deslauriers & Francis 1991), the type of mist nets used (Heimerdinger & Leberman 1966, Pardieck & Waide 1992), tape-luring (Schaub *et al.* 1999) to name a few. Predators may be a further important factor affecting the avian movement activity and subsequent mist-net capture efficiency. As predation may affect bird fitness, their behaviour is adjusted in many ways to minimise the risk of predation (Cresswell 1993, 1998, Witter *et al.* 1994, Dierschke 2003). Given that risk of predation is affected by habitat (Whittingham & Evans 2004), the anti-predator response of birds should vary in accordance with habitat type and structure. Yet, these topics have received little attention. In *Acrocephalus* warblers, for example, only nest defence behaviour (Kleindorfer *et al.* 2003), chick reactions (Kleindorfer *et al.* 1996, 1997) and risk assessment in relation to predator type and distance (Kleindorfer *et al.* 2005) were examined. While chicks of Moustached Warbler *Acrocephalus melanopogon* reacted differentially to aerial versus terrestrial predators (Kleindorfer *et al.* 1996, 1997), no interaction was found between predator type and distance in adult *Acrocephalus* warblers (Kleindorfer *et al.* 2005).

We postulate that the presence of predators may have effects on movement patterns and capture rates in birds. To test this, we performed experiments with Reed Warblers *Acrocephalus scirpaceus* occupying dense reedbed vegetation, and Tree Sparrows *Passer montanus* inhabiting open bushes, using silhouettes of Marsh Harrier, potentially an important predator of both species.

Figure 1. Real-size silhouettes of Marsh Harrier as used in the experiments (photo A. Trnka).

METHODS

Data was collected in a small fishpond system near the village of Pusté Úľany (NW part of Podunajská nížina lowland, SW Slovakia, 48°14'N and 17°35'E) from 30 June to 7 August 2004. The study area is over 30 ha, and includes large areas of water and terrestrial reed beds (*Phragmites australis* – 20 ha), reedmace (*Typha* sp. – 5 ha) and bushes (*Sambucus nigra* predominantly – 5 ha). In reeds, 4 smaller study plots (10 m^2) and 4 plots in bushes were randomly selected. A mist net of 10 m in length was placed within each plot. The distance between nets was at least 100 m. The four identical Marsh Harrier silhouettes (scale 1:1) were made from plywood and were, at the midpoint of the net, free-hanging 1 m above the vegetation to move on the wind (Fig. 1). Silhouettes were alternately placed at two nets in each habitat. Nets were visited every 60 min and captured birds were identified, sexed, and aged if possible, ringed and released about 200 m from the nets immediately thereafter. All nets were operated at the same time for 5 hours after sunrise and 5 hours before sunset, during ten experimental and ten control sample dates in each habitat in the morning, and the same in the evening, except during rain or strong winds. There was no effect of time of the day (morning vs. evening) on capture rates of birds, and the distribution of trapped Reed Warblers and Tree Sparrows over the day did not differ from random (Pearson $\chi^2 = 18.0$ ($df = 14$) and 13.0 ($df = 11$), $P = 0.21$ and 0.29, respectively). The vertical position of each trapped bird was recorded when removed from the net. The lower and upper positions represented the two bottom and two top shelves respectively. Concurrently with these experiments, to avoid misinterpretation of the results, we examined the effect of other environmental factors, such as reed structure and weather conditions, on the number of captured birds. Temperature, air moisture and air pressure, direction and speed of wind, precipitation and cloud cover were measured by digital meteorological equipment in ten sampling days. Reed structure was estimated at the end of July in each reedbed study plot, i.e. after the reed growth period. Height and diameter of dry (old) and green (current year) reed were determined by counting and measuring all stems within one square of 0.5 x 0.5 m located in the centre of each plot. Similarly, reed density was assessed in three squares.

Statistical analyses

We used principal components analysis (PCA) for data reduction of environmental variables that potentially affected net capture rates (temperature, air moisture, speed of wind, precipitation and cloud cover). Air pressure showed weak variance (range = 995 to 1004, median = 1003, n = 10 sampling days) and its distribution differed significantly from normal even after log transformation ($W = 0.65$, $P < 0.001$). We excluded it therefore from further analyses and believe that it could not affect bird abundance *per se*. PCA extracted two factors where number of days into the season, temperature and precipitation loaded in PC1 and air moisture, speed of wind and cloud cover loaded in PC2. Factor scores were used in the multiple regression as independent variables and the number of captured birds (either warblers or sparrows) was treated as dependent variables. The effect of silhouette on capture rates was examined by three-way ANOVA, where the presence/absence of a predator, bird species and the position in the net (top vs. bottom) were fixed factors. The effect of net position was controlled for by residual analysis (bird abundance as dependent variable and plot as independent variable). All data were inspected for normal distribution (Shapiro–Wilk test) prior to the statistical tests.

RESULTS

In total, 442 Reed Warblers (7.2% of which were retrapped) and 408 Tree Sparrows (31.4% retrapped) were caught between the end of June and beginning of August 2004. Juvenile birds predominated in both species (89.1% and 78.9%, respectively). Number of captured birds was affected neither by weather conditions nor by time of season (Reed Warbler: $r^2 = 0.171$, $F_{2,9} = 0.72$, $P = 0.52$; Tree Sparrows: $r^2 = 0.532$, $F_{2,9} = 3.98$, $P = 0.07$). Similarly, no effect of reed bed structure on capture rates was found in Reed Warbler ($F_{3,76} = 0.24$, $P = 0.87$), although the reed differed considerably between the study plots in diameter and height of stems ($F_{3,193} = 4.82$ and $F_{3,193} = 6.11$, $P < 0.01$ and $P < 0.001$, respectively).

However, significant interactions between species, vertical distribution of captured birds and the presence of the predator occurred (Table 1). Based on post-hoc comparison (Scheffé), the presence of a predator did not affect the trapping rate of Reed Warblers ($P = 0.36$, Fig. 2A), but significantly less Tree Sparrows were caught when the predator was present ($P < 0.01$, Fig. 2B). Furthermore, more Reed Warblers were captured in the

Table 1. Numbers of birds trapped by species, vertical distribution, and presence of predator.

Factor	SS	*df*	MS	*F*	*P*
Species	0.02	1	0.02	0.01	0. 92
Vertical distribution	7.81	1	7.81	3.28	0.07
Predator	145.79	1	145.79	61.30	0.001
Species x vertical distribution	0.20	1	0.20	0.08	0.77
Species x predator	66.61	1	66.61	28.00	0.001
Vertical distribution x predator	177.01	1	177.01	74.42	0.001
Species x vertical distribution x predator	198.45	1	198.45	83.44	0.001
Error	742.07	312	2.38	-	-

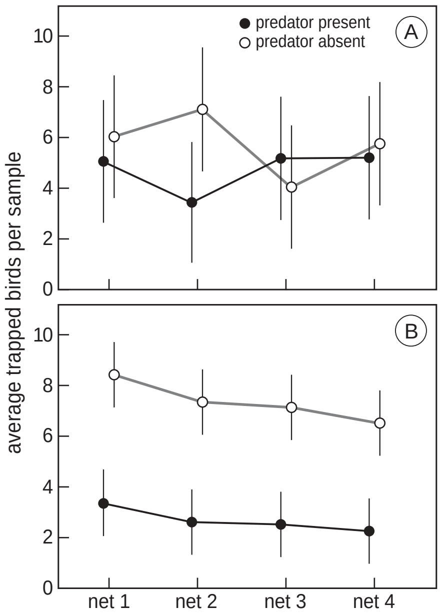

Figure 2. The effect of predator presence or absence on numbers of the Reed Warblers (A) and Tree Sparrows (B) trapped in mist nets. Error bars are 95% confidence intervals.

upper half of the mist net when no predator was present (8.8 vs. 5.6 birds trapped per sample, $P < 0.01$), whereas when the predator was present more birds were captured in the lower part of the net (3.3 vs. 4.7, $P < 0.01$). No similar pattern was found for the Tree Sparrow (both $P > 0.5$). Exclusion of re-traps from the analyses did not change the outcome of any test.

DISCUSSION

The results obtained in this study clearly showed differences in movement patterns between species during experiments with Marsh Harrier silhouettes. It has been established that weather conditions can influence bird movements and mist-net capture efficiency (Jenni *et al.* 1996, Åkesson *et al.* 2001, 2002, Erni *et al.* 2002). In our study, however, neither these factors, nor time of season, affected the number of captured Reed Warblers or Tree Sparrows. This might be explained by the fact that mist-netting was carried out only during good weather. Capture rates of Reed Warblers were not affected by differences in reed bed structure, although according to other studies, height of stems is an important factor influencing abundance and distribution of this species during breeding (Poulin *et al.* 2002, Martínez-Vilalta *et al.* 2002) or post-breeding periods (Trnka & Prokop 2006). Our results may in part be caused by the experimental setup, in which the 'predator' was present during several sampling days, although other factors as the distribution of food sources or the position of the study plots might have had an effect as well.

Nevertheless, it is evident from this study that the two species responded to the presence of a predator, but each in a different way. The decrease in trapping rate of Tree Sparrows when a predator was present suggests that this species avoids attacks by reducing movements. In contrast, trapping rates of Reed Warblers did not drop when a predator was present but given the shift of captured birds to the lower parts of the nets they moved closer to the ground where they were possibly safer for aerial predators. This shift is striking as previous studies (Bairlein 1983, Pambour 1990, Honza & Literák 1997, Gyurácz & Bank 2000) showed that Reed Warblers generally prefer the upper parts of reed beds. Apparently, our results provide evidence that birds adjust their vertical movements in reed beds to the prevailing attack situation.

Predation risk of birds depends on habitat and body features (Whittingham & Evans 2004), thus it is to be expected that there is a differential response between species and habitat. We have not been able to separate these two effects. For this purpose, the same species should be tested in reed beds as well as bush habitats and/or both species in the same habitat. Unfortunately, this was not possible in this study. Generally speaking, species have different responses to predators, independently of habitat, which may be an adaptation to predation. For example, Tree Sparrows usually forage in flocks, unlike the solitary Reed Warbler, so their vigilance towards a raptor is noticeably increased (Lima 1995, Roberts 1996). Species' flight ability and escape responses may also play an important role, which relates to their morphological traits (Moreno-Rueda 2003).

It is evident that risk assessment behaviour (Swaisgood *et al.* 1999) and detection distance (Lind *et al.* 2003) play an important role in predator-prey interactions. In our study, dense and tall reed beds provided Reed Warbler more concealment against aerial predators than open bushes occupied by Tree Sparrows, where shelter is scarce. Risk assessment and intensity of anti-predator responses to gliding raptors in Reed Warblers was unlike that in Tree Sparrows which occupy lower and sparser vegetation, as demonstrated by their vertical spatial distribution. This study provides support for the idea that aerial predators can cause changes in distribution and activities of their prey and so influence results of habitat selection and bird migration studies using mist nets. To improve the interpretation of data obtained by mist-netting, we recommend, therefore, to record, and report on, the presence of raptors in mist-net studies.

ACKNOWLEDGEMENTS

We would like to thank Gregorio Moreno-Rueda and an anonymous referee for critical comments that improved the manuscript. Julie Black and Jouke Prop kindly improved English of the manuscript. This study was partially supported by the Scientific Grant Agency VEGA, project No. 1/3257/06, and was conducted in compliance with the laws of Slovakia

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SAMENVATTING

Het verplaatsingspatroon van vogels is een belangrijk kenmerk van hun voedselzoekgedrag. Omdat zangvogels in dichte vegetatie moeilijk zijn te observeren, worden hun verplaatsingen door de vegetatie vooral onderzocht met behulp van mistnetten. De resultaten van mistnetvangsten kunnen beïnvloed worden door een scala aan factoren, zoals weersomstandigheden, habitat, gebruik van playbacks, enz. Een andere belangrijke factor zou de aan- of afwezigheid van predatoren kunnen zijn, die zowel de activiteit van de zangvogels als het vangstsucces in de netten zou kunnen veranderen. Het onderhavige artikel bespreekt een experiment met silhouetten van de Bruine Kiekendief *Circus aeruginosus* in een Slowaaks gebied met visvijvers, dat tot doel had te onderzoeken of kleine zangvogels hun habitatgebruik aanpassen aan de aanwezigheid van deze predator. De kleine zangvogels in kwestie waren de Kleine Karekiet *Acrocephalus scirpaceus* en de Ringmus *Passer montanus*. De Kleine Karekieten waren in het onderzoeksgebied voornamelijk in de aanwezige rietvelden te vinden, de Ringmussen in het vlierstruweel. Als de onderzoekers kiekendiefsilhouetten plaatsten, ging het vangstsucces van Ringmussen in het vlierstruweel aanzienlijk omlaag, terwijl de Kleine Karekieten in het riet vaker onder in plaats van boven in het mistnet werden gevangen. Het verschil in reactie tussen Ringmus en Kleine Karekiet kan te wijten zijn aan de soort, de habitat, of aan beide factoren tegelijk. De auteurs concluderen dat de aanwezigheid van vliegende predatoren invloed kan hebben op het verplaatsingspatroon van kleine zangvogels door de vegetatie en op de vangstresultaten in mistnetten. Om vangsten met mistnetten juist te interpreteren, is het daarom aan te bevelen de aanwezigheid van roofvogels goed te documenteren.

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Corresponding editor: B. Irene Tieleman
Received 18 November 2005; accepted 28 February 2006