BTO
Looking out for birds

Sparse vegetation predicts clutch size in Common Redstarts *Phoenicurus phoenicurus*

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Capsule Amount of sparse vegetation show a direct link to reproductive success.

Aims To examine the influence of sparse vegetation on clutch size of Common Redstarts *Phoenicurus phoenicurus*.

Methods Clutch size and the amount of sparse ground vegetation within territories were measured.

Results Clutch size was positively correlated with the amount of sparse vegetation. Clutches in territories with the highest amounts of sparse vegetation contained approximately one more egg than clutches in territories with the lowest amount of sparse vegetation.

Conclusion The presence of sparse vegetation is correlated with clutch size and thus reproductive success. This finding suggests a direct link between habitat degradation through the loss of sparse vegetation and observed population decreases of bare-ground foraging birds. The results strengthen the argument that the implementation of sparse vegetation in agri-environment schemes is likely to improve the breeding success of bare-ground foraging birds, such as Common Redstarts.

Intensification of farmland management has had dramatic and widespread negative influence on farmland biodiversity since the middle of the last century (Robinson & Sutherland 2002, Green *et al.* 2005, Klejin *et al.* 2009). For example, the populations of several farmland birds have shown marked and ongoing declines in many European countries (Fuller *et al.* 1995, Donald *et al.* 2006). To counteract the decline of farmland species, several countries have implemented agri-environment schemes (Kleijn *et al.* 2004). Unfortunately, the agri-environment schemes have so far only moderately supported biodiversity increases, possibly because they are only rarely targeting the specific needs of species of conservation concern (Kleijn *et al.* 2001, Perkins *et al.* 2011).

Several ground-feeding farmland birds inhabiting grassland dominated landscapes need bare ground, sparse vegetation and short stubble fields (hereafter called sparse vegetation) for in which they forage (Vickery *et al.* 2001, Butler & Gillings 2004, Atkinson *et al.* 2005, Schaub *et al.* 2010). Denser and more homogenous swards reduce the detectability and accessibility of prey leading to a decrease of habitat quality for insectivorous birds (MacCracken & Tallowin 2004). Furthermore, a denser sward structure increases the risk of predation (Whittingham & Evans 2004). Yet

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agricultural intensification has tended to result in denser and more homogenous swards (Benton *et al.* 2003) and a lot of measures promoted by agri-environment schemes, e.g. grassy ecological compensation areas, low-intensity and extensive meadows, set-aside land or wildflower areas, are not characterized by sparse vegetation and bare ground. Therefore it has been suggested that the improvement of agri-environment schemes requires the implementation of measures to increase the amount of sparse vegetation in grasslands (Schaub *et al.* 2010).

To date, the benefit of sparse vegetation on biodiversity has been shown using studies on the behaviour of individuals in relation to the availability of sparse vegetation. For instance, radiotracked Eurasian Hoopoes *Upupa epops* predominantly use sparse vegetation for foraging (Weisshaupt *et al.* 2011). Or in a habitat choice experiment in aviaries, Common Redstarts *Phoenicurus phoenicurus* caught mealworms almost exclusively in sparse vegetation when mealworms were provided in both sparse vegetation and dense meadow at the same time (Martinez *et al.* 2010). However, whether these behavioural responses to sparse vegetation are relevant for the demography of the population is far from clear. For example, Schön (2011) suggests that naturally occurring patches of sparse vegetation might be a pitfall for Eurasian Skylarks, with high attractiveness yet low breeding success.

Therefore, if a direct link between sparse vegetation and a demographic parameter could be demonstrated, this would strengthen the arguments for implementing measures designed to enhance the amount of sparse vegetation in agri-environment schemes.

Here I examined the influence of sparse vegetation on clutch size in Common Redstarts. I define sparse vegetation as ground vegetation with permanent limited or little vegetation and parts of bare ground, thus structures where sit-and wait predators such as Common Redstarts can easily detect and pick up prey items. In Central Europe Common Redstarts inhabit mainly high-stem orchards and gardens (Schmid *et al*. 1998) and they have suffered a steep decline in many European countries during the second half of the last century (Bruderer & Hirschi 1984, BirdLife International 2004). Thus, the Common Redstart is one of 50 priority bird species for recovery programmes in Switzerland (Keller *et al*. 2010). Former studies have shown that Common Redstarts prefer territories with a high amount of sparse vegetation, and that they mainly forage on such areas, and even prefer sparse vegetation for foraging when prey biomass is much lower in sparse vegetation than in surrounding dense meadow (Martinez *et al*. 2010, Schaub *et al*. 2010). However, it remains unclear if the amount of sparse vegetation directly affects reproductive success. In the present study I used clutch size as an indicator of reproductive success and tested whether the amount of sparse vegetation in a territory is associated with clutch size.

METHODS

Study site and field methods

The study was conducted during the breeding seasons 2010 and 2011 in northwestern Switzerland. The study site covered a mosaic of orchards, vineyards and gardens in mostly intensively managed grasslands. Within the study site I surveyed a population of about 40 pairs of Common Redstarts, where about one-third of the pairs were breeding in natural cavities and the other two-thirds usually breeding in nestboxes. During several visits from mid-April onwards each potential territory was visited at least three times. If a territory was occupied, I searched for the nesting site of the pair by checking all the nestboxes and cavities known from previous breeding seasons. If the pair did not nest in one of these sites, the adults were observed to obtain hints about the location of their nesting site. From the 41 and 40 occupied territories in 2010 and 2011, respectively, the nesting sites in 73 % and 55 % of the occupied

territories were found. The located nests were then visited every second day until the female started to incubate and at this point clutch size was determined. Nestboxes and cavities which could not be easily examined were monitored with the help of a small torch light and a laryngeal mirror. However, there were still several nests (17 nests and 5 nests in 2010 and 2011, respectively) where assessment of clutch size was not possible. The number of eggs at the start of breeding was used as a measure of reproductive success in the analyses. I chose clutch size as an indicator of reproductive success as it is an oft-used factor for the determination of reproductive success (Högstedt 1980, Christians 2002).

Between May and July, I mapped the habitats of all the Redstart territories with known nesting site on a circular plot with radius 50 m (i.e. 7850 m^2) around the nesting site. The size of the plots corresponded to the size of a Redstart territory that usually covers an area between 1400 m^2 (Menzel 1971) up to 10000 m^2 (Glutz von Blotzheim 1988). Especially when feeding, young Common Redstarts tend to forage closely around the nest (own unpublished data) and usually stay in close distance (< 50 m) to the nest. Therefore, I assume that most nests were more or less centrally placed within territories and that the size and circular shape of the investigated plot was reasonable. For each plot I mapped roads, trees and all occurring vegetation types. The percentage of each vegetation type in the circular 'territory' was then determined with a grid of 2500 points. For further analysis all occurring vegetation types were grouped into two habitat types (sparse vegetation and 'other', Table 1). The percentage of the points that were assigned as sparse vegetation was then used as the measure of habitat quality. The same method was applied in an earlier study on Common Redstarts (Martinez *et al*. 2010).

Table 1. The 13 vegetation types that were considered as sparse vegetation and the 7 vegetation types that were considered as 'other'. *Forest vegetation was mainly represented by *Fagus silvatica* dominated woods with open ground, which is the reason why it was considered as sparse vegetation.

Category	Vegetation types
Sparse	Pasture, maize fields, potato fields, mustard fields, vines, woods, forest*, lawn, vegetable garden, non-asphalted roads, ruderal vegetation patches, small sparse vegetation patches
Other	Meadow, cereal fields, thickets, scrubs, hedges, asphalted roads, buildings

Statistical analysis

In most passerine species, second broods or replacement broods are in general smaller than first broods (Klomp 1970), and this is the case in Common Redstarts (Glutz von Blotzheim 1988). Therefore, I only included broods with breeding start date before 15 May in the analysis. To assess the relation of habitat quality (i.e. the percentage of sparse vegetation in a territory) to clutch size, I used a linear regression model with the number of eggs as the dependent variable and the percentage of sparse vegetation as predictor variable. I controlled for the differences between years by also including the factor 'year' into the model. The visual check of the residuals from the linear model did not show any signs of violation of model assumptions. All analyses were done using the statistical software R (R Development Core Team 2011).

RESULTS

Sparse vegetation cover in territories ranged from 2.80 % up to 91.02 % (mean $\pm$ se = 45.04 % $\pm$ 4.48, n = 30). Common Redstart pairs in territories with a high proportion of sparse vegetation had higher clutch sizes than pairs in territories with a low proportion of sparse vegetation (linear regression: slope = 0.019, t = 2.123, P = 0.043, Fig. 1). Average ($\pm$ se) clutch size was 5.54 $\pm$ 0.42 eggs (n = 13) in 2010 and 6.59 $\pm$ 0.19 eggs (n = 17) in 2011. The difference in clutch size between year was not significant (linear regression: effect of second year = 0.654, t = 1.479, P = 0.151).

DISCUSSION

Clutch size of Common Redstarts increased with increasing amount of sparse vegetation in the territories (Fig. 1). The average clutch size in territories with the lowest amount of sparse vegetation was about one egg smaller than the clutch size in territories with the highest amount of sparse vegetation. Therefore, if sparse vegetation could be increased in otherwise suitable habitat, the population size of the Common Redstart is likely to increase. Several other declining European farmland birds, e.g. Hoopoes, Woodlarks *Lullula arborea* and Eurasian Wrynecks *Jynx torquilla*, also prefer sparse vegetation for foraging (Schaub *et al.* 2010, Arlettaz *et al.* 2011, Weisshaupt *et al.* 2011). It is probable that similar effects of sparse vegetation as described for Common Redstarts play a major role in their ecology and that their populations would also benefit from an increase of sparse vegetation in their habitats.

Two non-exclusive explanations may account for the correlation between the amount of sparse vegetation and clutch size in Common Redstarts. First, females may adjust their clutch size on the basis of territory quality and tend to lay more eggs in better territories. Females that adapt clutch size to environmental factors have been observed in several other passerine species (Högstedt 1980, Hussell & Quinney 1985). My results suggest that this is also the case in Common Redstarts, with females adapting clutch size to the amount of sparse vegetation in their territories. However, other factors that are correlated with the amount of sparse vegetation could explain my results. Nevertheless, as Common Redstarts prefer territories with a high amount of sparse vegetation and clearly prefer sparse vegetation for foraging (Martinez *et al.* 2010, Schaub *et al.* 2010) this explanation seems to be reasonable. Second, high-quality individuals may get the better territories, i.e. territories with higher amounts of sparse vegetation, than low-quality individuals. As the individuals of the best quality may lay more eggs than low-quality individuals (Klomp 1970, Christians 2002), a correlation between the amount of sparse vegetation and the clutch size could also be expected.

In both explanations for the correlation between the amount of sparse vegetation and clutch size, the amount of sparse vegetation is a key predictor of the quality of Common Redstart territories. Therefore, if the amount of sparse vegetation could be increased in Common Redstart habitats the average clutch size of affected populations is likely to increase. Such an increase in the population clutch size is likely to result in higher reproductive success. Nevertheless, other aspects such as predation rates on chicks could be negatively correlated with the amounts of sparse vegetation in the territory, and thus higher clutch size does not definitely provide evidence that increasing the amount of sparse vegetation will indeed result in an increase of population size. In order to definitely prove a causal relationship between sparse vegetation and reproductive success, experimental studies should be conducted.

Overall, my results not only confirm the findings of earlier studies showing the importance of sparse vegetation for the foraging behaviour of Common Redstarts (Martinez *et al.* 2010, Schaub *et al.* 2010), but show that the presence of sparse vegetation is correlated with clutch size and thus with an important measure of reproductive success. The results therefore reveal a direct link between habitat degradation through the loss of sparse vegetation and observed population decreases.
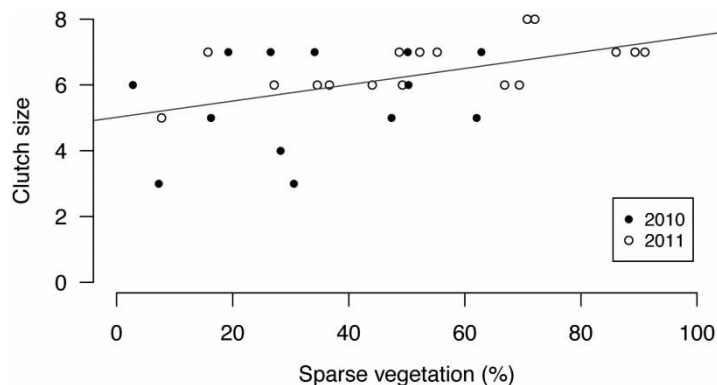
Figure 1. Regression of clutch size on the percentage of sparse vegetation in Common Redstart territories. Pairs in territories with high proportion of sparse vegetation had higher clutch sizes than pairs in territories with low proportion of sparse vegetation. Black dots: data from 2010 ($n = 13$), open dots: data from 2011 ($n = 17$), grey line: linear regression line. Note that one dot from 2010 (clutch size: 6, sparse vegetation: 49 %) overlaps with a dot from 2011.

Based on this study, I suggest that agri-environment schemes aimed at bare-ground foraging birds would be implemented by promoting sparse vegetation in grasslands. In order to provide evidence for a positive effect of sparse vegetation on population size of bare-ground foraging birds, the influence of 'sparse vegetation management measures' on populations of bare-ground foraging bird species should be monitored.

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