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What attracts birds to newly mown pasture? Decoupling the action of mowing from the provision of short swards

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Many bird species flock to forage on newly mown grass swards. Several potential benefits are offered by such swards, including increases in prey availability (flush of foliar prey, reduced physical obstruction to surface and soil prey) and a foraging environment with fewer visual obstructions, so allowing predators to be detected more easily. We performed a field experiment using captive Common Starlings *Sturnus vulgaris* foraging in bottomless enclosures on newly mown swards (within 1 h) and old mown swards (48 h). We performed the experiment during winter months and standardized sward height to exclude other confounding effects in order to determine the temporal benefits of mowing for species foraging on soil invertebrates. We found no differences in the vigilance or time budgets of Starlings foraging on newly or old mown swards. Intake efficiency (prey captured per 100 roots) was greater on newly mown swards, suggesting that Starlings used less energy to obtain their prey on that substrate. It is possible that mowing alters the microclimate of the soil and sward, causing invertebrate availability to decline over time, which causes the lower foraging efficiency. Mowing is a technique often used to manipulate grassland habitats in ecological research; it has recently been advocated as a conservation management tool for wintering bird populations. We suggest that care should be taken when designing such studies to avoid confounding the factors under investigation with temporal changes in prey availability.

Mowing is a management practice used in agriculture to produce silage and hay. As grassland crop production has switched away from hay to silage in recent years, meadows are mown earlier and more often (Chamberlain *et al.* 2000). Mowing may affect the sward and its associated invertebrate community, for example by reducing arthropod abundance after cutting (Purvis & Curry 1981, Morris 1990). However, the act of cutting itself may cause a temporary flush in foliar invertebrates (Vickery *et al.* 2001). This flush may explain why birds such as Common Starlings *Sturnus vulgaris*, wagtails *Motacilla* spp. and pipits *Anthus* spp. are seen foraging in freshly cut hay and silage meadows (Vickery *et al.* 2001). However, these species also forage preferentially on short swards (Perkins *et al.* 2000, Atkinson *et al.* 2004) and Starlings mainly forage on below-ground invertebrates. Thus, it is not clear whether the association between these birds and mowing is because of a flush in foliar prey availability or because of the newly created preferred foraging habitat. The creation of short swards in grassland habitats has recently been advocated as a management strategy for insectivorous birds, even during the winter months (e.g. Milsom *et al.* 1998, Whittingham & Evans 2004, Wilson *et al.* 2005). Thus, it is important to determine how mowing affects species that forage on all types of invertebrate prey, both above and below ground.

In this paper, we begin to address this issue by assessing how time since mowing affects the foraging

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success of Starlings feeding on soil invertebrates whilst controlling for sward height. Starlings primarily consume leatherjackets (Tipulidae) and earthworms (Annelida) (Feare 1984). In order to restrict the focus of our study to soil-dwelling prey we conducted it during winter months when foliar and surface invertebrate activity is minimal. We created two treatments: newly mown grass (1 h) and old mown grass (48 h) whilst controlling grass height at 3 cm. We predicted that if mowing has an effect on soil invertebrates, Starling foraging rates and foraging success would be higher in the newly mown grass, whereas if Starlings are only attracted to newly mown swards because of the height of the grass, irrespective of the availability of prey, foraging rates and foraging success would not vary between treatments. We did not expect to find a difference in the time allocated to foraging or vigilance, because these parameters are related to habitat visibility (sward height), which was the same in both treatments (C. Devereux *et al.* in review). Using foraging rates (i.e. capture rates) to estimate prey availability is the preferred method of predicting food availability because it measures the prey that birds can extract rather than the overall prey abundance that would be determined using direct means, such as soil cores (Olsson *et al.* 2002).

METHODS

This study took place at the Oxford University Farm, Wytham, Oxfordshire, UK, during December 2001 and March 2002. The experiment was performed in a permanent meadow regularly used by the resident Starling population for foraging. We compared the foraging behaviour and success of captive Starlings feeding in swards mown (a) within 1 h and (b) 48 h before. A 0.5 × 1.5-m block of the pasture field was randomly assigned to a treatment and a Simplicity 6108 8-hp lawn tractor mower was used to cut the grass. Most grass clippings were blown from the block by the mower but any that remained were raked and removed. Both treatments created a sward height of 3 cm for the experiment, which Starlings are known to forage on successfully (Devereux *et al.* 2004). Prior to mowing, swards were approximately 5–6 cm high. The area was covered with anti-bird mesh for at least 4 weeks before trials to preserve natural prey abundance by preventing depredation by wild animals, and livestock were excluded by using electric fencing. Each individual Starling received two trials presented in a randomized order, one on newly mown grass and one on grass mown 48 h previously. At testing, three bottomless cubic mesh enclosures (side length 0.5 m) were arranged linearly within the block with their sides touching.

Adult Starlings were captured at the University Farm under licence (English Nature) and were housed indoors in groups of two or three. They were maintained under a light–dark cycle that reflected prevailing conditions. Starlings received a diet of turkey starter crumb, softbill pellets and mealworms *Tenebrio molitor*. Crumb and pellets were available *ad libitum* and mealworms were replenished daily after trials were completed. Water for drinking and bathing was available at all times.

Twelve of 25 Starlings held in captivity were randomly chosen as focal individuals whose behaviour was studied, and each had two companions for the experiment selected from the remaining stock. Each focal bird had the same companions for both of its foraging trials, and neither the focal nor the companion birds received more than one foraging trial in a day. Birds were tested in groups of three (one animal per enclosure) consisting of a focal bird (occupying the central enclosure) with its two companions. Starlings are social foragers and show a greater likelihood of foraging in groups. The behaviour of the focal individual was recorded using a digital video camera placed 3 m from the cage. The birds were observed from outside the field to note when foraging began, and if any of the birds did not forage within a 10-min acclimatizing period the trial was abandoned. Trials lasted 15 min after the first probe by the focal bird, which usually occurred about 1 min after release into the enclosures. We conducted 24 trials (12 birds × 2 mowing treatments). Trials were not performed in strong wind or rain or when the ground was covered with frost or snow. Birds were released at the capture site once all trials were completed.

Behavioural data were extracted from videotapes using Noldus Observer Video Pro 4 (Noldus Information Technology 1997). Two states with measured duration (head-up, head-down) and three instantaneous events (probe, root, eat) were recorded. We distinguished between time spent actively foraging and time spent performing other behaviours, and results were restricted to the periods of active foraging. An active foraging bout was initiated with a head-down (head below the body's horizontal plane) and terminated by a head-up (head above the body's horizontal plane) lasting longer than 5.6 s. This value of 5.6 s was the median length of

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a head-up period during a similar previous study (C. Devereux unpubl. data), and appeared to distinguish short scans whilst foraging from longer interruptions to foraging behaviour. 'Probe' and 'root' were both prey-searching behaviours occurring during head-downs. 'Probe' was classified as the initial investigation with the bill that caused a hole in the ground; it provides a measure of the number of foraging patches investigated. A 'root' was a further stab within the hole that functions to expand it to search for and extract a food item; it gives a measure of search intensity within patches.

The following response variables were estimated from the behavioural recordings: mean length of a searching bout (head-down, s), searching rate (number of head-downs per s foraging), mean length of a scanning bout (head-up, s), scanning rate (number of head-ups per s foraging), probing rate (probes per s foraging), rooting rate (roots per s foraging), intake rate (prey captured per s foraging) and capture efficiency (number of prey captured per 100 roots). Some behavioural responses that were not normally distributed (mean length of a searching bout and mean length of a scanning bout) were logarithmically transformed to meet test assumptions. Data were analysed using General Linear Models (GLMs) to investigate the explanatory variable time since mowing (1 h or 48 h) whilst controlling for two confounding variables: month and presentation order. Individual was included as a random effect. Probabilities quoted are two-tailed.

RESULTS

One bird was excluded from the analysis because glare from the sun on the camera lens prevented detailed coding of the video, limiting our analysis to 11 birds. As predicted, vigilance levels did not vary with the two sward height treatments (sum of head-ups: $F_{1,9} = 1.64$, $P = 0.23$). There was no difference in the total time spent foraging (sum of head-downs: $F_{1,9} = 0.05$, $P = 0.82$), nor was there a difference in the length of individuals' searches (mean-head down: $F_{1,9} = 0.54$, $P = 0.48$) or their rate (head-down rate: $F_{1,9} = 1.54$, $P = 0.25$). There was no difference in probing rate ($F_{1,9} = 0.24$, $P = 0.64$).

Rooting rate varied significantly with mowing treatment (Table 1). Rooting rate was greater on old mown swards than on newly mown swards. Although there was no statistical difference in intake rates between the two mowing treatments, there was a weak trend towards higher rates on newly mown swards (Table 1). As a result of the lower rooting rate combined with this trend, capture efficiency (number of prey captured per 100 roots) was 71% greater on newly mown swards (Table 1).

DISCUSSION

Starlings did not differ in the amount of time they spent foraging on newly mown grass and grass mown to the same height 2 days previously. However, Starlings foraged more efficiently on newly mown swards. Starlings captured more prey per searching effort in newly mown swards, despite their lower rooting rate, suggesting a higher reward rate. This result suggests that Starlings gain advantages by foraging on newly mown grass not only because of the creation of grass at a preferred height but also because of an increase in foraging benefits. Both intake rate and foraging efficiency are important determinants of a small bird's survival: energy demands must be met during the day for survival during the night. Our results suggest that although no more prey were captured on newly mown swards, energy expenditure was reduced because fewer roots were required for each prey captured.

There are at least two explanations for why grassland birds, such as the Starling, flock to forage on newly mown grass. First, mowing reduces the height of the sward. Many species, such as Starlings, wagtails and thrushes *Turdus* spp., prefer short swards as a foraging habitat (Whitehead *et al.* 1995, Perkins *et al.* 2000, Devereux *et al.* 2004). Several

Table 1. Rooting rate, capture rate and foraging efficiency of Common Starlings foraging on freshly mown and old mown (48 h previously) grass swards. Results are quoted in the form of mean ± se.

Foraging variable	Old mown	Freshly mown	
Root rate (roots s^{-1})	1.40 ± 0.097	1.23 ± 0.083	$F_{1,9} = 6.71$, $P = 0.03$
Intake rate (prey s^{-1})	0.016 ± 0.005	0.022 ± 0.003	$F_{1,9} = 2.63$, $P = 0.143$
Capture efficiency (prey per 100 roots)	1.05 ± 0.284	1.80 ± 0.372	$F_{1,9} = 4.99$, $P = 0.05$

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mechanisms may underpin this choice, including greater visibility for monitoring predators and conspecifics, improved prey accessibility and better mobility for foragers (Whittingham & Markland 2002, Butler & Gillings 2004, Whittingham & Evans 2004, Wilson *et al.* 2005). Recently, it has been shown that the main benefit of short swards for Starlings during the winter is improved visibility for predators and/or conspecific monitoring (Devereux *et al.* 2004). Although intake rate (prey captured per s during foraging) is the same on grass cut to either 3 or 13 cm, more time is devoted to foraging on the shorter sward because less time is devoted to long periods of vigilance. Therefore, more prey can be captured over time.

The second explanation for the preference for newly cut grass is that mowing changes invertebrate activity or availability, for example by causing a temporary flush of prey (Vickery *et al.* 2001). The effects of mowing on flushing foliar invertebrates are intuitive (Dunwiddie 1991, Cattin *et al.* 2003), but it is less obvious why mowing could influence soil invertebrates. It is possible that the action of mowing changes the activity rates of soil-dwelling prey because of noise and vibration, especially when large machinery is used. Prey may respond to the disturbance by changing their activity rates in some way that translates into an increase in capture efficiency for foragers.

Alternatively, mowing could affect prey availability by acting on the microclimatic requirements of soil invertebrates. Leatherjackets overwinter as III and IV instar larvae. They remain active and continue to feed at temperatures below 5 °C and can survive overnight frosts, but prolonged (> 10 h) periods below –5 °C cause significant mortality (Freeman 1967). They are also prone to desiccation, and microclimatic conditions created by the sward may be important in their survival (McCracken *et al.* 1995, Blackshaw & Coll 1999). A tall, dense sward may experience less extreme temperature and moisture fluctuations than a short, sparse sward (McCracken *et al.* 1995). In this study the height of the sward was reduced from a premanipulated level of 5–6 cm to 3 cm. It is possible that this relatively small reduction could have affected the soil surface microclimate. Leatherjackets could detect such changes by monitoring temperatures or light incidence and respond by moving deeper into the soil, thus requiring an increased effort from foragers for their capture. Over time, such a sward may contain fewer prey accessible to small foraging birds, which can only utilize the top few centimetres of the soil. If such prey movements also occur when swards are shortened by grazing, this may help to explain why small bird populations in grassland have not increased (Siriwardena *et al.* 1998) despite the fact that their preferred habitat, short pastures, has become more abundant through the rise in sheep numbers and stocking densities (Fuller & Gough 1999, Shrubb 2003). In contrast to conditions under the lower stocking densities of the past, current very high stocking densities may keep the grass permanently short with no ‘recovery period’ when below-ground invertebrates move closer to the surface once more.

Mowing is often used as a technique to manipulate grassland habitats in ecological research. For example, bird breeding success has been shown to vary with the timing of mowing (e.g. Green & Stowe 1993, Green 1995) or its frequency (Beintema *et al.* 1985, Beintema & Muskens 1987). Mowing has also been used in studies of foraging and anti-predator behaviour and has been proposed as a conservation management tool in creating preferred foraging habitats (Milsom *et al.* 1998, Devereux *et al.* 2004). The results of this study suggest that care should be taken when considering the design of ecological experiments that use mowing as a technique to be able to separate temporal changes in prey availability from factors under study.

To conclude, we have decoupled the effects of mowing (reducing the sward height) from its action (disturbance, soil microclimate). Although disturbance effects have sometimes been cited as a possible explanation for why foraging birds follow tractors cutting grass for hay and silage (Vickery *et al.* 2001), no evidence had previously existed. We have shown under controlled semi-natural conditions that mowing can improve a Starling’s short-term efficiency at extracting prey from the soil, and that this result is independent of sward height.

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