Leaving an uncut grass refuge promotes butterfly abundance in extensively managed lowland hay meadows in Switzerland

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SUMMARY

The main goal of this study was to experimentally test whether maintaining a fraction of a meadow uncut would create a refuge that can efficiently conserve butterflies in extensively managed meadows registered as biodiversity promoting areas, the most common type of agri-environment scheme in Switzerland. Leaving part of the meadow uncut was expected to benefit butterflies by providing shelter and food resources once the rest of the meadow has been mown. The measure was experimentally applied since 2010 in 12 sites of the Swiss lowlands (Plateau). There were two experimental meadows per site, with one mowing regime applied at random within the pair. One meadow was managed according to the standard regulations for meadows in biodiversity promoting areas, meaning that the meadow was entirely mown at least once a year, but not before 15 June (control meadows). The second meadow was only partially mown, and a grass refuge of 10-20% of its area was left uncut during mowing operations (refuge meadows). In 2013 we conducted Pollard walk surveys to assess the efficiency of the refuge scheme. Results indicate that after mowing the uncut refuges were occupied by butterflies, with much higher abundances than in control meadows. Keeping an unmown grass refuge within hay meadows would be a simple and easy measure to promote butterfly populations within current agri-environment schemes.

BACKGROUND

The intensification of agricultural practices has led to spatially and temporally over-simplified agricultural landscapes throughout most of the western European lowlands. Among invertebrates, diurnal butterflies (Lepidoptera) have been drastically affected by these changes. As a result, more than 20% of European grassland butterfly species are now considered as threatened (Van Swaay et al. 2006, Ekroos et al. 2010). In Switzerland 35% (78 species) appear on the Swiss Red List, most of these occurring in dry grasslands at low to medium altitude (Wermeille et al. 2014).

In order to promote semi-natural farmland habitats and counter biodiversity loss, agri-environment schemes (AES) were introduced in Switzerland in 1993. Formerly termed ecological compensation areas, Swiss AES were recently renamed biodiversity promoting areas (BPA). Extensively managed meadows are the most common type of BPA in Switzerland (52% of the whole area devoted to BPA), covering about 7% of the total agricultural area of the country. BPA meadows cannot be fertilised or treated with pesticides. They must be mown at least once a year, but not before 15 June in the lowlands.

Swiss BPA, as well as other European AES, has had only moderate positive effects on biodiversity so far (e.g. Kleijn et al. 2006, Aviron et al. 2009), notably upon invertebrates. The main reason has been suggested to be excessive landscape fragmentation and a lack of source populations to allow colonisation of otherwise suitable habitat (Ekroos et al. 2010). We further suggest that current BPA do not offer the necessary spatio-temporal heterogeneity within farmland for successfully restoring invertebrate biodiversity. In other words BPA extensively managed meadows are mown almost simultaneously, leaving nowhere for butterflies to feed, roost and reproduce.

Butterflies experience both sedentary and mobile life history stages, with each stage depending upon specific resources. Alteration of a single resource, such as host plant availability for caterpillars, can have drastic effects on butterfly population dynamics (e.g. Johst et al. 2006). They can be massively impacted by mowing operations on meadowland, especially due to sudden decreases in the availability of shelters, egg-laying sites and nectar sources (Dover et al. 2010, Cizek et al. 2012). Not surprisingly, leaving areas of uncut grass (refuges) after mowing operations has been advocated for mitigating these negative effects (Dover et al. 2010, Humbert et al. 2012). Such refuges likely maintain some continuity in the availability of host plants, nectar sources and shelters, while guaranteeing a diversity of microclimatic conditions throughout the season. In addition to providing food and shelter for adult butterflies, uncult grass refuges may further decrease the direct mortality of caterpillars and pupae caused by mowing machinery (Valtonen et al. 2006, Humbert et al. 2010). This would in particular benefit rare species whose caterpillar and pupae stages coincide with the mowing date (Walter et al. 2007).

The aim of this study was to experimentally test, at field scale, whether butterflies would use and benefit from such refuges among meadowland (Figure 1). This study was carried

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Data were analysed with generalised linear mixed effects models using Poisson error distribution. The response variable was butterfly abundance/transect, while mowing regime was a fixed effect, and study site (12 spatial replicates) a random effect. To appraise differences among mowing regimes, a post hoc test was performed using the function `relevel` of R.

CONSEQUENCES

The average (± standard error) number of adult butterflies counted per transect was 1.08 (± 0.40) in the control meadows; 0.75 (± 0.33) in the mown part of the refuge meadows; and 3.25 (± 1.42) in the uncut refuge of the refuge meadows (Figure 2). No difference in butterfly abundance was found between the control meadows and mown area of the refuge meadows (estimate = -0.37, z = -0.84, p = 0.40). In contrast, the uncut areas of the refuge meadows harboured higher butterfly abundance, by a factor of about three, than both control meadows (estimate = 1.10, z = 3.40, p < 0.001) and the mown area of the refuge meadows (estimate = 1.47, z = 3.92, p < 0.001). By far the most dominant species was meadow brown *Maniola jurtina*, followed by Essex skipper *Thymelicus lineola*, painted lady *Vanessa cardui*, marbled white *Melanargia galathea* and small white *Pieris rapae*.

DISCUSSION

The fact that butterfly densities in control meadows and in the mown part of the refuge meadows were comparable but three times lower than in the uncut grass refuges indicates that the butterflies actively used the refuges. Dover et al. (2010) did...
not observe (but this was not quantified) any mass dispersal of butterflies after mowing in Spain, which suggests that butterflies do not move to neighbouring uncut meadows to seek the resources which have abruptly vanished from their previous habitat. Altogether, this suggests that systematically leaving unmown grass refuges within every meadow is a good measure to enhance butterfly abundance. The occurrence of very few unmown semi-natural grasslands across the Swiss Plateau from mid-June to mid-July might explain why butterflies have become so rare in our modern lowland agricultural landscapes.

Given the positive effects of this measure for butterflies (and also orthopterans and wild bees; Humbert et al. 2012, Buri et al. 2013), subsidies could be paid to farmers to compensate for any resulting hay losses. This measure would be easy to integrate within current AES prescriptions because leaving a section of a field unmown is extremely simple to implement.

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