Effects of habitat characteristics and ride management on the abundance of the wood white butterfly in a Buckinghamshire wood[1]

R. Jeffree

Summary

Habitat transect and woodland management practice data were used to investigate the factors influencing the abundance of the wood white butterfly (*Leptidea sinapis* L. (Lepidoptera: Pieridae)) in Whitecross Green Wood, Buckinghamshire. Adult butterflies were counted during the summer 2003 flight period along a transect route divided into 35 sections each 50m long. Eight explanatory environmental variables were measured in each section. These were combined with data on mowing regimes in a general linear model (GLM). The abundance of the larval host plant, meadow vetchling *(Lathyrus pratensis* L.), was found to be a significant determinant of butterfly numbers.

A second GLM explored the main effects of habitat characteristics and management on the abundance of the larval foodplant. In descending order of significance, the most important variables were orientation, number of cuts to the ride margin in the last five years, and shade. Results were used to make habitat management recommendations for the conservation of the wood white butterfly at the study site.

Introduction

The British range of *Leptidea sinapis* (Linnaeus 1758) (Lepidoptera: Pieridae), commonly known as the wood white butterfly, has been declining for the last 150 years (Warren 1992), apparently at an increasing rate. Between 1970 and 1999, its UK distribution fell by 62% (Asher 2001). The butterfly is now confined to a few isolated colonies in southern England (Warren and Bourn 1998). It is a habitat specialist preferring shade levels of 20-50% (Warren 1985), which may explain why its distribution is restricted to woodland rides or clearings, disused railway lines and coppiced woodland (Warren and Bourn 1998).

The traditional practice of coppicing opens up patches of woodland and allows sunlight through to ground vegetation. Only 3% of woodland is actively coppiced in Britain today (Asher 2001) following a near total cessation around the turn of the twentieth century. This, combined with the fact that the wood white is slow to colonise new sites (Cadbury 1990), is thought to have contributed to its decline (Warren and Bourn 1998).

This study attempted to establish which elements of the habitat structure and ride management at the site contributed most to its attractiveness to the wood white, measured by adult butterfly abundance. Having established the important influence of the abundance of the larval foodplant meadow vetchling, *Lathyrus pratensis* (Linnaeus 1758) (Fabaceae) upon butterfly numbers, the same habitat structure and ride management data were used to determine the factors influencing its abundance. Transect data for Whitecross indicate healthy annual wood white populations dating back to 1986 (Woodell, R. pers. comm. 2003). It was thought that the infrequent

[1] This is an abridged version of an undergraduate dissertation submitted by Rebecca Jeffree to the School of Biological Sciences, University of Oxford in May 2004. A copy is held by the Department Of Zoology Library, University of Oxford.

disturbance of the rides in the study site and resultant presence of tall grass or light scrub, combined with a high abundance of the main larval foodplant, contributed to the success of the insect at this site (Woodell, R. pers. comm. 2003). However, these assumptions had not yet been tested.

Materials and Methods

The Study Site

The study site, Whitecross Green Wood, is a Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust (BBOWT) Nature Reserve situated seven kilometres south of Bicester on the Buckinghamshire-Oxfordshire border (National Grid Reference - SP599149). Until the 1960s the site consisted mainly of hazel coppice with oak and ash standards, until 60% of this was felled and replaced with conifers, though there are current plans to regenerate the broadleaved woodland on site. Coppicing of the remainder of the wood ceased during the 1990s due to deer damage, but has recently to some extent been revived within a small enclosure (BBOWT 2002). The site has over 1700 m of floristically rich woodland rides, which have long supported a thriving population of wood white butterflies. Each is cut piecemeal in 50 m sections for hay every summer (BBOWT 2002; Woodell, R. pers. comm. 2003).

The main woodland rides are 9 m wide with a ditch running along both edges. The majority of the rides consist of a central strip which is mown annually and flanked by two 1.5 m strips leading up to the ditch, that are cut on a three-year rotation. Rides with particularly high species diversity are mown to the ditch every year to prevent scrub and bramble encroachment (Woodell, R. pers. comm. 2003).

Survey Methods

Adult wood white counts were started late in May 2003, a week or two into the flight period. The transect route was walked between 12.00 and 15.00 on a weekly basis when weather conditions were most suitable for adult butterflies on the wing (Pollard, 1977). The criteria quantified by Warren (1984) were an air temperature of 17°C or more, or lower temperatures during bright sunshine.

Midway into the flight period, a day was set aside to make observations of adult butterfly feeding behaviour. Individuals were observed visiting flowers of the larval foodplant as well as the nectar plants tufted vetch *(Vicia cracca),* marsh thistle (*Cirsium palustre*), red clover (*Trifolium pratense*) and selfheal *(Prunella vulgaris)*. All of these flower throughout June, July and August. Separate counts of each were made per section. Tufted vetch is also sometimes used as a larval food plant (Butterfly Conservation 2004; Warren 1984, 1985), but it is believed that meadow vetchling is the primary larval foodplant (Wiklund 1977; Asher *et al*. 1994).

In addition to butterfly count data, eight environmental variables were recorded per section using the following methods:

Variable	Method
Ride orientation	basic orienteering compass in direction transect was walked
Shade level	ranked arbitrarily on a scale of 1 to 5 depending on what percentage of the ground was in shade. 1 = 0-20%, 2 = 20-40%, 3 = 40-60%, 4 = 60-80%, 5 = 80-100%
Host plant abundance	flower head counts (Warren 1985)
Nectar source abundance of *T. pratense*	
Nectar source abundance of *P. vulgaris*	
Nectar source abundance of *V. cracca*	
Nectar source abundance for *C. palustre*	
Abundance of plants deemed suitable for oviposition	individual plant counts

Adult wood white numbers were pooled for each section across the six days of butterfly data collection. The raw values for orientation were converted so that orientation was on a scale of one to 90% away from north, so those approaching 90% ran roughly in an east-west/west-east direction.

Analysis

A General Linear Model (GLM) analysis was performed for the response variable wood white abundance. All plant species values and wood white counts were ln (N+1) transformed to meet the assumption of normality of error and homogeneity of variance. All explanatory variables measured in this study were included.

Cutting regimes were incorporated into the GLM by including the mean number of years since the section was cut to the ditch and the mean number of cuts made to the ride margin over the last five years. Since this rotation is carried out piecemeal, one side of the ride is not necessarily cut at the same time as the other, so a mean was taken of the two values.

A second GLM model was fitted, this time with meadow vetchling abundance as the response variable, again using a ln (N+1) transformation. The model focussed on factors that could be manipulated by management to increase the abundance of the host plant, so potentially competitive plant species were ignored.

A block effect was included in both models to minimise the error variation. Blocking was included on the basis that sections in the same ride running in the same orientation were not independent. There were four blocks.

Results

Adults

There was a significant positive relationship between the abundance of the larval foodplant (meadow vetchling) and the abundance of adult wood whites. In terms of management practices, neither of the two variables (mean number of years since the section was cut and mean number of cuts to the ride over the last five years) had significant effects on adult butterfly counts. *For further details see Appendix.*

Host Plants

Table 1 (*see Appendix*) shows that block had no significant effect, but shade, orientation and the average number of cuts to the ride margin in the last five years were all significant determinants of meadow vetchling abundance.

There was a negative relationship between meadow vetchling abundance and both shade level and the number of cuts to the ride margin in the last five years. Within the range of 20° to 65° the model predicts that as the ride orientates away from a north-south direction the abundance of the larval foodplant increases.

Discussion

The first GLM indicated that wood white abundance has a strong, significant positive correlation with the abundance of the larval foodplant, meadow vetchling. The most likely explanation for this is the importance of meadow vetchling as a larval food source and site for oviposition.

The importance of meadow vetchling as a nectar source for the wood white butterfly does not account for the correlation observed. Although observations of adult feeding behaviour in this study suggest that meadow vetchling is a nectar source, contrary to the findings from Warren's earlier study at Ravenstone Road Copse, Northamptonshire (Warren 1984), no evidence was found for any significant correlation between ride popularity and the abundance of the other four nectar sources counted. For this reason, it does not seem plausible that meadow vetchling as a nectar source could alone account for the significant correlation between meadow vetchling and the wood white. It is known to visit a wide variety of plants and it may be that the overall plant species index is more important than individual plant abundance, as shown by Warren (1985).

A second GLM examined which environmental variables were important for encouraging meadow vetchling growth. Orientation of the ride, shade level and the total number of cuts to the margin in the last five years were all significant determinants of the abundance of meadow vetchling.

Ride orientation yielded the most significant result. As the ride was orientated away from north, the abundance of the host plant increased. The most likely reason for this is that east-west orientated rides receive longer hours of direct sunlight (Warren 1985; Asher *et al*. 1994). Since plant growth depends heavily on light availability and warmth, a strong correlation between plant abundance and orientation is to be expected. This also explains why there was a significant negative correlation with shade.

There is a notable discrepancy between the two main GLM results. While the first GLM shows meadow vetchling distribution to be the main determinant of adult butterfly distribution, the factors affecting the abundance of meadow vetchling do not appear to affect the abundance of wood whites. There may be a number of reasons for this, as follows.

Organisms vary greatly in their associations with environmental features, so it is not surprising that the factors affecting the host plant do not match the factors significant for butterfly number (Dennis 2003). Although this study suggests that a high abundance of host plant is attractive to the butterfly, it would be a mistake to assume that, despite the results, this really is the only important factor (Dennis 2003). Dennis (2003, 2004) and also Shreeve and Dennis (2004) encourage the measurement not only of consumable resources, such as nectar plants and host plants, but other essential features of the vegetation that are utilised by the butterfly for processes like thermoregulation, roosting, locating a mate and escaping predators. Thus, a further study may reveal that this discrepancy is the result of an omitted habitat variable. Although the nectar sources included in the analysis were available for most of the flight period, further investigation on more than one day needs to be made into the full range of nectar sources utilised and for how long they are available, as well as other resources like the ones mentioned above - pupation sites, for example.

It is also possible that there may be bias in measurements towards a particular sex. According to Dennis (2004) females are often under-recorded. A difficulty in this study was that male and female wood whites are extemely similar and it is particularly difficult to distinguish between them. A future study should strive to overcome this problem and thus measure the extent of this bias. Another possible bias is one described by Wicklund (1977), who found that a Swedish population of wood whites separated breeding and foraging activites spatially; foraging occured mainly within the wood, whereas breeding occured in the areas of meadow beside the wood. Whether or not the same rules apply to British populations is not entirely clear, but an effect of this sort may offer some explanation for the discrepancy in results of this study.

Another reason may be that due to the layout of the Whitecross transect route, a good range of the variables deemed to be important for meadow vetchling were simply not tested well enough for wood white abundance. For example, the main ride runs in the direction northwest-southeast, but there are not many other rides in other orientations. So in order to test orientation sufficiently, ideally one would have access to one or more north-south orientated rides intersecting with some west-east orientated rides. This would perhaps offer a more robust experimental setup. Assuming that wood whites do indeed prefer intermediate shade (Warren 1985), but also benefit from abundant host plant that in turn is encouraged mainly by open aspects, then a good range of different orientations of rides that intersect should be a consideration of a woodland manager aiming to produce ideal habitat for wood whites.

The presence of an adult butterfly in a particular section of a colonised wood like Whitecross may in fact give limited information about the suitability of the vegetation in the immediate vicinity. In addition to noting simply the presence of an adult, information on the behaviour of the insect, such as searching or dispersal flying, may be extremely useful for discriminationg between suitable and unsuitable habitat.

Despite the difficulties, the findings should be of interest to woodland managers. The predictive model formula produced by the second GLM should persuade a manager to manipulate the orientation, shade level and mowing frequency of the ride margin to encourage meadow vetchling growth. Rides running east-west benefit most from management (Kirby 1992). The model suggests that meadow vetchling has a preference for more open rides but it has been shown that the wood white thrives under intermediate shade conditions (Warren 1985). It would be better to avoid too many fully open rides, instead ensuring a variety of shade levels, since the decline in wood white range has been attributed to increased shading of scrub edges of woods (Asher 2001). Light levels may be increased through ride widening, introducing panels of coppice bordering the ride, or creating scallop edges (Anderson 1989; Kirby 1992; Warren and Fuller 1993).

The model also suggests that fewer cuts to the ride margin within a five-year period result in a higher abundance of meadow vetchling. The section with the highest concentration of meadow vetchling actually had a mean value of one cut to the margin within the last five years. A cutting regime of once every five or more years seems an appropriate management recommendation. This result fits with suggestions by R. Woodell (pers. comm.) and Warren and Bourn (1998) that infrequent disturbance of the woodland rides has resulted in high plant diversity and encouraged wood whites. The probable explanation for this is that meadow vetchling requires low scrub to scramble up and if rides are cut too frequently then scrub has little opportunity to invade.

Acknowledgements

Thanks to: Owen Lewis, Ben Woodcock, Darren J. Mann and Paul Dixon for their guidance throughout; Becky Woodell for her help and allowing access to her BMS data; Stuart Douglas, Dorothy Leys and my family, who accompanied me during fieldwork; Roger L.H. Dennis for his very helpful comments.

Rebecca Jeffree, The Wilderness, The Drive,
Maresfield, Uckfield, East Sussex, TN22 2HA
becca_jeffree@yahoo.co.uk

References

Anderson, M.A. 1989. Opportunities for habitat enhancement in commercial forestry practice. In Buckley, G.P. (ed) *Biological Habitat Reconstruction*. Belhaven Press, London.

Asher, J, Warren, M.S., Fox, R., Harding, P.T., Jeffcoate, G., Jeffcoate, S. 1994. *The Butterflies of Berkshire, Buckinghamshire and Oxfordshire*. Pisces Publications.

Asher, J. 2001. *The Millennium Atlas of Butterflies in Britain and Ireland*. OUP.

BBOWT. 2002. *Whitecross Green Wood Nature Reserve*. The reserves guide. This can be viewed on the internet at:
http://www.bbowt.org.uk/pages/reserves/leaflets/WhitecrossGreen.pdf

Butterfly Conservation. 2004. www.butterfly-conservation.org

Cadbury, J. 1990. The Status and Management of Butterflies on RSPB Reserves. *RSPB Conservation Review* 4: 40-46.

Dennis, R.L.H. 2003. Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. *OIKOS* 102:2.

Dennis, R.L.H. 2004. Butterfly habitats, broad-scale biotope affiliations, and structural exploitation of vegetation at finer scales: the matrix revisited. *Ecological Entomology*. Unpublished document.

Fitter, S.R., Fitter, A., Blamey, M. 1996. *Wild Flowers of Britain and Northern Europe*. Harper Collins Publishers. ???

Kirby, P. 1992. *Habitat Management for Invertebrates: a practical handbook*. Royal Society for the Protection of Birds.

Pollard, E. 1977. A method for assessing changes in the abundance of butterflies. *Biological Conservation* 12: 115-134.

Shreev, T.G. and Dennis, R.L.H. 2004. Resources, habitats and metapopulations - whither reality? *OIKOS* 106:2.

Stace, C. A. 1997. *New Flora of the British Isles*. Cambridge University Press.

Warren, M.S. 1984. The biology and status of the wood white butterfly, *Leptidea sinapis* L. (Lepidoptera: Pieridae), in the British Isles. *Entomologist's Gazette* 35: 207-223.

Warren, M.S. 1985. The Influence of Shade on Butterfly Numbers in Woodland Rides, with Special Reference to the wood white *Leptidea sinapis. Biological Conservation* 33: 147-164.

Warren, M.S. 1992. The Conservation of British Butterflies. In Dennis, R.L.H. ed. *The Ecology of Butterflies in Britain*. Oxford University Press.

Warren, M.S. and Bourn, N.A.D. 1998. Butterfly Conservation Species Action Plan: wood white, *Leptidea sinapis.* Unpublished document.

Warren, M.S. and Fuller, R.J. 1993. *Woodland rides and glades: their management for wildlife*. 2nd Edition. Joint Nature Conservation Committee.

Wiklund, C. 1977. Oviposition, feeding and spatial separation of breeding and foraging habitats in a population of *Leptidea sinapis* (Lepidoptera). *OIKOS* 28: 56-68.

Appendix

Adults

The fitted model for the response of wood white abundance to meadow vetchling abundance ($F_{1,33} = 12.81$, $p = 0.001$) is:

Ln (wood white abundance + 1) = 0.21 + 0.13*Ln (meadow vetchling abundance +1)

The R squared value for this model is 0.297, meaning that it has explained 29.7% of the variation in the data set.

Host Plant

Table 1. GLM output for abundance of larval foodplant meadow vetchling against environmental data

Block	$F_{3,28}$=0.72	p=0.54
Shade level	**$F_{1,31}$=4.98**	**p=0.03**
Orientation	**$F_{1,31}$=22.46**	**p<0.0001**
Mean no. years since margin last cut	$F_{1,27}$=0.27	p=0.61
Mean no. cuts of the ride margin in the last 5 years	**$F_{1,31}$=17.56**	**p=0.0002**

The fitted model produced using the second GLM is:

Ln (meadow vetchling abundance + 1) = 1.26 + [-0.60*Ln (shade level + 1)] + [-1.23*Ln (average number of cuts + 1)] + [0.12*Ln (orientation + 1)]