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Investigating the effect of browsing and differing hedgerow parameters on Brown hairstreak *Thecla betulae* egg numbers across East and West Sussex

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Abstract

- British Lepidoptera, especially those with more specialized habitat requirements show evidence of decline greater than other taxonomic groups, with agricultural intensification and mechanisation being the main identified cause behind the Brown hairstreak's decline.
- An adult survey was conducted in July/August 2014, yielding 5 observations of imagines at a well-known population hotspot, Knepp Castle Estate. Due to their elusiveness, focus was shifted to more representative egg searches carried out in winter
- 200m of >50% blackthorn hedgerow on several sites in East and West Sussex was systematically searched in 10m sections, yielding 31 ova. Different hedge parameters which were hypothesized to influence egg distribution were recorded, with studies by Merckx & Berwaerts (2010) and Fartmann & Timmermann (2006) as rough guides
- Statistical analyses found no links between varying hedge parameters and the number of eggs recorded, although due to the small size of the dataset which may not be representative of the whole region this cannot be deemed conclusive.

Introduction

It is a sad paradox that insects, the most diverse and species rich group of living organisms (Gaston, 1993) which comprises the vast bulk of terrestrial biodiversity and provides humans with vital ecosystem services, is largely overlooked if not outright scorned by the general population (Pyle et al, 1981). Vast amounts of professional entomology research focus on pest species of agricultural crops (ibid). Some neglect is also seen in biodiversity conservation policies (Cardoso et al 2011) – with more conspicuous vertebrates receiving more attention. Diurnal members of the order Lepidoptera, the butterflies, are somewhat of an exception. Aesthetically appealing to humans and with common British species being recognised by many members of the general public, they can be used as effective 'flagship' or 'umbrella' species for wider conservation initiatives. Flagship species are charismatic organisms which appeal to the public and attract attention; the idea with umbrella species is that they can be used as a 'conservation proxy' for other species which share the same habitat, considering the financial and logistical constraints that landscape-scale multi-species approach poses (Simberland, 1998). Indeed, the Knepp Castle Estate Wildland project (where adult and egg surveys for this study have been carried out, in July/August and December respectively) uses the Purple Emperor butterfly *(Apatura iris)* as one of its symbols (Knepp Safaris, 2014), and Lepidoptera are cited as 'the most frequent conservation targets amongst invertebrates' (New, 1997).

Hedgerows play a massively important role in landscape ecology, providing habitat for many species, particularly edge specialists, as well as acting as corridors for dispersal (Forman & Baudry, 1984). They are also a source of biotic and

environmental influences on adjacent fields and pastures (ibid.) Small flying insects use windbreaks provided by hedgerows as shelter (Lewis 1969). The hedgerow system in Britain has been under severe decline for the past 50 years, as a result of post-WWII agricultural intensification and mechanisation prompted by the 1947 Agriculture Act which sought to attain self-sufficiency in food production (Robinson & Sutherland, 2002). 121 000km of hedgerow were lost just between 1984 and 1990, equating to about one quarter, for all UK (Barr et al, 1991). In the preceding decade, between 1971 and 1981, the mean amount of hedgerow reported to be removed per farm was 480.2m (Macdonald & Johnson, 2000). As well as hedgerow removal itself, increased pesticide input associated with agricultural intensification is known to severely impact non-target species, and has been shown to negatively affect hedgerow Lepidoptera (Cilgi & Jepson, 1995). In the UK, the rate butterflies' decline has been greater than that of bird and plant species (Thomas et al, 2004), thus putting them in focus of conservationists. Detailed knowledge of particular species' habitat and microclimate requirements is imperative to successful conservation.

Immature life stages of butterflies are much more susceptible to predation and destruction resulting from inappropriate management, owing to their very limited mobility. Thomas & Emmet (1989) report 50-100 per cent of Brown Hairstreak eggs are destroyed in the process of hedge trimming; on undisturbed sites 25-45 per cent of eggs are killed by disease, and less often by predators (ibid). Although widely distributed across England and Wales, it has been perceived as a rare species – adult butterflies are seldom seen, and colonies persist at low densities over extensive areas,

often encompassing hundreds of hectares (Thomas & Emmet 1989). For species with low population densities, habitat connectivity is important to prevent local extinctions. It has suffered a visible decline through the North of its range in the British Isles, with much fewer sightings throughout the Midlands; in the nineteenth century the Brown Hairstreak was regularly recorded in the Lake District (Heath, Pollard & Thomas, 1984). The loss rate per decade has been calculated at 9% from records between 1980 and 1984 (Warren 1993)

This study sets out to investigate the influence of hedgerow parameters such as aspect, height, sucker abundance, recent mechanical flailing and browsing by cattle and deer on Brown Hairstreak egg densities.

Methodology

Study species

The Brown Hairstreak (*Thecla betulae)* is a large (38-45mm) butterfly belonging to the family Lycenidae, which also includes the Coppers' and the Blues (Meyrick 1927). *Thecla betulae* caterpillars in Britain, the hatching of which is synchronised with the budburst of blackthorn (*Prunus spinosa)* (de Vries et al, 2011) are monophagous, being highly specialised on the host plant. Bullace (*Prunus insititia)* has been cited as supplementary food on a few sites (Thomas & Emmet, 1989). Across continental Europe, the females readily lay their eggs on other *Prunus* species (Stefanescu, 2000). On the other edge of their geographical range, in the Russian Far East, eggs are laid on a number of other host plants, such as apricot (*Armeniana manchurica)* (Dantchentko

et al, 1995). The dorsally-compressed, globular ova, circa 0.7mm wide and 0.6mm high, are covered with thick white wax (Thomas & Emmet, 1989) and bear resemblance to miniature golf balls. They remain on their bushes for 8 months (Heath, Pollard & Thomas, 1984). Unlike most other Lycenidae, the Brown Hairstreak is thought not to exhibit myrmecophily, the mutualistic relationship of immature life stages with ants, although this has been observed on occasions outside the British Isles (Stefanescu, 2000). Adults are rarely seen on the wing (Frohawk, 1934), due to their secretive nature and a tendency to congregate high up in the crowns of "master trees" (predominantly ash) to collect honeydew secretions (ibid). Imagines are inactive at air temperatures below c. 20°C, emerging on sunny mornings from around 08.00 hrs (Thomas & Emmet, 1989). Due to the adults' elusiveness, egg surveys conducted in winter are the method of choice for investigating the distribution and abundance of the species (M. Blencowe 2014, pers. comm., 17 Oct.)

Methods

20 separate 10 metre sections of hedgerow on different sites (see *Figure 2.)* across Sussex were measured, and searched for eggs starting at bottom left corner, working up in 1m sub-sections.

Egg surveys were carried out in December 2014 and January 2015; with preliminary fieldwork and an attempted adult butterfly survey carried out in July/August 2014. Hedge parameters recorded (Table 1.) were chosen after preliminary fieldwork in the summer, with the study by Merckx & Berwaerts (2010) as a guide. As one of the initial premises of my study was to investigate the effect of recent (<2 years)

mechanical trimming on egg numbers, however 4 out of the 20 sampled sections showed evidence of recent cutting and thus analyses of this variable were not possible.

Table 1. Hedge parameters recorded

Variable	Classes
Geology	Clay; Sandstone; Chalk
Aspect of hedge	N;W;E;S
Next to road	Y;N
Adjacent environment	Pasture; Arable; Scrub; Woodland
Height of hedge	0-1m; 2m-3m; >3m
Width of hedge	0-1m; 1m-2m; 2m-3m; >3m
Sucker abundance	None-Few; Few-Moderate; Moderate-Abundant
Evidence of recent mechanical cutting	Y;N;
Browsed by livestock	Y;N;

Hedges were sampled on several sites around Hassocks, Albourne, Sayers Common (03/12/2014 and 13/01/2015), Westmeston and Ditchling (16/12/2014 and 11/01/2015), as well as around the southern block of Knepp Castle Estate (20/12/2014) in the vicinity a known and identified master tree ash (Benton's Lane) (A. Nightingale 2014, pers. comm., 29 Jul). In addition, surveys of adult Brown Hairstreaks were carried out on 30/07/2014, 05/08/2014 and 06/08/2014.

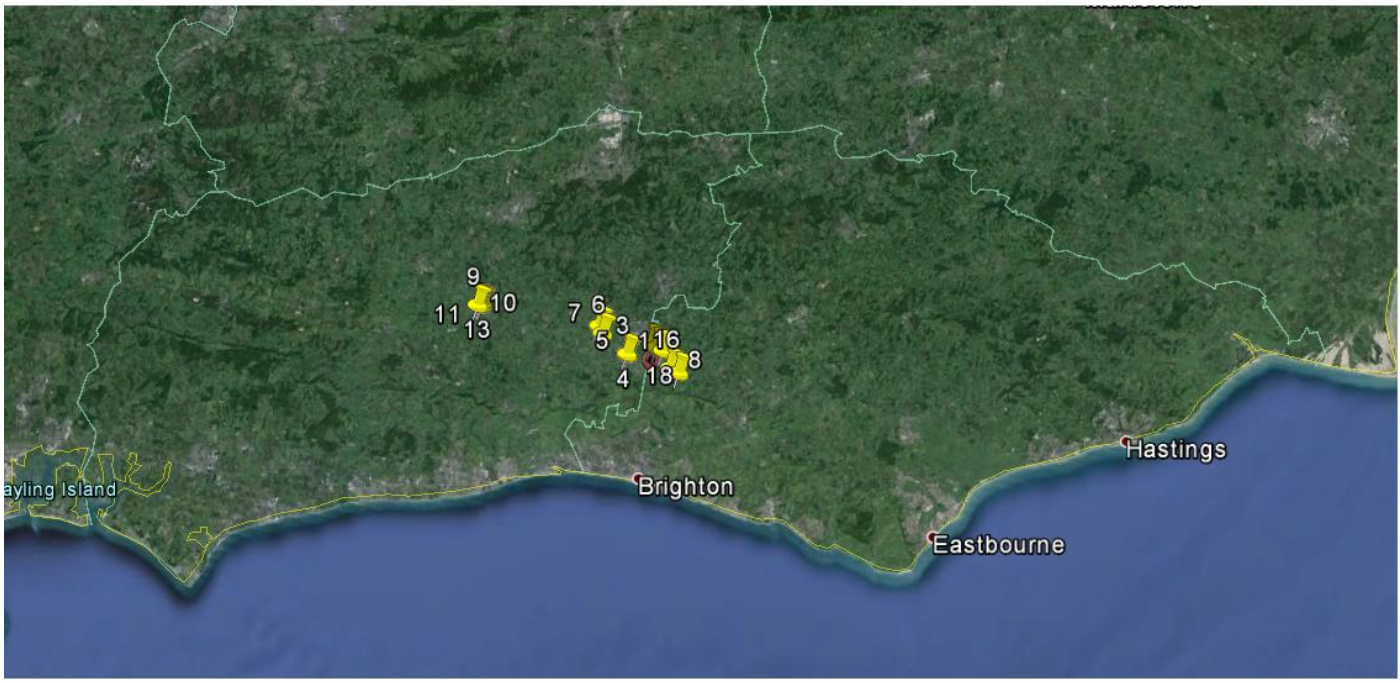


Figure 1. Map showing sampled hedge sections within West and East Sussex (Google Maps, 2014)

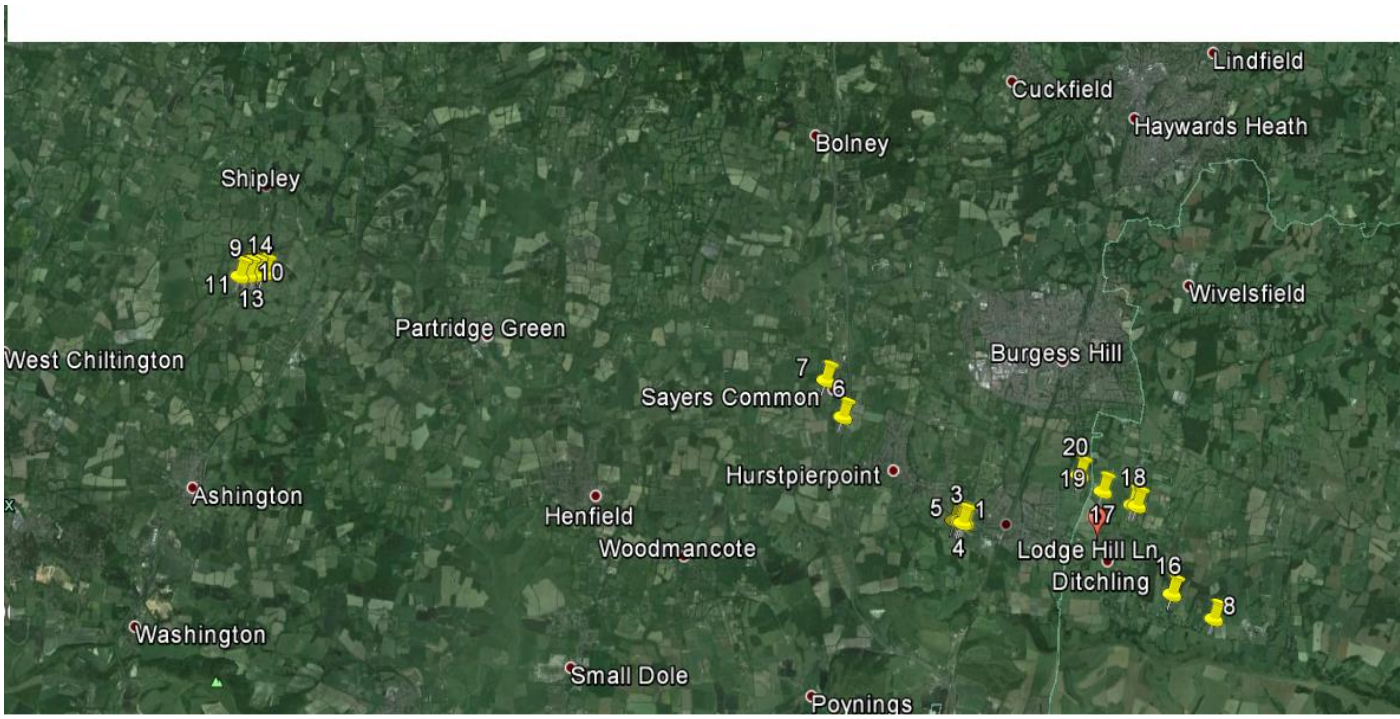


Figure 2.. Enlarged map of sampled sections (Google Maps, 2014)

Statistical analysis

In order to test the hypothesis that Browsed sections will have fewer eggs than Non-Browsed, the Mann-Whitney U Test was conducted. It is used to determine the presence of a statistically significant difference between two independent samples. It is a non-parametric alternative to the T-test (Dytham, 2010).

Merckx & Berwaerts (2010) report "sections with ample young growth were characterised by consistently higher egg densities than sections where young growth was restricted". In order to test the hypothesis that sections with a greater abundance (Moderate-Abundant) of suckers will have more eggs than those with fewer suckers (None-Few; Few-Moderate), the Kruskall-Wallis test was conducted, using IBM SPSS Statistics 22. It is an extension of the Mann-Whitney U test where there are more than 2 samples being tested for differences (ibid).

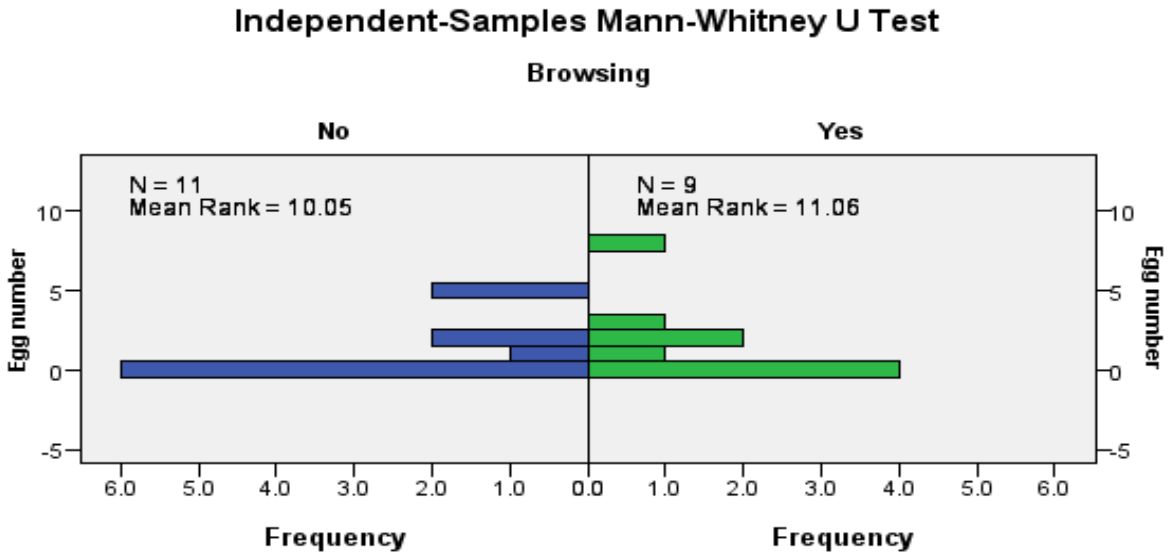
It is likely the results will be confounded by the small size of dataset. Certain variables are under-represented in the samples, for example only two east-facing and two north-facing sections were surveyed.

Results

In total, 200 metres of hedgerow were systematically searched in 10m sections; producing 31 ova in total. Eggs were present in 50% of samples, with the highest number in one 10 metre section being 8 eggs. The average number of eggs found was 3.1, with a standard deviation of 2.23. An adult butterfly

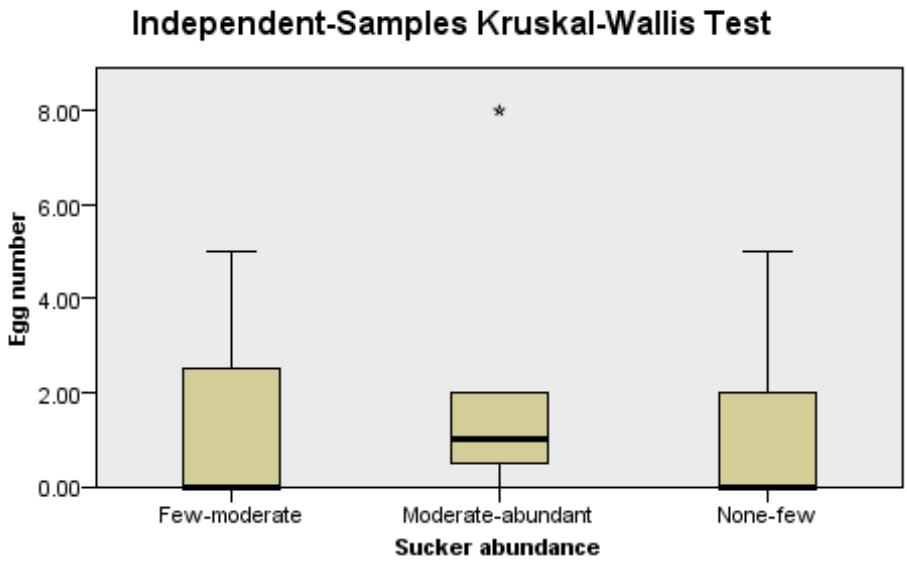
Figure 3. Number of eggs in different hedge aspects

During the adult survey, 2 Brown Hairstreaks of unidentified sex were observed on 30/07/2014 in an ash tree at the southern edge of Northern Wood, in the Southern Block of Knepp Castle Estate (50.967221, -0.378700); an additional 2 were observed on the same tree a week later on 06/08/2014. 1 male was recorded on another ash close nearby (50.967712, -0.376558) on 05/06/2014.



Total N	20
Mann-Whitney U	54.500
Wilcoxon W	99.500
Test Statistic	54.500
Standard Error	12.255
Standardized Test Statistic	.408
Asymptotic Sig. (2-sided test)	.683
Exact Sig. (2-sided test)	.710

Figure 4. Output of the Mann-Whitney Test statistic, comparing egg distributions in Unbrowsed and Browsed sections



Total N	20
Test Statistic	.787
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	.675

Figure 5. Output of the Kruskal-Wallis Test, comparing egg distributions in different sucker abundance categories

Discussion

Statistical tests interpretation – testing hypotheses

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i) Effect of browsing on egg numbers

H_0: There is no difference in egg numbers in Browsed and Non-browsed sections

H_1: There is a difference in egg numbers in Browsed and Non-Browsed sections.

The critical value for two samples of 9 and 11 is 23 at the 5% level of significance. The calculated Mann-Whitney U value is 54.50, we thus accept the null hypothesis (H0); there is no difference in egg numbers for Browsed and Non-Browsed sections.

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ii) Effect of sucker abundance on egg numbers

H_0: There will be no significant difference in egg numbers between the 3 categories of sucker abundance.

H_1: There will be a significant difference in egg numbers between the 3 categories of sucker abundance.

The critical value for 3 samples of 7, 7 and 6 is 5.792517 at the 5% level of significance. The calculated Kruskal-Wallis H value is 0.787, we thus accept the null hypothesis (H_0); there is no significant difference in egg numbers between the 3 categories of sucker abundance.

Compared with other studies, the egg densities found were low – with the mean at 3.1 (SD=2.23). Fartmann & Timmermann (2006) report an average density of 9 eggs per 10m hedgerow. Merckx & Berwaerts (2010) have shown a considerable year-to-year fluctuations in egg numbers on the same sites; it is likely numbers across Sussex this season are lower than observed in previous years (A Nightingale, pers. comm. 20 Dec).

One of the study's original premises was to investigate the effect of geology and thus soil type differences on the presence of *Thecla betulae*. In the field I realised the extent of vegetation differences between the heavily waterlogged Wealden clay soils of West Sussex and better drained sandy soils of East Sussex. Roadside and field boundary hedgerows in East Sussex see prevalence of hawthorn (*Crataegus* spp*)* and hazel *(Corylus avellana).* Scarcity of blackthorn, which *Thecla betulae* larvae in the British Isles feed exclusively on, is likely the reason for the apparent cut-off in distribution (see map in figure); and thus the prospect of carrying out egg surveys on previously selected sites was abandoned. More focused searches were thus carried out on other sites across West Sussex, including Knepp Castle Estate, where, due to the cessation of hedge flailing several years ago, and abundance of suitable egg laying habitat as well as the presence known "master trees", one would expect to find many eggs. Thomas & Emmet (1989) identify "heavy, low lying land that is heavily wooded and contains many indented wood-edges and numerous small, sheltered hedged fields, with *Prunus* as an abundant shrub" as ideal haunts for the species. However, the herbivores (fallow, red and roe deer, as well as longhorn cattle and Exmoor ponies) present in the southern block of the estate, cause observable changes to hedge structure through browsing (pers. obs.). Cattle differ greatly from more conventional "conservation grazers", sheep, in that rather than nibbling they eat with a rasping tongue (Oates 1995), causing more damage to young blackthorn growth. In the preliminary fieldwork in August, deer were seen browsing hedgerow bushes standing on their hind legs, allowing them to access higher branches. In the field, there seems

to be somewhat of an association between browsing, which leaves a dense network of thicker and woodier stems, and lichen growth – this may make egg laying impossible for the female butterflies. Neil Hulme (2014) makes the same observation, having reported greater numbers of eggs outside the estate where browsing pressure is less intense, and suggests the reason for greater incidence of grazing at Knepp is a decreased availability of grass for grazing, caused by the expansion of Fleabane *(Pulicaria dysenterica)*. Incidentally, fleabane is cited as the Brown Hairstreak's main sources of nectar, alongside *Rubus* spp. and thistles *(Cirsium* spp.) (Thomas & Emmet, 1989), which are also common around the estate (pers. obs).

With regards to hedgerow management, the study proved to be inconclusive as an insufficient number of trimmed sections was sampled; and the analyses showed no significant differences in egg numbers between browsed and unbrowsed sections, nor between sections with different sucker abundances. Analyses of the influence of aspect, hedge height, flailing and proximity to road were not conducted due to an insufficient number of samples for particular categories of the variables.

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