Microhabitat requirements of caterpillars of the critically endangered butterfly *Chazara briseis* (L.) (Nymphalidae, Satyrinae) in the Czech Republic

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Abstract. We report the larval microhabitat preferences of the critically endangered Hermit butterfly, *Chazara briseis* (L.) (Nymphalidae, Satyrinae), from a population inhabiting steep basaltic hills of the Ceske Stredohori highlands, Czech Republic. Based on field records of 61 pre-pupation larvae, we argue that they require dry, south to south-west exposed slopes containing short tufts of their fescue host-plants (*Festuca ovina* L. agg.) growing on exposed bedrock. These conditions have been maintained by traditional sheep grazing, recently supplemented by trampling along tourist paths. These preferences are practically identical to those found in an earlier study near Halle an der Saale, Germany, situated 180 km to the northeast. Despite the larval preference for short-sward vegetation, *C. briseis* also requires taller-sward and even shrubby patches providing nectar and shelter for adults. Heterogeneity of conditions is also necessary for several co-occurring endangered insects, including Lepidoptera. Efficient conservation of *C. briseis* should be planned and practised over the whole area of occurrence of the population.

Introduction

The Hermit, *Chazara briseis* (Linnaeus, 1764) (Nymphalidae, Satyrinae) is increasingly threatened throughout the European part of its range. Its global distribution includes the Mediterranean region, Europe up to southern Scandinavia, southern Russia, Asia Minor, Central Asia, and Northern China. This specialist of xeric grasslands was once widely distributed in all warmer regions of Central Europe. It underwent a severe decline during last decades due to habitat loss caused mainly by abandonment of grazing and by subsequent successional overgrowth, locally hastened by intentional afforestation of its sites (e.g. Dolek & Geyer 1997; Reinhardt et al. 2007). The speed of the decline is illustrated by the situation in the Czech capital Prague, where the butterfly was so common in the 1950s that it was nicknamed "the Prague butterfly", but it completely disappeared after the 1980s (Kadlec et al. 2008). In the whole country, the species occurred in 60 atlas grid cells (10 × 11 km) prior to the 1950s, but occurs in just three cells presently (Benes et al. 2002; Czech butterfly recording scheme). Similarly rapid losses are under way in Austria, Germany, Hungary, Poland, Romania, and Slovenia (Ebert & Rennwald 1991; Buszko 1993; Van Swaay & Warren 1999; Cremene et al. 2005; R. Verovnik pers. comm.).

In 2006 we made an autecology research of the last large (meta)population in the Czech Republic, in the Ceske Stredohori highlands. The population appeared prospering, containing over 1000 adults of each sex in ten separate but mutually interconnected colonies, and exhibiting a high within-population genetic diversity. Less optimistically,

our findings were remarkably similar to those found a decade ago in Germany, Halle an der Saale region, 180 km to the NW from our study area, within a volcanic chain forming a continuation of the Ceske Stredohori highlands. This German (meta)population appeared as abundant, structured, and genetically diverse (Seufert & Grosser 1996), but despite these signs of a healthy status, it has become nearly extinct during just a decade (M. Dolek, pers. comm.). We also discovered, in the Czech population, that inseminated females required a strikingly long period of about three weeks to complete egg maturation. This pattern, characteristic for several genera of large Satyrinae (Garcia-Barros 2000), resulted in only 25–50 per cent of adult females living long enough to lay any eggs during their lifetime (unpubl. data). This demographic load decreases the effective population size to a half, or even a quarter, of the census population. Viable populations of *C. briseis* thus must contain twice to four times as many individuals than populations of "normal" butterflies. Because large populations require large areas of habitat, restoration of suitable habitat conditions over large pieces of land appears as the only chance to preserve *C. briseis* in Central Europe.

In this study, we focus on larval habitats of the Ceske Stredohori population. We (i) describe the larval requirements of the Ceske Stredohori populations; (ii) compare them with the situation at geographically close sites in Germany; and (iii) discuss the conservation implications of the larval requirements.

Material and methods

Study system. The studied population inhabits steppic grasslands on ten basaltic hills at the southwestern edge of the Ceske Stredohori Highlands, NW Czech Republic (–). The grasslands are believed to have been present there for the entire Holocene owing to grazing pressure combined with a highly continental climate in rain shadows of the Krusne Mts (Lozek 2000). They were traditionally used as sheep pastures, whereas the intermingling landscape consists of arable fields and orchards. The grazing management has been declining gradually from the early 20th century onwards, some of the hills were intentionally afforested, and the land use changes accelerated in the 1960s (intensification of agriculture, further decline of sheep grazing), and again in the 1990s (closure of remaining commercial sheep farms).

The hills represent an important refuge for the steppic flora and fauna in Central Europe. Besides of *C. briseis*, they host the last Czech populations of several species of Lepidoptera, such as the lycaenid butterflies *Polyommatus damon* (Denis et Schiffermueller, 1775) and *Pseudophilotes vicrama* (Moore, 1865), the arctiid moth *Watsonarctia casta* (Esper, 1785), and the noctuid *Sideridis lampra* (Schawerda, 1913). Notable Orthoptera include *Euchorthippus pulvinatus* (Fischer-Waldheim, 1846), *Oedipoda germanica* (Latreille, 1804), *Stenobothrus eurasius* (Zubowsky, 1898), and *Modicogryllus frontalis* (Fieber, 1844). The area also harbours one of the last viable populations of European souslik, *Spermophilus citellus* (Linnaeus, 1766), in Czechia (Cepáková & Hulová 2002). Parts of the hills are protected as reserves, and their managers, approximately from 2000 onwards, are battling the natural succession by

small-scale sheep grazing and scrub clearance. Another important activity is a tolerated use of one of the hills for aeronautic sports, such as hang gliding and paragliding.

Chazara briseis adults appear in mid-July, but the females start laying eggs as late as late August (unpubl. data). They do so singly, utilising shorter-sward patches, maintained by grazing or trampling. The host plants are fescue grasses (*Festuca ovina* agg., *F. pallens* H.) and *Sesleria albicans* Sch. (Ebert & Rennwald 1991) (Poaceae). The larvae emerge at the end of September, overwinter in the first instar, and pupate in early summer.

Data and analysis. We searched for caterpillars at Rana hill, a colony that hosted almost 40% of the total adult numbers (870 out of 2300) in 2006, for a total of three nights in 2007 (May 30, June 1 and 3, 2007). We always begun at sunset and used torch light to search short-sward patches, where we observed the majority (26 out of 30) of oviposition events during the mark-recapture study in September of the previous year. These places were either grazed by sheep, or occasionaliy trampled owing to proximity of walking paths. For each caterpillar found, we recorded the closest hour, temperature, cloudiness, wind, behaviour (feeding, resting, crawling), and its body length. We then delimited a circle with a 0.25 m^2 surface around the larva and ortho-photographed it from a height of 1.5 m. These photographs were subsequently used to quantify the proportional amount of open soil and rocks, host-plants and other vegetation, using the program DIVA-GIS version 5.2.0.2 (www.diva-gis.org). For each positive record we also measured the height of the vegetation, inclination, and geographical aspect. We established the minimum distance to the nearest shrub (up to 5 meters), habitat type (distinguishing short-sward steppe – maximum height of vegetation < 50 cm and long-sward steppe – height of vegetation > 50 cm), and habitat structure (open – grasslands without shrubs, shrubby – grasslands with sparse growth of shrubs, forest steppe – mixture of grassland, scrub and occasional trees). The data were compared with similar data from a German population near Halle an der Saale (Seufert and Grosser 1996), using χ^2 tests.

Results

During the three-night search, we located a total of 61 *C. briseis* larvae at 55 separate plots (6 plots hosted two larvae) (Fig. 1). The length of the caterpillars was 18–38 mm (30.7±3.7SD), corresponding to the last two larval instars.

The prevailing weather was mild, with half-overcast sky and weak gusts of wind. The temperature was around 10 C, dropping to 4 C before sunrise. The first caterpillars were observed around 10 pm, the last were still active at 3 am. Most of the interim time ($n = 49$), they fed on fescue grasses from the *Festuca ovina* group, whereas only twelve larvae crawled or rested on barren substrate ($n = 2$) or on herbaceous material ($n = 10$). The fescue tufts used were narrow, with a surface of 120–240 cm^2; only few larvae fed on narrower or wider ones.

All larvae were found on slopes exposed mainly to the S or SW (Tab. 1). The habitat was short-sward steppe, locally overgrown by shrubs (the mean distance from larvae

Tab. 1. Comparison of conditions of larval sites at two nearby regions hosting populations of *Chazara briseis*. In all cases except for n (sample size), means ± *SD*, Chi-sq values of tests, and *P* values are presented. Data for the German population are from Seufert & Grosser (1996).

Population	n	Inclination (°)	Exposition (°)	Barren ground (%)	Turf height (cm)
Ceske Stredohori (Cz)	55	17.5 ± 5.8	180.8 ± 31.4	31.7 ± 13.3	22.8 ± 8
Halle an der Saale (D)	26	20.8 ± 6.6	172.8 ± 31.6	23.6 ± 20.1	14.3 ± 6.3
Chi-sq values		0.1424	0.0905	0.5964	0.9867
P		>0.1	>0.1	>0.1	>0.1

to the edges of the nearest shrub: 120±70 cm). All occupied plots were either grazed by sheep a year before ($n = 40$) or trampled by visitors ($n = 15$). The turf was short and sparse (Tab. 1, Fig. 2).

In the German population (Seufert & Grosser 1996), caterpillars were found in remarkably similar conditions. Their habitats were also restricted to volcanic hills, and the conditions at occupied plots were practically identical to the conditions within the Czech population (Tab. 1). There were no differences between conditions in the Czech and the German population (all χ^2 tests were non-significant at $P > 0.1$).

Discussion

We located a relatively high number of caterpillars during the three-night searches. This was likely because we restricted the sampling to sections of the Rana hill with short steppic vegetation, where a year before we actually observed ovipositing females, i.e. the mothers of the investigated larvae. The area with suitable conditions is rather restricted on the hill, covering no more than 30 ha, whereas the remaining 140 ha of the hillsides is covered by tall-sward formations dominated by *Stipa* spp., completely unsuitable for the butterfly.

The caterpillars used either grazed or trampled micro-sites. Both grazing and trampling favour the low growing tussocky host plants (*Festuca ovina* agg., *Sesleria albicans*) over tall-bladed ones (e.g., *Stipa* spp.) (cf. Hill et al. 1992) thus increasing host plant supply. They also maintain bare bedrock (Fig. 2), which, here and in other studies (Dolek & Geyer 1997; Königsdorfer 1997; Leopold 2001), appears to maintain a warm and dry microclimate suitable for the *C. briseis* development (examples from other butterfly species, e.g., Thomas 1995; Fartmann 2006; Maes et al. 2006). The decline of the heterogeneous, non-intensive grazing, once carried out by most of the village households across Central Europe, is widely recognised as the main reason for the *C. briseis* decline. Once the grazing is terminated, the conditions change dramatically from short, tussocky vegetation to taller-sward. Grass feeding by sheep, on the other hand, probably does not harm the caterpillars owing to their nocturnal activity and the ability to wander among host-plants, e.g., if entire the tussock is consumed.

The hills were left ungrazed for almost a decade during the 1990s, after the last commercial sheep farms in the area left and before local conservationists established a conservation grazing regime. During that time, the only active disturbance was trampling by hikers

Fig. 1. A caterpillar of the Hermit (*Chazara briseis*). Rana Hill, Ceske Stredohori, Czech Republic, May 30, 2007.

and fans of aeronautic sports. For some time, it was feared that these activities may harm the grassland vegetation. This view is changing rapidly as it is becoming clear that limited trampling is beneficial for *C. briseis* and other species profiting from the presence of patches of barren ground.

The short-sward patches with barren bedrock – i.e., the larval habitat – represent just one of several resources required by *C. briseis*. Further resources include nectar supply, critical for this long-lived species (Garcia-Barros 2000), and shelter. We observed that if the ground cover was appropriate for larvae, sparse solitary shrubs nearby did not affect the occurrence of caterpillars, and the shrubs instead provided shelter for ovipositing females (unpublished data). It follows that managing localities for *C. briseis* requires maintenance of heterogeneous conditions via applying such measures as fencing to temporarily exclude grazing animals.

Heterogeneity of conditions is also necessary for other co-occurring and endangered species. While some such species require the short sward utilised by *C. briseis* larvae (e.g., the butterfly *P. vicrama*, the mammal *S. citellus*), others prefer taller herbaceous vegetation. Perhaps the most dramatic case is represented by *Polyommatus damon*, an endangered species occurring in the Czech Republic in just four populations. The butterfly is absolutely intolerant to sheep grazing (e.g., Kudrna 1998; Dolek & Geyer 2002), in striking contrast to *C. briseis*. While past landscapes consisted of fine-grained patchworks allowing sensitive insects to track temporarily suitable sites (e.g., Kruess & Tscharntke 2002; Saarinen & Jantunen 2005), modern landscapes consist of large and homogeneously managed tracks of land, and conservation management strives to pack entire past habitat diversity into limited space of reserves (Morris 2000; Bourn & Thomas 2002; Wenzel et al. 2006).

The striking similarity between the Czech Ceske Stredohori and the German Halle an der Saale populations, and the pessimistic fate of the latter, allow some speculation on the Czech population's future. The German population has been declining rapidly despite its seemingly good condition a decade ago (M. Dolek, pers. comm.). The underlying reason seems to be the requirement for large numbers of individuals, plus the complex habitat requirements of the butterfly: short-sward larval habitat, taller-sward nectar-rich sites, and sheltering shrub. To prevent a decline of the Czech population, it is necessary to expand the current conservation grazing to a considerably larger area, while maintaining sufficient extents of taller-sward grassland and scrub. This requires comprehensive management of the entire area, including restoration of more favourable conditions in long-abandoned orchards at the piedmonts of the hills, now covered by impenetrable scrub. This will incur considerable cost, but the positive news is that there

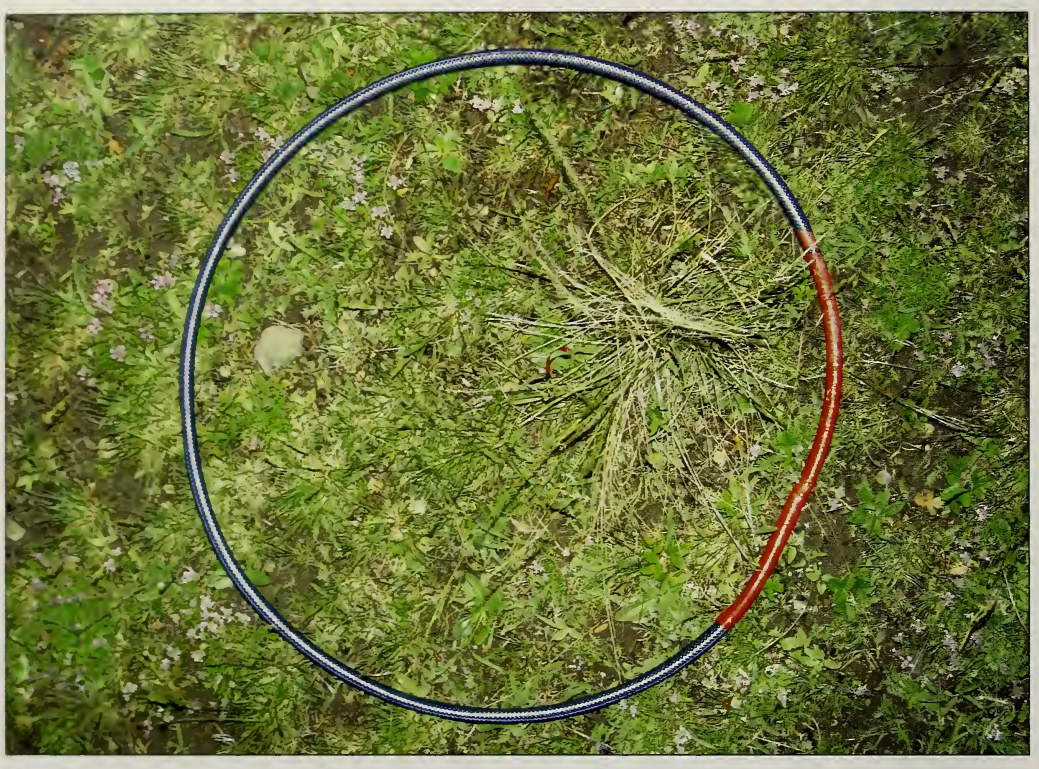

Fig. 2. Suitable microhabitat structure occupied by *C. briseis* larvae. Short-sward grassland with high proportion of exposed bedrock.

is enough space for a generous restoration project, as much of the land is currently unused. Conserving the system is also easily reconcilable with a regulated recreation use of the hills by hikers and aeronautic sports fans. A species action plan, now under preparation, should secure coordination of all these activities.

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Fig. 3. Shrubby short-sward steppic grasslands in the Ceske Stredohori hills host a number of endangered insects besides C. *briseis*. The habitats are under serious threat due to ongoing successional processes.

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