The Duke of Burgundy Butterfly (*Hamearis lucina* Linnaeus 1758).

Observations regarding its ecology on Omberg in Östergötland, Sweden.

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A new colony of *Hamearis lucina* has been found on Omberg, a granite horst on the eastern shores of Lake Vättern. This colony thrived in association with a plantation of young spruces but must have had its origins from the small populations around the forest fringes in the area. Observations were made on male territorial behaviour, on the choice of food plant (*Primula veris*) location and on the pattern of oviposition. The results were applied to a management regime so that *lucina* would continue to flourish after the removal of the spruces. Very restricted food plant locations were surveyed and confirm that the larvae need just the right conditions of warmth and humidity to grow and pupate. These are the conditions that occur naturally during the successions from grassland to scrub and forest and allow naturally occurring populations of *lucina* to last only a few years in one site.

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Introduction

The Duke of Burgundy has become rare in Northern Europe, especially in Great Britain, where it has declined rapidly in recent years. Much of its decline is due to intensive modern forestry and agriculture with the use of herbicides and pesticides, factors which are responsible for the decline of the European biodiversity of as a whole.

In Sweden this butterfly is dependent on the cowslip (*Primula veris*) as its food plant. But previous work in Britain has shown that the mere presence of the food plant is not sufficient for the survival of this butterfly, and this has also been shown in Sweden.

In Sweden it occurs sparsely in the south-eastern parts of the country, with stable populations in the central parts of the island of Öland, around Lake Mälaren, parts of SE Småland, and along the Eastern Shore of Lake Vättern. One of the largest mainland populations may occur on the north-eastern slopes of Omberg

The Duke of Burgundy on Omberg

Omberg is a ten-kilometre long granite horst lying twelve kilometres south of the town of Vadstena. Its summit is about 260 m above sea level and 170 m above Lake Vättern. The surrounding limestone strata influence its clay soils, which results in a rich diversity of plant-life, including rare species of orchids in the marshy areas.

Being partially dependent on lime-rich soils, the cowslip occurs commonly on Omberg and along the shores of Lake Vättern south of Omberg.

Fig. 1. Habitat for the Duke of Burgundy Butterfly, ***Hamearis lucina****, on Omberg. Photo: Ivan Kruys.*

Fig. 1. Typisk miljö för gullvivefjäril, ***Hamearis lucina****, på Omberg.*

H. lucina has been traditionally known to occur on Omberg in small numbers in an area of pasture known as Renstadfällan, which is heavily grazed by horses. More recently it was discovered on the areas bordering the Ombergsliden ski-slope, about 3-km further north, where it occurs both next to the ski-slope and just west of the car park which lies at the bottom of the ski-slope.

On 25 May 1992 Ivan and Ulla Kruys discovered at least 20 individuals of *lucina* on the slopes of Omberg in an area of about 1-hectare about 500m south of the ski-slope (Fig. 1). Small colonies where two or three individuals may be seen at one time were to be found along east-facing forest fringes in the surrounding area. However, the sight of so many butterflies at any one time is unusual and is an indication of a strong population that may have had its origins in one of the small colonies nearby. The area had been planted with Norway Spruce and the trees were about 4-5 years old at the time. The vegetation around the smaller trees had been kept clear by means of herbicides, but where the trees had grown larger the vegetation consisted of a lush mixture of grasses and wild flowers, cowslips being a common species.

During the following two weeks, every visit to the area revealed at least as many individuals, the numbers fading gradually after 10 June.

The above confirms the statement made by Thomas and Lewington (1991) that woodland colonies can be quite large after extensive forestry plantation.

It must be noted that all the colonies of *lucina* are located on the eastern slopes of the horst. Those colonies that occur south of Omberg along the shores of Lake Vättern are small and

Fig. 2 (above) and 3 (below). After mating the female lays a batch of up to four eggs on the under-surface of each cowslip leaf.
Photos: Ivan Kruys.

Fig. 2 (överst) och 3 (underst). Efter parningen lägger honan grupper om upp till fyra ägg vardera på undersidan av gullviveblad.

Fig. 4 (above) and 5 (below). The larvae tend to feed at night and make characteristic holes in the leaves. The pupae, which overwinter, are difficult to find.
Photos: Ivan Kruys.

Fig. 4 (överst) och 5 (nederst). Larverna äter på natten och gnager karakteristiska hål i bladen. Pupporna, som övervintrar, är svåra att hitta.

are all on the east side of stands of trees and bushes, i.e., where they receive morning and early afternoon sun.

Observation Methods

The numbers of individuals are rough estimates based on visual observation. Observations of behaviour, oviposition, etc., were made while the observer was stationary, either sitting or standing. Occasionally binoculars were used as an aid.

In order to minimize damage to food plants and surrounding vegetation, examination of food plants for eggs and larvae was made on a random sample basis, involving all types of locations for the food plants, from nearly full shade to full sun.

Observations were made for three consecutive years (1993-95) with an average of four visits per flying season (20 May -15 June) between 09.00 and 16.00 hrs. Windy and cold days with temperatures under 16 °C were avoided.

Observations

Male Territories

The males held territories that were positioned so that they could not see each other. This implied that sometimes two or three males would

use the same young spruce as a territorial observation post, possibly indicating that the borders of a territory may vary according to what the individual male could see. This meant that in dense ungrazed vegetation several males would defend territories while positioned only within half a metre of each other. No male observation post was higher than 50 cm above the ground, the average being 10- 15 cm above ground level when spruces were not used as observation posts.

Any encroaching insect of any size equal to, or larger than, *lucina* would be fervently chased away. On one occasion the intruder was the Four-spotted Chaser (*Libellula quadrimaculata*), a dragonfly that would normally prey on *lucina* which was instead driven away by a vigorous male defending its territory!

When one male flying up to defend its territory was seen by other males, they would all fly up together, sometimes to result in the establishment of new territories or the chance finding of sedentary females.

Flowers are seldom visited, indicating that the *lucina* imago is short-lived, but one male was observed taking nectar on a dandelion flower.

Courtship and Mating

A male would chase away another intruding male, but if the intruder turned out to be a female the flight assumes a spiral character around the female, which then seeks a suitable place for mating to take place. Actual copulation (Fig. 2) takes place without apparent need for further stimulation, much in the same way as with lycaenids, and lasts up to about twenty minutes, depending on temperature.

Oviposition

Takes place from about mid-morning onwards. The female lays a batch of up to four eggs at a time (most commonly 2-3, though Stoltze gives a max. of 6) on the under-surface of a cowslip leaf and up to about 1 cm from the edge (Fig. 3). Neither plants growing in full sunshine nor in deep shade are chosen. Instead, eggs are laid either on:

1. cowslips growing in a sector between the east or north side and within 50 cm of a bush, or
2. cowslips surrounded by tall grasses up to 50 cm high, or
3. amongst lower vegetation where there is tree shade cover for about 40% of the day.

The chosen leaf was often one that grew at an angle of between 40-60 degrees to the ground. The youngest leaves growing more vertically were seldom chosen, neither were eggs laid on leaves placed more horizontally and closer to, or touching the ground.

No cowslips growing on the south or west sides of bushes were chosen if the surrounding vegetation did not give adequate shelter.

The restricted choice of plant suitable for ovipositing often led to two females laying eggs on the same leaf, a strategy not necessarily advantageous to the survival of the colony, But the maximum number of eggs seen on one leaf was 7, consisting of two batches. As not only the position of the cowslip but the position of the leaf seems to be critical, oviposition on two separate leaves of the same cowslip was observed only once.

Oviposition on any other species of food plant was not observed.

Larvae

After hatching about ten days after oviposition, the hairy larvae soon begin to make holes in the leaf, to finally lead to considerable damage to the leaf in the form of large holes, which may completely destroy the leaf. The edges are not eaten in the first place and the sight of these large characteristic holes can reveal the presence of larvae (Fig. 4). The larvae tend to feed at night, and crawl down to the base of the cowslip during the day. It may be that, apart from some protection from predation, their hairiness protects them from fungal attacks in the highly humid conditions that they thrive in. The larvae seek adjacent plants in the event of the total destruction of the plant upon which they hatched, but starvation may occur if suitable plants are not found after too many larvae hatch on one cowslip.

Pupation takes place at about the end of July

among debris around or near the base of the food plant. The pupae (Fig. 5), which overwinter, are difficult to find.

Discussion

It is clear that the choice of the individual cowslip food plant is based on the need for both warmth and humidity to provide the right conditions for *lucina's* larval growth. A plant growing in a sunny position may provide too much warmth, and would be too dry later in the day. Similarly, a plant exposed to the prevailing westerly winds would be in too dry a location. Furthermore, plants growing in dry sites are more likely to dry up before the larvae are ready to pupate.

During hot summers in Sweden, as experienced during the 1990's, the leaves of a cowslip plant die back completely at the end of July, just when the larvae are ready to pupate. This explains why a second generation is unlikely to exist in the northern limits of *lucina's* range and why it occasionally exists in southern England, where the climate is more humid and where conditions are favourable to the continued growth of new *Primula* leaves later in the summer. In central Europe a second generation is also possible, if not the rule, after late summer rains and the re-growth of the food plant. For similar reasons *lucina* is univoltine near the Mediterranean (Tolman and Lewington 1997).

Experiments to investigate factors for the location of chosen food plants may be difficult to carry out since any caging around a food plant may itself produce a microclimate and may not reproduce the actual conditions the larvae experience without caging or sleeving.

It would be interesting to survey the oviposition pattern in a cool rainy summer to see if the choice of food plant location is different.

Suggested Management Regime for *H. lucina* in Nature Reserves

The restricted breeding prerequisites for the Duke of Burgundy Butterfly lay the basis for a management regime that as closely as possible resembles the intermediate stages of change of open land to scrub and forest. If the locality is allowed to change to forest, the butterfly will-gradually disappear or spread away to other sites, as has been the case in the past, and would have been the case on Omberg if the regional authorities in Östergötland had not removed the young spruces and made the area into a nature reserve after negotiations with the landowner.

The establishment of the north-western part of Ostmossen Nature Reserve was the result of the above discovery of the Duke of Burgundy Butterfly and the Early Purple Orchid (*Orchis mascula*) in the new spruce plantation. (The name of the reserve comes from the name of the lime marsh at the foot of the slope, which was previously designated as a reserve by the Östergötland regional authority.) Grazing in the upper area where *lucina* and Early Purple Orchids occur has been restricted to late summer. A small stand of spruces where the colony of *lucina* was centred was allowed to remain. The result after three years was an expansion of *lucina* in the reserve, to perhaps reach a population of over 1000 individuals. This is a much larger colony than would usually occur in the wild, but can act as good basis for the survival of the species on Omberg.

Askling and Ignell (1995) have placed *lucina* as a primary inhabitant of both forest and scrub and forest fringe, and as a secondary species of open grassland. This should modified to classify *lucina* as having scrub and forest fringe as its primary habitat, with actual forest and open pasture being secondary. As soon as grazing has diminished and the pasture begins to revert to scrub, the habitat becomes a primary *lucina* habitat.

For the conservation of *lucina,* cowslips growing in long grass and other vegetation, together with a suitable distribution of bushes and trees are necessary. It is therefore clear that heavy grazing, coupled with the crushing of the food plant, is not a regime to be applied. It is also advantageous to preserve clumps of thickets and trees to provide the right amount of shade, as is the case on Öland.

However, light grazing coupled with occasional clearing of excessive overgrowth after pupation in August is desirable to prevent the cows-

lips being over-dominated by other vegetation. This has been the policy at Ostmossen since it became a nature reserve, and the stands of early purple orchids have continued to flourish as well as the Duke of Burgundy butterfly.

Acknowledgements

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Sammanfattning

Gullvivefjärilens (*Hamearis lucina* Linn. 1758) förekomst på Omberg i Östergötland har här beskrivits. 1992 upptäcktes förekomsten av fjärilen inom ett område bestående av ca 1 hektar ängsmark planterad med gran. Detta ledde till att Länsstyrelsen i Östergötland avsatte området till naturreservat, och granarna avlägsnades för att skydda gullvivefjärilen och orkidéfloran. Området är beläget på en ostsluttning vid Ombergs norra del. En skötselplan utformades för att gynna gullvivefjärilens krav på värdväxtens (*Primula veris*) lokalisering, som bör vara i ett varmt läge men skyddat från uttorkning av delvis skuggande omgivande växter.

Äggläggningen skedde på gullvivor som antingen växte på ost- eller nordsidan av en buske, eller på gullvivor som växte i långt gräs. Det fanns inga tecken på att gullvivor som växte i fullt solljus åts av larverna. Inte heller valdes gullvivor som växte i mer än 40 procent skugga. Det begränsade valet av värdväxter ledde ofta till att två eller fler honor lade ägg på samma blad. Bladen som har angripits av gullvivefjärilens larver visar ett typiskt mönster bestående av hål utan att inkludera bladets kant.

Brist på de rätta villkoren vad beträffar värmen och fuktigheten som omger den valda gullvivan leder till att en andra generation gullvivefjäril är nästan omöjlig i Skandinavien. Däremot förekommer detta i England och centrala Europa, där somrarna kan gynna en andra generation.

I och med att Ostmossen blev reservat och att åtgärder för att främja förekomsten av gullvivefjärilen vidtogs, har förekomsten av arten ökat betydligt. Fortsatt skötsel bestående av lätt sensommarbete och tillfällig slyröjning efter att larverna har hunnit förpuppa sig bör säkra fjärilens framtid på Omberg.