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Moving pictures: the world of meaning of two meadow butterflies

Daniel Kuster and Johannes Wirz

Summary

Butterflies are fascinating creatures. Although most of us know little about their biological role in biotopes, they are greatly admired for their obvious contribution to the ensoulment of landscapes. What exactly does this concept mean? This study used a number of approaches to these insects. In particular, single animal observations of the activities of two species living in extensively used grasslands, the mazarine blue (*Cyaniris semiargus*) and the marbled white (*Melanargia galathea*), were converted into ethochronograms, which allow for a clear distinction between frequent versus rare behaviours and reveal patterns of sequential activities that are species specific, as well as in unison with the particular environments. The results presented provide first steps towards the elucidation of the concept of ensoulment. It will be shown that the elaboration of spaces of soul activity (*Seelentätigkeitsräume*) by single species reveals their organ-like character and that their subsequent integration contributes to the whole atmosphere of grasslands in a way similar to that of instruments in an orchestra, each contributing to the whole experience (*Gesamterlebnis*) of a symphony.

Introduction

Thus we imagine each isolated animal as a little world that exists for the sake of and because of itself. Goethe (1820)

At first glance Goethe seems to be saying here that animals should be seen as isolated from their surroundings, as if they are in a glass cabinet in a museum. But his writings on morphology make it clear that we should understand the development of animal form as much ‘from inside outwards’ as ‘from outside inwards’, i.e. as the result of specific inner formative potentials yet in complete harmony with the external conditions present. So it is obvious from this that it is right to pay attention to the intimate interrelationship between an animal and its habitat. For instance, that each meadow butterfly species is necessarily adapted to its flight biotope would not have primarily interested Goethe but rather *how* the butterfly relates to the flowers, structures and other animals in the entire meadow community. Looked at in this way, each species shapes its own habitat. Of course, the various meadow insect species share the same flight biotope, i.e. physically the same space, but mentally they live in different worlds. Each butterfly species experiences its own meadow, its own ‘isolated world’.

These considerations are behind the aims of this paper. Using two common butterfly species we try to develop a deeper insight into their habitats, to sketch satisfying pictures of these creatures and ultimately to investigate them regarding their significance for the

Translator’s note: in the German original ‘Falter’ refers to both butterflies and moths. As this paper makes only passing reference to moths, ‘Falter’ is here translated as ‘butterfly’.

ensoulment of landscapes or, to use a term coined by Steiner (1924), for the ‘astralisation’ of landscapes. Bockemühl (1997, p. 177) described this ensoulment as the inner nature of the animal that ‘appears consciously on the surface of awareness if, instead of interpreting sensorial facts psychologically, we experience the phenomenon by seeing through it’. The inner nature of animals shows outwardly in their sympathies and antipathies; in their intentional orientation towards particular components of their habitats and their total blindness to others; in their directed attention reflected in specific movement and behavioural sequences and in the complete harmony of form, colouring, behaviour and habitat.

Anyone familiar with observing single animals may have discovered what restraint they must exercise to focus their attention exclusively on a single animal for a long period when surrounded by the diversity of flowers, insects, birds etc. in a beautiful natural, unfertilised meadow. And they will have experienced almost painfully how reducing their observations to frequency and duration of the animal’s activities at first destroys its magic and the mood of the place. At the same time – and this is the thesis of this work – they will have noticed how in re-appraising such observations a surprising degree of precision can be developed in the spatial-temporal dynamics of the animal’s behaviour. In such an act of inner recreation a feeling supported by concepts arises that reveals more about the animal, landscape and ‘soul mood’ than did the first impressions gained during the act of observation (Kuster & Wirz 1996; see also Marti 1989). Furthermore, single animal observations provide an opportunity to observe oneself as the physically active observer. A butterfly’s radius of activity and flight speed vary from place to place, likewise how close the observer can get without disturbing it. Similarly, a long sojourn on a flower or intense interactions immediately manifest in the observer’s mind as drowsiness or increased alertness respectively. Thus the observer becomes acquainted with not only the external observations but also, through self-observation, with the specific characteristic of the butterfly.

Starting point

There are manifold ways of approaching the worlds of specific animals and a variety of lines of enquiry and methods have been tried. Suchantke (1974, 1976, 1991) has drawn attention to the morphological connection between the markings and the surroundings of butterflies. He was able to demonstrate in tropical butterfly communities that the markings (colour and pattern) of various butterfly species in a particular flight biotope are very similar. He termed this the *biotope marking*. It means that similarities between the markings and the play of colours and light in the habitat are not the result of a systematic relationship, but rather a reflection, a mirroring of the close connection between an organism and its surroundings. Tinbergen (1967) first described behavioural biological aspects of butterflies in their habitats from studies of the grayling (*Hipparchia semele*) in heathland in the Netherlands. Although a functional treatment of the observations predominated in these studies, they frequently contain more pictorial elements, for instance where the author speaks of the ‘living crust’ in relation to the colour match between the markings of this butterfly that show at rest with those of its place of rest. Vereijken (1990) who clarified the biotope marking phenomenon with the speckled wood (*Pararge aegeria*),

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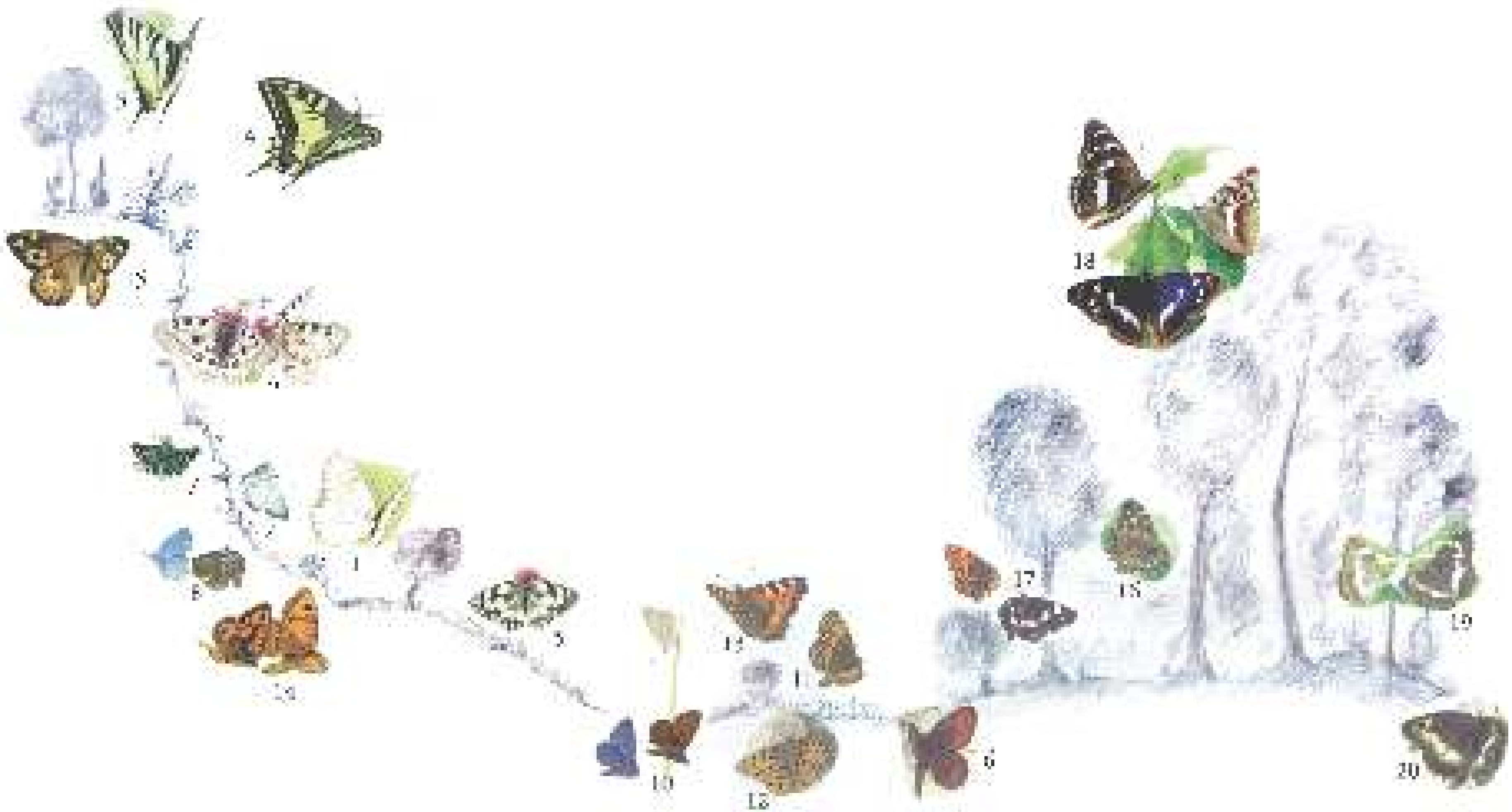

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among others, drew attention to several phenomena of the connection between observer, markings and behaviour and critically examined the development of concepts and drawing of conclusions.

Based on studies of grasshoppers in the Camargue, Marti (1989) presents an exemplary integrated method of observation that brings together impressions and moods as well as various disciplines such as morphology, ethology and ecology. These lead to a comprehensive picture of the multilayered relationship of the organism of an animal to its surroundings. Moreover, his real achievement is not just an ecological 'Identikit' picture of each grasshopper species present – for example to form a basis for species and biotope conservation – but much more its demonstration that the relationship of the observer to the animals and their habitats can be successfully deepened and intensified thereby enabling insights into the vitality of a landscape organism.

In contrast to the situation in the Camargue, where individual grasshopper species live in different biotopes on the Rhone delta and are integrated at a higher level, in a meadow habitat we are concerned with a complex, spatial-temporal dovetailing of qualities which manifest in the multitude of butterfly species and the frequency of their occurrence. Nevertheless we might expect that meadow butterflies, like Camargue grasshoppers, express the specific structures or 'organs' of their biotope.

Landscape and butterfly wing markings

Central European cultural landscapes in their original and, in a certain sense, ideal form exhibit a rich mosaic within a very narrow compass and can now be found at only a few localities in Wallis and Jura, on the Swabian Alps or at Kaiserstuhl. Sunny, warm, rocky regions; poor grassland; cultivated meadows rich in flowers; field margins and pasture; scrub and hedgerow; woodland and clearing abut each other and are intermingled. The great diversity of butterfly species that exist here reflects in coloration and behaviour the qualities in the habitats (Fig 1).

In the warm, almost glittering, sunny, rocky steppe of Wallis a few strikingly bright butterflies such as the brilliant black-veined white (*Aporia crataegi*), the almost transparent apollo (*Parnassius apollo*), the elegant scarce swallowtail (*Iphiclides podalirius*) and the fast-moving swallowtail (*Papilio machaon*) are on the wing as early as the beginning of May. According to Suchantke (1991), together with the marbled white (*Melanargia galathea*) which appears later, these species belong to the 'heliophil complex'.

With a little attention one can also find in the same part of the landscape the unobtrusive, darkish browns (*Erebia spp.* etc.), the earth-coloured grizzled skipper (*Pyrgus malvae*) and the blues. They are notable for living relatively close to the ground and thus belong to the 'geophilic complex'. In both markings and flight pattern the males of the adonis blue (*Lysandra bellargus*) and the chalk-hill blue (*Lysandra coridon*) show a transition to the heliophil complex: their shining blue wing upper sides can be seen as they fly part of the time in the lighter areas over the natural, unfertilised meadow vegetation.

The light is dimmer in the vicinity of hedges, scrub and free-standing trees. Here the elements of woodland and more open landscape encounter each other and interpenetrate. Woodland plants such as lords-and-ladies (*Arum maculatum*) and dog's mercury

(*Mercurialis perennis*), among others, grow beside the meadow flowers. Butterflies of this transitional landscape swap back and forth between woodland and meadow. They form an 'intermediate' group comprising the orange-brown meadow fritillary (*Mellicta parthenoides*) with its smooth flight, the Queen of Spain fritillary (*Issoria lathonia*), the small tortoiseshell (*Aglais urticae*) and several others.

If one lets one's imagination replace the white of the heliophilic marbled white with orange-brown, the result is approximately the markings of the wall brown (*Lasiommata megera*) or of the rust-brown grayling. These two butterflies readily switch between scrub, woodland edge and vegetation-free, often rocky, places preferring warm spots sheltered from the wind.

Spring woodland before the leaves come out expresses an intermediate type of lighting conditions that manifests not only in the profusion of violets and wood anemones (*Anemone nemorosa*) in bloom but also in the impressive map butterfly (*Araschnia levana*) whose spring generation looks like a meadow fritillary. In contrast, the map's summer generation changes to black and white, not unlike the purple emperor (*Apatura iris*) or the white admiral (*Limenitis camilla*). In their richly contrasting black and white markings they reflect the coloration of their woodland flight territory, an *umbrophil* biotope. The purple emperor presents an unforgettable picture in the late mornings at the beginning of July. With a powerful flight it emerges from the shade of the tree crowns to play about them in the gleaming light with graceful, sweeping arches, lighting up for a while and again vanishing into the shade. The two grayling species – woodland (*Hipparchia fagi*) and great banded (*Brintesia circe*) – also show that there are distinct biotopes for woodland and woodland edge, each with distinguishable lighting conditions. The contrast of the bright bands from the dark background of the woodland species is attenuated and almost washed out in the markings of those of the woodland edge. The great banded grayling (*Brintesia circe*) lives in more open woodland that is hot and dry or on scrubby heathland with free standing pine and oak.

These examples may suffice to illustrate the relationship, first identified by Suchantke, between the light qualities of European landscapes and the markings of their common butterflies. Whether it is according to gender or mood, butterflies always maintain a specific, actual relationship to their environment. They actively seek not only sustenance at particular locations and from specific flowering plants but also mating partners, or they try to avoid them. They are dependent upon specific egg-laying and larval-fodder plants which they look for at particular places and times. Furthermore, the imago stages need resting and dormancy conditions. Understanding how butterflies are actively involved with their surroundings is essential for gaining insight into their 'spaces of soul activity' (*Seelentätigkeitsräume*; Klett 2002).

Questions and methods

In comparison with the natural history of mammals and birds there are only a few comprehensive accounts for insects. Jean Henri Fabre's *Souvenirs Entomologiques* (in Guggenheim & Portmann 1961) is particularly outstanding. He devoted himself until an advanced age to very accurate observations of the activities of sand wasps, wild bees,

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Since 1928 modern astronomers have positioned *thirteen* constellations across the ecliptic. Their astronomical boundaries assign 23° of the ecliptic to Libra (the Balance), while the yearly *Sternkalendar* reduces this to a mere 18°. Overall, the *Sternkalendar* divisions give a considerable imbalance when used by biodynamic farmers, giving some 50% more time in 'Earth-days' than in 'Flower-days,' on average. These considerations may be relevant to the recent Baumgartner *et. al.* result[1], discerning a 3rd harmonic rhythm in mistletoe bud morphology.

The subject could be one of practical importance, if indeed mistletoe can be used in treatment of cancer, and if moreover a high or low lambda-value could be shown to relate to its 'virtue' or healing quality (the authors do not hint at whether high or low λ-values might be preferable in this respect). It has at times seemed to me that Agnes Fyfe's pioneering work *Moon and Plant*, concerning the times at which mistletoe should be picked, was less than clear in its findings. The Baumgartner *et al.* study, if replicated, could indicate an unexpected new sidereal dimension to the choosing of peak times for harvest. For a credible replication one prefers that the persons gathering the data be not themselves aware of the biodynamic calendar.

One could compare this result with Maria Thun's work with several goats in her garden[11]. Daily milkings showed that milk quality and volume were optimal at 'warmth-days', i.e. when the Moon was in front of a fire-constellation (which has not to-date been replicated). The Baumgartner *et al.* study may have found the opposite, viz. an effect peaking on water-days, i.e. when the Moon is in front of a water-constellation. On the view here suggested, the rather arbitrary notion of boundary-positions between constellations has no vital significance, and what matters is the temporal positioning of the sidereal waveform maxima.

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[11] Maria Thun, *Milch und Milchverarbeitung* 1985, 1991 Stuttgart.

spiders, beetles and moths in his Provence garden and with a wonderful style compressed his findings into a kind of 'natural history'. Later, field researchers such as Baerends (1941) and Tinbergen (1967) focused increasingly on specific aspects, i.e. they were less interested in sand wasps in general (Portmann 1953), but instead studied, for example, the reproductive behaviour of butterflies or the orientation of digger wasps to their nest sites.

We should not underestimate the significance of quantitative methods of modern butterfly ecology for qualitative approaches to its research. They give an overview of species diversity and the frequency of occurrence of a particular animal and provide a reminder that the totality of the ensoulment of a locality depends on all players. Furthermore, many observation visits allow an insight into the dynamics of appearance and disappearance of individual species during the annual cycle. Data on butterfly species diversity, frequency and population structure are currently obtained by transect methods (Pollard & Yates, 1993; Settele 1999). This involves walking a fixed route at regular intervals and identifying and counting all butterflies seen within five metres. Using mark-release-recapture (Shreeve 1992) it is possible to make statements about the dispersion, i.e. the inflow and outflow, of animals into and out of the population. It has been possible to monitor the flight of individual animals of for instance a North American apollo butterfly species using radar. This research allows conclusions to be drawn about the response of butterflies to changes in their habitats such as decreasing size and increasing isolation (Roland et. al. 1996; Caldwell 1997).

With less mobile species an observer equipped with a dictation machine can record a wealth of information on the behaviour and space utilisation of individual animals. This involves noting all activities such as visits to flowers, interactions, resting, flying, mating and egg laying as well as the locations visited – in short the species-specific behaviour. These observations enable determination of, on the one hand, the importance of the resources in a particular habitat and, on the other hand, the essential requirements of the species (Dover 1989). Direct single animal observations enable a distinction to be made between frequent and rare behavioural patterns and tell us whether and how the habitat is used differently by the different sexes. We can then sketch a picture of the spatial and temporal occurrence of the behavioural activities and, through this, of the way the animal lives that provides differentiated viewpoints in relation to landscape ensoulment and spaces of soul activity. Furthermore, this approach also provides material for resolving questions about auto-ecology from which recommendations can be made for the protection of endangered species, for instance in discussions about fragmentation and regional networking of isolated biotopes (Turchin, Odendaal & Rausher 1991; Shreeve 1992; Baur & Erhardt 1995; Schulz 1998; Bosshard & Kuster 2001).

The aim of this study was to ascertain the significance of the species-specific soul aspect of the world of the marbled white and of the mazarine blue (*Cyaniris semiargus*) starting from mood pictures, phenological investigations, walking transects and extensive observations of individual animals. These two species were chosen for various reasons. These butterflies always attract attention because of their markings and way of behaving, and certainly our preference for them was an important factor. But they are also particularly suited to extensive individual animal observations because they fly at different times, are still relatively common in flower-rich tall oatgrass (*Arrhenatherum elatius*) meadows that have not had fertiliser, and show a comparatively limited mobility.

Transect monitoring was used on three dates in the flying season to determine species diversity and frequency. Single animal observations were carried out on the marbled white for about twelve hours and on the mazarine blue for nine hours recording detailed data on frequency, duration and location of activities. It was equally important to keep a diary of observations regarding prominent impressions and mood pictures etc. arising during the field visits. Against this background we developed the following questions:

1. How do the males and females of the species investigated behave in the same flight biotope?
2. What is the importance to each species of the same meadow habitat regarding food supply, larval fodder plants and other necessities for their lives?
3. What empirical knowledge can be gained of the landscape qualities and what are the observer's inner impressions and practical experiences when following and studying individual animals?

The quantitative results are not the goal but rather an indispensable building block in a holistic picture of the butterfly in its environment. As Portmann (1952) observed, quantitative data allow us to make objective the 'hard to access reality of inwardness'. So it is not a matter of formulating a precise, quantitative result from the numerical relationships and the percentages determined, but rather, by using *ethochronograms*, i.e. graphic appraisal of activities observed, of making a contribution to assessing the relationship to the environment of the animal as a centre of activity (inwardness) and ultimately of relating it to the context of the mood pictures. 'The individual characteristics and modes of behaviour that are gathered into a systematic picture are not the result (...), but a necessary milestone on a path we must ourselves always establish anew, yet which, in doing so, becomes meaningless unless we tread it personally.' (Bockemühl 1997, p. 180)

The actors

The marbled white shows a striking black and white patterning (Fig. 2) which in the female is dusted with yellow. The sex-specific differences are not immediately recognisable in the markings but can easily be observed in the behaviour. It flies from the middle of June and, depending on the weather, can be found until the end of July. The female drops individual eggs into tall vegetation. Most of the larvae that hatch from these eggs overwinter after the first instar. The fodder plants comprise various grasses against whose green or yellow stalks the similarly coloured larvae are frequently overlooked. The older larval stages are not active at night. Pupation and metamorphosis take place deep in the vegetation (Schweizerischer Bund für Naturschutz 1987, Ebert 1991).

The mazarine blue flies on unfertilised, dry to mesophile tall oatgrass meadows with two to three generations from May to October, or in upland localities with only one generation (Fig. 3). The wing upper surfaces of the males are a cool violet blue and of the females, mostly brown, sometimes underlaid with blue. Her eggs are laid individually in the flowerheads of red clover in which the larvae develop. As with the marbled white,

On this approach, it would not greatly matter if persons disagreed over the exact 'ruling' planet, just so long as one agreed as to whether it was 'above' or 'below' the Sun. For example, suppose that, despite millennia of tradition, a reader inclined to the view that the beech tree was 'ruled' by Jupiter, this would only slightly alter its mean period[8] and it would still be very different from that of a tree which one supposed to be 'ruled' by an inner planet Venus or Mercury, whose periods would approximate to that of the synodic period; or rather, like the tides of the sea, half of that[9].

A Sidereal Rhythm: Sowing Time versus Yield

It is of interest to compare these bud data with a larger-amplitude effect, of crop yield as a function of sowing time. The results here show the 3rd harmonic of the sidereal lunar month – in other words, a 9-day rhythm. A summary of evidence in this area has been published as *Evidence for Lunar-Sidereal Rhythms in Crop Yield: A Review*, by the present writer and Gerhard Staudenmaier[10]. Yield data from several different crops are plotted against lunar celestial longitude at the time of sowing. The effect which tends to show up here is often called the 'Thun effect'. A 'third harmonic' means that one counts up to 120° and then starts again, going through three cycles per Moon-orbit. One thus goes through the 'four elements' of the zodiac three times, if each Moon-element is conceived as occupying thirty degrees. Thus, if the best-fit waveform has the equation

$$\lambda = A\sin 3(\theta - p)$$

where A is amplitude of the waveform, θ (theta) is celestial longitude of the moon and 'p' is phase of the waveform, then the position of 'p' that gives maximum amplitude signifies the correct or optimal zodiac framework for the data.

Over the decades, biodynamic investigators have discussed the duality of zodiac signs versus constellations, as if one or other were the correct choice. What they call 'signs' are always those of the tropical zodiac, while the constellations are those whose boundaries were invented in the 1930s by anthroposophists. Rejecting this duality, I rather suggest that one is here looking at a star-rhythm: Vettius Valens in the 2nd century A.D. inserted the four elements into the sidereal or star-zodiac and that framework may be the one here relevant. This traditional star-zodiac is a 'best-fit' of equal divisions over the unequal twelve ecliptic constellations. Various marker stars defined it, such as Spica at 30° of the Virgin.

[8] Using the above equation gives 27.5 days for Moon-Jupiter conjunctions.
[9] Edwards viewed the cherry tree as ruled by the Moon, and inferred that this would lead to the Full and New moons as timing its λ-waveform (*Vortex*, p.93). In Fig. 2 these occur several days after the Venus-events shown and so do not well synchronise with the peaks or troughs.
[10] www.biodynamic.org.uk/Research.htm#evidence

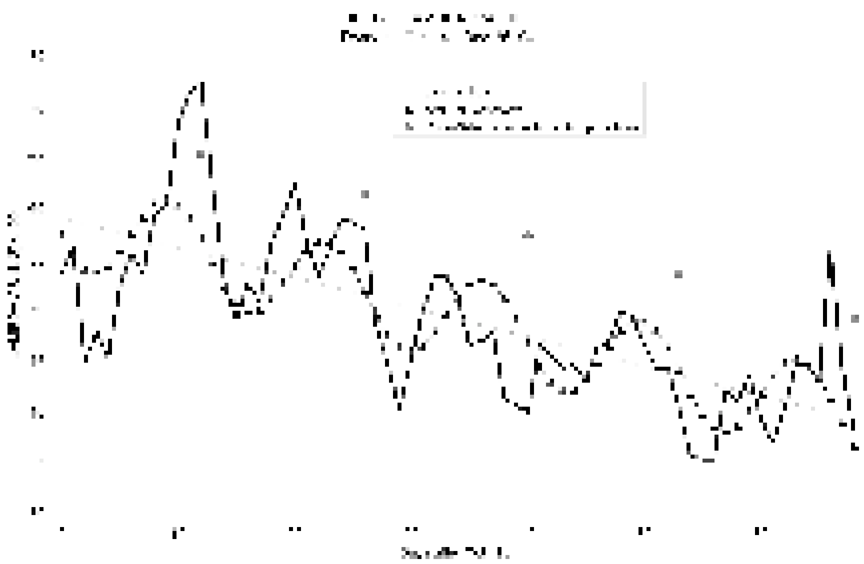

Figure 3.

and ‘2’ in the sine function gives two cycles per month. The months concerned are looking very much like the two lunar months of 29.5 and 27.3 days. If one felt confident with the first of these, done over three months of fairly continuous data, the second, estimated from merely two months data, seemed a little conjectural.

My impression was, that Edwards had not in this manner attempted to estimate the period of his lambda-oscillation that he was finding, and so no expectations of his were likely to have influenced things. If any continuous-period data are available, for a minimum of three months, this would assist in further evaluating the subject. Most of the data-sets he sent me were of merely two months’ duration. These appeared to me as largely a waste of time: for the rather delicate hypothesis he was formulating, whereby different tree-species have differing bud wave-periods, three months of continuous data is surely a minimum for obtaining any robust conclusions. I therefore never published any results on the subject, however I would be happy to analyse further such data-sets. The contrast in period of cherry and beech may deserve further investigation.

Edwards tended to interrupt his sequence of observations for a week in the middle, owing to Christmas, and such a break limited the feasibility of analysis. His thesis was, that the period depended on the planet ‘ruling’ the tree in its conjunctions with the Moon. The word ‘synodic’ means meeting and while we normally use this as meaning meeting with the Sun, it here alludes to the monthly meetings of the Moon with a planet. For slow-moving Saturn the period is close to the sidereal lunar month, around 27.5 days, while for the cherry tree, traditionally ruled by the Moon, it was nearer to 29.5 days, i.e., the period of the Moon’s meetings with the Sun.

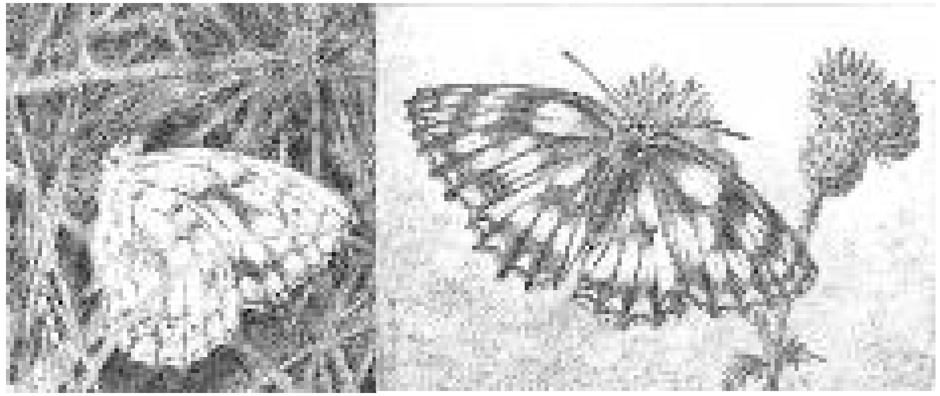

Figure 2. Marbled white females (*Melanargia galathea*): (left) egg laying; (right) flower visiting (1.15 x natural size).

Figure 3. Mazarine blue females (*Cyaniris semiargus*) (left) egg laying; (right) flower visiting (1.9 x natural size).

pupation takes place on the ground (Schweizerischer Bund für Naturschutz 1987, Ebert 1991).

Location and flight community

The research site is situated near Oltingue (Alsace, France) in a meadow landscape divided into small patches. The presence of old vineyards and warm, dry woodland of oak and hornbeam communities indicates a relatively mild climate. The landscape’s small plots resulting from splitting due to inheritance were once used for mixed farming including ridge and furrow cultivation, scattered fruit trees and meadow. Today the small plots with unfertilised grassland are retained almost solely on the steeper slopes. Maize is cultivated on more level ground. Figure 4 shows the observation locations and the agri-

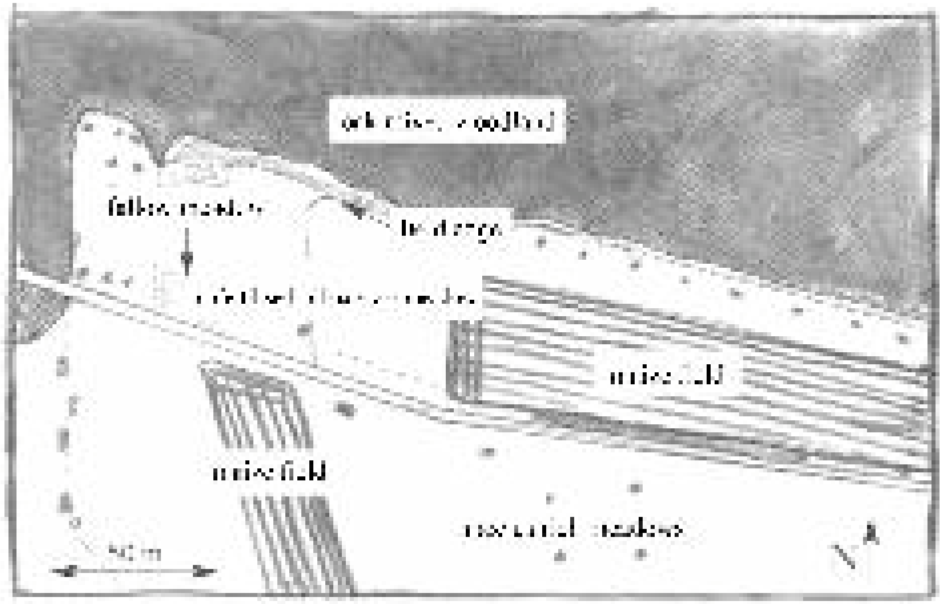

Figure 4. Map of the study area showing land usage in 2000 and 2001.

cultural uses of the broader surroundings. A sample area of 100 square metres was investigated on three visits (June to August) to correspond with the frequency of occurrence of both butterflies and the food plants relevant to them (Fig. 5).

In a period of two and a half months in three transect walks it was possible to identify 32 butterfly species (Table 1). Butterflies from all the complexes described by Suchantke were represented, thus confirming the high quality of the landscape mosaic with its richness of structural variety. Table 1 also shows the link between frequency of occurrence of the individual species and the course of the year. Some butterflies were found in early summer (orange tip, small heath, speckled wood, chequered skipper [please see Table 1 for Latin names]); some peaked around the solstice (marbled white, heath fritillary, ringlet) and others characterised the high summer flight community (meadow brown, second generation sooty copper, burnet moths). In contrast to the wealth of flowers which strikes any observer immediately, the butterflies, apart from the meadow browns whose common occurrence everyone notices, are often represented in small numbers. Once a less common species is spotted its unmistakable mode of life is captivating. The small heath suns itself inconspicuously with its closed wings always facing the sun. The great banded grayling crosses the meadow rapidly with a long glide. Just as the richness of the meadow depends on the wealth of flowers and vegetation structures, so also the air above it vibrates with the multitude of movements and behaviours of the butterflies – each species in its own way, uninterchangeably.

The biotope quality requirements of butterflies show that the diversity is largely determined by the mosaic structure of the location. Of the 32 species, nine are in a narrow

Normally, the data Edwards sent me had at most a couple of months of continuous data through the winter months, with a week or two's break during Christmas which rather prohibited or at least severely undermined this kind of analysis[6]. However, I found that, with the beech, hornbeam and sycamore data-sets he sent me, the mean period seemed to hover around half of 27.3 days, the lunar sidereal month.

Beech was traditionally ruled by Saturn, which moves only very slowly, and so, were Edwards correct in saying that planetary rulerships were relevant to these rhythms, then one could expect a substantial difference in the mean periods between the outer and inner planets. If conjunctions of the Moon with Saturn are indeed determining the rhythm, then this would generate a period more or less indistinguishable from that of the sidereal month (or, rather, half that) operating[7].

If, on the other hand, one believed that Venus was ruling a tree, for example the cherry tree, then one would by the same logic expect a period nearer to the synodic month, because of the way Venus' position in the zodiac hovers around that of the Sun, i.e. its mean period would be (half of) the meeting period between the Sun and Moon.

A beech tree in Dornach, Switzerland had the λ-value of its buds measured daily over two months, October-December 1994 (with only three days omitted), and the results are shown in Fig. 3 (overleaf). A linear regression line was put through the data, and a best-fit sinewave had a period half of 27.0 days and an amplitude 1.8% of its mean value. This time the peaks are falling a few days before the Saturn-Moon conjunctions and oppositions, also shown in the diagram. The two months' data are here hardly sufficient for conclusions to be drawn with confidence, but the period does look similar to the 27.3 sidereal lunar month as one would expect for a Saturn-rulership. Saturn was going retrograde and this gave a Moon-Saturn cycle in the heavens of 28 days, one day longer than the cycle shown by the tree buds, so the two are not here matching up very well. It was not the fault of the beech-tree, so to speak!

Summarising, it may help to write the two wave-equations as

Cherry bud rhythm: $\lambda = \lambda_m + 0.013\sin 2(2\pi d/29.5 - p_1)$

Beech bud rhythm: $\lambda = \lambda_m + 0.018\sin 2(2\pi d/27.0 - p_2)$

where

- λ_m is the mean value of λ, around which it oscillates, as shown by the trendline (Fig. 1);
- 'd' is the number of days starting from whenever one begins;
- 'p' is the phase, i.e. position of the waveform;
- the amplitudes are 1.3% and 1.8% respectively,

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[6] But, Edwards' book (*Vortex*, p.228) seemed to display several successive months of beech-data, 1984-5.

[7] The mean period of a Moon- Saturn cycle will be 27.4 days, i.e just over one sidereal month, as given by the equation: 1/T = 1/27.3 – 1/(30x365) days.

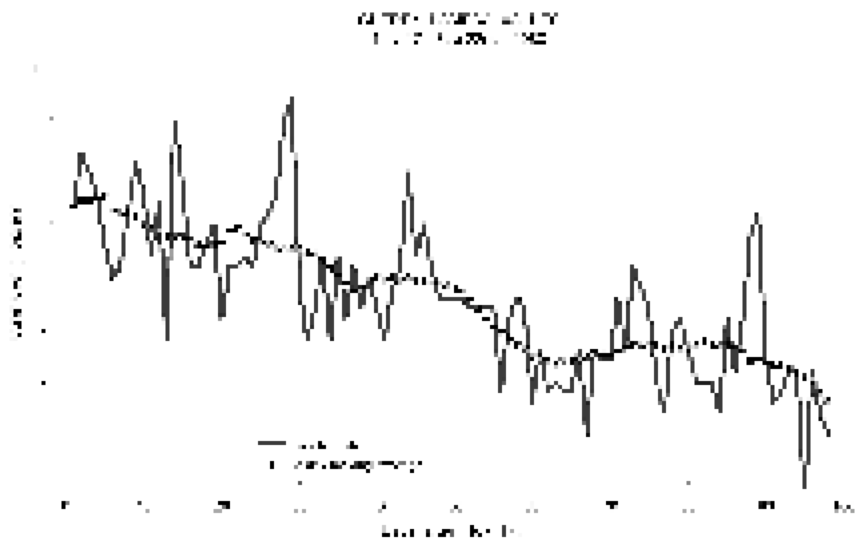

Figure 1.

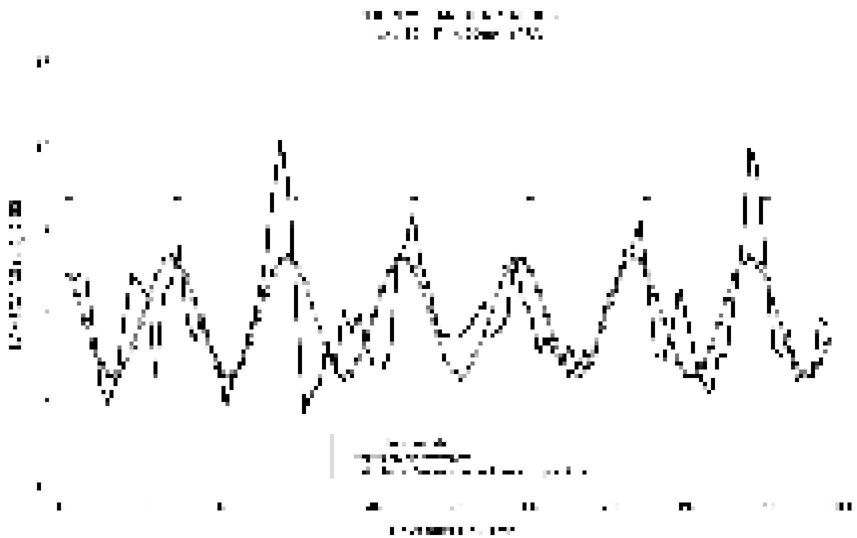

Figure 2.

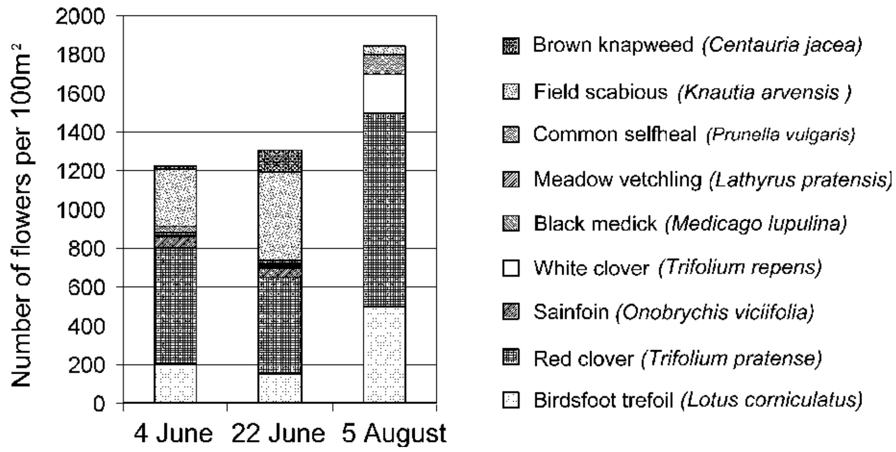

Figure 5. Phenology of flowering of food plants preferred by the butterflies in the species-rich tall oatgrass meadow at Oltingue in 2001.

sense limited to meadows and grassland. The remainder, apart from the wandering butterflies, need demarcation lines and territories. They clearly reveal the added value of areas structured in smaller divisions and interpenetrating one another, a feature whose habitat value greatly exceeds the sum of the values of the individual areas.

First encounters with the marbled white

In the meadow landscape with scattered fruit trees, especially on an old vineyard, the microclimate is already warm and sheltered when round about it is still cold and windy. In the background is a dry, mixed woodland primarily of oak. On a wooded hilltop in the distance eastwards across meadows and arable land a castle ruin can be made out. South of it is a hill with fruit trees on terraces that vary in width according to the gradient. In the distance, blackcaps and garden warblers repeat their rapid cadences to the accompaniment of the song thrush's fanfares and the drumming of the black woodpecker deeper in the woodland. A yellowhammer whistles its pleasant, though not very melodious, song from a wayside thorn bush, sharply interrupted by the harsh, grating '*shack-shack*' of a red-backed shrike perched conspicuously on a dry, bare branch. The meadows would be ready for mowing, but, who knows, perhaps the farmer hesitates to cut down the richly flowering brown knapweed (*Centauria jacea*), field scabious (*Knautia arvensis*), sainfoin (*Onobrychis viciifolia*), ox-eye daisy (*Leucanthemum vulgare*), red clover (*Trifolium pratense*), and birdsfoot trefoil (*Lotus corniculatus*).

Closer observation shows that the meadow flower picture does not present a uniform sea of colour. The farmer has created through less intensive management a grassy woodland margin between the protruding woodland and the hay meadow. Here the sea of flowers no longer dominates but instead there is an open, grassy area of brome (*Bromus*),

Table 1. Frequency of occurrence of butterfly (and two moth) species in the study area in summer 2001 on the dates: Transect area 2,750 m^2.

			4 Jun	22 Jun	5 Aug
			Animals recorded		
swallowtail	*Papilio machaon*	heliophil, open landscapes, migratory within a limited range			1
pale clouded yellow	*Colias hyale/alfacariensis*	heliophil, open grassland, wandering butterfly		1	
large white	*Pieris brassicae*	heliophil, open landscapes, wandering butterfly		2	2
small/green-veined white	*Pieris rapae+napi*	heliophil, open landscapes, wandering butterfly	2	2	3
wood white	*Leptidea sinapis*	heliophil, meadows close to woods	4	1	11
orange tip	*Anthocharis cardamines*	heliophil, meadows close to woods	3		
white admiral	*Limenitis camilla*	umbrophil, woodland edges, woodland glades		2	1
peacock	*Inachis io*	'individualist', wandering butterfly	2		
painted lady	*Cynthia cardui*	intermediate, wandering butterfly	2		
small tortoiseshell	*Aglais urticae*	intermediate, wandering butterfly		1	
silver-washed fritillary	*Argynnis paphia*	intermediate, woodland edges, roadsides, clearings			2
Queen of Spain fritillary	*Issoria lathonia*	Intermediate, tracks, field margins, wandering butterfly			1
marbled fritillary	*Brenthis daphne*	intermediate, hot bramble-rich woodland edges		1	
heath fritillary	*Mellicta athalia*	intermediate, dry meadow landscapes	1	2	
great banded grayling	*Brintesia circe*	umbrophil, dry wooded and scrubby meadowland			1
marbled white	*Melanargia galathea*	heliophil, dry meadows		25	1
meadow brown	*Maniola jurtina*	geophil, grassland managed extensively		78	380
hedge brown	*Pyronia tithonus*	intermediate, field margins, woodland edges			95
ringlet	*Aphantopus hyperanthus*	geophil, meadows near woodland		23	
small heath	*Coenonympha pamphilus*	geophil, grassland managed extensively	3		
speckled wood	*Pararge aegeria*	intermediate, woodland tracks, woodland edges	1		
wall brown	*Lasiommata megera*	intermediate, warm, dry biotopes	1		7
sooty copper	*Lycaena tityrus*	intermediate, grassland managed extensively			16
brown argus	*Aricia agestis*	geophil, dry meadows, unfertilised grassland			1
mazarine blue	*Cyaniris semiargus*	geophil, grassland managed extensively	4	3	18
common blue	*Polyommatus icarus*	geophil, grassland managed extensively	4	2	8
chequered skipper	*Carterocephalus palaeomon*	intermediate, woodland margin structures	1		
small skipper	*Thymelicus sylvestris*	intermediate, field margins in open landscape			2
large skipper	*Ochlodes venatus*	intermediate, field margins, woodland edges			2
dingy skipper	*Erynnis tages*	geophil, roadsides, unfertilised meadows		1	1
variable burnet moth	*Zygaena ephialtes*	neglected dry meadows		1	
six-spot burnet moth	*Zygaena filipendulae*	dry to mesophile tall oatgrass meadows, field margins		8	12

Correspondence

The fortnightly tree-bud rhythms of Lawrence Edwards

Nick Kollerstrom

The careful work of Baumgartner *et al*.[1] suggests that a rhythm one-third the period of the sidereal lunar month (i.e. a 9-day elemental rhythm) is present in the so-called 'λ-value' of mistletoe fruit. The latter function pertains to the shape of a berry and is a mean of several readings taken in a day. The results of this team contrast in a perplexing manner with the rhythms approximating to half of a sidereal lunar month (i.e. about 14 days, a tidal rhythm) which Lawrence Edwards had found in the lambda-values of tree-buds during their winter months of dormancy[2] .

Mr Edwards kindly sent some of his lambda-value tree-bud data to the author, for several trees, for example beech and cherry, and I analysed them, being curious as to their period. The diagrams show the method: a trend-line was subtracted out (the 'moving average') and then the shape of the waveform was ascertained, which best fitted the data. The two diagrams show the method (see Figs 1 & 2 overleaf). Daily lambda-readings were taken over a 3-month period[3] . After a 15-day moving average was subtracted from the data, a best-fit waveform was put through it using a least-squares method to fit it.

The amplitude, phase and wavelength[4] were varied, and these seemed feasible to estimate because, as can be seen in Fig. 2, there were almost seven complete cycles present in the data. The mean value for λ was 2.8 and the best-fit sinewave shown had an amplitude of 1.3% of this mean value. For these cherry data its period came to half of 29.5 days. The dates of lunar conjunctions and oppositions with Venus are also plotted in Fig. 2, and synchronise with the peak values of this fortnightly sinewave. The cherry tree is given by Culpeper's *Complete Herbal* as ruled by Venus; the beech by Saturn[5].

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1 'Misteltoe berry shapes and the zodiac', Stephan Baumgartner, Heidi Flückiger and Hartmut Ramm, *Archetype* **10**, 1-20, 2004 (*Elemente der Naturwissenschaft* **79**, 2-21, 2003).

2 Lawrence Edwards, *The Vortex of Life.* Floris Books, 1993.

3 In fact 16 days were missing from the 98 days of this series (4 days over Christmas being the largest gap) and I had to interpolate values.

4 The equation for the waveform in figure 2 is $\lambda' = a \sin(2\pi t/T - p)$ where 'a' is amplitude, i.e. size of the waveform, 'T' is the period (14.8 days in this case) and 'p' is the phase, i.e. where the peaks appear; then the variable 't' is the sequence of days on which the measurements were made. As the first graph shows, the function λ has a mean value of 2.8.

5 *Culpeper's Complete Herbal*, Foulsham's: Nicholas Culpeper, *The English Physician*, 1652.

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Translated by David Heaf from 'Der Schachbrettfalter (*Melanargia galathea*) in ökologisch unterschiedlichen Lebensräumen des Kulturlandes', Johannes Wirz and Daniel Kuster, *Elemente der Naturwissenschaft* **80**, 26-44, (2004).

wood melick (*Melica uniflora*) and tor grass (*Brachypodium pinnatum*), here and there topped by a few greater knapweed (*Centaurea scabiosa*). A strip several metres wide has not been managed for a long time. Some thistles, travellers's joy (*Clematis vitalba*) and a few brambles have spread into this fallow land to the extent that the former meadow pasture is no longer visible. Typical meadow flowers occur only on the margins.

If after this wider survey attention is focused on the immediate surroundings, the richness of experiences seems at first to be diminished. The section selected features leaf shapes, a confusion of stalks and a few flowers. After some moments one sees individual ants, some 'cuckoo spit', i.e. the foam encapsulated clutch of eggs of a common froghopper (*Philaenus spumatius*), or a beetle creeping sluggishly across a leaf. Whereas the wider survey lets us sense the whole atmosphere of a location, here we look into a small landscape backdrop that is relatively lacking in features and that at first promises little stimulus or interest. But this first impression is deceptive. More attentive observation reveals an unexpected richness of animal life. The great insect group is represented by many orders and a large number of individuals.

In this diversity the butterflies form part of an order that knows how to pull out all the stops. The great fliers such as the swallowtail or the great banded grayling inspire the observer with their long flights high over the site; the meadow butterflies fascinate with their dynamic interplay between flight and resting behaviour and lastly there is the seemingly lethargic burnet moth that stays for a long time on flowers or stems. The butterflies are without doubt more strongly earthbound than the majority of the birds. Yet within the insect group they are closest to the sky. Matching the flowers in colourfulness, they distance themselves greatly from other orders such as grasshoppers and beetles that only rarely leave the protective shelter of the herbs and grasses.

In the mornings a few marbled whites fly in the fallow and in the grassy woodland edges, swinging to and fro over the predominantly grassy areas. Despite their black and white patterned wings they seem very light-coloured in flight and stand out strikingly from their surroundings (Fig. 6). Sometimes they disappear into the dense confusion of grass, reappearing to alternate between smooth and fluttering flight. During their zig-zag flight deep in the vegetation below the flower heads they appear to be attached to specific areas. Natural obstructions such as hedges, paths and cultivation frequently, though not always, restrict their flight territories. But less obvious boundaries such as freshly mown meadows turn them back too. The spatial connection is briefly abandoned during encounters with other light-coloured butterflies, those of their own species or whites.

The neighbouring flower-rich meadow seems peaceful at first glance. Only a few dark bumble bees attract attention. From close to, some marbled whites can be made out practically covering the flowerheads of brown knapweed with their fully opened yellowish, black and white wings (Fig. 2b). As they vigorously suck up nectar they bob their wings up and down and when bees or other insects approach, they flap them violently. If a new arrival nevertheless lands, it is driven off with targeted wing beats. Encounters with other marbled whites are extremely rare.

The butterflies on the flowers seem bigger and altogether darker than those seen previ-

Figure 6. Patrolling marbled white male in the brome grass meadow.

ously over the grassy fallow. The undersides of the closed wings of the examples on the flowers are somewhat yellowish and more strongly patterned than those in the fallow. They can be identified as females. At this time of day the males and females occupy different habitats.

In the afternoon, with the sun still high in the sky, the site is flooded with brilliant light that damps down its object character. It is peaceful over the fallow and the woodland margin, but over the flower meadow an army of insects is milling around. Marbled whites, meadow browns, bees, bumblebees and hoverflies overfly and fight over the purple-red *Centaurea* species. The number of marbled whites in the flower meadow is significantly higher than it was in the morning as the males can now be seen visiting the flowers. As a result, the hot afternoon hours bring much insect interaction with aggressive encounters in which the females with violent flapping of their wings try to prevent approaching males from landing, usually successfully. If this fails they fly off in a chase. It is impressive to watch two upwardly spiralling butterflies as they not infrequently drift out of the meadow area. Usually after only a few seconds the male is shaken off by the female through her sudden, vertical plunge. Her other way of escaping the male involves suddenly darting sideways. Whereas the male carries on staggering around, the female returns to the patch of flowers and alights on one. It is difficult to observe marbled whites in other activities. A late morning copulation on a flower and some egg depositing completes the picture of their behaviour. Against the background of these observations the research questions can be made more precise:

relationships? The marbled white has held our attention cognitively, one might even say abstractly. Thoughts or abstractions no longer express the butterfly species in the fullness of soul experience but in the light of thinking. By nothing else than direct observation we have moved from the butterfly to its ‘companions’ and thence back to its habitat. We experience in both direct observation and in the reams of figures that the butterfly says something about itself, its wider surroundings and its habitat. We notice that becoming deeply involved with duration and frequencies of behaviours has not weakened our interest in the butterflies. On the contrary, it has strengthened it. We no longer just experience the butterflies but rather begin to understand them.

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is preferred. In all cases there are noticeable sex-specific preferences. At one time it is the males that make a clearer selection, at another, the females. Duration and frequency of flower visits may correspond with each other, though not necessarily. This implies a discrepancy between the visual stimuli of nectar plants and those derived from their substances. Our observations suggest also looking for intrinsic factors regarding flower preference, possibly even inherited factors. It would be interesting to compare the flower preferences of butterflies at the various study sites under identical conditions to see if there is any adaptation. The phenomenon of differential preference should be taken into consideration in projects to re-establish the marbled white. Its populations could be increased by planned sowing or planting.

It is clear from our observations that there is no direct correlation between the size of a butterfly population and the flowering density of the main nectar plants. Based on average density there are fewer butterflies flying at Oltingue than at 12 Jucharten although knapweed is 10 times more common at Oltingue, scabious 300 times.

The frequency of interactions can be attributed to two different factors. Either they are an expression of a diverse flight community of butterflies and other insects in a biotope or they are (also) the result of limited availability of appropriate nectar plants. Our studies show that interactions in flight point to diversity and on flowers to limited availability. Despite our assertion above, in our view it would be possible to increase the value of the relic biotope at 12 Jucharten for the marbled white by establishing more brown knapweed there.

Finally, the appraisal of the turns has provided striking confirmation of the connection between the size and the geometry of a site. Our results indicate that analysing the frequencies of behaviours at habitat boundaries helps to estimate the quality of habitat networks or at least of sites which meet part of a butterfly's requirements.

A number of criteria result from observing the marbled white that should be taken into consideration in its management and conservation. In doing so the living conditions of other butterfly species and insects will of course be improved. These include:

- preventing fertiliser inputs in order to preserve the porosity of vegetation structure, for example by establishing margins as buffer zones beside arable fields;
- developing adequate stocks of the most important nectar plants, brown knapweed and scabious;
- late mowing from mid-July, on at least 10% of the area (staggered mowing) of grassland in use to ensure egg-laying and early larval development;
- small biotopes call for negotiating enlargement of habitats as well as precautions for networking with supplementary sites, field margins and fallow for egg-laying and larval development and/or flower rich permanent meadows in the immediate vicinity for nectar supply.

Conclusion

After an arduous journey involving hours of following individual butterflies, meticulously transcribing the recordings and analysing the various behavioural activities we return to the field. What have we gained through reducing it all to numerical and temporal

- How does the marbled white live in its surroundings?
- What are the habitat requirements for the sex-specific behaviour?
- What is the part played by the vegetation structure?
- Why are there behavioural differences depending on time of day?
- Where do the encounters take place?
- During the flight phase the female lays over 200 eggs (Sonntag 1982). Where does her egg laying take place and does she have spatial and temporal preferences for it?

Extensive observation of individuals and presenting them in ethochronograms are promising methods for answering these questions.

Marbled white activities

In the period 24 June to 5 July 2001 the behaviour of 30 females and 26 males was observed at various times of day for a total of 7.6 hours and 4.6 hours respectively. At temperatures below 15°C and above 30°C little activity was observable and it hardly differed between males and females. In contrast to the meadow brown which flies even at low temperatures and is hardly influenced by the oppressive afternoon heat, the marbled white reveals its most differentiated behaviour at 25°C (Sonntag 1982).

As Figure 7a shows, the males spend 70% of their time in flight; 20% visiting flowers and the remainder divided between resting and interacting. Two different flight modes are distinguishable: a fluttering patrol flight keeping amongst the blades and stems of the vegetation and a site orientation flight that is purposeful, rapid and in a straight line. The proportions are different in the females. She flies only 15% of the time and spends 70% on flowers (Fig. 7a). The flight frequency is approximately the same for both sexes and that of flower visits differs only by a small amount. This means that the duration of both activities differs between the sexes. Both sexes prefer knapweed and field scabious (Fig. 7c). Females visit a wider range of plant species. A comparison of activities following a flight movement shows that over 80% of flights of females result in flower visits, i.e. most flights are for foraging. With males other activities follow, namely patrol flights and interaction. Not surprisingly the flight distances of each sex are very different. The average distance covered, i.e. the distance between the start and finish of a single flight is about five metres for 70% of females, and for the remainder only about one metre, whereas with males 50% are about five metres, 20% one metre (Fig. 7b) and the remaining third more than five metres.

The importance of high flower density shows in the individual flights. On 43% of the flights of about 5 metres a flower visit results; by females as much as 70%. Brown knapweed, with 70% of flower visits, is preferred above red clover or field scabious, the most common nectar plants in the study area. Greater knapweed (*Centaurea scabiosa*), reported in other work as the preference (Sonntag, 1982, Ebert 1991), was not visited.

In contrast to the frequent patrol flights and the relatively common interactions, direct observation yielded only one copulation. Why only one is not clear. Either the daily number of freshly emerged adult females is small or mating took place in the early morning before observation began and/or it was concealed by the tall vegetation. A few times

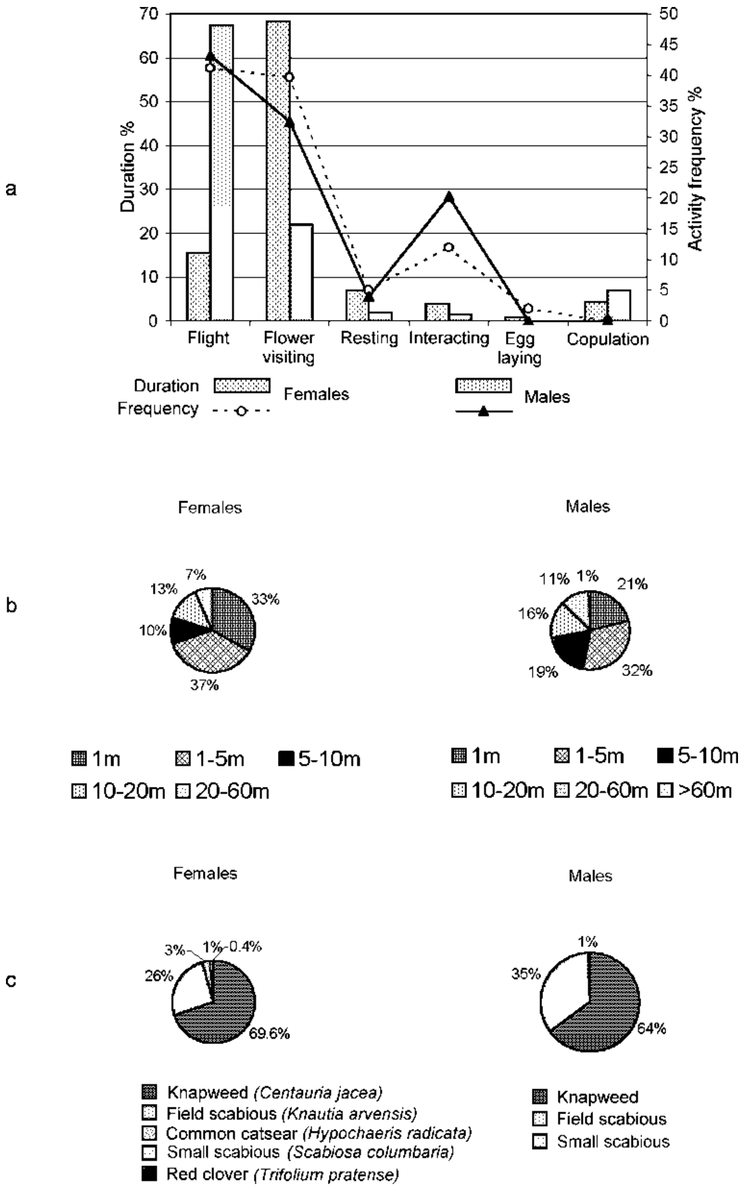

Figure 7. a) Ethochronogram. Duration and frequency of behaviours of both marbled white sexes.
b) Average flight distances (length between the start and finish of a single flight).
c) Flower preferences of marbled white butterfly.

At 12 Jucharten and Oltingue a significant part of the activities of males, namely 15%, was connected with the way they behaved at the edges of the biotope. With the females at all three sites it was less than 5%; short flight lengths and durations guaranteed that females remained in the biotope.

The type of flight is very important when discussing biotope boundaries. Based on a random movement model, inward and outward migration increase with the length of the boundaries of the site but decrease in proportion to its area. This model has two implications. On the one hand it certainly agrees with observation and with practical experience of the way the butterflies flit about their habitat without the observer being able to discern any definite direction. But it runs counter to our intuition that the activities of butterflies, and other animals incidentally, are intentional, i.e. they are directed and dependent on inner factors such as instincts as well as on outer stimuli.

If calculations are made of the number of turns per hour and the ‘geometry factor G of the site’ (length of borders divided by site area) the following figures (turns/h/G) result: 12 Jucharten, 0.0043; Latschgetweid, 0.0042 and Oltingue, 0.0065. At the two sites which satisfy all development stages as well as all modes of behaviour of the adult marbled whites, the calculated values are practically the same despite the very different sizes and resources of the sites. They confirm the random movement model. But at Oltingue where searching for females and egg-laying take place at locations other than that of feeding, the value is about 50% higher. More movements to and across biotope boundaries take place here than one would expect from the random movement model. Depending on the qualities of the biotope a population shows *not only* random *but also* directed movements. If the number of interactions on flowers is symptomatic of the availability and quality of appropriate nectar sources then the value for turns per hour per geometry factor enables statements to be made about the quality of networking or the ‘patch context’ of a site.

Discussion

The findings from the application of single animal observations to the marbled white butterfly show how the biology of this species, the difference between the sexes and the use and quality of the various habitats are bound up with one another.

As with many other insects, female behaviour is wholly devoted to reproduction. Brief flight durations contrast with long flower visits. With the males it is the reverse, i.e. long flights and short flower visits. The *frequencies* of flights are however species specific and approximately the same for both sexes in the respective habitats. However, both duration and frequency of flight movements also show a habitat-dependent component. They are lowest in the relic habitat and highest in the richly structured mosaic landscape at Oltingue. Latschgetweid holds an intermediate position. It would appear that the small size of a habitat has a negative influence on mobility – as with the behaviour of a caged animal in a zoo – whereas a varied habitat increases it.

The butterfly populations of the three study sites show varying preferences for the main nectar plants. At 12 Jucharten and Latschgetweid the preferred food plants are also the most commonly occurring ones. But this correspondence does not apply at Oltingue. Although here field scabious is four times more common than brown knapweed, the latter

Oltingue reflects the spatial differentiation of habitats (see Fig. 3b), so also can the same differentiation offer an opportunity to optimise mating strategies. Comparing the behavioural activities at other sites might eventually corroborate the effect of such biotope differentiations.

Another ‘anomaly’ can be discerned from the distribution of interaction frequencies. At 12 Jucharten, encounters between individuals of the same sex, whether males or females, are far more frequent than at the other two sites (Table 3). This is explained by examining the raw data for single animal observations (not shown). The ratios of the number of interactions during flight to those that happen on flowers are for the three sites as follows: 12 Jucharten, 0.16; Latschgetweid, 1.85 and Oltingue 1.84. Thus on the site with the relic habitat encounters of butterflies on flowers are about 11 times more frequent than at the other two sites. Accordingly, the majority of interactions at 12 Jucharten are not the result of searching for mates but of competition for scarce food resources. Interactions on flowers serve as an indicator of the quality and quantity of the nectar supply of a given biotope.

Turns

Butterflies exhibit various behaviours at biotope borders. At hard borders such as woodland edges, wide roads and, depending on what they contain, occasionally arable fields the butterflies return to their habitat in broader or narrower ‘U’ turns (Schicktzelle & Baguette 2003). Soft borders comprise transitions into grassland, for example fertilised meadows, fallow and narrow farm tracks. The expressions ‘hard’ and ‘soft’ should not be interpreted as invariable. According to the species a hard boundary can become a soft one or vice versa (Ries & Debinski 2003). Thus it certainly happens that a marbled white flies over a woodland edge as a continuation of meadow vegetation in a vertical direction or an individual on crossing into a meadow treated with fertiliser suddenly turns back into its biotope as if it had hit an invisible wall.

The quality of borders is significant in many respects. They are the lines at which migration inwards and outwards can take place, i.e. they may support the genetic diversity of a population or threaten the existence of small populations.

In our experimental design the duration of turns is included in the category ‘flight’ but their frequency was recorded separately (Figs. 5a and 5b). On several occasions at 12 Jucharten we were able to observe that butterflies, usually males, though in rare cases females too, flying over the surrounding arable fields would suddenly leave the observation zone with a rapid flight in a straight line. Although we looked for the butterflies in meadows, field margins and hedgerows in the near vicinity and further off we could not find any.

In most cases after some time they returned to the biotope. At Latschgetweid turns were somewhat rare. As our vantage point lay roughly in the centre of the pasture, the distances to the surrounding woodland were probably too far. The Oltingue site showed a similar frequency of turns to 12 Jucharten. Unlike with the relic population, where only outward migration occurs because within a radius of several hundred metres there are no marbled whites flying, inward and outward migration is clearly a feature of the quality of the Oltingue landscape with its mosaic of small plots.

on the field visits mating butterflies were disturbed and they reacted by flying more than 100 metres away.

The number of egg layings observed was also small. Seven of the eight recorded took place in the tall brome grass in the fallow biotope. One occurred in the flower-rich, unmown tall oatgrass meadow. The female flutters deep into the tall vegetation, lands on a blade of grass and, after a pause, bends the abdomen forwards to drop an egg onto the ground. No egg layings were noted on the fallow nor on the orchid meadow mown on 1 July. After a successful egg laying the females always move between ten and twenty metres away.

These observations may be summarised in a mood picture. Moving from flower to flower, the females quietly tie tight knots in the activity meshwork of the meadow. Their whole existence is taken up with foraging and reproduction. The long flower visits with short flights from flower to flower awakens a sense of internalised devotion. Sharply contrasting with this is the aggressive wing flapping to drive competitors off flowers. After mating, repelling the attentions of the males results in conspicuous, lofty flights that protrude from the tight meshwork. The long horizontal flight after successful egg laying has the result that the female transfers the closely knotted pattern of switching from flower to flower to a new part of the meadow.

The males weave, more actively and with faster rhythms, a wide-meshed network within the vegetation. The areas for patrol flights and flower visits may overlap but do not have to. They only fly through the space above the vegetation when they are pursuing a potential mate or on the rare moves from one location to another. The restless searching of the male contrasts with the busy calmness of the female.

The species-typical behaviour of the marbled white varies according to conditions at the particular time of day. Thus it happens that when it is very hot the sex-specific behaviours retreat into the background and both males and females predominantly visit flowers. When the availability of appropriate nectar plants becomes limited, frequent, though unintentional, interactions become inevitable. If the observations on single animals are applied to the whole population it becomes clear that richly structured mature grasslands with high flower densities and a minimum area of half to one hectare offer ideal conditions for proliferation. Unfertilised meadowland that is cut once a year or left to fallow, though not for too long, are the biotopes of the marbled white. The butterfly needs areas in which the maturing process of vegetation can reach completion.

Comparison with the mazarine blue

Although the mazarine blue occupies the same meadow landscapes as the marbled white, it is associated with different structures and nectar plants, and has different developmental dynamics. The main difference is that the blues produce two flight generations, i.e. they are dependent on nectar and larval fodder plants in both the spring and the summer. In our cultural landscapes these requirements are met by mowing for haymaking. The ideal habitat is a managed meadow cut twice a year containing red clover and birdsfoot trefoil, i.e. richer in growth and yield than the biotope of the marbled white.

Blues show striking marking differences between the sexes. Compared with the marbled white, there is a much greater tendency for the inexperienced or inattentive observer to spot only the blue winged males at first. The females live unobtrusively in the vegetation and even when sucking nectar from birdsfoot trefoil they are hardly noticeable because the prostrate flowers develop entirely within the leaf zone. They depend on the red clover for egg laying. Figures 10 and 11 show that the *Leguminosae* are by far the most attractive nectar plants. Adults of the second generation occasionally visit common selfheal (*Prunella vulgaris*).

In both flight generations, the males and females of the mazarine blue are adapted to the differing conditions that prevail in spring and late summer after the first mowing. This is especially noticeable with the males, whose greater openness to the surroundings is characterised by their blue coloration, in that the two flight generations have developed different female seeking behaviours. In order to find females during their relatively rare passes in the dense, tall vegetation of an early summer meadow the males primarily rely on keeping watch from specific, largely exposed points (Fig. 8). Darting from their lookout they chase all insects that fly past and after interaction return to the same spot. Whereas with some of the more mobile species such as the peacock (*Inachis io)* and the small tortoiseshell (*Aglais urticae*) the lookouts are distributed over a large area of landscape, the less mobile species restrict themselves to a few 'perches' along woodland tracks in a limited range of only a few hundred metres. These include not only the blues, among

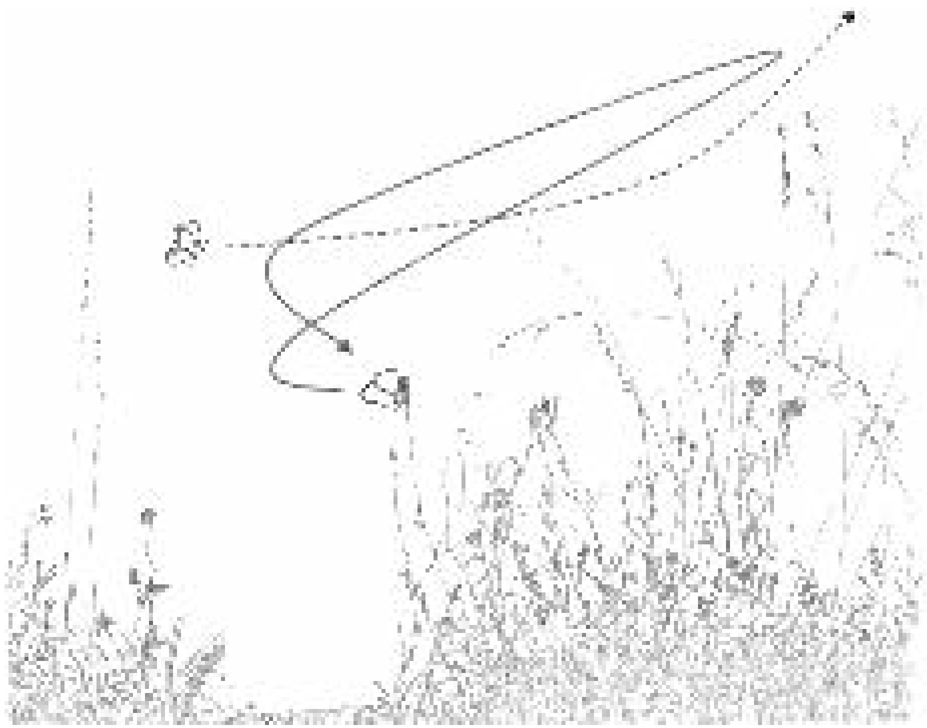

Figure 8. Lookout behaviour of mazarine blue male (1st generation, solid line) in the tall oatgrass meadow at the beginning of July.

Interactions

Interactions of both sexes at all three sites lasted less than 5% of the total observation time. Whilst this is small, the frequencies tell a different story (Figs. 5a & 5b) in that for both sexes they are of the same magnitude as the frequencies of flower visits. That the encounters of males and females with other insects such as butterflies, bees and bumblebees are more frequent at Latschgetweid and especially Oltingue compared with 12 Jucharten is a direct result of the species diversity and the high number of insects visiting flowers at the two sites. Here butterflies feeding on flowers formed the majority of insects disturbed by new arrivals.

However, it may seem surprising at first that females in all three areas meet more often than males rather than the reverse (Figs. 5a & 5b, Table 3). At the 12 Jucharten and Latschgetweid sites females are approached by males in two thirds or more of all cases, i.e. these comprise the majority of interactions experienced by females. But in contrast, males seeking mates meet females of the same species in only 10% of all cases (Table 3).

The situation is more complex at Oltingue where interactions between the sexes are much lower than at the other two sites (Figs. 5a & 5b) and where at the same time the incidence of a partner of the opposite sex available to meet is very similar (10% difference).

Why is it that individuals who try to avoid contact with the opposite sex of their species come into contact with them more often than those who deliberately seek contact and why are there sites such as Oltingue where the butterflies most frequently encounter individuals of the opposite sex?

We believe that the differences are connected with various mating strategies. At 12 Jucharten and Latschgetweid, where one and the same habitat satisfies all the requirements of butterflies, males react to most 'objects' flying past, amongst which are also other individuals of the same sex. At Oltingue, where egg-laying and habitats for larvae and especially for freshly emerged females are separated from the feeding site, male hunting for mates is more targeted. Just as the high total flying time of the males at

Interactions:	with males	with females	with others
Females			
12 Jucharten	67	30	3
Latschgetweid	73	6	21
Oltingue	54	1	45
Males			
12 Jucharten	89	8	3
Latschgetweid	64	8	28
Oltingue	16	42	42

Table 3. Percentage distribution of frequencies of interactions. 'With others' comprises interactions with butterflies, bumble-bees and other bee species.

for females. In both sexes the flight frequency was lowest in 12 Jucharten and highest in Oltingue.

Flower visits

At the 12 Jucharten and Latschgetweid sites the flower visits were directly related to the frequency of occurrence of the main nectar plants. At 12 Jucharten both sexes flew to brown knapweed (*Centarea jacea*) (Figs. 5a & 5b; Table 2) which is seven times more common than field scabious (*Knautia arvensis*). However, 40% of visits by females are to flowers of other species. In addition there is a good correlation between frequency and duration of flower visits for females whereas males feed exclusively on a preferred knapweed. At Latschgetweid, scabious, 25 times more common than knapweed, is preferred. Although flowers other than scabious are visited, they are almost insignificant as a source of nectar, as shown by the duration of visits to scabious which range from 95 to 100 percent.

The relationships are more complex at the Oltingue site. Here females show a 2.5 times greater preference for knapweed although this plant is present at only a quarter the density of that of knapweed. Clearly the frequency of occurrence of flowers is not the deciding factor. The duration correlates with the frequency of flower visits, indicating that the flower landed on is usually used as a source of nectar. With the males it is different. They land on both flower species with equal frequency but they spend almost double the time on knapweed compared with scabious (see also Kuster & Wirz 2005). This suggests that the two flowers are not distinguished visually by the males at this study site. Is the quantity and quality of nectar a deciding factor in the time spent on a flower? It would be interesting to investigate whether the preference for knapweed at Oltingue is a characteristic of the marbled white population there and thus shows an adaptation to the site or whether it is by default as a result of the great attractiveness of the scabious to other insects who successfully take possession of this nectar source and keep competitors off.

	Brown knapweed		**Field scabious**		**Other flowers**	
	Frequency	Duration	Frequency	Duration	Frequency	Duration
Females						
12 Jucharten	59	63	20	23	21	14
Latschgetweid	12	-	79	100	9	-
Oltingue	70	70	27	26	3	4
Males						
12 Jucharten	90	100	2	-	8	-
Latschgetweid	8	5	78	95	13	-
Oltingue	49	64	49	35	2	1

Table 2. Percentage frequencies and durations of flower visits.

these the brown argus (*Aricia agestis*) and the small blue (*Cupido minimus*), but also the speckled wood (*Pararge aegeria*). In our study, these perches were also often defended by the males on particular days. After the first mowing of the meadow, when more open regrowth provides greater visibility and more room for flight, the males devote themselves to patrols over the flight territory lasting for several hours (Fig. 9). The duration of flight is double that of the first generation, i.e. 60% versus 30% (see Figs. 10 & 11). During these patrol flights the males usually wander over an area of several hundred square metres, where, in comparison to the first generation, far more butterflies are encountered, identified as potential mates and pursued. The preferred strategy is active searching. Unlike species such as the whites (*Pieris*) or the brimstone (*Gonepteryx rhamni*), the mazarine blue behaves like the marbled white in that it patrols an area within relatively narrow limits. In doing so it tries to avoid 'overflyable obstacles' such as tracks and field boundaries.

As with the marbled white, the frequency of the flights of both sexes is almost the same, although for the blues the flights are shorter in length. Over 90% of the flights of the females in both generations are less than five metres. For the males this applies to over 50% of the flights in the first generation and 80% in the second generation (Figs. 10 & 11). The blues can establish viable populations in very small spaces, for example on roadside verges, provided that the nectar and larval fodder plants are present in sufficient numbers.

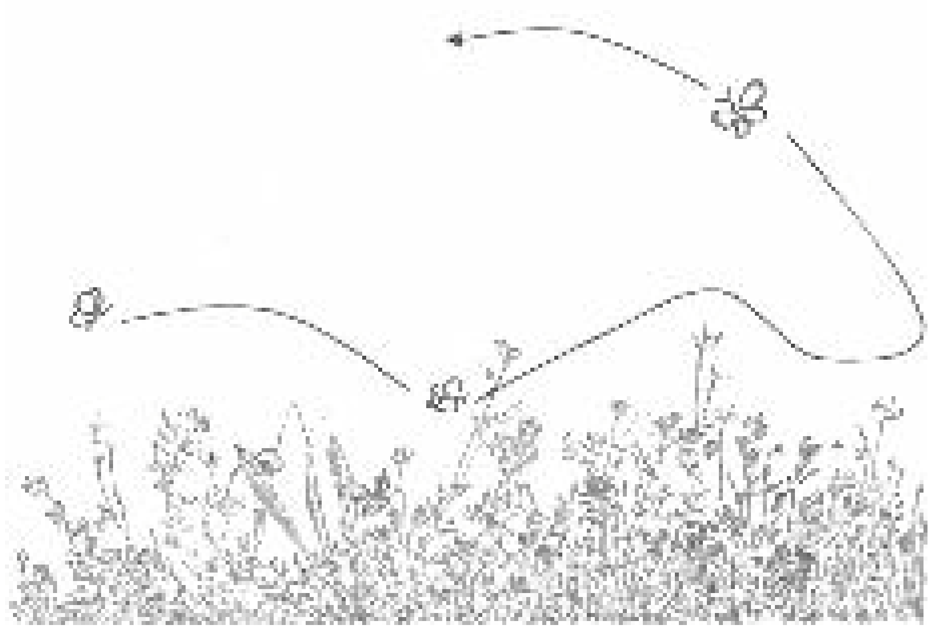

Figure 9. Patrol flight behaviour of mazarine blue male (2nd generation) in the meadow regrowth at the beginning of August.

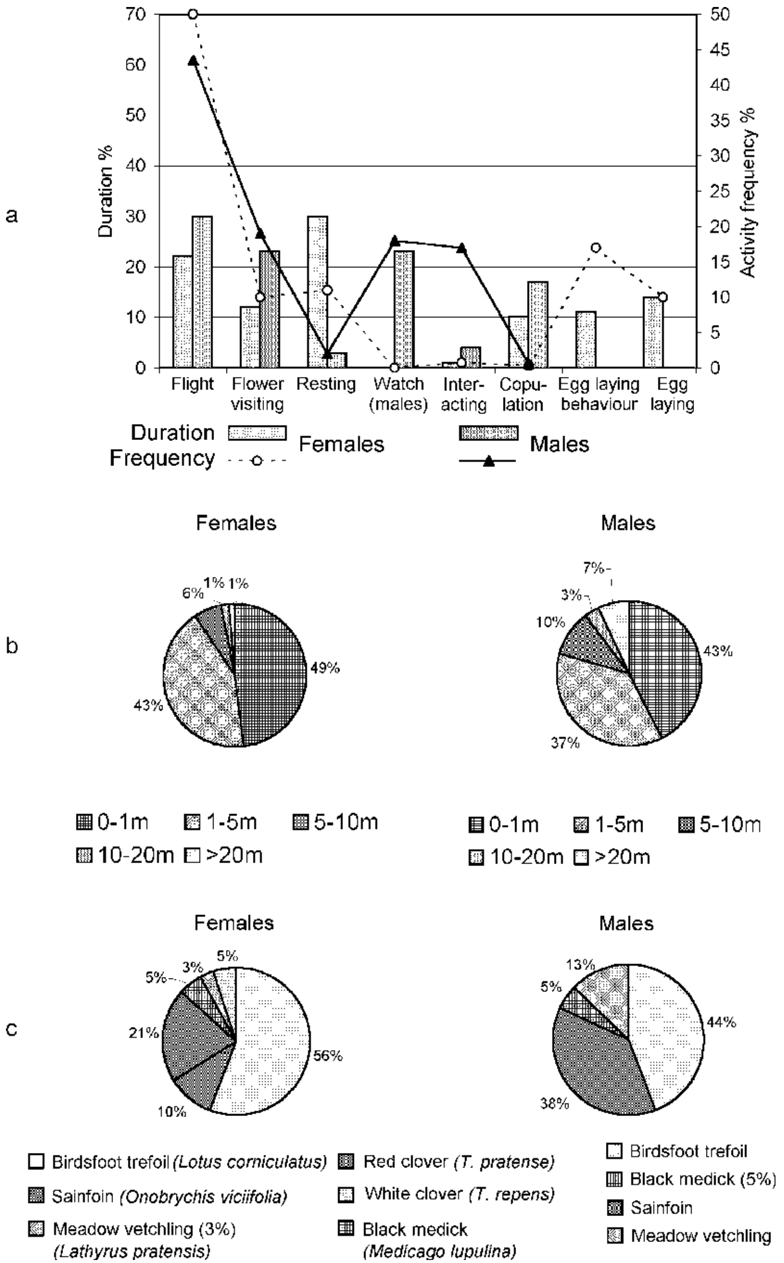

Figure 10. a) Ethochronogram. Duration and frequency of behaviours of both mazarine blue sexes (1st generation).
b) Average flight distances (1st generation).
c) Flower preferences of mazarine blue butterfly (1st generation).

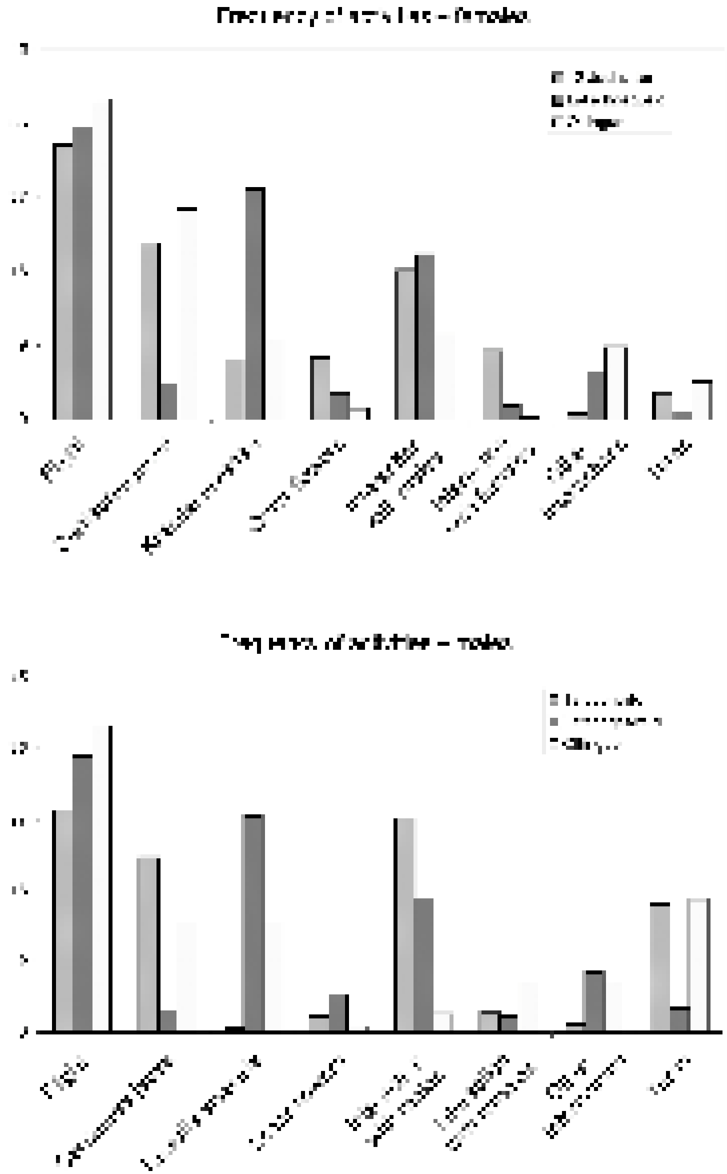

Figure 5. Percentage frequencies of activities of the marbled white butterfly; flower visits to brown knapweed (*Centaurea jacea*), field scabious (*Knautia arvensis*), and other flowers shown separately.

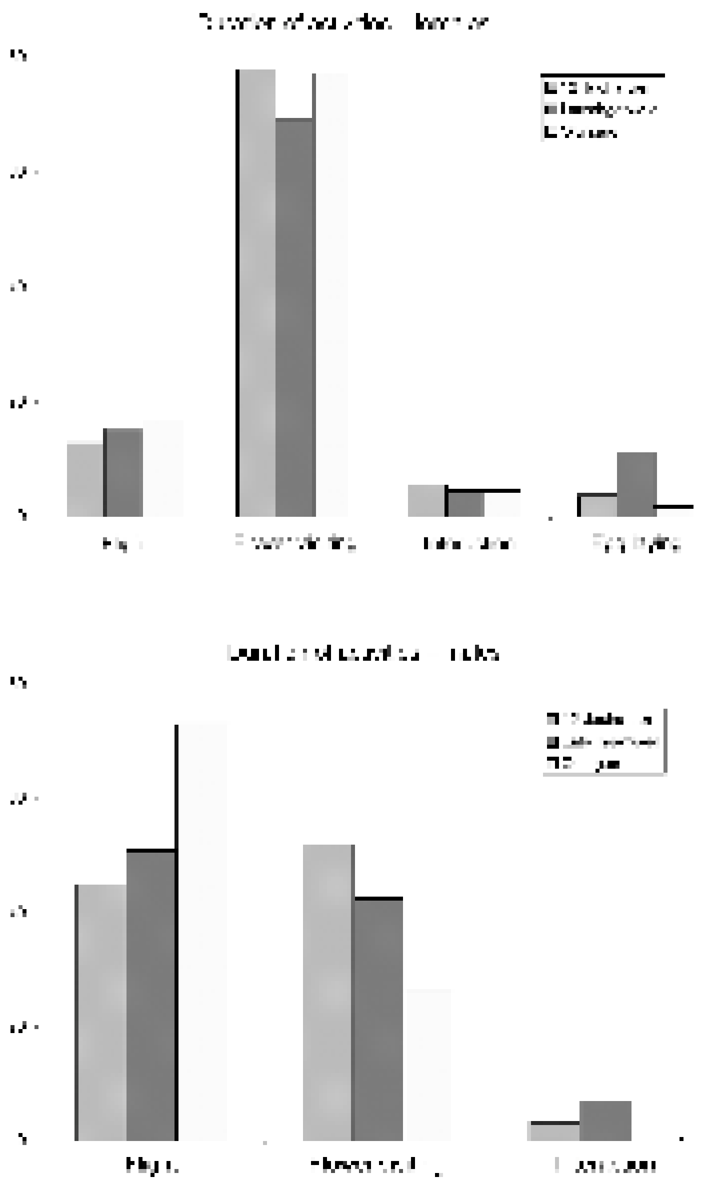

Figure 4. The percentage distribution of the duration of various activities of females and males of the marbled white butterfly.

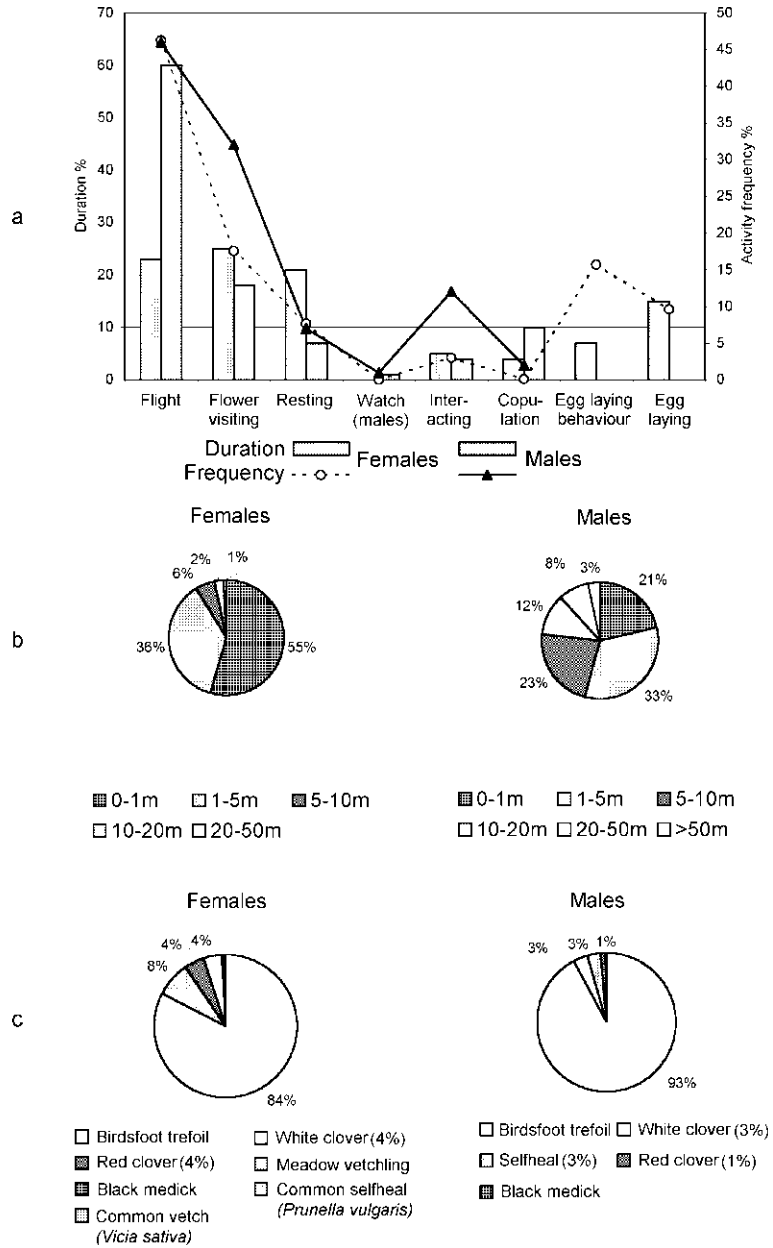

Figure 11. a) Ethochronogram. Duration and frequency of behaviours of both mazarine blue sexes (2nd generation).
b) Average flight distances (2nd generation).
c) Flower preferences of mazarine blue butterfly (2nd generation).

The number of matings is small in comparison with the number of interactions. It is clear that in this case too the females are mated shortly after emergence and, as the low frequency of interactions in the first generations shows, can successfully protect themselves in the tall, dense vegetation from approach by the males. Compared with the first generation, in second generation patrol flights the males met significantly more females who were visiting flowers or laying eggs. As soon as a male landed with open wings in the vicinity of a female, she crept more deeply into the vegetation and thus made herself invisible. Mating, usually on a plant stem, generally takes several hours and thus because of its duration comprises a significant part of the life cycle.

The proportion of time spent on reproductive behaviour by females of both generations is almost the same. A quarter of their time is spent on egg laying on the sole egg laying plant, red clover. The number of flights to new flower heads is significantly higher than the number of actual egg layings. Eighty percent of successful egg laying occurred on green to light pink tinted flowers of five to ten millimetres in diameter. They occurred less frequently in full grown red flowers. Egg laying followed a strict pattern. The female turned several times on her own axis and busily examined the fresh flower with her antennae. Then she bent her abdomen and in most cases laid a single egg, though now and then up to four eggs, amongst the individual flower buds. The mazarine blues more 'devoted' and time consuming egg laying behaviour in comparison with the marbled white, is reflected again in the rhythm between this activity and flower visiting, which for the blue is roughly equal, but for the marbled white, greatly predominates.

As Suchantke shows in various studies on biotope markings of butterflies, the males and females of the blues show particularly contrasting relationships to light and warmth. Our observation of the generally greater flight activity of males and the consistently larger share taken by the reproductive behaviour of the females of both generations supports the view that the 'sparkling splendour of the males' largely radiates the light as 'spirit light in the cosmos', whereas the darker females 'allow light and warmth to flow into reproduction'. That the male's behaviour in hunting females is attuned to the different meadow conditions through the season further points to his greater flexibility and openness to the surroundings.

Prospect

We have supplemented the morphological correspondences of markings with landscape found by Suchantke with our observations regarding an essential, fundamental factor that is common to all animals, namely the *active relating* of the individual of a species to its habitat. Our findings show how the butterfly as an organ within an overall living whole '...fulfills certain firmly delineated functions and in such activities is connected with and in communication with other members of the structure...' (Suchantke 1965). We have learnt something about the 'world of meaning' (Uexküll 1956) of the two meadow butterflies and about their active *search* and *avoidance* behaviour regarding particular objects and conditions present in their flight biotopes.

The results of the ethochronograms are summarised in Table 2. We confirmed the impressions of the marbled white described in the mood pictures and understood their sig-

straight-line flights that can be several hundred metres in length take place over arable fields. Over flower-rich areas the behaviour changes back to nectar intake. Males also continue patrol flights over taller vegetation or over less densely sown arable crops such as maize.

The duration of different behavioural activities

In accord with first impressions, at all sites males are significantly more mobile than females (Figs. 4a & 4b). The flight activities of males and females comprised between 45 and 57 percent of the total observation periods but with the females it was less than 25%. The situation was the reverse with the duration of flower visits. Males spent from 30% to a maximum of 45% of the time on flowers whereas for the females it was 75% regardless of site. Interactions, which for mated females is an annoyance but for males part of mating strategy, take up only 5% of the observation time in both sexes.

Apart from egg-laying, which lasted longer at Latschgetweid than at the other two sites, the duration of all female behavioural activities varied within narrow limits independently of site. This difference is in our view attributable to a fortunate coincidence as egg-laying was observable only rarely.

The situation is different with the activities of the males. Their flight duration is considerably longer than at the two other locations. Flower visits are correspondingly shorter. The reasons for this are discussed further below. The difference points to a finding made by other authors in the field of morphology in relation to the often striking colours of the males of butterflies or birds compared with the 'camouflage markings' of the females. The site-dependent duration of behavioural activities of males is an indication that they manifest the qualities of the site more strongly than females who instead internalise such qualities, devoting them wholly to reproduction (Suchantke 1965). With the marbled white this difference shows not in the markings, which are similar in both sexes, but in the dynamic engagement with the qualities of the landscape.

The duration of interactions of males is shorter than that of females at the 12 Jucharten and Oltingue sites. In relation to a mating strategy of males actively seeking females, one would expect the reverse relationship (see below). And why the 12 Jucharten site, which has a relative paucity of individuals, especially females, showed longer interactions than at Oltingue is not immediately clear. It is helpful to look at the frequency of behaviours.

Flight frequencies

Percentage durations of activities give a relatively static picture of butterfly activities. As during direct field observations individual events happen in series with others, the frequency of behavioural activities can convey their sequence and dynamics.

Figures 5a and 5b show the frequencies of flights, flower visits, interactions and turns. The number of flight movements differs little between the sexes. Based on the average flight duration, male flights last 2.5 to 4 times longer than those of females. Most flights of the latter are for foraging and feeding; when moving from one flower to another the distances are often less than a metre and take only a few seconds (see also Kuster and Wirz 2005). Males make such flights too but the majority are patrol flights and for searching too small because according to Birrer (personal communication) practically all butterflies of mesothermophilic unfertilised grassland fly here – a flight community of about 50 species (Schweizerischer Bund für Naturschutz 1987). In Oltingue, 32 species were observed, thus confirming the importance of a richly structured, extensively managed landscape divided into small plots of land.

A rough estimate was made of the density of the two most common butterflies – the marbled white and the meadow brown – by dividing the number of butterflies by the areas of the respective transects. The densities expressed as the number of butterflies per $100m^2$ for the marbled white and meadow brown at the three sites were respectively: 12 Jucharten, 1.8 and 0; Latschgetweid, 10.8 and 4.1; and Oltingue surprisingly only 0.9 and 2.8. In relation to the overall study site areas, at 12 Jucharten, the relic biotope in fragmented surroundings, the figures project to a population of barely 30 individuals, at Latschgetweid, a largely enclosed habitat, to about 1300. In the open landscape of Oltingue such an estimate would be invalid. From the size of the cultural landscape and its diverse mosaic of traditional management the butterflies there have access to many habitats of optimal quality. It is surprising that the relic population has survived until today. It is probably as a result of planned management of the land.

Behavioural activities

The repertoire of behavioural activities of the marbled white is at first glance relatively limited (Kuster & Wirz 2005). The males, in search of females, make zigzag patrol flights of long duration over a wide range just above the surface of the vegetation. In addition, there are pursuit flights of short duration sometimes covering long distances over the vegetation or spiralling up into the air. During these flights all butterflies with light coloured wings are approached, the darkly coloured ones only rarely, which evidences a faculty for visual selection in searching for a mate. The short flights of less than one metre in order to change from one flower to another are the polar opposite of the long, straight flights over the vegetation during intentional change of location. Furthermore, the behaviours that follow this can be distinguished: nectar sucking with wing movements; sunning with outspread wings and resting with closed wings. On rare occasions there are long mating events deep in the vegetation.

The female is significantly less mobile. She spends most of her time sucking nectar from flowers. Her flights are usually shorter than one metre and serve to change from flower to flower (see also Sonntag 1982). Once mated females without exception avoid further approaches by males. After successful egg-laying they fly 10 to 20 metres away across the vegetation. Females suck nectar with resting wings which are almost always open. They sun themselves and rest like males. Egg-laying in the vegetation takes about three minutes, though sometimes longer than 20.

We deal separately with the so-called 'turns', i.e. behaviours along the boundaries of the habitat. At 'hard' boundaries such as woodland, roads and tracks, the butterfly returns immediately into the habitat. 'Soft' boundaries such as grassland, arable fields or hedges are flown across. They return to the habitat area in circuits of varying width. Individuals that have gone too far from the habitat do not return, i.e. migration has taken place. Fast

	marbled white	**mazarine blue**
markings and flight territory of females	the warm yellow coloration corresponds to the sunlit flower zone, to the main haunt 'dry, bright, mature to the point of flowering'	the dark brown colouration corresponds to the flight zone and haunt close to the ground 'moist, fresh, young'
egg laying	eggs are dropped in vegetation comprising mature grasses	eggs are fixed to young red clover flowers
markings and flight territory of males	the cold black and white colouration is a picture of the richly contrasting structure of the flight territory	the dark blue colouration is a picture of the flight territory above the vegetation
female-hunting behaviour vegetation	patrol flight between exposed stems in two-layered brome grass: gesture like 'basso continuo'	before first mowing: lookout behaviour in the tall vegetation of a June meadow: like a 'horn entry in an orchestra' after the first mowing: patrol flight over the meadow during regrowth like a 'flute solo'
behaviour sequences	clearly delineated sequence of activities with time of day and spatial separation of the sexes	rapid, repetitive sequence of all activities without time of day separation of the sexes
activities according to time of day	increasing activity with increasing sunlight; decreasing with very hot weather	little difference
flowers	purple flowers such as *Centauria* and *Knautia*, radially opening upwards	yellow birdsfoot trefoil, zygomorph, opening sideways
space-time surroundings	stable brome grass or mosaic with flower-rich field margins and tall oatgrass meadows, later mowing 'generative'	tall oatgrass meadows mown twice are flown by both generations in the regrowth stage 'vegetative'

Table 2. Summary of single animal observations of the marbled white and mazarine blue.

nificance in that the separation of the habitats of the males and females is a result of their differing soul tendencies. Males patrol the egg laying site where presumably most of the adult butterflies emerge. The females are mainly occupied with foraging and feeding. The eggs are deposited without care in mature grass stands. Markings, flowers and the spatial-temporal conditions emphasise the close relation of this species to the mature, generative stage of the habitat.

The mazarine blue's behaviour seems in many respects to be the polar opposite of that of the marbled white. The markings are very different; it shows only small behavioural differentiation according to the time of day; the eggs are deposited carefully and it has a strong connection to the vegetative developmental stages of its habitat. It would be interesting to develop these sketches and extend them by investigation of other species. This is reserved for a future study.

Such characterisations change the meadow from seemingly an almost uniform receptacle to a differentiated space of animal communities. The 'active relating' of a butterfly species to its nectar, egg laying and larval fodder plants and to its sleeping and resting places etc, results in a network of soul relationships that forms part of a definite atmosphere, often only appreciable through its mood, and which, within the meadow biotope, presents a soul organ in the structure of the living whole we designate as 'meadow habitat'. Our study makes clear that each butterfly species, whilst being one sided and limited, at the same time constitutes part of the 'soul of the landscape' in all its completeness.

With the marbled white and the mazarine blue we have got to know two members of a flight community and understood how to appraise their contribution to the ensoulment of a place. The two species unmistakably bear the stamp of the range of their individual experience. Just as with an orchestral symphony the inexperienced ear will not necessarily immediately notice the wind section is missing but the connoisseur will sense that without it the piece lacks something, so it is with the behaviour of meadow flight communities. Each animal species plays its irreplaceable part. Losing a species is like amputating a limb, i.e. restricting the potential of a biotope and thus in consequence always impoverishing the full range of experience. This points to a challenge in the protection and conservation of nature and landscapes that all practical work and interventions should face, namely the deliberate observation and experiencing of the worlds of meaning, i.e. the forming of relationships with individual actors at a particular place.

Acknowledgement

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der amongst the vegetation. If we go into the site we are guaranteed to meet grasshoppers – the most noticeable being the large gold (*Chrysochraon dispar*) with its unmistakable metallic gleam. Funnel spiders have built their webs everywhere; beetles clamber along grass stems and on the trunks of solitary pines great thoroughfares of ants can be observed climbing up to the aphids and scrambling down again with swollen abdomens. In the early morning one can come across deer grazing.

A methodological digression

Goethean scientists often question the usefulness of quantitative methods. Indeed, dispensing with both the richness of practical experience and the wealth of form and colour in favour of abstract numerical and size relationships has to be properly justified. We should like to detail two out of a variety of reasons that support such an approach. The first is connected with the discrepancy between the whole person's experience of the 'atmosphere' (Kuster & Wirz 2005; Bockemühl 1997) and the precision of observations through reduction. Attempting to connect in an unconditional way with a situation or a landscape atmosphere is always associated with 'imprecision' regarding details, even when practised properly. When critically appraising a recreation of a richly experienced observation it is possible to notice that in experiencing the moods haphazardly or unconsciously a selection from the fullness of objects, processes and details has been made. The observer and perceiver is part of the whole that is to be grasped and therefore is also a shaper of that whole (Hauskeller 2003). Furthermore if we try to compare various landscapes and their moods, we soon notice something that Goethe (1795) characterised early in his zoological works, namely that an infinitude of possible justifiable comparisons exists but they lead to grasping the 'whole' only in general, indistinctly.

Reducing holistic experience to individual features or modes of behaviour at first loses the totality of the context. The analytical approach enables details and contours to be added. If previously 'experiencing the sensorial phenomenon' characterises what contemplating it really involves, then 'experiencing the relationships elaborated in thought' in creative involvement with the data obtained contributes just as much to an integral understanding and, in fortunate instances, even does so in an original way. This is why Goethe was so keen on itemisation of descriptions of bones, their sizes, positions and numbers and recommended tables as an appropriate tool in developing a *biology of type*. What studying quantitative relationships definitely needs to learn from the holistic approach is attention and respect, participation and wonder. And in return the latter approach will profit from the precision of observations based on reduction followed by their cognitive elaboration. It is not 'either, or' but 'not only, but also' that characterises efforts towards an integral biology.

The butterfly fauna

Mood-creating experiences find a numerical expression in the spectrum of butterfly species and their frequencies of occurrence. As transect counts were performed only for a few weeks at the two sites apart from Oltingue, the findings are incomplete. At 12 Jucharten only six of the 22 species found at Latschgetweid were recorded. This number is certainly meadow, 3%; woodland, 12%; fields, 33%; roads and industry, 36%. Newly established roadside verges, a natural meadow and a meadow with a clover-grass mixture in the immediate surroundings provide valuable sources of nectar. The embankment is managed according to botanical criteria and mowed at the beginning of August.

The Latschgetweid site, a pine-juniper-pasture in the valley of the River Birs was originally a sheep pasture under extensive management and is also under nature conservation (Fig. 1b). Its species-rich brome grass meadow is on a south facing slope and is completely surrounded by woodland (Fig. 2b). The vegetation of the unfertilised grassland is open with a clear division of layers and clear vertical structures of grasses and flowering herbaceous plants (Fig. 3b). The number of nectar plants seems at first sight to be relatively modest (Table 1) but in relation to the total area of the site it is considerable. There is a tendency towards scrub growth in some places. A detailed management plan involving mosaic mowing aims to restore the original conditions. In 2000, the first areas selected were mowed on 1 July and the last on 15 August.

The Oltingue site is a 0.85 hectare species-rich tall oatgrass meadow (see Kuster & Wirz 2005 and Fig. 2c) situated in a landscape that is divided into small areas of grass and arable crops. Its vegetation structure is illustrated in Figure 3c. Compared with the other two sites, it has an extremely high flower count for plants relevant to butterflies (Table 1). Its separation from surrounding biotopes is somewhat artificial as shown by the frequent interchange of the butterflies between one area and another. The study site is mowed at the end of July. As the interconnections are optimal, however, sufficient alternative areas for feeding and egg-laying in the immediate neighbourhood escape mowing.

Mood pictures

The mood and experiential diversity of the Oltingue site has already been described in detail elsewhere (Kuster & Wirz 2005). In comparison with Oltingue, the 12 Jucharten site provides an enormous contrast. The embankment site imposes an unreasonable demand on the marbled white. The site's approaches are already spoilt by the noise of traffic from the road and from the nearby vehicle testing station. And depending on the farming activities at the time, the drone of agricultural machinery can be heard coming from the arable fields. Just as the site itself, through its small size and modest botanical resources, is easily overlooked, so also the few butterflies present are hardly noticeable. Only in the immediate vicinity of the site are a few marbled whites visible; a solitary blue butterfly catches the light on a red clover flower and a few bees can be seen.

The Latschgetweid site presents a complete contrast. Whatever time of day one visits the biotope, a sea of butterflies can be seen fluttering above and through the more open vegetation. Even here the flower diversity seems at first sparse, but the plentiful insects attract the observer's attention to the multitude of flowers. Although the traffic noise from the roads is not reduced acoustically by the enclosedness of the site, one's awareness of the noise is greatly diminished. And how noisy this study site really is only became apparent during later transcription of the recording. The great banded grayling (*Brintesia circe*) sails across the meadow; countless blues are on patches of birdsfoot trefoil (*Lotus corniculatus*) and innumerable marbled whites and meadow browns wan-

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a
b
c

Figure 3. Ground-level cross-section views at the sites during the main flying season of the marbled white butterfly: a) 12 Jucharten, b) Latschgetweid, c) Oltingue.


a
b
c

Figure 2. View of the study areas during the main flying season of the marbled white butterfly: a) 12 Jucharten, b) Latschgetweid, c) Oltingue.

The marbled white butterfly (*Melanargia galathea*) in ecologically different farmland habitats

Johannes Wirz and Daniel Kuster

Summary

The behaviour of the marbled white butterfly (*Melanargia galathea*) in habitats with distinct ecological qualities and differing patch contexts (wider surroundings) is investigated. Observation of individual butterflies is used as a tool to develop a differentiated view of duration and frequencies of typical activities. Species and sex-specific behaviours can be identified, but in only a few cases do they prove to be independent of habitat-specific qualities. In comparison with the benefits and limitations of qualitative approaches, a detailed quantification is justified and reveals unexpected results regarding preference for nectar plants, differences and dynamics of interactions with other insects and the significance of size and geometry of habitats. Some criteria for facilitating the protection and development of populations of the marbled white are presented.

Introduction

As a result of intensification of land use over the last century, many of the once common farmland butterflies and moths such as the meadow brown (*Maniola jurtina*), the small heath (*Coenonympha pamphilus*), the marbled white (*Melanargia galathea*), the blues and the six-spot burnet moth (*Zygaena filipendulae*) have either disappeared (Jeanneret *et al.* 2000) or have become confined to small relic localities such as roadsides, field margins and embankments (Bosshard & Kuster 2001). Many factors influence the survival of butterfly communities including the size of the site; the quality and vegetation pattern of its botanical resources; its interconnection with and proximity to similar biotopes as well as its location, exposure and geometry (Hering & Beinlich 1995; Ellingson). Small relic patches of habitat are exposed to many negative influences of intensive agriculture such as mechanical stress through the passage of machinery, and chemical pollution through the unavoidable application of fertilisers and herbicides (Klaus *et al.* 2001). Such factors affect all developmental stages of a butterfly species namely eggs, larvae, pupae and imago.

Moreover, small populations show an increased susceptibility to not only intrinsic population swings, for instance as a result of genetic restriction through inbreeding, but also other environmental influences, and they suffer from outward migration of individuals from the biotope.

Information about selected species in largely optimal habitats allows the important habitat requirements to be worked out and a comparison to be made with places of lower habitat quality.

In this study we observed butterflies at three sites. In addition to phenological investigations of flowering plants and estimates of butterfly species diversity and frequency of occurrence, we used single animal observations of the marbled white to identify the requirements for the maintenance and even development of viable populations of this species. Its behavioural repertoire has been described in an earlier article (Kuster & Wirz 2005, see page 1 of this issue). It was a once common meadow species in the Swiss midlands. Today there are only small relic populations present and all these are endangered. The marbled white's relatively short flight range makes it especially suitable for single animal observations.

The butterfly was studied in areas of differing biotope quality: a pine-juniper-pasture surrounded by woodland; a landscape divided into small meadows and fields and, as a representative of a relic site, an embankment in ecologically poor surroundings.

Methods

During the marbled white's flying season (mid-June to end-July) the flower diversity and frequency of occurrence as well as the vegetation structure was documented at all three study sites. Flowering herbaceous plants were counted within representative areas. Transect counts (see Pollard & Yates 1993) of the occurrence of the common butterfly species along 5-metre wide strips of measured lengths were carried out and a rough estimate of the density and population size of the marbled white obtained.

Single animal observations (cf. Kuster and Wirz 2005, see page 1 of this issue) were made on several days and at different times of day at temperatures over 20°C and under a cloudless sky. Observation durations for males and females respectively at the three sites were (h:min): 12 Jucharten 2:10, 7:14; 'Latschgetweid 3:19, 4:01; Oltingue 8:39, 14:02. Observations were dictated onto a minidisc digital recorder, transcribed and the duration of behavioural activities and their frequencies determined. The duration of each activity was expressed as a percentage of the total observation time. The percentage frequency of activities was related to the sum of all individual activities. For quantitative comparisons the various flight activities were categorised as follows: male patrol flights; interaction flights; change of place flights and female flights after egg-laying. We did not differentiate the behaviours during the periods of immobility. Resting and sunning on flowers as well as sucking nectar were categorised as 'flower visits' as these comprised 90% of the total duration (cf. Sonntag 1982; Kuster & Wirz 2005).

Interactions of the individuals under observation at a particular time were subdivided into three categories: encounters with 1. same species / same sex; 2. same species /opposite sex; 3. other insects, i.e. primarily butterflies of other species, honey bees and bumblebees.

Study sites

The three study sites differed regarding their size and the use and management of the land in the immediate surroundings (Table 1). 12 Jucharten (Fig. 1a) is an embankment under nature conservation on the edge of fields managed according to integrated production guidelines in the vicinity of an industrial area and a heavily used road. The brome grass meadow that is in the process of reverting to wilderness is part of an embankment stretching for 600 metres between the fields and alongside a track, separated from the rest by a

Site:	12 Jucharten	Latschgetweid	Oltingue
Size (ha)	0.2	2.1	0.84
Type	margin of brome grass	pine-juniper-pasture	tall oatgrass meadow
Number of relevant nectar plants per 100m²	17.5*	123**	1124***
Site surroundings	small island surrounded by natural meadow, woodland, arable land and an industrial estate	brome grass completely surrounded by woodland	embedded in a mosaic landscape with great structural richness

* brown knapweed (*Centarea jacea*), field scabious (*Knautia arvensis*), birdsfoot trefoil (*Lotus corniculatus*), carthusian pink (*Dianthus carthusianorum*)

** brown knapweed, field scabious, birdsfoot trefoil, mountain clover (*Trifolium montanum*), carthusian pink

*** brown knapweed, field scabious, white clover (*Trifolium repens*), sainfoin (*Onobrychis viciifolia*), red clover (*Trifolium pratense*)

Table 1. Study site data

newly planted belt of woodland (Fig. 2a). The vegetation higher up the slope shows significant ingress of fertiliser from the field. The vegetation structure is correspondingly dense (Fig. 3a). Apart from showing few linear structures it gives the impression of a dense carpet that has almost become matted. The species count and frequency of nectar plants for butterflies are both low (Table 1). The surroundings are of poor quality. For an imaginary circle of radius seventy-five metres from the centre of the biotope, the percentages of its circumference passing over the various land uses are as follows: brome grass

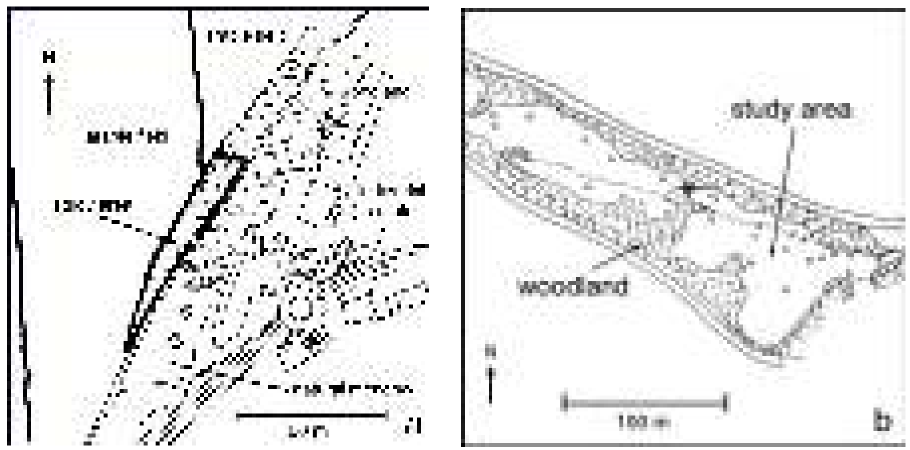

Figure 1. Size and plan of the two study sites 12 Jucharten (a) and Latschgetweid (b)