The following pages on various topics are concerned *inter alia* with

Butterfly Wing-vein Notation
and Wing-patterns of the Lycaenidae (The Blues etc.)

They are unmodified extracts from ch. 1.1 and ch. 5.0 of *EUROPEAN BUTTERFLIES: A PORTRAIT IN PHOTOGRAPHS*.

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Introduction

On inspection, a butterfly's wing appears as a number of **pattern-elements** on a background. The background colour is often fairly even in appearance, and when this makes it appropriate to do so, it is referred to as the **ground-colour**.

A most important fact is that the positions of the pattern-elements are largely controlled by the so-called veins. In consequence, the pattern-elements may be divided into three main types: localised elements positioned between veins; localised elements on veins; and extended (linear) elements on veins.

It is convenient to describe the venation of the wings here, because it is similar in all families. I shall also define the notation used for labelling the wing-veins.

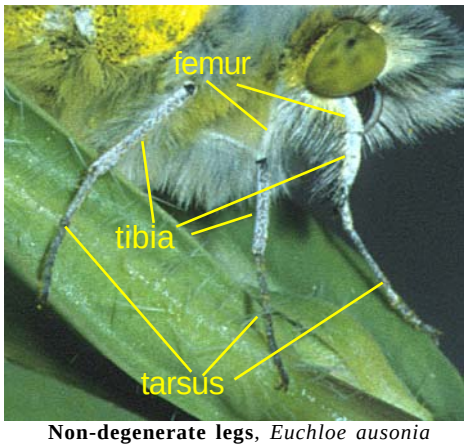
Despite the organising role of the veins, however, the resulting surface patterns of colour and shape in different taxa may be very different. For this reason, as already mentioned, wing-patterns themselves will be discussed on a subfamily basis in the introductory chapter of each division, except to mention here that the notation used to name pattern-elements stems from the notation given here to name veins.

Legs will be described here because they too are generally similar in all families, except for the forelegs which do distinguish families, and, in certain subfamilies, the sexes.

Legs

A butterfly's leg has three main sections: **femur** (thigh), **tibia** (shin) and **tarsus** (foot), which are jointed to each other. The tarsus consists generally of five articulated segments ending in a somewhat complicated **claw**, but in more recently evolved families there has been a progressive trend for the forelegs to degenerate.

Thus, in the presumably more primitive families, Hesperiidae (Skippers), Pieridae, as illustrated (Whites etc.), and Papilionidae (Apollos, Swallowtails etc.) all three pairs of legs are fully developed in both sexes. In the three major European Lycaenidae subfamilies, Polyommatinae (Blues), Lycaeninae (Coppers) and Theclinae (Hairstreaks), the tarsus on the foreleg of the male, but not the female, is degenerate structurally. This discriminates the sexes in appropriate photographs. The degeneration of the forelegs is more complete in the Nymphalidae (Vanessids etc., Fritillaries and Browns) to the extent that the forelegs are useless for walking in both sexes. Actually the male's legs are the more degenerate, but the forelegs are more-or-less concealed by body 'hairs' and usually cannot be recognised in photographs. Lycaenidae subfamily Riodininae, (Metalmarks), are intermediate between the other Lycaenidae subfamilies and the Nymphalidae, there being some foreleg degeneration in both sexes.



Non-degenerate legs, *Euchloe ausonia* (Eastern Dappled White)

Wings

The following brief description of wing development is based on Nijhout (1991), a book that deals extensively with the science of butterfly wing-patterns.

In broad terms, the adult wing consists of two lamellae (sheets of cells) which form the ventral (underside) and dorsal (upperside) wing-surfaces. Although the inner faces of the sheets are stuck together, there are certain **lacunae**, tube-like spaces, between them which form the so-called **wing-veins**. The lacunae are, in the main, radial from the wing-root to the outer periphery of the wing. The lacunae carry haemolymph, a fluid that is roughly equivalent to the blood and lymph of mammals. Also, inside the lacunae are fine **trachea** (air tubes) that supply oxygen to the wings. The outer surfaces of the lamellae carry the **wing-scales** or **scales**.

The early development of wing-lamellae, in the later part of the larval stage, is accompanied by development of lacunae. One is the **bounding lacuna** near, but inside, the periphery of the lamellae. The others radiate from the root of the lamellae, some branched, to the bounding lacuna. The two ends of the bounding lacuna are at the root of the lamellae just anterior to and just posterior to the bunch of radial lacunae. The overall pattern is recognisably similar to the venation of the adult wing. The lacunae, with the exception of the bounding lacuna, are penetrated by what can be called the **primary tracheation**.

Later, as the wing-lamellae grow, the primary tracheation is replaced by **secondary tracheation** in which certain of the earlier lacunae are abandoned and some new connectivities are created. The adult venation is the secondary system, composed of what may be called **developed veins**, plus a few **atrophied veins** left over from the primary system. Furthermore, the cells outside the bounding lacuna die and it then becomes the boundary of the adult wing. Any feature that involves a butterfly's wing-outline, such as a tail, results directly from a corresponding kink in the bounding lacuna.

Wings are, of course, covered in scales. The colours on a butterfly's wing are entirely due to the colour of the scales, except that the underlying **membrane** is usually brown, when it is not colourless, and may become visible in very worn individuals. Scales are of two principal types: **under scales** (also known as **ground scales**) and **cover scales**. Commonly they are arranged in rows roughly transverse to the radial veins, with the two types of scale alternating, though in a few instances they are more random, e.g. in the Parnassiinae (Apollos). Usually, too, the cover scales are larger and more brightly coloured than the under scales and cover them.

Thus, it is usually the case that the pattern and colour of a butterfly's wing are due to the cover scales. When the cover scales are lost, through wear for example, most butterflies become more drab as the under scales become more apparent.

Each scale is a single colour, and in many cases the colour is a pigment. Pigments produce colours from whitish, through yellows and oranges to red, and also browns and blacks.

Blues, purples and greens are **structural colours**, as are all the iridescent colours. A structural colour arises from some repeated structure in or on a wing-scale, such as parallel ribs on the surface or a repeating layer structure in the bulk (many more possibilities are known). If the repetitions are suitably spaced they will reflect certain colours more than others and so seem coloured. And, in particular, the effect can depend on the direction of the light falling on the scale and the direction in which the reflected light is viewed. Thus it is that many iridescent colours come and go depending on these relative directions. It may be noted that purple/violet gleams on the Apaturinae (Purple Emperors) and the Lycaeninae (Coppers) are generally produced by structured, black-pigmented scales.

In addition to under scales and cover scales, male butterflies carry modified scales, **androconia**, that produce pheromones. Androconia are generally different in structure from normal scales and are extremely variable between species. In cases where they are aggregated into patches, androconia can produce a distinctive appearance that is part of the overall wing-pattern.

Notation

Wing-regions

The edges of the wing are: the **costa**, the anterior (front) edge; the **outer margin** or just **margin**, the distal (outer) edge; and the **inner margin**, the posterior (rear) edge. I shall refer to the whole wing-edge as the **periphery**.

The **fw apex** is the pronounced angle in the wing-periphery where the costa and the margin meet. The **anal angle**, on forewing and hindwing, is an abrupt turn where the margin and the inner margin meet, but in some groups the anal angle is not well-defined.

The wing-surface may be divided roughly into three parts: the **basal area**, nearest to the thorax; the **discal area**, in the central region of the wing; and the **submarginal area**, beyond the discal area up to the wing-margin. Also, the **apical region** is the wing-surface close to the fw apex.

Wing-veins

As regards the so-called veins, it is simpler to start with the hindwing. In the adult there are five developed **root-veins** radiating from the wing-root, some of which branch to produce altogether nine developed **peripheral veins** at the wing-periphery (and there are also certain atrophied veins). Some species have a short **precostal vein**, labelled pc, which will not be discussed further.

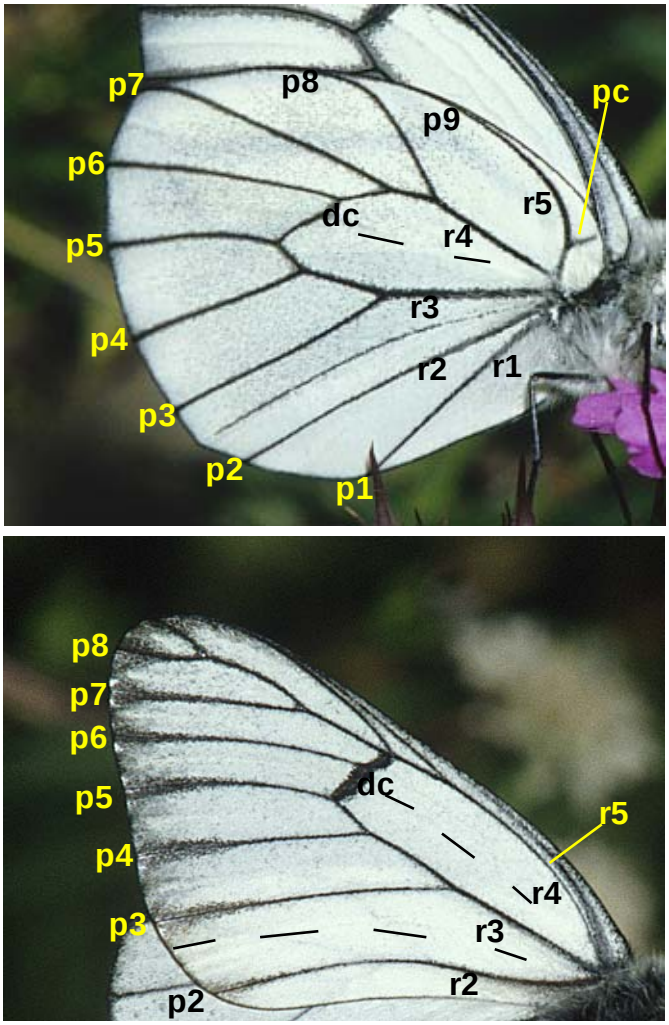
The natural scientific approach to notation is to give primacy to the root-veins and treat the peripheral veins as secondary. In such notations there may be conventional names for root-veins, e.g. costal, medial, radial, anal etc. The branches are then given names such as radial 1, radial 2 etc. There can be several variants of this approach depending on whether the tracheae or lacunae, or indeed the primary or secondary system, are treated as principal.

For wing-pattern description and recognition, however, it is convenient to adopt a non-fundamental *ad hoc* notation. The system used here is indicated in the illustrations.

The **developed veins** are numbered, starting from the inner margin. Thus the root-veins are labelled r1 to r5. Of the nine veins reaching the periphery, the first two are the ends of the unbranched root-veins r1 and r2. The next six are branches of root-veins 3 and 4, and the last is the continuation of the unbranched root-vein r5.

The nine peripheral veins are labelled p1 to p9, where p1 and p2 are, of course, the same veins as r1 and r2, and p9 is the same as r5. Veins p3 to p8 do not correspond uniquely to any root-vein. The lack of numerical correspondence between p9 and r5 is unfortunate, but is rarely confusing because patterns associated with veins at the wing-periphery and at the wing-root are usually well segregated. Indeed, it is commonly the case that rows of spots etc. are organised by either the peripheral or the root-veins, but a single row is never, I think, organised by both. Thus, having the root series and the peripheral series of labels is actually very convenient in pattern analysis.

In addition to the developed veins, **atrophied veins** can also



Labelling of wing-veins *Aporia crataegi* (Black-veined White).

The developed veins are naturally lined by black scales. One atrophied vein on the hw (between r2/p2 and r3/p3) is also lined by black scales; the other on the hw and the two corresponding atrophied fw veins are indicated approximately by thin, black dashed-lines.

influence pattern-elements. As indicated, one atrophied vein runs simply from the wing-root to the margin between the developed veins r2/p2 and r3/p3. The other runs from the wing-root, between developed veins r3 and r4, part way to the wing-margin. Where this atrophied vein ends, there are some small transverse veins. The space around the atrophied vein, bounded by veins r3 and r4 and by the small transverse veins is named the **wing-cell** or **cell**. The small transverse veins at the end of the cell are called the **disco-cellular veins**. The exact arrangement of trachea and lacunae at the cell end is complicated: there are atrophied lacunae that, in the primary system, connected the medial vein to p5 and p6 plus some newer short lacunae that link up r3 and r4 to p5 and p6 in the secondary system. This complex of veins is labelled vein dc, for simplicity.

There is also the bounding lacuna, originating from the primary system, around the periphery of the wing. None of the atrophied veins is numbered.

The forewing-veins correspond to the hindwing-veins with two main differences. The first root-vein is absent, so the four developed root-veins are labelled r2 to r5 and correspond structurally to r2 to r5 on the hw. Secondly, vein r4 has several more branches towards the costa than does vein r4 on the hw. Thus there may be up to twelve veins at the periphery. The number of branches does, however, vary between families, and even between species in the same family. In the illustration there are eleven developed veins, which is normal for the Pierinae (Whites).

As regards the peripheral veins, the first seven on the fw correspond to veins p2 to p8 on the hw (as already remarked, there is no vein r1 and therefore no vein p1 on the fw). There is no correspondence between the next 2, 3 or 4 (depending on species) veins, these being the extra vein branches on the fw. The final peripheral vein on the fw, being root-vein r5, does correspond with the hw.

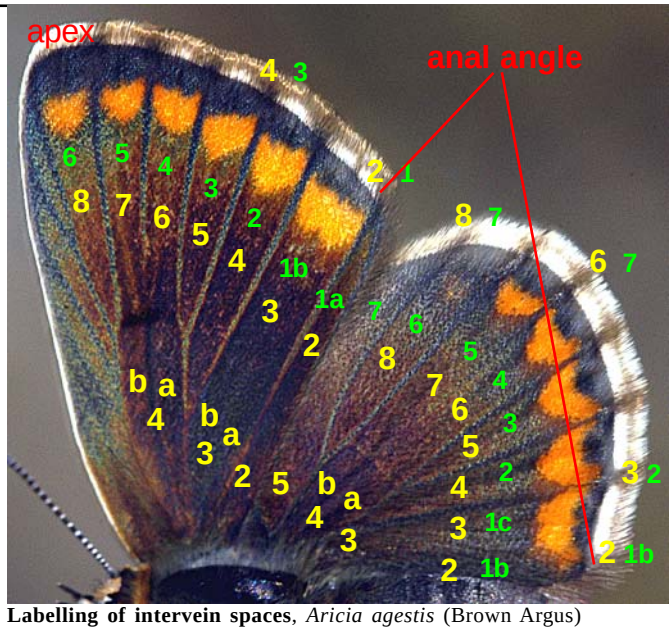
Thus, consistency of notation between wings is achieved by designating the first seven peripheral fw veins as p2 to p8, and the last peripheral vein as r5 along its whole length from root to periphery. In fact this vein usually intersects the costa fairly far from the fw apex, so the use of r5 along the whole length is not inappropriate. This, of course, leaves several peripheral veins unnamed, lying between p8 and r5, but being relatively minor branches below the costa it is rarely necessary to pick one out individually. I shall name them collectively the **antecostal veins** (a more natural name would be subcostal, but that name is used for fw vein r4 in some notations).

The atrophied veins on the fw correspond to those on the hw, and are not numbered.

It is important to stress that the numbering system used here differs from the existing conventional system of numbering, as described by Higgins and Riley (1981) or Nijhout (1991).

To compare the two systems (present system first):
hindwing, veins p1, p2, p3, p4 to p9 are v1a, v1b, v2, v3 to v8;
forewing, veins p2, p3, p4 to p8 are v1, v2, v3 to v7.

The conventional system uses names instead of numbers for the root-veins.



Labelling of intervein spaces, *Aricia agestis* (Brown Argus)

The present notation for labelling spaces between the peripheral veins is marked in yellow. The notation it replaces is shown in green. A few peripheral veins are also labelled in a similar way. Space 1 on the hw is hidden by the body. Space 4 (4a and 4b) in the basal region is the cell.

Intervein Spaces

It is the notation for the intervein spaces that really matters in identifying pattern-elements. I shall number spaces rigorously according to their anterior vein (the vein in front of the space in question). In the conventional system spaces are usually, but not invariably, labelled according to the posterior vein, as illustrated.

The inconsistencies of the conventional system are:
on the hw, veins v1b, v1a (concealed) and none-existing are posterior to spaces s1c, s1b and s1a (concealed);
on the fw, v1 and none-existing are posterior to s1b and s1a.
Thus the labelling of spaces does not match the labelling of the veins.

The conventional system also lacks internal consistency between the wings, since spaces s1c and s1b on the hw correspond to spaces s1b and s1a on the fw.

The conventional system also suffers the inconvenience of not having a numerical system for labelling spaces near the root, even though pattern-elements are often found there.

The conventional notation can also be inconvenient in one other particular, when it comes to real spot patterns. The atrophied vein between p2 and p3 often splits pattern-elements in this space. When this happens, it is easy to develop the present notation to label a twin pair of pattern-elements in space s3 as 3a and 3b. In the conventional notation the corresponding unsplit spots are numbered 1c on the hindwing and 1b on the forewing, and there seems to be no felicitous development of this notation to distinguish members a split pair. This point is better appreciated in the context of real patterns, discussed in the sections on the various subfamilies.

Lycaenidae: Introduction to Structure etc.
The following subsections will first describe some aspects of structure and wing-patterns common to the whole family, and then deal in turn with matters that are more pertinent to each subfamily, where the main thrust concerns wing-patterns. An important aspect of this is to introduce a nomenclature and a notation for the various pattern-elements which crop up frequently in various species. These will be used repeatedly and consistently in the Group Chapters without being redefined.

As it turns out, it is possible to discuss the Lycaeninae, Theclinae and Riodininae relatively briefly, based on the description and notation developed for the Polyommatinae.

Certain topics are general to all families and accordingly are discussed in the General Introduction:

the names of the regions and edges of the wings;

the notation for labelling the veins;

androconia;

ground-colour.

Lycaenidae: Tails
A number of Lycaenidae spp have a tail on the margin of the hw. When only one properly-developed tail is present on Lycaenidae spp (but not necessarily in other families), the tail is situated always where vein p3 meets the wing-margin, see p. 9.

Lycaenidae: Androconia
The males of some species have very obvious patches associated with androconia in the basal region of the upfw, stretching into the discal region. These patches generally have a rough and hairy look, because of the size, shape and orientation of the androconia and are particularly useful for separating the sexes of those *Agrodiaetus* spp whose males have brown uppersides (Anomalous Blue Group, ch. 5.5). Such a patch will be referred to as an **androconial patch**.

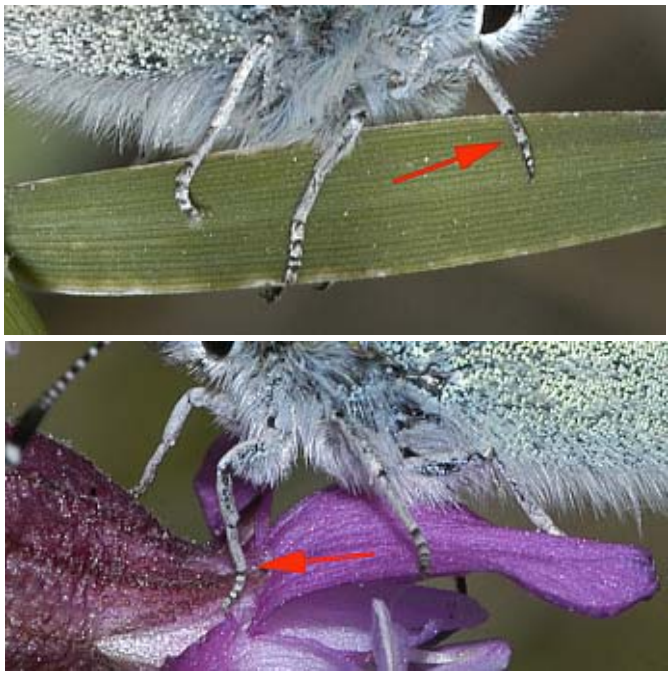
Lycaenidae: Ground-colour
The ground-colour is not entirely uniform in many cases. In particular, on the upss of many female Polyommatinae spp, there is a mixture of dark scales and blue scales which may be referred to as a **blue suffusion** on a dark ground colour or *vice-versa*. On both sexes, there is often blue scaling on the ground-colour in the basal region of the unhw, referred to as a **basal blue flush**.

Lycaenidae: The Legs
Butterfly legs have been described generally for all species in the General Introduction, but because the legs differ visibly in males and females of Lycaenidae spp they can be very helpful in distinguishing the sexes, even from photographs.

The tarsus on the male's foreleg is shortened compared to the female, has lost its articulation and the tip is a simple point. The midlegs and hindlegs of the male and all legs of the female are normal. As may be seen in the illustrations, the normal tarsus has five segments of which the one nearest the tibia is relatively long so the flexibility is mainly in the remoter half of the tarsus.

The illustrations are taken from good-quality, normal pictures, i.e. the pictures originally included the whole butterfly and so were not of unduly high magnification. The sexual dimorphism of the foreleg tarsus, however, is obvious. The particular points to look for are: flexure in the female tarsus, often resulting in it being convex towards the butterfly's body; a tarsus with a rather square end in the female, and a pointed end in the male; and a short rigid tarsus on the male that is *always* slightly convex away from the body, and which, taken as a whole, looks like certain Crustacean legs.

It is clear that normal pictures which show the legs can be used to identify the sexes unambiguously. But, it can be the case that good pictures of legs are bad pictures of wings, so sometimes one gains a lot by taking several pictures of one insect.



Sexual dimorphism in the foreleg tarsus of the Lycaenidae

The arrows point directly at the centre of the foreleg tarsus of a male (upper) and female (lower) *Scolitantides* (Baton Blue Group) sp, ch. 5.11.

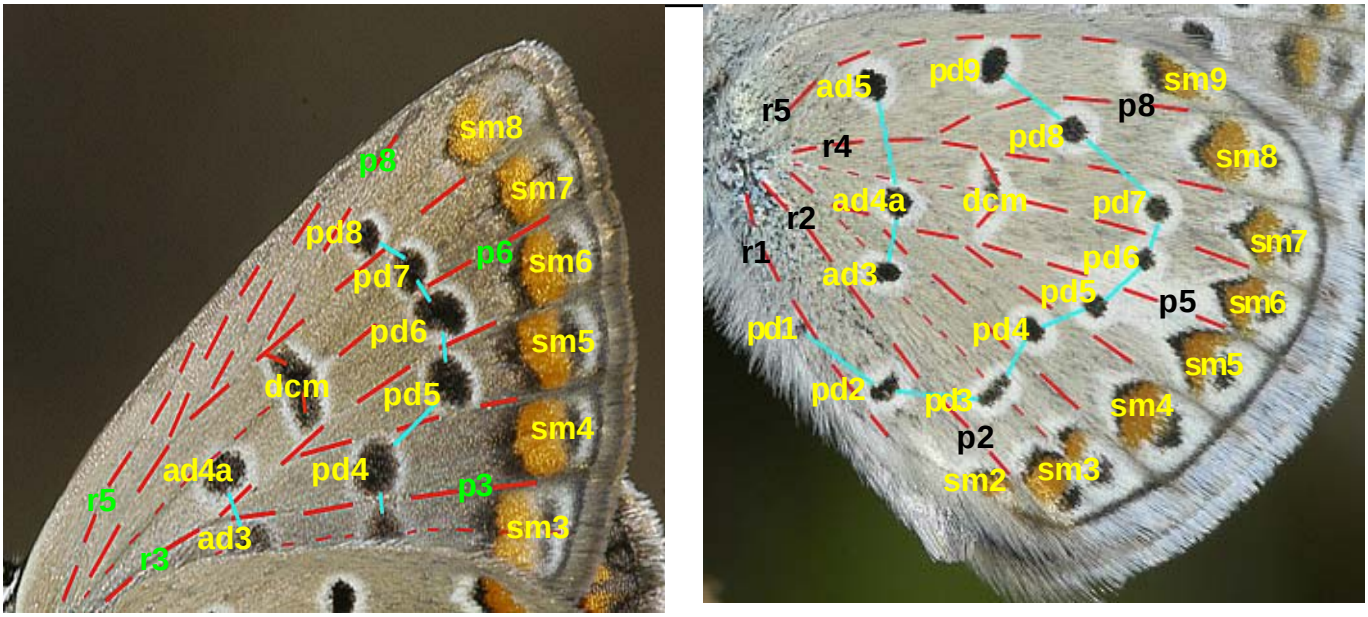
Polyommatinae (Blues): Introduction to Wing-patterns
It is possible to relate the wing-patterns of the Polyommatinae spp to a basic set of pattern-elements described in the following subsections. The differences between various species arise because corresponding basic elements can differ in size and shape etc. or can be absent. Some imagination is required, however, to accommodate the species in the Tiger and Long-tailed Blue Group, ch. 5.16, into a common scheme.

Polyommatinae: Intervein Pattern-elements, Under-hindwing
The basic unfw and unhw pattern-elements correspond to a considerable degree. The underside illustrations, shown on the next page, are chosen to show as far as possible a complete set of basic Polyommatinae pattern-elements.

Veins are always notated with a single letter plus a number, and spots etc. by two letters plus a number if they are in a row and by three letters if they are an isolated feature.

Because the veins are roughly radial, the pattern-elements lying between the veins are organised into roughly transverse rows. Within each row the elements are similar in character.

Wing-pattern Analysis **Introduction to Lycaenidae**



Pattern-element and vein notation, Polyommatinae (Blues) spp

Pattern-element (yellow) prefixes etc: **ad** - antediscal; **pd** - postdiscal; **sm** - submarginal; and **dcm** - disco-cellular mark. Vein (green or black) prefixes: **r** - root veins; and **p** - peripheral veins. Developed veins - red dashes. Atrophied veins, shorter and thinner red dashes. The pale-blue lines link postdiscal and antediscal spots. To avoid confusion, only a few veins are labelled. The numbers of the unlabelled veins are obvious by inter- or extrapolating the numbers of those marked (atrophied veins are unnumbered). Both pictures are of *Polyommatus icarus* (Common Blue), ch. 5.1.

Just inside the wing-margin there is a **submarginal (sm) band** consisting here of a series of eight **compound elements** between developed veins. The elements are labelled sm1 to sm9, the number corresponding to that of the peripheral vein immediately anterior to the element in question. Element sm1 is hardly ever present. Each compound element, when fully-developed, is composed of a central orange mark and two black marks lying respectively inside and outside the orange mark. In the present case there are also white marks, respectively inside the inner black mark and outside the outer black mark, but in general the white marks are variable in relation to the black marks. The black and white marks will be referred to as the **submarginal inner [outer] black [white] marks**, or variants using pale and dark.

The submarginal inner white marks are very well-developed on some species and have the appearance collectively of a prominent white belt, referred to as the **ante-submarginal white belt**.

Element sm3 has two roughly mirror parts created by the atrophied vein that bisects it. This double element may be referred to as the **anal element**, and when necessary its components are labelled sm3a and sm3b, the latter being anterior (i.e. further forward) to the former.

Somewhat further from the margin, lying in the same spaces between the peripheral veins as the submarginal elements, is a series of spots, nine in number here. These are the **postdiscal spots**, collectively referred to as the **postdiscal (pd) row**, as indicated. Generally, the spots are roughly circular roundels of black with a white outline. Spot pd1, nearest the inner wing-margin is, as here, generally less well-developed and, as mentioned, rarely has a corresponding submarginal element sm1. The effect of the atrophied vein is evident in the distortion of the spot pd3, which lies inside the anal element. Sometimes this spot may be split, and would then be pd3a plus pd3b.

The second row of spots, further yet from the submarginal band, is the **antediscal (ad) row** composed of **antediscal spots** lying between the root veins, as indicated. It has 3 spots in the illustration, similar in appearance to those in the postdiscal row. (It might seem appropriate to name this the basal row, but this name is better reserved for a further row of spots inside the antediscal row, which exists on the Lycaeninae (Coppers), see later). The antediscal spots can be numbered relative to the root veins in a way that corresponds to the system used for the postdiscal spots relative to the peripheral veins. Thus, the three spots shown are ad3, ad4a and ad5. Spot ad4b, when it exists, lies in the anterior half of the cell and if spot ad3 is split by the atrophied vein (General Introduction) it would become ad3a and ad3b. Spot ad4b is usually absent in Polyommatinae spp.

It follows from the notation that ad3 is always directly basad of pd3. Other ‘in-line’ pairs are ad4a and pd6, ad4b and pd7, and ad5 and pd9.

Polyommatinae: Intervein Pattern-elements, Under-forewing

Some small differences between the forewing and hindwing underside patterns arise mainly from differences in venation.

The absence of vein r1 on the fw means there can never be a spot pd1 nor an element sm1; and in practice spot pd2 and element sm2 are rarely developed. Thereafter, spots pd3 etc. and elements sm3 etc. correspond to those on the hw. Spot pd9 and element sm9, however, are usually absent because the antecostal veins on the fw cramp the space where these pattern-elements would occur and their development is thus inhibited.

As regards the antediscal spots on the fw, spots ad3 and ad4a may exist, but ad5 is almost invariably absent because of the antecostal veins. When present, spot ad4a is the unfw **cell-spot** which is occasionally double when ad4b exists.

Polyommatinae: Supervein and Linear Pattern-elements

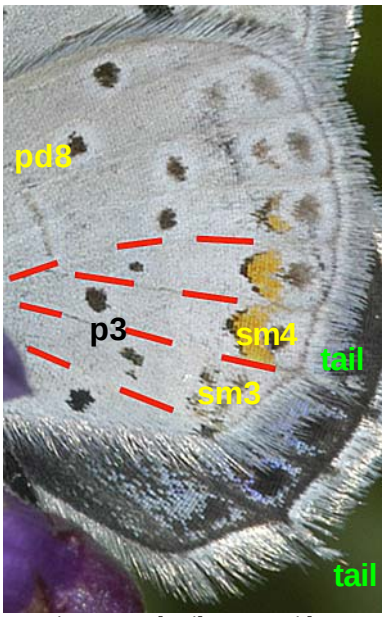
As regards pattern-elements lying on the veins, probably the most important is the dark mark with an irregular white outline situated on top of the disco-cellular vein at the end of the cell. This has been variously named the discal (or discoidal or disco-cellular) spot (or fleck or mark). I shall refer to it as the **disco-cellular mark (dcm)**; disco-cellular to emphasise that it lies on the disco-cellular vein, and mark because I shall reserve 'spot' for roughly circular elements, and 'mark' for less regular shapes.

Another important pattern-element is the extended white region lying inside the submarginal band between elements sm5 and sm6, and extending inwards between spots pd5 and pd6. This is often called the **white flash**, and is loosely situated on vein p5. In a number of species, the flash is narrow and elongated, lying nearly along the full length of vein p5/r3 to reach the basal region. Then it is better named the **white stripe**. The white flash and white stripe are essentially unhw pattern-elements, though something like the white stripe crops up on the unfw occasionally.

There is a tendency for triangular black marks to form on the ends of the veins at the wing-margin. These marks are oriented to point inwards between each submarginal element. Sometimes the resulting row of **vein-end marginal marks** may be of significance.

Commonly, developed and atrophied veins attract lighter or darker scales. The vein notation itself can be used to label such features. The dark **marginal line** is produced by dark scales aggregating on the atrophied bounding lacuna.

Sometimes dark scales produce lines along the midlines between the veins (see the picture of a Hairstreak unfw on p. 9). These **dark midlines** can be recognised because they bisect the postdiscal spots and submarginal elements (but postdiscal spot pd3 and submarginal element sm3 may be dissected by an atrophied vein).



Erratic spot and tails, Lycaenidae spp

Labelling as before. The erratic spot is pd8. The insect is *Cupido argiades* (Short-tailed Blue), ch. 5.14.

Although **wing-fringes** are often white in the Polyommatinae spp, it is not uncommon for them to be wholly or partly brown, as shown in one illustration. The fringes may also be **laddered** in a darker colour around the projections of the vein-ends, i.e. there is a transverse row of repeated pattern-elements of pale and dark colours in the fringe (this is often called chequering, but this word more properly refers to a two dimensional alternation of colour).

Polyommatinae: Upperside Wing-patterns

Generally, the uppersides of Polyommatinae spp, especially males, have far fewer pattern-elements than their undersides. Those elements that appear are, in the main, a reduced set of the underside elements and no extra notation is needed, except for the two following minor developments.

The veins are often lined black, especially toward their ends in the submarginal region. This may be termed **[submarginal] vein-darkening**.

The dark margin often diffuses inwards to form quite a broad feature. It is convenient to refer to this as the **wing-border**, whether narrow or not.

Polyommatinae etc: Landmark Features

It can be difficult to identify exactly which pattern-element is which in worn or partly visible insects. When necessary, however, one can often navigate from a few 'landmark' features.

The disco-cellular mark is present on the uns of most Polyommatinae spp and is easily recognised. It lies between the antediscal and postdiscal rows, and helps to identify the cell end. Radially beyond the middle of the disco-cellular mark is vein p6 which lies between spots pd6 and pd7, and then between elements sm6 and sm7.

Element sm3, the anal element, usually shows distinct signs of incipient division and so can be recognised. Other submarginal elements and the corresponding postdiscal spots may then be identified by counting. Alternatively, when the submarginal band is poorly-developed, the anal element is still usually present, so spot pd3 can be identified and hence the other postdiscal spots, but care must be taken counting along the postdiscal row because some spots can be absent.

Spot pd8 on the unhw is often anomalous: in several Polyommatinae spp it is positioned out of line with its neighbours and towards the wing-base, as illustrated; and also, in these and other species, it can be small or absent. For these reasons I shall refer to spot pd8 as the **erratic spot**.

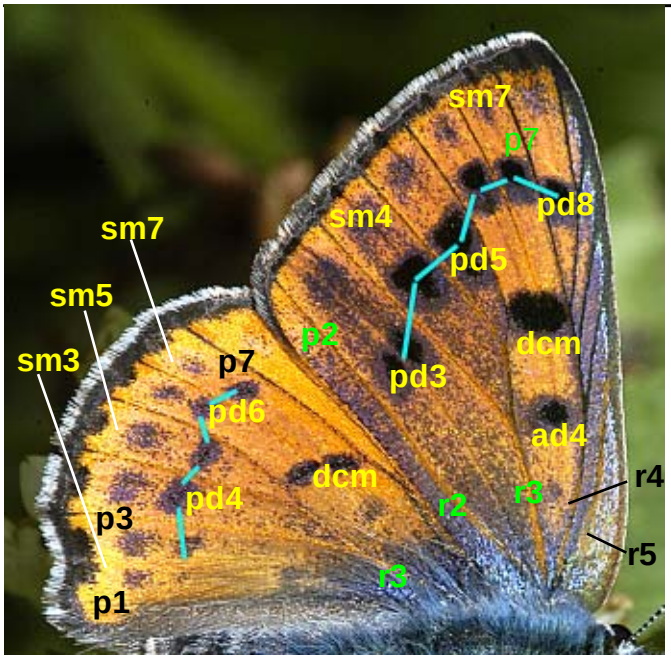
When the erratic spot is out of line with its neighbouring postdiscal spots, it can be identified easily, and is a useful landmark. In these cases, spots pd8 and pd9 may stand roughly perpendicular to the hw costa and the pair are then referred to as the **colon-mark**. In the illustration, the erratic spot is too far forward to produce a proper-looking colon-mark.

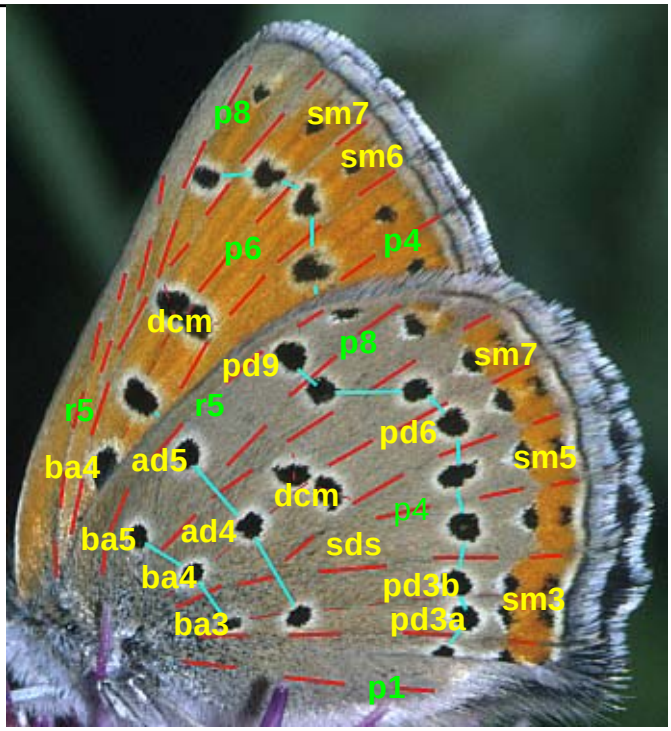
Vein p2 meets the wing-periphery at the anal angle, the point where the margin and inner margin meet. Thus the anal angle can be used to identify vein p2.

When present, a **tail** on the hw is a more striking feature than the anal angle and it identifies where vein p3 meets the wing-margin, as illustrated (see also p. 9). More care is needed, however, with some species which have a series of kinks in the hw profile at p2, p3 etc. and associated scallops.

As reflected by their names, the rows of spots rather conveniently divide the wing-surface into its three major regions: the **basal region** from the thorax to the antediscal row; the **discal region** between the antediscal and postdiscal rows; and the **submarginal region** between the postdiscal row and the outer wing-margin. It may be noted that the disco-cellular mark is roughly in the centre of the discal region.

Wing-pattern Analysis **Introduction to Lycaenidae**





Wing-pattern notation, Lycaeninae (Coppers) spp

The same notation and labelling as for the Polyommatinae spp (pp 6-7) is used here on *Lycaena alciphron* (Purple-shot Copper), ch. 5. 17, with the following additions. Pattern-element prefixes etc: **ba** - basal; and **sds** - subdiscoidal spot, when present. Some veins are labelled in black, for visibility, and the spots in the unhw basal row are, like the other rows, joined in blue.

Lycaeninae (Coppers): Underside Pattern-elements

The uns pattern of the Lycaeninae is rather similar to the Polyommatinae (Blues). The notation used for the latter, already described, can therefore be used here if it is slightly extended to recognise two extra features present on the Lycaeninae: there is an extra transverse row of intervein spots between the wing-root and the antediscal row, referred to as the **basal row (ba)**; and there may occasionally be an extra intervein spot adjacent to the disco-cellular mark, the **subdiscoidal spot (sds)**. This spot is absent in the illustration but its position is marked.

The basal row is present on the uns of most Lycaeninae species and the spots are numbered in the same way as the antediscal spots. In the illustration, ba2 to ba4 exist on the unhw, but only ba4 is visible on the unfw. The existence of these spots reliably distinguishes Lycaeninae spp from Polyommatinae spp.

The subdiscoidal spot is normally present in only one species, *Lycaena tityrus* (Sooty Copper). Its existence slightly confuses the simple arrangement of three transverse rows, but one must recognise that this categorisation does not arise from any basic principle.

The effect of the atrophied veins is often rather large. In the illustration of the unhw, atrophied veins have completely split the disco-cellular mark, postdiscal spot pd3 and the black marks in the anal element sm3. Thus, although extra spots and dark marks commonly appear in the Lycaeninae, these are not a fundamental development. The notation labels the split postdiscal spot as pd3a and pd3b and the split anal element as sm3a and sm3b.

The elements of the submarginal band on Lycaeninae spp have the orange and black marks present on Polyommatinae spp, but the overall appearance is quite different. On the unhw, where the submarginal band is well-developed in most species, the submarginal orange marks are usually joined up to produce an orange belt of nearly uniform width, while the inner and outer black marks remain as discrete marks between the veins and, of course, lie inside and outside the orange belt.

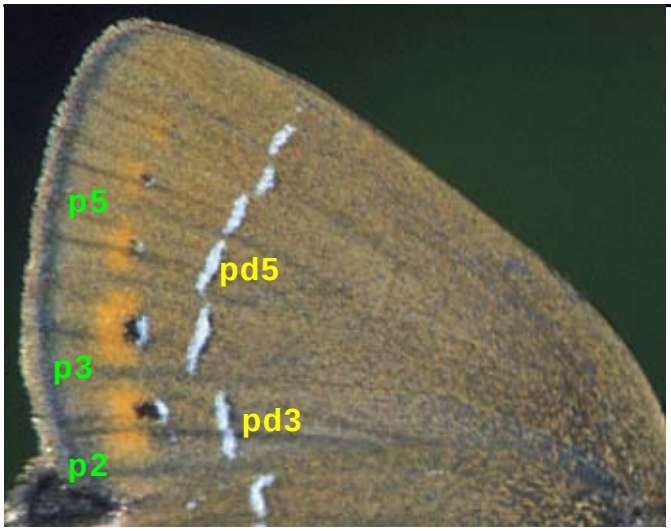
Lycaeninae: Upperside Pattern-elements

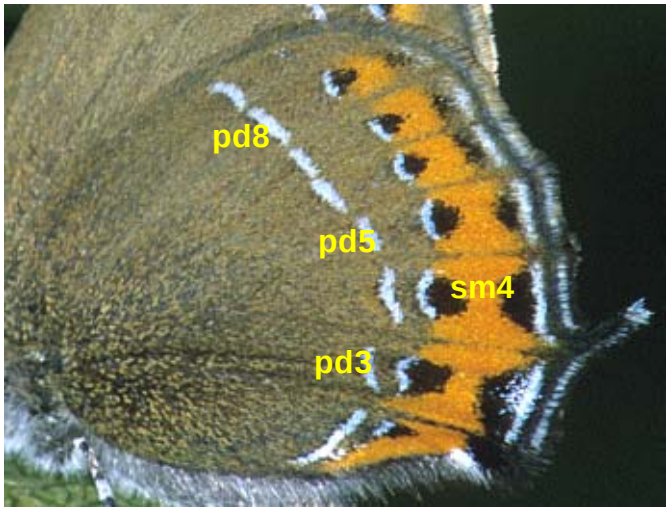
Commonly, the upperside wing-patterns of females and sometimes of males (as illustrated) have a considerable number of dark pattern-elements. Those present correspond to various of the uns elements, but are less sharply-defined in general.

The illustration shows a fairly complete postdiscal row and disco-cellular marks on both wings. There is one antediscal spot in the cell and a trace of a basal spot, too, on the upfw. On the uphw there is a vaguely-defined antediscal spot in the cell.

As regards the submarginal band, on the uphw it consists of outer black marks at the margin fused to the dark border, well separated from smudgy inner black marks with brighter orange in the space between. On the upfw, all that exists is the row of smudgy inner black marks.

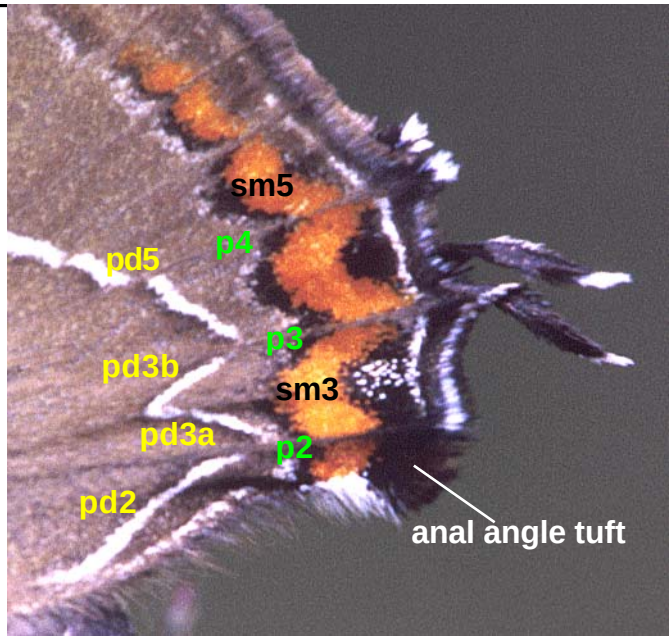
Often females, and sometimes males, have an extensive dark suffusion on the ups that obscures the dark marks of the wing-pattern. In males, the structure of the dark scales is often responsible for a violet gleam.





Hairstreak details

The upfw and unhw of *Satyrium pruni* (Black Hairstreak), ch. 5.19, is partially labelled with a notation based on that developed for the Polyommatinae spp, p. 6-7. The unfw has some dark midlines referred to on p. 7 and below.



Wing-pattern details of some Theclinae (Hairstreaks)

Various pattern-elements in the unhw tail region of female *Satyrium w-album* (White-letter Hairstreak), ch. 5.19, using the usual notation.

Theclinae (Hairstreaks): Introduction to Wing-patterns

There is no characteristic pattern-element common to all species in subfamily Theclinae, but ten out of the thirteen in Europe have the **hairstreak**, a transverse white stripe on the uns of one or both wings. The remarks that follow apply mainly to the *Satyrium* spp in the Black Hairstreak Group, ch. 5. 19, and the *Callophrys* spp in the Green Hairstreak Group, ch. 5. 21.

European species have certain underside wing-pattern-elements that correspond to those of subfamily Polyommatinae (Blues). It is therefore appropriate to use the same notation for these homologous pattern-elements: the uns submarginal bands, broadly similar in appearance in both subfamilies; and the uns postdiscal rows of what are white dashes on the Theclinae and are spots on the Polyommatinae. It is these white dashes, more-or-less joined up to create the impression of a white line, that are the hairstreak.

Theclinae: Pattern-elements

Following the notation developed for the Polyommatinae spp, the submarginal elements are naturally labelled sm2, sm3, sm4 etc., as illustrated. Similarly, the series of white dashes which make up the hairstreak are labelled pd2, pd3, pd4 etc., as illustrated.

Care must be taken, particularly on the unfw, to distinguish the line of the veins from the dark midlines that can be equally prominent in places. There is no problem if one recognises that veins lie between the white dashes of the hairstreak and between the submarginal elements.

The features of particular interest in the present subfamily often lie on the unhw in the vicinity of the anal angle.

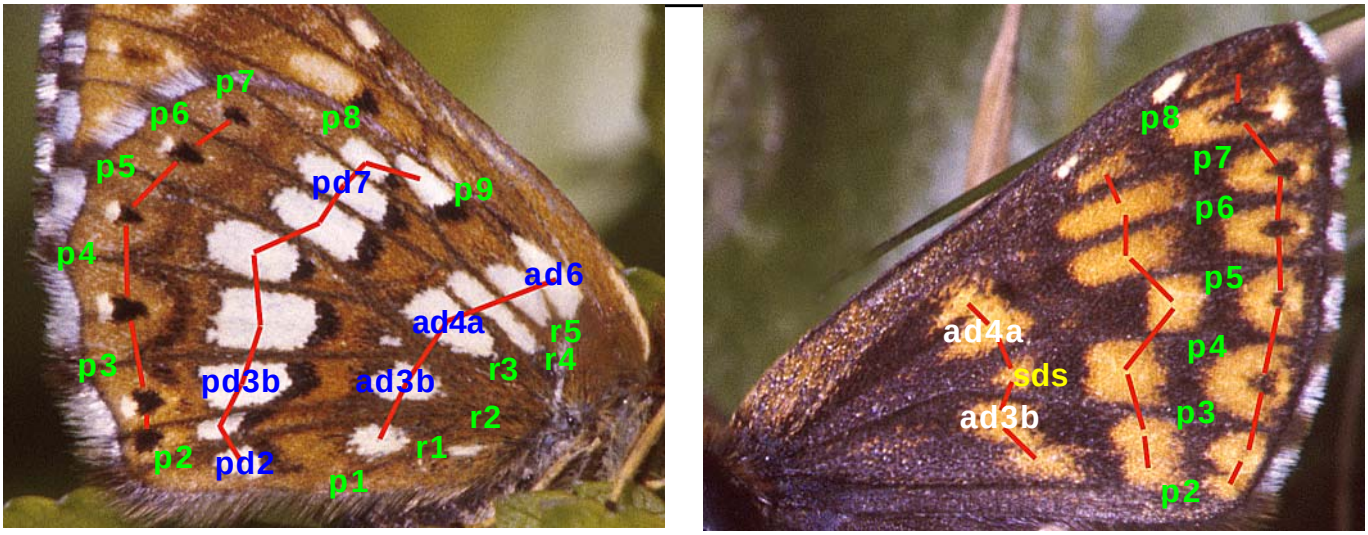
The atrophied vein lying between developed veins p2 and p3 often has a pronounced effect on the postdiscal dash pd3 on the unhw. In the illustration of *S. w-album*, this dash is divided into two parts, pd3a and pd3b, pointing in very different directions to form an inward pointing V. Also, the atrophied vein makes the submarginal element sm3 asymmetrical in some species, but this is not the case in the illustrations.

The outer white marks in the uns submarginal bands are dash-like, and lie close enough to the wing-margins to form what look like distinct, white lines along the wing margin of some species, as illustrated. The exception to this is that the outer part of element sm2 consists of a black tuft which breaks up the marginal white line. I shall call this the **anal angle tuft**, so as to avoid any confusion with the black tip on the abdomen of female *Satyrium acaciae* (Sloe Hairstreak).

There is almost always a tail at the end of vein p3, and sometimes, as illustrated on *S. w-album*, a second smaller tail at the end of vein p4.

A number of species have more or fewer uns pattern-elements, which will be described in the appropriate species sections.

Wing-pattern Analysis **Introduction to Lycaenidae**



Wing-pattern notation, some Riodininae (Metalmarks)

The red lines connect spots in the antediscal and postdiscal rows, and dark marks in the submarginal band of *Hamearis lucina* (Duke of Burgundy), ch. 5.22. On the upfw, the red line along the antediscal row is drawn through what is probably a subdiscoidal spot, sds (see p. 8), which is not strictly a member of the antediscal row. A selection of spots are labelled in blue or white or yellow, and the veins in green.

Riodininae: Introduction to Wing-patterns

The wing-pattern of the European species is recognisably related to the Polyommatinae (Blues) spp and Lycaeninae (Coppers) spp, already described.

On the unhw, the two rows of large, white marks and the submarginal marks can be named the antediscal row, the postdiscal row and the submarginal band, by analogy with apparently corresponding rows etc. on the Polyommatinae spp and Lycaeninae spp. Presumably the rows etc. on the latter subfamilies and on *Hamearis lucina* (Duke of Burgundy) have a common evolutionary ancestry, i.e. are homologous.

Riodininae: Pattern-elements

Looking at the pattern in detail, the unhw submarginal elements consist of a dark triangular mark with a white edge on its outer side plus a more-or-less-developed curved dark mark on the inner side. These marks are reminiscent of the submarginal outer and inner black marks and the outer white marks commonly found on the unss of Polyommatinae spp, where often they have an orange mark sandwiched between them.

The notably large and numerous unhw white marks correspond to postdiscal spots pd2 to pd9, and antediscal spots ad2, ad3b, ad4a, ad4b, ad5 and what will have to be named ad6, i.e. the large, white mark lying between vein r5 and the wing-costa. In contrast, there is no discernable disco-cellular mark. Because the atrophied vein between developed veins p2 and p3 is close to vein p2, mark pd3 is split quite asymmetrically with mark pd3a much smaller than pd3b. For the same reason mark ad3a is absent.

The upfw pattern is similar to that on the unhw in so far as it consists of the same three main rows etc., but here they consist of orange marks, with the submarginal band containing black, roughly-triangular marks within the orange. The elements in the submarginal band extend to sm9, in the space beyond vein p8. As indicated, the antediscal row consists apparently of five orange marks. Counting from the inner wing-margin, the first two correspond to spots ad3a and ad3b, roughly equal in size because on the fw the atrophied vein lies roughly half way between veins p2 and p3. The fourth and fifth marks, shaped like a pair of inward pointing arrows-heads, lie in the cell between veins r3 and r4, and are thus marks ad4a and ad4b. Strictly, the mark in the middle of the row is not in the antediscal row because it lies in a space between veins which have branched: it corresponds, in fact, to the subdiscoidal spot referred to in connection with the Lycaeninae spp, particularly *Lycaena tityrus* (Sooty Copper) where it is restricted to the unhw, p. 8. There is a corresponding small unhw white mark on *H. lucina*, too.

The other interesting features are the pale, elongated marks on the upfw between the antecostal veins, which are conveniently named the **antecostal marks**.

As will be seen, the uphw has a reduced pattern along the above lines and the unfw is roughly similar to the unhw. The latter wings are less often seen in their entirety in photographs.

The reduction in size of the male foreleg means that it is not easily seen in photographs, and males often seem to have just four legs. The small precostal vein on the hindwing cannot normally be seen in photographs.