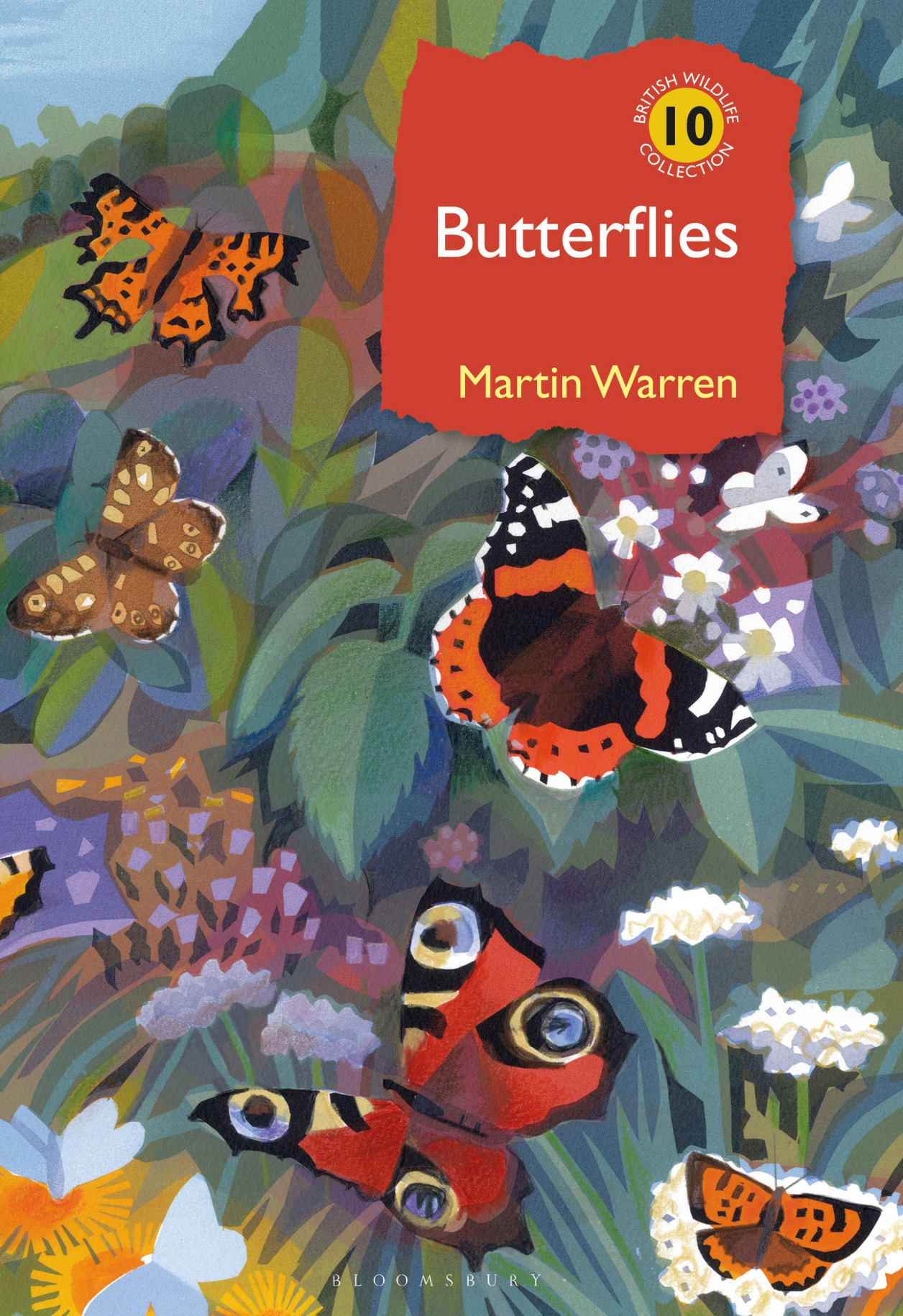
BRITISH WILDLIFE
10
COLLECTION
Butterflies
Martin Warren
BLOOMSBURY

# Butterflies

BRITISH WILDLIFE COLLECTION 10

# Butterflies

## A natural history

Martin Warren

BLOOMSBURY WILDLIFE
LONDON • OXFORD • NEW YORK • NEW DELHI • SYDNEY

To Dee, Richard, Jenny and Rachael

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HALF TITLE: Small Blue.
FRONTISPIECE: Swallowtail.

# Contents

# Preface

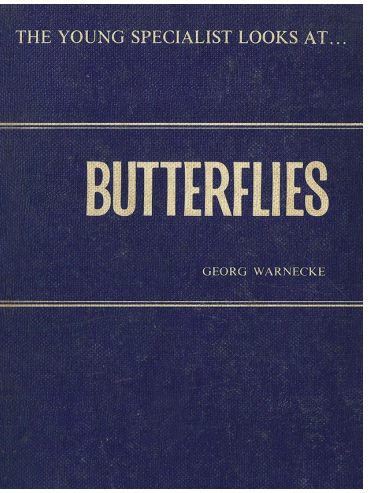
A common misconception about butterflies is that they are dainty, fragile creatures, blown about by the wind and at the mercy of the elements. Down the ages, they have often been seen as vaguely otherworldly, as if they come from a spirit world beyond the earth. The Greeks named them *psuche*, our 'psyche', which is the same word as the Greek for mind or soul. In our own age, 2,000 years on, their delicate beauty seems to symbolise the vulnerability of the natural world in the face of the juggernaut of humanity.

In this book, I will show that butterflies are not, in fact, particularly fragile, or at least no more than any other insect. They are, rather, tough survivors in a highly competitive world in which a myriad of other species regard them as food. Butterflies are the culmination of millions of years of evolution, with each species finely honed to its environment. Every stage of their life-cycle, from egg, to voracious caterpillar, to dormant chrysalis, to winged adult, has, in effect, been perfected.

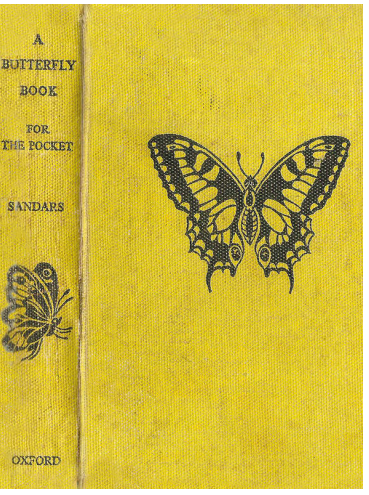
I became fascinated by butterflies and moths as a young child. But at first it was not the adults that excited me as much as the caterpillars. I found hairy 'woolly bears', looping 'inch-worms', spiny ones, bobbly ones, even caterpillars with little tussocks and brushes studded along their backs. All of them captured my imagination and drew me into their miniature world. I collected them in pots and cages, found the right plants for them to feed on, and watched each caterpillar grow and finally turn into a chrysalis. I remember, too, watching breathlessly, as my first butterfly struggled from the dry skin of its chrysalis to unfurl its wings and fly. I felt curiously honoured, the boy explorer of a new world.

Most of my caterpillars turned out to be moths. But I didn't care. I collected and reared as many kinds as I could. Watching the adults emerge was as exciting as opening a present at Christmas. To me they made the perfect pets. No cat or dog would transform itself before my

**OPPOSITE PAGE:**
Chalk Hill Blues basking in the evening light before roosting.




My early inspiration came from books like *The Young Specialist Looks At Butterflies* by Georg Warnecke (1964) and *A Butterfly Book for the Pocket* by Edmund Sandars (1939).




very eyes and turn magically into such a beautiful creature. No other captive animal offered the wonderful variety of butterflies and moths. I felt as proud as a parent as each one emerged and took its freedom.

To begin with, my bibles were *The Young Specialist* book on butterflies and Edmund Sandars' *A Butterfly Book for the Pocket*, although I soon graduated to *The Observer's Book of Butterflies* and *The Observer's Book of Larger Moths*, and then on to more grown-up books. They told me a little about rearing caterpillars and a bit about their intricate life-cycles. But the details were sketchy at best, and I had to learn the hard way, by trial and error. Of course there were casualties, but each failure spurred me on to do better next time, and learn more about my craft. For example, I remember my disappointment when a plump little moth emerged from its cocoon with what I thought were deformed wings. But, as it turned out, the moth was perfectly healthy. It was a female Vapourer moth, which is naturally wingless (in fact it has vestigial wings that are incapable of flight). A harsher lesson happened when a caterpillar erupted into clusters of white parasitic cocoons. But my initial horror turned to fascination as I read about the life of these tiny flies which lay their eggs inside an egg or caterpillar and feed inside the living body until ready to burst out, alien-like, from the dying host.

It was not long before I began to gravitate towards butterflies. They were easier to see than moths, especially when they gathered to feed on the large Buddleja bush in the garden: including colourful Peacocks, Small Tortoiseshells, Red Admirals. I found other butterflies as we walked the chalk hills near my home in Dunstable, Bedfordshire. I was lucky to have a mentor in an elderly neighbour who owned an impressive hoard of bird eggs (gathered in the days when bird-nesting was still legal) as well as a collection of pinned butterflies and moths. Under his guidance I made a small collection of my own, trying to get a male and female of each species. With my two chums, Bob and Barney, I scoured the downs and lanes in search of new species. As Peter Marren remarks in his eulogy to butterflies, *Rainbow Dust* (2015), we were the last generation to collect butterflies with a clear conscience. Today the net and the killing bottle have long since been replaced by the camera.

My collecting phase was short-lived. For me, dead butterflies were no match for living ones and I began to travel further afield in search of more exotic species. In time, this childhood crush turned into a fascination for butterflies that has lasted my whole life. By great

good fortune I was able to turn it into a career. When I graduated in zoology at Imperial College London, I had first thought of a medical career. But instead, partly inspired by Rachel Carson's *Silent Spring* (1962), I became interested in conservation and completed a master's degree in that subject at University College London. The job prospects for conservationists at that time were very limited, but I was undaunted. Luckily for me, I spotted an advert for a PhD on the Wood White butterfly, based at Monks Wood Experimental Station near Huntingdon, run by the Nature Conservancy Council (NCC), the government advisory body for conservation. I like to think that my know-how in rearing butterflies came in useful at the interview. I landed the job and, in 1976, I moved to Monks Wood.

The station had been set up in 1963 primarily to study the effects of pesticides on wildlife. The single-storey building was situated next door to a wood of the same name that has long been famous for its butterflies, and was now a National Nature Reserve. Butterflies were firmly on the scientific agenda at Monks Wood. Eric Duffey was looking into the ecology of the Large Copper, reintroduced to the nearby Woodwalton Fen. Jack Dempster was studying our largest butterfly, the Swallowtail. My predecessor at Monks Wood, Jeremy Thomas, had based his PhD thesis on the Black and Brown Hairstreaks, and had recently moved to Furzebrook Research Station in Dorset to study the Large Blue. The station also hosted the Biological Records Centre, and was in the process of publishing the first atlas of British butterflies, masterminded by John Heath.

Scientists at Monks Wood had begun the first-ever Butterfly Monitoring Scheme, initiated by my supervisor Ernie Pollard. One of my tasks was to validate the new method, which consisted of simply counting butterflies every week along a fixed route, known as a transect. Some scientists thought this method was just too simple to provide worthwhile results. But as it turned out, its strength lies in its simplicity. It has been proven to be scientifically valid and yield invaluable data. Not only is the UK Butterfly Monitoring Scheme still running, more than 40 years later, but the same method is used in countries around the world. Butterflies are now regarded as finely tuned indicators of change, and, by assessing their varying fortunes, we gain an insight into the impacts that we humans are making on global ecosystems.

The next assignment, after completing my doctorate on the Wood White, was to investigate another rare and declining butterfly, the Heath Fritillary. At the time, it was thought to be a prime candidate

for national extinction, following the demise of the Large Blue in 1979. By cobbling together some small grants, I raised enough funds to survey the last populations of the Heath Fritillary in Kent and southwest England under the guidance of Jeremy Thomas. Fortunately, we were just in time to save it. When I started my first full-time job with the NCC in 1983, I was able to push a plan to help the butterfly by improving its habitat, both on nature reserves and on private land. This, the first comprehensive conservation plan for any British butterfly, gave us hope that we might do the same for other declining species – of which, unfortunately, there were a great many.

As part of my job as a butterfly specialist, I ran seminars across the UK and conducted a detailed survey of around 300 important sites in southern England known as 'Prime Butterfly Areas'. It gave me an insight into the problems facing butterflies, and the need for the right habitat management to ensure their future. Since those days, I have conducted similar studies of the Marsh Fritillary, High Brown Fritillary, Chequered Skipper and Silver-spotted Skipper.

I was able to put all this experience to good use when I was employed by the charity Butterfly Conservation in 1993 as their first Conservation Officer. I felt privileged to join a group of activists who were passionate about butterflies and moths, and eager to do their best to try and conserve them. Together we started 'Action for Butterflies', a blueprint for conserving every British species. We compiled detailed action plans for all the species most under threat, drawing on expertise from around the country. Implementing the plans by stages enabled us to convert what were then only theories into practice. More than a quarter of a century further on, we are still learning, and my colleagues are now pioneering the conservation of butterflies and moths at a landscape scale. Thanks to a concerted effort by thousands of volunteers, and the help of a plethora of conservation bodies, scientists and sympathetic landowners, we have been able to improve the fortunes of several species.

In this book, I hope to share some of the fascinating discoveries that I and others have made about butterflies. I will also explain some of what we have learned about managing their habitats, and the field craft needed to study them. In short, I have tried to write the kind of book that I would love to have read as a young naturalist, and also to say something that even well-versed and experienced butterfly watchers might enjoy. I hope it provides some insight into how butterflies live, as well as explaining how simple observations can add

to our understanding of their ecology and improve their chances of survival. Despite many decades of study, there are still huge gaps in our knowledge that will keep future generations of naturalists busy. Deeper understanding will be fundamental to enable us to conserve butterflies in an increasingly hostile world. But acquiring more knowledge will only be effective if enough of us care about them. I am forever optimistic that we will continue to do so.

## Acknowledgements

I am deeply grateful to the many friends and colleagues who have commented on the various chapters of this book. My special thanks go to Peter Marren, who was instrumental in honing the concept of the book and its target audience, and who patiently edited the entire text to correct my frequent lapses into jargon and make it more readable. I am indebted to Peter Eeles, not only for checking the whole book for factual errors but for generously donating so many of his beautiful images. I am also deeply grateful to several other colleagues who read through some of the chapters and made valuable comments, including Nigel Bourn, Caroline Bulman, Hans van Dyck, Mark Shaw and Christer Wiklund. Needless to say, any remaining errors are my own.

Many talented photographers allowed me to use their photos within the book, enabling me to detail some of the remarkable life-stages, habitats and behaviours of butterflies: Jim Asher, Andy Brown, Jamie Burston, Richard Carter, Patrick Cashman, Andrew Cooper, Peter Eeles, Nina Fatouris, Neil Freeman, Bob Gibbons, Barry Henwood, Dan Hoare, Neil Hulme, Maria Justamond, Roger Key, Will Langdon, Iain Leach, Stephen Lewis, Vince Massimo, Dave Miller, Yasuhiro Nakamura, Geoff Nobes, Gary Norman, Saskya van Nouhuys, Andrew Fusek Peters, Simon Phelps, Trevor Sawyer, Bas van de Schootbrugge, Marcin Sielezniew, Hans Smid, Chris van Swaay, Keith Tailby, Nick Upton, Christer Wiklund, Bodo Wilts and Ian Woiwod.

I would also like to thank my wife, Dee, not only for putting up with an absentee husband for some of the time while I was writing this book, but also for her patience as I tarried on hillsides, photographing and watching butterflies, and (worst of all from her point of view) for hanging around on cold winter's days while I looked for butterfly eggs. Lastly, I would like to thank the editors at Bloomsbury Publishing for their help and support, especially Katy Roper and David Campbell, and Hugh Brazier for copy-editing.

chapter one

# Why we love butterflies

On a bleak, overcast day in January I make an entomological pilgrimage to London to see a very special butterfly. In the depths of the British Library lies an ancient manuscript and, preserved within it, I've been told, is a faded specimen of a Small Tortoiseshell. It was found half-squashed inside the handwritten pages of *The Theatre of Insects*, by Thomas Moffet (1553–1604), and appears to be the model for a watercolour drawing made around 1592. If so, this specimen is much older than any in the collections of the Natural History Museum. It's possibly the oldest butterfly in the world (apart from ancient butterflies preserved in amber). When it was alive, perhaps visiting Moffet's garden in Wilton, the Spanish Armada was of recent memory, London was suffering one of its periodic outbreaks of plague, and the dramatist Robert Greene was denouncing a certain William Shakespeare as an 'upstart crow'.

After registering and being ushered into the quiet book-lined room, I am presented with the box in which Moffet's manuscript is kept. I open the leather binding and peruse those venerable pages. The handwriting is neat and legible, on hand-ruled lines, but the words are in Latin. The book was never published in Thomas Moffet's lifetime, and it had to wait until 1658 for an English translation, as part of Edward Topsell's wonderfully titled *History of Four-footed Beasts and Serpents*.

Glued into the pages of the manuscript are watercolour paintings, among them our Small Tortoiseshell. They look as bright as the day they were painted, and most of them are surprisingly accurate (far better than the crude woodcuts in Topsell's History). I can identify nearly all of Moffet's butterflies, moths and caterpillars, and I am struck by their quality. More than 400 years ago it seems there were proto-entomologists quite capable of drawing accurately from life.

**OPPOSITE PAGE:**
The Peacock is one of our most dazzling butterflies, with eye-spots that Thomas Moffet described as having 'sparks of the colour of the Rain-bow'.

And, of course, someone needed to search for all those caterpillars, butterflies and moths, and to distinguish one from another. We shall probably never know who did it, but it suggests that there were field naturalists even before there were any nature books.

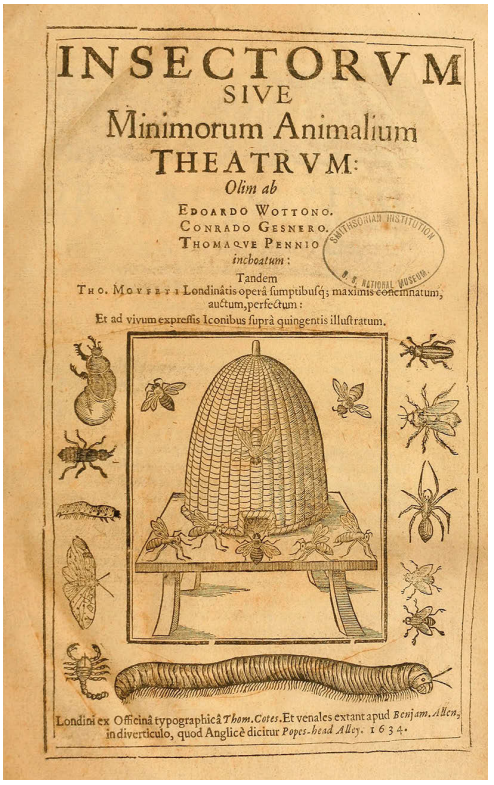
These paintings have never been published, and few people even know of their existence. Even fewer have inspected the actual butterfly, contained within a glassine packet tucked into the manuscript. A handwritten note states that it was found loose among the pages on 18 April 1977. The wings are intact and spread in the sloping style in which early collectors mounted their butterfly specimens. It has lost its head and body, so I could not tell the butterfly's sex. As you might expect, it is worn and almost transparent, with only a shadow of its original colours and pattern remaining. But it is a precious object all the same and, for me, well worth the long train ride. Perhaps it was the very specimen that prompted Moffet's ecstatic description of the Small Tortoiseshell (although in his day it lacked a name):

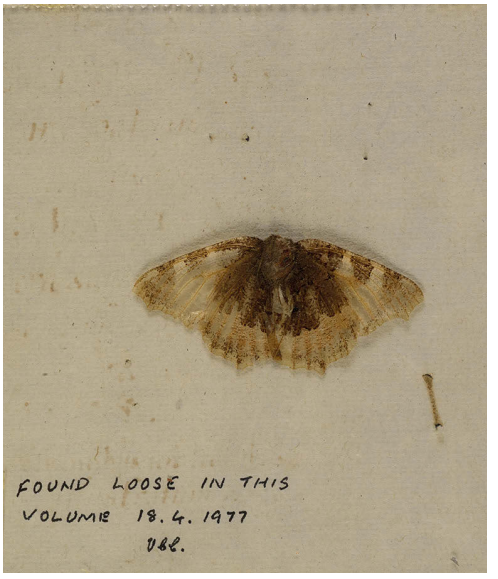
> [The butterfly] *is wonderful beautiful, the wings are light blood-colour, dipt with black spots, they shine with small long beams dispersedly drawn like threads to the very outmost of the coat, and this is adorned within with golden crooked lines like the Moon, being itself a murry* [i.e. mulberry-coloured], *nicked on the sides like a Saw: the body is purple coloured from black, the eyes shine like gold, the feet and horns are black.*

This is not exactly the kind of thing you would find in a modern field guide. It is more of a poetic evocation of a Small Tortoiseshell, in a medley of metaphors and colours. It seems to me that Moffet was not only fascinated by butterflies but positively inspired by their beautiful colours and patterns. Here is another example of his butterfly writing, his bejewelled Peacock:

> [It] *may be said to be the Queen or chief of all, for in the uttermost part of the wings, as it were four Adamants* [diamonds] *glistering in a beazil* [broach] *of Hyacinth, do show wonderful rich, yea almost dazzle the Hyacinth and Adamant themselves; for they shine curiously like stars, and do cast about them sparks of the colour of the Rain-bow; by these marks it is so known, that it would be needless to describe the rest of the body though painted with* [a] *variety of colours.*

I think it is safe to assume that Thomas Moffet loved butterflies.


INSECTORVM
SIVE
Minimorum Animalium
THEATRVM:
Olim ab
EDOARDO WOTTONO.
CONRADO GESNERO.
THOMAQVE PENNIO
inchoatum:
Tandem
THO. MOUFFETO Londinâtis operâ sumptibusq; maximis concinnatum,
auctum, perfectum:
Et ad vivum expressis Iconibus suprà quingentis illustratum.
Londini ex Officinâ typographicâ Thom. Cotes. Et venales extant apud Benjam. Allen,
in diverticulo, quod Anglicè dicitur Popes-head Alley. 1634.




**LEFT AND ABOVE:** Moffet's *Insectorum sive Minimorum Animalium Theatrum* (*Theatre of Insects or Lesser Animals*) was first published in Latin in 1634 and in English in 1658.

The Small Tortoiseshell found pressed inside the original manuscript of Moffet's *Theatre of Insects*, written in 1592, may be the oldest butterfly specimen in the world.

Medieval manuscripts are sometimes decorated with butterflies (and pretty moths – they made no distinction then). It proves that people were aware of butterflies and recognised different kinds. There is also confirmation by the 14th-century chronicler Jean Froissart, who recalled playing with butterflies as a boy by attaching them to his hat with fine flaxen threads. Medieval moralists would warn their audience of the dangers of chasing after butterflies, for God would see their folly and bad consequences might follow – a twisted ankle or a broken leg, for instance. Perhaps that was their divine purpose: to signify the lure of false promise. Thomas Moffet himself believed that God had created butterflies to humble us, for no man or woman wore garments half so colourful: 'How can he choose but admire the bountiful God, who is the Author and giver of so rich treasure.' It is probably worth adding that Moffet, like so many of his Protestant contemporaries, was a Puritan.

Nearly a century later, the naturalist John Ray (1627–1705) spoke for all the ages when he, too, faced the question of what butterflies were *for*. Preachers taught that God had a reason for creating every

one of his creatures, be they ever so small, but what was the purpose of butterflies? Ray answered as follows:

> *You ask what is the use of butterflies? I reply to adorn the world and delight the eyes of men: to brighten the countryside like so many golden jewels. To contemplate their exquisite beauty and variety is to experience the truest pleasure. To gaze enquiringly at such elegance of colour and form devised by the ingenuity of nature and painted by her artist's pencil, is to acknowledge and adore the imprint of the art of God.*

In other words, in loving God it was impossible not to love his most jewel-like creation: the butterflies. Writing in the next century, Ray's successor, the thoroughly secular artist Moses Harris, agreed. He prefaced his appropriately gorgeous butterfly book, *The Aurelian*, with these words taken from Psalm 111: '*The works of the Lord are great, sought out of all them that have pleasure therein.*' He might have added the next line but one, which is: '*He hath made his wonderful works to be remembered.*'

But that was that, more or less. No one back in John Ray's day seemed particularly interested in how butterflies actually lived, and, apart from the 'cabbage white', it seems that they even lacked familiar names (although it is just possible that 'admiral', 'brimstone' and 'bella donna' or Painted Lady are old folk-names). In his posthumously published *History of Insects*, John Ray did his best to sort out the known species of British butterflies, with the help of a small band of assistants in his native Essex. He correctly deduced that butterflies differ from moths by having clubbed antennae. He divided the 40-odd species then known by their colours, and gave them all short Latin tags in lieu of a proper name. For example, his Wood White was '*small, white with a black mark in the corner of the upper forewings: faintly marbled below*'. Ray was important not only for his intelligent interest in the natural world, and his sense of order, but also for his influence. On butterflies and other insects he made a start which others were eager to follow and develop. Notable among his followers was his friend James Petiver (1663–1718).

Petiver could be described as the first butterfly collector. A herbalist and apothecary by trade, he presided over a gloriously untidy home museum, like a vast attic, full of skins, feathers, packets of seeds, shells and preserved specimens of all kinds. He published résumés of its contents in illustrated catalogues, the last and best of which was a pamphlet on British butterflies. Petiver was the first to give proper


The frontispiece of *The Aurelian*, published in 1766, gives us an insight into early butterfly collecting. The collector is the author and illustrator, Moses Harris, with his spoils displayed in little boxes. The collector with his 'clapper' net is probably intended to be Harris too.

names to butterflies, and some of his coinages are still used today, including 'hairstreak', 'fritillary', 'tortoiseshell' and 'argus'. During the ensuing 18th century, collecting and rearing butterflies and moths became a popular, even a fashionable, hobby among the well-to-do. It also provided work for artists and cabinet makers, and created a commercial market for two of the most beautiful butterfly books of all time, *The English Moths and Butterflies* (1749) by Benjamin Wilkes and *The Aurelian* (1766) by Moses Harris. The study of butterflies and moths was also the aim of the world's first entomological society, the Society of Aurelians, founded in the 1720s or 1730s and named after the *aureliae* or chrysalids of butterflies.

By the end of that century, all but a handful of British butterflies had been discovered, and their life-cycles written up and illustrated. And by then most of them bore the names we use today. No wonder

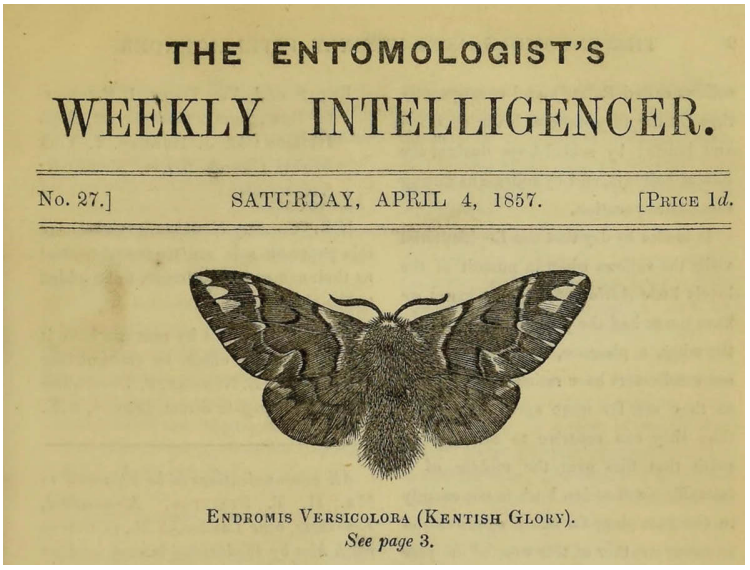
many of them sound so quaint now. Would any modern-day naturalist have had the colour sense to come up with 'clouded yellow' or 'silver-washed' or 'high brown' (which is another way of saying 'rich brown')? Do we ever stop to think how odd it seems to name a butterfly after a heath, or a wall, or after the Duke of Burgundy or the Queen of Spain? All the same, I think that these imaginative names, which in many cases are older than their scientific names, reveal something of the great admiration Enlightenment men and women felt for butterflies and their 'transformations'. They also say something about those pioneer Aurelians. They were not scientists in the modern sense but cultivated individuals with a great curiosity about the natural world. Among them were professional artists and silk pattern designers, teachers, craftsmen, gardeners – and poets. They were filled with wonder at the beauty and wonderful life-cycles of butterflies and moths.

Butterfly collecting, you might say, was a form of love. Its history is a long one: in the British Isles men chased butterflies, nets aloft, killing bottles rattling, for two-and-a-half centuries (it was nearly always men; women specialised in rearing butterflies, and recording their images in paint and needlework). Their collections are now in museums, row upon row of perfectly pinned and set specimens, with little labels attached recording the date and place of capture. It is easy today to dislike the idea of killing butterflies for fun – in Britain there was never any great scientific necessity for it – but it was the

The Glanville Fritillary was named after Eleanor Glanville, who first discovered this butterfly species near Lincoln in the 1690s. It was originally named the Lincoln Fritillary but later became the Glanville Fritillary in her honour. Apart from the migrant Berger's Clouded Yellow, it is the only British butterfly to be named after its discoverer.

popularity of collecting that made butterflies among the best-studied insects in the world. Many a lifelong love of nature, including my own, has begun with a butterfly net. Collections were also used to educate and enthuse others. Most Victorian entomologists were collectors of some sort. Henry Bates and Alfred Russel Wallace collected butterflies professionally, and Charles Darwin was a keen beetle collector. And these old collections still have their uses. They have been used by researchers to study genetic changes in response to habitat fragmentation, and the Natural History Museum is currently examining old specimens and their labels for evidence of climate change.

Butterflies had the good fortune, or misfortune, to be the perfect subject for the specimen collector. Unlike dragonflies, their colours lasted after death. Unlike beetles, they were easy to identify. They could be pinned and mounted in lifelike postures with the wings displayed to best advantage, and, so long as they were kept away from bright lights and nibbling bugs, they would last indefinitely. The hobby became even more popular after the railways opened up access to places like the Fens and the New Forest, while the bicycle became almost as important an item of equipment as a net. Perhaps even more importantly, butterfly collecting was sociable; the fun could be shared. Every town once had a natural history society. In its heyday there were journals with names like *The Entomologist's Weekly Intelligencer*, and numerous best-selling books – which became



THE ENTOMOLOGIST'S

WEEKLY INTELLIGENCER.

No. 27.] SATURDAY, APRIL 4, 1857. [PRICE 1*d.*

ENDROMIS VERSICOLORA (KENTISH GLORY).

*See page* 3.

*The Entomologist's Weekly Intelligencer* was a weekly newsletter that ran from 1856 to 1861. It was edited and paid for by Henry Tibbats Stainton as a way of sharing information on insects, including dates and places of capture. The engraving is of a Kentish Glory moth.

cheaper and more useful as print technology improved. The butterfly collector even became a stock character in novels – for example, the butterfly-chasing vicars of Trollope – and a prime example of English eccentricity (although the North Americans and, interestingly, the Russians were just as keen).

A broad range of famous people have been inspired by butterflies. For Vladimir Nabokov, one of the greatest novelists of the 20th century, they were a lifelong obsession. Winston Churchill tried to turn his garden at Chartwell into a butterfly sanctuary. Walter Rothschild amassed perhaps the largest and most important butterfly collection ever. One could compile an anthology of butterfly writing from Keats and Kipling to Edward Thomas and Virginia Woolf. The Dutch Old Masters loved to paint butterflies in their still life arrangements, while Victorian artists often painted fairies with diaphanous butterfly wings. Psyche, the female embodiment of the soul, was usually painted with a pair of butterfly wings or a white butterfly hovering over her head. Damien Hirst used butterflies as a metaphor for death. Beethoven has a butterfly on his grave; it stands for the eternal glory of a great artist.

Butterflies are not just pretty. They are as familiar as the flowers in our gardens, and by great good luck some of our most colourful butterflies love gardens. We welcome them as heartily as the robin perched on the spade, and we even plant favourite flowers to attract them. There seems to be something about butterflies that never fails to raise our spirits. Advertisers and designers of greetings cards have noticed this and capitalised on it. If you look for them, butterfly icons are everywhere, in card shops, on supermarket products, in full-page adverts in glossy magazines. But what are they saying exactly? Many things, it seems. The butterfly used to advertise the Open University is presumably a stand-in for knowledge, and the freedom it brings. The Monarch butterfly in the sports car ad suggests speed, lightness and perhaps economy (the North American Monarch can fly over 1,500km on occasional top-ups of nectar). The tinselled butterfly on a birthday card means – what? – simple happiness? A party spirit? The one on the shampoo bottle hints at an 'organic' product using natural products. Advertisers do not need to spell it out. A butterfly can stand for many things: naturalness, freedom, good health, joy and love, all positive and life-enhancing qualities. It is a very versatile symbol, and that can only be because of the way we feel about them.

New Age ideas about butterflies, too, assert their positive qualities. Learn from the butterfly, they say. Compare your life with theirs and ask yourself questions. Are you as free as a butterfly? Are you as happy or as fulfilled? Like the sparkly butterflies on greetings cards, it has nothing to do with real butterflies and everything to do with human feelings and emotions. Butterflies seem happy and carefree because these are the human qualities we project onto them. It is hard to imagine a Beatrix-Potter-like tale of a miserable butterfly.


Butterflies are widely used in advertising, as in this advert for a washing machine.

Of course, these days we also feel concern. The Georgian and Victorian butterfly chasers didn't have to worry so much about depleting the stock. The open woods around London were full of fritillaries and hairstreaks, and the flowery pastures and parks fairly danced with butterflies of all sorts. It would have beggared belief to suppose that one day their numbers would fall so low that 'vulnerable' and 'endangered' would become frequent words in every butterfly book, and in the 'action plans' of conservationists. Today, butterflies have begun to symbolise something darker: fragility and our rape of the planet. Conservation is the main driver of butterfly study today, and the bulk of the limited resources are directed towards trying to save them in the face of unprecedented demands on the land. Fragility is back in fashion, but it is the butterfly's survival that seems fragile, not their bodies. I will return to this grave subject in the last chapter of this book.

Deep feelings about butterflies are nothing new. Three thousand years ago an ancient Egyptian called Nebamun was clearly very fond of them. On the wall of his tomb chamber is a hunting scene replete with birds in a marshy landscape, and among the birds are some butterflies, scared from the reeds by the huntsman's cat. They are carefully painted and have been identified as the African Monarch, *Danaus chrysippus*, still found in the Nile valley. Perhaps Nebamun liked those butterflies so much that he was trying to ensure that he would see them again in the afterlife.

The ancient Greeks saw something deeply spiritual in butterflies, as if they transcended earthly life and represented something eternal – for the Greek word *psyche* meant both 'butterfly' and 'soul'. But Aristotle, and later classical philosophers and writers, wrote about

African Monarch butterflies are depicted in a mural from the tomb of Nebamun, 1350 BC.

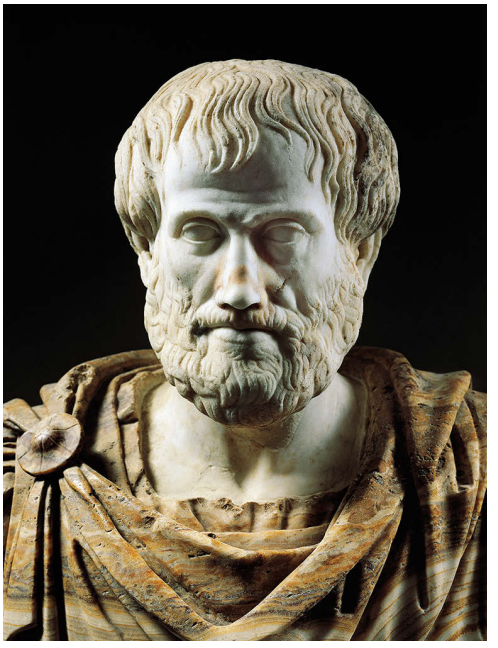
them matter-of-factly, and the butterfly's otherworldly aspect survives only in images, for example on vases and seals.

Surprisingly, butterflies are not mentioned in the Bible, not even once. But what interested Christian mystics was their journey from a crawling, earth-bound caterpillar, through a tomb-like chrysalis to the eventual release of the air-bound butterfly. There were obvious parallels with the passion and resurrection of Christ, and also in the journey of the human soul through life, death and afterlife. Perhaps that is what interested the ancient Greeks too. It set butterflies apart from the rest of insects, an annoying lot on the whole, and lent them an air of grace and even divinity – one which survives in modified, debased, form on a tablet of soap or a birthday card.

These are just some of the reasons why, I suggest, we love butterflies. The rest of this book will be about the real lives of butterflies, how

they adapt to their environment, feed, find a mate, and survive for long enough to pass their genes on to the next generation. It will be about egg-laying and the single-minded determination of the caterpillar to grow and grow, and the long sleep of the chrysalis before the awakening and release of the adult butterfly. It will also discuss how we study butterflies and discover more about their secret lives, and apply that knowledge in our attempts to conserve them, along with their natural habitats.

I have loved butterflies, and studied them, all my life. I hope my experiences, and those of other butterfly lovers, will interest you and perhaps inspire you to see these insects in a new light, and to make your own observations and discoveries. We know quite a lot, far more than did those butterfly pioneers and collectors of previous times. But the more we know, the more we realise how ignorant we still are about some aspects of the lives of even common butterflies. What we can assert from this brief summary of our relationship with butterflies is that our love of them is eternal, and that it evokes in us a healthy curiosity about the natural world. And that leads ineluctably to discovery and knowledge.



Aristotle was the first ancient writer to mention caterpillars and butterflies, and he included them in his grand survey of animal life, *Historia Animalium* (*History of Animals*), in the 4th century BC.

# Butterfly basics

chapter two

The life of a butterfly is surprisingly complex. Before becoming the beautiful winged insect we all know, it has passed through three contrasting early stages. Life begins as a tiny egg laid on or near a carefully chosen plant. The female butterfly must take care that the emerging caterpillar will find enough food. The caterpillar must then grow quickly to reduce the chances of being eaten, and find safe places to change its skin (several times) before making one last, radical skin-change to turn into a chrysalis. The chrysalis, too, must be hidden from hungry predators. To understand a butterfly, you need to know about the four different stages of its life-cycle, each with its own requirements and challenges. Without that knowledge, meaningful conservation would be impossible. Fortunately, over some 300 years of study, British butterflies have become some of the best-known insects on the planet.

## Butterfly origins

The first insects evolved in the Devonian period around 420 million years ago, probably along the shoreline, at roughly the same time as the land was being colonised by plants. All insects have segmented bodies, three pairs of legs, and an external skeleton (the *exoskeleton*) made not of bone but of chitin (an equally hard but more flexible substance similar to our fingernails). It took several million years more for the first winged insects to appear. The best-known examples are the giant dragonflies and cockroaches of the Carboniferous coal forests, whose modern-day counterparts, though smaller, are remarkably similar. The more advanced insects, such as bees, beetles and butterflies, evolved later.

Butterflies and moths are members of the order Lepidoptera ('scaly-wing'), in which the wings are covered by thousands of tiny, overlapping scales. Exactly when the first members of this order evolved has only

**OPPOSITE PAGE:**
A 34 million year-old fossil relative of the Duke of Burgundy was found on the Isle of Wight in 1889.

recently become clear. One of the oldest known fossils of a moth comes from Charmouth in Dorset. It flew around 190 million years ago, towards the end of the Triassic. But in 2016, scientists investigating an ancient lake in northern Germany found an even earlier moth fossil (van Eldijk *et al.* 2018). When they examined fine sediment from cores drilled into the former lake they found perfectly preserved scales from the wings of primitive moths that turned out to be around 200 million years old. The scales were hollow and resembled those of a modern family of moths (the Glossata), allowing the researchers to deduce that these primeval moths possessed a coiled proboscis. Since they could not sip nectar from flowers, for flowers had not yet evolved, they must have found some other source of liquid sustenance, perhaps sap leaking from injured trees.

In London's Natural History Museum there are some exceedingly rare and beautifully preserved fossils of ancient butterflies. It may be surprising that such delicate creatures fossilise at all, but a few have been preserved in ancient rocks. One of these unlikely exhibits is a specimen found in limestone from the Isle of Wight. Its wings are still attached and you can even make out some of the colour and the banded pattern. It looks like a modern butterfly but is actually 34 million years old. It even has a name, *Lithopsyche antiqua* ('ancient stone butterfly'). More than 100 other butterfly fossils have been described, with the oldest dating to around 53 million years ago in the early Eocene.

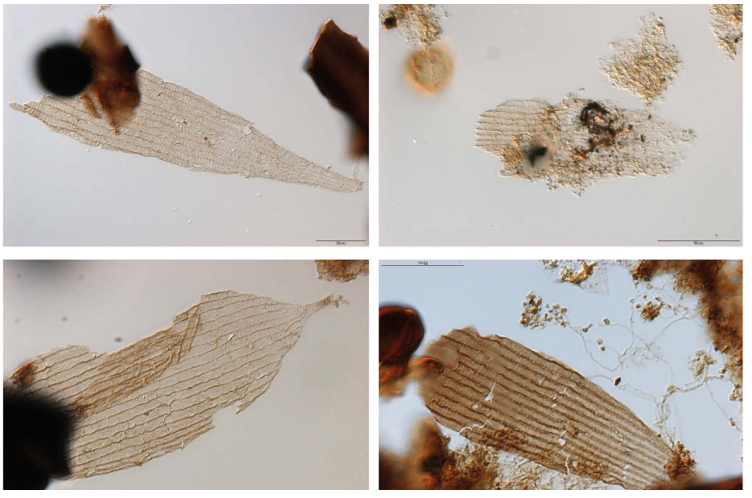
Other evidence can inform us of the origins of butterflies and moths. Modern gene sequencing provides an independent way of looking back in time, identifying the genes that make up butterfly

This fossil butterfly from the Isle of Wight, measuring 3cm across, preserves the patterns on its wings (the two pieces are the upper and lower impression on the rock). It looks similar to some modern-day metalmark butterflies in the family Riodinidae, and may be a very distant relative of our Duke of Burgundy.

DNA and comparing the relationships between different groups. The results suggest that the real origin of the Lepidoptera was far earlier than the oldest known fossils, perhaps 300 million years ago, right at the start of the Permian (Kawahara *et al.* 2019). Butterflies appeared much later. Genetic evidence indicates that the first butterflies, which might have resembled the skippers, originated about 100 million years ago, in the mid-Cretaceous. And so it is quite possible that butterflies flew around the lofty heads of giant dinosaurs (Espeland *et al.* 2018).

The same kind of genetic research offers an insight into the relationship of butterflies to moths. The nearest relatives of butterflies are not some of the larger moths, as was once thought, but micromoths in the family Gelechiidae, and the burnet and forester moths in the Zygaenidae. Interestingly, the burnets are the most butterfly-like of all moths, flying by day with vividly coloured wings, and even possessing clubbed antennae similar to those of butterflies.

Of course, nothing is known about how the ancestral butterflies and moths behaved, or how their life-cycles developed. There are no equivalent fossils of eggs, caterpillars or chrysalids to offer clues. We are thrown back on inference to imagine how butterflies might have evolved. It seems likely that they were a break-away group from moths that became day-fliers, probably because the emergence of the first flowering plants offered a vast new source of food, both for adult butterflies and for their caterpillars. Flowers offered an enormous evolutionary opportunity. The coexistence of flowering plants and butterflies would have resulted in an evolutionary burst, with many butterfly species becoming specialised and basing their



These ancient scales from the wings of a moth date from 200 million years ago (van Eldijk *et al.* 2018).

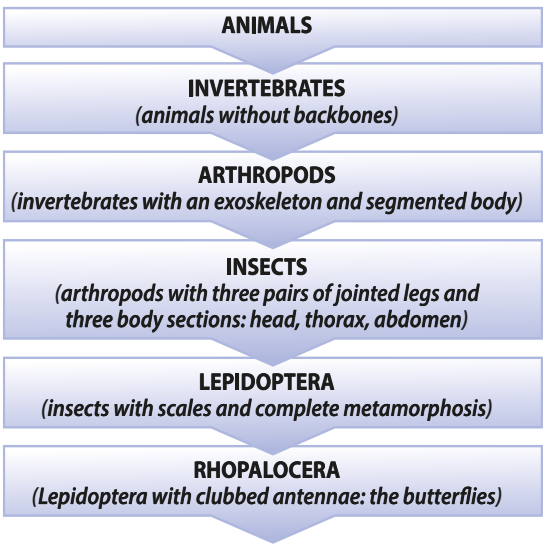
Many butterflies are specialists that use a single food-plant for their caterpillars. The Small Tortoiseshell has evolved to feed exclusively on the Common (Stinging) Nettle. It is possible that the stinging plant helps to prevent its caterpillars from being eaten by large herbivores.

existence on a particular group of plants, or even a single species of plant. Quite likely, then, flowers and butterflies evolved together, in tandem.

Over time the number of species of butterflies and moths multiplied. Some lines died out while others evolved into the species we know today. Worldwide, there are currently around 160,000 described species of Lepidoptera, making it one of the most widespread and successful groups of insects. Most of these are moths. There are 'only' 19,000 species of butterfly known on earth, although new species are being described all the time. Theoretical estimates of the actual number of Lepidoptera species range from 250,000 to 500,000 (Espeland *et al.* 2018). If correct, this would make butterflies and moths one of the most species-rich orders of animals on the planet.

## Butterfly families

Like all living organisms, butterflies are divided into families with shared characteristics. These are then subdivided into the genus (a group of closely related organisms) and then species. In Britain you can often identify the family of a particular butterfly from its colour alone. Any white or yellow butterfly is likely to be in the Pieridae, a blue or copper-coloured one in the Lycaenidae, a brown or orange-patterned one in the Nymphalidae. Modern genetics have reduced British butterfly families from the traditional seven to six. The browns, which used to have a family of their own, the Satyridae, are now considered to be a subfamily within the Nymphalidae (the Satyrinae).




Simplified butterfly family tree.

**Butterfly families in Britain and Ireland**

| Family | English names | Characteristics |
|---|---|---|
| Papilionidae | Swallowtails | Large butterflies, often with tails. Just one species in Britain, the Swallowtail |
| Hesperiidae | Skippers | Small grey or brown butterflies, rather moth-like and fast-flying. Many rest with forewings at an acute angle to the hindwings |
| Pieridae | Whites and yellows | Medium-sized butterflies with white or yellow wings. Includes the Large and Small Whites, the Brimstone, and the clouded yellows |
| Riodinidae | Metalmarks | Small to medium-sized butterflies, often with vibrant marks (hence the name metalmarks). Just one species in Britain, the Duke of Burgundy |
| Lycaenidae | Hairstreaks, coppers, blues | Small to medium-sized butterflies. Blues often have brown-coloured females. Hairstreaks often have small false heads on the hindwing with small 'hairs' mimicking antennae |
| Nymphalidae | Vanessids, fritillaries, browns | Medium to large-sized butterflies. Vanessids include common species like Small Tortoiseshell, Red Admiral and Peacock; fritillaries have chequered orange-brown wings; browns are typically brown with white eye-spots |

**ABOVE:** Representatives of the six British butterfly families. Top row, left to right: Swallowtail (Papilionidae), Small Skipper (Hesperiidae), Small White (Pieridae); bottom row, left to right: Duke of Burgundy (Riodinidae), Holly Blue (Lycaenidae), Gatekeeper (Nymphalidae).

### Butterflies in Britain and Ireland

Some countries have more butterfly species than others. As a rule, there are more species in tropical countries and hardly any at all in the coldest parts of the world. There are far more butterflies in Africa than in Europe, more butterflies in Greece than in Germany, and more in Germany than in Great Britain. Being a series of islands, and cool and rainy ones at that, we are doubly disadvantaged. The English Channel represents an impassable barrier for all but migratory species. While continental Europe (excluding Turkey) holds around 480 species of butterfly, there are only 60 on the British list, plus a few migrants that do not usually survive our winters. If we add Ireland, the total rises to a princely 61, for Ireland has a species not yet found in Great Britain, the recently discovered Cryptic Wood White (see Chapter 5).

Of our 61 former resident species, five have become extinct. The distinctive British race of the Large Copper died out around 1864; the Mazarine Blue went in 1905; the Black-veined White in the 1920s; the Large Blue in 1979; and the Large Tortoiseshell probably sometime in the 1980s (occasional Large Tortoiseshells are seen in most years, and some temporary breeding has been observed, but these are thought to be migrants). Attempts have been made to re-establish certain extinct species, notably the Large Copper at Woodwalton Fen, but these ultimately failed. The only success is the Large Blue, which has been re-established using stock imported from Sweden (see Chapter 13).

The families have other common characteristics, including the food-plants used by the caterpillars. Some of the skippers and most of the browns are grass feeders; the whites mainly feed on cabbages and wild crucifers; and many of the blues need vetches. Hairstreaks tend to feed on trees and shrubs, coppers on docks, fritillaries on violets and vanessids on nettles. A complete list of species with their usual food-plants is given in Appendix B.

## Butterflies versus moths

Telling a butterfly from a moth is not as easy as you might think. There are moths that look a bit like butterflies and vice versa. This is perhaps not surprising, given that butterflies are just one small group of Lepidoptera. The best distinguishing feature is the antennae. Butterflies have clubbed antennae, hence the name of their suborder, Rhopalocera or 'clubbed horn'. But, although this is the best technical definition, a few moths, notably the burnets, also have swollen ends to their antennae, making them resemble butterflies.

Then we can turn to habits. Butterflies of course fly by day, and most of them are brightly coloured. But some moths also fly by day, and some of them are colourful too. So it not surprising that people get confused.

In Britain there are only 59 or so species of butterfly, and so it is easy enough to recognise them all and know they are not moths. In cases of doubt, the following should clinch it:

1 Butterflies have clubbed antennae. True, but the skippers have rather swollen (rather than clubbed) tips to the antennae, similar to those of the burnet moths. The skippers can be distinguished by their straighter antennae.

2 Butterflies rest with their wings closed above their body like pages of a book. True, apart from the Dingy Skipper, which rests with wings flat, like the flaps of a coat. A few moths, such as the thorns, rest with their wings closed in a butterfly-like posture.

3 Butterflies lack a mechanism for hooking the front and back wings together. Moths have a spine or bristle on the underside of the hindwing (the frenulum), which catches in a hook or pad on the forewing (the retinaculum). This is not always easy to see, but is a reliable way of distinguishing moths from butterflies. Butterflies link their wings by means of a protruding lobe on the hindwing close to the body. There are no exceptions to this rule in Europe, but there is an Australian skipper butterfly which has a moth-like hook-and-catch, suggesting a common ancestry between skippers and moths.

The one certain way of telling moths from butterflies is that the former have a hook-and-catch mechanism connecting the forewing to the hindwing, shown here on a Small Elephant Hawk-moth.

The clubbed antennae are less obvious in some butterfly species, for example the Dingy Skipper, which has a swollen tip.

In flight, the day-flying Burnet Companion moth can easily be confused with the Dingy Skipper.

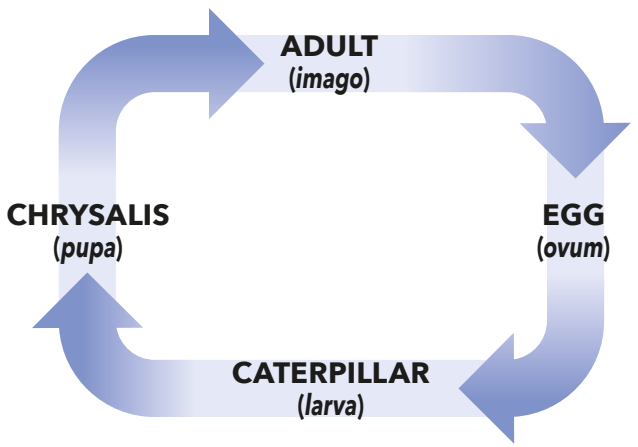
In Britain, we have a large number of day-flying moths – at least a hundred – which can confuse butterfly watchers. In flight, the Dingy Skipper resembles two day-flying moths, the Burnet Companion and Mother Shipton. They are all brownish with a similar buzzing flight, keeping low to the ground. They also fly at about the same time in similar grassy places. I have often mistaken them in the field. Most other day-flying moths are more obviously moth-like. There are, for instance, three species of forester moths, with shiny green wings, and seven burnet moths, with red spots on dark wings. The Cinnabar moth can also look quite butterfly-like, but is black and red, and rests with its wings flat (unlike most butterflies). There are also some larger day-flying moths such as the furry brown Oak Eggar and Fox Moths, and even day-flying hawk-moths such as the two bee hawk-moths and the migrant Hummingbird Hawk-moth. But, seen close up, they are obviously plump-bodied moths and not butterflies. You are far more likely to mistake the bee hawk-moths for bumblebees!

## Early stages in brief

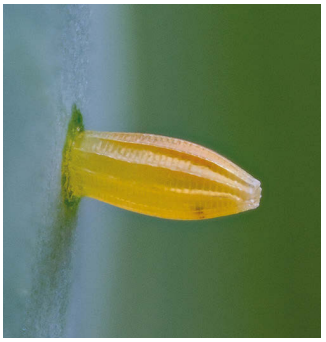
The life-cycle of a butterfly moves through four separate stages. Scientifically these are described as the ovum, larva, pupa and imago, but I prefer to use the more familiar names of egg, caterpillar, chrysalis and adult. The transition through the stages is known as a *metamorphosis* (literally 'shape-changing'). Over half of the British species have only one generation per year, and so in their case the life-cycle lasts exactly one year. A few of these have a partial second brood in some regions (see Appendix B). Most other species are double-brooded, typically with a spring and a summer generation, while a few may have three or even four broods per year. One species, the Mountain Ringlet, may sometimes have a generation that lasts two years, with its caterpillar lasting two winters.

No butterfly flies in the coldest weather, and overwintering is a mostly dormant period in the life of a butterfly. Depending on the species, it may overwinter as an egg, a dormant caterpillar, a chrysalis or a hibernating adult. Whatever the stage, it remains constant for every species. The Brimstone, for instance, overwinters as an adult. It never overwinters as an egg, caterpillar or chrysalis. Only one British species can overwinter in two stages: the Speckled Wood, either as a caterpillar or chrysalis.

Like all advanced insects, a butterfly's body is divided into three segments: a head, a thorax (to which the legs and wings are attached) and an abdomen. Adult butterflies do not grow any further, and so their hard exoskeleton lasts them all their brief lives. Nor is there any growth at the egg or chrysalis stage. All the growth in the life of a butterfly is done at the caterpillar stage, and its skin must be shed three to six times (depending on the species) before it is fully grown.




The butterfly's life-cycle.

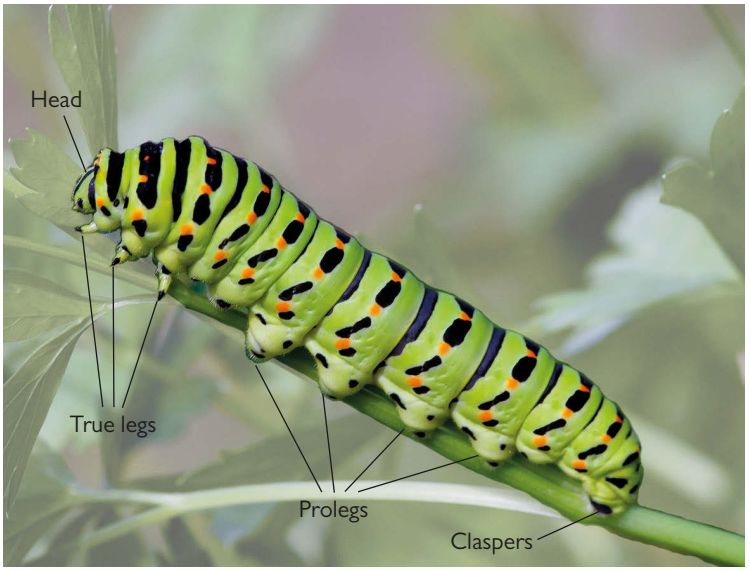


**ABOVE:** Butterfly eggs of different shapes. From left to right, the bottle-shaped egg of Small White, flat egg of Common Blue, smooth oval egg of Speckled Wood.

Butterfly eggs come in all shapes and sizes; they can be sculptured or smooth, bottle-shaped or flat or oval. The shape usually goes with the family – all the whites have bottle-shaped eggs, while those of the browns are more or less spherical. Those of the blues, hairstreaks and coppers are typically sculptured and flattened like a button, while the eggs of the skippers tend to be rounded like little cushions.

The larvae of butterflies and moths are conventionally known as caterpillars. The caterpillar does two basic things: it eats and it grows. Although they come in various shapes and colours, all caterpillars share the same basic construction. Each has a head made of hardened cuticle and a soft body made up of 13 segments. The head bears two powerful mandibles ('jaws') that can shear leaves into bite-sized chunks before they are swallowed. Beneath the mandibles are two bristled, sensory protuberances (*maxillae*) that 'taste' the food and guide it into the jaws. Below these structures is a lower lip (*labium*) with an organ known as the *spinneret* that enables the caterpillar to spin silken threads. On either side of the head lie six simple eyes, known as *stemmata*, which can detect movement, as well as light and shade, but not detail. Attached to the head are also two small antennae and numerous bristles, both of which help the caterpillar to sense the world around it.

Each of the first three segments of the body has a pair of 'true' legs ending in a tiny claw – the six legs that are common to all insects. This part of the body will eventually become the thorax of the adult butterfly. Behind that are 10 abdominal segments, each with a small hole known as a *spiracle* through which the caterpillar respires (see below). Attached to four of these segments are pairs of fleshy *prolegs* or 'false legs', plus a pair of claspers on the terminal segment. The prolegs bear circular pads containing microscopic hooks that enable the caterpillar to grip tightly onto a stem or twig. A simple gut runs



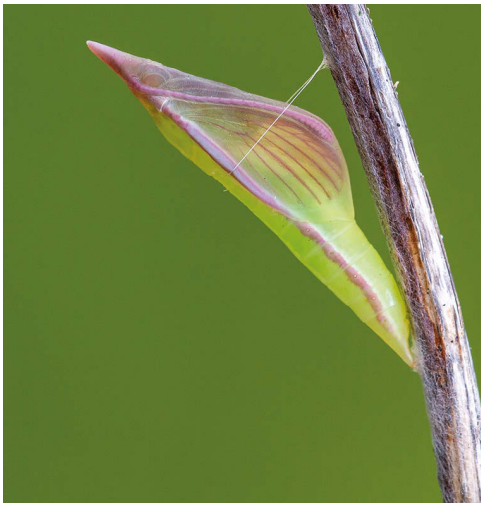

The main features of a caterpillar (in this case, a Swallowtail).

the full length of the body, ending in the anus, which produces waste pellets known as *frass*. Many caterpillars are well camouflaged to blend in with their surroundings. The best way to find them is to look for feeding damage on the food-plant, or the piles of frass the caterpillars leave behind.

The variety of caterpillar shapes and colours, even on our own small list of species, is amazing. Some are hairy or spiny or warty, others are smooth. Some are green, others brownish, or with blobs of different colours, either helping to camouflage them or make them distasteful. Whatever its appearance, the caterpillar eats, and goes on eating, with periodic rests for a skin-change, until it is fully grown.

Once full-grown, the caterpillar usually wanders away from its food-plant and chooses a place to turn into a chrysalis. To all appearances, the chrysalis seems dormant. By contrast with the caterpillar, it has a hard 'shell', though is usually flexible enough to allow the odd wriggle. Within, though, it is much more active. Inside the shell, tiny buds within the former caterpillar's body develop into the respective parts of the adult butterfly. Most chrysalids are attached to a plant, leaf or stem by a set of hooks (known as *cremasters*) and a pad of silk, but others, notably those of the white family, are attached by a silken girdle. A few, such as the Grayling, pupate just under the soil surface.

The chrysalis stage normally lasts two or three weeks, but in some species it can last the whole winter. When it is ready, the chrysalis darkens, then, shortly afterwards, breaks open, and the butterfly



**ABOVE:** Caterpillars come in various forms. Top left: the well-camouflaged Meadow Brown; top right: the woodlouse-shaped Common Blue; above: the spiny White Admiral.

**RIGHT:** The Wood White chrysalis is suspended by a silken girdle.

emerges. Once the emerging butterfly has crawled free and dried its wings, it flies off in pursuit of a mate. The mated female lays her burden of eggs and the cycle begins all over again, season after season, year on year.

Butterfly lives are attuned to their food-plants. Sometimes this plant is very specific. Five of our eight fritillaries feed only on violets, chiefly the Common Dog-violet. The Marsh Fritillary is another specialist, whose caterpillar feeds mainly on Devil's-bit Scabious. Similarly, two blue species, the Adonis and Chalk Hill Blues, feed only on Horseshoe Vetch, a plant found mainly on chalk downs, while the Purple Hairstreak feeds on the buds and young growth of oak trees. Other species are less choosy. The caterpillars of many browns and skippers will feed on a variety of grasses, and those of the Large and Small White will feed on a range of wild and domestic crucifers. The food-plants used by all the British species are listed in Appendix B.

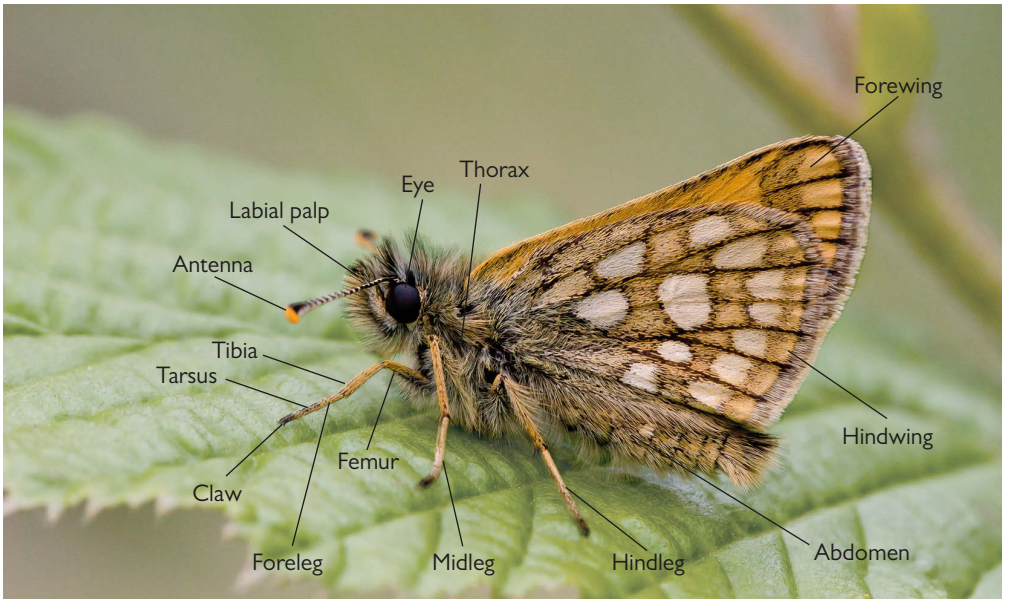
## Butterfly bodies

One of the things that captivated me when I first reared caterpillars as a schoolboy was witnessing the seemingly miraculous emergence of a butterfly from its chrysalis. The process starts when a small crack appears behind the head of the chrysalis, and a shrivelled creature struggles out. Its wings are mere pouches, but over the ensuing minutes these swell and expand as *haemolymph* (the insect equivalent of blood) is pumped into them, and slowly this bedraggled creature turns into a butterfly. You never tire of watching it happen.

An adult butterfly has three basic functions: flying, feeding and mating. Its head is packed with sense organs enabling the butterfly to see, smell and taste the world around it. It has two compound eyes, a pair of antennae and a long, coiled proboscis snuggled between a pair of hairy palps that help the butterfly to sense and taste its food (the palps look a little like a butterfly moustache). The eyes are large and made up of thousands of light-sensitive cones called *ommatidia*. Under a lens the eye resembles the hexagonal structure of a honeycomb, and each element receives a dot of light so that what the butterfly eye sees is made up of thousands of tiny spots. This means that the butterfly probably has poor distance vision but sees relatively well in close-up, and is certainly capable of detecting light, shade and some detail. A butterfly is particularly sensitive to movement, important if it is to avoid a suddenly pouncing predator. This explains why butterflies are so quick to respond to disturbance, and why we need to be slow and stealthy to creep up on them unawares.

As you might expect, butterflies have good colour vision and in fact can see a wider spectrum of light than humans, notably at the high-frequency ultraviolet end of the spectrum. This helps them when searching for flowers, for the latter often have hidden ultraviolet patterns. Some flowers that are plain-looking to our eyes, such as bindweed, have ultraviolet 'honey-guides' running into the centre to direct butterflies and other pollinators. Butterflies, including some of the blues and whites, may themselves have ultraviolet patterns within their wings, which are used as signals when attracting a mate. In Europe, there are several species of clouded yellow that look rather similar to us, but each has a hidden pattern in the ultraviolet so that the insects presumably have no difficulty in distinguishing one another.

Butterflies lack jaws. Unlike their caterpillars they cannot munch solid food. Instead, they have a coiled hollow tongue, the *proboscis*, designed for feeding on liquids such as the nectar in flowers. Nectar




The basic structure of the adult butterfly (in this case, a Chequered Skipper).

contains an energy-rich mixture of simple sugars and other nutrients that are crucial to maintain flight, egg-laying, and mating behaviour (including fighting rivals). The proboscis consists of two tubes that are separate when the butterfly emerges but quickly zip together to form a single unit. Butterflies use this inbuilt 'straw' to draw nectar and other liquids, much as we would drink a milkshake. The butterfly has to be careful not to gum up the narrow tubes with thick liquids, but fortunately the nectar of flowers is usually suitably dilute (around 20–40 per cent sugar is preferred).

The length of the proboscis varies considerably from species to species. The Small and Large Skippers have long tongues in relation to their body size, while others, such as the Meadow Brown and Gatekeeper, have comparatively short tongues. As we will see in the next chapter, this partly governs what species of plant they can feed on.

One of the chief ways in which butterflies sense their surroundings is with their antennae. These are covered with minute filaments and pits, not visible to the human eye, that enable them to detect specific scents (the equivalent of the human nose) (Carlsson *et al.* 2013). When a butterfly alights on a flower, it often dips its antennae to 'taste' the scent before feeding. When laying eggs, a female continually dips its antennae towards the plant to see whether it is right for its caterpillars. There are other taste receptors on the ends of the butterfly's legs (the *tarsi*) as well as in the hairy palps on either side of the proboscis. At