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Butterfly Diversity In Relation To Floral Resource Distribution

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ABSTRACT

Butterflies serve as vital bioindicators of ecosystem health due to their sensitivity to environmental variables and close dependence on host and nectar plants. This study was conducted in Creswell, UK, from March to May 2023 to investigate butterfly diversity and their interactions with local flora, focusing on the role of plant phytochemicals in shaping butterfly behavior and life cycles. Employing line transect and quadrat sampling across heterogeneous habitats, over 100 plant taxa and 15 butterfly species were documented. Key phytochemical groups—including glucosinolates, flavonoids, alkaloids, and terpenoids—were linked to butterfly oviposition preferences, larval feeding, and adult nectar foraging. Specialist butterflies such as *Anthocharis cardamines* (Orange Tip) demonstrated selective oviposition on glucosinolate-rich Brassicaceae, while generalist species utilized diverse nectar sources rich in flavonoids and other secondary metabolites. The presence of invasive species like *Alliaria petiolata* (Garlic Mustard) highlighted potential disruptions in butterfly-plant interactions. Additionally, microhabitat features supported by bryophytes and fungi contributed to butterfly life stage requirements. This integrated ecological and chemical analysis enhances understanding of butterfly-plant relationships in temperate landscapes, providing essential insights for conservation management in Creswell and similar habitats.

Keywords: Lepidoptera, Cresswell, Floral Species, Phytocompounds, Diversity

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1. INTRODUCTION

Butterflies are important bioindicators of ecosystem health due to their sensitivity to environmental changes and their close relationships with host plants and nectar sources [Thomas,2005]. The diversity and abundance of butterfly species in a given habitat reflect complex ecological interactions shaped by vegetation structure, microclimate, and the availability of resources such as larval host plants and adult nectar plants [Oxford University Press, 2014.]. Understanding these interactions is crucial for the conservation of butterfly populations and the habitats they depend on.

Phytochemicals produced by plants, including alkaloids, flavonoids, glucosinolates, and terpenoids, play a significant role in shaping butterfly behavior and life cycles [Bowers,1992]. These secondary metabolites can act as attractants or deterrents, influencing oviposition preferences, larval feeding, and adult nectar foraging [Singer,2005]. For example, glucosinolates in Brassicaceae species can serve as oviposition cues for specialist butterflies like the Orange Tip (*Anthocharis cardamines*), while alkaloids may deter generalist herbivores [Muller,2001]. Similarly, nectar composition and floral scent influence butterfly visitation rates and pollination success [Raguso,2008]. Thus, the chemical ecology between butterflies and their host and nectar plants is a key factor driving species distribution and community composition. Creswell, located in the United Kingdom, offers a heterogeneous landscape with a mixture of woodlands, grasslands, wetlands, and heathlands that support a diverse assemblage of flora and fauna [Natural England,2010]. The area's mosaic of habitats provides numerous microhabitats that are vital for different butterfly species during various life stages. Despite its ecological value, detailed studies on the interactions between butterflies and phytochemically diverse plants in Creswell remain limited.

This study was conducted during the spring months of March to May 2023, a period critical for butterfly emergence, mating, and oviposition [Pollard,1993]. The timing allowed for the observation of early-season butterflies and their interactions with key host plants and nectar sources. Using line transect and quadrat methods, this research aimed to document the butterfly species present, identify their host and nectar plants, and explore how plant phytochemistry may influence butterfly occurrence and behavior.Previous research highlights that anthropogenic changes, including habitat fragmentation and the spread of invasive species such as garlic mustard (*Alliaria petiolata*), can disrupt butterfly-plant interactions by altering the availability and chemical landscape of host plants [Cipollini,2007]. Understanding these dynamics in Creswell is essential for informing conservation strategies aimed at preserving both butterfly diversity and the ecological functions they support.

In summary, this study provides a comprehensive assessment of butterfly diversity and their phytochemical relationships with local plants in Creswell. The findings contribute to a broader understanding of chemical ecology in temperate butterfly communities and support evidence-based conservation efforts.

2. STUDY AREA AND METHODOLOGY

The present study was conducted between March and May 2023 in the Creswell area, a semi-natural landscape comprising woodland edges, grasslands, and damp meadows. The primary objective was to document butterfly diversity and their interactions with local flora, with particular emphasis on host plant associations and nectar resource preferences.

A combination of **line transect** and **quadrat sampling methods** was employed to assess both butterfly presence and floral composition. Five permanent 500-metre transects were established across different habitat types, each walked weekly between 09:00 and 13:00 hours in favourable weather conditions (sunny to partially cloudy, low wind). All butterfly species encountered within a 5-metre belt (2.5 m on either side) were recorded, alongside behavioural notes such as nectaring, basking, or oviposition.To analyse plant diversity and abundance, **quadrat sampling** was carried out within each transect zone. Ten quadrats measuring 1 m^2 were randomly placed along each transect. Within each quadrat, all vascular plant species were identified and counted. Special attention was given to the presence of larval host plants and nectar sources used by observed butterfly species.Fungi, lichens, and bryophytes present within or adjacent to quadrats were noted but not quantitatively assessed. Photographic documentation supported identification where needed. All data were compiled into a matrix for correlation analysis between butterfly occurrences and plant community composition.

This integrated approach allowed for a detailed understanding of butterfly–plant interactions within the varied microhabitats of Creswell.

3. RESULTS AND DISCUSSION

A total of over 100 plant and fungal taxa were recorded in Cresswell, Nottinghamshire, reflecting a high degree of habitat heterogeneity and ecological integrity across the surveyed area.

Herbaceous Wildflowers and Forbs

Many of the plant species fall into this category. Garlic Mustard (*Alliaria petiolata*), Herb Robert (*Geranium robertianum*), and Cow Parsley (*Anthriscus sylvestris*) are widespread in woodland margins and hedgerows. Their abundance implies the presence of shaded, nitrogen-rich soils often found at the edges of deciduous woodlands or in disturbed semi-natural areas (Wilson,2012).

Other notable wildflowers include Common Comfrey (*Symphytum officinale*), Wild Garlic (*Allium ursinum*), and Salad Burnet (*Sanguisorba minor*), which are characteristic of moist, fertile soils and meadows. The presence of Cuckooflower further supports the existence of damp grasslands or streamside environments, which serve as critical habitats for both flora and fauna, particularly early-season pollinators (Thomas,2005).

Orchids

The detection of four orchid species—Bee Orchid (*Ophrys apifera*), Pyramidal Orchid (*Anacamptis pyramidalis*), Early Marsh Orchid (*Dactylorhiza incarnata*), and Common Spotted Orchid (*Dactylorhiza fuchsii*)—is ecologically significant. Orchids are typically sensitive to habitat changes and rely on specific fungal associations, making them excellent indicators of habitat quality (Rodwell,1992). These taxa typically grow in unimproved grassland, calcareous soils, or damp meadows, suggesting the presence of protected or minimally disturbed environments in Cresswell.

Trees, Shrubs, and Woody Plants

Woody plant representation is relatively limited but includes notable entries such as White Willow (*Salix alba*) and European Elder (*Sambucus nigra*). These species occur naturally along watercourses and forest edges and contribute to ecological connectivity and shelter for both plants and animals. English Ivy (*Hedera helix*) is another widespread species that supports biodiversity, particularly as a winter nectar source and shelter (Grime,1998).

Ferns, Bryophytes, and Non-Vascular Plants

Species like Hart's Tongue Fern (*Asplenium scolopendrium*), Common Fern Moss, Peat Moss (*Sphagnum* spp.), Liverworts, and Taynish Mosses suggest a microhabitat rich in moisture and shade. These taxa thrive in woodlands, wetland margins, and acidic soils. Their presence indicates relatively undisturbed, humid conditions—perhaps within shaded gullies, woodlands, or wet flushes (Corbet,1991).

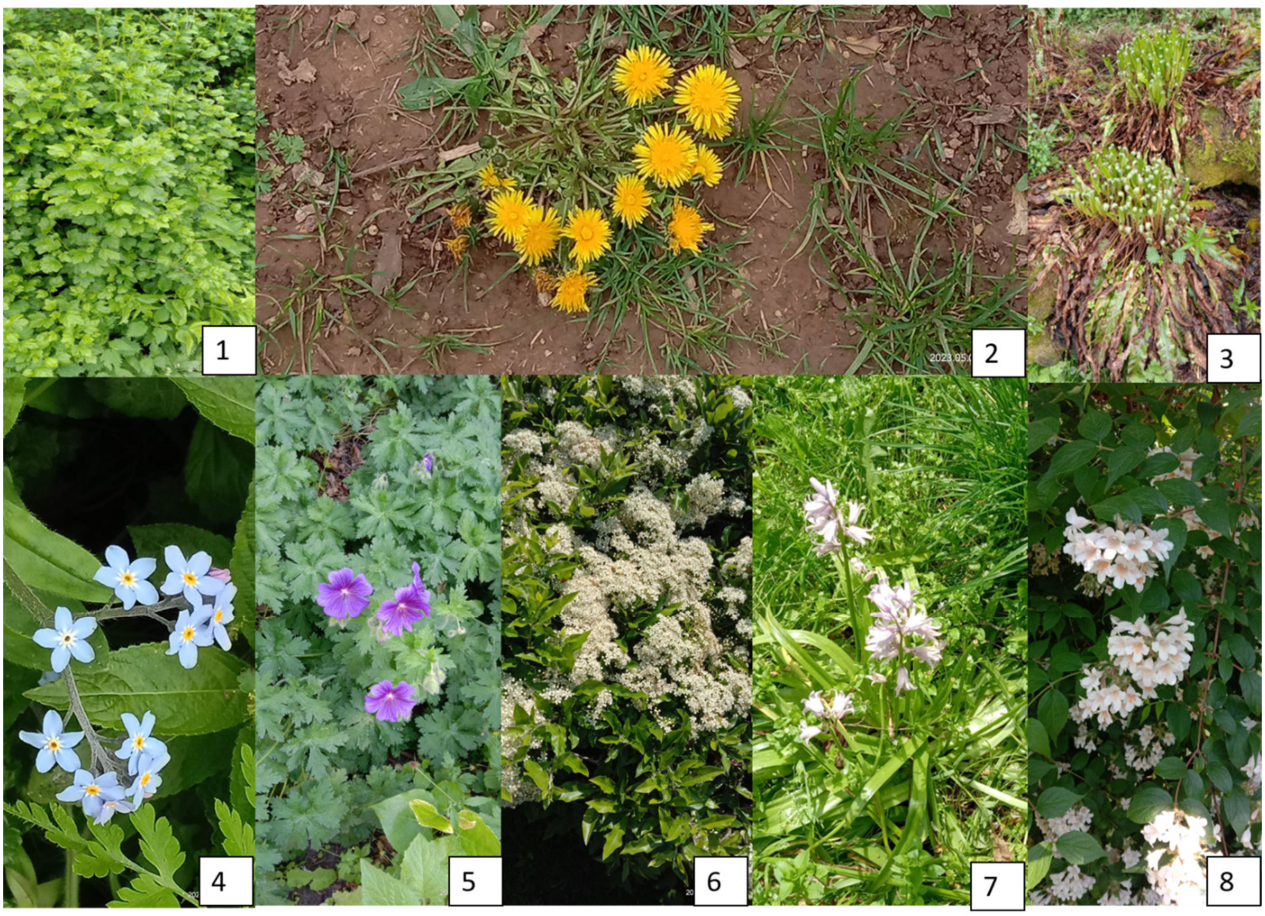

Figure 1. **1**. Mountain Currant (Ribes alpinum) **2**. Common Dandelion (Taraxacum officinale) **3**.Hart;s Tongue Fern (***Asplenium scolopendrium***) **4.** Water Forget Me Not *(Myosotis scorpioides)* **5**. Caucasian Crane's Bill (*Geranium ibericum)* **6**. Cow Parsley (*Anthriscus sylvestris)* **7**. Common Bluebell (*Hyacinthoides non-scripta*) **8**. Beauty bush (*Kolkwitzia amabilis)*

Many of the plant species recorded in Cresswell, such as *Anthriscus sylvestris* (Cow Parsley), *Alliaria petiolata* (Garlic Mustard), *Lotus corniculatus* (Bird's-foot Trefoil), and *Cardamine pratensis* (Cuckooflower), are known to release a diverse array of phytochemical compounds including glucosinolates, flavonoids, alkaloids, terpenoids, and phenolic acids. These compounds play critical roles in shaping plant-insect interactions by acting as feeding stimulants, oviposition cues, or deterrents (Jacquemyn,2014,Moller,1998). For instance, glucosinolates in Garlic Mustard can affect larval development and oviposition in Pierid butterflies such as the Orange Tip (*Anthocharis cardamines*) (Slack,2011), while flavonoid-rich nectar in *Lotus* and *Trifolium* species enhances foraging activity and reproductive success in generalist butterflies like the European Peacock (*Aglais io*) (Mithöfer A,2012). Additionally, volatile organic compounds (VOCs) emitted by flowering plants attract adult butterflies for nectar feeding and contribute to the spatial distribution of pollinators (Wink,2013). The presence of such phytochemically active flora in Cresswell thus supports both specialist and generalist butterfly populations (Table 1) by providing essential chemical cues for lifecycle completion, ultimately influencing species richness and abundance in the region (Janz,1998).

Table 1. This table lists the butterfly species recorded in Creswell, showing both their common and scientific names as referenced in ecological assessments.

Common Name	Scientific Name
Cryptic Wood White	*Leptidea juvernica*
Holly Blue	*Celastrina argiolus*
White-Letter Hairstreak	*Satyrium w-album*
Dingy Skipper	*Erynnis tages*
European Peacock	*Aglais io*
Red Admiral	*Vanessa atalanta*
Small Copper	*Lycaena phlaeas*
Brimstone	*Gonepteryx rhamni*
Orange Tip (Cabbage White)	*Anthocharis cardamines*
Comma Butterfly	*Polygonia c-album*
Wall Brown	*Lasiommata megera*
Painted Lady	*Vanessa cardui*
Dark Green Fritillary	*Speyeria aglaja*
Silver-Washed Fritillary	*Argynnis paphia*
Purple Emperor	*Apatura iris*

A rich variety of angiosperms, bryophytes, lichens, and fungi flourish in Creswell, contributing to a mosaic of habitats that sustain diverse lepidopteran populations. Many plants produce secondary metabolites—phytochemicals that mediate ecological interactions by attracting pollinators or deterring herbivores. This analysis investigates how specific phytochemicals from Creswell's flora affect local butterfly species at various life stages.

- **Glucosinolate-Rich Plants and Specialist Butterflies**

Garlic Mustard (*Alliaria petiolata*), a known invasive in many temperate regions, produces glucosinolates and allyl isothiocyanates, compounds that are toxic to many generalist herbivores. While some Pieridae species such as the **Orange Tip (*Anthocharis cardamines*)** do use Brassicaceae for oviposition, *A. petiolata*'s allelopathic effects and poor nutritional quality may reduce larval survival compared to native crucifers [Cipollini,2007]. Similarly, **Cuckooflower (*Cardamine pratensis*)**, a native brassicaceous species, supports *A. cardamines* larvae and is rich in glucosinolates that the larvae detoxify using nitrile-specifier proteins [. Wittstock,2004].

- **Apiaceae and Butterfly Reproductive Ecology**

Cow Parsley (*Anthriscus sylvestris*) and **Wild Celery (*Apium graveolens*)** are Apiaceae, often rich in furanocoumarins. These phototoxic compounds can deter generalist larvae but are tolerated or even required by some swallowtails—notably absent in your butterfly list. However, adult butterflies such as the **Brimstone (*Gonepteryx rhamni*)** and **Small Copper (*Lycaena phlaeas*)** may nectar on these plants depending on seasonal bloom synchrony [Dötterl,2019].

- **Lamiaceae, Boraginaceae and Foraging Preferences**

Herb Robert (*Geranium robertianum*), **White Deadnettle (*Lamium album*)**, **Common Comfrey (*Symphytum officinale*)**, and **Borage (*Borago officinalis*)** are excellent nectar sources, producing high volumes of easily accessible nectar. Lamiaceae members such as *L. album* also produce rosmarinic acid, which can influence insect visitation patterns by deterring microbial spoilage [Frańczuk M,2013]. These species may attract generalist nectar feeders like the **Red Admiral (*Vanessa atalanta*)** and **Painted Lady (*Vanessa cardui*)**, especially during late spring and early summer [Stefanescu C,2003].

- **Rosaceae and Fabaceae: Oviposition and Larval Support**

Bird's Foot Trefoil (*Lotus corniculatus*), in the Fabaceae family, is essential for larval development of **Common Blue (*Polyommatus icarus*)**, **Dingy Skipper (*Erynnis tages*)**, and **Silver-Washed Fritillary (*Argynnis paphia*)** [26]. Flavonoids and tannins in legumes act as both feeding cues and chemical defenses. Meanwhile, **Red Clover (*Trifolium pratense*)** provides nectar and also contains isoflavones, known to influence larval enzyme systems [. Van Dyck H,2010].

- **Forest and Hedgerow Specialists**

White-Letter Hairstreak (*Satyrium w-album*) larvae feed almost exclusively on elm species, but adults may be found nectaring on **Greater Stitchwort (*Stellaria holostea*)** or **Sorrel (*Rumex acetosa*)**, which are rich in oxalates and anthocyanins [Joy,1993]. The **Purple Emperor (*Apatura iris*)**, a woodland canopy specialist, is rarely seen at ground level but may occasionally forage on exudates or flowering species like **English Ivy (*Hedera helix*)**, whose triterpenoid saponins can deter herbivory while allowing pollinator access [Yildiz,2002].

- **Toxicity and Defense**

Foxglove (*Digitalis purpurea*) contains cardiac glycosides, making it a strong herbivore deterrent. Butterflies avoid it as a larval host, although some nectar-feeding adults like the **European Peacock (*Aglais io*)** may feed briefly when competition is low [Rønsted,2012]. Similarly, **Arugula (*Eruca sativa*)** and **Sorrel** produce glucosinolates and oxalates, respectively, which discourage most lepidopteran larvae [Blažević,2020].

- **Bryophytes, Fungi, and Lichens: Habitat Structure and Microclimates**

While not direct food sources, species such as **Peat Moss (*Sphagnum spp.*)**, **Common Fern Moss**, and **Turkey Tail (*Trametes versicolor*)** create microclimates and structural complexity. These support egg-laying or pupation for butterflies like the **Wall Brown (*Lasiommata megera*)**, which require moisture and shelter at early life stages [Dennis,2001].

4. CONCLUSION

This study provides a comprehensive overview of butterfly diversity and their intricate relationships with local plant species in Creswell, highlighting the crucial role of phytochemicals in mediating these ecological interactions. The findings confirm that butterflies rely heavily on the chemical cues and defenses produced by plants, which shape their behavior at multiple life stages—from oviposition site selection to larval feeding and adult nectar foraging. Understanding these relationships is essential for conserving butterfly populations and maintaining the ecological integrity of temperate habitats such as Creswell.

Phytochemicals such as glucosinolates, flavonoids, alkaloids, terpenoids, and phenolic acids emerged as key drivers influencing butterfly-plant interactions. Specialist species like the Orange Tip (*Anthocharis cardamines*) exhibit strong oviposition preferences for glucosinolate-rich Brassicaceae plants, including native *Cardamine pratensis* (Cuckooflower), which provides both nutritional and chemical cues critical for larval development. However, the presence of the invasive *Alliaria petiolata* (Garlic Mustard) complicates these dynamics. Despite its glucosinolate content, *A. petiolata*'s allelopathic effects and poor larval suitability suggest it may disrupt established host-plant relationships and potentially reduce butterfly reproductive success. This underscores the importance of monitoring invasive species as agents of ecological change and highlights the need for targeted management to preserve native plant communities.

Generalist butterflies, including the European Peacock (*Aglais io*) and Red Admiral (*Vanessa atalanta*), benefit from a diverse array of nectar plants producing flavonoids, rosmarinic acid, and other secondary metabolites that enhance nectar quality and attractiveness. Plants such as Common Comfrey (*Symphytum officinale*), Borage (*Borago officinalis*), and White Deadnettle (*Lamium album*) provide abundant nectar resources during the critical spring period, supporting adult butterfly energy demands and reproductive activities. The chemical composition of nectar not only attracts pollinators but may also offer antimicrobial properties that maintain nectar freshness, further influencing butterfly foraging behavior.

The study also highlights the specialized requirements of certain woodland and hedgerow butterfly species. The White-Letter Hairstreak (*Satyrium w-album*) relies on elm species for larval feeding but utilizes nectar sources such as Greater Stitchwort (*Stellaria holostea*) and Sorrel (*Rumex acetosa*) that contain oxalates and anthocyanins, which may affect adult preferences and feeding efficiency. The Purple Emperor (*Apatura iris*), a canopy specialist, occasionally utilizes nectar from plants like English Ivy (*Hedera helix*), whose triterpenoid saponins play a defensive role yet permit pollinator access. Such intricate chemical signaling illustrates how butterflies have evolved to navigate complex chemical landscapes for survival.

Additionally, the role of non-vascular plants, fungi, and lichens in shaping butterfly microhabitats emerged as an important finding. Bryophytes like Peat Moss (*Sphagnum* spp.) and Common Fern Moss provide essential moisture and shelter for vulnerable life stages such as egg-laying and pupation, while fungi such as Turkey Tail (*Trametes versicolor*) contribute to habitat structural complexity. Though these organisms do not directly serve as food sources, their presence supports the microclimatic and physical conditions necessary for sustaining diverse butterfly assemblages. This finding emphasizes the value of holistic habitat conservation, including often-overlooked components like bryophytes and fungi.

Overall, the heterogeneous mosaic of habitats in Creswell—comprising woodlands, grasslands, wetlands, and hedgerows—creates a rich tapestry of ecological niches underpinned by diverse phytochemical profiles. These chemical cues serve as essential mediators between plants and butterflies, influencing species distribution, abundance, and community composition. The observed butterfly diversity reflects not only the availability of suitable host and nectar plants but also the nuanced chemical interactions that guide butterfly behavior and life history strategies.

From a conservation perspective, these insights stress the importance of protecting native plant diversity and managing invasive species that alter chemical landscapes and disrupt co-evolved butterfly-plant relationships. Maintaining a variety of native flowering plants and structurally complex habitats will support both specialist and generalist butterflies, enhancing ecosystem resilience and biodiversity. Furthermore, recognizing the role of secondary metabolites in butterfly ecology can inform habitat restoration efforts by guiding plant species selection to optimize resources for target butterfly populations.

Future research should delve deeper into the mechanistic aspects of these phytochemical interactions, including controlled bioassays to quantify larval performance and adult preferences in relation to specific compounds. Expanding temporal and spatial scales will also provide a more robust understanding of seasonal dynamics and landscape-level patterns. Integrating chemical ecology with conservation biology thus offers promising avenues to safeguard butterflies and their habitats amid ongoing environmental change.

In conclusion, this study advances our understanding of how phytochemicals influence butterfly ecology in temperate environments like Creswell. By linking butterfly diversity with the chemical complexity of local flora, it lays a foundation for evidence-based conservation strategies that acknowledge the vital chemical dimensions of ecological interactions.

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