Functional significance of butterfly wing morphology variation

By : Shreeve, Tim **[Oxford brookes university]** ; Konvicka, Martin **[University South Bohemia]** ; **Van Dyck, Hans** **[UCL]**

The relatively large and colourful wings are by far the most apparent feature of adult butterflies. Butterfly wing morphology varies between species, but often also within species. This variation extends to colour, pattern, size, shape, thickness, distribution of mass and venation pattern, and has attracted much attention from evolutionary biologists. Butterfly wings have a range of interacting functions: flight, thermoregulation, intraspecific signalling and communication with predators. Wing size and shape, relative to body mass and thoracic muscle mass, are important determinants of flight dynamics. Changes in these traits may indicate changes in flight power, and probably the ability to sustain flight. This has particularly been studied in a context of habitat fragmentation. Manoeuvrability and the efficiency of flight is, however, also dependent on the way butterflies move their wings. The analysis of in flight biomechanics warrants more detailed attention. Detailed studies of butterfly body temperatures indicate that for many species adult activity becomes optimal within the range 28–38 °C. However, some butterflies fly with lower body temperatures and differences may occur within species. Warming by the adoption of species-specific basking postures to absorb solar radiation is affected by pigment and scale properties of the wings. There can be a complicated interplay between morpholog- ical variation, geographical variation of temperature and weather-dependent microhabitat use, affecting activity. Butterfly wings have communicative functions to predators, but only a few studies have attempted to quantify background matching of butterfly wings. Once detected, the presence of startling devices (e.g. wing tails) alter the chance of consumption. The effectiveness of marginal eyespots on the wings warrants, however, further experimental testing. The quantitative nature of UV coloration extends to many species and to date, predation studies have ignored this component. There is also a UV component to butterfly vision. Hence, it is essential to consider this if we want to understand intraspecific communication and mating behaviour. The functioning of all the elements of wing morphology depends on habitat structure. Many species show geographical or altitudinal variation in wing morphology, and seasonal variation within species with more than one generation a year. With increasing information on wing morphology and flight on individual species it is becoming evident that generalities are becoming harder to make. There is an urgency to understand fully this aspect of butterfly ecology to help understand how increasingly vulnerable species function and persist.

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We discuss methodological problems with the assessment of butterfly UV wing patterns by UV photography. Given proper standardization UV photography is a suitable method to qualitatively assess UV wing patterns for use in morphology or systematics. It has been suggested that structural ultraviolet (UV) patches on the wings of butterflies play a role in sexual selection. UV patches may be condition-dependent signals of mate quality. Colour variation across climatic gradients is a common ecogeographical pattern; yet there is long-standing contention over underlying causes, particularly selection for thermal benefits. We tested the evolutionary association between climate gradients and reflectance of near-infrared (NIR) wavelengths, which influence heat gain but are not visible to animals. Latitudinal variation of wing: thorax size ratio and wing-aspect ratio in Drosophila melanogaster. Evolution 52: 1353–1362.CrossRefGoogle Scholar. Berwaerts, K. & Van Dyck, H. 2004. Evolutionary significance of phenotypic plasticity in plants. Advances in Genetics 13: 115–155.CrossRefGoogle Scholar. Brakefield, P.M. & Frankino, W.A. 2009. Flight morphology of Neotropical butterflies: palatability and distribution of mass to the thorax and abdomen. Oecologia, Berlin 84: 491–499.Google Scholar. Srygley, R.B. & Dudley, R. 1993. The functional morphology of wings has been described in a number of insect orders43-46, but the relationship between the circulatory and tracheal systems in wings has only been explored in detail for a few groups11. In V. cardui, we observed that wing veins provide pathways for the tidal flow of air and hemolymph (Fig. 26. Watt, W. B. Adaptive significance of pigment polymorphisms in Colias butterflies. I. Variation of melanin pigment in relation to thermoregulation. Evolution 22, 437–458 (1968). 27. Watt, W. B. Adaptive significance of pigment polymorphisms in Colias butterflies. II. Thermoregulation and photoperiodically controlled melanin variation in C. eurytheme.