The Study of Butterflies

3. Intra-specific Variation

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Part 1. The Naming of Indian Butterflies, *Resonance*, Vol.5, No.6,p.8-14, 2000.
Part 2. Flight, Fuels and Senses, *Resonance*, Vol.5, No.8, p.4-12, 2000.

In this part of the series on butterflies, we look at the types of variations found within species as well as their causes.

The species is the fundamental unit of classification in biology. The concept of a species is generally understood to imply a group of freely interbreeding individuals that can produce fertile offspring. In the case of butterflies, during the 18th and 19th centuries, species were distinguished by the structure of the head, legs, and wing veins, besides the pattern and colouration on the wings and body. During the 20th century, however, the study of chitinous parts of the genitalia, especially of males proved a very useful diagnostic tool for identifying and differentiating species. This approach gained ground rapidly, and by the end of the second decade of the 20th century had been universally accepted. The theoretical basis of this is that the specialized structures of the genitalia prevent the successful copulation of unrelated individuals from different species. In fact, it was often seen that butterflies from different locations, even those separated by great distances or natural barriers such as mountains, had identical genitalia, although superficially they may have looked sufficiently different to have been awarded specific status by earlier workers. Therefore, there was a great deal of re-shuffling of butterfly names.

However, there is no hard and fast rule about what difference in genitalia constitutes sufficient grounds for the distinction of a species: in this, experts are guided by experience and a 'feel' for the subject. Sometimes, there are minor differences in the genitalia of individuals that obviously belong to the same species. In other cases, minor differences may be considered adequate grounds for separating what are obviously different species. In yet other cases, the grounds are so fluid that the decision to create several species or merely an 'umbrella' species is solely at the discretion of the researcher, 'pending further work in the field', which usually means breeding all the potential species and comparing their early stages. This is a rather tall order, since it not only means obtaining fertile eggs from different parts of the range of the different types, but also sufficient quantities of the larval host plants.

The latest method of classification is to use molecular information (see also *Resonance* Vol. 5, No. 6, pp. 60-68, 2000). Although this approach has been extensively applied to many vertebrates and plants, it has not been widely used for butterflies yet. There is every likelihood, though, that there will be considerable reshuffling of the names of butterfly species yet again.

Although the species is considered the unit of classification in biology, in the case of butterflies it is often necessary to create further sub-divisions, called sub-species and forms. Sub-species are essentially populations that belong to the same species but are superficially different. Such differences, usually of colour, pattern or wing shape are believed to be caused by climatic and geographic factors, hence sub-species are also called geographical variations (see *Box* 1). For example, in Indian butterfly species that are widespread, individuals from southern Indian

Box 1. Clines

Many butterflies occupy vast ranges, covering parts of Europe, Africa, Asia and Australia. As part of their adaptation to survive in the varied environments they inhabit, one often finds that the same butterfly species looks quite different in different parts of its range. Such different forms, called geographical variations or sub-species, are usually named to facilitate reference to them.

In a number of cases, such named sub-species were obtained from widely separated areas. Subsequent work in the intervening areas brought to light specimens intermediate between the two named sub-species, so that instead of distinct forms it was found that the forms gradually merged into each other. Such gradients in one or more characters, whether colours, pattern, wing shape or size, are called clines. Julian Huxley coined this term in 1939. In India, a number of butterfly species have clines along the length of the Himalayas.

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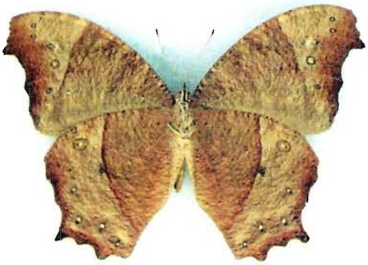
populations are usually small and dark, while those from the eastern Himalayas and the hills of north eastern India are large and dark, and those from the western Himalayan populations are large and pale.

Butterflies from drier areas are generally paler than members of the same species from wetter areas. Similarly butterflies from higher elevations are paler than their relatives found at lower altitudes. In the Rocky Mountains of North America, there are several closely related butterfly species that occur in altitudinal belts with species from higher altitudes being darker than those from lower elevations. In the Himalayas, the common copper, *Lycaena phlaeas* Linn. is found from about 1000 m elevation, or even slightly lower, to at least 4600 m. Specimens from the lower part of the range are dark and richly coloured, whereas the ones at high elevation are pale, with washed-out colours. There is no other superficial difference between the populations. This phenomena in the Himalayas might have to do with the fact that there is much less precipitation at high altitudes than at lower altitudes. Thus, the paleness of high elevation populations may be a response to the drier climate rather than, say, the greater ultraviolet radiation associated with high altitudes.

This brings us to the difference in colour and form caused by humidity. In terms of humidity, most of India is a land of extremes. The hot, dry summers, with relative humidity below 10%, often near 1%, are followed by the south west monsoon which drenches us for the best part of four months, raising humidity levels to over 80%. Butterflies that are on the wing both before and during or after the rainy season are faced with two completely different environments in which to fend for themselves. The nearly barren landscape of the pre-monsoon months changes to lush countryside teeming with predators of all shapes and sizes that are on the lookout for rich protein sources like insects on which to feed their young.

Many Indian butterflies have developed 'eyespots' (see *Figures* 1, 2 and *Box* 2) on various parts of their wings. These are dark



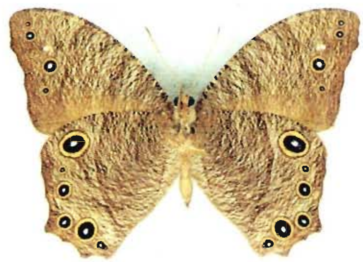


Figure 1 (left). The dry season form of the common evening brown, Melanitis leda. The underside patterns, of which one is shown here, are very variable. Note the series of pale dots along the outer edge of the hindwing, as well as the produced tips of the forewing.

Figure 2 (right). The wet season form of the common evening brown. Note the series of eyespots along the edge of the hindwing and the aborted tip of the forewing. There is very little variation between individuals in this form.

spots, often with a white speck resembling a glint in the eye, encircled by a broad yellow ring. Some species have only a single pair of eyespots, whereas others have eight or more pairs of these markings. A number of species have greatly developed eyespots on their wings during the monsoon months, which are reduced to almost invisible specks in individuals that emerge during the dry winter or summer. Such variations are known as seasonal forms, the wet season form (WSF) being the form on the wing during or immediately after the monsoon and the dry season form (DSF) being the one on the wing during the rest of the year. Earlier, all these forms were named separately, but now such names are used only for a few species, such as the spotless grass yellow, *Eurema laeta* Boisduval, whose WSP is known as *venata* Moore. In other cases, it is sufficient to add WSF or DSF after the butterfly's name, as the case may be.

In an African butterfly, *Bicyclus anynana* Butler, subject to such seasonal variation, the ability to change with the seasons was lost after 20 generations of breeding under fixed laboratory condi-

Box 2. The Creation of Eyespots

Eyespots are found on the wings of certain butterflies sometimes only at certain seasons. The position, number, size and colour of these are determined in four stages during the late larval and early pupal stages. The eyespots are formed around an organizing focus, where high levels of a certain protein, coded for by the distal-less regulatory gene, causes the eyespot pattern to emerge.

Using normal surgical practices, researchers transplanted such organising *foci* to different sites on the wing of an African butterfly, *Precis coenia*, about 3 hours after pupation. Eyespots were duly formed at the new sites and absent from the sites from where the distal-less protein had been removed.

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tions. When WSF and DSF strains were bred at constant temperatures for 20 generations they lost the ability to change forms at different rearing temperatures. It is not known whether this loss of forms can be reversed, and, if so, how many generations of rearing in a seasonal environment will it take for the seasonal forms to re-appear.

Seasonal variation is not restricted to the development of eyespots. In butterflies that resemble dry leaves such as the Oakleaf butterflies (*Kallima* sp.), the camouflage is only effective if the butterfly resembles a dry dead leaf during the dry season and a wet dead leaf during the monsoon. In order to achieve this resemblance, the ground colour of the wings, particularly the underside, i.e. the surface that is exposed when the wings are held together over the insect's back, is much darker in the WSF than in the DSF. Besides, the tips of the wings are produced in the DSF while in the WSF these are reduced, probably because dead leaves are more likely to be intact during the dry season than during the wet season, when the dampness and mould causes the leaves to rot rapidly.

Among the whites (Pieridae), in which there are no eyespots, the effect of increased humidity is to darken colours, usually on the underside of the wings. Pale yellow becomes chrome yellow, rust coloured spots appear and black markings often develop a deeper tone and are more extensive. Among the black and white or black and orange striped sailers and sergeants (*Neptini* and *Athyma* genus), the WSF usually has broader black stripes as compared to the DSF.

However, it is often possible to find wet and dry season forms on the wing at the same time. In such cases, this is believed to be the effect of the immediate environment of the larvae and pupae of these butterflies. Those larvae living on the banks of streams or in humid valleys yield the WSF and the larvae living in exposed situations on dry plains or hillsides yield the DSF. Being highly mobile in the adult stage, both forms may then congregate on sources of food or other attractants. The difference in form is not known to affect mating habits in any way.

We now come to differences caused by temperature. In a largely tropical country like India, temperature is inseparably linked with humidity, since only clouds or rainfall can cause a pronounced and prolonged drop in temperature, while the lack of clouds will result in quite high temperatures, even during winter. Therefore, in most Indian butterflies, the effects of humidity described above may also be linked to temperature.

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In some Himalayan and Palaearctic butterflies, though, one sometimes comes across an extremely dark individual, with the wing pattern rather different from the normal. Such individuals evidently pupated in exposed situations, so that they were in uncomfortably close contact with the winter snow. On emergence, such individuals are dark or melanic. This effect can be artificially created by placing the pupae of various Palaearctic butterfly species in a refrigerator. It was found that much depended on the point of development at which the pupa was subjected to cold: individuals given cold treatment immediately after pupation, or shortly before emergence, were the most affected. From the above observations, it was concluded that intense cold at certain times resulted in the darkening of the wing colours. Such forms are not separately named and are merely referred to as melanic forms.

Yet another type of seasonal variation is common among some Himalayan butterflies, especially swallow tails of the genus *Papilio*. Female *Papilio* of the last generation of the year lay eggs in September and even October. The larvae that hatch from these eggs do not get enough to eat, either because of the cold winter, precludes normal feeding, or because the leaves of the host plant are shed as the plant prepares for winter.

Thus, the first generation of the following spring comprises stunted individuals, whereas the summer generations, with enough food available to larvae are normal.

Stunted individuals of any species may also be found at any time

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of the year. The reason is usually that the insect was unable to eat properly during the larval stage. These individuals, that appear sporadically, are no more than freaks of nature and are not included when the species is being described.

Speaking of freaks of nature, there are also some unusual forms caused by genetic aberrations. The better known ones include individuals, especially of those species in which males and females have different colours or patterns on their wings, that bear traces of the pattern of both sexes. In very rare cases, one forewing and hindwing are those of a male, while the opposite pair is of a female. Such freaks are quite rare and are known as gynandromorphs.

The last type of variation we will look at is one, which occurs frequently enough and differs enough from the majority or norm to be given a name to facilitate reference to it. In butterflies, in many cases, males and females are superficially identical and can be separated only by examining the genitalia or by other physical characters, such as the development of the forelegs, etc. In a number of cases, however, males and females have different colours or patterns on their wings. These are called sexually dimorphic species. Among these, there are several species where the females have several forms that are quite different from each other despite having emerged from the same batch of eggs. The common mormon (*Papilio polytes* L.), the great mormon (*Papilio memnon* L.) and the Danaid eggfly (*Hypolimnas misippus* L.) are examples of this phenomena. In the great mormon, not only the colour and pattern differ: some forms have prominent tails at the bottom of their hindwings, which others lack. Females of the common mormon look remarkably like certain other butterflies. In India, where three forms of the common mormon occur, one form is identical to the male and does not resemble any other species but the other two look very much like the common rose (*Pachliopta aristolochiae* F.) and the crimson rose (*P. hector* L.), respectively. The forms of the common mormon are called *Papilio polytes* female form *cyrus* F., form *stichius* Hüb. and form *romulus* Cr., respectively.

In some cases, such variation is not restricted to the females but can occur in either sex. An example of this is the plain tiger *Danaus chrysippus* L. The species is found from Africa through Asia to Australia. In India, it is a common butterfly, occurring throughout the plains and also in the hills to over 2000 m elevation. The typical form is illustrated in *Figure* 3. Every now and then, one finds an individual, which lacks the white band on the forewing. Such individuals are referred to as form *dorippus* Cramer. The form *alcippoides* Moore is identical to the typical form but has the hindwing more or less white. Both these forms are not very common. They appear randomly, at any season and at any place where the species occurs. They appear to be independent of climatic and environmental factors and are likely to be caused by the interaction of certain genes with one another.

Figure 3. The typical form of the plain tiger Danaus chrysippus. One form lacks the white band on the forewing while another has the hindwing more or less white.

The variation in the colours and patterns on the wings of butterflies and their shape is genetically controlled. More often than not, the variations are caused by the response of the insect's genes to external factors such as humidity, temperature and geographical factors. However, there are instances where variation appears to be caused by purely internal factors, i.e. the interplay of dominant and recessive genes. It is believed that such random interactions as well as modifications caused by external factors may often given rise to new species in the course of time, especially if different forms confer some advantage to their bearers in different environments.

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Almost everything that distinguishes the modern world from earlier centuries is attributable to science, which achieved its most spectacular triumphs in the seventeenth century.

Bertrand Russell
History of Western Philosophy