THE ROLE OF GENETICS IN THE TAXONOMY OF THE LEPIDOPTERA

by WILLIAM HOVANITZ

Genetics is the study of inheritance. Its role in the organization of all the different kinds of moths and butterflies is solely that of an aid in the understanding of the characteristics used for classification especially with regard to their inherited variability. Of the two kinds of variability that may exist in wild organisms, part is heritable and part is imposed upon the organism by the direct influence of the environment. Only the heritable is of immediate interest to the phylogeny of the Lepidoptera. It is necessary for the taxonomist therefore to distinguish clearly between these two; this is done by breeding experiments and by testing the survival of the characters concerned under the action of differing ecological conditions.

Lepidoptera and especially the butterflies provide excellent examples of the role of the single genetic factor, or gene, in the evolution of a group. Dimorphism or polymorphism is commonly known in many of the butterflies. Among the *Colias* butterflies, for example, nearly every species in the world is dimorphic for color pattern differences between the sexes and in addition the females are dimorphic for a color pattern character, some being white and others being orange or yellow. Papilios of the *bairdii* group are dimorphic in much the same way, some being yellow and others being black; here both males and females are involved, and there is little sexual dimorphism. A classical case of dimorphism of this sort is in *Argynnis paphia* of Eurasia. A melanic form (genetically dominant) is present in differing frequencies in various populations. Changing frequencies of polymorphic forms in the same areas are known. Industrial melanism in Europe is in reality a rapid dimorphic change in which a recessive gene for light coloration has been replaced in a period of a few years by a dominant gene for black coloration. Presumably this change has been caused by selection for some phenomena associated with the industrial conditions in western Europe.

Another kind of dimorphism that should not be confused with the genetic form is that which is created by the organism's developmental response to changed climatic conditions during its life. This is the well known seasonal dimorphism such as we have in the *Anthocaris*, for example, in which a dark form occurs in the spring and a lighter-colored one in the summer. Similar changes occur in the *Pieris, Colias, Melitæa,* etc. These are non-genetic and have no influence on phylogeny directly. They do indicate the response of the organism to changes in the environmental conditions. In many cases they are parallel to, and duplications of, possible genetic differences which occur in the formation of geographic races. There is no way of distinguishing genetic from the non-genetic forms except by breeding, and in phylogenetic work therefore one must be very cautious in making judgments based solely upon study of the dead insect.

In those cases where variation is caused by many genes working together it may not be possible to distinguish the genetic classes involved in the variation. In such a case, there are no definite forms that can be considered polymorphic and the variation blends together in one continuum. This is known as polygenic or multiple factor variation. Variation, such as in the species of butterflies that vary from the northwest to the southwest in a continuous gradient from black or dark in the north to very light in the south, is of this type. *Melitæa chalcedona* of the coast of southern California is dark, while the races of the desert are red or orange-brown varying continuously through the mountain passes in one continuum of variation. The variation is genetic because the desert and other races have all been bred together and still show their specific differences.

Geographic races may be composed of the combination of several gene differences, each of which controls a specific character of the insect's wing. For example, in *Argynnis (Speyeria) callippe* of California. coastal races differ from the inland ones by a white band across the middle portions of the wings. The western Sierran races possess unsilvered spots on the underside of the wings; all the others are silvered except in the southern end of the distributional range of the Sierran race where the populations are dimorphic for the spot coloration. The high desert races possess green coloration on the underside of the wings not carried by the coastal races. The genes controlling these characters and many others are present in varying combinations in each race but since they are recognizable as units, the variation is not considered continuous. The key often may be found in intermediate zones where polymorphism may truly exist as it does in the southern Sierra.

Most genic color variations in the butterflies are adaptive in the sense that the gene producting a certain color variation is also responsible for some greater ability of the butterfly to survive in a given area. Tests were made of this for the white color gene in *Colias*. The white form in a given species is always found more commonly in colder or cloudier areas of the world as compared with the orange or yellow forms. This would indicate their greater survival value in such areas. If the survival value were dependent upon the adult's activity in the different weather conditions in these geographical areas then a simple test should show whether or not this was true, namely, observation of the relative frequency of the two forms in the same population at different times of a single day, when the conditions of the atmosphere pass through all the great changes comparable to the more general geographic ones. For this test, it was essential that the butterflies be present in tremendous numbers so as to get reliably large numbers to differentiate morning from noon and afternoon if the differences were slight. Such conditions were found in the valleys of California where *Colias eurytheme* is present in huge quantities during the summer and where the night temperatures are low and the day temperatures high. These tests did indeed show that the white form had different habits from the orange form at the same time of the day. It was comparatively more active in the cool part of the day than the orange form. This activity difference is sufficient to account for all the geographical differences of these dimorphic forms.

The last example of a method by which genetics is of aid in the taxonomy of the Lepidoptera that I shall bring up is that of the analyzing of the results of hybridization. Here our studies have indicated, both by analyzing wild populations as well as in breeding of the insects, that the former "form" *eriphyle* of *C. eurytheme* is in reality a western race of *C. philodice*. Likewise such tests have shown that hybridization is not an uncommon phenomenon in many butterflies. Ten percent of the wild individuals in the areas where *C. eurytheme* and *C. philodice* overlap are hybrid products. The formerly known *Colias boothi* of the arctic is now known to be in reality a hybrid product of the meeting and blending of the species *C. nastes* and *C. hecla*. *Colias hyale* and *Colias croceus* of Europe blend together in southern Russian territory and separate on the other side as two different species *Colias erate* and *Colias fieldi*.

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Dept. of Biology, California Institute of Technology, Pasadena, Calif., U. S. A.

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WILLIAM D. FIELD, Associate Curator, Div. of Insects,
U. S. National Museum, Washington 25, D. C., U. S. A.