

2. *Variation and Mimetic Analogy in Lepidoptera.*—Mr. Bates (whose interesting book of travels, *The Naturalist on the River Amazon*, is exciting much attention in England, and which we trust will be reprinted here) has contributed an elaborate paper to the *Transactions of the Linnæan Society*, vol. xxiii (1862), entitled *Contributions to the Insect Fauna of the Amazon Valley, Lepidoptera, Heliconidæ*. The materials were gathered by the author during eleven years of travel and research in the Amazon region. The introduction to this paper treats, among other subjects, most largely of the highly curious one above referred to, i. e., the extraordinary mimetic resemblance which certain butterflies present to other butterflies belonging to distinct groups. There are also collections of pregnant facts upon variation and divergence into races. We had marked many pages for extract; but room has not been found for them. It seems less needful to copy large parts of Mr. Bates' narrative now, since a good abstract of his paper has recently appeared in the *Natural History Review*. The bearing of Mr. Bates' observations may be inferred from the remark of his reviewer: "it is hardly an exaggeration to say, that, whilst reading and reflecting on the various facts given in this memoir, we feel ourselves to be as near witnesses as we can ever hope to be of the creation of a new species on this earth." The two subjects, *variation* and *simulation*, as may be inferred, are considered in respect to their bearing upon Mr. Darwin's theory, of which Mr. Bates is a zealous upholder, although his observations were made before this celebrated theory was promulgated. The facts set forth about variation appear excellently to illustrate the formation of races and nearly related species through gradual divellent variation; and those on mimetic analogy are not only wonderfully curious, but are most ingeniously applied to illustrate the doctrine of natural selection, under a peculiar phase.

We will first notice some of the reported facts about *variation*. Such an amount and such gradations of variability as Mr. Bates reports of butterflies, we have ceased to think very extraordinary in the vegetable world; yet we had been led to suppose that forms in the animal world were everywhere more definite and fixed. But Mr. Bates' observations seem to have convinced him "that there is a perfect gradation in variability, from butterflies of which hardly two can be found alike, to slight varieties, to well marked races, to races that can hardly be distinguished from species, to true and good species." In the genus *Ceratinia*, for instance, those parts of structure [i. e. the veining of the wings] which form fixed generic characters in other groups are here variable in the sexes, and in individuals of the same sex. *C. Ninonia* "evidently varies in different ways in different localities; yet the local varieties are not definite, the segregation of the races is not complete: so that it is embarrassing to decide whether to treat the form as one polymorphic species, including the variations under one and the same definition, or to describe separately the type and the local varieties. Besides these incomplete local modifications, easily traceable to the type, there are, as often happens in the case of prolific, widely distributed, and variable species, a number of other forms rather more strongly marked and better defined, which inhabit regions rather more distant from the locality of the type than those which the mere varieties inhabit. These are admitted on all hands to be distinct species; but I think it would be difficult to prove

that these were not also varieties of *C. Ninonia*, which have become more completely segregated from the parent form." The examples are given. This is essentially what De Candolle concludes of Oaks, as we have seen in a former article. *Mechanitis Polymnia* affords one of the most striking cases. The typical form of the perfect insect, as figured by Cramer, prevails at Para and elsewhere in the region of the lower Amazon. There all the specimens are very much alike: while at Ega, on the Upper Amazon, very few individuals conform to the Cramerian type. Among the numerous forms, one, which he names *M. Egaënsis*, predominates; but all the intermediate forms between it and the typical *M. Polymnia* occur there, only in fewer numbers. At St. Paulo, 260 miles further west, the species was again extremely variable, some individuals coming near the type, but none identical with it. The varieties were quite different from those of Ega; the *M. Egaënsis* was wholly absent, but a new variety abounded, of which there was no trace at Ega; this has been figured and described as a distinct species. The complete set of connecting forms convinced the observer that all belonged to one species, disseminated over a large area, and modified in certain districts. He affirms that the varieties were of such a nature, as to form and colors, that they could not be thought to be hybrids between two or more distinct species. And also, that the amount of local modification in no way accorded with obvious differences in the local conditions; for the species was, on the one hand, totally changed within 260 miles of very similar soil and climate, but, on the other hand, was constant in districts 600 miles apart and very different in physical conditions. Extending the view up to the eastern slopes of the Andes, there are said to be still other forms, some of them clearly varieties of *M. Polymnia*, although they have been described as species; others more sharply defined and having the appearance of true species. So Mr. Bates thinks that, —

"The conclusion is unavoidable that these apparently distinct species are modifications, as well as the undoubted varieties are; for we have the species in all stages of modification,—simple variation, local variety scarcely distinguishable from a mere variation, complete local variety, and well marked race or species. The forms of *M. Polymnia* found in South Brazil confirm this view. At Rio Janeiro the well marked race or species *M. Lysimnia* alone is found; at Bahia (traveling towards the home of the type, *M. Polymnia*), *M. Lysimnia* in company with *M. Nesæa*; at Pernambuco (further northward) *M. Nesæa* alone occurs; at Pará this form is seen no more, and *M. Polymnia* in its typical dress monopolizes the field. These facts seem to teach us that, in this and similar cases, a new species originates in a local variety, where the conditions are more favorable to it than to the typical form, and that a large number of such are simultaneously in progress of formation from one variable and widely distributed species. The new species cannot be proved to be established as such, unless it be found in company with a sister form which has had a similar origin, and maintaining itself perfectly distinct from it. Cases of two extreme varieties of a species being thus brought into contact by redistribution or migration, and not amalgamating, will be found to be numerous when the subject is inquired into." "It is an advantage to a form to have a sphere of life different from its allies; when two sister forms keep themselves distinct in a locality, it is a sign that they have acquired sufficient difference to fill two separate spheres. If they paired together they would soon become one again. Nature may be said to place a premium on diversity; for she thus destroys the incompletely formed race, and preserves the completely formed one. The case of *Mechanitis Polymnia* differs from that of

Leptalis Theonoe in exhibiting the production, generally, of only one local form in a district, instead of many. As far as my observations go, this seems to have been the most frequent course in nature. More than one new race would with difficulty be formed in a limited area, when the individuals live in close neighborhood, except in such cases as our *Leptalis*, where rigid destruction of intermediate forms is going on, thus restricting the choice of mates to the surviving forms; or in such genera as *Ithomia*, where there is no doubt the insects carefully select their exact counterparts in pairing."

In the latter case, where each sort strictly interbreeds, the races once originated would be kept distinct as long as they existed. Mr. Bates asserts that in the *Ithomiæ* and allied genera, "where a number of very closely allied species fly together, they keep themselves perfectly distinct, there are no hybrid forms, and, on observing individuals in copula, I almost always found the pair to be precisely the same in color and markings." The exception was in *Mechanitis Polymnia*, above mentioned, "a polymorphic species, whose local varieties are in an imperfect state of segregation." This pairing of exact counterparts would—upon principles which we have particularly explained in this Journal—accelerate the diversification or divergence into races, by enabling each advance of variation to be held. And it would, as Mr. Bates remarks, enable a number of closely allied forms to exist, either together or in contiguous areas, without amalgamating.

In his remarks upon *Mechanitis Polymnia*, as illustrating the course apparently followed by nature in the formation of local species, the author repeats that:—

"We find, in this most instructive case, all the stages of the process, from the commencement of the formation of a local variety (var. *Egaënsis*) to the perfect segregation of one (var. *Lysimnia*) considered by all authors as a true species. In this species, most of the local varieties are connected with their parent form by individuals exhibiting all the shades of variation; and it is on this account only that we know them to be varieties. In the species allied to *Ithomia Flora*, the forms are in a complete state of segregation (with the exception of *I. Illinissa*, which throws light on the rest), and therefore they are considered as species; they are, in fact, perfectly good species, like all other forms considered as such in natural history. It is only by the study of variable species that we can obtain a clue to the explanation of the rest. But such species must be studied in nature, and with strict reference to the geographical relations of their varieties. Many closet naturalists, who receive disconnectedly the different varieties of any group, treat them all as independent species; by such a proceeding, it is no wonder that they have faith in the absolute distinctness and immutability of species."

The *mimetic analogies*, of which many of the *Heliconidæ* are the objects, have been mentioned by modern authors who have written on the group; "but no attempt has been made to describe them fully or to explain them." Mr. Bates exhibits the more striking cases in a tabular view, which gives some idea of the extent to which this imitation prevails, and, of the various tribes of Lepidoptera to which the imitators belong. It is concluded that the *Heliconidæ* are the *imitated*, because they have all the same family aspect, while the imitators or analogous species are dissimilar to their nearest allies,—are perverted, as it were, from the facies of the group to which they severally belong.

"The resemblance is so close that it is only after long practice that the true can be distinguished from the counterfeit when on the wing in their native

forests. I was never able to distinguish the *Leptalides* from the species they imitated, although they belong to a family totally different in structure and metamorphosis from the *Heliconidæ*, without examining them closely after capture. They fly in the same parts of the forest, and generally in company with the species they mimic. I have already given an account of the local modifications to which the *Heliconidæ* are subject. It is a most curious circumstance that corresponding races or species of counterfeiting groups accompany these local forms. In some cases I found proof that such species are modified from place to place to suit the peculiar forms of *Heliconidæ* there stationed."

The details in evidence of this are fully explained and illustrated by plates. Nothing can be more curious. The *Ithomiæ* imitated are excessively numerous in individuals; the imitating *Leptalides* are rare, not more than one to a thousand of the other. The latter has not been found in any other district or country than in those inhabited by the *Ithomiæ* which they counterfeit. The resemblance is often carried to minutiae, such as the color of the antennæ and the spotting of the abdomen. Not only are the *Heliconidæ* thus imitated; some of them are themselves imitators, i. e., they counterfeit each other, species belonging to distinct genera having been confounded, owing to their close resemblance in coloring and marking.

"These imitative resemblances, of which hundreds of instances could be cited, are full of interest, and fill us with the greater astonishment the closer we investigate them; for some show a minute and palpably intentional likeness which is perfectly staggering. I have found that those features of the portrait are most attended to in nature which produce the most effective deception when the insects are seen in nature."

Similar imitations are said to occur in the Old World, in other families of Butterflies and Moths; but no instance is known of a tropical species of one hemisphere counterfeiting a form belonging to the other. Other orders of insects supply such cases in certain families. "Many instances are known where parasitic bees and two-winged flies mimic in dress various industrious or nest-building bees, at whose expense they live in the manner of the Cuckoo. I found on the banks of the Amazon many of these Cuckoo bees and flies, which all wore the livery of working bees peculiar to the country." Mr. Wallace has noticed two similar and equally striking instances of mimicry in birds.

Now, as to the final cause of these mimetic analogies,—

"When we see a species of Moth which frequents flowers in day-time wearing the appearance of a Wasp, we feel compelled to infer that the imitation is intended to protect the otherwise defenseless insect by deceiving insectivorous animals which persecute the moth and avoid the wasp. May not the *Heliconide* dress serve the same purpose to the *Leptalis*? Is it not probable, seeing the excessive abundance of the one species, and the fewness of the other, that the *Heliconide* is free from the persecution to which the *Leptalis* is subjected?"

"I believe that the specific mimetic analogies exhibited in connection with the *Heliconidæ* are adaptations,—phenomena of precisely the same nature as those in which insects and other beings are assimilated in superficial appearance to the vegetable or inorganic substances on which, or amongst which, they live. The likeness of a Beetle or a Lizard to the bark of the tree on which it crawls cannot be explained as an identical result produced by a common cause acting on the tree and the animal."

A full series of such imitations by insects, both of inanimate and of living objects, is then given. That such imitative resemblances as we are considering are of the same class as these, and subject to the same explanation, is obvious from the fact of one species mimicking an inanimate object, while one of an allied genus imitates an insect of another family. They are all evidently "adaptations having in view the welfare of the creatures that possess them." Every species maintains its hold upon existence only through some endowment enabling it to withstand the various adverse circumstances to which it is exposed; and the means are of endless diversity,—organs of offense, great fecundity, capabilities for wide dispersion, and, among the rest, the adaptive resemblances of a defenseless species to one which enjoys some kind of protection. The multitudinous swarms of slow-flying *Heliconidæ* on the Amazon, apparently defenseless, must enjoy some immunity from the insectivorous animals. Mr. Bates never saw them preyed upon by birds or Dragon-flies, or molested by Lizards when at rest; and their dead bodies set out to dry were rarely attacked by vermin. They all have a peculiar smell. So it is probable that they are unpalatable to insect enemies. "If they owe their flourishing existence to this cause, it would be intelligible why the *Leptalidæ*, whose scanty number of individuals reveals a less protected condition, should be disguised in their dress and thus share their immunity."

This naturally leads to Mr. Bates' explanation of the process by which these mimetic resemblances and other such adaptations are brought about. The admirer of *natural selection* finds here a beautiful application of the principle. Given the *Heliconidæ* as they are, segregated and in course of segregation into variations, varieties, races, and species under conditions of natural selection which are still occult, and supposing (what their flourishing numbers prove) that their taste, odor, or something else, affords a comparative immunity from the attacks of their natural enemies, the existence of their more exposed analogues, in each locality, would seem to depend upon the closeness of their resemblance to the protected *Heliconidæ* of the district, such resemblance being apparently the only means of escaping extermination by insectivorous animals. As the imitated species vary from place to place, so must the imitators if they would retain their hold upon life. And, of all the variations which are constantly arising, only those which do resemble the protected form near enough to deceive the insectivorous enemy, will retain their hold. This is natural selection, the insectivorous animals being the selecting agents; and the operation proceeds to draw out steadily, in certain favorable directions, the suitable variations which arise from generation to generation, as a result of the extermination of those sorts or varieties which are not enough like the protected species to deceive the enemy.

"If a mimetic species varies, some of its varieties must be more and some less faithful imitations of the object mimicked. According therefore to the closeness of its persecution by enemies, who seek the imitator but avoid the imitated, will be its tendency to become an exact counterfeit,—the less perfect degrees of resemblance being, generation after generation, eliminated, and only the others left to propagate their kind." "The fact of one of the forms

of *Leptalis Theonoë*, namely *L. Lysinoë*, mimicking an Ega, not an *Ithomia*, but a flourishing species of another quite distinct family (*Stalachtis Duvalii*), shows that the object of the mimetic tendencies of the species is simply disguise, and that, the simple individual differences in that locality being originally in the direction, not of an *Ithomia*, but of another object equally well answering the purpose, selection operated in the direction of that other object." "When the persecution of a variable local form of our *Leptalis* is close or long continued, the indeterminate variations naturally become extinct; nothing then remains in that locality but the one exact counterfeit, whose exactness, it must be added, is henceforth kept up to the mark by the insect pairing necessarily with its exact counterpart, or breeding in and in. This is the condition of *L. Theonoë*, &c. When (as happens at St. Paulo, where a greater number of individuals and species, both of *Ithomia* and *Leptalis*, exists) many species have been in the course of formation out of the varieties of one only, occasional intercrossing may have taken place; this would retard the process of segregation of the species, and, in fact, aid in producing the state of things (varieties and half-formed species) which I have already described as there existing." "Such, I conceive, is the only way in which the origin of mimetic species can be explained. I believe the case offers a most beautiful proof of the truth of the theory of natural selection. It also shows that a new adaptation, or the formation of a new species, is not effected by great and sudden change, but by numerous small steps of variation and selection."

At a time like the present, when the notion that species are derivative, somehow or other, is received as the most probable opinion by such an increasing number of competent observers and thinkers—including, it may be added, the names of Lyell and of Owen,—and when it appears to the thoroughly conservative and well-informed President of the Linnæan Society¹ "that the tide of opinion among philosophical naturalists is setting fast in favor of Mr. Darwin's hypothesis," such illustrations of the latter as Mr. Bates has presented are worthy of attentive consideration. But we need not agree with Mr. Bates in his conclusion that the impression produced "of there being some innate principle in species which causes an advance in organization in a special direction," so that the result is "a predestined goal," is untenable, and the appearances which suggest such idea, illusory. Because variations are picked out, preserved, and led to useful ends by natural selection, it does not follow, nor has it ever been shown, that they occur lawlessly and at random.

A. G.

3. *Flora Australiensis: a Description of the Plants of the Australian Territory*; by GEORGE BENTHAM, F.R.S., P.L.S., assisted by FERDINAND MÜLLER, M.D., F.R.S. & L.S., Government Botanist, Melbourne, Victoria, vol. I. (*Ranunculaceæ* to *Anacardiaceæ*.) London: Reeve & Co.

¹ Address of George Bentham, Esq., President, read at the Anniversary Meeting of the Linnæan Society, May 25, 1863. Published at the request of the Fellows. It is mainly a critical review of the recent progress of biological (i. e. in its properest sense, physiological) science, and is in almost every respect well-considered and forcible. In referring to Professor Wyman's paper, in this Journal, on the production of Infusoria, Mr. Bentham, probably relying upon others, has failed to appreciate the thorough care, appositeness, and simplicity of his experiments,—which, as we judge, stand at an advantage over Pasteur's,—especially in the very point remarked on, viz: the degree of heat applied. This was not only considerably higher in some of Wyman's experiments than in Pasteur's, but must have been far more efficient, as it was not exposure to dry heat, but boiling.