ALFRED R. WALLACE ON THE COLORS OF ANIMALS.

By Thomas Bland.

The interesting work entitled "Tropical Nature," by Mr. Alfred R. Wallace, contains a discussion on the nature and origin of the colors of animals and plants, intended to show how far and in what way "these are dependent on the climate and physical conditions of the tropics." The author remarks:

"The complex laws and unexpected relations which we have seen to be involved in the production of the special colors of flower, bird and insect, must give them an additional interest for every thoughtful mind; while the knowledge that, in all probability, each style of coloration, and sometimes the smallest details, have a meaning and a use, must add a new charm to the study of nature."

Having resided within the tropics in South America and the West Indies, I perused the work in question more particularly to learn to what extent the author's views can be applied to the coloration of the shells of terrestrial mollusca, certain of which have, for many years engaged my attention. I made notes for reference, using freely the author's language, and now offer them, for publication, considering that they will be interesting to others. I add remarks, desiring to elicit information.

Among naturalists, Wallace observes, "color was long thought to be of little import, and to be quite untrustworthy as a specific character. The numerous cases of variability of color led to this view . . . but it now begins to be perceived that these cases, though tolerably numerous, are, after all, exceptional; and that color, as a rule, is a constant character. . . . The more we examine it, the more convinced we shall become that it must serve some purpose in nature, and that, besides charming us by its diversity and beauty, it must be well worthy of our attentive study and have many secrets to unfold to us."

Wallace discusses the "Theory of heat and light as producing color." He says one of the most obvious and most popular of these theories is "that color is due to some direct action of the heat and light of the sun, thus at once accounting for the great number of brilliant birds, insects, and flowers, which are found between the tropics. . . . It is undoubtedly the case that there are an immensely greater number of richly colored birds and insects in tropical, than in temperate and cold countries, but it is by no means so certain that the *proportion* of colored to obscure species is much or any greater." The author remarks that it is when we come to the vegetable world, that the greatest misconception on this subject prevails, adding that twelve years of observation among the vegetation of the eastern and western tropics had convinced him that, "in proportion to the whole number of species of plants, those having gayly colored flowers are actually more abundant in the temperate zones than between the tropics."

In regard to the "Classification of organic colors," we find Wallace writes, "that neither the general influence of solar light and heat, nor the special action of variously tinted rays, are adequate causes for the wonderful variety, intensity, and complexity of the colors that everywhere meet us in the animal and vegetable worlds. Let us, therefore, take a wider view of these colors, grouping them into classes determined by what we know of their actual uses or special relations to the habits of their possessors. This, which may be termed the functional and biological classification of the colors of living organisms, seems to be best expressed by a division into five groups, as follows:—

Animals
1. Protective colors.
2. Warning colors.*
3. Sexual colors.
4. Typical colors.

Plants —5. Attractive colors.

Protective colors, Wallace states, are "exceedingly prevalent in nature, comprising those of all the white arctic animals, the sandy-colored desert forms, and the green

* *a*. Of creatures specially protected. *b*. Of defenceless creatures, mimicking *a*.

birds and insects of tropical forests. It also comprises thousands of cases of special resemblance — of birds to the surroundings of their nests, and especially of insects to the bark, leaves, flowers or soil, on or amid which they dwell. Mammalia, fishes and reptiles, as well as mollusca and other marine invertebrates, present similar phenomena; and the more the habits of animals are investigated, the more numerous are found to be the cases in which their colors tend to conceal them either from their enemies or from the creatures they prey upon. . . . It is becoming more and more evident that the need of protection has played a very important part in determining the actual coloration of animals."

On the theory of "Protective Colors," Wallace speaks as follows:

"Obscure or protective tints in their infinitely varied degrees are present in every part of the animal kingdom, whole families or genera being often thus colored. Now the various brown, earthy, ashy, and other neutral tints are those which would be most readily produced, because they are due to an irregular mixture of many kinds of rays; . . . . We may expect these brown tints to occur when the need of protection is very slight, or even when it does not exist at all; always supposing that bright colors are not in any way useful to the species. But whenever a pure color is protective, as green in tropical forests, or white among arctic snows, there is no difficulty in producing it, by natural selection acting on the innumerable slight variations of tint which are ever occurring. Such variations may, as we have seen, be produced in a great variety of ways: either by chemical changes in the secretions, or by molecular changes in surface structure; and may be brought about by change of food, by the photographic action of light, or by the normal process of generative variation." It is impossible, "without exact knowledge of the habits of an animal and a full consideration of all the circumstances, to decide that any particular coloration cannot be protective or in any way useful."

The sandy color of desert forms is referred to as an illustration of protective color. We see this characteristic color in the terrestrial mollusca of our arid regions, comprised in W. G. Binney's *Central Province*. When Mr. John H. Redfield saw the interesting shells collected by Mr. H. Hemphill in Utah, he wrote to me, "I was much struck with the resemblance in general aspect of most of the Utah forms with the helices of the dry desert regions of the old world. It is what we might expect, and what we see in the flora, even where genera and species are different." The red color of some varieties of *Helix nemoralis* is declared by Dr. Weinland to be protective on trunks and among decayed leaves of beech trees. I lately received specimens labelled var. *fagorum* Weinland.

As to "Warning Colors," Wallace notices that such are "exceedingly interesting, because the object and effect of these are not to conceal the object, but to make it conspicuous." As the best examples of these especially protected creatures, Wallace refers to two families of butterflies, the species of which are generally large, all conspicuously and often most gorgeously colored,— all fly slowly and never attempt to conceal themselves, yet no bird, spider, lizard or monkey (all of which eat other butterflies), ever touches them. "The reason simply is that they are not fit to eat, their juices having a powerful odor and taste that is absolutely disgusting to all these animals. Now we see the reason of their showy colors and slow flight. It is good for them to be seen and recognized, for then they are never molested; but if they

did not differ in form and coloring from other butterflies, or if they flew so quickly that their peculiarities could not be easily noticed, they would be captured, and, though not eaten, would be maimed or killed."

In explanation of what is called Mimicry, Wallace states:—"Wherever there is a large group of directly-protected forms (division *a* of animals with warning colors), there are sure to be found a few otherwise defenceless creatures which resemble them externally so as to be mistaken for them, and which thus gain protection, as it were, on false pretences (division *b* of animals with warning colors).

[*To be concluded.*]

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(*Concluded from page 55.*)

"Warning Colors," says Wallace, "differ greatly from the last class, inasmuch as they present us with a variety of brilliant hues, often of the greatest purity, and combined in striking contrasts and conspicuous patterns. Their use depends upon their boldness and visibility, not on the presence of any one color; hence we find among these groups some of the most exquisitely-colored objects in nature. . . . Conspicuousness being useful, every variation tending to brighter and purer colors was selected; the result being the beautiful variety and contrast we find."

In this connection I may mention an incident related by the eminent botanist, Mr. Chas. Wright, which occurred to him in Cuba. He refers to *Oleacina* and its allies (possibly the species was a *Streptostyla*) as being carnivorous, and having a smooth, polished, delicate shell, yet possessing "the power to capture and devour others many times larger than themselves." Wright states that often, in climbing rocks, he needed both hands for support, and, at such times, if a shell attracted his attention, he used to put it between his lips until his hands were free. He thus learned that the watery or slimy secretion which these animals emit, in the case of the group in question, is bitter; and in the larger species, very decidedly so. Wright adds: "May not the bitterness produce a benumbing effect on their prey? I have discovered a like bitterness in no other shell and I have collected many species in this way, using my mouth as a temporary box." The brilliant polish of the shells, alluded to by Wright, may be as well calculated to *warn* enemies as the more striking colors of other species.

I may refer, also, to the fact that several species of *Helix*, occurring in Europe, as well as *Hyalina alliaria* (the latter introduced into the United States), are distinguished by a peculiar smell, which is also a source, probably, of protection.

The class of "Sexual Colors" comprises all cases in which the colors of the two sexes differ. This difference, Wallace says, "is very general and varies greatly in amount, from a slight divergence of tint up to a radical change of coloration. Differences of this kind are found among all classes of animals in which the sexes are separated, but they are much more frequent in some groups than others."

Proposing to confine my consideration of Wallace's views on animal coloration, to the terrestrial mollusca, I shall not further refer to sexual colors, inasmuch as the inoperculates are amphisexual, and I am not aware of, and cannot suppose, that there is any sexual diversity of color in the operculates, which are unisexual.

"Typical Colors" include all species which are brilliantly or conspicuously colored in both sexes, and for whose particular colors we can assign no function or use. It comprises a number of showy birds and insects, a few mammalia, a number of marine fishes and abundance of mollusca, star-fishes and other marine animals.

In respect to the theory of typical colors, Wallace remarks: "The remaining kinds of animal colors,

those which can neither be classed as protective, warning, or sexual, are for the most part readily explained on the general principles of the development of color which we have now laid down. It is a most suggestive fact, that, in cases where color is required only as a warning, as among the uneatable caterpillars, we find, not one or two glaring tints only, but every kind of color disposed in elegant patterns, and exhibiting almost as much variety and beauty as among insects and birds. Yet here, not only is sexual selection out of the question, but the need for recognition and identification, by others of the same species, seems equally unnecessary. We can then only impute this variety to the normal production of color in organic forms, when fully exposed to light and air and undergoing great and rapid developmental modification."

With respect to the terrestrial mollusca, the question of typical colors is of much importance. Considering that full exposure to light and air is in a great measure essential to the normal development of color, whether typical or not, the inquiry as to whether the shells of arboreal species of terrestrial mollusks exhibit more variety and intensity of color than of those living generally under cover, on the ground, is of special interest. The beautiful and variously-colored *H. picta* of Cuba is, as Wright states, a high climber, — he "observed many young in the top branches of a high tree, just felled, on the very top of the mountains, in Yateras" whilst *H. stigmatica*, of the same island, "lives under stones or among dead leaves," is dull in color, and "never found fairly in the daylight." The most highly and variably colored land-shells in Jamaica are the species of *Lia*, "distinguished from the rest of the *Cylindrellidæ*, not only by their smooth polished surface, but by their purely arboreal habits."

The *Achatinellæ* of the Sandwich Islands are divided by Gulick into two groups of genera. The first consisting of seven genera, all arboreal in their habits; the second group comprising three genera, the species of two of which, with few exceptions, live on the ground. I believe that the former, the arboreal species, are more highly and variously colored than the latter. The same is the case in *Bulimus*.

With regard to the color of the North American species, W. G. Binney thus generalizes — "our snails are quite plain and exceedingly uniform; in this respect, also, differing essentially from the species of the Old World. They vary from yellowish-green through horn-color to chestnut, most of them being simply horn-colored. This is perhaps owing to the fact that our species do not infest our gardens and open fields, but are generally confined to forests, sheltered under logs and stones, and are rarely seen abroad, except during twilight, or on damp and dark days." "The European species, on the other hand, follow in the track of cultivation, and are common in gardens and fields, on walls and hedges, and other places exposed to the action of light" (Terr. Moll. V). Here I would again refer to the remark of Wallace, already quoted, — "We may expect these brown tints to occur when the need of protection is very slight, or even when it does not exist at all."

With respect to local causes of color-developments, Wallace refers to the presence of peculiar elements or chemical compounds in the soil, the water, or the atmosphere, or of special organic substances in the vegetation; and remarks that a wide field is thus offered for chemical investigation.

"It seems," Wallace writes, "a fair conclusion that color *per se* may be considered to be normal and to need no special accounting for,

while the absence of color (that is, either *white* or *black*), or the prevalence of certain colors to the constant exclusion of others, must be traced, like other modifications in the economy of living things, to the needs of the species. Or, looking at it in another aspect, we may say, that amid the constant variations of animals and plants, color is ever tending to vary and to appear where it is absent; and that natural selection is constantly eliminating such tints as are injurious to the species, or preserving and intensifying such as are useful."
