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THE COLOURS OF ANIMALS.

The Colours of Animals: their Meaning and Use especially considered in the case of Insects. By Edward Bagnall Poulton, M.A., F.R.S., &c. With Chromolithograph Frontispiece and Sixty-six Figures in Text. (London: Kegan Paul, Trench, Trübner, and Co., Limited, 1890.)

THIS new volume of the International Scientific Series gives an excellent summary of the most recent researches as to the varied uses of the colours of animals, and more especially of those admirable observations and experiments on variable protective colouring with which Mr. Poulton's name is associated, and which mark an era in this branch of natural history. The main outlines of the subject are so well known, both to naturalists and to general readers, that it will only be necessary here to indicate some of the more important of the matters now first treated in a popular work, and to make a few remarks on some of the more difficult problems discussed in the volume.

The first chapter gives a short but very clear statement of the physical cause of animal colours, and contains some valuable observations on the effect of thin films of air or of liquids in the production of iridescent colours. In some cases dried insects lose some of their metallic colours, but these reappear when the specimen is dipped in water. Even living beetles have been observed to lose their lustre after hybernation, and to regain it after drinking water. Then we have a sketch of the general uses of colour to animals, and it is shown that the frequent dark colour of arctic insects has probably a physiological use in enabling them to absorb as much heat as possible during the brief period of their existence under an arctic sun. This is supported by some direct observations; but the further suggestion that the white colour of so many arctic birds and mammals has also a physiological use in checking the loss of heat through radiation is less satisfactory. Not only is there no evidence to show that the loss of animal heat is at all influenced by the colour of the fur or feathers, but it is evident that the same result could be brought about by a very slight increase in the texture or thickness of the covering, such as actually occurs in all arctic animals. In the seventh chapter there is a very interesting discussion on the way in which the white winter coat of arctic animals is produced, and it is shown that in the American arctic hare the brown hairs of the summer coat turn white at the tips, while a quantity of new white hairs grow among them, producing at once the thickening of the coat for warmth and the change of colour for protection. That this last is the only function of the colour is well indicated by the case of the raven, which is found in the extreme north of the polar regions, even during the most intense colds of winter, wherever the reindeer and musk-sheep range. Yet it is here as black as elsewhere, although the occasional occurrence of pied and even of white ravens in various parts of Europe and America shows that a white race could be produced if that colour was of any advantage to the bird in its arctic habitat.

Two chapters are devoted to a subject which Mr. Poulton has made especially his own, the variable protective colouring of insects. This was first noticed by the late Mr. T. W. Wood, the well-known natural history artist who furnished many of the best illustrations for Darwin's "Expression of the Emotions in Man and Animals," and the result of his experiments were brought before the Entomological Society of London in 1867. Since then a few other observations have been made by several naturalists, but little was known of the extent or of the exact causes of the adaptation till Mr. Poulton carried out his experiments for several years in succession, and on so extensive a scale that in one year over 700 larvæ of the small tortoiseshell butterfly (*Vanessa urticæ*) were observed under various surroundings, and the colours of the resulting chrysalides recorded. In this way pupæ were obtained varying from black to nearly white or metallic golden colours, in each case corresponding more or less closely to the coloured surfaces on which they were suspended. By changing the coloured surroundings at different stages of the process, and by blinding some of the larvæ, it was ascertained that the period of susceptibility is the quiescent stage just before the change to the pupa state, and that in this case vision has nothing to do with the change of colour. By a number of ingenious experiments, it was ascertained that the whole surface of the skin is sensitive to the action of variously-coloured light, and the effect on the pupa-skin is produced, not directly, as by some photographic action, but by a physiological process acting through the nervous system. In some cases even the cocoons spun by the larvæ are modified by the surrounding colours; and still more curious changes are effected in the larva itself when, as in so many cases, the same species feeds on several plants having differently-coloured leaves. Even the presence of numerous dark twigs has been shown to cause a corresponding change of colour in the larva of the peppered moth (*Amphidasis betularia*). These two chapters afford a beautiful example of a very difficult and interesting inquiry leading to an explanation of some of the most curious colour-phenomena in the animal kingdom. Mr. Poulton points out the essential difference between this mode of colour-adjustment and that of the chameleon, and of some crustacea, frogs, and fishes, which can rapidly adjust their colours to new surroundings, in the following passage:—

"The essential difference between the two kinds of adjustment is that, in the one case, the pigmented part of certain cells contracts in obedience to nervous stimuli, and thus alters the general appearance; while in the other case the coloured part is actually built up of the appropriate tint, or loses its colour altogether and becomes transparent in obedience to the same stimuli. The frog or fish has a series of ready-made screens which can be shifted to suit the environment; the insect has the power of building up an appropriate screen. In many cases, however, the green colour of caterpillars is due to the ready-made colour of the blood, which becomes effective when pigment is removed from the superficial cells, but which disappears when the latter are rendered opaque. Here, however, the superficial cells form the screen which has to be built up, or from which the colour must be dismissed; and in certain species

even the colour of the blood is entirely changed in the passage from a green to a dark variety, or *vice versâ*. Hence it is to be expected that the changes occurring in an insect will occupy a considerable time as compared with those which take place in a frog. Another difference between the two processes is that the stimulus from the environment falls upon the eye in the one case, and probably upon the surface of the skin in the other."

Mr. Poulton's work is of special importance for the numerous experimental proofs he gives of the protective value of many of the peculiarities in the colour markings or attitudes of insects. Thus the green lizard (*Lacerta viridis*) generally failed to detect a "stick caterpillar" in its position of rest, although the insect is seized and greedily devoured directly it moves. The value of the tufts of hair, called "tussocks," on many caterpillars was also proved experimentally.

"A caterpillar of the common vapourer moth (*Orgyia antiqua*) was introduced into a lizards' cage, and when attacked, instantly assumed the defensive attitude, with the head tucked in and the 'tussocks' separated and rendered as prominent as possible. An unwary lizard seized the apparently convenient projection; most of the 'tussock' came out in its mouth, and the caterpillar was not troubled further. The lizard spent a long and evidently most uncomfortable time in trying to get rid of its mouthful of hairs."

There is a most excellent account of the larva of the lobster moth (*Stauropus fagi*) which is protected by its marvellous resemblance to a withered beech-leaf and its stipules, and is also able to assume a terrifying attitude, when it resembles some large and strangely formed spider. When one of these larvæ had assumed the terrifying attitude, a marmoset monkey was much impressed by the alarming sight, and only ventured to attack after the most careful examination, and even then in the most cautious manner. A lizard exhibited the same caution before the larva was attacked. The same insect is also to some extent protected from ichneumons by two black marks, exhibited only when attacked, which resemble those produced by the stings of ichneumons, and thus prevent an attack, since these parasites always avoid larvæ which are already occupied.

Two chapters are devoted to an excellent account of the various forms of mimicry, a subject which, however interesting, has been so often treated that there is comparatively little new to be said upon it; and then we have two chapters on sexual colours, which will offer material for a few remarks, as the whole subject is full of difficulties, and requires much more observation and experiment before the problems it presents can be satisfactorily settled.

Mr. Poulton fully accepts Darwin's theory of female choice as the source of the greater part of the brilliant colour, delicate patterns, and ornamental appendages that exist among animals, and especially among birds and insects. Much stress is laid on the observations of two American writers on the courtship of spiders. These show that spiders resemble birds in the strange postures and long-continued antics of the male during courtship, and that he always exhibits whatever portion of his body is most conspicuously coloured.

"The female always watches the antics of the male intently, but often refuses him in the end, 'even after dancing before her for a long time.' Such observations strongly point towards the existence of female preference based on æsthetic considerations."

To the last four words we demur, as being altogether unproved. Why *æsthetic* considerations? Why not a deficiency in activity, or in size, or in some exciting odour, or in the excitability of the female at the moment? Any of these causes, or others unknown to us, may determine the acceptance or rejection of a male spider; and it is to be noted that the long-continued and careful observations of these American authors have not enabled them to adduce a single case in which any deficiency of colour was observed in a rejected male. There is, indeed, one case in which two well-marked male varieties of a species exist—one red, the other black; and these assume different attitudes in courtship. Messrs. Peckham say: "the *niger* form, evidently a later development, is much the more lively of the two, and whenever the two varieties were seen to compete for a female, the black one was successful." On this Mr. Poulton remarks: "It must be admitted that these facts afford the *strongest support* to the theory of sexual selection"; but there is not a particle of proof that the black colour was the cause of the selection rather than the "superior liveliness" which all breeders of animals believe to be the most attractive characteristic a male can possess.

Mr. Poulton speaks continually of the possession of an "æsthetic sense by those creatures in which sexual ornament occurs, but no proof whatever of this is given, other than the fact that insects do recognize diversities of colour, and that a few birds collect bright objects, as in the case of the bower-birds. This habit, existing in a few species only of one of the highest groups of birds, can hardly be held to be a proof that in all birds, even in such comparatively low types as ducks and Gallinaceæ, slight variations of colour in the male determine the choice of the female.

This æsthetic sense is supposed to exist even in insects, and some very doubtful facts are alleged in support of this view. It is stated that if all the brightly-coloured butterflies and moths in England were arranged in two divisions, the one containing all the beautiful patterns and combinations of colours, the other including the staring, strongly-contrasted colours and crude patterns, we should find that the latter would contain, with hardly an exception, the species in which independent evidence has shown, or is likely to show, the existence of some unpleasant quality. The former division would contain the colours displayed in courtship and when the insect is on the alert. And it is added that there is an immense difference between the two divisions—the one most pleasing, the other highly repugnant, to our æsthetic sensibilities, because the pleasing colours have been determined by the insect's sense of what is *beautiful*, the displeasing colours by the need for what is *conspicuous* to a vertebrate enemy. If there is, indeed, any such great and constant difference due to these causes, it must exist in all countries, and in all groups where these causes have come into play; but it is very doubtful whether any such difference does exist. In looking over a general collection of butterflies few would decide that the Danaidæ, Acræidæ, and Heliconidæ showed any deficiency in beauty and harmony of colour; yet they are pre-

eminently the groups in which warning colours are predominant. So, also, the American and Eastern sections of the genus Papilio which are both subjects of mimicry and have all the other characteristics of protected groups with warning colours, are all exquisitely beautiful, with their rich green or crimson spots on a velvety black ground. And if we turn to birds, in which, as there are no known warning colours, all that are not protective are supposed to be due to sexual selection, we find, among much that is beautiful, great numbers of the harshest contrasts and most inharmonious combinations of colour that it is possible to conceive. Such are the blues and yellows and reds of the macaws and of a great number of other parrots; the equally harsh colours of the barbets and the toucans; the contrasted blue and purple or magenta and black of many of the chatterers. In many of these, no doubt, the texture of the surface is so delicate and the colours so bright and pure that we cannot but admire the tints themselves, although it is impossible to claim for the mode in which they are combined even the rudiments of æsthetic beauty. On the other hand, we find really beautiful combinations of colour and marking where sexual selection has certainly not come into play. Such are the exquisite tints and patterns of the cones, cowries, olives, harps, volutes, pectens, and innumerable other molluscan shells; while many of the sea-anemones, and considerable numbers of the caterpillars with warning colours, are equally beautiful.

Still more doubtful and more opposed to reasonable probability is the statement that "our standards of beauty are largely derived from the contemplation of the numerous examples around us, which, strange as it may seem, have been created by the æsthetic preferences of the insect world"—alluding, of course, to the colours and structures of flowers as being due to the need of attracting insects to fertilize them. Here objection may be taken, first, to the term *preferences* as applying to mere beauty in the flower, and still more emphatically to the term *æsthetic*, which there is not a particle of evidence for believing to enter at all into an insect's very limited mentality. Insects visit flowers wholly and solely, so far as we know, to obtain food or other necessaries of their existence, and every fact connected with the colours of flowers can be explained as due to the advantage of conspicuousness amid surrounding foliage, and distinctness from other flowers which are especially suited to different species of insects. When cows and horses refuse to eat the acrid buttercup, we do not say that the glaring yellow colour is repugnant to their æsthetic sensibilities, and that their dislike to the plant as food is the result; yet this would be less improbable than that bees and butterflies have any admiration of or liking for flowers independent of the supply of their physical wants. Moreover, a large part of the beauty *we* see in flowers is independent of colour, and is due to the graceful forms of individual flowers, their elegant groupings, and their charming contrast to the foliage which surrounds them. We now know that much of the variety in the form and position of flowers is dependent on their own physical needs, the protection of the pollen and the germ from rain, wind, or insect enemies, and that it has been produced by natural selection acting under the limitations due to the fundamental laws of vegetable growth. The purity and intensity of the colours are due to the fact that such colours offer a greater contrast to the ever-varying tints of foliage, twig, and bark, seen under constant modifications of light and shade, than would be offered by more sober hues; and thus it is that flowers usually exhibit the purest and brightest colours, which, combined with their elegant or curious forms, and the exquisite setting of green foliage which surrounds them, produce a general effect which is to us inexpressibly charming. But we have no reason to believe that any of the lower animals are affected in the smallest degree by these truly æsthetic feelings, and the use of the term as applied to them is simply begging the question, and is, therefore, not scientific.

It is because Mr. Poulton himself admits that the theory of sexual selection is still to some extent *sub judice* that the preceding remarks have been made in the way of protest against the use of terms which themselves tend to prejudge the case. In his chapters on this subject he has brought many arguments in its favour, some of which are ingenious and novel; but they all appear to rest on very slender evidence or to admit of another interpretation. They will, however, be useful as an incitement to further observation on this most interesting question, which, in all probability, will not be finally settled by the present generation of naturalists.

The book is well illustrated by numerous excellent woodcuts and a coloured plate, and there appear to be few if any misprints, the only one calling for remark being the placing of the cut at p. 34 upside down, so that the resemblance to a catkin is lost. Mr. Poulton is to be congratulated on having produced so readable and suggestive a volume on one of the most attractive departments of natural history, and on having by his own researches contributed so largely to the solution of some of the more interesting problems which it presents.

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A HAND-BOOK OF ASTRONOMY.

Hand-book of Astronomy. Parts II. and III. By George F. Chambers, F.R.A.S. (Oxford: Clarendon Press, 1890.)

IN commenting upon the first part of this revised edition of Mr. Chambers's "Descriptive and Practical Astronomy," we pointed out the utter insufficiency of the portion devoted to the study of the sun, inasmuch as it left solar spectroscopy altogether out of consideration. Such an arrangement is a breach in the continuity of scientific inquiry, and a grievous fault in a hand-book that makes some pretence to give facts in historical sequence.

The second volume deals with instrumental and practical astronomy, and in it we find spectroscopical astronomy interpolated; the work that has been done in this direction following the description of the instruments employed. This circumstance, however, at once exhibits an inconsistency, for, if spectroscopy properly follows a description of the spectroscope, then telescopy should follow a description of the telescope; whereas in the former volume the aspects of the heavenly bodies were described, and in this the instruments by means of which they are observed.