

## The Protective Colours of Animals

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To the ordinary observer the colours of the various kinds of molluscs, insects, reptiles, birds, and mammals, appear to have no use, and to be distributed pretty much at random. There is a general notion that in the tropics everything—insects, birds, and flowers especially—is much more brilliantly coloured than with us; but the idea that we should ever be able to give a satisfactory reason why one creature is white and another black, why this caterpillar is green and that one brown, and a third adorned with stripes and spots of the most gaudy colours, would seem to most persons both presumptuous and absurd. We propose to show, however, that in a large number of cases the colours of animals are of the greatest importance to them, and that sometimes even their very existence depends upon their peculiar tints. It is an almost universal rule that each animal either has enemies which seek to feed upon it, or that it seeks itself to feed upon other animals. In the first case, it has to escape its enemies or it cannot long continue to live. This it does either by its swiftness of flight, by its watchfulness, or by hiding itself from view. Some species come abroad only at night, some burrow under ground, many hide themselves among leaves, or bark, or stones, and thus escape destruction. Their enemies, however, are as swift and as watchful as they are themselves, and they can in most cases only escape them by avoiding observation. To do this, they must not be too conspicuous; and thus any kind of colouring that renders them hardly visible while seeking their food or attending to their young, actually tends to preserve their lives, and often alone enables them to secure the safety of their offspring. But the enemy who is in pursuit of them is in just the same predicament. He, too, must be concealed by his colour, or he will be seen afar off and his prey will seek a secure concealment. In that case he will simply starve to death, and his race will cease to exist. It thus appears that almost every kind of animal requires concealment; and it might therefore be thought that colour must always be injurious, and ought never to exist. And as colour not only exists; but abounds

among the various classes of animals, it may be thought that we have here a *reductio ad absurdum*, and that protective colouring cannot be of much importance.

Fig. 1.—The Buff-Tip Moth.

Further examination, however, shows us that even gay colours are very often protective, because the earth and the sky, the leaves and the flowers, themselves glow with pure and vivid hues. In other cases conspicuous colouring is useful to an animal, as when it is protected by the possession of a deadly sting or a nauseous taste, and the bright or unusual colour warns its would-be enemies to avoid it. There are also a great number of animals who appear to be sufficiently able to take care of themselves without resorting to concealment, and with these the tendency to the production of colour, which seems to be inherent in organic beings, exhibits itself unchecked. Taking all these facts into consideration, we find that there is an ample field for the development of blight and conspicuous colour on the one hand, and for the display of an infinite variety of protective tints on the other, dependent on the structure, the habits, and the instincts of the different kinds of animals. Let us now consider a few familiar examples of protective colouring. Owing to the mildness of the winter of 1877, and the dampness of the following spring, my garden was overrun with slugs, and I had to wage continual war against them. On every damp evening I would go round the borders, examining the choicest plants, and, taking the slugs off with a knife, deposit them in a jar of strong brine. While doing this, many of them, on being touched, would contract and drop to the ground, and though they fell close under my eyes, I often had some trouble to find them again, owing to their close resemblance to the small pebbles with which the soil abounded. They varied in colour from nearly white, to brown, yellow, and nearly black, and when contracted into an oval lump, they were exactly like the variously-coloured wet pebbles. One black slug with an olive-yellow under-surface, when contracted was wonderfully like a blackish flint pebble broken in two, showing the yellowish inside so common in such stones. It may be said that this was only an accidental resemblance, and at first it did not strike me as being anything else; but when, time after time, I lost sight of a slug beneath my very eyes, and had often no other means of finding it again but by touching the various small stones with my

knife till I found a soft one, the conviction forced itself upon me that here was a case of true  
Fig. 2.-The Lappet Moth

protection, and that what deceived me would also; probably sometimes deceive the birds and other animals that feed upon slugs. In the tropical forests I had often in the same way to resort to the sense of touch to supplement that of sight, in distinguishing between the phasmidae or "stick insects" and real pieces of stick; and as in this case it is universally admitted that the resemblance is a protection to the insects, since it saves them from the attacks of the numerous tropical insectivorous birds, we may well believe that our familiar slugs are similarly protected from the thrushes and other birds which feed upon them. We will now consider some other cases of protection by colour among animals of our own country, before proceeding to those more wonderful developments which occur chiefly in tropical lands. Every collector of beetles must have observed how many of our Curculionidae or weevils are brown or speckled, and also that they have the habit, on being touched or alarmed, of falling down on the ground, drawing in their legs and antennae, and there becoming undistinguishable from small lumps of earth or stones. Others, however, which are found constantly on nettles and herbage, are beautifully green, and these usually run or fly away when alarmed. A curious little beetle, *Onthophilus sulcatus*, is brown and furrowed, so as exactly to resemble the seed of some umbelliferous plant. The beautiful Musk-beetle, which usually rests upon the leaves of willows, is green; while the *Saperdas* and *Rhagiums*, which frequent timber or posts, are invariably brown or yellowish. It is, however, among our moths, which are at once more conspicuous and more defenceless, that the best examples of protective colouring in this country are to be found. The beautiful green *Agriopsis aprilina* and the dusky *Acronycta psi* rest during the day on the trunks of trees, and are often completely concealed by their resemblance to the green and grey lichens which surround them. The Lappet-moth (*Gastropacha querci*), when at rest, so disposes its rich brown wings as to resemble, both in shape and colour, a dead leaf (Fig. 2); while the Buff-tip moth (*Pygoera bucephala*) so contracts its wings that it looks exactly like a thick piece of broken stick, the yellow patch at the extremity of the wings giving the appearance of the freshly-broken end (Fig. 1).

Fig. 3.-Jacobreae Caterpillars

This is a case which well illustrates how impossible it is to decide from the appearance of a specimen in a cabinet whether the colours of an animal are or are not protective, for no one would imagine that this handsome and conspicuously-coloured moth could ever deceptively resemble a bit of dead stick, and so obtain protection from its enemies. It is a very common thing in the tropics to find beetles and moths which resemble bird's droppings, and the same occurs in this country; for Mr. A. Sidgwick, in a paper read before the Rugby School Natural History Society, says: "I have myself more than once mistaken *Cilix compressa*, a little white-and-grey moth, for a piece of bird's dung dropped upon a leaf, and, vice versa, the dung for the moth. Two other moths, *Bryophila glandifera* and *B. perla*, are the very image of the mortar walls on which they rest; and in Switzerland I amused myself for some time in watching a moth, probably *Lctrentia tripunctaria*, fluttering about close to me, and then alighting on a wall of the stone of the district, which it so exactly matched as to be quite invisible a couple of yards off. It has also been noticed that the general tints of the moths which are on the wing in autumn and winter correspond to the prevailing hues of nature at those seasons. The Rev. Joseph Greene states that the great majority of the autumnal moths are of various shades of yellow and brown, like those of the autumnal foliage; while the winter moths of the genera *Oheimatobia* and *Hybernia* are of grey and silvery -tints. It is among the caterpillars, however, that protective colouring is the most general and conspicuous. An immense number of these creatures are green, corresponding with the tints of the leaves on which they feed, or brown when they rest on bark or twigs; while a large number of the larvae of the *Geometridre* or *Loopers* have the habit of sticking themselves out rigidly like sticks, which they exactly resemble in shape as well as in colour. Everyone knows, however, that there are a number of very brightly-coloured caterpillars, and it may be asked how these are protected, or why the others need protection if these can do without it. The answer to this question is most instructive, and affords the most conclusive proof that various examples of protective tints in nature really have the effect we impute to them. It has been found by repeated observation and experiment that every green and brown caterpillar, without exception, is greedily eaten by birds, and even by frogs, lizards, and spiders,

and that they endeavour to conceal themselves from these numerous enemies by feeding usually at night, while during the day they remain motionless upon leaves, twigs, or bark, of the same colour as themselves. The brightly-coloured caterpillars, on the other hand, were found to be universally rejected by birds when offered to them, and even by lizards, frogs, and spiders. None of these would touch the common spotted caterpillar of the magpie moth (*Abraxa grossulariata*), nor those of the *Cucullia verbasci*, *Callimorpha jacobaeae* (Fig. 3), or the *Anthrocera filipendulae*. Sometimes the caterpillars were seized in the mouth, but always dropped again, as if in disgust at their taste. The same rule was found to apply to all the hairy or spiny caterpillars; and, what is very interesting, the habits of these creatures are correspondingly different from those of the green and brown eatable species. They all feed during the day; they do not conceal themselves, but feed openly, as if courting observation, and secure in the knowledge of their safety from all enemies. 1. This connection of gay colours and bold habits with non-edibility, throws light on many other cases of bright colouring which might otherwise be adduced as opposed to the theory of protection. Thus, among our beetles we have such conspicuous creatures as the lady-birds (*Coccinellidae*) and the "soldiers and sailors" among the Malacoderms, which are all conspicuous and defenceless insects, never hiding themselves, or seeking concealment, or feigning death, as do so many other beetles. The reason is now found to be that, like gaudy caterpillars, they are generally unfit for food. The same explanation may be given of the conspicuous whiteness of certain moths. One of these, *Spilosoma menthrasti*, is very common, but when given by Mr. Stainton to a brood of young turkeys among hundreds of other worthless moths after a night's "sugaring," it was always rejected, each bird in succession picking it up and then throwing it down again, as if too nasty to eat. The same thing has been observed with the showy butterflies forming the family *Danaidae*. Insect-eating birds were observed by Mr. Belt in South America, catching butterflies which they brought to their nest to feed their young; yet during half an hour they never brought one of the *Danaidae*, which were flying lazily about in great numbers. But there are other modes of protection, besides a nauseous taste which renders concealment unnecessary. Either weapons or armour have the same effect, if they are sufficiently perfect of their kind to render it

useless or dangerous for their enemies to attack them. The best example of armed insects are the bees and wasps, and among these conspicuous colours are the rule, while they usually fly about and seek their food without any attempt at concealment. Other insects have so hard a covering, or such awkward spines, as to be practically uneatable, and among tropical insects many of these are conspicuously or gaudily coloured. One of the few examples we have of this group are the little Ruby-tail wasps (*Chrysis*) which have no stings, but have the power of rolling themselves up into a ball, which is very hard; and they are so gorgeously coloured as to appear like some curious jewels. Others, again, obtain protection by extreme rapidity of flight, and by concealing themselves in holes or among flowers when at rest, and these are often brilliantly coloured, as in the case of the common Rosechafer. These few examples are merely intended to show that it is no argument against the use of protective colours in some animals, that many others have brilliant and clearly non-protective hues. In those cases, the creatures have certainly some substitute which enables them to live and continue their race. What this substitute is we can in some cases find out, but in many others we are too ignorant of the habits and surroundings of the species to determine whether its peculiar colours are or are not protective, or, if they are not, to determine what are the peculiar conditions which enable it to dispense with this particular kind of safeguard. An excellent example of a brilliantly-coloured insect, which yet obtains protection by its colours, is afforded by the caterpillar of the Emperor moth (*Saturnia pavonia-minor*). The green body adorned with pink spots pre-eminently beautiful and in most situations conspicuous; but it feeds on the common heather, and its colours then so completely harmonise with the young green shoots and small pink flowers, that it is with difficulty detected. Leaving now these familiar examples, to be found everywhere around us, let us cast a glance over a wider field, and see how the general conditions of existence, affecting many different groups of animals at once, influence their coloration for protective purposes. And first let us transport ourselves to the great deserts of the earth, and inquire what kind of animal life we find there. Canon Tristram has travelled much in the Sahara, and he thus describes the characteristic colours of its animal life: "In the desert, where neither trees, brushwood, nor even undulations of the surface, afford the slightest protection against its foes, a

modification of colour which shall assimilate an animal to that of the surrounding country is absolutely necessary. Hence, without exception, the upper plumage of every bird, whether lark, chat, sylvian, or sand-grouse, and also the fur of all the smaller mammals, and the skin of all the snakes and lizards, is of one uniform isabelline or sand colour." This is not a characteristic of one desert, but of all. In a recent account of the Steppe of Erivan in Asia Minor, it is said that "a remarkable feature of the animal inhabitants of the Steppe, insects and reptiles, and especially of the lizards, is the most perfect coincidence of their colouring with the colouring of the Steppe." More prominent examples of this prevalent tint are such animals as the camel and the lion, which are exactly of the usual tints of sand and sandy rock. Let us go now to the arctic regions, and we find these reddish-yellow tints entirely wanting, and instead of them pure white, or in a few cases dark-brown or black, where conspicuousness seems of more importance than concealment. All the bears of the globe are brown or black, except the polar bear, which is white. The polar hare, the snow-bunting, the snowy-owl and the jer-falcon, are also white or nearly so; while the arctic fox, the ermine, and the Alpine hare, change white in winter, as does our own Highland ptarmigan. This last bird is a fine example of protective colouring; for its summer plumage so exactly harmonises with the lichen-covered stones among which it delights to sit, that a person may walk through a flock of them without seeing a single bird; and when it changes to white in winter it is equally protected amid the snow which covers the mountains. A striking exception to the usual white covering of arctic animals is the Musk-sheep, or Musk-ox as it is often erroneously called. This animal is of a dark-brown colour, easily seen among the snow and the ice, but the reason of this is not difficult to explain. The Musk-sheep is gregarious, and derives its protection from this habit. A solitary strayed animal would soon become the prey of the polar bears or even of the arctic foxes; it is therefore of more importance that it should see its comrades at a distance, and so be able to rejoin them, than that it should be concealed from its few enemies. Another case is that of the sable, which retains its rich brown fur throughout the severity of a Siberian winter, but at that season it frequents trees, feeding on fruits and berries, and is so active that it catches birds among the branches. Again, the common raven is found in the extreme arctic regions, but is always black; and this is probably because it has no

enemies, while, as it feeds on carrion, it does not need to be concealed from its prey. These three cases are exceedingly valuable from a theoretical point of view, for they prove the incorrectness of a common notion that animals may change to white in the arctic regions either from the direct effect of cold, or from some influence of the white reflections from the snow; and they teach us that only those animals become white to whom that colour is useful, while those which either do not require protection or to whom dark colours are actually beneficial, remain totally unaffected. The cause of change must therefore be sought, not in the direct action of external conditions, but in the same general laws of variation and selection which have modified all the other characters of animals in the way most beneficial to them. Nocturnal animals offer equally good examples of protective colouring. Mice, rats, bats, and moles, are all of dusky or blackish hues, and are therefore very difficult to be seen at night; when alone they move about, while during the day they conceal themselves in holes or underground. When concealment by day as well as by night is required, as in the case of owls and goatsuckers, we find dusky mottled tints, assimilating with bark or earth during the day, and not very conspicuous at night. In some few cases nocturnal animals are conspicuous, a striking example of which is the North American skunk, which has much white about it and a large white tail which it carries erect in the most conspicuous manner possible. But the horrible odour emitted by this animal makes it universally dreaded, and its conspicuous tail is thus a signal-Hag to all carnivorous animals not to attack it—a parallel case, in fact, to the white moth, which we have already seen was rejected by birds which eat so many other moths. Equally striking as a proof that colour is largely protective is the fact, that nowhere but among the evergreen forests of the tropical and sub-tropical zones do we meet with birds the ground-colour of whose plumage is green. Parrots, which are confined to such countries, are generally green, with small patches of vivid colours. In the Eastern tropical islands many pigeons are as green as parrots, and there are numbers of other groups which are of the same colour. Such are the barbets, a family of fruit-eating birds, especially abundant in tropical Asia; the green bulbuls (*Phyllornithidae*); the Bee-eaters; the Turacos of tropical Africa; the little White-eyes (*Zosterops*) of the eastern tropics; and many other groups. These all frequent thick foliage,

with which their colours so exactly harmonise that it is most difficult to detect them. Contrast these with the ordinary colouring of the birds of the region of deciduous trees, of which our own country is a fair example. Here anything approaching a pure green is unknown, while brown or olive is the almost universal body-colour of the plumage. This is the tint which is least conspicuous among the leafless trees and bushes, which prevail for so large a part of the year, and when the need of protection is greatest. Among reptiles these protective tints are very apparent. Our lizards and snakes are all more or less brown or olive tinged, while in the tropics alone they are often of a vivid green, exactly corresponding with the vegetation they dwell among. The curious geckos-flat lizards with dilated toes, which cling to the trunks of trees or to rocks- are often finely marbled with green and grey, so as exactly to resemble the lichen-covered surface on which they cling. Some arboreal snakes of the genus *Dipsas* are, however, nocturnal; and these, like all other nocturnal animals which require to be concealed, are of dusky colours, being of various shades of black, brown, and olive. Many fishes even, present clear examples of protective colouring. Such as rest on the bottom, like the flounder, skate, sole, or Miller's Thumb, are invariably of the colour of the bottom, and often singularly speckled, so as to resemble sand or gravel. Such as swim near the surface of the water are almost always dark-bluish or greenish above, and white beneath, colours which evidently tend to their concealment from enemies in the air above them or in the water below. The brilliantly-coloured fishes from warm seas are many of them well concealed when surrounded by the brilliant seaweeds, corals, sea-anemones, and other marine animals, which make the sea-bottom sometimes resemble a fantastic flower-garden. The pipe-fish and sea-horses (*Hippocampus*) are excellent examples of this style of colouring. Some of them are greenish, resembling floating sea-weed; but in Australia there is a large species which is covered with curious leafy appendages, and all of a brilliant red colour, and this lives among red sea-weed, and is then perfectly concealed. It is, however, among tropical insects that the most perfect and wonderful cases of protection by colour and marking are to be found, and a very few examples of these must now be given. The best known and most celebrated are the leaf-insects of the genus *Phyllium*-curious large insects, whose wings and wing-covers are broad and flat, shaped and veined exactly like leaves,

while their legs, head, and thorax have all flat dilatations, like the stipules of many plants; and the whole being of the exact green tint of the foliage of the plant they live on, it is actually impossible to detect them when they are not in motion. The walking-stick insects, or spectres, are equally curious. These are long cylindrical insects, often nearly a foot long, and of the exact colour of pieces of greenish or brown sticks. If they have wings, these fold up closely, and are concealed under wing-covers of the same stick-like appearance; while the head and legs are so shaped and jointed as either to fit closely on to the stick-like body, or to appear like branched twigs. These creatures hang about shrubs in the forests, and can seldom be distinguished from small twigs and branches which have fallen from the trees overhead. They remain quite motionless during the day, and feed at night, and they hang anyhow across the foliage, holding on by two or three of their legs only, while the others are closely fitted, to the body, and they thus give themselves that unsymmetrical appearance which belongs to accidentally-broken twigs. A few of the species are still further protected by curious green, leafy excrescences all over the body, so as to look exactly like a piece of dead twig overgrown with a delicate moss. Such a one was brought to the present writer in Borneo by a Dyak, who assured him that moss had grown over the insect while alive, and it was only by very close examination that it could be discovered that the supposed moss was really part of the integument of the insect. Even among butterflies, whose gay colours seem only adapted to render them conspicuous, there are equally wonderful examples of protective marking. It was first pointed out by Mr. T. W. Wood (to whose skilful pencil we are indebted for the illustrations to this paper) that our beautiful little Orange-tip butterfly (*Anthocharis cardamines*, Fig. 4), although so conspicuous when on the wing, is perfectly concealed when resting in the evening in its favourite position among the flower-heads of the wood parsley (*Anthriscus sylvestris*).

Fig. 4.- The Orange-tip Butterfly

Its under surface is beautifully mottled with white and green, which strikingly assimilate with the white and green flower-heads of this plant. Much more wonderful, however, and perhaps the most wonderful of all imitative insects, is the leaf-butterfly of India (*Kallima inachis*, Fig. 5). This is a rather large and handsome butterfly, of

a deep bluish colour, with a broad orange band across the wings. It is thus sufficiently conspicuous; but it flies very quickly, and in a zigzag manner, so as to be caught with great difficulty. It is when at rest that it requires protection, and this it obtains by its colour and markings on the under surface, and by its peculiar habits. The upper wings have an acute lengthened apex, which is exactly the shape of the tip of the leaf of many tropical trees and shrubs; while the hind wings are produced into a short narrow tail, which well represents the stalk of a leaf. Between these points runs a dark curved line, representing the mid-rib, and from this radiate a few oblique markings for the veins of the leaf. The colour of the under side of the wings closely imitates that of dead leaves, but it varies almost infinitely through shades of bright yellow, reddish, ochre, brown, and ashy, just as leaves vary in their different stages of drying and decay. Even more remarkable is the manner in which the diseases and decay of leaves are represented by powdered dots and blotches, often gathered into little groups, so as to imitate in a most marvellous way the various fungi which attack decaying leaves. But to render the disguise effective, it is necessary that the insect should assume the position of a leaf, and this it does most perfectly. It always settles on an upright twig or branch, holding on by its fore legs, while its body (concealed between the lower margins of the wings) rests against the stem which the extremity of the tail, representing the stalk, just touches. The head and antennae are concealed between the front margins of the wings, and thus nothing is seen at a little distance but what appears to be a dead leaf still attached to the branch. Yet further, the creature seems to have an instinct which leads it to prefer to rest among dead or decaying leaves, which are often very persistent on bushes in the tropical forests; and this combination of form, colour, marking, habit, and instinct, produces a degree of concealment which is perfectly startling.

Fig. 5.-Leaf Butterfly of India

You see this gay butterfly careering along a forest path, and suddenly rest upon a shrub not three yards from you. Approaching carefully, you look for it in vain, and you may often have to touch the branches before it will dart out from under your very eyes. Again you follow it, and mark the very branch on which it has seemed to rest; but in vain you creep forward, and scan minutely every twig and leaf. You see nothing

but foliage-some green, some brown and decaying-till the insect again starts forth, and you find that you have been actually gazing upon it without being able to see any difference between it and the surrounding leaves. After repeated experiences of this kind, and knowing exactly what to look for, you are able sometimes, to detect it in repose, and are then more than ever amazed at the completeness of the deception, and at the same time profoundly impressed with the protection that must be afforded by this wonderful disguise-a protection whose effect is seen in the wide range and extreme abundance of the species. In this case, and in -that of the moss-covered stick-insect, we see the extreme perfection of imitative colouring; and we can only understand how this has been produced, by always keeping in mind the very much more numerous cases of slight or partial protection by colour or marking. We can only now briefly indicate some of the steps by which such protection is brought about. None of the characters of animals are more valuable than their colours, though this may appear doubtful when we look at the constant tints and markings of so many animals in a state of nature. There is, however, good reason to believe that even, in cases, these variations are constantly occurring, but, owing to the fact that the tint of each animal is useful to the species, all important deviations from it soon die out. Certain it is that almost every domesticated animal varies in colour, and these varieties, nor being hurtful as in a state of nature, are increased and multiplied without end. Now, if we suppose an animal to suffer from being too conspicuous, any variation of colour or marking tending to make it less conspicuous will give it a better chance of life; and as offspring tend to be like their parents. These less conspicuous varieties will often leave successors similarly endowed; but these again varying, some, among them will be still more protected; and thus the protective tints will tend to become more and more perfect in each succeeding generation, till their enemies, finding the pursuit too difficult, will confine their attention chiefly to other species. Then there will be no more change till some new enemy appears, when a further advance may take place till the protection becomes sufficiently perfect to place our supposed animal in a slightly better position than its neighbours. It has been a difficulty to many persons to understand how such variations could explain the curious cases of the Alpine hare, the ptarmigan, and many other animals which become white in winter only, when the ground is

covered with snow and that colour serves as a protection. It has, however, been observed, that a slight seasonal change takes place in many animals. Thus, in Siberia, the wolf, the horse, the cow, the roe, elk, reindeer, and two kinds of antelope, all become paler in colour during winter. Now, if either of these species migrated northward, till it came to inhabit a country where the winter snow remained on the ground for half the year varieties in which the seasonal change was more and more pronounced would have an advantage, and thus, in the course of many generations, an animal might be produced which changed colour as completely as do the arctic fox or the ptarmigan. We must now conclude this very brief outline of one of the most curious chapters in natural history. We have shown how varied and how widespread are protective colours among animals; and, if we add to these the cases in which conspicuous colours are useful, sometimes to warn enemies from such as are distasteful or are possessed of dangerous weapons, at other times to aid wandering species to recognise their companions or to find their mates, we shall become satisfied that we have a clue to much of the varied coloration and singular markings throughout the animal kingdom, which at first sight seem to have no purpose but variety and beauty.

1. For a full account of these interesting experiments, see "Contributions to the Theory of Natural Selection," 2nd Ed., p. 117.