

PROTECTIVE COLORATION OF ANIMALS,

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OUTLINE.

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The protection of animals from their enemies by means of their coloration is one of the most interesting phases of evolution and also one of which we see many examples. The fact that such a protection exists has long been recognized, but until comparatively recently no systematic investigations have been made and no adequate explanation has been offered for its presence and the perfection to which this protection has been carried.

Protective coloration is an advantage to animals for two purposes.

1st, They are rendered inconspicuous so that they may approach their prey.

2nd, They are concealed or protected from their enemies. The last object is effected in three ways.

1st, They are protected from their enemies by being made inconspicuous.

2nd, Inedible animals are protected by being made conspicuous. This method of coloration is called warning colors.

3d, Edible animals are protected by being made conspicuous to resemble inedible animals. This resemblance is called mimicry. These methods of coloration have been accounted for by three theories.

1st, Protective coloration has been imputed to a peculiarity originally created with the animals.

2nd, It has been claimed that it is caused by the direct action of the climate, surroundings, food, and habits of the animal.

3d, It has been accounted for by the theory of natural selection.

The first theory does not admit of much discussion but it

is very improbable, as the law of variation would certainly have changed all the animals from their original type during the length of time they have existed. Animals when changed from one place to another change in color to match their new environment. Also wild rabbits which are always gray or brown, when domesticated will in a few generations vary to black and white, and the same thing happens in the case of rats, mice, and pigeons.

Although the second explanation may be true to a very slight extent, it will soon be found to be inadequate to deal with all the various phases of the phenomena. It is also contradicted by many well-known facts, such as the cases where the wings of insects very closely resemble the leaves of trees even to the venation and shape of the leaf. A resemblance which manifestly could not be brought about by anything relating to the climate or food of the animal. As both of these theories are proved either inadequate or untrue it is left to the theory of natural selection to solve the problem.

PROTECTION EFFECTED BY RENDERING THE ANIMAL INCONSPICUOUS.

Concealment more or less complete is necessary to many animals who have no other method of approaching their prey or of escaping from their enemies. And the infinite variety of ways in which this is effected as well as the perfection of these methods is astonishing. The development of all these methods of coloration is very easily explained by the theory of natural selection.

The law of variation causes every animal to differ to some extent from its parents. And if that difference between itself and others of its species would make it less conspicuous to its enemies it would have a better chance to live and reproduce than those who were not favored in this way.

By the law of heredity its offspring would resemble it and some of them would be less conspicuous than their parent. This being the case they would survive till finally a species of animals would be developed that would be almost entirely inconspicuous.^A Species so protected would retain this coloration or continue to perfect its disguise. Because any individuals that would revert to the original type would be immediately killed by its enemies.

As this process of selection has been carried on for many thousands of years, all animals are exactly suited to their surroundings.

Desert animals are as a rule the color of the desert. The lion is almost invisible when crouched among the rocks and sands of his native haunts. Antelopes are more or less sandy colored and camels are exceptionally so. The Egyptian cat and the Australian kangaroo are of the same color.

The birds of the desert are still better protected in this way as is shown by the stonechats, the larks, the quails, and the goat suckers which abound in the deserts of the old world.

Reverend Tristram says, "In the desert where neither trees, bush, wood, or undulation of the surface afford an animal the slightest protection from its foes, a modification of color which is assimilated with the surroundings is absolutely necessary. Therefore the upper plumage of every bird without exception, whether lark, chat, sylvan, or sand grouse, and also the fur of all the smaller mammals and the skin of the snakes and lizards are of one uniform sand color."

Still more striking are the examples of protective coloration seen among the Arctic animals, all of whom possess the white color which best conceals them amid the ice and snow of the polar regions. The Polar bear which lives constantly on the snow and ice is

the only one of his family that is white. A remarkable example of evolution in this respect is found in the case of the ermine, the Alpine hare, and the Arctic fox, all of these animals are white in the winter and gray or brown in the summer when the ice and snow have melted for white would be a very conspicuous color at that time. Among the Polar birds the Ptarmigan is an excellent example. In the winter its plumage is white as snow but in the summer it is the same color as the lichen covered rocks upon which it sits.

Among nocturnal animals are many excellent illustrations of protective coloration, rats, mice, bats, and moles have all developed colors that will render them least conspicuous at night. Owls are of a dark mottled tint which harmonizes so well with the bark of the tree upon which they sit that even in daylight one might easily be mistaken for a dead snag. When they are startled they will close their eyes and stretch out making the resemblance more perfect.

The tiger is apparently an exception to the theory that all animals will have protective coloration that can be benefited by it. But upon examining more closely into his habits it will be found that he is protected by his apparently conspicuous stripes, for his natural haunts are in the jungle where the bamboos and reeds grow thickly. And when he is at rest the vertical stripes with which his body is adorned are very easily mistaken for the stems of the bamboo. The leopard and others of the cat tribe live among the trees and their coats have become mottled which enables them to blend with the leaves of the trees in which they are crouched. The puma does not stay among the leaves but clings close to the trunk of the tree and consequently its fur is a uniform ashy-gray color. Almost every one has noticed the great difficulty in finding small quails and to a less extent small turkeys when they are hiding in the grass. This is

simply another example of protective coloration combined with an instinct to crouch down among leaves and grass of their own color. The wood-cock is an excellent illustration for the various browns, yellows, and pale ash colors found in fallen leaves are all reproduced in his plumage and when, according to its habit it rests among the leaves on the ground, it is almost indistinguishable from its surroundings. Snipes are so colored that they are inconspicuous among marshy vegetation where they live.

The wood-dove when crouched in the fir tree is scarcely discernable while it would be easily recognized in any other foliage. The Robin red-breast would seem to many of us at first sight to be conspicuously colored but it will be noticed that he always sits in a bunch of dead leaves where it is possible, which makes him quite inconspicuous. Among the reptiles most of the tree lizards are green and one frog which lives on lichen colored walls very closely resembles them. In the tropics are many snakes which live among the trees and these snakes are green with white or dusky bands around them. This combination is very useful to them for it enables them both to approach their prey and to escape from their enemies.

It is easily seen that with most fishes the back is dark in color and the belly is light, and it is easily seen how this has been brought about. When the enemies of the fish see it from above the dark color of its back appears to be the same color as the bottom of the stream, and when they are below it the white belly harmonizes with the sky above. The fishes that live among the coral reefs have many gorgeous colors like the coral where they are found. The sea horse (Hippocampus) of Australia is adorned with large leaf like appendages resembling sea weed which are of a brilliant red color and they always live among sea weed of that hue so that when they are

not in motion it is impossible to detect them.

One species of pipe fish is provided with a prehensil tail by which it coils around objects, and then floats with the current thus greatly resembling a sea weed.

But it is in the insect world that we find the principle of protective coloration developed to the highest degree of perfection. There are thousands of species of insects that pass the day clinging to the bark of trees and in every case they are the exact color of the bark upon which they rest.

The Cicindelidae or tiger beetles illustrate this to a marked degree. One kind that inhabits grassy banks is of a green color. Another species found on the sand have a brown color due to their environment. The Cicindela Gloriosa which is of a deep velvety green color is found only upon mossy stones in the bed of a brook where it is exceedingly hard to detect. A large brown species of the same family is found only on the dead brown leaves along the forest paths.

Some beetles of the family Cassidae are very easily mistaken for dew drops both from their shining gold color and the position which they take on the leaf.

A very striking case of protection is found in the Indian "Callina Inachis". The upper surface of the wings is showy but the under side is always some shade of ash, brown or ochre such as are found among dead, dry, or decaying leaves. The apex of the upper wings is extended into a sharp point after the fashion of the leaves in the tropical forests.

The lower wings are produced into a short narrow tail and between these two points runs a dark curved line exactly corresponding to the mid rib of a leaf. From this line branch off side lines

which represent the lateral veins of the leaf. A still more extraordinary part of this resemblance is that among different species we find represented leaves in all stages of decay, blotched, mildewed and filled with holes, and in some cases irregularly covered with powdery black spots which closely resemble the minute fungi which grow on dead leaves.

If such an insect sat with its wings outstretched this remarkable coloration would be of no advantage to it, but along with this coloration it has been developed a peculiar instinct which enables it to make use of its advantages to the highest degree.

When it is at rest it always sits upon a nearly upright twig with the wings fitted closely together over its back having the antennae and head concealed between them. The little tails on the hind wings touch the branch and a perfect stem is formed for this apparent leaf which is supported by the legs which are small and inconspicuous.

The irregular outline of the wings gives exactly the appearance of a leaf. Thus with all these characters combined it forms a disguise that is absolutely perfect. We have several examples of this method of concealment among our common butterflies, some of them resembling oak leaves and others those of other trees.

Among moths are many interesting illustrations of this principle. One species that rests on the trunks of trees during the day time is very much like the lichens on the bark. The lappet moths resemble in shape and color a brown dry leaf. The larvae of the peacock moth harmonize in color with the heather upon which they feed also having pink spots on them which greatly resemble the bloom of that plant.

The canker worm and the larvae of many other moths have

have the habit of standing erect upon the stems of trees. This attitude combined with their color makes them appear much like small dead things. The order orthoptera characterized by the locust and grasshoppers furnishes many good examples of protective coloration.

The Mantidae and Locustidae are the exact tint of the leaves upon which they live and in many instances the veins of the wings are modified so as to resemble a leaf. This protection is carried to the furthest possible extent in the Phyllium or walking leaf in which not only the wings are perfect imitations but also the legs and thorax are flat, dilated and leaf like so that when it is resting upon the plant on which it feeds, the closest examination is often insufficient to detect it. Some even are covered with an excrescence which exactly resembles the moss found on dead sticks.

WARNING COLORS.

A second method of protection due to coloration is called "Warning Colors." they occur on those insects and animals which are not desirable for food or have some means of protecting themselves but are not predacious.

If the insects which are distasteful or injurious to their enemies were not given some special marking by which they might be known. Their distastefulness would be of no benefit to them for they would be killed before it could be discovered that they were injurious. But if their enemies could discover that an insect with a certain marking had better be left alone, the insects that are marked in this manner will be unmolested and will be able to reproduce abundantly, while others of its species that have no distinctive marking will be killed. As this process of natural selection continues it will easily be seen that a species will in time be developed

that will be very gorgeously and strikingly colored.

All of the stinging hymenoptera, bees, wasps, hornets, and others are very brightly colored and there is no instance where they are colored to resemble any plant or flower.

The golden wasps which do not sting but roll up into a very hard ball are strikingly colored. The insects of the order Hemiptera nearly all emit an offensive odor and as a consequence are nearly all bright colored.

The lady bugs (Coccinillidae) are all brightly colored being red with black spots and they also emit such a disagreeable odor that no bird will eat them.

The great family, Carabidae, almost all possess a bad taste combined with a bad odor, but as they are almost all nocturnal and predacious conspicuous warning colors would be of little use to them however they all possess a metallic lustre which, while being inconspicuous at night when they are securing their food, is quite easily seen in the day time.

Our most showy butterflies, such as the Monarch, are very distasteful to birds, who will never touch them. Taking these cases and many others not mentioned here it can be regarded as an almost certain rule that, those insects which are not desirable as food, and are neither nocturnal or predacious, will possess warning colors.

There are some insects that are not distasteful that have methods of frightening away their enemies. The firefly frightens away anything that might wish to eat it by means of its phosphorescent glow. The larvae of the Sphingidae show a strange method of protection in the peculiar but harmless horn with which they are armed, and the threatening attitude which they assume when disturbed, which might lead other animals than children to think they can sting. Other

Other larvae have a very grotesque face which they raise up when approached with the effect of scaring away its more timid enemies.

MIMICRY

Another phase of protective coloration is mimicry. In this certain animals, and more commonly certain insects, which have no means of defense, have been so developed by means of natural selection that they come to resemble very closely other animals or insects that have some means of defense.

If in a certain region there were two kinds of insects one of which was distasteful and brightly colored and the other had not either of the qualities, and was not protected in any way, then the second would easily fall a prey to the birds. If some of this kind resembled in some way the first kind, then they would be spared under the supposition that they were not good to eat. This process would continue, till in time the harmless species would exactly resemble the distasteful insects in coloration and habits and would in this way be protected. The imitators must be fewer in numbers than those imitated or the birds would be willing to take the chances of getting one of the distasteful insects in hopes of getting one of the desirable variety.

In a great majority of cases the animals which resemble each other inhabit the same region and the resemblance never extends to the inner structures but is only of the outer appearance and habits.

The flies of the genus *Volucella* which deposit their eggs in the nests of bees upon whose larvae their own young feed are very much like the bees, a resemblance which protects them when they enter the hive to lay their eggs.

The resemblance of moths to butterflies and of locusts to beetles has often been noticed. In South America there is a group of common butterflies call the Heliconidae, they have elongated wings and are strikingly colored and they also are slow weak fliers and would easily fall prey to any bird that chose to attack them, but they have a strong, pungent odor and no bird will molest them. There are also in the same region butterflies belonging to the family Pieridae which are not distasteful to the birds but they exactly resemble the Heliconidae in form, coloring, and manner of flight but they have none of the internal structures in common. The wings, thorax, abdomen, and antennae have all been elongated to resemble the Heliconidae. Different genera of the Pieridae resemble different genera of the Heliconidae, they always frequent the same locality and their comparative numbers are about as one to one thousand. The Heliconidae is also imitated by other families of butterflies.

A more familiar instance of the same thing is seen in the case of the Monarch and the Viceroy. The Monarch is a large, gaudy, slow flying butterfly which is very distasteful to the birds and the Viceroy is another butterfly not so plentiful but inhabiting the same place and having almost exactly the same coloration as the Monarch but not possessing the disagreeable taste.

Lepidoptera also mimic insects of other orders. For instance the common clear-winged moth is almost exactly like a bumble bee, another species resemble wasps, hornets, and other Hymenoptera.

There are many cases where species of beetles resemble others of the same order. The beetles that have no means of defence have developed a resemblance to beetles that have a bad taste, strong armor, or are very strong and active. There are cases where beetles mimic insects of other orders. For instance a South American Longicorn re-

sembles a bee in that its thorax, body, and legs are densely covered with hair.

Another beetle of the Longicorn family resembles a wasp having the abdomen banded with yellow and very much restricted at the base.

Another beetle is exactly like the large metallic blue wasp. One of the most remarkable cases of mimicry is that of a cricket of the Philippine Islands which is so much like a species of the tiger beetle that it is almost impossible to tell them apart.

Many of the diptera closely resemble wasps and bees for protection. One genus of small spider in South America that feeds on the ants is exactly like the ants themselves which renders it much easier to approach its prey.

It would be very difficult for much mimicry to exist among the vertebrates on account of the difficulty in changing the body structure due to having the skeleton of the inside of the body instead of on the outside, but it is found to some extent among them particularly among the reptiles.

In Mexico there is a very poisonous snake whose color is bright red with black bands and narrow yellow rings. In the same region there is a harmless snake relatively less numerous but with exactly the same markings and shape. Some harmless snakes make a practice of flattening out the head when disturbed which makes them appear like a poisonous snake. Others will rattle their tail in the grass and leaves to resemble a rattle snake. Some of the small tree frogs look very much like beetles as they sit among the leaves.

There are several instances of mimicry among birds both for protection and for the purpose of procuring their food.

The only case of imitation known of among mammals is that

of the Insectivorous Cladolates which very closely resembles a squirrel so that they more easily approach the insects upon which it feeds.

Taking all these instances and many more not mentioned here it will easily be seen that nearly all of the animal kingdom aside from man, depends at least to some extent upon the principle of protective coloration for their existence.

And that these various methods of protective coloration are the direct result of the process of natural selection which has been in operation for thousands of years to effect these wonderful results.