Protective Coloration in the Coleoptera.

Graduating Thesis.

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Thesis,- Outline.--

Title-- Protective Coloration in the Coleoptera.

Introduction--

Definition of the subject, and a limitation of its province.

Discussion of protection by means other than coloration.

Discussion--

A classification of the different kinds of protective coloration.

Cryptic colors.

Examples.

Warning colors.

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Protective Coloration in the Coleoptera.

One of the fundamental laws of nature is the arrangement by virtue of which every living thing has its natural enemies from which it must be protected or suffer the extinction of the species. These so called enemies are not, of course, enemies because of hatred or spite, as are enemies in the human family, but the enmity is rather the result of the natural instinct of some species to secure their food by preying upon other species. In the economy of nature we find that it is not only the large and powerful animals that prey upon the small and weak, but that there is a kind of provision for keeping the balance which works like an endless chain. This may be illustrated by taking a common case from nature. The larger carnivorous animals prey upon smaller animals which may in turn feed upon insects. These insects or their near relatives may in turn, be found gaining their living by sucking the blood of the first large flesh eating animals or living as parasites in or upon them, or by eating their carcasses after death.

There seems to be a tendency always working toward the extinction of the weaker species by the more powerful ones, or by those of their own kind which are better adapted to the conditions of life in which they are placed. To counterbalance this tendency many of these smaller species acquire, or are provided with, some special adaptation to protect them from their foes, or to help them in their search for food. These adaptations take various forms. They may enable their possessor to run more swiftly so as to escape pursuit, or on the other hand they may enable some other animal to run or fly more swiftly and so more easily capture its prey. Another way by which an advantage is gained is by special means of concealment,

on the one hand from the pursuers, and on the other , from the pursued. Still another special means of protection is the possession of some nauseating odor, bad taste,or dangerous sting,or painful or poisonous bite. Examples of these latter may be found especially among the lower animals, as snakes and toads, and among the insects. Other kinds of adaptation for protection are seen in the quills of the porcupine, the extremely hard body covering of some animals,as some beetles and the armadillo, the spines of some caterpillars,and the inky fluid with which some squids hide themselves from their enemies.

These adaptations for protection may be classed as active and passive means of defense, according to whether or not the animal possessing it has to exercise volition to make the protection apparent and of use to it, or the simple possession of the adaptation is in itself a protection without the exercise of volition by the animal possessing it.

Protective coloration, the subject with which we have to deal is an example of almost exclusive passive defense, since the animal so colored is so entirely without his knowledge of the benefits he receives by virtue of the coloring. There are cases , however,where the protection would not be of any value to the animal unless accompanied by a voluntary act. This is true in the case of some lepidopterous larvae which resemble twigs of trees when they assume the position of a twig. Herethe coloration would be of small value if the insect did not take the position that would best carry out the deception. But in a general way we may say that protective colors afford an instance of passive defense.

Protective coloration is now almost universally believed to be

the result of a process of natural selection made possible by the natural variations that occur in every kind of life. By reason of these variations those individuals of each species which have varied in the direction of the protected forms stand a better chance of escape from the enemies of the species than do those that do not have this variation. The individuals that survive then transmit the same characters varying more widely than in their own case, to some of their offspring, who will in turn transmit the same variation in a greater degree to a greater proportion of their own offspring; and in course of time the variation becomes so wide that under the same circumstances the protection approaches perfection. Some, especially among the older writers , are opposed to the theory of natural selection, preferring to believe that every thing is the result of creative design rather than of natural selection or evolution. It seems perfectly in accord with any rational belief to reason that even if we do accept the divine origin of things, we may believe that an all wise Creator may have chosen to modify the creatures of the earth, in accordance with the changing conditions of their environment, by a gradual process of natural selection of the fittest, rather than by abrupt changes of form and structure. However that may be, this paper is not for the discussion of that phase of the subject. No matter what view we accept of the cause of protective adaptations, it does not alter the fact that the benefits of the variation are enjoyed none the less by the animal possessing it.

Animal colors have been arranged in a system of classification on a basis of the purposes which they serve. Since a modification of this system is to be used in this discourse, it may be well to give the table in the original, before giving the modification. The table is as follows: -

I. Colors which cause the animal to resemble some part of its environment, or to mimic the appearance of some other species. (Apatetic colors).

A. Colors which conceal an animal by causing it to resemble some part of its natural surroundings. (Protective and aggressive resemblance: Cryptic colors).

1. Concealment as a defense against enemies. (Protective resemblance: Procryptic colors) . Ex. Colors by which palatable insects are concealed.

2. Concealment enabling an enemy to catch its prey. (Anticryptic colors: Aggressive resemblance). Ex. Colors of the lion, tiger, and some other beasts of prey.

B. False warning colors and false signalling colors deceptively suggesting something unpleasant to enemies or attractive to prey, (Protective and aggressive mimicry, and alluring colors: Pseudosematic colors).

1. Colors which deceptively suggest something unpleasant or dangerous to an enemy. (Pseudaposematic colors: Protective mimicry). Ex. Hornet-like bug,&c.

2. Colors which deceptively suggest something attractive to prey, or enable an enemy to approach without suspicion. (Alluring colors and aggressive mimicry: Pseudepisematic colors). Ex. Mantis which is colored like a pink flower, Volucella, and thus attracts other insects upon which it feeds.

II. Warning and signalling colors , which suggest something unpleasant to an enemy or aid in the escape of other members of the same species. (Sematic colors).

1. Colors to warn an enemy off by denoting something unpleasant or dangerous. (Warning colors: Aposematic Colors). Ex. Gaudy colors of nauseous or dangerous insects.

2. Colors which enable individuals of the same species quickly to recognize and follow each other.(Recognition marks: Episematic colors). Ex. White tail of rabbit.

III. Colors used in courtship. (Epigamic colors). Ex. Brilliant colors of some male birds and insects in cases where the female is of dull or obscure color.

Since the above classification includes colors both protective and aggressive, it requires some revision to make it conform to the subject of this discourse. The plan or scheme of classification to be used for the purposes of this paper is to divide the subject of protective colors into three general heads, viz. Cryptic colors, Aposematic colors or warning colors, and what we shall speak of as true mimicry. These will be considered, and instances of each cited later.

This paper is to deal more espscially with specific examples of each of these divisions from the order COLEOPTERA, as indicated in the title. No part of the animal kingdom better illustrates the principles of pritective coloration than does the class Hexapoda, or the insects, and no order among the insects gives more striking and varied examples than does the order COLEOPTERA. There are perhaps some more conspicuous examples to be found among some of the larger insects, but none are more characteristic or interesting.

Cryptic colors, or obscuring colors.

The colors which tend to render their possessor more difficult to be seen, are usually colors that make the animal harmonize with the background upon which it is found. This resemblance is made more complete in some cases, by special adaptations in form and external structure. This is,like all other phases of protective coloring, entirely the result of natural processes, and without the volition of the insect. Kirby and Spence in their "Entomology", give an instance tending to prove that the animal itself does sometimes use volition in the matter. The case referred to was one of a small beetle living on chalk hills in England, which, naturally black, covers itself with chalk dust so as to hide more easily from its enemies. It seems that the more plausible explanation of the case is that the insect becomes covered with the chalk dust simply by coming in contact with the chalk, just as a stone mason becomes the color of the lime with which he works.

There are several families of Coleoptera the members of which , almost without exception, are so colored as to be almost hidden from wiew in their natural environment. Among these may be mentioned as examples, the Cicindelidae, the Buprestidae, the Elateridae, all of the families of the sub-order Rhynchophora, many of the species of the family Cerambycidae, and in fact some species in nearly every family. The general rule seems to be that insects whose habits are terrestrial and those that live in dark and secluded situations, are of black or other dark colors, while those that live on foliage and in bright light are of bright and shining colors, and so in each case are protected by resembling their surroundings.

The species Cicindela lepida, is a small insect which is found on

the sand-hills, and is of a very light almost white color above, corresponding closely with the color of the sand which is of a very light shade. Other species of the same genus, as C. vulgaris and C. generosa, are colored in a similar manner, and are found in the same situations, as sand-hills and river banks. C.belfragei is a black species,which occurs only in localities of a darker soil. Another species of the same family, Tetracha virginica, is found in the grass and climbing upon vines in search of food. It is of a dark green color very much the same as the color of the grass. The family furnishes numerous other examples similar to the ones already given but no more need be mentioned.

In the family Cerambycidae there are several species of a prevailing brown color usually marked with gray, which are found on the bark of trees. They closely resemble the bark of these trees on which they are found and the resemblance is heightened by the rough elytra of the insects. They are one of the best cases of protective coloration. A fine example is the species Leptostylus aculiferus, found in our locality on elm trees.

The family Buprestidae is another one showing good examples of harmonizing colors. the beetles included in the family are for the most part of dark rather obscure colors with metallic coppery lustre, and are often captured upon leaves and bark.

The Elateridae are somewhat similar to the Buprestidae in appearance, and display much the same adaptations, but are much less important, in an economic way at least.

In the family Scarabaeidae occurs the Goldsmith beetle, Cotalpa lanigera, which feeds upon the leavse of the cottonwood, and is protected upon them by its brilliant colors. In this family occur

also many small black or brown beetles that feed on excrement, but it is doubtful if their color is of any great benefit to them.

The suborder Rhynchophora is full of almost perfect types of this variety of protective coloration. A great majority of its species live upon vegetation, and there are practically none that are conspicuous, most of them in fact are very obscure. The roughened body covering of most species is also an aid to their obscurity. Many species live on the bark of trees and these are as a rule, of a dull color, brownish or black. One specimen of the genus Lixus has a decided rusty tinge, and is found on a plant,(Polygonium) the bark of which has the same rusty tinge. Other species are found on blossoms and are of much lighter colors, some tropical species having very beautiful colors.

Warning colors.

In warning colors we are confronted with an entirely different set of conditions from those we considered under the head of obscuring colors . The latter being unprotected sought to escape notice while the latter having some form of protection, seek to warn their enemies of the fact by the possession of some characteristic and conspicuous coloring, so that they may not be mistaken for the unprotected forms, and suffer their fate. Some of the most common means of defense with which these insects are furnished are nauseating taste, bad odors, and exceedingly hard body covering, all of which tend to render them unpalatable or absolutely inedible to birds and other insect eaters. Other insects possess a painful or dangerous sting, and their conspicuous colors warn their enemies of that fact.

Several of our common families are known to be inedible and they are as a rule conspicuously colored. Some of the families most typi-

cal of this character are the Coccinellidae, the Meloidae, the Tenebrionidae, some of the Chrysomelidae, most of the Lampyridae, and occasional species in other families.

The Coccinellidae are as a family immune from the attacks of birds and are known to be distasteful to them. They are nearly all colored some conspicuous shade of red or yellow, which is usually quite in contrast with their surroundings. Since these are all insects beneficial to man, it seems a fortunate provision that they are inedible. Megilla maculata is a common species of red and black color.

The Meloidae are well known on account of the blistering property of their body fluids, often made use of in medicine. These beetles are of various colors but are almost always conspicuous, and are not molested by birds. Several of these beetles commonly known as potato beetles, Epicauta cinerea, E. pennsylvanica, and Pyrota mylabrina, are good types showing also the colors common in the group.

The Tenebrionidae do not show the brilliant colors common to the unpalatable insects, but most of them have a characteristic appearance that probably serves the purpose of distinguishing them as well as brighter colors would.

The Lampyridae is another family that is free from the attacks of the usual insect enemies. The members of the family are as a rule colored with some easily noticeable shade of red or yellow, and the light giving apparatus is thought to be a protection to the insect from the nocturnal insect eaters.

Although the Chrysomelidae are not as a rule, protected by any special adaptation, there are yet some species in this family that are not attacked by birds seemingly on account of some bad taste as there is no noticeable odor . One of especial interest on account

of its economic importance is the Colorado potato beetle, Doryphora decimlineata, familiar to everyone, which probably owes its abundance in a measure at least, to the fact that birds and fowls will not eat it and so it has not so much to contend with as have its unprotected rivals. Many species of Chrysomelidae belonging to various genera are of the most brilliant blue, green, and coppery colors, and are often seen in exposed places, so if our general assumption is true they are inedible. The subject of warning colors is interesting but not especially instructive nor is it of great importance.

Mimicry.

The subject of mimicry is the next one to be considered, and it is the most interesting phase of the whole subject of protective coloration to many people. The term mimicry in its biological sense was first applied by Mr. Bates, to a case of deceptive resemblance noticed among certain butterflies in the tropics. The term has since been accurately defined and limited in its biological application by Mr. Wallace. His definition in the form of a description is as follows:"A certain species of plant or animal possesses some special means of defense, as a sting, nauseating odour or taste, or a hard integument, that other species of the same locality do not possess. The unprotected species closely resembles the first in form, color, and external points, although structurally different and often totally unrelated." Mr. Wallace has also given us a very clear and accurate statement of the conditions under which mimicry may occur. "In mimicry-

" The imitators occur in the same area and occupy the same station as the protected species.

"Imitators are always more defenseless.

"Imitators are always less numerous in individuals.

"Imitators differ from the bulk of their allies.

"The resemblance is external and visible only, never extending to the internal characters, or to such as do not affect the external appearance". Even with so concise a statement as this as to the conditions allowing the assumption of a case of mimicry, we are often at loss to know whether or not some case is properly a case of genuine mimicry or not.

It is always well to be conservative in this matter and not assume a case of mimicry without undisputable evidence. We should also take into consideration the fact that this form of adaptation is acquired to deceive only birds and other animals of a lower degree of intelligence and consequent feebler powers of discrimination than our own. When we make allowances for this, we find many cases that might deceive birds and lower animals and so be good cases of mimicry, in which the resemblance does not seem to us to be so striking as we might expect in a case of mimicry.

Some of the explorers in the tropics have described many well founded examples of mimicry that occur there, but in this paper only those examples that have been observed in our own locality, will be considered.

A species of Meloidae not attacked by birds, Epicauta cinerea, is closely resembled by an edible species of Cerambycid, Mecas inornata, which is edible and also much less abundant than the protected form, occurs in the same area on closely associated plants, and in number of individuals is much less. It is also somewhat different from the typical Cerambycids.

Another Cerambycid, Monilema annulatum, and a Tenebrionid, Eleodes longicollis, closely resemble each other in form and color, both of them being shining black in color, and rather spindle shaped or cyl-

indrical in form. When we find that the Tenebrionid is unpalateable, and that the two are found in the same situations in the same area, and that the genus Monilema departs very widely from the usual form of the Cerambycidae, we then have what appears to be an indisputable instance of mimicry, fulfilling all of the conditions under which it occurs.

Still another member of this family, often found in the state, shows an example of mimicry. This is Batyle ignicollis, and the insect it mimics is a Meloid, Nemognatha bicolor, which like the rest of its family is inedible. Both of these are found on flowers and foliage in the same locality, both are black and have a red prothorax, they are about the same in size, and the imitator cannot be considered a typical member of its family.

Many cases have been observed of beetles that mimic Mutillids and other stinging Hymenoptera. Atype of these is found in a little Clerid (Clerus dubius*), that very closely copies the appearance of a small stinging velvet ant, (Mutilla leona), the female of which is armed with a very effective sting. The habits of these insects are not the same so far as known, but the resemblance is so striking and complete that there can be little doubt that it is a true case of mimicry. The Mutillid is rufous with the abdomen ornamented with grey and black bands. The color of the Clerid is the same, the rufous color extending over about one third of the elytra, the rest of the elytra is colored to correspond to the abdomen of the imitated species. It seems improbable that the resemblance would be so exact if it did not serve some purpose, so we are forced to believe that it is a case of mimicry although the habits of the insects may have changed so that there is no longer any advantage gained by the resemblance.

* There is some doubt as to the species.

It is impossible to give here the many various and beautiful examples in protective coloration and mimicry described by tropical explorers as occuring in the tropics, but they show only further proof of what has already been sufficiently illustrated.

There are many cases of brilliant colors in insects that can not be explained as protective colors. These are sometimes referred to as sexual colors, but some of them cannot be explained even that way so we are left to decide that we do not know the reason why they should be as they are. They do not properly come in this discourse and so will not be considered further.

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Insect specimens used were from my own collection or from the collection of the K.S.A.C.